CAA2023

50 years of synergy

Amsterdam

3-6 April 2023

Abstract Book

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ACROSS THE HORIZON
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Faculty of Humanities

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Gemeente Amsterdam

Celebrating 50 years of CAA in Amsterdam!

The Dutch-Flemish chapter of CAA is excited to welcome the 50 year anniversary conference of CAA to the Low Countries for the first time since CAA1995. The CAA2023 conference is hosted by the University of Amsterdam (UvA), the place where computer archaeology in the Netherlands was born. You will be welcomed in Amsterdam by staff and students of ACASA, the Amsterdam Centre for Ancient Studies and Archaeology, that is offering a shared archaeology curriculum together with Vrije Universiteit Amsterdam, in which digital archaeology is playing an increasingly important role.

Nominally, CAA is a Dutch organization, and Dutch archaeologists have been actively involved with CAA since the early 1990s. Dutch archaeologists started the first national chapter outside the UK in 1995, and have been members of the CAA Steering Committee for many years. In the late 2000s, archaeologists from Flanders have joined their Dutch colleagues to form CAA-NL/FL. Since then, we have organized annual conferences in the Netherlands and Flanders, and have hosted meetings together with CAA-DE.

This conference represents the whole of Dutch and Flemish digital archaeology. The organization is therefore shared with colleagues and student volunteers from the Vrije Universiteit Amsterdam, University of Leiden, Saxion University of Applied Sciences and University of Groningen in the Netherlands, and the universities of Ghent, Leuven, Antwerp and Vrije Universiteit Brussel in Belgium. We would like to thank them all for their contribution and support.

We hope that you will enjoy this anniversary CAA conference as an opportunity to meet old and new colleagues, to exchange ideas and to learn from your peers. We also hope that you will find some time to explore the city of Amsterdam with its many cultural and culinary delights, and that you will return home with good memories. We expect that this 50 year anniversary conference will be the start of many new and exciting developments in the discipline and in CAA itself, and we are very much looking forward to hosting you all.

The organizing committee,

Jitte Waagen

Philip Verhagen

Alex Brandsen

Ronald Visser

Devi Taelman

Piraye Hacıgüzeller

Laura van der Knaap

Venues and Events

Workshops at the Vrije Universiteit Amsterdam

On Monday 3 April CAA2023 will host a full day of workshops for participants. These will take place at Vrije Universiteit Amsterdam, in the Hoofdgebouw, the Nieuwe Universiteitsgebouw, and the W&N gebouw.

Hoofdgebouw: *De Boelelaan 1105, 1081 HV Amsterdam*

Nieuwe Universiteitsgebouw: *De Boelelaan 1111, 1081 HV Amsterdam*

W&N gebouw: *De Boelelaan 1085, 1081 HV Amsterdam*

Sessions at the RAI Congress Centre

All sessions will take place at the conference venue, RAI Amsterdam Congress Centre. It has excellent connections to all parts of town and to the airport. The venue has a high standard of services and excellent catering.

To plan your travel to Amsterdam and the RAI, please see the Travel page.

For the floorplan of the RAI, please see the next page.

Europaplein 24, 1078 GZ Amsterdam

Icebreaker Reception at Zuiderkerk

The traditional CAA Icebreaker Reception is included in the conference fee, and will take place in the Zuiderkerk in the centre of Amsterdam on 3 April 2023 from 17:00 – 20:00.

Zuiderkerkhof 72, 1011 WB Amsterdam

Conference Dinner at House of Watt

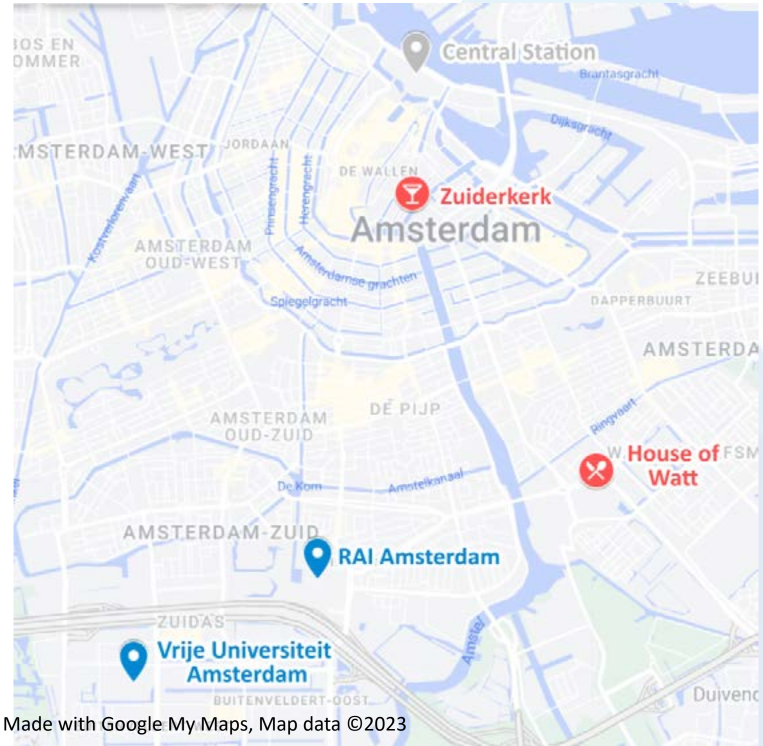
The CAA Conference Dinner will be held at House of Watt on 5 April 2023 from 19:00 – 01:00, and will feature a karaoke stage! This will be a 5-course 'walking dinner' with one complementary welcome drink included, and will cost 60 EUR. There is a limited number of places available, so make sure to book your spot on registration!

House of Watt is a half an hour walk (or 13 min cycle!) from the RAI, or you can take metro 51 from RAI to Amsterdam Amstelstation. From there it's a 7 minute walk.

James Wattstraat 73, 1097 DL Amsterdam

Conference Dinner at House of Watt

A city walk is available through ArchaeoTrail! This unorthodox Medieval Amsterdam city tour is for those interested in the lesser-known historical and archaeological stories of Medieval and Late Medieval Amsterdam and includes some local lore and famous places. he walk can be made at your own convenience. Please download the ArchaeoTrail app on your smartphone, select 'Add Trails', enter code '5977' and select 'Download Trail'. Have fun!



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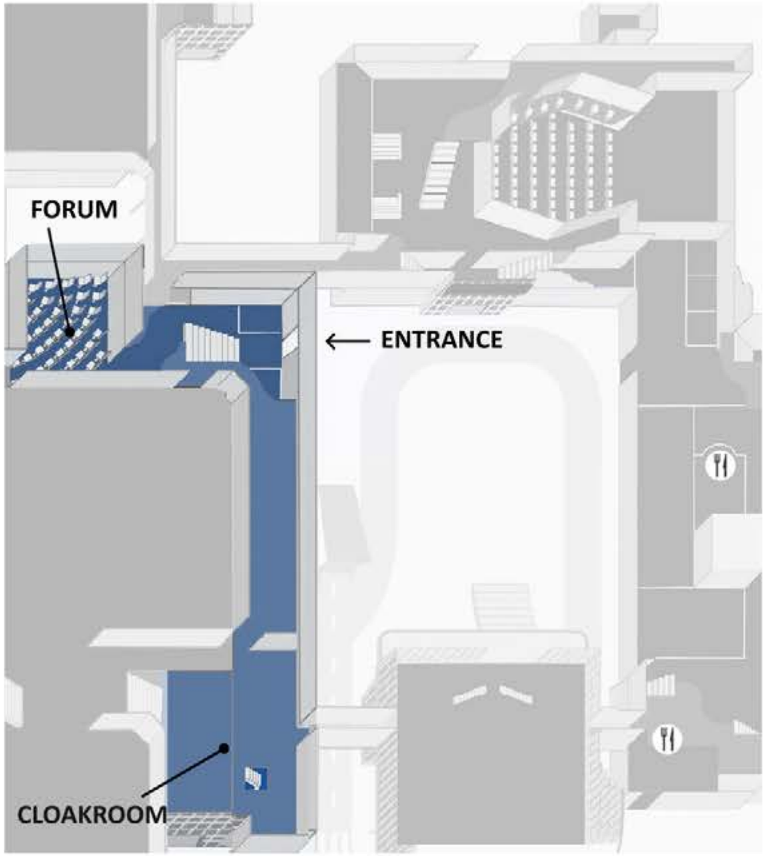
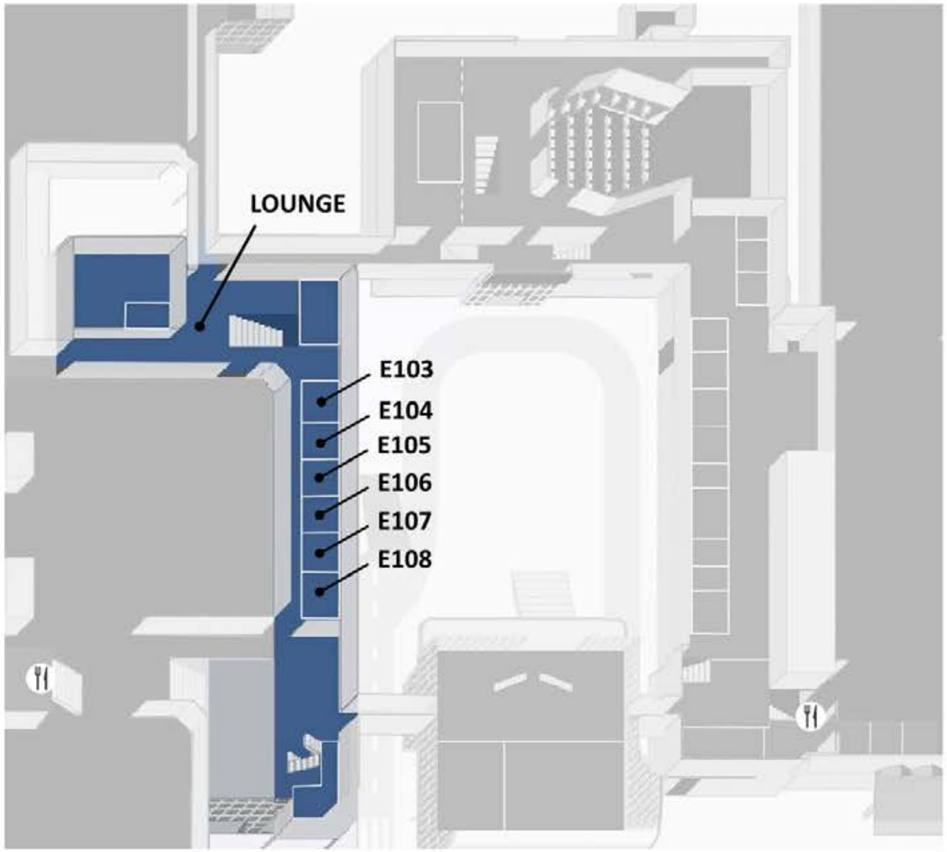
RAI Amsterdam Map

RAI Amsterdam, Ground Floor



RAI Amsterdam, First Floor



Preliminary Schedule

Monday 03-04-23: *Workshops at Vrije Universiteit Amsterdam*								
	WN-S631	**HG-0G25**	**WN-S607**	**WN-S655**	**HG-0G10**	**NU-4B05**	**HG-0G23**	**NU-4B11**
SLOT 1 **09:00 - 12:00**	A Basic Introduction to Open Source GIS using QGIS	CRMarchaeo Workshop: a stepping stone to FAIR practice	Realistic material modelling and rendering for 3D scanned archaeological artefacts in Blender	Introduction to deep-learning			Developing 3D Scholarly Editions. Storytelling in Three Dimensions	3D Artifact Documentation with the GigaMesh Software Framework
SLOT 2 **13:30 - 16:30**	Documentation of cultural heritage data with Field		Agent-based modelling for archaeologists (group 1)		Sharing and maintaining software with GitHub and Git	Agent-based modelling for archaeologists (group 2)		
Icebreaker Party 17:00 - 20:00 Zuiderkerk								

Tuesday 04-04-23: *Conference sessions at RAI Congress Centre*

	FORUM	E103	E104	E105	E106	E107	E108	LOUNGE
SLOT 1 **08:30 - 10:00**	Welcome + keynotes							
SLOT 2 **10:30 - 11:50**	43. Synergies in 3D Spatial Analysis	04. "Hey Google, stop that looter": digital technologies against cultural heritage crimes; critical approaches, ongoing solutions and beyond		"24. How Are Archaeological Narratives about the Past Constructed? – Analysing Argumentation in Archaeology 31. Better Together: Exploring methods and applications for the synergy of multiproxy data in the study of archaeological mobilities. "	01. Integrating mobile computing technologies into traditional archaeological methods	Poster Session	05. For new epistemologies in Archaeology: using probability, networks and mathematical models to build archaeological knowledge	Posters
SLOT 3 **13:00 - 15:00**		07. Open Analytical Workflows and Quantitative Data Integration in Archaeological Prospection	"18. Modelling Ancient Cities: methods, theories and tools "	13. An inventory of the Sea: our shared marine heritage challenges and opportunities		12. Chronological modelling: formal methods and research software		
SLOT 4 **15:30 - 17:30**					19. Building a Collaborative & Interoperable Information Ecosystem: A conversation to bridge archaeological data systems and infrastructures		32. A Bridge too Far. Heritage, Historical and Criminal Network Research	
Optional City Walk								

Wednesday 05-04-23: Conference sessions at RAI Congress Centre

<table>
<tr><th></th><th>Forum</th><th>E103</th><th>E104</th><th>E105</th><th>E106</th><th>E107</th><th>E108</th><th>Lounge</th></tr>
<tr><td>SLOT 1
08:30 - 10:30</td><td rowspan="3">11. The Age of #Archaeogaming: The Past and Future of Archaeology + Video Games</td><td rowspan="3">"22. Machine and deep learning methods in archaeological research – creating an integrated community of practitioners "</td><td>33. Bayesian Inference in Archaeology: new applications and challenges</td><td>39. Web-database solutions for the excavation datasets</td><td rowspan="2">30. Crossing Landscapes of the Past: Developments in Modelling Mobility and Connectivity in Archaeology</td><td rowspan="2">15. Reproducing, Reusing, and Revising Code and Data in Archaeology</td><td rowspan="3">08. Where do you draw your lines? Mapping transformation of archaeological practice in the digital age.</td><td rowspan="3">Posters</td></tr>
<tr><td>SLOT 2
11:00 - 13:00</td><td>03. Our Little Minions pt. V: small tools with major impact</td><td>02. Studying uncertainties in archaeology: A new research agenda</td></tr>
<tr><td>SLOT 3
14:00 - 15:40</td><td>41. Capacity building for open data persistence in archaeology</td><td></td><td></td><td>23. Understanding Archaeological Site Topography: 3D Archaeology of Archaeology</td></tr>
<tr><td>SLOT 4
16:30 - 16:50</td><td>AGM</td><td colspan="7"></td></tr>
</table>

Thursday 06-04-23: Conference sessions at RAI Congress Centre

<table>
<tr><th></th><th>Forum</th><th>E103</th><th>E104</th><th>E105</th><th>E106</th><th>E107</th><th>E108</th><th>Lounge</th></tr>
<tr><td>SLOT 1
08:30 - 10:30</td><td rowspan="2">20. Simulations for the past, simulations for the future</td><td rowspan="2">10. Computer applications in archaeology – Bringing South Asia together</td><td rowspan="2">06. Stay connected: Developing Mobile GIS for team-based collaboration in archaeological research</td><td></td><td rowspan="4">29. How do we ensure archaeological data are usable and Reusable, and for whom? Putting the R in FAIR for archaeology’s data</td><td rowspan="2">26. For a Bright Future: Challenges and Solutions for the Long-Term Preservation of 3D and Other Complex Data in Digital Cultural Heritage</td><td rowspan="2">37. Modelling the semantics of space – the relationship of entities creating space</td><td rowspan="4">Posters</td></tr>
<tr><td>SLOT 2
11:00 - 13:00</td><td>44. Roads to Complexity: Technological and Quantitative Approaches to Human and Objects Connectivity</td></tr>
<tr><td>SLOT 3
14:00 - 16:00</td><td></td><td rowspan="2">16. Archiving information on archaeological practices and knowledge work in the digital environment: workflows, paradata and beyond</td><td rowspan="2">34. Computational Approaches and Remote Sensing Applications in Desertic Areas</td><td rowspan="2">35. Indigenous Knowledge and Digital Archaeology: potential, problems and prospects</td><td>38. Computational Modeling Water-Based Movement</td><td>28. Digital Humanities, Digital Archaeology</td></tr>
<tr><td>SLOT 4
16:30 - 18:30</td><td></td><td>14. Robotics and Archaeology - on the state of the art and beyond</td><td>27. Exploring new ways of visualizing archaeological data</td></tr>
</table>

Posters

Location: E107 (poster session) + Lounge

11. Studying the development of irrigation system in southern Mesopotamia

Dengxiao Lang, Delft University of Technology
Maurits Ertsen, Delft University of Technology

The landscape of south Mesopotamia can be regarded as a hydraulic landscape, as the history of the region is actually the history of the complex water systems structured by natural and man-made channels, irrigation canals, levees, marshes, and swamps (Wilkinson et al., 2015). Wilkinson et al., (2015) suggested that the channel breaks could provide water to irrigated fields, and groups of fields would eventually be structured along irrigation canals with associated management in and modification of the society. However, the history of irrigation management and the development of the irrigation landscape in southern Mesopotamia has not been explained clearly. We claim that exploring how irrigation systems are evolving from small-scale to large-scale, from short-term to longer-term, and from individual to collective could provide further understanding of the development of the environmentally and socially created irrigation systems of Mesopotamia – and of other times.

Before the current study, we already developed the Irrigation-Related Agent-Based Model (IRABM) and Advance Irrigation-Related Agent-Based Model (AIRABM) (Lang and Ertsen 2022a, 2022b) IRABM provides the theoretical and methodological discussion of exploring the interactions between irrigation-related agents and understanding how these interactions could create water and yields pattern. AIRABM shows the dynamics of farmlands in response to farmers' decision-making both at individual and collective levels. Based on these two models, we extend farmers' decision-making process – not only within the same canal but also in canal expansion. Again, there are two levels decision-making. Individual farmers could make the decision on sowing of their own farmlands. When there is a poor harvest situation along the canal, upstream and middle stream farmers would follow the collective decision making process of gradually lowering their gate capacity if there are continuous poor harvest years. In cases of good harvests and water availability, the model agents will consider expanding along the existing canal or even create another canal.

We have used empirical archaeological data for Mesopotamia in this model, providing the model with the flexibility of irrigation demand, river discharge, gate capacity, etc., which allows the modelling framework to be modified for any irrigation system, both old and new. As such, this computation-based methodological research could support discussions on emerging societies in south Mesopotamia as well as in general. As in Mesopotamia, the development of irrigation systems results from both natural and human water system evolution(s). Our results will illustrate how patterns in irrigation systems can emerge from decisions made by heterogeneous agents.

References

Lang, Dengxiao, and Ertsen, W. Maurits. 2022a. "Conceptualising and Implementing an Agent-Based Model of an Irrigation System." Water 14 (16): 2565. https://doi.org/10.3390/w14162565.

Lang, Dengxiao, and Ertsen, W. Maurits. 2022b. "An Advanced Irrigation-Related Agent-Based Model for Analysing Farmland Dynamics in Response to Farmer Decision-Making in an Irrigation System." Agricultural Systems. Submitted.

Wilkinson, J. Tony, Rayne, Louise, and Jotheri, Jaafar. 2015. "Hydraulic Landscapes in Mesopotamia: The Role of Human Niche Construction." Water History 7 (4): 397–418. https://doi.org/10.1007/s12685-015-0127-9

44. Identifying streets in precolonial urban space of Islamic East Africa

Monika Baumanova, University of West Bohemia

The built environment represents one of the key components of urban material culture. Around the globe, urbanism has often been classified and assessed on the basis of presence of features in the built environment, such as public buildings or congregation spaces for a range of communal activities. As part of public space, streets have become instrumental in understanding the built environment as urban, while their character provides clues as to the nature of social interaction (Jervis et al. 2021).

In Islamic towns, the urban space may typically be characterised as represented by narrow winding streets, which facilitate controlled movement and small-scale interaction between the urbanites (Baumanova et al. 2019). In some parts of the world, where the preserved structures of the urban environment do not form dense compact units, the characteristics or even the presence of the past street network have been difficult to assess. This is the case of the coast of East Africa, where Islamic Swahili towns existed for centuries before the colonial era. Streets however, have been discussed to a limited extent as part of exterior space, due to the fact that the layout of standing buildings has for decades been documented through 2D ground plans, as isolated structures or small blocks of houses.

Two sites on the Swahili coast, Jumba la Mtwana and Mnarani, were documented with a photography and a 3D scanner in 2021 to provide the first systematic record of the preserved stone architecture on these sites, which date approximately to the 14th-15th century. This documentation facilitated an assessment of the spatial layout from various perspectives. First, the existing plans produced with total station were complemented with the record of isolated walls and low-lying features such as wells, creating a more detailed picture of the urban space. Second, it showed that some streets perhaps may not be identified from an aerial perspective or from 2D layouts, but only stand out through 3D views relating real-life experience, because some streets featured doorways, were partly roofed or run in parallel with walls. The presented comparative layout and street views, which imitate the visual environment and movement around the urban space, create a more complex picture of the street network, which featured interlocking streets rather than just isolated short passageways or cut-throughs. This allows for considerations of intra-town communication networks, which appear to have been composed of short streets intersecting at right angles. This provides an interesting comparison e.g. with the historic Middle Eastern towns where streets twist and turn, limiting long-distance views but rarely interlocking at right angles.

References:

Baumanova, M., Smejda, L. and Ruther, H. 2019. Pre-Colonial Origins of Urban Spaces in the West African Sahel: Street Networks, Trade & Spatial Plurality. Journal of Urban History 45(3): 500-516.

Jervis, B. Cembrzynski, P., Fleisher, J., Tys, D. and Wynne-Jones, S. 2021. Archaeology of Emptiness? Understanding open urban space in the medieval world. Journal of Urban Archaeology 4: 221-246.

65. Building Persistent Online Open Databases in Archaeology: Bulgarian Perspective and Experience

Nikola Theodossiev, Sofia University St. Kliment Ohridski

Since 2004, reports from about 80% of the archaeological excavations carried out each year in Bulgaria have been regularly published on an international online database with open and free access. The annual reports on the Bulgarian sector of the database are in bilingual format: in English and Bulgarian and almost all of them regarding excavations from 2006 onwards are accompanied with illustrations. Currently, the database contains reports from over 1120 archaeological sites excavated in Bulgaria and is constantly increasing. In addition, it also maintains a Facebook page with over 15,000 likes.

The poster will feature the various experiences and challenges in maintaining such a long-lasting online comprehensive national resource. It will specify and address the main factors that contributed to persistence on the Internet.

What is needed to constantly maintain an online open database for 18 years now? Here are some of the key points that will be further detailed in the poster:

- A renowned international institution to get engaged in the endeavor and to supervise and run the project.
- Securing constant and adequate funding and support from public and private organizations and donors.
- Easy to manage and handy platform hosted on a server of a reliable institution.
- A professional company or institution to support and maintain the platform.
- A reliable national partner from a renowned academic institution with a good reputation, being able to successfully promote the platform to archaeologists in the country and engage them to cooperate, building a trust in the relevant archaeological community.
- Good personal contacts of the national administrator with archaeWologists in the country and building a holistic national network of professionals willing to cooperate.
- A centralized administrative control of the archaeological excavations in the country, supervised by central bodies (Archaeological Institute, Ministry of Culture, or else), where it is mandatory for all archaeologists doing excavations to prepare and submit standardized final reports and documentation for central archives.
- Building a strong international community on social media, particularly on Facebook, to engage a wider audience of archaeologists and non-professionals and to further promote the platform and disseminate knowledge.
- Last, but not least, a devoted team of experts to get engaged with such an endeavor.

While each country in Europe has its specific national regulations and different modus operandi regarding archaeological excavations, archiving and publicizing the results, some of the factors that contributed to the success of the Bulgarian database are universal and well applicable to all the countries across Europe and beyond.

95. Photogrammetry and 3D point cloud processing software as a tool against looting: an efficient combination to create a catalog of stolen objects

Florence Gilliard, CH

Modern photogrammetry software allows scientists to get an accurate tridimensional representation of an archaeological site at a certain point in time. By regularly processing 3D models of the same place, comparisons can be done. To make this looting visible, a point-based processing software like CloudCompare is needed. Indeed, by analyzing the differences between two clouds and detecting the changes, stolen objects can easily be identified.

Thus, knowing exactly which artefact was removed from its context allows the archaeologists to go back to the photogrammetry software and process a new accurate model of the exact missing piece, out of existing photos. Thanks to the precision of that new model, the researchers have a representation of the looted artefact, on which measurements can be taken and details are clear, whilst other particularities are noticeable. Hence, a catalog of stolen objects can be done with these exact data, easily sharable with authorities.

This poster will show the possibility that digital technologies offer to fight cultural heritage crimes. A step-by-step methodology will be presented in order to get those results, with practical examples all along.

117. Spatial soil information as a proxy for archaeological predictive modelling in arid regions: the Serevani plain example (Kurdistan, Iraq)

Mathias Bellat, University of Tübingen
Benjamin Glissmann, Tübingen University
Ruhollah Taghizadeh-Mehrjardi, Tübingen University
Tobias Rentschler, Tübingen Unviersity
Paola Sconzo, Università degli studi di Palermo
Peter Pfälzner, Tübingen University
Thomas Scholten, University of Tübingen

Key words: Soils Science, Archaeological predictive modeling (APM), Machine learning, Ancient Near East, Landscape archaeology, Statistics

Background:

Archaeological predictive modelling (APM) is a powerful tool for collecting quantitative data used in cultural heritage management, preventive archaeology or more broadly for landscape planners (Nicu et al., 2019). The data used for APMs varies from one study to another and there are no "common" data sets to all these models besides digital elevation models and other remote sensing data. When it comes to predicting archaeological settlements, environmental factors seem preeminent (e.g., geology, soils, precipitation, and temperature). However, soil information has been often omitted from APM and not tested with statistical models, or their impact on the prediction model was assumed to be marginal. To the best of our knowledge, we are still in the early stages of understanding soils and their properties for settlement dynamics and their interactions with landscape development in an archaeological context, especially in dry regions. Therefore, in the current research, we aim to fill a methodological gap in APM regarding the role of soil information and its high potential to improve prediction models and to better understand the role of soils for settlement dynamics.

Subject:

Our studied area is located in Selevani plain, Iraqi Kurdistan covering over 800 km2 from the Bek'hair anticlines to the Tigris River and Mosul dam lake with the climate being arid in a temperate zone. The surveyed area contains 336 sites dating from the Paleolithic to the

Islamic period. We sampled 101 soil profiles at different depth increments (0 – 10 cm; 10 – 30 cm; 30 – 50 cm; 50 – 70 cm; 70 – 100 cm) for archaeological classification and soil analyses. Then, soil properties were measured, and Soil Quality Ranking (SQR) was computed. SQR further was used as an input APM and the results showed if soil information is able to improve the prediction accuracy (Fathizad et al., 2020). The models were compared using different metrics and statistics (Verhagen, 2007).

Discussion:

Our work (session S34, ID 117) aims at not only to give the most accurate models for archaeological prediction maps in dry regions, but it will also be a first step in defining the settlement patterns in the Selevani plain. Indeed, prediction maps give precious information on the valuable's environmental elements of archaeological settlements. Once combined with the concept of Site Exploitation Territories (SET) prediction maps will help to depict the past societies' geographical areas and their settlement patterns.

Reference:

- Nicu, Ionut, Alin Mihu-Pintilie, and James Williamson. 2019. 'GIS-Based and Statistical Approaches in Archaeological Predictive Modelling (NE Romania)'. Sustainability 11 (21): 5969. https://doi.org/10.3390/su11215969.
- Verhagen, Philip. 2007. Case Studies in Archaeological Predictive Modelling.

Archaeological Studies Leiden University 14. Leiden: Leiden University Press.

- Fathizad, Hassan, Mohammad Ali Hakimzadeh Ardakani, Brandon Heung, Hamid Sodaiezadeh, Asghar Rahmani, Abolhasan Fathabadi, Thomas Scholten, et Ruhollah Taghizadeh-Mehrjardi. 2020. « Spatio-Temporal Dynamic of Soil Quality in the Central Iranian Desert Modeled with Machine Learning and Digital Soil Assessment Techniques ».Ecological Indicators 118 (novembre): 106736. https://doi.org/10.1016/j.ecolind.2020.106736 .

134. Predicting the Biome: a new machine learning approach to animal depictions in rock art

Mirte Korpershoek, Bournemouth University
Marcin Budka, Bournemouth University
Phil Riris, University of Bournemouth
Sally Reynolds, Bournemouth University

Recently, machine learning has increasingly been applied to the study of rock art images, often in order to aid with style analysis (Kowlessar et al. 2021, 121) or to introduce new methods of object detection, and possibly, identification (Jalandoni, Zhang, and Zaidi 2022, 6). However, machine learning has so far been under-used when analysing to what extent representative rock art depictions reflect the palaeoenvironments they were created in. Rock art studies traditionally focus on interpretation, even though they may also provide information on a region's environmental history by considering which animal species are depicted and, in some cases, what kind of plant motifs are illustrated. These types of analyses can lead to information on species' presence and even provide insight into how environmental changes affected animal presence in the past (Yeakel et al. 2014, 14473).

Here we attempt the application of a Decision Tree algorithm for classification that predicts the type of biome of a region based on which animal species are depicted in the local rock art: the model will be trained using animal depictions from rock art sites from Brazil, Colombia and Australia, which are each linked to one or more type(s) of biome where they may occur. Based on this a prediction is made that can match each rock art containing region to a type of biome. Early results will be discussed, but one expected outcome would be that the model will be able to match new images from each rock art site used in the training set to their region's contemporary biome.

When this approach is successfully used in other contexts, it may provide insight into which rock art containing regions have had stable environments throughout the years, and which ones were subjected to more environmental changes. It is also expected that regions with a larger variety of animal depictions can be more confidently matched to a biome than regions containing depictions of only a selected few animals. It may thus additionally shed light on which rock art creating cultures reflect their environment the most accurately, which may aid with research into the motive behind rock art creation per region.

References

Kowlessar, Jarrad, James Keal, Daryl Wesley, Ian Moffat, Dudley Lawrence, Abraham Weson, Alfred Nayinggul, and Mimal Land Management Aboriginal Corporation. 2021. "Reconstructing rock art chronology with transfer learning: A case study from Arnhem Land, Australia. " Australian Archaeology 87 (2): 115-126. https://doi.org/10.1080/03122417.2021.1895481

Jalandoni, Andrea, Yishuo Zhang, and Nayyar A. Zaidi. 2022. "On the use of Machine Learning methods in rock art research with application to automatic painted rock art identification. " Journal of Archaeological Science 144: 1-14. https://doi.org/10.1016/j.jas.2022.105629

Yeakel, Justin D., Mathias M. Pires, Lars Rudolf, Nathaniel J. Dominy, Paul L. Koch, Paulo R. Guimarães Jr., and Thilo Gross. 2014. "Collapse of an ecological network in Ancient Egypt. " PNAS 111 (40): 14472-14477. https://doi.org/10.1073/pnas.1408471111

157. Modeling landscape evolution and archaeological site distributions in eastern South Africa: a geo-archaeoinformatic approach

Anastasia Eleftheriadou, Interdisciplinary Center for Archaeology and the Evolution of Human Behavior, ICArEHB

Coastal resources may have had a significant impact on modern human cognition and survival. However, the lack of records dating back to glacial periods makes it difficult to understand the long-term evolutionary consequences of living in coastal zones (Erlandson 2001). These gaps are being filled in Msikaba, South Africa's east coast, where researchers have documented numerous artefacts on fossil soils (paleosols) dating from the Early to the Later Stone Age, indicating that humans stayed in a coastal context during glacial periods. Yet, these sites haven't been systematically studied (Fisher et al. 2020).

This project aims to fill this gap by mapping the exposed archaeological records in South Africa's east coast and modelling the location of stratified archaeological horizons. A semi-automated classification algorithm will be used to determine the location of paleosol exposures from satellite remote sensing imagery. The combination of these data with archaeological and geomorphological proxies will allow the development of a site location model for identifying potential archaeological sites. The model will be validated through survey and the surface archaeological records discovered will be documented using an unmanned aerial vehicle (UAV) and Global Navigation Satellite System (GNSS). For the exploration of stratified archaeological records, a geoarchaeological survey will be conducted to gather geophysical and sedimentary data. Ground Penetrating Radar and core samples will be used to develop a process-based stratigraphic model, which will enhance our understanding of the geomorphology and formation processes of the paleosols. As a result, it will be possible to quantify and visualize the relationships between geomorphic history, subsurface architecture, and archaeological visibility and preservation (Clevis et al. 2006).

In addition to providing new insight into the impact of coastal resources on Homo sapiens' survival, the project also uses a novel methodological approach combining archaeoinformatics and geoarchaeology. The integration of sedimentological and geophysical data in archaeological computer simulations will enhance the validity of our models and thus improve our understanding of landscape evolution and human behaviour (Clevis et al. 2006). Furthermore, geo-archaeological simulations written in Python scripts can be used to promote code-sharing in archaeology and assist future research on sites situated in aeolian contexts. To conclude, this project will enrich the archaeological record of South Africa with more sites dating to glacial periods, using archaeoinformatics and geoarchaeology. Thus, it will shed light on the implications of living in coastal environments in the evolution of our species, as well as set the foundation for future archaeoinformatic studies on aeolian landscapes.

158. Digitization as a Form of Protection of pre-Columbian Mummified Human Remains

Judyta Bąk, Jagiellonian University

Mummified human remains as biological material are subject to constant processes (natural and / or mechanical) that generate deterioration of their condition, e.g. skin crumbling (Miazga 2017). Therefore, it is imperative to take further steps to protect this type of material from progressive degradation. 3D scanning makes possible to capture spatial and detailed documentation of mummies, as well as to obtaine further data for future scientific studies.

The purpose of the scientific poster is to present the initial observations and to define the use of digitization in the proposed research topic. Moreover, there is also an indication of the need to search for new techniques of protection and conservation of biological materials.

159. CORPUS NUMMORUM – A Digital Research Infrastructure for Ancient Coins

Ulrike Peter, Berlin-Brandenburg Academy of Sciences and Humanities
Karsten Tolle, Goethe-University
Jan Köster, Berlin-Brandenburg Academy of Sciences and Humanities
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Corpus Nummorum (CN) is a joint project of the Berlin-Brandenburg Academy of Sciences and Humanities, the Münzkabinett Berlin and the Big Data Lab of the University of Frankfurt. As part of an overarching international endeavour to create a corpus of Greek coin types based on Linked Open Data, it indexes ancient Greek coins from various landscapes and collections and develops typologies. The coins and types are published in the multilingual web portal www.corpus-nummorum.eu, using numismatic authority data and FAIR principles.

Our poster aims to present the CN-Editor that was developed as a multifunctional open-source web app to manage the project's data regarding coins, types, dies and related information. It provides extensive search and evaluation functions. The backend to store the data consists of a MySQL database and a PHP JSON API. Images are handled via the API and can be stored in a separate IIIF service. Its modular structure allows for a quick functional extension or an adaption to other object types, thus making it attractive for projects beyond numismatics. The CN-Editor represents a digital research infrastructure that enables and encourages the re-use of aggregated data and unrestricted collaboration with other scholars or institutions. It uses the PHP framework Laravel (v. 8) and vue.js (v. 2.6). Upgrades to Laravel v. 9 and vue.js 3 are in progress. The code is licensed under the GNU GPLv3 and can be freely reused and adapted. The CN-Editor and further descriptions how to install and use it are available in Github under: https://github.com/telota/corpus-nummorum-editor.

At present, CN is being further developed within the framework of our projects "Data quality for Numismatics based on Natural language processing and Neural Networks (D4N4)" and "Ikonographie und KI-Methoden in der Numismatik (IKKINUM)" financed by the German Research Foundation and with funds from the State of Berlin. The aim of D4N4 and IKKINUM is to establish AI-research tools for numismatics that can also be used as services separately or integrated as part of the CN-Editor. Our approaches are particularly well applicable for object categories that combine images and text and are available in large quantities. These involve: a) natural language processing (NLP) methods for multilingual and non-standardized coin descriptions and their linking to a hierarchical iconographic thesaurus and b) image recognition of designs and their elements by means of deep learning. The NLP generated data shall allow for more sophisticated semantic searches on the given coin and type data. Furthermore, a new Graphical User Interface shall also allow for semantic searches for users with no SPARQL experience.

Deligio, Chrisowalandis, Karsten Tolle, and Sebastian Gampe. 2022. NLP-on-multilingual-coin-descriptions. GitHub Repository. Link: https://github.com/Frankfurt-BigDataLab/NLP-on-multilingual-coin-datasets

Gampe, Sebastian, and Karsten Tolle. 2019. "Combination of machine learning methods of image and natural language recognition on ancient coin data." In Proceedings of CAA 2019 (in print)

Klinger, Patricia, Sebastian Gampe, Karsten Tolle, and Ulrike Peter. 2018. "Semantic Search based on Natural Language Processing – a Numismatic example." Journal of Ancient History and Archaeology 5 (3): 68–79. https://doi.org/10.14795/j.v5i3.334.

161. Implementing Digital Documentation Techniques for Archaeological Artifacts to Develop a Virtual Exhibition: the Necropolis of Baley Collection

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Kristen Jones, Queen's University Department of Geography & Planning
Hristina Klecherova, Institute of Information and Communication Technologies - Bulgarian Academy of Sciences
Stefan Alexandrov, National Archaeological Institute with Museum - Bulgarian Academy of Sciences

The field of virtual reality is quickly growing across many disciplines over the past decade, if none more important than the field of archaeology and cultural heritage. Numerous artifacts are uncovered each year by archaeological excavations around the world, and only a select few are displayed and recorded in museums while the rest remain hidden away in storage facilities. The use of virtual reality photography provides a potential solution to this problem. This project aims to optimize a computational workflow for digitally documenting these artifacts through an in depth analysis of the Necropolis of Baley collection of burial vessels currently held by the National Archaeological Institute with Museum at the Bulgarian Academy of Sciences in Sofia, Bulgaria. The prehistoric settlement of Baley dates to the Bronze and Early Iron Age in the Middle and Lower Danube Basin and the collection thus far includes over 450 burial artifacts. This project focuses on a selection of the most representative artifacts that have been conserved and restored. Through the use of three methods of documentation, a virtual exhibition will be developed for mobile and web browsers to showcase this important collection to the public and scientific professionals. The objects are photographed on a robotic turntable at 2-4 angles to get complete coverage of the entire surface. The images are processed two-fold: first to generate scaled photogrammetric 3D models, and second to create virtual reality movies that can easily be shared online. Utilizing another growing industry, 3D scanning, a handheld structured light scanner will be used to document the objects. A comparison will be conducted comparing the 3D results of the photogrammetry to the 3D scanner to determine the optimal workflow for large scale documentation of archaeological artifacts. The resulting 3D models and VR movies will be embedded in the online exhibition. This project shows the applications of integrating documentation techniques in an online environment. For the scientific community, the 3D models can provide a virtual object that can be fully manipulated and viewed with 3D glasses for analysis, measurement, and collaboration. These models combined with the VR movies will also showcase important collections to the public in an interactive way to promote the cultural heritage to the public that may otherwise be unavailable.

202. Archaeoriddle discoveries: On the relationship between rabbit-skinners and poppy-chewers

Simon Carrignon, McDonald Institute for Archaeological Research, University of Cambridge
Alfredo Cortell-Nicolau, University of Cambridge
Leah Brainerd, University of Cambridge
Joseph Lewis, University of Cambridge
Charles Simmons, University of Cambridge
Enrico R Crema, University of Cambridge

Archaeo-riddle is a project, whose scope is to test and improve archaeological inference by assessing the usefulness of its methodological tools. In order to do this, at the Computational and Digital Archaeology Laboratory (CDAL), we have developed an in silico interaction process between some supposed last hunter-gatherers (the rabbit skinners) and some early farmers (the poppy chewers). As in most neolithisation processes, the early farmers will eventually spread over all the available space (the world so-called Rabbithole), leading to the extinction of the last hunter-gatherers. But how did this exactly happen? Under which conditions? Was this a peaceful expansion, led by culture transmission and interaction processes? Or was it rather a product of cultural conflict? How important were the demographic patterns of each group within this expansion?

These and other questions are the ones posed by the archaeo-riddle project. Nothing new. These are rather classical questions in archaeological research. The main difference is that, in this case, because we know what happened, we know the answer to these questions, and the parameters that guided this expansion process. However, the participants (anyone can participate by downloading the data from the website we designed here https://acortell3.shinyapps.io/Archaeo_riddle/) will not have this parametric information, but only standard archaeological data.

The project was already presented in the last CAA (Oxford) and it is now starting to receive the first data requests from potential participants. We have designed an

engaging strategy, by presenting it like a game (which is what it is!). In doing this, we regularly publish new data, cheesy videos with supposed interaction processes and have designed a narrative of a supposed academic rivalry between two researchers: Dr. Hardy Stones and Dr. Fancy Pants, both of whom claim to be right about what happened during this neolithisation process in Rabbithole. Aside from generating engaging material, these stories here and there give information about the process (some of it may be misleading, just like real archaeology!). This poster is one of those stories, where Dr. Stones defends his theory of a peaceful transition to farming economies, but better put it in his own words:

"This paper re-evaluates the history of Rabbithole and its two main populations (the "Poppy-chewers" and the "Rabbit-skinner") using all the published set of dates spanning from 7400BP to 6500BP, from ca 40 settlements of central and Western Rabitthole, including the most recent publication by Stones et al. 2022. To explore the history of the region and the relationship between its original habitants, we developed a specific quantitative method called "Test of Balanced Equilibrium" (TBE), that demonstrates undoubtedly that Rabbit-Skinners and Poppy-Chewers, though radically different in term of subsistence strategies, were having very intense and peaceful interactions.

Not that I need this, because as you know, I was already there with my time machine, but just to follow some of the most advanced archaeological methods I have personally developed".

206. Use and contribution to the field methodology of Mobile Gis in forest contexts. The case study of boreal forests (Skåne, Sweden)

Giuseppe Cirigliano, Università degli studi di Siena

Mobile GIS is one of the tools that increasingly often brings important help during fieldwork operations. In particular, here we can see how this has contributed during the ground verification of some data from laboratory analyses.

The project "Artificial intelligence and landscape analysis; expanding methods and challenging paradigms" carried out by a team of researchers from the Digital Archaeology Laboratory, at Lund University (Sweden), deals with the study of landscapes' use from a diachronic perspective. The work that is presented here refers to the southern area of Sweden, precismaente in the region called Skåne. To do this, it has been used a set of high-resolution digital data, which had been obtained by lidar. Processing of these data, it is possible to observe the presence of numerous anomalies on the ground's surface. In some cases, it is possible to overcome obstacles like for example, the vegetation that otherwise could be a limit to the analyses. This is a very important aspect, especially for contexts like Sweden, where over 70% of the soil is covered by forests (the second-largest percentage in Europe). For archaeological research, these wooded areas represent contexts that are rarely studied, due to the intrinsic difficulties of operating in such spaces for the heavy ground coverage.

In particular, the work focused on identifying clearance cairns that are an important sign of past and present agricultural work activities in the fields. These are often hidden under the canopy of trees. Once all the processing phases in the laboratory have been completed, the identification through AI/deep learning has been necessary to organize surface surveys aimed at the verification and the percentage of accuracy of the work done by artificial intelligence.

The selected test areas had in common the dense presence of tall vegetation. In this type of environment, organizing a survey aimed at verifying data must take into account of particular difficulties:

- difficult orientation skills
- efficiency of the group work
- Be sure to check with accuracy all areas of interest

It is thanks to the use of mobile GIS that in this case, it was possible to overcome all these difficulties. In fact, it allowed us to transfer and visualize the project directly on mobile devices (smartphones and tablets) and thanks to GNSS navigation systems. Moreover, we were able to record the route and investigate all the pieces of evidence.

The benefits of such use have made ground verification operations extremely faster and more accurate. They also facilitated significantly, making it possible to observe our position in relation to a Basemap formed by raster data resulting from laboratory analysis.

References

Gordon, Jody Michael, Erin Walcek Averett, and Derek B. Counts. 2016. "Mobile Computing in Archaeology: Exploring and Interpreting Current Practices." In Mobilizing the Past for a Digital Future; the Potential of Digital Archaeology, edited by Erin Walcek Averett, Jody Michael Gordon, and Derek B. Counts, 1–32. The Digital Press @ University of North Dakota. http://dc.uwm.edu/arthist_mobilizingthepast/2.

Küçükdemirci, M., Landeschi, G., Ohlsson, M & Dell'Unto, M. in press: 'Investigating Ancient Agricultural Field Systems In Sweden From Airborne Lidar Data By Using Convolutional Neural Network', Archaeological Prospection.

Lindholm, Karl-Johan, Erik Ersmark, Andreas Hennius, Sakarias Lindgren, Kjetil Loftsgarden, and Eva Svensson. 2021. “Contesting Marginality: The Boreal Forest of Middle Scandinavia and the Worlds Outside.” Chapter. In The Global North: Spaces, Connections, and Networks before 1600, edited by Carol Symes, 9–36. Amsterdam University Press. https://doi.org/10.1017/9781641894906.002.

209. The old abbey church of Notre-Dame de Bernay: a collaborative project using 3D

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Tanguy Béraud, University Paris 1 Panthéon-Sorbonne
Thibault Menuge, University Paris 1 Panthéon-Sorbonne

Bernay Abbey was founded at the beginning of the 11th century by the Duchess Judith of Brittany, wife of Richard the Second, Duke of Normandy. The exact date and conditions of the foundation remain unknown, just like the progress of the worksite of the abbey in the decades that followed. For centuries, some events affected the Abbey including several fires and restorations which have never been precisely tagged. In the 1950's, the monument was eventually fully considered as a major piece of Romanesque architecture and a few works have been carried out by the specialists.

An authenticity review appeared to be one of the major steps of the study of the Abbey. Where was the construction when Judith died in 1017? From the foundation to nowadays, what kind of tools could be used for both the archeological study and the management of restorations through the owner and the pedagogical valorization with the museum?

In order to gather all the knowledge already produced and that to come, the construction of a database proved to be essential. As this is an elevated monument, we have chosen to experiment with HBIM (Heritage Building Information Modeling). The BIM approach is often limited to the modeling of a digital model or its construction through software. In practice, BIM tends to generalize a methodology of collaborative work through the design and operation of a project on a heritage building. This collaborative aspect differs from cooperation, in the direction that each actor in a project does not pursue their objectives accompanied by their collaborators but shares their problems. Cooperation in our project shouldn't be limited to a process of planning the sequence of tasks to be performed. This approach theorizes the question of human interactions. However, in the context of BIM, which is intended to be methodologically centered on IT, it is necessary to question the human and software relationship.

To renew our knowledge of the abbey, the building archaeology is essential. To do this, it was essential to acquire the information necessary for its understanding. Thanks to the 3D digitization we have made a complete recording of the volume and elevations of the monument. In view of these vast dimensions and the desired precision for the realization of the BIM, we opted for a laser-grammetric survey coupled with a photographic coverage. The cloud of colored points allowed the construction of a 3D model meshed and then textured with photo-grammetry. Based on these new data, different documents were produced as a support for study and interpretation. In 2022, a first campaign of study of the building could have thus been carried out.

Digital applications, interdisciplinarity and collaboration are essential for the realization of this work. They allow us to study the abbey in different but complementary ways. Going beyond our respective thesis topics, this work will be transmitted to the city and the museum in order to maintain the knowledge and the preservation of the monument.

231. Photogrammetric terrain model of the San Isidro site in El Salvador. Data processing and archaeological analysis

Joachim Martecki, University of Warsaw

A unique feature of archeology is the extraordinary ability to adapt solutions from other disciplines and use them for its own purposes. Techniques and solutions derived from geodesy, are present in archeology for a long time, but in recent years modern instruments and technologies have become more popular.

Archaeologists use public sources of terrain data, as well as LIDAR or aerial photogrammetry to map the site and its vicinity they intend to study Along with geophysical surveys, these practices become standard research elements during field prospecting, the initial phase of research, which allows you to look at the site from a wider perspective and identify the most interesting fragments for excavation.

By participating in the San Isidro archaeological project in El Salvador, I undertook the task of conducting the spatial analysis of the site. I carried out the entire process, from taking aerial photos using a drone, through selecting the best images, and preparing the photogrammetric model, to conducting spatial analysis such as determining the axis of the urban pattern, comparing the size of mounds, and define the level of density of structures in the center of the site.

It is worth emphasizing that when conducting research in developing countries, such as El Salvador, researchers have to deal with problems that they would not even think about, accustomed to the realities of Western countries. There are no institutions responsible for sharing or even collecting data about the area. In addition, social conditions, influence, for example, safety during the research.

Poster intended to present not only the processes and results of my research in El Salvador, but also challenges that I had to face while gathering and analyzing the data.

Szymański, Jan, Krzysztof Misiewicz, Radosław Mieszkowski, Joachim Martecki. 2022. "Regional Patterns, Local Techniques: Remote Sensing and Archaeology at prehispanic site of San Isidro, El Salvador", Journal of Archaeological Science: Reports 45.

Szymański, Jan. 2020. "Recent Research at San Isidro, El Salvador, in the Context of the Southeastern Mesoamerican Archaeology", Estudios Latinoamericanos 40:1-28.

Kurczyński, Zdzisław. 2014. "Fotogramteria", Warszawa, Wydawnictwo Naukowe PWN SA

262. Multiproxy modelling of urban demography – the case study of Palmyra, Syria

Iza Romanowska, Aarhus Institute of Advanced Studies
Joan Campmany Jiménez, Aarhus University
Katarina Mokranova, Centre for Urban Network Evolutions, UrbNet, Aarhus University
Julia Steding, Aarhus University
Eivind Heldaas Seland, University of Bergen
Rubina Raja, Aarhus University

Demography is among the most fundamental social system components playing a role in virtually all processes affecting human communities past and present. It tells us whether past people lived in resource-scarce or

bountiful environments, whether their economic activities were scalable and what kind of population pressure was present when a cultural innovation emerged (Hassan 1982; Henrich et al. 2016). However, making robust population

estimates and reconstructing plausible models of population dynamics remain problematic in historical disciplines. They require an approach that can explore the implications of theories about population dynamics and formally compare

them against historical and archaeological data sources serving as proxies of population size, structure and spatial distribution. The first challenge is integrating such datasets, testing their representativeness of the studied phenomenon and their robustness in terms of coherence and completeness. Second, it requires robust methods for integrating insights coming from different data sources to reconstruct and interpret the socio-natural relationships and social processes that drove past human groups within a context of a dynamic and complex system. Computational modelling is an appropriate method to tackle this challenge.

Here, we present the data, methods, and results of a multiphased interdisciplinary project aiming at reconstructing the demographic dynamics of the ancient city of Palmyra. It showcases how archaeologists can use diverse data proxies and apply computational modelling methods to them in order to gain a fuller picture of the population dynamics of a past community. To achieve this goal we integrated a range of data proxies collected by the Palmyra Portrait Project and the Circular Economy and Urban Sustainability in Antiquity Project: funerary data, inscriptions, built environment, as well as urban and hinterland reconstructions. This multiproxy approach allowed us to gain significant insights into different aspects of the urban evolution of the city and also to overcome some of the uncertainty inherent in the archaeological record.

268. The application of CLR and ILR transformations in the compositional analysis of geochemical data

Laszlo Ferenczi, Univerzita Karlova
Martin Janovsky, Univerzita Karlova
Jan Horak, Czech University of Life Sciences Prague

Large-scale geochemical surveys are currently on the rise in archaeology. They produce a huge amount of geochemical data, which need to be processed properly, by compositional data analysis. Advancing earlier applied methods (e.g. one-way ANOVA, stepwise discriminant analysis), principal component analysis (PCA) of center log ratio (CLR), or isometric log ratio (ILR) transformed values turned out to be a suitable way of processing multi-variate data, and the subsequent spatial interpolation can then be displayed to evaluate the results of multi-element analysis. This method was developed further to determine anthropogenic, geogenic, or agricultural-anthropogenic influences, also in spatially limited, or anthropogenically poorly enriched areas, identifying signals, which could indicate activities in the surroundings of archaeological sites. Thus, soil chemistry functions as a survey tool, producing proxy data, which can be compared to other types of archaeological evidence from surveys and excavations1,2.

Our poster presentation addresses the application of PCA on log-transformed and isometrically log-transformed geochemical data in the context of archaeological surveys, using medieval settlements as examples, and discusses the problem of low-eigenvalue components. As a rule of thumb, only factors affecting data variability are discussed in scientific papers (explanatory approach). Removing low-eigenvalue components from the interpretation makes sense in this case. In the context of an archaeological study, however, the procedure may be different, since even the small variations may reveal archaeological activities (exploratory approach). Although we are aware of the problematic nature of such signals, there are misconceptions over the role of such components, and their predictive value cannot be automatically eliminated3, which is a potentially interesting topic to explore also in the context of geochemical signals.

References

1. Horák, Jan, Martin Janovský, M. Hejcman, Ladislav Šmejda, and Tomáš Klír. 2018. "Soil Geochemistry of Medieval Arable Fields in Lovětín near Třešť, Czech Republic." Catena 162: 14–22. https://doi.org/10.1016/j.catena.2017.11.014.

2. Horák, Jan, Martin Janovský, Tomáš Klír, Ondřej Malina, and Laszlo Ferenczi. 2022. "Multivariate Analysis Reveals Spatial Variability of Soil Geochemical Signals in the Area of a Medieval Manorial Farm." Catena. In press.

3. Jolliffe, Ian T. 1982. "A Note on the Use of Principal Components in Regression." Journal of the Royal Statistical Society. Series C (Applied Statistics) 31 (3): 300–303.

278. The use of Photogrammetry and Computer Vision with Python programming language for plotting lithic surface scatters

Jovan Galfi, ICArEHB
Anastasia Eleftheriadou, Interdisciplinary Center for Archaeology and the Evolution of Human Behavior, ICArEHB

Surface lithic scatter features can often span hundreds of square metres (Olszewski et al. 2005; Foley and Lahr 2015) and as such present a big task for researchers to tackle. In many parts of the world these are often the most common source for our understanding of stone tool production technologies as well as indirect information about their makers and time periods when these areas were occupied. Their documentation often requires a lot of manual work and bulky equipment which can often be too impractical for work with in remote areas. Total Station or GPS devices are not always available, and the method presented here ideally requires a drone, or if needed only a handheld camera or even a smartphone.

The availability of drones, powerful personal computers and similar technologies in the previous years has made many aspects of archaeological field work more manageable and accessible. Here we present the results of our innovative methodological approach using the OpenCV python library and photogrammetry. With the combination of several different Python packages (OpenCV, Numpy, Pandas, Matplotlib) we have managed to create a workflow to localize individual artefacts and lithic scatters that can later be used for spatial analysis without the use of Total Station or DGPS. This approach can be also used as a preliminary step for the better organisation of surface surveys, through the detection of high-density lithic scatters in the landscape. While this is still a proof of concept, if developed further, it would greatly improve the scientific output acquired from lithic scatters, and greatly reduce time required for data processing.

Foley, Robert A., and Marta Mirazón Lahr. 2015. 'Lithic Landscapes: Early Human Impact from Stone Tool Production on the Central Saharan Environment'. PLOS ONE 10 (3): e0116482. https://doi.org/10.1371/journal.pone.0116482.

Olszewski, Deborah I., Harold L. Dibble, Utsav A. Schurmans, Shannon P. McPherron, and Jennifer R. Smith. 2005. 'High Desert Paleolithic Survey at Abydos, Egypt'. Journal of Field Archaeology 30 (3): 283–303. https://doi.org/10.1179/009346905791072233.

298. Archaeoriddle discoveries: Granalejos II-b, the ultimate revelations

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Simon Carrignon, McDonald Institute for Archaeological Research, University of Cambridge
Charles Simmons, University of Cambridge
Leah Brainerd, University of Cambridge
Joseph Lewis, University of Cambridge
Enrico R Crema, University of Cambridge

Archaeo-riddle is a project, whose scope is to test and improve archaeological inference by assessing the usefulness of its methodological tools. In order to do this, at the Computational and Digital Archaeology Laboratory (CDAL), we have developed an in silico interaction process between some supposed last hunter-gatherers (the rabbit skinners) and some early farmers (the poppy chewers). As in most neolithisation processes, the early farmers will eventually spread over all the available space (the world so-called Rabbithole), leading to the extinction of the last hunter-gatherers. But how did this exactly happen? Under which conditions? Was this a peaceful expansion, led by culture transmission and interaction processes? Or was it rather a product of cultural conflict? How important were the demographic patterns of each group within this expansion?

These and other questions are the ones posed by the archaeo-riddle project. Nothing new. These are rather classical questions in archaeological research. The main difference is that, in this case, because we know what happened, we know the answer to these questions, and the parameters that guided this expansion process. However, the participants (anyone can participate by downloading the data from the website we designed here https://acortell3.shinyapps.io/Archaeo_riddle/) will not have this parametric information, but only standard archaeological data.

The project was already presented in the last CAA (Oxford) and it is now starting to receive the first data requests from potential participants. We have designed an engaging strategy, by presenting it like a game (which is what it is!). In doing this, we regularly publish new data, cheesy videos with supposed interaction processes and have designed a narrative of a supposed academic rivalry between two researchers: Dr. Hardy Stones and Dr. Fancy Pants, both of whom claim to be right about what happened during this neolithisation process in Rabbithole. Aside from generating engaging material, these stories here and there give information about the process (some of it may be misleading, just like real archaeology!). This poster is one of those stories, where Dr. Pants defends his theory of a violent transition to farming economies, but better put it in his own words:

"This paper explores crucial information revealed by the discovery of an impressively well preserved and decorated pottery sherd found at the site Granalejos II-b, next to the city of Granalejos, in the northern regions of Rabbithole. This ceramic, on top of presenting all the typical marks of Poppy-chewers pottery making techniques, shows a remarkable scene of war between the Rabbit-skinners and the Poppy-chewers proving, once again, how Dr. Stones's arguments are intrinsically flawed and without any empirical ground. Not that I need this, because as you know, I was already there with my time machine, even though Stones keeps saying I wasn't"

360. Generative models applied to the reconstruction of profiles of iberian pottery fragments

José M. Fuertes, Universidad de Jaén
Manuel Lucena, Universidad de Jaén
Pablo Navarro, CENPAT - CONICET
Celia Cintas, IBM Research Africa

The fragment is one of the most common elements that the archaeologist finds in any excavation. It seems reasonable to invest time and work in the correct definition of methodologies that allow improving any process of handling, identification and cataloging of said elements. In the context of the research project: {\em Aproximación a la clasificación de fragmentos de cerámica ibera mediante técnicas de geometric deep learning (ref: 1381115; FEDER-UJA 2020)}, this communication is part of what was published in full in reference 1. We present a line of research leading to providing generative models based on deep learning to the expert archaeologist to facilitate these processes.

363. The preliminary results of application of remote sensing and machine learning methods in the studies of flint mining landscape in Egypt

Sylwia Buławka, Institute of Archaeology and Ethnology of Polish Academy of Sciences
Nazarij Bulawka, Landscape Archaeology Research Group, Catalan Institute of Classical Archaeology

The archaeological studies of flint mining are a vast topic in prehistoric research worldwide. A variety of methods have been used. Many of them focus on the studies of the unique relief of terrain in areas where flint was extracted.

Egypt is ideally situated to examine both natural and human-made terrain changes in the landscape. It has extensive desert regions devoid of or merely sparsely vegetated, and many such areas are intact. Taking that, the search for flint extraction points can be particularly promising with a computational or remote sensing approach.

Flint raw material deposits were found in Egypt between Esna in the south and Cairo in the north, along the wadis near the Nile Valley. Archaeological investigations have been carried out at several flint mines in Egypt. Among the best known are Nazlet Khater, Nazlet Safaha, Wadi el-Sheikh or the Eastern Desert mines (Vermeersch 2002; Briois and Midant-Reynes 2014; Köhler, Hart, and Klauzner 2017). From the Palaeolithic through the New Kingdom, their use has been dated differently at each location. These archaeological sites come in great numbers, many of which have not yet been located. The studies conducted so far did not allow an understanding of the extent of the mining activities.

The paper will present the result of the application of remote sensing, Machine and Deep learning methods in the studies of flint mining in Egypt. Two test areas have been selected for the studies, representing the best-preserved mining landscape.

The data used in the project are high-resolution WorldView, Google Earth Pro, Sentinel 2 multispectral imagery and Copernicus Digital Elevation Model (DEM) (GLO-30), which were selected because they represent the best resolution among freely available data.

The paper will present the preliminary results of the project and discuss the potential and issues in the study of flint mining on the selected examples in Egypt. The plans for future projects will also be discussed.

Briois, François, and Béatrix Midant-Reynes. 2014. "Sur Les Traces de Georg August Schweinfurth: Les Sites d'exploitation Du Silex d'époque Pharaonique Dans Le Massif Du Galâlâ Nord (Désert Oriental)." Bulletin de l'Institut Français d'Archéologie Orientale. PP -.

Köhler, E Christiana, Elizabeth Hart, and Michael Klauzner. 2017. “Wadi El-Sheikh: A New Archaeological Investigation of Ancient Egyptian Chert Mines.” PLoS One. PP -. https://doi.org/10.1371/journal.pone.0170840.

Parcak, Sarah, David Gathings, Chase Childs, Greg Mumford, and Eric Cline. 2016. “Satellite Evidence of Archaeological Site Looting in Egypt: 2002–2013.” Antiquity 90 (349): 188–205. https://doi.org/10.15184/aqy.2016.1.

Vermeersch, Pierre M. 2002. “Palaeolithic Quarrying Sites in Upper and Middle Egypt.” Egyptian Prehistory Monographs. Leuven: Leuven University Press PP - Leuven.

366. Inferring shellfishing seasonality from the isotopic composition of biogenic carbonate: a Bayesian approach

Gabriel D Lewis, University of Massachusetts, Amherst
Jordan F Brown, University of California, Berkeley

Background:

Seasonal economic rhythms represent a long-standing concern of archaeological scholarship. To detect these rhythms, archaeologists have often looked to bivalve shells. Bivalves grow their shells by accretion, so that the chemical properties (e.g., oxygen isotope composition) of a given growth band record environmental conditions (e.g., sea-surface temperature) at the time the band was formed. In this way, isotopic variations between successive growth bands record variations in sea-surface temperature throughout the year. These isotopic data are quantitative and the physical processes conditioning them are well understood. However, studies usually rely on semi-qualitative expert assessments of isotope ‘profiles’ on a case-by-case basis, limiting the reproducibility of each analysis, the comparability between studies, the size of datasets, and the scope of research questions (Kwiecien et al. 2022).

Subject:

We present a fully modeled and automated framework for deriving statistically sound and reproducible estimates of harvest seasonality on the basis of isotopic data from shell material (modeled on the California mussel). This approach allows detailed characterization of the uncertainties inherent in isotopic determinations of seasonality, facilitates analysis of larger samples necessary to address intra- and inter-site and diachronic variability, and offers a principle for combining multiple lines of evidence while properly accounting for the uncertainties of each.

We estimate a given shell’s death date (i.e., day of year) using oxygen isotope measurements taken at known positions along the shell growth axis, measured from the shell margin. We first convert each shell’s sequence of isotope measurements into a sequence of sea-surface temperatures, using a formula theoretically and experimentally validated for the species studied. Then, for each day of the year, we estimate the probability that the organism died on that day given the shell’s sequence of temperatures, using Bayes’ Theorem to invert the conditional distribution of ocean temperatures at that time of year at the expected collection locale, estimated by regression. Using similar reasoning, we apply a Bayesian mixture model to multiple shells sampled from the same location to estimate the annual distribution of shellfish harvest intensity for that location.

In this study, we assume a constant mean growth rate (often appropriate for California mussel), but the model can just as well incorporate an empirically-derived species-specific relationship between growth rate and time of year.

Discussion:

A Bayesian framework such as this can be extended to holistically address larger questions of site seasonality and flexibly incorporate a wide variety of seasonal/temporal indicators across the history of settlement at a site or within an entire region. Such study of complex human eco-management systems articulates well with the distinct but allied goals of paleoclimatologists working to refine high-resolution studies of individual archives (de Winter, Agterhuis, and Ziegler 2021), offering a window onto the spatial and temporal structure of human engagements with dynamic environments (Hadden et al. 2022). Many published datasets already exist that could support such large-scale research aims, but for problems of intercomparability. The method presented here allows us to leverage these legacy datasets without costly physical reanalysis, while also providing a framework for updating analyses with the latest high-resolution results.

References:

de Winter, Niels J., Tobias Agterhuis, and Martin Ziegler. 2021. “Optimizing sampling strategies in high-resolution paleoclimate records.” Climate of the Past 17, no. 3: 1315-1340. https://doi.org/10.5194/cp-17-1315-2021.

Hadden, Carla S., Gregory A. Waselkov, Elizabeth J. Reitz, and C. Fred T. Andrus. 2022. “Temporality of fishery taskscapes on the north-central Gulf of Mexico coast (USA) during the Middle/Late Woodland period (AD 325–1040).” Journal of Anthropological Archaeology 67: 101436. https://doi.org/10.1016/j.jaa.2022.101436.

Kwiecien, Ola, Tobias Braun, Camilla Francesca Brunello, Patrick Faulkner, Niklas Hausmann, Gerd Helle, Julie A. Hoggarth et al. 2022. “What we talk about when we talk about seasonality–A transdisciplinary review.” Earth-Science Reviews 225: 103843. https://doi.org/10.1016/j.earscirev.2021.103843.

Workshops (Monday)

A Basic Introduction to Open Source GIS using QGIS

Prof. Scott Madry, University of North Carolina

This workshop will be an introduction to the QGIS Open Source GIS system. No previous GIS experience is required, and participants will, at the end of the session, have sufficient experience to continue their learning experience on their own. Participants will provide their own laptops and will load the QGIS software before the workshop (https://www.qgis.org/en/site/forusers/download.html). QGIS runs on Windows, Mac, and Linus systems. A sample dataset will be provided, along with a digital copy of my 2021 book: *Introduction to QGIS Open Source Geographic Information System* (https://locatepress.com/book/itq). Subjects covered will include vector and raster data and data processing, web-based data sources, archaeological data analysis, finding data, creating your own data, QGIS remote sensing analysis, and using GRASS and other Open Source systems using the QGIS processing toolbox.

CRMarchaeo Workshop: a stepping stone to FAIR practice

Jane Jansen, Intrasis

In this workshop we will explore how to use CRMarchaeo, an extension of CIDOC CRM, to link a wide range of existing documentation from archaeological excavations. The CRMarchaeo extension has been created to promote a shared understanding of how to formalize the knowledge extracted from the observations made by archaeologists. It provides a set of concepts and properties that allow clear explanation (and separation) of the observations and interpretations made, both in the field and in post-excavation. Attendees will work through a series of case studies that reflect different excavation documentation practices: from 1950s style day books through to context recording sheets. Followed by database/CAD combos and on to modern integrated object oriented database/GIS systems, like Intrasis. The aim is to explore archetypical solutions and provide attendees with hands-on experience of mapping actual documentation practice to CRMarchaeo. This can then be applied to their own documentation, both current and historical, back in their own institutions and lead to integrated reusable composites being available for internal and external use.

3D Artifact Documentation with the GigaMesh Software Framework

Prof. Hubert Mara, Jan Philipp Bullenkamp MSc & Florian Linsel MA, Martin-Luther-University Halle

The increased quality of low-cost and industrial 3D-acquisition devices typically using the principle of Structured-Light-Scanning (SLS) leads to more objects being digitized at excavations and in archives. Additionally, photogrammetry provides similar high-resolution 3D-datasets. Therefore both digital acquisition techniques get continuously integrated into the archaeological practice – especially for ceramics. In this workshop there will be two workshop parts: in the first half day, we will teach data acquisition with a 3D recording system (SFM, maybe SLS), so that the data can be processed over the lunch break. The second session will use these datasets for analyses and documentation using GigaMesh. The GigaMesh Software Framework is developed by the Forensic-Computational-Geometry-Laboratory (FCGL) as part of the eHumanities working group at the Martin-Luther-University of Halle. It provides a number of processing and analysis methods for 3D-data, the main format being the Stanford-Polygon (PLY) for triangular meshes. For the daily tasks of an archaeological excavation, we will show how profile lines can be rapidly computed as vector drawings in the XML-based Scalable-Vector-Graphics (SVG) format, rollouts (or unwrappings) of decorated vessels, and small features visualization using the MSII filter for e.g. fingerprints and sealings. Additionally, we will show data inspection and cleaning as preparation and for quality insurance of Open Data publications. The content of the workshop will enable archaeologists to improve or set up their own 3D-acquisition-based ceramic documentation pipeline similar to long-term users like the Honduras excavation of the Commission for Archaeology of Non-European Cultures (KAAK) of the DAI Bonn.

Introduction to deep-learning

Djura Smits MSc
Sven van der Burg MSc
Dr. Pranav Chandramouli
Dr. Cunliang Geng, Netherlands eScience Center

This is a hands-on introduction to the first steps in Deep Learning, intended for researchers familiar with (non-deep) Machine Learning. Deep Learning has seen a sharp increase in popularity and applicability over the last decade. While Deep Learning can be a useful tool for researchers from a wide range of domains, taking the first steps in the world of Deep Learning can be somewhat intimidating. This introduction aims to cover the basics of Deep Learning in a practical and hands-on manner so that upon completion, you will be able to train your first neural network and understand what next steps to take to improve the model. We start by explaining the basic concepts of neural networks and then go through the different steps of a

Deep Learning workflow. Learners will learn how to prepare data for deep learning, how to implement a basic Deep Learning model in Python with Keras, how to monitor and troubleshoot the training process and how to implement different layer types, such as convolutional layers. The workshop will be taught with data and examples relevant to archaeologists.

Sharing and maintaining software with GitHub and Git

Ben Companjen, University of Leiden
Stéphanie van de Sandt, Vrije Universiteit Amsterdam
Dr. Alex Brandsen, University of Leiden

Realistic material modelling and rendering for 3D scanned archaeological artefacts in Blender

Tijm Lanjouw MA, 4D Research Lab, University of Amsterdam

Modelling archaeological artefacts with 3D scanning techniques or photogrammetry has become widespread and very popular. Although archaeologists have largely mastered these techniques, the step to realistically render surface characteristics of objects is not often taken. On many models found online, shadows and highlights are often fixed on the textures, while transparency is rarely considered. In 3D graphics, realistic rendering of surface characteristics is known as Physically Based Rendering (PBR). In a PBR approach the object's physical properties such as metalness, roughness and diffuse colour reflection are approximated through various texture maps. In this workshop we are going to discuss the basic principles of PBR, how to scan or acquire data for PBR rendering, and how to create texture maps that approach a realistic visualisation of your archaeological artefacts. And all this in open source and free 3D modelling software Blender: https://www.blender.org/download/.

Developing 3D Scholarly Editions. Storytelling in Three Dimensions

Dr. Costas Papadopoulos, University of Maastricht
Prof. Susan Schreibman, University of Maastricht
Kelly Gillikin Schoueri MSc, University of Maastricht
Sohini Mallick MSc, University of Maastricht

Digital storytelling is the latest in a long tradition of various modalities for communicating context and meaning about our histories and societies. However, when adding 3D elements to interactive digital storytelling, there is arguably less development than other digital formats. Indeed, 3D models for digital cultural heritage are typically presented in more of an information space rather than a narrative space. Sketchfab and other such platforms allow for hotspot labels on the 3D model, thus augmenting it in the form of annotative enrichment. It is also common for museum collections to publish online 3D models of individual objects together with their associated metadata. In terms of rich storytelling capabilities, 3D models are frequently reduced to animations in which there is some form of guided linear narrative over camera movements that lead a user through the virtual space. There are, however, a few recent examples of prototypes that allow for the real-time exploration of 3D models that privileges the model as central to the story being told and from which to frame a narrative. Smithsonian's Voyager Story (https://3d.si.edu/; Smithsonian 2022a) is one such narrative-oriented platform that the PURE3D Project (https://pure3d.eu), funded by PDI-SSH to develop a national Dutch infrastructure for the publication and preservation of 3D scholarship, has been exploring for the development of a framework for 3D Scholarly Editions (Schreibman and Papadopoulos, 2019; Papadopoulos & Schreibman, 2019).

Voyager Story

Voyager Story is a 3D editing interface that has been developed by the Smithsonian Institution as part of a larger 3D digitisation ecosystem. It provides a flexible framework and intuitive editing environment for multiple types of digital content, as well as the modalities of designing engagement between the model and the accompanying narrative. Voyager Explorer is the front- end, end-user view of the curated 3D model – a number of examples can be explored via the Smithsonian's online 3D collection. The Voyager ecosystem is wholly open-source and is published with good documentation on their GitHub website (Smithsonian 2022b). Despite this, it is currently an under-used tool for publishing 3D narratives online.

Workshop Format

This is a full day, hands-on workshop which is divided into two parts. The workshop will startwith a brief introduction to the PURE3D infrastructure, followed by hands-on training with Smithsonian's Voyager Platform that has been adapted by the project as one of the web viewers for creating 3D scholarly editions. For this, we will use one of PURE3D's pilot projects, a 3D reconstruction of the battlefield of Mount Street Bridge; a battle during the 1916 Irish Easter Rising. Using training material that has been developed for the needs of the project and already tested with students, heritage professionals, and researchers, participants will use Voyager Story to develop 3D narratives in the form of: a) Annotation Labels: expandable hotspots as spatially aware annotation); b) Articles: HTML-based pages with text and multimedia that can either overlay the 3D model or be situated to the side of it; and, c) guided tours: a flexible combination of annotation, articles, camera movements and a set of analysis features, such as alternative material shaders, light settings measuring tape and slicer tool (Smithsonian, 2022). In the second part of the workshop, participants will use their own 3D models to start conceptualising them in the context of a 3D Scholarly Edition. Although due to time constraints, it will not be possible for participants to develop their own, the guided conceptualisation of their work will give them the opportunity to think through the premises of such scholarship and will provide them with a preliminary concept should they wish to further develop their 3D work to be ingested into PURE3D. Participants are expected to bring to the workshop any material that may be useful to contextualise their 3D models (such as text-based information, images, maps, videos, hyperlinks, etc.) and provide a sufficient amount of metadata and paradata for their work.

Workshop Audience

This workshop is suitable for researchers and educators who work on or would like to embark on the use of 3D in their practice. Museum professionals and representatives of cultural heritage institutions who have been developing digital collections or plan on digitising their holdings will benefit from getting to know how the infrastructure that the PURE3D project is developing can provide the means to develop rich annotated and contextualised narratives around 3D models. No prior experience in 3D modelling is required.

References

Schreibman, S. and Papadopoulos, C. (2019). Textuality in 3D: three-dimensional (re) constructions as digital scholarly editions. International Journal of Digital Humanities 1, 221–233. https://doi.org/10.1007/s42803-019-00024-6

Smithsonian (2022a). Voyager Overview. Available at https://smithsonian.github.io/dpo-voyager/explorer/overview/ (Accessed 26 August 2022).

Smithsonian (2022b). Smithsonian Github. Available at https://smithsonian.github.io/dpo-voyager/introduction/ (Accessed 26 August 2022).

Papadopoulos, C. and Schreibman, S. (2019). Towards 3D Scholarly Editions: The Battle of Mount Street Bridge. DHQ: Digital Humanities Quarterly, 13(1). http://www.digitalhumanities.org/dhq/vol/13/1/000415/000415.html

Documentation of cultural heritage data with Field

Juliane Watson, DAI Berlin

Field (formally known as iDAI.field) is an Open Source cross-platform tool for the documentation of archaeological field research. It enables researchers to deal with different needs from a variety of disciplines and methods like excavation, survey, architectural, or object studies. The core data model is designed to deal with most circumstances but can be adapted as needed while also maintaining as much standardization as possible. The very robust synchronization between clients supports distributed work, collaboration, and data entry in the field or in other places with no internet coverage. Spatial data, images, and drawings, as well as descriptive data can be stored, managed and interlinked. Multiple type catalogues can be included and linked with findings. While the data is stored in a NoSQL database, the various export and import functionalities allow for the integration of other fieldwork software like, for example, QGIS and survey2gis into the toolchain as well as statistics software like R. This workshop is designed to offer the participants hands-on experience with the program and enable them to use the software independently for their own projects. With version 3.0, released in Spring 2022 the Project configurations are stored in the database itself and can be created and edited in a configuration editor, a graphical user interface was integrated into the desktop application, so that every project/person can customize the application.

Agent-based modelling for archaeologists

Iza Romanowska, Aarhus Institute of Advanced Studies
Ronald Visser, Saxion University of Applied Sciences
Doug Rocks-Macqueen, Landward Research
Laura van der Knaap, Leiden University

In the last few years simulation approaches, such as agent-based modelling, have become increasingly popular among archaeologists. The aim of this workshop is to provide an introduction to agent-based modelling for archaeologists who have no previous experience in building archaeological simulations. Participants will finish the workshop with an understanding of agent-based modelling methods and the essential functionality of NetLogo. The workshop will focus on explaining the process of developing a simulation as well as provide a practical hands-on introduction to NetLogo – an open-source platform for building agent-based models. NetLogo's user-friendly interface, simple coding language and a vast library of model examples make it an ideal starting point for entry-level modellers, as well as a useful prototyping tool for more experienced programmers. The first part of the workshop will be devoted to demonstrating the basics of modelling with NetLogo through newly developed open educational resources. These are guided tutorials that will take you through the NetLogo software and show you how to model with it, developed as part of the Erasmus+ project – Agent-Based Modelling for Archaeologists. This introduction will give each participant enough skills and confidence to tackle the second exercise of the day: building an archaeologically-inspired simulation in a small group. Here we follow the popular concept of a "Hack-a-Thon" where participants aim to code a problem in small groups. The aim is for participants to work together to solve an archaeological problem. In this way, participants will walk away from the workshop with a piece of working code that they can use in future research. No previous coding experience is necessary. Please bring your laptop along and install NetLogo beforehand: https://ccl.northwestern.edu/netlogo/download.shtml

Sessions (Tuesday-Thursday)

Tuesday

01. Integrating mobile computing technologies into traditional archaeological methods

Dr Ying Tung Fung, Hebrew University of Jerusalem and University of Oxford
Prof Gideon Shelach-Lavi, Hebrew University of Jerusalem

Location: E106

Although mobile computing is not new to field archaeology (Ancona et al. 1999), it is not until the past two decades mobile devices and applications have become more common. This gives us a more efficient way to collect and record data and allows us to put data in relational contexts easily (Wallrodt, 2016). The digitalising technique is replacing the traditional paper forms in a positive way, but it is still evolving and needs improvement for a better integration between the design of mobile applications and conventional archaeological collection and recording methods. Archaeological projects usually involve a large amount of data, which cannot be easily recorded, organised and stored without any hassle. Mobile devices and applications provide many benefits for data collection process as survey and excavation points and polygons can be marked in software such as ArcGIS and GPS applications in advance. Data can be recorded and uploaded by multiple team members to mobile devices offline and then to computational devices to build up master datasets and relational databases, which are ready to be used for computational analysis.

However, paperless documentation is still new and there are still obstacles we have to overcome. For example, we have several cases of using mobile devices such as PDA and iPad (e,g, Canals et al., 2008; Ellis, 2016; Gordon et al., 2016; Motz, 2016) as well as custom-developed mobile application (e.g. Fee, 2016) to record data, but these applications have their limitations and challenges. Developing a new application requires extra works and cost to make it available on different operation systems and future maintenance are needed for long-term project, while using existing software limits the ways of which data are recorded and collected for specific archaeological project (Wallrodt, 2016). There are also technical problems such as features setting, choosing a suitable database model and exporting data to computational devices (Fee, 2016), and problems in applying the digital methods in different regions around the world especially the developing regions (Sayre, 2016).

Along with the continuous advancement of mobile applications and devices in recent years, the above issues have been minimised. Open-source applications such as FAIMS Mobile and HumanOS provide customisation services for specific projects (Ballsun-Stanton et al., 2018; Colleter et al., 2020). Other free and open-access applications such as DigApp and TaphonomApp allow a more flexible operation as they can be easily modified by users (Martín-Perea et al., 2020). The innovation of the device iPhone 12 pro LiDAR, meanwhile, provides a new way to scan and record features using mobile devices (Cohen-Smith et al., 2022). It is timely to evaluate the advantages and limitations of applying these new applications and devices in archaeological research, and how to better integrate mobile computing methods with traditional archaeological recording methods.

This session welcomes papers that discuss and evaluate the new mobile applications and devices in archaeological collection and recording processes. The topics include, but not limited to: the use and review of innovative mobile devices and applications in archaeological projects, the benefits, limitations and challenges of using these applications and devices. As well as how to overcome or minimise problems to improve the integration of mobile computing technologies with traditional archaeological methods, and suggestions and prospects for future development of using mobile computing in archaeology.

References:

Ancona, M., Dodero, G. and Gianuzzi, V., 1999, September. RAMSES: a mobile computing system for field archaeology. In International Symposium on Handheld and Ubiquitous Computing (pp. 222-233). Springer, Berlin, Heidelberg.

Canals, A., Rodríguez, J. and Sánchez, R., 2008. The 3COORsystem for data recording in archaeology. Journal of Anthropological Sciences, 86, pp.133-141.

Caraher, W., 2016. Slow archaeology: Technology, efficiency, and archaeological work. Mobilizing the past for a digital future: The potential of digital archaeology. Part 4.1.

Ellis, S.J., 2016. Are we ready for new (digital) ways to record archaeological fieldwork? a case study from Pompeii. Mobilizing the past for a digital future: The potential of digital archaeology. Part 1.2.

Fee, S.B., 2016. Reflections on Custom Mobile App Development for Archaeological Data Collection. Mobilizing the past for a digital future: The potential of digital archaeology. Part 2.1.

Gordon, J.M., Averett, E.W., Counts, D.B., Koo, K. and Toumazou, M.K., 2016. DIY Digital Workflows on the Athienou Archaeological Project, Cyprus. Mobilizing the past for a digital future: The potential of digital archaeology. Part 1.4.

Motz, C.F., 2016. Sangro Valley and the Five (Paperless) Seasons: Lessons on Building Effective Digital Recording Workflows for Archaeological Fieldwork. Mobilizing the past for a digital future: The potential of digital archaeology. Part 1.3.

Sayre, M., 2016. Digital Archaeology in the Rural Andes: Problems and Prospects. Mobilizing the past for a digital future: The potential of digital archaeology. Part 1.6.

Wallrodt, J., 2016. 1.1. Why Paperless: Technology and Changes in Archaeological Practice, 1996–2016. Mobilizing the past for a digital future: The potential of digital archaeology. Part 1.1.

SLOT 2	
10:30 - 10:50	310. A trial of using a newly developed mobile application for data collection and recording in the field *Ying Tung Fung (Hebrew University of Jerusalum)**
10:50	379. FAIR data in the field *Adela Sobotkova (Aarhus University)*; Shawn Ross (Macquarie University); Brian Ballsun-Stanton (Macquarie University)*
11:10	316. Utilizing mobile applications for LiDAR data field surveys and archaeological interpretations *Miroslav Vuković (University of Zagreb)*; Hrvoje Potrebica (University of Zagreb); Luka Drahotusky-Bruketa (University of Zagreb)*
11:30	364. Archaeological 3D models: mobile devices vs classical devices and techniques in archaeological documentation and presentation *Nenad C Joncic (National Museum of Serbia)**

SLOT 3	
13:00	166. Applying Mobile GIS and the Cultural Stone Stability Index to Monitoring Stone Decay of Excavated Structures at Archaeological Site Stobi, Republic of North Macedonia *Kristen Jones (Queen's University Department of Geography & Planning)*; George Bevan (Queen's University Department of Geography & Planning); Kaelin Groom (Arizona State University); Casey Allen (The University of the West Indies); Dimitar Nikolovski (National Institution Stobi)*
13:20	85. Documentation and Communication: Methods for Mobile LiDAR and Photogrammetry in Practice *Nikolai Paukkonen (University of Helsinki, Muuritutkimus Oy)**
13:40	337. Scan to BIM using the iPad Pro: modelling a Neolithic passage tomb at Dowth Hall, Co. Meath, Ireland *Eimear Meegan (Virtual Lab Dublin)*; Jessica Mendoza (Carleton Immersive Media Studio); Maurice Murphy (Virtual Lab Dublin); Clíodna Ní Lionáin (Devenish Nutrition)*
14:00 - 14:20	183. Critical evaluation of SLAM-based mobile LiDAR mapping methods for documentation of archaeological cave sites and subsequent integration with multimodal and multi-scalar datasets *Dominique Rissolo (University of California, San Diego)*; Holley Moyes (University of California, Merced); Eric Lo (University of California, San Diego); Hilda Lozano Bravo (University of California, Merced); Scott McAvoy (University of California, San Diego); Shane Montgomery (University of Calgary); Samuel Meacham (Centro Investigador del Sistema Acuifero de Quintana Roo); Helena Barba-Meinecke (Instituto Nacional de Antropologia e Historia); Falko Kuester (UC San Diego)*
14:20 - 14:40	**Discussion**

310. Field trial of using a custom mobile application for data collection of wall structures

Ying Tung Fung, Hebrew University of Jerusalum

In the past two decades, the use of mobile computing techniques has become increasingly common in archaeological research. This includes the use of newly developed, open-access and open-source mobile applications to record data in the field (Wallrodt 2016). Although these digital applications improve the efficiency of data collection, it is important to consider how well they can be integrated with conventional paper methods (Caraher 2016). Since studies on the reflection of custom applications, such as the PKapp developed in 2012 (Fee 2016), are relatively uncommon, this paper discusses a new mobile application developed specifically for the ERC-funded The Wall Project at the Hebrew University of Jerusalem (https://thewall.huji.ac.il). This paper discusses the need and process of developing the application, reflections on using it for data collection and potential future developments.

We developed this application rather than using other existing sources because it was specifically designed for recording wall structure measurements and information. The data need to be collected from chosen forts that are distributed along a 400 km long wall. Therefore, we needed an application with a simple and straightforward interface to fit the need for a quick and handy data recording process. The application is advantageous over other existing applications with various functions integrated into one: allowing multiple team members to record simultaneously, combining the mobile functions of GPS, code scanner and camera, supporting automatic-filled information and built-in diagrams for recording structures and working offline.

The application was designed and went through a test for compatibility with ArcGIS Pro and a quality assurance process by our team. The major features of the application include a simple interface that allows automatically filled information for date, time, recorders' names and object IDs for forts, as well as barcode scanning to identify recording units for forts that correlate data with paper forms and artefact bags. It also has in-built diagrams for immediate data input, and the data as Excel files can be automatically updated and stored in mobile phones. These data can be transferred to a sharing platform with internet access and are ready to be imported and analysed in ArcGIS Pro after data cleaning.

In July 2022, the application was used in the field survey in southern Mongolia for the first time, mainly to record measurement data and remarks for walls, forts and information related to collection of ceramic shards. Our field experience shows that the application can record all the required data fast and easily. The output can be edited and then joined to any layers in ArcGIS Pro for analysis efficiently. For example, identifying the statistical distribution of fort size and the spatial distribution for larger forts. Meanwhile, we identified a limitation that it can be time-consuming to record data in the correct orientation with the fixed in-built diagrams of forts. Another limitation is that the barcode scanning for recording units of forts can be mixed up when they are close to each other.

We also used the traditional paper method to record the data because the mobile and paper methods involve two different approaches: the former focuses more on speedy data recording whereas the latter focuses more on the details of collected artefacts in different collection units. The data relating to potshards collection were recorded on paper forms and then the data were transferred manually to the Access database. The conventional methods are currently still advantageous in terms of recording drawings on paper, showing maps and images of structures, and tracking and recording artefacts collection areas with GPS devices.

We intend to improve the existing limitations for a more useful usage in our future survey and project. This includes developing an option for users to customise settings in the field for different specific purposes, uploading site lists in advance with automatically filled coordinates and object IDs, and allowing built-in images with automatic detection of orientation. In the future, we will consider how the digital application can be better integrated with the existing and paper methods. Potential developments include adding functions for sketching on a whiteboard, uploading base maps in advance, and tracking and recording points, lines and polygons.

References

Caraher, W. R. 2016. Slow Archaeology: Technology, Efficiency, and Archaeological Work. In EW Averett, JM Gordon and DB Counts (eds) Mobilizing the Past for a Digital Future: The Potential of Digital Archaeology (pp.421–442). Grand Forks: The Digital Press @ the University of North Dakota.

Fee, S.B., 2016. Reflections on Custom Mobile App Development for Archaeological Data Collection. In EW Averett, JM Gordon and DB Counts (eds) Mobilizing the Past for a Digital Future: The Potential of Digital Archaeology (pp.221–236). Grand Forks: The Digital Press @ the University of North Dakota.

Wallrodt, J., 2016. Why Paperless: Technology and Changes in Archaeological Practice, 1996–2016. In EW Averett, JM Gordon and DB Counts (eds) Mobilizing the Past for a Digital Future: The Potential of Digital Archaeology (pp.33–50). Grand Forks: The Digital Press @ the University of North Dakota.

379. FAIR data in the field

Adela Sobotkova, Aarhus University
Shawn Ross, Macquarie University
Brian Ballsun-Stanton, Macquarie University

Critical data and metadata must be captured in the field or risk being lost. For the past 10 years, the Field Acquired Information Management Systems (FAIMS) project has maintained a comprehensive and customisable field data capture platform used in archaeology and other fieldwork domains (Ballsun-Stanton et al 2018). This platform ultimately incorporated a range of features and capabilities to incorporate the Findable, Accessible, Interoperable, and Reusable (FAIR) principles and other best practices into born-digital datasets created during fieldwork (Wilkinson et al 2016). This paper discusses what elements of the FAIR principles most benefit from incorporation into digital field data recording systems, then reviews relevant FAIMS Mobile features, and finally presents lessons from our experience that could be incorporated into other recording systems or otherwise embedded in field data recording practices.

Ballsun-Stanton, B, Ross, SA, Sobotkova, A and Crook, P. 2018 FAIMS Mobile: Flexible, open-source software for field research. SoftwareX 7: 47–52. DOI: https://doi.org/10.1016/j.softx.2017.12.006.

Wilkinson, M. D., Dumontier, M., Aalbersberg, I. J., Appleton, G., Axton, M., Baak, A., … Mons, B. (2016). The FAIR Guiding Principles for scientific data management and stewardship. Scientific Data, 3, 160018. https://doi.org/10.1038/sdata.2016.18

316. Utilizing mobile applications for LiDAR data field surveys and archaeological interpretations

Miroslav Vuković, University of Zagreb
Hrvoje Potrebica, University of Zagreb
Luka Drahotusky-Bruketa, University of Zagreb

Introduction

The research area in this paper revolves around the Kaptol micro-region, and its Late Bronze and Iron Age sites, and the LiDAR/ALS (LiDAR – light detection and ranging, ALS – airborne laser scanning) scans completed in 2014 (Potrebica & Rakvin, 2019). The Iron Age communities in this area belong to the Eastern Hallstatt Cultural Complex, and based on the research conducted so far, the settlements show a high degree of organization with an almost urban structure (Potrebica 2019) The ALS dataset in question provided a completely new perspective on some of the sites in the Požega Valley and revealed several previously unknown sites. The area contains complex traces of past human activities including settlements, fortifications, paths and cemeteries to just name a few. A large number of new features that resulted from data analysis forced us to invent new tools to help us with field surveys aimed at checking LiDAR data on the ground.

Methods and materials

The dense deciduous forests and the complex geological background in our research area form a challenging landscape for the interpretation of ALS data. To that effect one of our first goals was to transfer the ALS data visualizations on to a mobile device so we could use GPS location services to position field teams in relation to features discovered by LiDAR. This enabled us to approach and document various features which would otherwise be difficult, if not impossible to find in the complex microtopographic environment in our research area. For these purposes we used mobile application Qfield, a mobile version of the QGIS program. The application proved to be easy to use and very effective. We loaded our QGIS projects onto the mobile device and used integrated mobile phone GPS to track our position in relation to the features visible on ALS data. Since our aim was to document and define all features from our dataset we also used a mobile application to record and store GPS points with georeferenced photographs for each individual feature located on the ground. The application Waypoint Manager served our purpose, as it allowed the storage of unlimited number of points along with geocoded photographs, and most importantly a seamless transfer of data in large number of common formats such as .gpx or .kmz.

Results

These mobile applications proved to be extremely valuable in cross-checking of ALS data. The first one enabled precise location of each individual feature. In some cases it is difficult to distinguish the relief forms from potential features. That is the reason why we use different visualization techniques in ALS data interpretation. The ability to switch through layers and different visualizations in the Field application while in the field proved crucial in the interpretational process. The second application served as a documentation tool for the features on the ground and allowed us to create a database of features and link them to photographs with precise GPS coordinates.

Discussion

So far Qfield has been used in archaeological research as a tool for open area field surveys or as a documentation tool (Montagnetti & Guarino 2021). This paper aims to present our methodology of using mobile applications for ALS data interpretation, although they can be used in wide variety of other forms of archaeological prospection. These applications could significantly improve our ability to deal with large remote sensing datasets in relation to archaeological context in the field.

References

Montagnetti, R. and Guarino, G., 2021. From Qgis to Qfield and Vice Versa: How the New Android Application Is Facilitating the Work of the Archaeologist in the Field. Environmental Sciences Proceedings, 10(1), p.6.

Potrebica, H., 2019. The Kaptol Group and the Požega Valley, Arheološki vestnik, 70, pp.487-516.

Potrebica, H. & Rakvin M., 2019. Study of the Kaptol micro-region, in: Early Iron Age landscapes of the Danube region, eds. Črešnar, M. & Mele, M., p. 141 – 160, Graz-Budapest

364. Archaeological 3D models: mobile devices vs classical devices and techniques in archaeological documentation and presentation

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With the appearance of phones and tablets with built-in LiDAR systems, the production of 3D models of archaeological contexts and objects using phones has increased significantly. Since the appearance of the first LiDAR phones in 2020, archaeologists have been trying to include this equipment in their work, but the initiative to use mobile phones to create 3D models in archaeology was present. However, if you look at the publications on the topic of LiDAR technology application on mobile devices, it seems that in other disciplines such as geology, forestry, etc., it is more quickly accepted and applied.

One of the most important questions is whether 3D models obtained by mobile devices using LiDAR and photogrammetry can be used for creating archaeological documentation and presentations. That is, whether they can match the quality, precision, speed of production, and possibilities of further application to 3D models obtained by classic techniques, methods, and devices. Like SLS 3D scanners, Terrestrial laser scanners, Terrestrial photogrammetry, Aerial photogrammetry, etc. methods and techniques for making 3D models in archaeology. In order to answer the question in the paper, we will apply a SWOT analysis to show the Strengths, Weaknesses, Opportunities, and Threats of 3D models made with mobile devices.

We will present the results of different software applied to different subjects and entities. A total of five objects, made of different materials, were selected for testing the 3D models of archaeological objects. When creating 3D models of archaeological objects and using different software, the recording conditions were always the same. For testing 3D models of archaeological contexts, five archaeological contexts were also selected, they were tried to be different from each other, both in terms of size and complexity. So they differ in content and type. When recording archaeological contexts, it was always taken care that the units were recorded in approximately the same conditions. Differences are caused by the passage of time or changes in weather conditions, such as light intensity, rain, fog, and other factors that may affect the results.

The iPhone 13 Pro Max mobile phone was used to create 3D models in combination with the following software: 3D Scanner App, Scanivers, Metascan, Polycam, WINDAR, PIX4Dcatch, EveryPoint. Most of the mentioned software has the ability to create 3D models using both LiDAR and photogrammetry technology. First, we will compare 3D models of objects and contexts made with different techniques in the same software, with the aim of determining the differences in the quality and precision of the obtained 3D models. Then they would be tested and scored among the software.

First, we will present the Strengths of each software and the resulting models.

Then we will highlight the Weaknesses of each of the software on the example of the obtained models.

Through the presentation and analysis of examples of the use of the obtained models in daily work, we will present the opportunities and advantages of applying this method of documentation.

As well as Threats that await us during the creation of models and their application in archaeological and musicological practice.

Based on the presented results, the best 3D models obtained with a mobile phone will be selected in terms of quality and precision, which will be comparatively analyzed with examples of 3D models obtained using classical methods. Again, SWAT analysis will be applied to show the differences between traditional 3D modelling methods and those done with mobile devices. With a special emphasis on those obtained with LiDAR technology.

166. Applying Mobile GIS and the Cultural Stone Stability Index to Monitoring Stone Decay of Excavated Structures at Archaeological Site Stobi

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INTRODUCTION

Archaeological excavation exposes historic stone structures to new environmental regimes, which, when combined with weakness inherent to the stone and mortar, can lead to rapid decay. Conservation efforts can seldom match the rate of archaeological excavation, and structures can be left for years. For this reason, an effective monitoring regime for stone decay of excavated structures is essential to identify decay mechanisms and their progression which can then be used for allocating limited resources to areas of highest risk. The use of mobile GIS applications can make this sort of recording significantly more efficient. This project will present the preliminary assessment of the proposed monitoring system workflow using mobile GIS data collection at the Archaeological Site of Stobi in the Republic of North Macedonia.

An effective monitoring system for stone decay should have several key components. First, it should not require extensive training and specialized knowledge in stone decay, instead be capable of implementation by archaeologists themselves. Second, it should be repeatable and robust over time and between different users such that intra-site and inter-site comparisons of decay processes can be made. Third, it should not require extensive sampling or expensive laboratory work. And finally, the system should be designed to be managed through contemporary GIS platforms. Stobi presents an ideal setting to implement this approach. The ancient city was the capital of the Roman Province Macedonia Secunda, inhabited from the 3rd century BCE until the 6th century CE and the site remained relatively undisturbed until its rediscovery in the late 19th century. Over the past century, excavation has been almost continuous exposing a significant portion of the site.

METHODS & MATERIALS

The Cultural Stone Stability Index (CSSI), an outgrowth of the field-tested Rock-Art Stability Index (RASI), meets the requirements listed above by generating intuitive scores between 1 and 100 for more than three-dozen scientifically validated stone decay elements across five categories (Allen et al, 2018). Each individual element is rated on a scale from 0-3: Not Present, Present, Obvious, Dominant. Rigorously tested and validated, scoring was designed to be straightforward and intuitive, allowing CSSI to be effectively utilized by all types of researchers.

CSSI was originally developed as a paper form completed in the field and then transcribed into a database post-field. The paper form was converted into a custom digital survey that is run using the mobile smartphone application Survey123, developed by ESRI for both iOS and Android where the data can be directly imported into ArcGIS software. The custom digital survey for CSSI at Stobi was translated into both English and Macedonian. Additionally, a Visual Reference Guide was developed that has examples of all the decay parameters used in CSSI identified on buildings at Stobi which was also translated into Macedonian and will be used for educational purposes and training.

The project selected a series of significant partially and fully excavated structures each in dire need of ongoing monitoring and conservation: the Theodosian Palace, Theater, Building with Arches, and Late Antique Settlement. These structures cover the geomorphic terraces of the site as well as a range of occupational periods (Folk, 1973).

RESULTS

The results of the pilot project implementing CSSI at Archaeological Site Stobi include scores for approximately 100 walls from 2019-2022 and in some buildings, two epochs of data for a selection of the walls. The data is being stored in a GIS that overlays the scores with the ground plan of the site.

When conducting our field assessment of various buildings on the site, a new element to the Stobi implementation of CSSI that was not used in previous iterations was added: the "Structural Risk Factor". This component adjusts scores when decay factors may or may not score as "Dominant", but have the potential to jeopardize the wall's load-bearing capacity..

In comparing CSSI scores to an initial visual inspection of the walls, it is clear that it can characterize decay in a more robust way and is more representative of the walls' condition. However, it was noted that recent conservation does not necessarily mean that the wall will receive a low CSSI score. Once conserved, a stone wall immediately begins to undergo the same mechanisms of decay despite appearing stable at first glance. Research on CSSI – and its predecessor RASI – have shown its robustness and replicability that can produce an informative semi-quantitative measure of stone decay. In other words, the scores are not necessarily an absolute measure of risk, but can provide a manager with validated and objective comparative data across a site, as long as the scorer has been trained.

DISCUSSION

The use of mobile devices for on-site data collection represents the next phase for many aspects of archaeological research, and stone decay monitoring is no exception. Final calculated scores in GIS give an overall assessment of the excavated structure's deterioration state and can be analyzed across scales from a single score for an individual wall or architectural feature to an entire building. Results can be used to identify areas most at-risk, so future conservation and intervention funds can be used more effectively. Furthermore, CSSI scores can also be compared with 3D geometric changes in the excavated structures as measured by high resolution 3D models and be integrated to digitally identify and highlight areas of high risk.

The CSSI represents a scientifically-validated, low-cost, and easy-to-use assessment for evaluating rock decay of built structures. Moving CSSI into the mobile digital space offers researchers an even more efficient option when gauging structural decay and stability in the field, regardless of any prior excavation and/or conservation efforts.

REFERENCES

Allen, C.D., S. Ester, K.M. Groom, R. Schubert, C. Hagele, M. James, and D. Olof. "A Geologic Assessment of Historic St. Elizabeth of Hungary Church Using the Cultural Stone Stability Index, Denver, Colorado" in Urban Geomorphology: Landforms and Processes in Cities, ed. M.J. Thornbush and C.D. Allen. (Elsevier, 2018): 277-302.

Folk, R.L. "The Geological Framework of Stobi". in Studies in the Antiquities of Stobi I, ed. J. Wiseman. (Beograd: National Museum of Titov Veles, 1973)" 37-57.

85. Documentation and Communication: Methods for Mobile LiDAR and Photogrammetry in Practice

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As already mentioned in the session description, the past two decades have seen mobile devices and applications becoming commonplace in archaeological fieldwork. However, performing spatial recording of data in the field has been lagging behind due to technical limitations. Lately the things have started changing, however with several new products and applications having been introduced during the last few years. Among these is the Apple Inc's iPhone 12 Pro, bringing LiDAR capabilities to mobile phones. Simultaneously, the development of photogrammetry has made mobile phones and light weight gimbal cameras potent tools for recording of accurate 3D models as well. Combined with cloud computing and 5G connectivity, it is possible to experiment and visualize excavation process in the field by accurate digital 3D representations of the site. This also allows for communicating the results in real time to remote specialists and stakeholders, who can evaluate the situation by using photorealistic representations of the site, instead of having to visit there in person.

In my paper I present various experiments and workflows used by Muuritutkimus Oy company in Finland. Muuritutkimus has been operating as an archaeological contractor for over 27 years, excavating and documenting hundreds of archaeological and cultural heritage sites, ranging from Neolithic period to 1900s. Over this time we have been at the forefront of testing and developing new ways to push archaeological documentation on a new level. By examining two cases from actual excavations I compare different tools for mobile 3D documentation and measurement. A target is recorded with various pieces of equipment or techniques, after which a threefold evaluation of differences is performed. These areas of evaluation include 1) accuracy and precision by using M3C2 plugin in CloudCompare (James, Robson and Smith 2017) 2) time constraints and 3) accessibility and ease of use.

My main focus is on iPhone 12 Pro and some of its applications that we have found useful; DJI Osmo Mobile gimbal cameras and photogrammetry performed with video recorded with them; and a Faro Freestyle 2 handheld laser scanner. Some of these have been studied on their own, (e.g. Losè et al. 2022, Cohen-Smith et al. 2022 and Maset et al. 2022), while other's potential has not been widely explored in academia. Reference data has been gathered using a Riegl VZ-400i terrestrial laser scanner with a JAVAD high-accuracy GNSS antenna. Some attention is also given to different ways to utilize Matterport platform, with data captured on an iPhone device. The end result will show some of the best practices, workflows and recommendations we have encountered after years of use.

Various problems remain. Georeferencing the recorded data accurately is often complicated. Equipment and software is still expensive, even if it now is a fraction of what similar results would have required ten years ago. Data format standards regarding distribution and archiving have not been established. Cloud services can be either complicated to use or require continuing payments and have various policies regarding copyright, for example. Furthermore, as photogrammetry and LiDAR scans become more abundant, archaeologists, it might be relevant to ask if there is a risk of starting to overlook other aspects of archaeological documentation and interpretation? Experiments in the field are required to push the development further and make these technologies commonplace in the world of archaeology.

References

Cohen-Smith, Hannah, Bickler, Simon H., Jones, Benjamin, Larsen, Bernie, and Apfel, Aaron. 2022. "New Tech for Old Jobs: Handheld LiDAR for Feature Recording". Archaeology in New Zealand, 64: 14–27.

James, Mike R., Robson, S., and Smith, Mark W. 2017. "3-D uncertainty-based topographic change detection with structure-from-motion photogrammetry: precision maps for ground control and directly georeferenced surveys". Earth Surf. Process. Landforms, 42: 1769– 1788. https://doi.org/10.1002/esp.4125.

Maset, Eleonora, Valente, Ricardo, Iamoni, Marco, Haider, May, and Fusiello, Andrea. 2022. "Integration of Photogrammetry and Portable Mobile Mapping Technology for 3D Modeling of Cultural Heritage Sites: The Case Study of the Bziza Temple". The International Archives of Photogrammetry, Remote Sensing and Spatial Information Sciences, 43: 831–837.

Teppati Losè, Lorenzo, Alessandra Spreafico, Filiberto Chiabrando, and Fabio Giulio Tonolo. 2022. "Apple LiDAR Sensor for 3D Surveying: Tests and Results in the Cultural Heritage Domain" Remote Sensing 14, no. 17: 4157. https://doi.org/10.3390/rs14174157

337. Scan to BIM using the iPad Pro: modelling a Neolithic passage tomb at Dowth Hall, Co. Meath, Ireland

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Introduction

The LiDAR scanner that has come as standard with Apple's iPhone and iPad Pro ranges since 2020 has made digital recording of built and portable heritage accessible to a much broader and far less specialist group than had previously been the case. Availability of this low-cost sensor naturally offers those involved in small scale, lower-budget research projects and community-based initiatives the opportunity to engage in data capture and digital heritage knowledge creation on a potentially transformative scale. There are, however, questions of quality and usability that must be addressed in order to establish the true value of this development as regards the documentation, analysis and dissemination of digital cultural heritage data. In a bid to do this, the current paper takes the recently excavated Neolithic passage tomb at Dowth Hall, Co. Meath, Ireland as a case study. It first considers the scanning of the upstanding and displaced megalithic remains uncovered here using an iPad Pro before outlining two novel methodologies (Workflow 1 and Workflow 2) devised with a view to automating, as much as possible, the conversion of the captured data to Building Information Modelling (BIM) geometry. Following on from this, the results of each workflow will be presented before discussion of their potential in the creation of HBIM (Historic BIM) models in which a range of attributes can be embedded, thus allowing for more effective collaboration between stakeholders in the management and conservation of built heritage.

Methods and Materials

The passage tomb remains that form the focus of this study are thought to date to the Middle Neolithic period in Ireland (c. 3000BC) and comprise two disturbed megalithic chambers, part of a megalithic perimeter kerb and a much-truncated cairn with an estimated diameter of c.40m, which today survives to a maximum of height of 1.6m but may have stood 5-6m tall originally (Ní Lionáin 2021, 4). In one of the two chamber areas (Area 1), a group of 7 in situ orthostats or uprights have been exposed together with 6 displaced orthostats and capstones which are lying in a prone position.

Using the iPad Pro's LiDAR scanner in conjunction with Laan Lab's Scanner app, this chamber area was recorded with ease and speed owing to the lightweight and portable nature of the device, which is particularly well suited to the exposed upstanding arrangement. The data captured was subsequently exported as e.57 point cloud files for cleaning and meshing in MeshLab. Here, where necessary, the point cloud was first segmented to allow for the isolation of individual stones, each of which underwent a process of cleaning that involved deletion of noise, deletion of overlapping vertices, merging of close vertices and computing of normals for point sets in preparation for surface reconstruction using the Screened Poisson filter.

Following the Workflow 1 protocol, the resulting mesh was imported to Rhino in .obj format where it was converted to NURBS in order to create a closed polysurface that could then be exported as a 2007 Solids .dwg file. This, in turn, was imported into Autodesk's designated BIM application, Revit and fully exploded to become native Revit geometry. Offering what is, perhaps, a more accessible alternative approach, Workflow 2, involved the importation of the MeshLab mesh into Blender from where it was exported as a .dxf file for importation into AutoCAD. Here, it was exported as a CAD Blocks .dwg file, which like the 2007 Solids file could be imported into Revit and fully exploded to become native geometry.

Results

Both workflows, while they employ different software applications for data processing, result in the creation of native BIM geometry which makes for a far more efficient project than that built using imported geometry. Visually, the workflow results are very similar, but technically Workflow 1, which employs Rhino, has a higher face count and thus a higher level of detail (fig. 1). However, Workflow 2, which employs Blender and AutoCAD is more accessible to students and educators as Blender is open source while AutoCAD, like Revit, can be accessed for free through Autodesk's education licensing system. Either way, it is clear that the scan data captured using the iPad's low-cost scanner can successfully be used to model the non-uniform geometry of megalithic building elements as Revit objects.

Discussion

Much like GIS, BIM software serves as a platform for the integration and visualisation of a variety of data types, allowing site drawings and/or, in the case of existing architecture, scan/photogrammetric data to be used as frameworks for the creation of volumetric models in which a range of information can be embedded, including material detail and building performance. Its value has long been recognised in the field of cultural heritage with HBIM representing a modification devised to accommodate the management of historic architecture, allowing the complex conservation issues that characterise the maintenance of these structures to be better identified, monitored and addressed through coordinated intervention (Sarıcaoğlu and Saygi 2022). Modelling the often-non-uniform components these buildings comprise, however, poses challenges not faced when dealing with modern, modular architecture. These difficulties are further exacerbated when dealing with the highly irregular morphology of archaeological remains, which likely accounts for the comparatively small number of cases in which BIM principles have been applied to archaeological built heritage (Moyano et al. 2020). The workflows presented here not only offer viable semi-automated solutions to this issue but, the use of the iPad in the data capture stage makes these approaches all the more affordable and achievable.

References

Moyano, Juan, Carlos P. Odriozola, Juan E. Nieto-Julián, Juan M. Vargas, José A. Barrera, and Javier León. 2020. "Bringing BIM to archaeological heritage: Interdisciplinary method/strategy and accuracy applied to a megalithic monument of the Copper Age". Journal of Cultural Heritage 45: 303–314. https://doi.org/10.1016/j.culher.2020.03.010

Ní Lionáin, Clíodhna. 2021. Preliminary Report (17E0242). Phase 1 Excavation and Phase 2a Testing Programme at Dowth Hall, Co. Meath. Unpublished report.

Saricaoğlu, Tuğba, and Gamze Saygi. 2022. "Data-driven conservation actions of Heritage Places curated with HBIM". Virtual Archaeology Review 13(27): 17–32. https://doi.org/10.4995/var.2022.17370

183. Critical evaluation of SLAM-based mobile LiDAR mapping methods for documentation of archaeological cave sites and subsequent integration with multimodal and multi-scalar datasets

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The often complex, multilevel morphology of caves can offer ideal test environments for SLAM-based mobile LiDAR systems for the documentation and mapping of subterranean archaeological sites (see Konsolaki et al. 2020; see also Di Stefano et al. 2021). This study involves systematic scanning in seven caves in Belize and on the Yucatan Peninsula of Mexico. Using the Emesent Hovermap system, a range of deployment strategies were developed, and varying data-capture techniques were employed, for the purpose of comparing the results of separate scans of the same environments and evaluation against existing datasets from different scanning or surveying modalities. The purpose of this study is to inform the use SLAM-based mobile LiDAR systems in caves with an emphasis on the specific objectives or expectations of a given scanning project while cautioning against the uncritical embracing of rapid-capture technologies.

Traditional cave survey and cartography still have significant interpretive value, but much can be missed (or left unrevealed) in terms of morphology and potentially meaningful spatial-contextual relationships. Cartographic representations of caves often emphasize idealized floor environments along with sample transverse and longitudinal sections. However, use of caves by humans (cross culturally) involves niches, shelves, alcoves, walls, and ceilings. The ability to better capture the geometries of these surfaces is often of great interest to the archaeologist. Terrestrial laser scanning (TLS) can be useful in this regard and can be complementary to standard (e.g., Disto and compass) techniques or SfM photogrammetry (when and where ample light can be provided). However, in certain subterranean environments TLS is not practical whereas mobile LiDAR is readily deployable.

Differing levels of accuracy notwithstanding, a major benefit of a mobile LiDAR systems (either handheld or UAV-based) is the ability to scan cave environments more rapidly than tripod-mounted laser scanners. Moreover, the varied terrain of caves lends itself to scanning technologies that can be used while crawling, climbing, or abseiling down vertical shafts – all offering improved line-of-sight opportunities and greater overall coverage. Of particular interest are partially flooded cave chambers, passageways, or tunnels, which can negate the use of tripods. The current study involved wading (on foot) as well as the use of a small boat with the Hovermap to address these challenges and to continue the scanning project through and across the cave in its entirety. In all cases, mobile LiDAR data-capture strategies and techniques must be adopted to maximize coverage, minimize drift (inherent to SLAM-based approaches), and ensure robust scan-to-scan alignment.

The study also involved comparing our Hovermap scan data with earlier TLS and total station datasets of the same cave environments at Las Cuevas, Belize. Additionally, new datum points and retroreflective targets were shot in using a total station, concurrent with the Hovermap survey, to further control our preliminary post-acquisition metrological analyses. These efforts are ongoing, with the goal of more effectively assessing confidence in SLAM-based mobile LiDAR (accounting for situational variables) and to better rank Hovermap as a primary or complementary documentation modality when choosing methods and techniques for a given scanning project. Although accuracy is often a primary driver, such decisions are also shaped by time, budget, access, cave morphology or cave characteristics, and other logistical or operational constraints or considerations.

Fusion and georeferencing of 2D and 3D data from other documentation modalities (such as TLS, total station survey, SfM photogrammetry, Disto and compass survey, as well as ground based and aerial remote sensing) can provide more holistic, revealing, and even didactic representations of archaeological and natural environments (Hess et al. 2015). Our efforts involving Hovermap have incorporated both legacy data (e.g., previous TLS scans) and newly acquired image-derived data (e.g., SfM photogrammetry) to provide additional detail of selected deposits or features in the caves. These combined data are rendered and visualized in both Potree and Viscore (a custom point-based visual analytics engine). For select caves in Mexico, we can connect underwater photogrammetry and station-to-station survey to Hovermap scans of partially flooded or dry cave passages, linking our local coordinates to other disparate local coordinate systems. By continuing the mobile LiDAR scans outside of the cave environment, we can rapidly capture surface features as well as surveyed ground control points, thereby linking the subterranean scans to global coordinates. These georeferenced data can then be visualized on or beneath a range of DEMs or other base maps.

References Cited:

Di Stefano, Francesco, Alessandro Torresani, Elisa M. Farella, Roberto Pierdicca, Fabio Menna, and Fabio Remondino (2021). 3D Surveying of Underground Built Heritage: Opportunities and Challenges of Mobile Technologies. Sustainability 13, 13289.

Hess, Michael, Vid Petrovic, Dominique Meyer, Dominique Rissolo, and Falko Kuester (2015). Fusion of Multimodal Three-Dimensional Data for Comprehensive Digital Documentation of Cultural Heritage Sites. In Proceedings of the 2015 Digital Heritage International Congress, edited by Gabriele Guidi et al., Volume 1, pp. 595-602. IEEE.

Konsolaki, Aliki, Emmanuel Vassilakis, Leonidas Gouliotis, Georgios Kontostavlos, and Vassilis Giannopoulos (2020). High Resolution Digital 3D Modelling of Subsurface Morphological Structures of Koutouki Cave, Greece. Acta Carsologica 49/2-3:163-177.

04. "Hey Google, stop that looter": digital technologies against cultural heritage crimes; critical

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Countering the devastation of archaeological sites caused by illegal excavations or voluntary destruction is at the forefront of worldwide governments agendas, but also cultural institutions and caring citizens are deeply concerned by this disruptive phenomenon. Looting (i.e., the unlawful removal of ancient artefacts conducted through non-scientific methods by robbers) is an old practice, dating back to ancient times. Recent events such as the 2004 Iraqi war, the 2011 'Arab Spring', ISIS's actions in the Middle East and North Africa, the COVID pandemic and the 2022 Ukraine war, determined a spiralling increase in looted items being available on the international antiquities market, both the legal and illegal ones. The last decade witnessed a growth in computer-aided technologies designed to monitor both looting activities and art markets, tools that have proven to be highly instrumental in halting/detecting unlawful behaviours. Remote sensing is being used to detect and monitor illicit excavations (Tapete and Cigna 2021) using multispectral imagery – investigated through both manual (Casana and Panahipour 2014; Contreras 2010; Stone 2008) and automatic recognition of looting patterns (Lasaponara and Masini 2021) –, SAR data (Tapete, Cigna and Donoghue 2016; El Haji 2021) and Multi-Temporal Analysis (Agapiou 2020). VHR imagery time-series deployed by Google Earth makes it now possible to locate several looted sites throughout the globe (Contreras and Brodie 2011; Parcak et al. 2016; Zerbini and Fradley 2018), opening avenues for the development of new methods of recognition. The potential of computer vision and machine learning methods applied to web-scraped content (Huffer and Graham 2018; Huffer, Wood and Graham 2019; Graham et al. 2020) is being investigated to track illicit on-line sales. Network Sciences derived methodologies have been studied to identify criminal networks of the antiquities trade (Tsiriogiannis and Tsiriogiannis 2016) and its actors within the so-called "grey market" of antiquities (Bowman 2008; Mackenzie 2019; Mackenzie and Yates 2016). Artificial Intelligence approaches are being developed to identify looted/robbed archaeological items appearing in the market (Winterbottom, Leone and Al Moubayed 2022). The monitoring, both manual and automatic, of Social Media, on-line forums and marketplace, as well as the deep web, is enabling to gather crucial information about the illicit market using both quantitative and content data (Al-Azm and Paul 2019; Hardy 2014, 2015, 2017, 2018; Paul 2018; Giovanelli 2018; Altaweel and Hadjitofi 2020; De Bernardin 2021). Databases of stolen objects and due diligence activities have been developed by enforcement units, such as the Comando Tutela Patrimonio Culturale in Italy and INTERPOL (Arma dei Carabinieri 2016). 3D imagery-fed blockchain technologies (Gandolfi and Cox 2018) are currently being investigated. The progresses of research in this domain are fast-paced and pushed by the increasing loss of archaeological contexts and Cultural Heritage items. The developed technologies are getting more specialized; however, they are often unable to achieve levels of sophistication that can concretely contribute to the fight against illicit trafficking. This session invites the submission of original papers in the areas outlined above (i.e. remote sensing, network sciences, computer vision, machine learning, data-mining, blockchain, qualitative and quantitative SM data analysis) and beyond that engage in a critical discussion on the approaches, solutions and outcomes of established and emerging technologies, in order to highlight the pros and cons of technological applications and to identify successful means and methods to concretely build systems able to fight and prevent the looting and the illicit trade of cultural heritage objects. We are also interested in new methods and applications that have not been fully explored yet in the domain of countering cultural property trafficking, but which should be taken into consideration for future developments, such as in the field of Network Sciences and Graph Theory. The session is mainly intended for researchers working in the broad domain of antiquities crimes using traditional and computational approaches; it also benefits those working in the described technologies and methods (remote sensing, machine learning etc.) in the broader context. The session is organized within the framework of the HORIZON EU RITHMS (Research, Intelligence and Technology for Heritage and Market Security) project, which aims to create an innovative, interoperable, and multifunctional Social Network Analysis (SNA) digital Platform able to identify criminal organised networks involved in trafficking of cultural property, thus providing investigators with valuable intelligence about the activities and evolution of those networks to support the prevention of future criminal offences.

References:

Al-Azm, A and Paul, K A 2019 Facebook's Black Market in Antiquities. Trafficking, terrorism, and war crimes. (June). Agapiou A 2020 Detecting Looting Activity through Earth Observation Multi-Temporal Analysis over the Archaeological Site of Apamea (Syria) during 2011-2012, Journal of Computer Applications in Archaeology, 3(1): 219-237. DOI: https://doi.org/10.5334/jcaa.56/

Altaweel, M and Hadjitofi, T A 2020 The sale of heritage on eBay: Market trends and cultural value, Big Data & Society, 7(2). DOI: https://doi.org/10.1177/2053951720968865. Arma dei Carabinieri 2016 PSYCHE : THE PROTECTION SYSTEM FOR CULTURAL HERITAGE HOME/2011/ISEC/AG/PRUM/4000002157. 2016. Available at http://tpcweb.carabinieri.it/SitoPubblico/psyche/generic.

Bowman, B A 2008 Transnational Crimes Against culture: Looting at Archaeological Sites and the 'Grey' Market in Antiquities, Journal of Contemporary Criminal Justice, 24(3): 225–242. DOI: https://doi.org/10.1177/1043986208318210.

Casana, J and Panahipour, M 2014 Satellite-Based Monitoring of Looting and Damage to Archaeological Sites in Syria, Journal of Eastern Mediterranean Archaeology and Heritage Studies, 2(2): 128–151. Contreras, D A 2010 Huaqueros and remote sensing imagery: assessing looting damage in the Viru Valley. Peru., Antiquity, 84(324): 544–545.

Contreras, D A and Brodie, N 2011 The Utility of Publicly-Available Satellite Imagery for Investigating Looting of Archaeological Sites in Jordan, Journal of Field Archaeology, 35(1): 101–114. DOI: https://doi.org/10.1179/009346910×12707320296838.

De Bernardin, M 2021 Palmyrene Funerary Portraits: a 'Conflict Antiquities' Case. In: Traviglia, A, Milano, L, Tonghini, C and Giovanelli, R (eds.) Stolen Heritage. Multidisciplinary Perspectives on Illicit Trafficking of Cultural Heritage in the EU and the MENA Region. Venice: Edizioni Ca' Foscari, pp. 79-95. DOI: http://doi.org/10.30687/978-88-6969-517-9/004

El Hajj, H 2021 Interferometric SAR and Machine Learning Using Opens Source Data to Detect Archaeological Looting and Destruction, Journal of Computer Applications in Archaeology, 4(1): 47-62. DOI: https://doi.org/10.5334/jcaa.70/

Gandolfi, E and Cox, G 2018 New approaches to Open Data in Archaeology: the blockchain revolution. Paper presented to 2018 Computer Applications and Quantitative Methods in Archaeology (CAA) international conference, Tübingen, 19-23 March, 2018. Available at https://2018.caaconference.org/wp-content/uploads/sites/22/2018/03/AbstractBook.pdf [Last accessed 17 June 2019].

Graham, S, Lane, A, Huffer, D and Angourakis, A 2020 Towards a Method for Discerning Sources of Supply within the Human Remains Trade via Patterns of Visual Dissimilarity and Computer Vision, Journal of Computer Applications in Archaeology, 3(1): 253-268. DOI: https://doi.org/10.5334/jcaa.59/

Giovanelli, R 2018 Provenance non verificabili nel mercato di antichità romane: case study sui 300 oggetti di più alto valore in vendita in eBay US, Archeomafie, X: 115-135. Available at: http://hdl.handle.net/10278/3740198.

Hardy, S A 2014 Using Open-Source Data to Identify Participation in the Illicit Antiquities Trade: A Case Study on the Cypriot Civil War, European Journal on Criminal Policy and Research, 20(4): 459–474. DOI: https://doi.org/10.1007/s10610-014-9250-x.

Hardy, S A 2015 Is looting-to-order "just a myth"? Open-source analysis of theft-to-order of cultural property, Cogent Social Sciences, 1(1): 1–22. DOI: https://doi.org/10.1080/23311886.2015.1087110.

Hardy, S A 2017 Quantitative analysis of open-source data on metal detecting for cultural property: Estimation of the scale and intensity of metal detecting and the quantity of metal-detected cultural goods, Tong, S. (ed.) Cogent Social Sciences, 3(1): 1–49. DOI: https://doi.org/10.1080/23311886.2017.1298397.

Hardy, S A 2018 Metal-Detecting for Cultural Objects until 'There Is Nothing Left': The Potential and Limits of Digital Data, Netnographic Data and Market Data for Open-Source Analysis, Arts, 7(3): 40. DOI: https://doi.org/10.3390/arts7030040.

Huffer, D and Graham, S 2018 Fleshing Out the Bones : Studying the Human Remains Trade with Tensorflow and Inception, Journal of Computer Applications in Archaeology, 1(1): 55–63. DOI: https://doi.org/doi.org/10.5334/jcaa.8.

Huffer, D, Wood, C and Graham, S 2019 What the Machine Saw: some questions on the ethics of computer vision and machine learning to investigate human remains trafficking, Internet Archaeology, DOI: https://doi.org/10.11141/ia.52.5.

Lasaponara, R and Masini, N 2021 Remote and Close Range Sensing for the Automatic Identification and Characterization of Archaeological Looting. The Case of Peru, Journal of Computer Applications in Archaeology, 4(1): 126-144. DOI: https://doi.org/10.5334/jcaa.73/

Mackenzie, S 2019 White-Collar Crime, Organised Crime and the Challenges of Doing Research on Art Crime. In: Hufnagel, S. and Chappel, D. (eds.) The Palgrave Handbook on Art Crime. London: Palgrave Macmillan UK. pp. 839–853. DOI: https://doi.org/10.1057/978-1-137-54405-6_37.

Mackenzie, S and Yates, D 2016 Collectors on illicit collecting: Higher loyalties and other techniques of neutralization in the unlawful collecting of rare and precious orchids and antiquities, Theoretical Criminology, 20(3): 340–357. DOI: https://doi.org/10.1177/1362480615607625.

Parcak, S, Gathings, D, Childs, C, Mumford, G and Cline, E 2016 Satellite evidence of archaeological site looting in Egypt: 2002 – 2013, Antiquity, 90(349): 188–205. DOI: https://doi.org/10.15184/aqy.2016.1.

Paul, K 2018 Ancient Artifacts vs. Digital Artifacts: New Tools for Unmasking the Sale of Illicit Antiquities on the Dark Web, Arts, 7(2): 12. DOI: https://doi.org/10.3390/arts7020012. Stone, E C 2008 Patterns of looting in southern Iraq, Antiquity, 82(315): 125–138. DOI: https://doi.org/10.1017/s0003598x00096496.

Tapete, D, Cigna, F and Donoghue, D N M 2016 ' Looting marks ' in space-borne SAR imagery: Measuring rates of archaeological looting in Apamea (Syria) with TerraSAR-X Staring Spotlight, Remote Sensing of Environment, 178(April): 42–58. DOI: https://doi.org/10.1016/j.rse.2016.02.055.

Tapete, D and Cigna, F 2021 Satellite Technologies for Monitoring Archaeological Sites. In: Traviglia, A, Milano, L, Tonghini, C and Giovanelli, R (eds.) Stolen Heritage. Multidisciplinary Perspectives on Illicit Trafficking of Cultural Heritage in the EU and the MENA Region. Venice: Edizioni Ca' Foscari, pp. 155-167. DOI: http://doi.org/10.30687/978-88-6969-517-9/007.

Tsiriogiannis, C and Tsiriogiannis, C 2016 Uncovering the Hidden Routes: Algorithms for Identifying Paths and Missing Links in Trade Networks. In: Brughmans, T., Collar, A., and Coward, F. (eds.) The Connected Past Challenges to Network Studies in Archaeology and history. Oxford: Oxford University Press. pp. 103–122.

Winterbottom, T, Leone, A, Al Moubayed, N 2022 A deep learning approach to fight illicit trafficking of antiquities using artefact instance classification, Scientific Reports, 12, 13468. DOI: https://doi.org/10.1038/s41598-022-15965-2.

Zerbini, A and Fradley, M 2018 Higher Resolution Satellite Imagery of Israel and Palestine: Reassessing the Kyl-Bingaman Amendment, Space Policy, 44–45: 14–28. DOI: https://doi.org/10.1016/j.spacepol.2018.03.002.

SLOT 1	
10:30 - 10:50 - 10:50	269. Once upon a time, there was an archaeological site. Then the looters came... A true story featuring archaeology of the war, archaeology through the war, and illegal excavations *Luigi Magnini (University of Sassari (Italy))*; Anna Michielin (University of Bologna); Cinzia Bettineschi (University of Augsburg); Giovanni Azzalin (University of Sassari); Marco Milanese (University of Sassari); Armando De Guio (University of Padova)*
10:50	315. Monitoring from space: satellite imagery for the identification of looting patterning and looters behaviour. *Maria Cristina Salvi (Istituto Italiano di Tecnologia); Riccardo Giovanelli; Michela De Bernardin (Istituto Italiano di Tecnologia); Arianna Travigli (stituto Italiano di Tecnologia)--*
11:10	371. A Solid Foundation? Creating Robust and Reliable Spatiotemporal Looting Data from Satellite Imagery in Egypt *Michelle D. Fabiani (University of New Haven)**

269. Once upon a time, there was an archaeological site. Then the looters came... A true story featuring archaeology of the war, archaeology through the war, and illegal excavations

Luigi Magnini, University of Sassari, Italy
Anna Michielin, University of Bologna
Cinzia Bettineschi, University of Augsburg
Giovanni Azzalin, University of Sassari
Marco Milanese, University of Sassari
Armando De Guio, University of Padova

From the '60s, metal-detectors start to appear throughout Europe and are welcomed by a fast-growing community. Detectorists have created organized online and offline communities to showcase their findings and share their experiences. Recently, this hobby has also found a place in tv shows which follow detectorists while recovering and pocketing historical and archaeological materials. Driven by a distorted passion for the ancient world, many hobbyist detectorists and collectors have firmly distanced themselves from looters, who intentionally go treasure hunting in archaeological areas in search of saleable artifacts for profit. Detectorists might indeed become a precious source of information for archaeologists by sharing the contextual information on the findings, as experienced in some regions; however, this is very rarely the case, as giving away the location of the findings might prevent them to recover new materials from the same spot. Unfortunately, materials without context are stripped away of most of their informative potential in terms of historical reconstructions (Thomas 2016). Furthermore, treasure hunt often does not just stop at the surface or near surface collection but leads to illegal excavation with the false aim of 'saving' what is left of our past. From hobbyist to looter, the step can be short.

This paper aims to analyse the different approach of archaeologists, looters, and amateurs towards Conflict Archaeology, and in particular the Archaeology of the First World War from an Italian perspective. We will not only focus on material remains of the modern conflict, but we'll consider landscapes, vegetation, and previous archaeological remains which have been (more or less) heavily impacted by the war events (De Guio and Betto 2010).

The project takes as starting point the case of the Longalaita site on the Asiago Plateau, a promontory controlling the Astico valley which has been occupied between the Middle and the Recent Bronze Age and that, subsequently, was affected by a massive militarization during the First World War. In fact, one of the strongholds of the Winterstellung – i.e. the main Austro-Hungarian trench line on the Asiago Plateau – was built exactly in the same spot. The military intervention disrupted the protohistoric stratification, up to a few tens of centimetres deep, destroying part of the site but, at the same time, revealing to the eyes of the modern archaeologists an exceptional view of the ancient human occupation of the area. Following a research excavation, the area has been impacted on several occasions by the activities of the so-called ‘recuperanti’, an Italian term with a tradition dating back to the early days of the post-war period (Magnini et al. 2020). Initially, the figure of the ‘recuperante’ acted out of necessity, retrieving metal scattered around the battlefields for resale. In more recent years, this figure has evolved variously into looters, private collectors, sellers of memorabilia, or amateurs, and managers of small, private museums (in the most virtuous cases).

The illicit activity perpetrated by the ‘recuperanti’ on the Longalaita site significantly affected not only the remains of the Great War, but also the protohistoric settlement. Sections rich in archaeological findings were excavated to recover ceramic fragments, that we have recovered carefully collected inside buckets and bags still left in situ to be carried away during the following visit. Ecofacts and lithics were discarded and there was no trace of metal artefacts, probably already seized. These activities were reported and documented through the combined use of photogrammetry and topographic surveys to reconstruct and quantify the damage with respect to the situation that was left at the conclusion of the scientific activities. Data acquisition was carried out whenever tampering with the status quo was detected.

The key to understanding the issue is combining a scientific point of view with a social and legal approach. In Italy, there is currently a rather strict legislation on research for archaeological purposes, but the concept of ‘minor cultural heritage’ has been introduced, referring to all those relics that have been produced in large quantities within industrial systems. This expedient ensures that amateurs can collect war relics but does not allow them to intentionally research or dig for them.

In Italy, the activity of private individuals searching for war memorabilia is a socially recognized and accepted hobby. On more than one occasion, city authorities honored the ‘recuperanti’ who handed over to the community ancient archaeological artefacts found during their ‘research’, ignoring the illegality of their activity. Their activity is also celebrated and disseminated through television broadcasts on nationwide channels, increasing the spread of the phenomenon and extending it to World War II contexts.

The increasing accessibility of new technologies for disseminating information and identifying potential archaeological sites has further emphasized the problem. New methodologies have, in fact, the dual function of providing useful tools for archaeologists and law enforcement agencies to fight clandestine excavations, but also allow looters to easily obtain information through online groups and social media and to speed up their raids using technologies which were inaccessible to private individuals only a few years ago.

Keywords: Conflict Archaeology; looters; WWI; metal-detector; 3D data analysis

BIBLIOGRAPHY:

- De Guio, Armando and Andrea Betto. 2010. “Archaeology of the Great War: molto di nuovo dal fronte occidentale.” In Archeologia della Grande Guerra / Archaeology of the Great War, 139–172. Trento.
- Magnini, Luigi, Giulia Rovera, Armando De Guio, Andrea Marra. 2020. “20 anni al fronte: indagini archeologiche della e attraverso la Grande Guerra sugli Altopiani Veneto-Trentini.” Archeologia Postmedievale 22: 47–56.
- Thomas, Suzie. 2016. “The Future of Studying Hobbyist Metal Detecting in Europe: A Call for a Transnational Approach.” Open Archaeology 2: 140–149.

315. Monitoring from space: satellite imagery for the identification of looting patterning and looters behaviour

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Illicit undocumented excavation of archaeological sites aimed at collecting material culture (‘looting’) to introduce it in the illicit market of antiquities is a pressing problem on a global scale, with enormous consequences both on the integrity of world cultural heritage and on cultural landscape preservation, and with wide-ranging implications in terms of security, economics, culture and society. It has reached a worldwide scale, favoured by the availability of technological resources and a growing level of scientific sophistication of looters.

The spreading of illegal pillaging activities occurs particularly in remote areas, where surveillance and access are complex, and increases during times of dramatic events such as pandemics, conflicts, and political instabilities. Due to the spread of the phenomenon and its geographic extension, and to the impossibility of physically inspecting unreachable areas or hazardous zones, surveillance via remote sensing has recently emerged as the most efficient approach to monitor ransacking occurrences (past and ongoing). Under favourable circumstances, in fact, looting can be exposed using UAV, airborne or Earth Observation (EO) data (Casana and Panahipour 2014; Lasaponara and Masini 2021; Tapete and Cigna 2019).

This paper focuses on the development of the first dataset of looted sites detected via remote sensing created with the goal of training, validating and testing mathematical models for their automated identification, in the framework of the first European Space Agency (ESA) funded project devoted to heritage security. ALCEO (Automatic

Looting Classification from Earth Observation) is a project aiming at developing Artificial Intelligence methods for the automatic detection and classification of cultural heritage looted sites on multitemporal Earth Observation (EO) data. The project addresses specific requirements of Law Enforcement Agencies involved in the project to provide them with a system for a faster and reliable identification and monitoring of both past and ongoing illicit plundering activities. Even when LEAs cannot intervene in real time to limit the damages of already undertaken illegal activities, the analysis of the distribution of looting pits and trenches enables to acquire criminal conduct patterns evidence and intelligence that can be used for behavioural profiling and further investigations. The evolution, in a multitemporal scale, of shape, number and patterning of looting pits and trenches can be used to understand looters' conduct and therefore to help modelling, preventing and anticipating their illicit activities.

Several case study locations in the so called 'source-countries' based in Europe and the Mediterranean basin, known for being afflicted by archaeological ransacking activities, have been selected to create a dataset that reflects different types of geomorphological and ecological settings: Arpinova, Cerveteri, Aquileia, Morgantina in Italy, Aswan in Egypt, Ebla and Dura Europos in Syria have been included. Multitemporal multispectral Very High Resolution satellite images (Quickbird, Worldview2, Pléiades) have been processed, enhanced and analysed; looting features have been visually detected, mapped and labelled in a GIS environment, annotating them based on a taxonomy structured around their physical characteristics (e.g. their shapes and size) and the level of confidence in their identification. The extent of the looting disturbance areas has been recorded as well, and labelled depending on the density and intensity of the phenomenon. The training dataset is being used to optimise and validate a Change Detection Machine Learning model that promises to identify in an autonomous way the appearance of episodes of illicit excavation on EO data time series. Monitoring the evolution of looting extension over time enables LEAs to form hypothesis on the future spreading of the phenomenon in a given area.

Initial automatic clustering of the looting occurrences and their analysis has validated a known model based on which looting features can be broadly subdivided in two main categories: a) single, isolated looting pits of circular or irregular shape; b) groups of looting pits/trenches that can range from sparse to overlapping. Isolated pits are usually dug by individual looters or to check if the area is potentially rich in finds: if the first pit returns valuable finds, a quick escalation of looting activities follows in the area. A high density of pits can reveal the existence of an extended archaeological area where illegal activities are conducted by organised crime groups.

The creation of this first training dataset of looted sites incorporating information provided by archaeological and LEAs' photo-interpreters will underpin further analysis and research on the phenomenon: the dataset will be released to the scientific community to be used as a benchmark for looting detection and to enable effective collaboration between the Machine Learning and the cultural heritage communities.

References

Casana, Jesse, and Mitra Panahipour . 2014. "Satellite-Based Monitoring of Looting and Damage to Archaeological Sites in Syria." Journal of Eastern Mediterranean Archaeology and Heritage Studies, 2, no. 2: 128–151. https://doi.org/10.5325/jeasmedarcherstu.2.2.0128

Lasaponara, Rosa, and Nicola Masini. 2021. "Remote and Close Range Sensing for the Automatic Identification and Characterization of Archaeological Looting. The Case of Peru." Journal of Computer Applications in Archaeology 4, no. 1: 126-144. https://doi.org/10.5334/jcaa.73/

Tapete, Deodato, and Francesca Cigna. 2019. "Detection of Archaeological Looting from Space: Methods, Achievements and Challenges" Remote Sensing 11, no. 20: 2389. https://doi.org/10.3390/rs11202389

371. A Solid Foundation? Creating Robust and Reliable Spatiotemporal Looting Data from Satellite Imagery in Egypt

Michelle D. Fabiani, University of New Haven

Introduction

Satellite imagery is an established tool in archaeology for detecting and documenting cultural heritage damage like archaeological looting. Both manual (e.g., Casana, 2015; Contreras & Brodie, 2010; Cunliffe 2014; Parcak et al., 2016) and automated (e.g., Altaweel, 2005; Lasaponara and Masini 2021; Lauricella et al. 2017) efforts at detection have become popular in recent years. To date, much of this work has focused on the detection and identification of looting and other man-made landscape changes (e.g., militarization, illegal construction – see Cunliffe 2014, Parcak et al. 2016) creating counts or measuring the spatial extent of looting on imagery. However, the validity of the data produced from these results is not always clear. Few studies – especially those using manual identification – are transparent with their methods and limitations. Casana (2015) indicates that they "developed a damage assessment protocol" without outlining the specifics of how it worked or what tools were necessary for others to replicate it. Though Parcak et al. (2016) provide reasonable detail on the identification of looting on a satellite image, they do not discuss how they extrapolated values for incomplete satellite coverage years nor the impact on their data. With no standardized or "best" practice for collecting and coding satellite imagery, replication and comparison across datasets are nearly impossible and attempts to shift towards proactive data collection are futile. Similarly, the lack of transparency in methods masks the potential for bias – whether by machine or human efforts – in the resultant data. As satellite imagery becomes an increasingly powerful source for data on cultural heritage destruction in times of conflict it is increasingly important to consider these challenges explicitly.

The current study argues the creation of robust and reliable spatiotemporal data on cultural heritage destruction requires several key considerations: (1) transparency, (2) triangulation, (3) metadata, and (4) sustainability. These are demonstrated through two methods for creating spatiotemporal data on cultural heritage destruction. The first follows satellite imagery coding of archaeological looting in Egypt from data collection to coding and validation using commonly available tools – manual detection and ArcGIS Pro. The second focuses on triangulation of open-source reports of cultural destruction and codification into a spatiotemporal dataset. It reviews both the data collection and data coding processes in depth for each project. It then illustrates their utility through a case study examining how looting attempts are distributed across space and time relative to environmental, economic, and sociopolitical stimuli. It ends with a discussion of the advantages and drawbacks of the proposed methods and recommendations for researchers seeking to o create robust and reliable spatiotemporal data on cultural heritage destruction.

Methods and Materials

The first project relies on panchromatic and multispectral high resolution satellite imagery (Worldview and GeoEye) collected from two sources – DigitalGlobe (now Maxar technology) and Google Earth Pro – for 150 archaeological sites in Lower Egypt from 2015 to 2017 (N=2199 images total). All images are then loaded into ArcGIS Pro and coded manually for evidence of archaeological looting attempts. Cross-validation between sources is used to measure the validity of the coding and imputation is used to address missingness in the data. These data are then aggregated to the site-month to create a spatiotemporal dataset that captures evidence of archaeological looting attempts and assessed for their validity. The second project uses incidents of cultural heritage damage and destruction coded from ASOR Cultural Heritage Initiative Reports in Syria from 2014 to 2017. The ASOR reports provide a near-real-time assessment of damage and destruction to cultural heritage locations in Syria. They reflect reporting from a variety of sources, verified and unverified, including governmental reports, news reports, social media, satellite images, personal images, and international NGO reports. Reports are coded according to a systematic codebook for incident details and measures of accuracy. These data are then aggregated to the governorate-month to create a spatiotemporal dataset that is compatible with other relevant datasets (e.g., conflict).

Results

Results of the validation show that both data collection approaches are flexible enough to produce usable data even with limited resources (e.g., if collection falls short of the census) and to allow data continuity if collection resumes later. The data coding procedures allows for a high degree of confidence in the resultant data. Despite a high degree of missing values in the data, the resultant spatiotemporal data are still useful for understanding the distribution of looting in response to environmental, economic, and sociopolitical stimuli.

Discussion

To move towards a proactive computational approach to cultural heritage protection, there must be reliable and robust spatiotemporal data. A greater focus on key considerations in the method by which data are created (transparency, triangulation, sustainability and metadata) is needed to produce robust and reliable spatiotemporal data. The methods discussed here while drawing on multiple types of data demonstrate attempts at incorporating all for considerations. They also account for both the potential for human error in the data collection and coding process as well as resource limitations that regularly face attempts to collect data in this area while being up front about those limitations.

References

Altaweel, M. (2005). The use of ASTER satellite imagery in archaeological contexts. *Archaeological Prospection* 12: 151-66. https://doi.org/10.3390/rs5126560.

Casana, J. (2015). Satellite Imagery-Based Analysis of Archaeological Looting in Syria. Near Eastern Archaeology, 78(3), 142–152. https://doi.org/10.5615/neareastarch.78.3.0142.

Contreras, D. A., & Brodie, N. (2010). The Utility of Publicly-Available Satellite Imagery for Investigating Looting of Archaeological Sites in Jordan. Journal of Field Archaeology, 35(1), 101–114. https://doi.org/10.1179/009346910X12707320296838

Cunliffe, E. (2014). Archaeological Site Damage in the Cycle of War and Peace: A Syrian Case Study.

Journal of Eastern Mediterranean Archaeology & Heritage Studies, 2(3), 229–247. https://doi.org/10.5325/jeasmedarcherstu.2.3.0229

Lasaponara, R and Masini, N. (2021). Remote and Close Range Sensing for the Automatic Identification and Characterization of Archaeological Looting. The Case of Peru, Journal of Computer Applications in Archaeology, 4(1): 126-144. DOI: https://doi.org/10.5334/jcaa.73

Lauricella, A., Cannon, J., Branting, S., & Hammer, E. (2017). Semi-automated detection of looting in

Afghanistan using multispectral imagery and principal component analysis. Antiquity, 91(359), 1344–

1355. https://doi.org/10.15184/aqy.2017.90

Parcak, S., Gathings, D., Childs, C., Mumford, G., & Cline, E. (2016). Satellite evidence of archaeological site looting in Egypt: 2002–2013. Antiquity, 90(349), 188–205. https://doi.org/10.15184/aqy.2016.1

05. For new epistemologies in Archaeology: using probability, networks and mathematical models to build archaeological knowledge

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Location: E108

Investigating the complex nature of the human past is of paramount importance to archaeology. Throughout the years, several theoretical proposals on how to perceive the past have been constructed. From formulating law-like statements (Binford 1972; Schiffer 1976) to symbolic and contextual approaches (Hodder and Hudson 2003), passing to symmetrical and ontological critiques (Olsen 2013; Olsen and Witmore 2015), archaeological theory has experienced change and shifts in relative interest in the last several decades. However, a fundamental question arises: how are archaeologists able to face the near infinite possibilities that constitute the past? On top of this already difficult conundrum, the basis of our work is nothing but fragmented material remains, mere shadows of things that once were. Is this an impossible task?

We believe not. By applying methods and ideas with a strong mathematical basis, archaeologists can strive to reduce subjectivity and engage with a larger realm of questions. For example, the Bayesian approach used in Archaeology has increased in the last decades (Otarola-Castillo and Torquato, 2018; Otarola-Castillo, Torquato, and Buck, 2021), being applied in the most different areas, but is it possible to increase its application from chronological modeling using radiocarbon calibration (Buck et al., 1991; Price et al., 2021), bioarchaeology (Konigsberg et al., 1992; De Angelis et al., 2021), zooarchaeology (Fisher, 1987; Baumann et al., 2020), artifact analysis such as lithics or ceramics (Buck et al.,1996; Murray et al., 2020) or spatial analysis (Kirkinen, 1999; Wright et al., 2020) to archaeological theory and epistemology?

The objective of this session is to explore frameworks that are able to embrace a sheer volume of possibilities that shape complex events of the past, demonstrating how to build a sturdy epistemological basis. We intend to explore Bayesian methodology, Network Theory and AI theory and applications to discuss multiple ways for constructing hypotheses about the Past. With this premise in mind, we welcome papers that:

- Propose ways to build archaeological knowledge with methods from analytical and statistical backgrounds (e.g Mathematics, Computer Engineering);
- Embrace social, economical and political questions in archaeological contexts while dealing with great amounts of data;
- Using algorithms to construct hypotheses for archaeological endeavours;
- Explore novel paths in the creation of theoretical viewpoints, with Artificial Intelligence and Deep Learning.

References:

Baumann, C., Wong, G.L., Starkovich, B.M. et al. (2020) – "The role of foxes in the Palaeolithic economies of the Swabian Jura (Germany)". Archaeology Anthropology Science, 12: 208

Binford, L. R. (1972). An Archaeological Perspective. New York: Harcourt.

Buck C.E., Kenworthy J.B., Litton C.D., Smith A.F.M. (1991) – Combining archaeological and radiocarbon information: a Bayesian approach to calibration. Antiquity, 65, pp. 808–821

Buck C.E., Cavanagh W.G., Litton C.D. (1996) – Bayesian Approach to Interpreting Archaeological Data. West Sussex, UK: Wiley

De Angelis, F.D., Veltre,V., Varano,S., Romboni,M., Renzi,S., Zingale,S., Martínez-Labarga, C. (2020) – Dietary and Weaning Habits of the Roman Community of Quarto Cappello del Prete (Rome, 1st-3rd Century CE). Environmental Archaeology, pp. 1–15.

Fisher D.C. (1987) – Mastodont Procurement by Paleoindians of the Great Lakes Region:Hunting or Scavenging?. in: Nitecki M.H., Nitecki D.V. (eds) The Evolution of Human Hunting. Springer, Boston, MA.

Hodder, I. and S. Hudson (2003). Reading the Past. Current approaches in interpretation in archaeology. Cambridge: Cambridge University Press.

Kirkinen T. (1999) – GIS-assisted data analysis-finding meanings in complex spatial data sets. in New Techniques for Old Times. CAA98. Computer Applications and Quantitative Methods in Archaeology. Proceedings of the 26 th Conference, Barcelona, March 1998, ed. JA Barceló, I. Briz, A. Vila, pp. 255–258. Oxford, UK: Archaeopress

Konigsberg L.W., Frankenberg S.R. (1992) – Estimation of age structure in anthropological demography. American Journal of Physical Anthropology, 89, pp.235-256

Murray, J.K., Harris, J.A., Oestmo, S., Martin, M., Marean, C.W. (2020) – A new approach to identify heat treated silcrete near Pinnacle Point, South Africa using 3D microscopy and Bayesian modelling. Journal of Archaeological Science, 34: 102622

Olsen, B. (2013). In Defense of Things. Archaeology and the Ontology of Objects. Plymouth: Altamira Press.

Olsen, B. and C. Witmore (2015). Archaeology, symmetry, and the ontology of things: A response to critics. Archaeological Dialogues, 22(2): 187-97.

Otaróla-Castillo, E., Torquato, M.G. (2018) – "Bayesian Statistics in Archaeology". Annual Review of Anthropology, 47, pp.435-453

Otaróla-Castillo, E., Torquato, M.G., Buck, C.E. (2021) – "The Bayesian Inferential Paradigm in Archaeology". Manuscript accepted to the Handbook of Archaeological Sciences, 2 nd ed. Forthcoming volume under contract (2022). Edited by M.Pollard, R.A. Armitage and C.M. Makarewicz. Wiley

Price, M. H., Capriles, J. M., Hoggarth, J.A., Bocinsky, R.K., Ebert, C.E., Jones, J. H. (2021) – End- to-end Bayesian analysis for summarizing sets of radiocarbon dates. Journal of Archaeological Science, 135, 105473

Schiffer, M. (1976). Behavioral Archaeology. New York: Academic Press.

Wright, D.K., Kim, J., Park, J., Yang, J., Kim, J. (2020) – Spatial modeling of archaeological site locations based on summed probability distributions and hot-spot analyses: A case study from the Three Kingdoms Period, Korea. Journal of Archaeological Science, 113, 105036.

SLOT 2	
10:30 - 10:50\	77. An Archaeology of probabilities *Daniel Carvalho (UNIARQ; FCT; LAQU); Joel Santos (University of Leicester)**
10:50	86. Similarity Network Fusion: Understanding Patterns and their Spatial Significance in Archaeological Datasets *Timo Geitlinger (University of Oxford)**
11:10	216. Modelling and measuring complexity of traditional and ancient technologies using Petri nets *Sebastian Fajardo (Mechanical, Maritime and Materials Engineering, Delft University of Technology)*; Jetty Kleijn (Leiden Institute of Advanced Computer Science (LIACS), Leiden University); Geeske Langejans (Mechanical, Maritime and Materials Engineering, Delft University of Technology); Frank Takes (Leiden University)*
11:30	305. Visual Quantity - Comparative Analysis of Decoration Occurrence and Distribution in Ancient Egyptian Funerary Monuments *Anja Wutte (TU Wien)**

SLOT 3	
13:00	*338. Structural Equation Modeling (SEM) and multiscalar statistics (Ripley´s K-function) as tools for understanding socio-economic relations by Middle Danube Germanic tribes and Slavs (1st Millenium AD. Central Europe)* *Marek Hladík (Institute of Archaeology, Czech Acad Sci Brno)*; Katarína Hladíková (Department of Archaeology, Comenius University in Bratislava)*
13:20	190. WEaning Age FiNder (WEAN): A tool for estimating weaning age from sequential isotopic analysis of dentinal collagen *Elissavet Ganiatsou (Laboratory of Physical Anthropology, Department of History and Ethnology, Democritus University of Thrace)*; Angelos Souleles (Laboratory of Physical Anthropology, Department of History and Ethnology, Democritus University of Thrace); Christina Papageorgopoulou (Laboratory of Physical Anthropology, Department of History and Ethnology, Democritus University of Thrace)*
13:40	82. Dig it: recent thoughts on archaeological epistemology *Geoff Carver (RGZM)**
14:00 - 14:20	104. There is no epistemology without creativity, or how to combine quantitative methods, material culture, and theoretical approaches *Tânia M Casimiro (FCSH-UNL)*; Joel Santos (University of Leicester); Inês Castro (FCSH-UNL)*
14:20 - 14:40	Discussion

77. An Archaeology of probabilities

Daniel Carvalho, UNIARQ/FCT/LAQU
Joel Santos, University of Leicester

Archaeological arguments usually fall in the "to be or not to be" discussions, where several suppositions are raised, not being possible to prove that some hypotheses are more plausible than others. Using a Bayesian perspective this paper presents a mathematical probabilistic approach that calculates the degree of likelihood for each of the hypotheses suggested for a specific discussion, calculating the probability for each one and quantitatively comparing each one with all others. This method will be applied even in situations where there is a huge lack of comparative data. To exemplify our proposal, a case study regarding a 2019 excavation will be used, since this specific place was appointed as a possible prostitution house, a hypothesis that was contradicted by other investigators. Our work, using the proposed methodology, will calculate the probability of several hypotheses.

This paper aims to create a framework to help archaeologists translate subjective and non-measurable data into a quantifiable and comparable form. What if we could have a structure that would propose different hypotheses for the same evidence, and score them according to their probability of most accurately describing its underlying cause or origin? Carlo Rovelli, although arguing about physics and the universe, stated that (2018, 43-44): "In this essentially uncertain world, it would be foolish to ask for absolute certainty. Whoever boasts of being certain is usually the least reliable", and he continues, "this doesn't mean either that we are completely in the dark. Between certainty and complete uncertainty there is a precious intermediate space – and it is in this intermediate space that our lives and our thoughts unfold". This was precisely our challenge. Even if there is no absolute certainty for anything, we would like to demonstrate that some hypotheses are more suitable to explain certain events than others and that this possibility is available to all archaeologists.

Rovelli, C. (2018) – "There Are Places in the World Where Rules Are Less Important Than Kindness". London: Penguin Books.

86. Similarity Network Fusion: Understanding Patterns and their Spatial Significance in Archaeological Datasets

Timo Geitlinger, University of Oxford

Spatial network analysis can be used to study a wide range of different archaeological phenomena. Since its earliest application in the 1970s and particularly in the last decade, network analysis has become increasingly popular in both theoretical and GIS-based archaeology. Yet, applications of material networks remained relatively restricted. Material networks are commonly based on geochemically sourced materials, shared presence of certain objects, or similarities in material assemblages. Thus, the edges of the network are usually defined through aspatial data. However, since archaeological data often are associated with spatial locations, these networks can be compared to spatial relations and patterns. This paper describes a specific kind of material culture network, so called similarity networks, and presents a new network analysis method to approach them: Similarity Network Fusion (SNF).

Basically, similarity networks are simple bipartite networks consisting solely of two classes of nodes; the archaeological context (i. e., a site) and attributes associated with this context (i. e., artefact types). However, unlike normal binary affiliation networks, the strength of the edges between nodes is weighed by the frequency of their shared attributes. Most archaeological applications of material culture networks seem to approach similarity by simply quantifying the number of co-occurrences of certain traits between two

nodes, without considering the relative importance of these traits for the whole network. In order to approach the relative importance of a network connection, statistical similarity measures need to be applied (Bourgeois, Kroon 2017). The similarity network analysis outlined in this case study relies on so called Similarity Network Fusion (SNF), a method commonly applied in genomic studies (cf. Wang et al. 2014). SNF is based on the integration of similarity networks derived from multiple datatypes (i. e., different object types) for the same set of samples (i. e., sites). In a first step, SNF calculates a similarity network between each pair of samples for each of the datatypes, allowing the application of a wide range of similarity indices. Secondly, all these networks are fused into a single similarity network by using a nonlinear, iterative approach; based on message-passaging theory, every network is updated and made more similar to the other networks after each iteration, before finally converging to a single network. In the iterative process strong similarities tend to be emphasised, while weak similarities are down-weighed through a K-nearest neighbours procedure, reducing the noise in the final network. Weak relationships are only retained if they are consistent across the whole dataset. SNF has proven to be particularly robust to heterogenous and noisy datasets containing only a small number of samples, but a large number of measurements, scale differences, and collection biases; arguably, these data conditions are not only common for genomic datasets, but are also typical for archaeological data. Furthermore, apart from integrating data SNF provides a set of additional network techniques, which are especially suitable for detecting subtypes and clusters in topological networks.

As a case study, the SNF approach was applied to Early Bronze Age, Middle Bronze Age, and Late Iron Age burial sites in Dorset. The data were derived from the published database of the Grave Goods project (Cooper et al. 2022). Within six regional study areas the Grave Goods project diachronically and at a series of scales analysed material culture and mortuary contexts from the Neolithic to the Iron Age Period. It considered many different categories such as grave hierarchy, grave type, monument type, numbers of buried individuals, or grave good types. In order to explore similarity-relationships two sets of different datatypes were prepared for the sites of each subperiod. The first set attempted to give a more holistic impression of burial rituals covering a great variety of aspects of the burial data. The second set only included the specific grave good type and the placement of the objects in relation to the buried body. As similarity measure the well-established cosine coefficient was applied. Based on an eigengap approach the optimal number of topological clusters in the different networks was determined.

To enhance the understanding of the meaning and relevance of the resulting network and topological clusters, the network was spatially represented and the clusters were correlated with five further attributes; they included the association of the burials with specific physiographic areas, the sex of the buried individuals of a site, the ratio of objects per grave, whether isotopic analyses suggest that the buried people were local inhabitants or moved into the area of their burial, or whether there is an association between clusters and a finer chronological subdivision of sites. The network analysis and the topological clustering of the sites revealed at least two possible spatial clusters within the Early Bronze Age and Late Iron Age networks—and two statistically significant correlations between clusters and further attributes of the burial sites objects per grave and chronology. These results clearly suggest the great potential of SNF for analysing big archaeological datasets, unveiling patterns within the archaeological record, and understanding the significance of these patterns for the structuration of the past landscape.

BOURGEOIS, Q. & KROON, E. 2017. The impact of male burials on the construction of Corded Ware identity: Reconstructing networks of information in the 3rd millennium BC. PLOS ONE, 12, e0185971.

COOPER, A., GARROW, D., GIBSON, C., GILES, M. & WILKIN, N. 2022. Grave goods: objects and death in later prehistoric Britain, Oxford, Oxbow Books.

WANG, B., MEZLINI, A. M., DEMIR, F., FIUME, M., TU, Z., BRUDNO, M., HAIBE-KAINS, B. & GOLDENBERG, A. 2014. Similarity network fusion for aggregating data types on a genomic scale. Nature Methods, 11, 333-337.

216. Modelling and measuring complexity of traditional and ancient technologies using Petri nets

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Technologies and their production systems are studied by archaeologists and anthropologists to understand complexity of socio-technical systems. Sequential approaches are used to model and analyse production systems; and as underlying principle for current methods to assess complexity. However, there are several issues that hamper agreement about what constitutes complexity and how we can systematically compare the complexity of production systems. We consider that computational modelling can help resolve these issues and will provide a replicable method to analyse complexity. We propose a novel approach to assess the behavioural and structural complexity of production systems using Petri nets.

Petri nets are well-known formal models that overcomes several obstacles of current approaches in archaeology and anthropology, such as the incompatibility of the intrinsic sequential logic of the available methods with inherently non-sequential processes, and the inability to explicitly model activities and resources separately. Petri nets developed as a vast framework to design and study distributed systems consisting of concurrently operating agents, that is components that operate independently except for occasional exchanges of messages or resources or to synchronize certain activities (Reisig and Rozenberg 1998). This has led to a wide range of methods and automated techniques in, for example, complexity metrics, structure-based analysis, verification and model checking, and system synthesis (Reisig 2013).

We modelled Petri nets for the ethnographic descriptions of the production of two traditional adhesive materials made by Ju/’hoan makers in Nyae, Namibia (Wadley et al. 2015). Here we modelled the procurement of raw material and production of adhesives made of Ammocharis coranica (Ker Gawl.) Herb. (Amaryllidaceae) and from Ozoroa schinzii (Engl.) R. Fern & A. Fern (Anacardiaceae) plants.

To gauge behavioural complexity of the production systems, we computed the reachability graphs for the Petri net models of the case studies with different numbers of makers available and with different number of changes in location for executing the processes. We compared the state space size of the models as proxy for the behavioural complexity of the production processes. We also compared the minimum number of available makers in the simulations that generated the maximum state space sizes with the ethnographic descriptions about the size of the Ju/’hoan hunting and collecting parties.

The A. coranica model in the scenario with one maker had the lowest number of reachable states with 621 and the O. schinzii model showed 663 states. The O. schinzii model without changes in location had 1203 reachable states. The simulations showed a strong increment in the number of reachable states after a second maker was available, and the number of reachable states for the A. coranica model (N= 4488) and the O. schinzii model (N=4350) were similar. Compared with these two models, the variant of the O. schinzii model without a location change almost doubled the number of reachable states when two makers were available (N= 8597). The number of reachable states for the complete O. schinzii model (N= 14074) and the variant without the transition 'Go back home' (N=29333) did not increase anymore once four makers were available. The increase in the number of reachable states of the A. coranica model continued until eleven were made available (N=34228).

Several actions in the production of A. coranica and O. schinzii adhesives can occur concurrently and the complexity generated by these activities in the two adhesive production systems modelled seems to be due to the processing of resources rather than the collection of diverse types of resources. The models indicate that some of the complexity in the procurement of the O. schinzii system is related to a location change event. The change in location is not well explained by differences in geographical location of the components, suggesting that changes in location serve to lower the behavioural complexity of producing the adhesive material by reducing the risk of failure during use or production.

Adding new individuals, in general lead to an increase of the state space size of the reachability graphs that occurred at a lower rate as more makers were added to the simulations. The Petri net models showed that real production scenarios with two to four individuals available facilitate gaining the benefits in flexibility and parallel execution derived from the concurrency potential. These scenarios may also reduce the disadvantages generated by communication and synchronization of activities and use of tools generated when more people are involved in the real processes.

The Petri net approach presented in this paper paves the way for future systematic visualization, analysis, and comparison of ancient production systems, accounting for the inherent complex, concurrent, and action/resource-oriented aspects of such processes. The results suggest that the complexity of ancient technologies can be attributed to multiple factors. Measuring complexity in terms of 'more' or 'less' is inadequate to understand the implications of those factors for human behaviour. Considering current debates about the complexity of technological systems and the need of understanding the differences between production processes of ancient technologies and their implications for past societies, Petri nets are a valuable addition to the set of methodologies for studying dynamics of ancient production systems.

REFERENCES

Reisig, Wolfgang. 2013. Understanding Petri Nets: Modeling Techniques, Analysis Methods, Case Studies. Berlin, Heidelberg: Springer Berlin Heidelberg.

Reisig, Wolfgang, and Grzegorz Rozenberg, eds. 1998. Lectures on Petri Nets I: Basic Models. Vol. 1491, Lecture Notes in Computer Science. Berlin, Heidelberg: Springer.

Wadley, Lyn, Gary Trower, Lucinda Backwell, and Francesco d'Errico. 2015. "Traditional glue, adhesive and poison used for composite weapons by Ju/'hoan San in Nyae Nyae, Namibia. Implications for the evolution of hunting equipment in prehistory." PLOS ONE 10 (10):e0140269. https://doi.org/10.1371/journal.pone.0140269.

305. Visual Quantity - Comparative Analysis of Decoration Occurrence and Distribution in Ancient Egyptian Funerary Monuments

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1. Introduction and Research Focus

Previous documentations and results concerning Egyptian tomb decoration are built on interpretation rather than empirical analysis data. In general, monuments are documented in stand-alone publications rather than comparative studies. Very little attention is given to compare Egyptian tomb decoration's occurrence and distribution among monuments. Decorations in Egyptian funerary monuments did not only fulfil the purpose of being decorative but represent an important part of the monument's layout. In funerary monuments the decoration program is an es-sential part of the overall concept (Snape, 2011). To study decoration is an im-portant aspect to understand the connection between spatial organization and room use and leads to a building typology which can be valid for a group of funerary monuments. Furthermore, the visualization of collected data enables cross-model comparisons.

The following explores quantitative relations of decoration scenes as well as comparative information to gain new insights about the monument's decoration and its relation to space.

2. Methods

This paper introduces methods of quantitative representation and occurrence of scenes to visualise relationships between decoration, accessibility, and daylight intensity. It suggests approaches to analyse distribution and occurrence of decoration with data visualisation and quantitative methods:

First, it is discussed how to handle decoration of a group of monuments. In focus are possibilities to compare distributions of different decoration scenes of a monument and visualise the data to provide comparison between the structures. This provides data to answer questions such as: How are scenes related to spatial layouts of monuments or the function of rooms? Do room accessibility, adjacency of spaces and the natural lighting situation influence the occurrence of a specific scene class?

Second, obtained data are presented in graphs to compute occurrences, quantities and qualities of scenes.

To obtain a higher degree of detail scenes of the presented monuments are categorised and organised in categories (decoration class), subcategories and sub-subcategories (Gruber, 2009; Gruber, 1995). To determine the relationship between accessibility of spaces, daylight to spaces and decoration, decorations are added to BIM based 3-dimensional models (Wutte, et alii, 2015).

Data are collected from publications, referenced and added to the 3-dimentional space model. That gives the opportunity to compare occurrence, distribution and quantity of a scene in space and among the analysed monuments. This implementation offers the possibility to search for decoration categories, highlight, locate and finally compare the position of a scene between the monuments. In a further step the analysis data are studied statistically to be able to query detailed results of the prevalence, distribution and preservation of decorations and specific scenes.

3. Quantitative and Comparative Information Results

The questioned information can be visualised in two different ways: spatial visualisation and diagram visualisation.

Spatial visualisation is supported by 3-dimensional models to represent decoration occurrence, distribution and location in space. Integration of decoration into a 3-dimentional system enables the location of specific scene categories in the monument and to make comparative statements.

Diagram visualisation by graphical representations produced with R represent quantity and quality (preservation) of scenes in monuments. Scatterplots illustrate categories, subcategories and sub-subcategories for each monument. Colour codes represent the preservation status of respective scenes, including well, moderate, not well, fragmented, not known and unfinished or destroyed.

4. Discussion

Review of related work suggests several research needs related to an analytical study of decoration. In contrast to traditional archaeological research this model enables quick access to data-based interpretation according to quantitative meth-ods. Digital models are enriched with semantic data to analyse, visualise and com-pare decoration in an adaptive, standardised, and reproducible way. A comparative study is used, by definition, to compare two or more variables and quantify rela-tionships. It documents variations and similarities between subjects or groups (Tilly, 1984). To fulfil the qualifications to compare properties of two or more buildings, gathered data has to be homogeneous. While most studies of Egyptian heritage focus on culture-historical aspects this project concentrates on statistical research by combining quantitative and visualisation methods to provide replica-ble and homogenous data.

Data of the analysed monuments reveal that natural lighting and accessibility of spaces are connected. Respectively, naturally lit spaces, such as open-from-above courtyards, were likely at least semi-public and accessible. The farther to the sanctuary the less natural light was entering. Simultaneously, the character of decoration changed.

5. References

Gruber, T. (2009) 'Ontology', Encyclopedia of Database Systems. Springer-Verlag. Available at: https://web.archive.org/web/20100715224852/http://tomgruber.org/writing/ontology-definition-2007.htm.

Gruber, T. R. (1995) 'Toward Principles for the Design of Ontologies Used for Knowledge Sharing', International Journal of Human-Computer Studies, 43(5–6), pp. 907–928. Available at: http://linkinghub.elsevier.com/retrieve/pii/S1071581985710816.

Snape, S. (2011) Ancient Egyptian Tombs: The Culture of Life and Death. Malden; Oxford; Chichester: Wiley-Blackwell.

Tilly, C. (1984) Big structures, large processes, huge comparisons. Russell Sage Foundation. Available at: https://www.jstor.org/stable/10.7758/9781610447720 (Accessed: 29 June 2020).

Wutte, A., Ferschin, P., Suter, G. (2015) 'Excavation goes BIM. Building Analysis of Egyptian Funerary Monuments with Building Information Modeling Methods.', in 20th International Conference on Cultural Heritage and New Technologies. Wien.

338. Structural Equation Modeling (SEM) and multiscalar statistics (Ripley´s K-function) as tools for understanding socio-economic relations by Middle Danube Germanic tribes and Slavs (1st Millenium AD. Central Europe)

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The research on the socio-economic relations of the Germanic and Slavic populations has a long tradition in the territory of Central Europe. From the archaeological data point of view, burial grounds played an important role in this process. In our paper, we will demonstrate the problematic aspects of the application of statistical analysis at the scale of intra-site analysis of burial grounds. We will present two case studies considering the Germanic burial grounds in SW Slovakia (Abrahám, Sládkovičovo, Kostolná pri Dunaji, 1st, and 2 nd century AD) (Kolník 1980) and the Slavic cemetery from Moravia (CZ – Prušánky-Podsedky, 9th century AD).

We will discuss problematic aspects of statistical analysis application. In the first case study, we focus on the exploration and interpretation of latent variables hidden behind the empirically observed attributes of the burial rite (we will therefore be moving into the analytical space).

In the second case study, we will discuss the problem of the interpretive relevance of the so-called statistically significant values. We will demonstrate it based on multiscalar statistics of spatial patterns in selected burial grounds (so we will move into „geographical“ space). The approach combines the analytical space with the concrete space of a burial ground (with a geoinformation model). It is very useful for assessing the relevance of the applied statistical analysis.

Case studies

Kostolná pri Dunaji, Abrahám and Sládkovičovo (SK - Germans) and Prušánky-Podsedky (CZ - Slavs)

Structural Equation Modeling - SEM

The application of exploratory methodologies to reduce the multidimensional analytical space (PCA, FA) came to the fore in the interpretation of burial rite in the post-war period, especially in the area of former Czechoslovakia. However, applying the methodologies often lacked relevant presentation and interpretation of the analysis results. On the contrary, it gave the impression that it is a controlled and easily reproducible process. The created models were in many cases burdened by significant distortion caused by the frequent influence of qualified estimates, which determined the individual steps of the analysis (Havelková, Hladík, and Velemínský 2013).

We will present a case study from three Germanic burial grounds from the Middle Danube area from the first two centuries AD (Kostolná pri Dunaji, Abrahám, Sládkovičovo) and the great Moravian burial ground of Prušánky-Podsedky (CZ). The Germanic cemeteries represent the only burial grounds dated to the Early Roman Period from the area of SW Slovakia that were investigated on a large scale and are therefore suitable for the application of this type of analysis. The Great Moravian burial ground of Prušánky-Podsedky (CZ) represents a completely excavated burial ground from the 9th century AD. It creates the relevant basis for the interpretation of the socio-economic relations of the population (564 individuals). The cemetery of Prušánky-Podsedky is located in the economic hinterland of one of the most important Great Moravian centers – Mikulčice-Valy.

Based on this data we will present the issue of the reduction of the multidimensional analytical space in archaeology. In the first step, we will show the results of the factor analysis and the creation of an interpretation model. In the second step, we will focus on verifying the model using structural equations modeling (SEM). SEM performs quantitative tests of theoretical models. Creating a theoretical model is one of the most challenging research steps. We first performed a confirmatory factor analysis (CFA) and we used its bootstrapping algorithms to simulate missing data. The second step was to test a more comprehensive structural equation analysis model. The model combined the CFA with the Path Model.

SEM confirmed many of the findings of the exploratory analyses and the validity of the structural equation analysis model. However, the confirmatory factor analysis revealed problems with the reduction of a multidimensional space. In multiple cases, the bootstrapping algorithms changed the nature of latent variables. The application of SEM allowed us to build a more stable theoretical model. The research has shown the potential of SEM when interpreting causal relationships in the past.

Ripley´s K-Function

The analysis of spatial patterns of cemeteries is a standard methodology used in archaeology. The interpretative potential is based on the assumption that the spatial organization of the burial ground was subject to social norms. One of the ways to look for spatial patterns is purely based on visual assessment (regularity in the arrangement of graves, intensity of clustering, and the degree of dispersion). However, for greater interpretive stability of the patterns (observations), it is advantageous to apply some of the analyses of spatial statistics.

We will present a statistical analysis of Ripley´s K- function, which determines the proximity of statistically significant clusters (Sayer and Wienhold 2013). Using Ripley´s K-function we examine the density of graves and spatial patterns in their arrangement (Qgis 3.24.0, ArcGIS 10.8, kernel density). An important fact when applying this analysis is its multiscalar nature. This property allows displaying spatial relations between graves on multiple levels in geographic space. In the case of testing the interpretive significance of the grave density or dispersion, we can assess the interpretive significance of different radii when calculating the density of graves (KD). In other words, this type of analysis allows us to answer the question of whether a statistically significant clustering radius is interpretatively relevant.

References

Havelková, Petra, Marek Hladík, and Petr Velemínský. 2013. "Entheseal Changes: Do They Reflect Socioeconomic Status in the Early Medieval Central European Population? (Mikulčice – Klášteřisko, Great Moravian Empire, 9th – 10th century)." International Journal of Osteoarchaeology 23: 237-51. https://doi.org/10.1002/oa.2294.

Kolník, Titus. 1980. Römerzeitliche Gräberfelder in der Slowakei. Vol. 1. Archaeologica Slovaca Fontes. Bratislava: Veda.

Sayer, Duncan, and Michelle Wienhold. 2013. "A GIS-Investigation of Four Early Anglo-Saxon Cemeteries: Ripley's K-function Analysis of Spatial Groupings Amongst Graves." Social Science Computer Review 31 (1): 71-89. https://doi.org/https://doi.org/10.1177/0894439312453276.

190. WEaning Age FiNder (WEAN): A tool for estimating weaning age from sequential isotopic analysis of dentinal collagen

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1. Introduction

Stable isotope analysis of bone and tooth collagen has been widely used by bioarcheologists for reconstructing breastfeeding and weaning practices in ancient societies. The new development of sequential isotopic analysis of dentine, which includes the segmentation of dentine, from crown to root into small sections, offers the potential to reconstruct diet in time-bound periods of life. As dentine forms in subsequent layers and is hardly influenced by dietary and environmental factors after its initial deposition, each section retains an isotopic signature reflecting its formation period.

Studies on fingernails from modern mother-infant pairs have shown that δ15N values of exclusive breastfed infants are elevated by approximately 2-3‰ above those of their mothers. The consumption of solid foods and fluids at the onset of weaning, causes the δ15N values to decrease throughout the weaning process. After the complete cessation of breast milk consumption (termed weaning age), δ15N values fall to a similar level as their mothers.

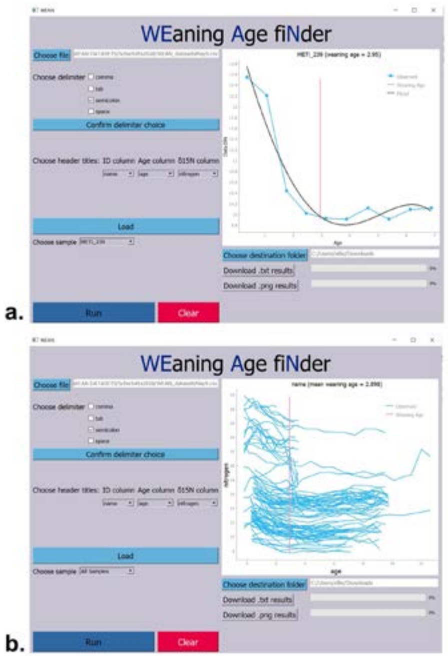
However, albeit infant feeding practices are often investigated, the estimation of weaning onset and completion are performed visually. The visual evaluation of each isotopic plot requires time and labor investment when analyzing many isotopic profiles at a time. Furthermore, this procedure enfolds the subjective judgment and the inability to compare isotopic profiles produced by different sampling protocols. To facilitate and standardize this process, we propose a streamlined procedure of weaning age estimation based on mathematical computation for which we developed the automatic tool WEAN.

2. Materials and Methods

The mathematical base of WEAN lies upon the automatic weaning age estimation based on the calculation of the elbow/ knee point of a curve. In mathematical terms, the point of a curvature, where the curve visibly angles, is defined as the knee/ elbow point. Bearing in mind that reference incremental dentine δ15N values associated with breastfeeding show a gradually declining pattern, which stabilizes soon after breastfeeding is no longer practiced, the completion of weaning process is assessed as the point where the isotopic curvature visibly bends (elbow/ knee point).

The application primarily, refines the age assignment with regression analysis and considers additional parameters for optimizing the accuracy of the estimations and the functionality of the tool. Specifically the tool:

- calculates the R2 value, which measures whether the regression model describes the data efficiently
- calculates of the trophic level shift between exclusive breastfeeding and age at completion of weaning (expected trophic level shift ranges between 2-3‰).
- evaluates the isotopic pattern to identify profiles not indicative of breastfeeding based on the sign of the derivative of the δ15N value of the weaning age. Weaning age estimations with negative derivative values indicate that δ15N has a decreasing tendency at the weaning age point indicative of breastfeeding. Positive derivative values are indicative of δ15N patterns that are not characteristic of breastfeeding/ weaning trend.



To test the accuracy of our model, we re-estimated 130 weaning ages and compared the result with the initial weaning age estimation. The initial estimations were performed visually by the authors based on isotopic profiles produced from deciduous first and second molars and first permanent molars. For comparing the published and the newly estimated weaning ages we calculated the Root Mean Square Error (RMSE), which shows their difference in years.

3. Results

WEAN is built in Python (code available on GitHub) and is freely distributed. The tool provides weaning age estimations for one or many individuals. The user needs to provide a CSV file with the age-at-increment assignment of each δ15N measurement (at least five per individual). The file can be easily imported, and the user can select the individual(s) they want to analyze through a drop-down list from a friendly user interface (Figure 1). The results obtained from WEAN can be easily exported in CSV format, individual and dataset charts are automatically produced and can be downloaded in PNG format (Figure 1).

WEAN re-estimated weaning ages from 119 out of 130 individuals and identified isotopic profiles that are not indicative of breastfeeding. Similar observations were reported on the original publications indicating the quality of the estimations. The mean RMSE between the estimations performed visually and with WEAN is calculated at 0.88 ±0.8 years.

4. Discussion

Stable isotope ratios of nitrogen have proven a reliable method to infer the weaning behavior of past populations. However, up to now a standardized methodology for the weaning age estimation is not available. WEAN introduces an approach to estimate the weaning age accurately and efficiently which is now performed with the same computational method enabling the comparison of different isotopic profiles.

The results show a strong correlation between the visual and the knee method underlining that a mathematical framework can be accurately applied in weaning age estimation. The majority of examined individuals obtained a weaning age, which was calculated automatically and did not differ from the visual observation. This indicates that despite the observed variability in δ15N individual profiles, a statistical and automated approach can be established. WEAN identifies isotopic profiles not indicative of breastfeeding and based on the results, the estimations of the tool are more accurate for isotopic profiles obtained from first permanent molars, therefore we suggest M1 as the optimal tooth type for breastfeeding reconstruction with WEAN.

Our research intends to facilitate the analysis of δ15N incremental data offering a less time-consuming and labor-intensive procedure through an easy-to-use operational environment.

Funding

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82. Dig it: recent thoughts on archaeological epistemology

Geoff Carver, RGZM

Archaeologists have a long history of either avoiding discussion of fundamental problems, or burying them under layers of obfuscation. Leaving unanswered, for example, the age-old question of whether or not archaeology is a science – and related questions of why we continue to oppose science and the humanities – leaves us in a state Schrödinger might have recognised. This state of uncertainty may be the result of disciplinary divisions: archaeologists alternately trying – or understandably reluctant – to do philosophy.

At the very least, the scientific method consists of disciplined observation and communication (i.e. the documentation and dissemination of those observations). The fact that scientific – archaeological – epistemology rests upon the data that results suggests a need to focus on our media, the data recording process and the structural relations linking data to our observations (i.e. linguistics via Lévi-Strauss). After all: garbage in, garbage out (as they say). But post-processualist discussions of such issues as reflexive methods and critiques of the idea(l) of separating description from interpretation in our documentation have tended to shift the focus towards interpretation and, hence, hermeneutics... which many believe have little or no bearing on our specialty, computer applications.

Yet… in keeping with the ideas of Marshall McLuhan, any solution needs to take computer technology into consideration; this would include recognising that computers run on logic (i.e. philosophy) and binary opposition (i.e. structuralism) – all or nothing, either/or – which complicates the process of modelling the probabilistic real world.

This presentation outlines a framework for finding – defining – a relatively firm foundation for archaeological reasoning (cf. Buccellati 2017), weaving a web or net of meaning which combines two related branches of philosophy: epistemology and ontology. Although suffering from a faulty structure, David Clarke's Analytical Archaeology (Clarke 1968) provided a useful starting point – built on attributes (David Hume called "qualities") – which can be reconciled with more recent work dealing with flat and Object-Oriented Ontologies (OOO; cf. Harman 2019).

Ontology is about what exists: entities and relations, which can be modelled using graphs as nodes and edges. Entities have attributes (length, width, colour, etc.), each of which has a value (i.e. "3.4," or "green"). The sum total of our documentation,

When we document or compare entities, we really record or compare the values representing a selected attribute: one artifact is longer than another (written descriptions, measurements, photographs, drawings, 3D scans, relations in databases, etc.).

Buccellati, Giorgio. 2017. A Critique of Archaeological Reason. Cambridge: Cambridge University Press.

Clarke, David L. 1968. Analytical Archaeology. London: Methuen.

Harman, Graham. 2019. Object-Oriented Ontology: A New Theory of Everything. London: Pelican.

104. There is no epistemology without creativity, or how to combine quantitative methods, material culture, and theoretical approaches

Tânia M Casimiro, FCSH-UNL
Joel Santos, University of Leicester
Inês Castro, FCSH-UNL

The archaeologists attending the conference for the Study Group of Roman Pottery, or the Conference of the Medieval and Later Pottery Research Group (these were random choices) rarely join in the same room in discussing what they study, and, despite chronology, they tend to discuss pottery. If the conversation between researchers that have similar interests rarely happens – even when they discuss pottery technology, they tend to do so in separate groups – what to say about the conversation between archaeologists that use different methods and engaging in different theories. That being said, how do we expect that people interested in things as different as statistics, computer science, quantitative techniques, and machine learning, to name just of the few things that are frequently discussed in the CAA conference, engage in conversations with people interested in pottery, features, landscape or in theoretical subjective and interpretative approaches such as phenomenology, semiotics, identity, among many others.

When the three authors of this talk met, this distinction seemed to be what separated us. One of us is a material culture specialist, another likes to combine literature, theory, and archaeology and the third is more into statistics and AI applied to archaeology. We soon learned that what united us was the possibility of creatively combining all types of different ways of looking into archaeology. Separately at least one of us would never go to a pottery conference and the others would never attend a computer or technology conference. Our presence here aims to demonstrate that we can work together in bridging different knowledge in the construction of past narratives.

In this paper, we intend to demonstrate how we have come to accomplish several of these connections between what could initially be considered different perspectives on archaeological debate. More than using technology as a method it has become an intrinsic part of our knowledge development aiming especially to provide more scientific reading to subjective interpretations while always focusing on human and non-human agents and different relational ontologies. We present two case studies in which we believe we were able to build that bridge. In the first case, using the Brainerd-Robinson coefficient, we were able to quantify, in a comparative way between sites, the wealth of those sites while in the second case, using quantification methodologies we tried to quantify the way senses impacted the value people attributed to things.

24. How Are Archaeological Narratives about the Past Constructed? – Analysing Argumentation in Archaology

Cesar Gonzalez-Perez, Incipit CSIC
Martin Pereira-Fariña, University of Santiago de Compostela
Raquel Liceras-Garrido, Complutense University of Madrid
Patricia Martin-Rodilla, University of A Coruña Beatriz Calderón-Cerrato, Incipit CSIC

Location: E105

Merged with session 31 (see below)

Background

How can data identified as a record of the cultural past be presented as evidence? How can these data support claims about the past that cannot always be verified? The elaboration of good and strong arguments is one of the key points to addressing this type of question. However, scientific publications often focus on showing how data has been obtained and analysed rather than arguing convincingly on a relatively small number of claims or points to be communicated. Especially, in the field of archaeological knowledge, arguing is particularly challenging due to its unique nature: claims about the past that cannot be indubitably verified (Lucas, 2019). Is it possible to analyse several lines of argumentation from the archaeological data to the conclusions and assess how well founded these conclusions are? The main aim of this session is to generate some cross-fertilization between argumentation theory and archaeological reason. Instead of treating the elaboration of arguments as a secondary step in the creation of archaeological knowledge, we should start considering it as an essential step, and enhance it with all the theoretical support that other studies in argumentation can provide.

Current Research

The most recent work studying argumentation of archaeological knowledge (Chapman and Wylie, 2016; Lucas, 2019; Smith, 2015) has developed proposals specifically focused on how good arguments can be elaborated. They are inspired by Toulmin's (Toulmin, 2008) model of argumentation, having several limitations related to the variety and richness of the different ways in which people build different types of arguments in the field. We argue in favour of applying state-of-the-art contributions in argumentation theory to archaeological knowledge. For instance, annotated text corpora (Fort, 2016) and Argument Analytics (Lawrence et al., 2016) can be applied as an alternative to the Toulmin model. These techniques can be used to improve the outputs generated by research work, such as reports, fieldwork diaries, or scientific publications. On the other hand, we acknowledge that different texts can provide alternative views of the same underlying data, thus developing alternative lines of reasoning. Texts sharing similar views or defending the same claims can be put together into a corpus to be annotated and studies which allows us to explore inter-textual relationships (Visser et al., 2018; Gonzalez-Perez, 2020), that is, discover how texts and authors are interconnected and how the content of various texts cross-references and relies on the meaning of others. Lastly, the computational treatment of archaeological arguments is a field to be explored. The current explosion in the development of Argument Mining (Lawrence and Reed, 2020), together with the automated reconstruction of the argumentative structure of texts, opens up the possibility of massive treatment of argumentative texts in archaeology.

Expected Contributions

Research is necessary to generate cross-fertilisation between argumentation theory and archaeological knowledge. We need to provide a good conceptualisation of the argumentation concepts (premises, conclusions, argument schemes, supports, attacks, etc.) tuned to the specific characteristics of archaeological knowledge. Only when a solid theoretical basis has been established, we will be able to refine existing computational models of argumentation to deal with archaeological texts as appropriate. Expected Themes Papers are welcome in this session about the following topics, among others:

- Philosophical accounts of argumentation
- Relationships between discourse makers and argumentation in archaeology
- Methodologies of discourse analysis applied to argumentation in archaeology
- Theories, ontologies and conceptual models of arguments in archaeology
- Uses of argument mining techniques for specific tasks in archaeological reasoning
- Annotation of archaeological texts
- Argument schemes for archaeological reasoning
- Argument analytics for archaeological arguments
- Argument analysis to question major archaeological paradigms (hunter-gatherers, gender stereotypes, state nations, complex societies, etc.)
- Visualisation of argument analytics for archaeological reasoning Audience
- The session will be of interest to:
- Archaeologists concerned with a richer and more nuanced representation of

archaeological reasoning

- Students working on how to better defend a claim
- Cultural heritage managers that use archaeological information for decision making • Developers of information systems aiming to capture and represent argumentation structures
- Publishers or archaeological texts interested in improving the soundness and cogency of their materials

References:

Chapman R and Wylie A (2016) Evidential Reasoning in Archaeology. London: Bloomsbury Publishing Plc. Fort K (2016) Collaborative Annotation for Reliable Natural Language Processing: Technical and Sociological Aspects. Hoboken, NJ: ISTE Ltd/John Wiley and Sons Inc.

Gonzalez-Perez C (2020) Connecting Discourse and Domain Models in Discourse Analysis through Ontological Proxies. Electronics 9(11), MDPI.

Lawrence J and Reed C (2020) Argument Mining: A Survey. Computational Linguistics 45(4): 765-818.

Lawrence J, Duthie R, Budzynska K and Reed C (2016) Argument Analytics.

Lucas G (2019) Writing the Past. Milton: Routledge.

Smith M (2015) How can Archaeologists Make Better Arguments? The SAA Archaeological Record 15(4): 18-23.

Toulmin SE (2008) The Uses of Argument. Cambridge [u.a.]: Cambridge University Press.

Visser J, Duthie R, Lawrence J and Reed C (2018) Intertextual Correspondence for Integrating Corpora. In: Calzolari N et al. (eds) Proceedings of the Eleventh International Conference on Language Resources and Evaluation (LREC 2018). Miyazaki, Japan: European Language Resources Association (ELRA), 3511-3517.

SLOT 1	
10:30 - 10:50	152. Deconstructing the constructed: Focused coding as a methodological tool to analyze archaeological narratives *Yashaswini Jayadevaiah (Indian Institute of Technology Kanpur (IITK))*; Koumudi Patil (Design programme IIT Kanpur)*
10:50	191. An approach to establishing a workflow pipeline for synergistic analysis of osteological and biochemical data. The case study of Amvrakia in the context of Corinthian colonisation between 625-200 BC in Epirus, Greece. *Kiriakos Xanthopoulos (Laboratory of Physical Anthropology, Department of History and Ethnology, Democritus University of Thrace)*; Angeliki Georgiadou (Laboratory of Physical Anthropology, Department of History and Ethnology, Democritus University of Thrace); Christina Papageorgopoulou (Laboratory of Physical Anthropology, Department of History and Ethnology, Democritus University of Thrace)*
11:10	200. Integrating multiproxy data to improve isotope-based geographic assignment approaches *Jason Laffoon (Leiden University)*; Till Sonnemann (University of Bonn)*
11:30	261. Vagueness and Uncertainty in Linked Open Data - its effects on semantic modelling, performance, classification and meaning *David Wigg-Wolf (DE)*; Karsten Tolle (Goethe-University); Florian Thiery (LEIZA); Allard Mees (RGZM)*

31. Better Together: Exploring methods and applications for the synergy of multiproxy data in the study of archaeological mobilities

Christianne Fernée, University of Bristol
Konstantinos P. Trimmis, University of Bristol

Merged with session 24 (see above)

Archaeological data are inherently multi-layered, commonly fragmented, and interpretations of past events are usually based on a variety of datasets that are often not linked together or aligned. To date, the problematic nature of archaeological datasets is well documented, and sparked the early criticism of endeavours in New Archaeology (e.g. Earle and Preucel 1987; Hole 1980; Hurst Thomas 1978; Shanks and Tilley 1982). However, as suggested by Hurst Thomas, 'trends in research swing back and forth like a pendulum' (1978: 240), thus meticulous analysis of archaeological datasets through applications of statistical and computational modelling are again the norm. In the last decade the interpretational 'gap' between the descriptive and testing statistical applications has been reconciled. The introduction of Data Science and Artificial Intelligence (AI) to the archaeological discourse are helping archaeologists to gain a deeper understanding of their data (see Fernée and Trimmis 2021). The involvement of these disciplines in the field of archaeology has the potential to pave the way for the integration of different datasets, brought together to address archaeological questions. Interpretations of archaeological data are not just increasingly based upon computational methods, but also on multi-proxy approaches. In this session we are interested in multiproxy approaches that have been developed to record, interpret and understand mobilities. It is common for projects to bring together quantitative data from multiple proxies, such as isotopes, radiocarbon dating, organic residue analysis and petrography, with qualitative approaches, and occasionally creative approaches, such as creative writing, applied arts, drama, and theatre (see methods discussion in Skeates 2010 for example). In addition to these multiple proxies, archaeological theory is also advancing, suggesting ways that interpretation can be broader, inclusive, less biased and more tailored to the societies under study. In this session, mobility refers to any form of human movement. From the short—term movement of people through spaces and places, singular migration events, to fully nomadic lifeways. The footprint of mobility results in data in many forms that gives insight into different aspects of mobility. Some of these include: 1) geographical information, from archaeological isotopes and aDNA, 2) biological implications, with evidence of the impact on the human body, and 3) material culture variations, with the replacement, continuation or transitions of material culture. Thus, a question arises; How can we achieve data synergy by bringing together so many different types of data, ways of collection, analysis, and interpretation, to help us record, interpret, and understand archaeological mobilities and their impact? Data synergy is employed in this session to describe data from multiple sources and/or disciplines that, when combined, are more valuable than any of the sources alone (see Higginson et al 2018). Regardless of the type of dataset, in this session, we contend that good data is dependent on four interlinking dimensions: a). Time (synchronising the collection and sharing of data), b). People (coordinating the collection and sharing of data), c). Technology (establishing the different technologies so that data can be transmitted), and d). Quality (ensuring data is good enough for the research purpose) (see Higginson et al 2018). The discussion will examine challenges in relation to these dimensions in order to make recommendations for the development of a data synergy protocol for use in multiproxy and multidisciplinary projects. In this session, we would also like to further expand the discussion onto ways that synergy can be achieved between quantitative and qualitative approaches, and approaches that link data analysis with thick description in an archaeological context. The session aims to present and discuss methods, applications, and case studies that advance data synergy in the study of archaeological mobility. The session welcomes papers that focus on but are not limited to: a) Discussing novel computational methods that advance the synergy of data collection, curation, analysis, interpretation, visualisation, and archiving. b) Presenting case studies where these synergies have been tested or achieved. c) Discussing ethics and good practice of such synergies in archaeological contexts. d) Presenting software applications, 'how to' ways, and solutions that communication and synergies can be achieved. e) Discussing future challenges that synergies can face on the landscape of the ever-increasing data qualities, quantities, and types. Overall, this session would like data science to be in synergy with current archaeological theory, that views archaeological evidence of mobility (and beyond) as more connected and entangled. People, as they move through space and between places, are in a constant and everlasting interaction with their surroundings, their own and other cultures. Archaeology, however, often look at people, environments, and material culture as single strands of evidence that can assist towards a better understanding of the past; and the consequent modelling of the future. We welcome researchers that are working to bring these strands together, particularly those working at the intersection between data science and archaeology. By bringing these researchers together this session hopes to advance a better understanding of how different data can work better together for the study of human mobility.

References:

Earle, T.K. and Preucel, R.W. 1987. Processual archaeology and the radical critique Curr. Anthropol., 28 (4) pp. 501-538 http://www.jstor.org/stable/2743487

Fernée, C. L. and Trimmis, K. P. 2021. Detecting variability: A study on the application of bayesian multilevel modelling to archaeological data. Evidence from the Neolithic Adriatic and the Bronze Age Aegean, Journal of Archaeological Science, 128, https://doi.org/10.1016/j.jas.2021.105346

Higginson, S., Topouzi, M., Andrade-Cabrera, C., O'Dwyer, C., Darby, S., Finn, D. 2018. Achieving Data Synergy: The Socio-Technical Process of Handling Data. In: Foulds, C., Robison, R. (eds) Advancing Energy Policy. Palgrave Pivot, Cham. https://doi.org/10.1007/978-3-319-99097-2_5

Hole, B. L. 1980. Sampling in archaeology: a critique. Annu. Rev. Anthropol., 9 (1980), pp. 217-234, 10.1146/annurev.an.09.100180.001245

Hurst Thomas, D. 1978. The awful truth about statistics in archaeology. Contributions to archaeological method and theory. Am. Antiq., 43 (2) , pp. 231-244, 10.2307/279247

Shanks, M. and Tilley, C. 1982. Ideology, symbolic power, and ritual communication: a reinterpretation of Neolithic mortuary practices. In I. Hodder (Ed.), Symbolic and Structural Archaeology1, Cambridge University Press, Cambridge pp. 29-154

Skeates, R. 2010. An archaeology of the senses: prehistoric Malta. Oxford: Oxford University Press.

152. Deconstructing the constructed: Focused coding as a methodological tool to analyze archaeological narratives

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Koumudi Patil, Design programme IIT Kanpur

Archaeological knowledge is innately a data-driven, multidisciplinary, plural, fragmented, contextual, provisional, and heterogenous body of knowledge. In this disciplinary practice, reliance is on empirical evidence. However, what an archaeologist makes out of it in the interpretational argument (that binds the empirical evidence to produce archaeological knowledge) gets established as the knowledge repository. In this process of knowledge production, claims and resulting narratives black box empirical evidence and process testimonies (considered or eliminated) through the act of interpretational argument. In such a case, is there a way to search for these in the interpretational argument? If it's possible, how to identify the gaps and leaps?

Considering this, the present paper retrospectively investigates the excavation teams' claim concerning the site of Śṛiṅgaverapura by using the Constructivist Grounded Theory's (CGT) Qualitative coding (Focused coding) as a methodological tool. Leading to a critical analysis of multiple aspects of the constructed archaeological narrative. The qualitative coding method used in this case example focuses on the ontological (agency of the site) and the empirical (validity of the claim) components.

Śṛiṅgaverapura, a village on the left bank of River Ganga in the Indian state of Uttar Pradesh, lays between 25035' N – 81039' E. The excavation was carried out for nine seasons (1977 – 78 to 1985 – 86) in seven locations. Among these locations, at SVP-4, a 230-meter-long interconnected burnt-brick structure was excavated and interpreted to be a 'Flood Water Harvesting and storage system' dating back to 100 BCE. The claim concerning this brick tank's function as a floodwater harvesting and storage system is the case inquiry.

Methods and materials

The Paper utilizes the CGT's Focused coding (FC) as the methodological tool to code the excavation report content, specifically the evidence and argument concerning the brick tank system and its function.

To trace, analyze and identify the agency of the site, the paper grounds itself in the concept of "translation" and follows the actor translations and the inscription production by coding written argument/script in the excavation report. Therefore, the paper treats the previous excavation team as an actor-network, its claims as site inscriptions, and the written material as site script through which the claims and narratives are proliferated. This is a retrospective tracing after the actor-network ceded to exist.

To critically analyze the empirical claim, the paper considers the quality of argument types- deductive, inductive, and abductive furthered using the well-recognized fallacies in reasoning evaluation.

The Archaeological writing content considered for this inquiry is solely drawn from the excavation report- 'Excavations at Śṛiṅgaverapura, 1977-86, Vol. 1', 1993 and authored by B. B. Lal (Chief excavator), published by the Archaeological Survey of India.

Discussion and Results

a. Identifying the claims, content, and arguments

The excavation report was studied to identify the made knowledge claims along with the presented evidence and argument. Then the content addressing the claim concerning the function of the Brick Tank from Chapters II, III, and IV is identified. Followed by the reading to identify and group the arguments into interrelated sets. After which, the content was transferred to excel, and around 260 sets (incidents and statements) were identified and coded. The present codes answering the two components under inquiry were attained after multiple rounds of reiterations. In the FC method, coding is done in two phases: initial and focused. The section below briefs the coding process, and see the table for an example.

b. Coding Qualitative data

i. Initial

Initial coding facilitates exploration and locates multiple possibilities present in the data, thereby allowing the development of new ideas. In this step, the codes represent the data closely. Incident coding was considered for initial coding as it served best to understand the site's agency by tracing the knowledge production process and the occurring translations incident by incident.

The data was coded in Excel over the computer manually. The initial coding enabled the identification of five components of an incident and statements without conclusions.

1. Primary Actor
2. Other actors
3. Premise
4. Caveat (if any)
5. Conclusion
6. Proposition-Statement

ii. Memos

Memos are preliminary analytical notes (extensive or crisp) that may include the code, comparisons, ideas about data, etc., that occur to the coder. "Through studying data, comparing them, and writing memos, we define ideas that best fit and interpret the data as tentative analytic categories ."

iii. Focused

In this, two different components are investigated. Firstly, the evidence and argument analysis to critically evaluate the archaeological claim, and secondly, the site's agency by tracing the occurring translations. FC of the first criterion of inquiry- identified the type of argument- inductive, deductive, abductive along with any fallacies (if observed). Concerning the site agency, the resulting analysis enabled the identification of incidents and statements in which the site's agency is exposed, covered, muted, or latent, including the nature of the agency.

c. Focused codes

Concerning the critical evaluation of the archaeological claim, coding facilitated the identification of argument types and fallacies, enabling the identification of gaps in the archaeological argument, therefore, in the made claim and narrative.

Concerning the site agency, coding enlisted six important actions because of which the site gains the agency as a Focal Actor setting obligatory passage points that are to be aligned to by multiple actors to be enrolled in the network, thereby translating the actors and the network resulting in archaeological knowledge production.

Implications

The present research at the case study level shows the existing gaps in the evidence and the faltering in the claim, therefore, the narrative concerning the functioning of Śṛiṅgaverapura brick tank. Thereby critically calling for further interventions to inquire about the observed gaps.

The adopted coding method would serve as a reliable and standard method to evaluate any archaeological claims and arguments retrospectively. The case application has also shown that this qualitative coding method is adaptable to critically understand ontological components (here, its site agency) and not just epistemic knowledge. However, depending on the component under inquiry, the coding would demand multiple revisions to observe the anomalies. It's a rigorous and time-demanding analytical method.

The analysis has a promising potential to develop into a full-fledged tool to analyze archaeological claims and narratives through machine learning and artificial intelligence adaptations, specifically considering the works in the field of Natural Language Processing . The possibility and limitation of this model adoption into ML need extensive research on multiple aspects, and multiple argument sets to state the least.

Table 1. Showing the Focused coding of the excavation report text – The first row are headings; the second row briefly introduces the coding details, and the third row is an example of a coded incident

Code ID	Excavation report Content	Incident Coding	Memo	Focused Coding – Argument	Focused Coding – Site Agency
Chapter/Page/lines/sl.no	The textual content of the excavation report	Primary Actor: Other actors: Premise: Conclusion: Caveat: Proposition: Statement:	Coder's observation and notes on the present argument, evidence, translation	Type of Argument Type of fallacy (if any)	Noticed role/roles and exhibited agency of the site in the incident
II/13/15-19/6	A look at fig. 2 and pls. IV and VI would show that the river takes here a horse-shoe curve. On fig. 2 one also notes a subsidiary channel of the river near the opposite bank where Basedhi is located. It is not unlikely that in ancient times, the river was flowing far away from its present left bank. During the driest part of the year, i.e. in the first half of June when the river level considerably goes down, one sometimes sees in the riverbed, close to the present left-hand bank, the bottom portions of some brick-lined wells.	Primary Actor: Excavation report author Other actors: fig. 2 and pls. IV and VI Premise1: Conclusion from the above incident with Code ID- II/13/13-14/5 Premise2: the river takes here a horse-shoe curve Premise3: a subsidiary channel of the river near the opposite bank where Basedhi is located Premise4: During the driest part of the year, i.e., in the first half of June when the river level considerably goes down, one sometimes sees in the riverbed, close to the present left-hand bank, the bottom portions of some brick-lined wells. Conclusion: It is not unlikely that in ancient times, the river was flowing far away from its present left bank		Inductive Argument (fallacy not observed yet)	The current physical components of the site actors (including the river's physicality and flood conditions) are identified and enrolled to make an interpretation of these actors' characteristics at the ancient time. Acknowledging that site is a multifarious (temporal) entity

References

Charmaz, Kathy. 2014. Constructing Grounded Theory. 2nd. London: SAGE.

Gurcke, Timon, Milad Alshomary, and Henning Wachsmuth. 2021. "Assessing the Sufficiency of Arguments through Conclusion Generation." arXiv. October 26. Accessed October 2022. https://arxiv.org/pdf/2110.13495.pdf

Lal, Brij Bihari. 1993. Excavation at Śṛiṅgaverapura (1977-86). Vol. I. New Delhi: Archaeological Survey of India.

Stab, Christian Matthias Edwin. 2017. "Argumentative Writing Support by means of Natural Language Processing." Argumentative Writing Support by means of Natural Language Processing. Darmstadt: The Technical University of Darmstadt. 194. Accessed 2022. https://tuprints.ulb.tu-darmstadt.de/6006/.

261. Vagueness and Uncertainty in Linked Open Data - its effects on semantic modelling, performance, classification and meaning

David Wigg-Wolf, DE
Karsten Tolle, Goethe-University
Florian Thiery, LEIZA
Allard Mees, RGZM

The Resource Description Framework (RDF) provides a graph-based modelling of knowledge as Linked Open Data (LOD). By providing an ontology composed of classes and properties a community can generate additional verbs (properties) and structure (classes). In addition, it is useful to provide norm-data (concepts) that can be used and reused within the community. These concepts are mainly instances of defined classes.

For the numismatic world, for example, this is provided by nomisma.org. The class nmo:Mint contains concepts like nm:rome or nm:london, and the property nmo:hasMint can be used to link to them. Similarly, for the ceramics domain, in the Samian Research Database and the LOD Hub archaeology.link by using the class lado:Potform, which contains concepts (e.g. Gaulish potforms) such as samian:pf_9 (Dragendorff 18), samian:pf_11 (Dragendorff 18/31) or samian:pf_2 (Dragendorff 15/17), the property lado:representedBy can be used to interlink an information carrier with its potform description.

However, when we want to exchange data it is not enough to simply say that the data is interoperable. If the ways of using the properties, classes and concepts are different, a simple merge of two RDF graphs would not work.

For this reason CIDOC-CRM goes one step further and also defines how to use and model with the ontology (following an event based approach). This helps to some extent, but it also raises the barrier to using it. There are also still situations where this is not enough.

At Graphs and Networks in the Humanities in 2022, for example, we already presented different ways to model vagueness and uncertainty in RDF[1], based on numismatic and ceramological real world data. This contains approaches such as quadruples, as is done using the Academic Meta Tool[2]. In the AMT quadruple approach amt:Concepts (rdfs:Class) are interlinked using an amt:Role (rdf:Property). The resulting AMT node containing vagueness information is represented by a blank node having four edges: rdf:subject, rdf:predicate, rdf:object and amt:weight. The weight is a "degree of connection" expressed in a vagueness describing a value between 0 and 1. However, the answer to how to handle this within RDF is still open, and extensions to RDF like RDF-star[3] show a broader need to solve it.

In our presentation we will provide more detailed results concerning metrics for how to measure different modelling approaches for vagueness and uncertainty based on the number of triples and also the impact on query performance.

In our previous work, we concentrated on how to deal with the problem of vagueness and uncertainty coming from the material itself, for example due to bad preservation. On top of the modelling itself this has an influence on classifying items. For example, when parts of a potform partially overlap with other classes. Whereas an only partially preserved vessel (e.g. footring only) may be attributed to a defined group of other concepts with this feature, the other candidates may have entirely different rims. Therefore, we worked on a reasoning approach following product logics to define the incertitude of the relations of partially preserved material.

Unfortunately, sometimes the concepts themselves are not certain enough for a given situation. If you take a concept such as nm:london, this is in fact an abstraction and was generated for communication. It might well be that each party of the communication understands this concept differently, and in most cases any differences are marginal and no problem. But it might be in other cases. However, humans have learned to deal with this. For example, in Celtic numismatics the term denomination often has a different meaning to what it has in the field of Roman numismatics. Generating the millions of sub-concepts representing such differences would be difficult and, depending on the granularity required, sometimes impossible.

References:

[1] Thiery, F., Mees, AW., Tolle, K. and Wigg-Wolf, DG. 2022 How to handle vagueness and uncertainty in graph-based LOD knowledge modelling. Dealing with archaeological numismatic and ceramological real world data. Squirrel Papers 4(1): No.2. https://doi.org/10.5281/zenodo.7184523.

[2] Thiery, F., Unold, M. 2018. Academic Meta Tool Ontology. Leonard Edition. URL: https://academic-meta-tool.xyz/ontology.

[3] Arndt, D. et al. 2022. RDF-star and SPARQL-star Draft Community Group Report 30 September 2022 URL: https://w3c.github.io/rdf-star/cg-spec/editors_draft.html.

200. Integrating multiproxy data to improve isotope-based geographic assignment approaches

Jason Laffoon, Leiden University
Till Sonnemann, University of Bonn

Isotope analysis has been widely applied in archaeological studies of migration and mobility. Recent developments permit the identification and recovery of increasingly more detailed information about past migrants. Strontium has become the most widely used isotope methods to study ancient migrations. The method has been applied to thousands of samples from a wide range of archaeological contexts around the world. In addition to strontium isotopes (87Sr/86Sr), oxygen (δ18O), sulfur (δ34S), and lead (20xPb/20xPb) isotopes in biogenic tissues also vary geographically and are increasingly applied in paleo-mobility studies often combined in multiple isotope approaches. These studies have demonstrated that migrations were far more common than traditionally assumed, but also that migration patterns were extremely dynamic and variable within and between different populations. A major limitation of the isotope method for investigating ancient mobility is the problem of equifinality whereby different regions have similar isotope values, making it difficult to accurately identify all migrants and prohibiting the precise determination of their origins.

Over the last few decades, considerable advancements have been made in mapping isotopic variation of different isotope systems at varying scales. This research has greatly improved our understanding of the processes conditioning environmental isotope variation and have led to improved maps of baseline isotopic variation. Known as isoscapes, they are now commonly used to track the origins of various animals, foods, and raw materials in various research fields ranging from wildlife ecology to food authentication, forensic anthropology, and archaeology. The ongoing development of larger and more reliable isoscapes combined with relevant computational tools (Ma et al. 2020) represent the most cutting-edge method to generate reliable inferences of geographic origins. Thus, the isotope-based geographic assignment approach, while in its infancy, has demonstrated great potential, but the limited case studies (Laffoon et al. 2017; Bataille et al. 2021) to date have yet to attempt to systematically incorporate other lines of non-isotopic evidence to identify potential origins more reliably.

In this paper, we present a revised version of the isoscape method for inferring the childhood origins of ancient migrants. The aim of this study is to test whether such an integrated multiproxy approach can indeed better constrain (improve the precision of) quantitative geographic assignments in provenance research and to explore both the potentials and limitations of such an approach for archaeological studies of human mobility. The multiproxy approach that we take uses dual isotope analyses and associated isoscapes to generate quantitative geographic assignments per individual, and combines the outputs of these predictive models with other non-isotopic (archaeological and geographic) data. More specifically, using GIS we integrate information concerning island colonization and settlement chronology, the location of archaeological settlements, terrain and slope to improve the precision of the geographic assignment method. This approach is applied to strontium and oxygen isotope data generated from the analysis of dental enamel of archaeological individuals recovered from several pre-colonial indigenous sites in the insular Caribbean. This region is ideal as a case study and validation of the method as there is abundant evidence for long-distance mobility of Indigenous peoples in this region. Furthermore, the spatial variation of strontium and oxygen isotopes are fairly well characterized and reliable isoscapes for both systems are already available (Laffoon et al. 2017).

The results include both new and previously published strontium and oxygen isotope data of human dental enamel obtained from numerous pre-colonial and colonial period individuals representing different regions and cultural affiliations. The human isotope data are then systematically compared to large-scale (macro-regional) strontium and oxygen isoscapes for the circum-Caribbean region using an interval approach: On a case-by-case basis, we can exclude possible places of origin if either of the isotope values fall outside of the range of isotopic variation for a given location. The model output is a map of potential origins for each individual. An additional Bayesian analysis is then applied to this map to further constrain individual origins. The results demonstrate that the precision of the isotope-based approach is highly dependent on the spatial distribution of baseline isotope values within the isoscape. The addition of archaeological and geographic data does improve the precision of the geographic assignments in several cases, but the improvement in precision is highly variable and dependent on numerous factors, including especially chronology, but also the quality and spatial coverage of the non-isotopic data sets.

Provenance studies have a long history in archaeological research but the capacity to reliably identify a specific source is highly variable depending on the nature of the analyzed material and the methods used. The development and continued improvement of isotope analyses and associated isoscapes now permit increasingly robust estimations of the provenance of a broad range of raw materials and objects in various research fields. The application of isotope-based methods for tracking the geographic origins of biogenic materials, including specifically animals and humans, in archaeological migration studies offers enormous potential. The approach presented in this paper is an attempt to push the boundaries of this method, and the results indicate that the precision of geographic assignments can indeed be improved at least in certain cases. We hope that this research will stimulate more interest in the systematic use of multiproxy approaches in archaeological provenance studies generally and investigations of individual human natal origins more specifically.

References

Bataille, Clément P., Klervia Jaouen, Stefania Milano, Manuel Trost, Sven Steinbrenner, Éric Crubézy, and Rozenn Colleter. 2021. "Triple sulfur-oxygen-strontium isotopes probabilistic geographic assignment of archaeological remains using a novel sulfur isoscape of western Europe." PLoS One 16, no. 5 (2021): e0250383.

Laffoon, Jason E., Till F. Sonnemann, Termeh Shafie, Corinne L. Hofman, Ulrik Brandes, and Gareth R. Davies. 2017. "Investigating human geographic origins using dual-isotope (87Sr/86Sr, δ18O) assignment approaches." PloS one 12, no. 2: e0172562.

Ma, Chao, Hannah B. Vander Zanden, Michael B. Wunder, and Gabriel J. Bowen. 2020. "assignR: An R package for isotope-based geographic assignment." Methods in Ecology and Evolution 11, no. 8: 996-1001.

191. An approach to establishing a workflow pipeline for synergistic analysis of osteological and biochemical data. The case study of Amvrakia in the context of Corinthian colonisation between 625-200 BC in Epirus, Greece.

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Introduction

Bioarchaeology has laboured for many decades to reconstruct the living conditions and socioeconomic aspects of past human experiences through the study of skeletal remains. In lack of either material or textual evidence, bioarchaeological approaches hold great value in developing a synergy effect with historical, demographic and archaeological data. Within the vastly broad area of bioarchaeological research lies oral pathology, and stable carbon and nitrogen analysis. These approaches are regarded today as powerful tools for archaeologists to monitor the shifts in the carbohydrate intake and the dietary protein consumption of past populations. Several previous studies have demonstrated the combination of both stable isotopic and dental health data to shed light on the lifestyle, diet, nutrition, and subsistence economies of past populations. Despite the significant efficiency in the correlation process of bioarchaeological data through varied statistical analyses, the estimations are still performed by the observation, interpretation and comparison of different statistical plots. To avoid time-consuming procedures, we generated a tool that enables the researcher to automatically find if there are any correlations between dental pathologies and isotope values.

Our research is part of an ongoing project entitled "APOIKIA: Ancient DNA analysis in novel multidisciplinary approach of ancient Corinthian colonization. Ancient Amvrakia and Ancient Tenea as demonstration examples". Amvrakia was officially founded in 625 BC during various colonisation endeavours of the Corinthians in Epirus, Greece. Five research institutes have partnered to enhance the archaeological research on the phenomenon of colonisation by elaborating current lines on the scientific network or carving new ones. The study presented here focuses on the osteoarchaeological and biochemical research field of the project.

Material and Methods

The osteoarchaeological material comes from various excavational periods of the Western Necropolis (WN) of Amvrakia that took place between 1993-2022. The WN of Amvrakia is one of the biggest and most undivided necropolises excavated so far in Greece yielding more than 600 tombs, burials and assemblages which in turn account for more than 1000 individuals. The fragmented state of preservation posed the challenge of establishing a convenient methodology for filtering and selecting the most appropriate samples for isotope analysis (Adams and Konigsberg 2008).

The methodology was designed on the basis of novel approaches to data collection and FAIR principles (Schmidt and Marwick 2020). Proprietary software is used as minimally as possible and only for transitioning from old but established methodologies into new tools based on free and preferably open-source software. The principle behind this is to maximise the longevity of data and maintain their expediency.

In particular, we create R programming language scripts that correlate paleodemographic, -pathological and isotope data by following revised methodology and utilising free cloud webware.

Results

We are presenting here a workflow pipeline that affords the researchers to simultaneously work on different types of data. By utilising free cloud webware they can record data simultaneously and collaborate in real-time even if their research workplaces are distant. We then tidy the data in the programming environment in order to extract correlation plots. Finally, we present the results in a suitable format for publication.

Furthermore, the current study has highlighted the opportunity to advance bioarchaeological studies through simulation models equivalent to the ones that have been presented in archaeological literature in the last decade (Chliaoutakis 2020). We are studying new ways to apply bioarchaeological data in Agent-Based Modelling in order to investigate correlations among spatial data of trading networks, archaeological data of the social organisation, and osteological data on stress markers and diet.

Discussion

The need to integrate archaeological data such as grave findings and burial datings in future studies ordinated the study -from its initial stages already- to set an open framework for collecting data. Therefore, this methodology is considered adaptable to further implementations of research tools and integrations with “Little Minions in Archaeology” as introduced by the CAA community in 2018.

References

Adams, Bradley J., and Lyle W. Konigsberg. 2008. ‘How Many People? Determining the Number of Individuals Represented by Commingled Human Remains’. In Recovery, Analysis, and Identification of Commingled Human Remains, 241–55. Humana Press. https://doi.org/10.1007/978-1-59745-316-5_12.

Chliaoutakis, Angelos. 2020. ‘AncientS-ABM: Agent-Based Modeling of Past Societies Social Organization v1.0.0’. CoMSES Computational Model Library, April.https://www.comses.net/codebases/50cf5d2a-0f37-4d4d-84e0-715e641180d9/releases/1.0.0/.

Schmidt, Sophie C., and Ben Marwick. 2020. ‘Tool-Driven Revolutions in Archaeological Science’. Journal of Computer Applications in Archaeology 3 (1): 18–32. https://doi.org/10.5334/jcaa.29.

43. Synergies in 3D Spatial Analysis

Gary Nobles, Oxford Archaeology
Alexander Jansen, Durham University
James Taylor, University of York
Markos Katsianis, University of Patras

Location: Forum

The purpose of this session is to bring together researchers who are combining the diverse archaeological fields with 3D spatial analysis. This will mark the 3rd and final explorative session into the application of 3D Spatial Analysis across the archaeological discipline facilitated through the CAA's Special Interest Group in 3D Spatial Analysis. While not essential, we would appreciate speakers to consider how their thematic area of expertise (e.g. lithics, ceramics, A-DNA, botany, zoology, chemical (phosphate) etc.) or other analytical area combine in 3D space and how the benefits of analysis in 3D space can help to develop the greater narrative. We continue to ask the fundamental questions: – What do 3D and 2.5D approaches afford us beyond traditional 2D perspectives, with innovations in 3D spatial analysis continuing? – Why do we, as archaeologists, want to apply 3D spatial analysis, how would we apply it and what questions would it help answer? – What added complexities does working in three dimensions bring, how do we make the most of them, and how do we resolve or theorise around such complexities? Papers are invited from those who are working in three dimensions from across the diverse spectrum of applications. We particularly welcome papers which bring together different aspects of archaeological analysis within 3D space. Papers should go beyond presenting methodologies involving the capture of data, by instead discussing the analysis of 3D (or 4D) datasets. Any form of 3D spatial data is welcome, papers may push the boundaries (theoretically or technologically) or be presented as position papers. Amongst others, past topics have included:

- 3D Landscape Archaeology
- 3D Excavation and Post-excavation Analysis
- 3D Material Studies (e.g. lithics, ceramics)
- Geochemical Analysis in 3D space
- Investigating Visibility/Gaze/Gesture/Mobility and Perception in 3D space
- Machine Learning/AI in 3D Space
- 3D Networks and Semantic Modelling
- 3D Analysis in Virtual Reality

Submissions from young researchers/early career researchers are particularly welcome. We want to enable researchers to discuss ideas, whether or not you have access to the best data, funding, big computer systems, or underlying technical knowledge. Such positional papers should focus on what we want to get out of 3D spatial analysis. In this aspect we encourage 'blue-sky thinking' particularly if the tools and capabilities are not yet in existence. Presenters can select one of two formats for their paper: papers which are more exploratory and 'blue-sky' in nature may prefer a 10-minute lightning talk format, while those with a more traditional structure may be better suited for a 20-minute standard format. The author(s) should specify their preference when submitting their proposal. If in doubt, contact one of the session organisers well before the paper deadline. The session will conclude with a discussion bringing together the session's principal themes which emerge from the presented papers, and incorporating elements from the discussions of previous years. Facilitated through the 3D Spatial Analysis CAA SIG, we endeavour to keep these discussions continuing beyond the meetings at CAA International.

SLOT 2	
10:30 - 10:50	314. Digital surface models of crops used in archaeological feature detection -case study at the site of Tomašanci-Dubarava in Eastern Croatia *Rajna Sosic Klindzic (University of Zagreb Faculty of Humanities and Social Sciences)*; Miroslav Vuković (University of Zagreb); Hrvoje Kalafatic (Institute of Archaeology Zagreb); Bartul Siljeg (Institute of Archaeology Zagreb)*
10:50	282. The Art of Dimensional Space - starlight, star bright *Gail Higginbottom (Incipit CSIC, Santiago de Compostela)*; Vincent Mom (DPP)*
11:10	137. From shape to grow conditions: a workflow combining micro-3D scanning, geometric morphometrics and machine learning for the analysis of past agricultural strategies. *Hector A. Orengo (Landscape Archaeology Research Group, Catalan Institute of Classical Archaeology)*; Alexandra Livarda (Landscape Archaeology Research Group, Catalan Institute of Classical Archaeology); Alexandra Kriti (Landscape Archaeology Research Group, Catalan Institute of Classical Archaeology); Ioannis Mylonas (Institute of Plant Breeding & Genetic Resources); Elissabet Ninou (Department of Agriculture, International Hellenic University)*

11:30	88. Grouping artefacts from archaeological deposits: 3D GIS and the interpretation of site formation *Joshua Emmitt (University of Auckland)*; Matthew Barrett (University of Auckland); Sina Masoud-Ansari (University of Auckland); Rebecca Phillipps (University of Auckland); Simon Holdaway (University of Au(ckland)*
SLOT 3	
13:00	99. Re-visualising Glazed Bricks of Ashur: From a puzzle to a 3D model *Anja Fügert (German Archaeological Insitute); Sebastian Hageneuer (University of Cologne)**
13:20	271. Best of both worlds: Visibility analysis of objects of different sizes based on algorithms and experimental studies *Kamil Kopij (Jagiellonian University, Institute of Archaeology)*; Kaja Głomb (Jagiellonian University, Institute of Applied Studies);*
13:40	54. Topology-based Scar Detection on Paleolithic Artifacts in 3D *Jan Philipp Bullenkamp (Martin-Luther University of Halle-Wittenberg, Institute of Computer Science)*; Florian Linsel (Martin Luther University of Halle-Wittenberg, Institute of Computer Science); Hubert Mara (MLU - Instiut für Informatik)*
14:00 - 14:20	20. Theorizing Time and Change for 3D GIS *Elaine A Sullivan (University of California, Santa Cruz)**
14:20 - 14:40	352. Photogrammetric documentation in 3D analysis of an Early Medieval burial mound in Kazimierzów, Poland. *Jakub Stępnik (Jagiellonian University, Institute of Archaeology)**
14:40 - 15:00	**Discussion**

SLOT 4	
15:30	377. Building and using an integrated 3D database *Rosie Campbell (University of Cambridge); Michael Boyd (The Cyprus Institute); James Herbst (The American School of Classical Studies in Athens); Hallvard R Indgjerd (Museum of Cultural History, University of Oslo)*; Nathan Meyer (University of California, Berkeley)*
15:50	33. All datasets are Meshes: Towards a new Ontology for 3D GIS *Paul Harwood (Runette Software Ltd)**
16:10	**Discussion**

314. Digital surface models of crops used in archaeological feature detection -case study at the site of Tomašanci-Dubarava in Eastern Croatia

Rajna Sosic Klindzic, University of Zagreb Faculty of Humanities and Social Sciences
Miroslav Vuković, University of Zagreb
Hrvoje Kalafatic, Institute of Archaeology Zagreb
Bartul Siljeg, Institute of Archaeology Zagreb

Introduction

The neolithic landscape of the Sopot culture in the area of Đakovština in Eastern Slavonija has in recent years been intensively studied through various research projects. A vast network of settlements situated only a few kilometers apart was uncovered thanks to aerial archaeology. The sites were further confirmed and chronologically determined by magnetometry, excavations and field surveys. Due to the large number of potential settlements some of the sites were studied in more detail than the others, and the geophysical surveys with a magnetometer proved crucial in providing an additional layer of detail to the archaeological interpretation of the individual "sites". Suddenly the overlaying datasets revealed not only vast settlement areas but also individual features within the data which could potentially be attributed to ditches, houses, pits and multiple other undefined features.

Methods and materials

During recent field work conducted in the first half of 2022 on the site Tomašanci-Dubrava we aimed to get a more detailed aerial view of the area and of the archaeological features identified by previous aerial archaeology interpretations. A drone was engaged to acquire a set of vertical photographs over a large area where two distinct neolithic enclosures were visible. The goal was to capture a detailed orthophoto of the feature in a maturing crop, since the area was targeted for magnetometry surveys later in the season.

Results

The captured data revealed the targeted feature as a cropmark in a field of maturing industrial peas, but due to the uniform surface in each individual photograph we had to overcome technical problems during the image-based modelling process which will also be discussed in the scope of this paper. Fortunately, the data also provided us with an opportunity to generate a digital surface model model of the crop field which revealed different levels of plant growth corresponding to subsurface archaeological features.

Discussion

The digital surface model revealed the fact that the subsurface archaeological features affect the rate of plant growth and that this can be directly observed on detailed DSM models. This fact has wider implications because it can serve as a basis for future research in this area especially if we consider application on a larger level where ALS data or aerial photographs taken by the state geodesic service can be used to create DSM models of wider areas.

References

Kalafatić, Hrvoje ; Šiljeg, Bartul ; Šošić Klindžić, Rajna 2021, Filling the network gaps: Bračevci – Bašćine, new Neolithic circular enclosure and medieval village, Annales Instituti Archaeologici (1848-6363) XVII (2021), 1; 13-14

Šošić-Klindžić, Rajna; Meyer, Cornelius; Milo, Peter; Tencer, Tomas; Kalafatić, Hrvoje; Šiljeg, Bartul 2021 All Round: Workflow for the Identification of Neolithic Enclosure Sites of the Sopot Culture in Eastern Slavonia (Croatia), ArchéoSciences 45; 123-126 https://doi.org/10.4000/archeosciences.8980

Kalafatić, Hrvoje; Šošić Klindžić, Rajna; Šiljeg, Bartul 2020 Being Enclosed as a Lifestyle: Complex Neolithic Settlements of Eastern Croatia Re-Evaluated through Aerial and Magnetic Survey, Geosciences, 10, 10; 10100384, 19 https://doi.org/10.3390/geosciences10100384

282. The Art of Dimensional Space - starlight, star bright

Gail Higginbottom, Incipit CSIC, Santiago de Compostela
Vincent Mom, DPP

Context

This paper is part of the final reporting on the EU-funded project SHoW: Shared Worlds (project no 800236: e.g. Higginbottom 2020, https://link.springer.com/article/10.1007/s10963-020-09139-z). SHoW investigates the roles that landscapes, skylines and astronomy played in past peoples' lives in order to determine the cultural relatedness between people along Europe´s Atlantic Façade. Specifically, it investigates the types of visual-scapes people chose for the erection of their megalithic monuments within and across regions, that clearly seem to have some kind of related megalithic tradition, but which is not yet fully understood. Focusing on the periods of intensive monument building in prehistoric Iberia (c. 4500-2500 B.C.) and Britain (c.3100-900 B.C.), the project uses visualisation technology, along with interdisciplinary approaches, to assist in the reconstruction of past visual worlds of the megalith builders. By investigating the role of the natural world, this project upholds and extends UNESCO's Astronomy and World Heritage Thematic Initiative, for the project recognises that the way people observed the land and the sky in the past is a repository for people's perception of their world.

We have argued in the past that traditional archaeological location modelling, whilst informative about spatial patterns across a 2D spectrum, is limited in its contribution to understanding human choice about location. Therefore, whilst we use 2D models, our primary approaches also adapt and use statistical analyses and enhanced 3D GIS and immersion software. In this way, we have a far better chance of understanding the locational choices people made and confirming the likelihood of these apparent choices, including their connection to astronomical phenomena. The research questions that we are investigating here are - to what extent were past people interested in Stars, individually, or as a set of phenomena like asterisms or circumpolar bodies. Our approaches in the past have shown us that 3D space can help to develop a greater narrative of the past (Higginbottom 2020, Higginbottom & Mom 2020) and this new investigation is no exception.

Methods and materials

For this presentation, we use topographic, astronomic, and atmospheric data, along with information on human vision and 3D-rendering techniques. More specifically, for this paper, we use the 25m LiDAR data made freely available by the Galician Xunta and OS Terrain 50 (post spacing of 50m (DTM grid); vertical interval of 10m (Contours)) from the Ordnance Survey of United Kingdom. We employ the software Horizon to build 2D-360o vertical viewsheds or horizon profiles and 2.5D enhanced topographic panoramas (Smith, A. G. K. 2020. Horizon user guide and implementation notes. Documentation Version 0.16 January 1, 2020; http://www.agksmith.net/horizon.).

We use the ASCII data obtained through the same software for creating our own landscape polar plots The ASCII data contains three pieces of information sampled at regular intervals (of 0.01o) in azimuth around the full horizon, which gives 36,000 x (azimuth or direction) and y co-ordinates (angular altitude), along with the distance of each azimuthal point from the observing position to the horizon.

We present 32, 2D enhanced horizon profiles and 2.5D panoramic landscapes previously created for Higginbottom et al's 2022 Galician dolmen work, where each monument has one horizon profile; along with c.30 of the same for both new and previously investigated sites of western Scotland. We obtained the list of the directions of the dolmens' corridor or entrance axes, measured in the field from magnetic north (azimuth) and corrected to True North readings by Vilas-Estévez (2016: 41). The orientations of the axis of each standing stone monument were either from Ruggles 1984 or our own field work, measured in the field from magnetic north (azimuth) and corrected to True North readings. The orientations will be examined in relation to their landscape connections.

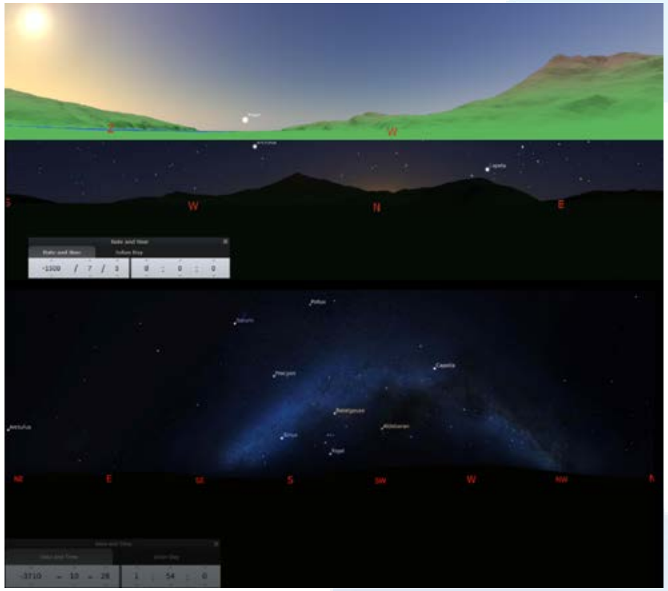
In the final visualisation stages, we inserted the above panoramic landscapes into the software Stellarium to create high-resolution 'videos' of the day and night skies at chosen dates and locations. These videos can be viewed in slow motion or real or accelerated time. Detailed astronomical behaviour as well as astronomical lighting effects can be effectively realised in this way (Figure 1). Finally, some sets of statistical analyses, along with comparative visual analyses between monuments were carried out.

Results & Outcome

We have previously demonstrated that prehistoric people in Scotland used the differences in natural light to illuminate the World around them at notable times of year through topographic choices (eg solstices, Higginbottom & Mom 2020), as well as through their monument orientations. In Galicia, we also saw that the monument builders chose very specific topographical locations for their dolmens (Higginbottom et al 2022a, https://doi.org/10.1080/20548923.2022.2078029 and astronomical targets for their dolmen axes (Higginbottom et al 2022b). We also saw that Time was 'staged' by prehistoric people at particular periods during the solar and lunar years, revealing the builders' own understanding off the progression of astronomical time in Bronze Age Scotland (Higginbottom & Mom 2021, doi:https://doi.org/10.1093/oxfordhb/9780198788218.013.36). This time, through 2.5D visualisation and statistics, we will demonstrate the relevance of individual stellar bodies, asterisms and the milky way for the builder's of prehistoric monuments. In this way, we thin the veil of our lack of understanding connected to past belief systems.

Non-doi References

Higginbottom, G., González García, A.C., Carrero-Pazos, M. & Vilas-Estévez, B. 2022b (accepted with minor revision) Landscape, orientation and astronomy in the 'Coast of Death' of NW Iberia. Submitted to Journal of the History of Astronomy. Ruggles, C.L.N. (1984). Megalithic Astronomy: A New Archaeological and Statistical Study of 300 Western Scottish Sites. British Archaeological Reports. Oxford: Archaeopress, 123. B. Vilas-Estévez, 2016. Were the megaliths of Galicia aligned …? MA Dissertation, University Wales - TSD



137. From shape to grow conditions: a workflow combining micro-3D scanning, geometric morphometrics and machine learning for the analysis of past agricultural strategies.

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Introduction

The shape of objects encloses information about their function. Geometric morphometrics (GM) in combination with statistical approaches have been employed to obtain quantifiable data about objects' shapes and use these data to define typologies and functionalities. Equally, animal bones (including human) and archaeobotanical remains have been analysed using similar approaches to obtain information, compare specimens and classify items.

During the last years the increased availability of 3D scanners and more efficient photogrammetry algorithms and software have facilitated the generation of 3D models of archaeological items. However, despite the multiplication of 3D models, little has been done to develop new workflows that can take advantage of the volumetric nature of these models and simple GM measures continue to be employed to define complex objects. Similarly, the questions under investigation have not evolved to take advantage of the detailed information that 3D models offer. This is even more evident in the case of archaeobotanical data, the small size (typically sub-centimetric) of which restricts their accurate 3D scanning.

In this paper we will present current ongoing work to develop a workflow based on a combination of micro-3D scanning, 3D GM and machine learning using archaeobotanical material. The objective is to go beyond the simple identification of seeds, to try identify the growing conditions of archaeological grains, which likely include the agricultural regimes employed by past societies.

Methods and materials

During the last two years a series of experimental cultivations of 23 varieties of barley under controlled agricultural regimes (including different degrees of irrigation and manuring) has been developed in collaboration with the Institute of Plant Breeding and Genetic Resources and the Hellenic University in Greece.

We have employed a metrology-grade 3D scanner to obtain digital twins of a selection of barley grains from different varieties experimentally grown under different agricultural regimes. Initial metrological comparison and quality analysis of a selection of these, has indicated the potential of full 3D shape analysis for the identification of past agricultural regimes as clear differences in shape have been identified between individual grains grown under different agricultural regimes. The next step in the workflow was the automated orientation and scaling of the grains which allowed the collection of 35 automatedly extracted measurements. These measurements were used to train a machine learning algorithm and apply it for the identification of different varieties of barley but also the agricultural regimes under which barley varieties were cultivated.

Results

Initial analysis and quality assessment (including Distance from Reference Mesh and Hausdorff Distance) show the scanning method faithfully represent grain shapes. Differences between scans of the same grains provided a maximum mean Distance from Reference Mesh of 5.527 µm to a minimum mean Distance from Reference Mesh of 0. 405 µm. Also marked differences between different varieties but also between the same varieties with difference cultivation regimes. For the few examples scanned up to now we have noticed mean differences of around 90 µm in seeds from the same varieties with similar cultivation regimes while those with different regimes showed mean differences of about 145 µm (0.145 mm).

Initial training of the machine learning algorithm showed mixed results with only a 62% accuracy. We believe this is due to the metrics selected (still not fully 3D aware) and the few training data still available.

Discussion

Although more scanning is necessary to obtain reliable data for the training and verification of the machine learning algorithm, the preliminary results of this workflow show excellent potential to differentiate between different varieties of the same species and also between different growth regimes. During the next few months the availability of training data will grow significantly allowing us to improve the algorithms. Also new 3D measures are being tested to improve the algorithm discriminatory capacity. This presentation will provide the last results and will discuss the methodological approaches and ways forward to extract important information enclosed in the shape of seeds. Given enough training data, this method could become a unique new tool for archaeobotanists as 3D scanning methods improve, become cheaper and more common.

88. Grouping artefacts from archaeological deposits: 3D GIS and the interpretation of site formation

Joshua Emmitt, University of Auckland
Matthew Barrett, University of Auckland
Sina Masoud-Ansari, University of Auckland
Rebecca Phillipps, University of Auckland
Simon Holdaway, University of Auckland

The recording of archaeological sites often involves the collection and depiction of features and deposits. In such cases artefacts may be represented as points, leaving relationships between artefacts up to interpretation and their association to perceived stratigraphic units. While this method has a long history in archaeology, it is also dependent upon the excavator and recording system to accurately identify contextual changes. In addition, the identification of depositional deposits may represent different processes than those that effected the deposited artefacts. An alternative is to use 3D density analysis to explore the relationships between artefacts in excavated contexts, which may then be related to deposits and features. Initially a visualisation method was developed to display clusters as a 3D density cloud, but the analytical value of this was limited. To move beyond visualisation, artefact points were clustered using DBSCAN as a way to isolate groups of artefacts that may be associated. Minimum numbers of artefacts and search distances are tested to find those that demonstrate the most meaningful clusters, and are compared against associated data such as artefact weight to better understand cluster composition. We test this method on an assemblage from Ahuahu Great Mercury Island, Aotearoa New Zealand.

99. Re-visualising Glazed Bricks of Ashur: From a puzzle to a 3D model

Anja Fügert, German Archaeological Insitute
Sebastian Hageneuer, University of Cologne

In the Neo-Assyrian period (9th–7th century BCE), the Temple of Ashur in the homonymous capital city Ashur (northern Iraq) bore a unique and impressive coloured glazed brick decoration. The reconstruction of this decoration is the aim of the ongoing GlAssur-Project, funded by the Deutsche Forschungsgemeinschaft (DFG) since 2018. Glazed bricks as building decor were then a novum for Mesopotamian architecture. The shiny, highly colourful, and water-proof surfaces which can be created with glazes were considered very attractive and glazed bricks were used to embellish and emphasise certain architectural features.

The excavations at Ashur led by the architect Walter Andrae took place between 1903 and 1914 under the auspices of the German Oriental Society (DOG). While working at the Ashur Temple the excavators unearthed 18 glazed brick facades still in situ, most of them dating to the 8th century BCE. Their representations are highly detailed, largely narrative in nature and often show the Assyrian king and his army conquering and destroying enemy cities. After carefully documenting the facades in descriptions, sketches and photographs they were dismantled and the bricks shipped to Berlin, were they are kept at the Vorderasiatisches Museum housed in the Pergamon Museum. When Andrae and his colleague Haller finally published their work on the Ashur Temple (1955), the sketches of the facades were considered lost, and the publication of the facades had to rely on the extant descriptions and photographs. In 2010 while working on a reassessment of the Ashur-Temple, its history and finds, Helen Gries fortunately rediscovered the sketches in the DOG archive (Gries 2017, 105–115).

In a database tailored to specific demands each of the more than 3000 bricks and brick fragments was measured and described, photographed under office- and UV-light and if possible, assigned to its former facade. Around 600 brick (fragments) were part of the facades found in situ. Reconstructing the original imagery of these facades is one main goal of the project. Based on the new photographic documentation, each brick is vectorized, distinguishing visually what is preserved and what is reconstructed. In the same way, the colours are reconstructed as well (Alloteau et al. 2022, 7–10). Finally, each facade is virtually and visually assembled. Placeholder bricks are filled in where bricks are missing and the original height of the image frieze in question is determined if possible. The final step is the visual reconstruction of the motifs in comparison to Neo-Assyrian imagery known from contemporary reliefs, wall-paintings etc.

Besides the reconstruction of the motifs and facades, another main goal of the project is the virtual reconstruction of the Ashur Temple itself and the positioning of the reconstructed and colourised motifs on its facades based on the excavation reports as well as the latest literature (Haller and Andrae 1955; Gries 2017). The positioning of the motifs upon the 3D model enables us to study the visibility and spatial distribution of the facades and to evaluate the possibility to detect even the richly decorated details of the motifs under varying light conditions. In this talk, we want to present our methods and findings of the digital reassembling, reconstruction, and analysis. Specific to the session S43, we would prefer a traditional 20-minute standard format.

Bibliography:

- Alloteau, Fanny, Odile Majérus, Floriane Gerony, Anne Bouquillon, Christel Doublet, Helen Gries, Anja Fügert, Ariane Thomas, and Gilles Wallez. 2022. "Microscopic-Scale Examination of the Black and Orange–Yellow Colours of Architectural Glazes from Aššur, Khorsabad and Babylon in Ancient

Mesopotamia” Minerals 12, no. 3: 311. https://doi.org/10.3390/min12030311

- Gries, H. 2017. „Der Assur-Tempel in Assur. Das assyrische Hauptheiligtum im Wandel der Zeit“, Wissenschaftliche Veröffentlichungen der Deutschen Orient-Gesellschaft 149, Wiesbaden.
- Haller, A., Andrae, W. 1955. „Die Heiligtümer des Gottes Assur und der Sin-Šamaš-Tempel in Assur“, Wissenschaftliche Veröffentlichungen der Deutschen Orient-Gesellschaft 67, Berlin.

271. Best of both worlds: Visibility analysis of objects of different sizes based on algorithms and experimental studies

Kamil Kopij, Jagiellonian University, Institute of Archaeology
Kaja Głomb, Jagiellonian University, Institute of Applied Studies

The visibility analysis has been a popular research direction in recent decades (an overview of the topic with further literature: Verhagen, 2018: 18–19). The most popular tools, GIS-based methods, do not take into account the maximum distance from which variously sized objects or body parts are visible. The question of the visibility of objects of different sizes has already been raised in the literature, and several solutions have been proposed to modify GIS-based visibility analysis (cf. Bornaetxea and Marchesini, 2021; Fisher, 1994; Ogburn, 2006; Wheatley and Gillings, 2000). Cognitive neuroscience research suggests that the human silhouette is processed differently from ordinary inanimate objects, and this process resembles the analysis of the face (Stekelenburg and de Gelder, 2004). This type of visual processing is qualitatively different from object processing, so the use of tools designed for this class is insufficient for the analysis of the visibility of hand gestures and facial expressions. In our paper, we would like to present the results of a comparison of the visibility analysis using modifications of GIS-based analyses published to date with the experimental results. For the latter, we will rely on the results of our experiments for the maximum visibility of rhetorical hand gestures, while for the visibility of facial expressions we will rely on the results of the classic experiment by Hager and Ekman (1979). The aim is not only to compare the different methods but also to present a model of the visibility of hand gestures and facial expressions.

Bornaetxea, T, Marchesini, I (2021) r.survey: a tool for calculating visibility of variable-size objects based on orientation. International Journal of Geographical Information Science, 00(00): 1–24. https://doi.org/10.1080/13658816.2021.1942476

Fisher: F (1994) Probable and fuzzy models of the viewshed operation. In Worboys, MF (ed) Innovations in GIS 1: selected papers from the First National Conference on GIS Research UK. London: Taylor and Francis, pp. 156–170.

Hager, JC, Ekman P (1979) Long-distance of transmission of facial affect signals. Ethology and Sociobiology, 1(1): 77–82.

Ogburn, DE (2006) Assessing the level of visibility of cultural objects in past landscapes. Journal of Archaeological Science, 33: 405–413. https://doi.org/10.1016/j.jas.2005.08.005

Stekelenburg, JJ, de Gelder, B (2004) The neural correlates of perceiving human bodies: an ERP study on the body-inversion effect. Neuroreport, 15(5): 777–780. https://doi.org/10.1097/00001756-200404090-00007

Verhagen P (2018) Spatial Analysis in Archaeology: Moving into New Territories. In Siart, C, Forbriger, M, Bubenzer, O (eds) Digital Geoarchaeology. Natural Science in Archaeology. Cham: Springer, pp. 11–25. https://doi.org/10.1007/978-3-319-25316-9

Wheatley, D, Gillings, M (2000) Vision, perception and GIS: developing enriched approaches to the study of archaeological visibility approaches to the study of archaeological visibility. In Lock, G (ed) Beyond the Map: Archaeology and Spatial Technologies. Amsterdam: IOS Press, pp. 1–27.

54. Topology-based Scar Detection on Paleolithic Artifacts in 3D

Jan Philipp Bullenkamp, Martin-Luther University of Halle-Wittenberg, Institute of Computer Science
Florian Linsel, Martin Luther University of Halle-Wittenberg, Institute of Computer Science
Hubert Mara, MLU - Instiut für Informatik

Stone tools are the name-giving central object classes for the longest chronological period of tool manufacturing, the Palaeolithic and hence gives us insights into the habits of early humans and the development of the human-tool-relationship. All human species, including the Neanderthals and anatomically modern humans (AMHs), have used at one point stone tools to cut, scrape or pierce other mostly organic material. These lithic tools are among the few surviving artifacts that can shed light on the different paths of evolution and extinction.

A central indicator for a strategy is the shape of a lithic artifact in all its surface details like scars and ridges. With anthropology successfully applying Geometric Morphometrics (GM) for shape analysis we were inspired to follow this approach implementing computerized methods.

One of the central analysis of stone tool manufacture is the investigation of scars. A scar is a rather concave area on the surface of an artifact, which is the remnance of a production step, a step from a raw material, unprepared nodule to functioning tool. Each of these steps are percussion or applied pressure to remove a layer, a flake, from the surface of the nodule. The main criteria for determining a production strategy are morphologic measures like roughness of convex ridges and especially concave scars.

The complex scar ridge pattern is often captured on manual drawings created by tracing photographs. For simple measures and to grasp an overview those drawings are helpful. However, like many other archaeological findings even the simplest lithic tool is a three dimensional objects. So we choose to apply the GM concepts directly to the surface captured with 3D acquisition techniques, which become more easily available for archaeological documentation overcoming the past obstacles of acquisition time and cost. So we start our analysis with cleaning and orientating the 3D-dataset, which are automatically enriched with technical metadata using the GigaMesh Software Framework as in Homburg et al., 2021. The next step is the application of the Multi-Scale Integral Invariant (MSII) filtering providing numerical values of surface curvature on the 3D mesh.

Given such a meaningful scalar function on a mesh, discrete Morse theory (DMT) provides us with a skeleton of extremal lines on the mesh. The maximal lines naturally lie on the ridges of lithic artifacts, so we just filter out minimal lines following valleys and less significant maximal lines induced by noise. Due to the soundness of the underlying topological method, we further get enclosed areas that can be merged together based on the found ridges and allow us to get a segmentation of the scars on the artifact.

For validation we have created a statistically significant subset of manually segmented simple and complex lithic tools from a dataset by Falcucci and Peresani, 2022, being available via Open Access. We evaluate the correctly found scars and show results of our DMT segmentation method using the best results possible when pipelining a range of parameters as well as a user guided approach in a graphical user interface. In addition we compare our results to the state of the art scar segmentation method by Richardson et al., 2014.

References:

Falcucci, Armando, and Marco Peresani. (2022). The Open Aurignacian Project. Volume 1: Fumane Cave in northeastern Italy. Version 1.0.0. https://doi.org/10.5281/zenodo.6362150.

Homburg, Timo, Anja Cramer, Laura Raddatz, and Hubert Mara. 2021. Metadata schema and ontology for capturing and processing of 3d cultural heritage objects. Heritage Science 9 (1): 1–19.

Richardson, Eitan, Leore Grosman, Uzy Smilansky, and Michael Werman. 2014. Extracting Scar and Ridge Features from 3D-scanned Lithic Artifacts. Archaeology in the Digital Era: 40th Annual Conference of Computer Applications and Quantitative Methods in Archaeology (CAA): 83–92. https://doi.org/10.1515/9789048519590-010.

20. Theorizing Time and Change for 3D GIS

Elaine A Sullivan, University of California, Santa Cruz

Context:

As 3D modeling technologies have increased in sophistication in the past two decades, so have the techniques used by scholars to represent the complexities of spatial archaeological data. 3D projects have included techniques to incorporate data uncertainty, visualizations integrated with original excavation documentation, models with embedded (and accessible) metadata and paradata, and multiple reconstructions of the same space based on alternative theories. But despite these advances for 3D analysis and presentation in general, there has still been a lack of theoretical engagement with the question of time.

The discipline of Archaeology has a long history of creatively imagining new ways to conceptualize chronology, developing pottery sequences, artifact seriation, tree-ring analysis, and radio-carbon dating to effectively investigate issues of change over time. One would expect that within the current computer revolution in the discipline, especially in the adoption of 3D and 3D GIS for field collection and data visualization, similar interest for developing new techniques to represent change over time would be of major interest. While industry and transportation have made significant leaps in incorporating time and temporal change in GIS systems in the past decades, the unique nature of archaeological data have not allowed for the same fundamental advances.

Indeed, more than twenty-five years after the publication of their article Timing is Everything, Daly and Lock's critique that 2D GIS are limited by their "inability to successfully incorporate temporal attributes in a meaningful and productive fashion… [and] are in no way reflective of the ways that past people, society, or culture situated and understood their activity" still rings true for 3D GIS (Daly and Lock, 1999, 289). A decade later, Gregory's lament that "we need to be able to take the crude representations of [time] that occur in databases, such as date fields or the names of eras, and interpret these in the more subjective, culturally specific and complex ways" duplicated the earlier arguments of Daly and Lock (2008). Taylor, in a 2020 summary of the representation of time in GIS, traced minimal advances in the field, stating that "the integration of spatial and temporal data, and its subsequent analyses remains relatively simplistic, and even somewhat elusive within the fundamental data structures that underpin the discipline" (Taylor 2020).

Project Summary & Implications:

This presentation will use a geo-temporal 3D GIS visualization model of the ancient Egyptian site of Saqqara, published in an open-access monograph with Stanford University Press in 2020, as a case-study to illuminate the field of Archaeology's problematic lack of interest in developing new means to visualize complex change over time. The Saqqara model visualizes architectural and environmental shifts at the site across 2500 years through the use of animated 'time slices,' one of the commonly used techniques in 2D GIS (Taylor 2020, 414-15). While the affordances of 3D GIS now allow for forms of spatial analysis that are inclusive of height and volume the underlying data models for 'time slice' chronology still parallels that of traditional GIS: individual elements are given a start and end time/date as a type of 'attribute.' These slices are linked to absolute dates or date ranges that reflect modern concepts of time and linearity.

My experience building the 3D model of Saqqara and attempting to represent complex change in a 3D GIS system illuminated the many challenges inherent in representing non-modern temporalities in GIS systems. In this presentation, I will review some of these issues and suggest that the existing ways we deal with time in 3D emerge directly from 2D GIS and replicate the inadequacies of that medium. I will suggest that the field needs to think more seriously about visualizing chronology and use the affordances of 3D to develop better strategies to incorporate aspects of the temporal systems of the cultures we are recording. The display of temporality is one critical aspect of a 3D spatial analysis, and the choices we make in its representation have profound effects on the output and conclusions of our projects. In imagining a truly 4D spatial analysis for Archaeology, I argue we need to conceive of and design new methods of interacting with data visualizations that expand our opportunities beyond the simplistic options commonly used today.

Citations:

Daly, Patrick and Lock, Gary. 1999. "Timing Is Everything: Commentary on Managing Temporal Variables in Geographic Information Systems." In New Techniques for Old Times. CAA98. Computer Applications and Quantitative Methods in Archaeology. Proceedings of the 26th Conference, Barcelona, March 1998, edited by Barceló, J.A., 287–96. BAR International Series 757. Oxford: ArchaeoPress.

Gregory, Ian. 2008. "Using Geographic Information Systems to Explore Space and Time in the Humanities." In The Virtual Representation of the Past, edited by Mark Greengrass and Lorna Hughes, 135–46. Farnham: Ashgate.

Taylor, James. 2020. "Space and Time." In Archaeological Spatial Analysis. Routledge. https://doi.org/10.4324/9781351243858

352. Photogrammetric documentation in 3D analysis of an Early Medieval burial mound in Kazimierzów, Poland.

Jakub Stępnik, Jagiellonian University, Institute of Archaeology

Methods

For years we as the Chodlik Archaeological Mission under the Polish Academy of Sciences have been excavating a small region of Chodelska Valley in the Lubelskie voivodship in Eastern Poland, a center for a local chiefdom before the expansion of the Piast Kingdom in 10th century. The main archaeological site of the area is a large stronghold in Chodlik with a triple rampart that covers an area of 8 ha (Miechowicz 2018:12-21). A group of burial mounds was found on the outskirts of the valley, near the rampart protecting the road through the swamps. The excavations were conducted on one of them, dating to the 8-9th centuries. What is found from the burial customs of this community are hundreds of cremated bones scattered on the top of the mounds. The excavations covered an area of ca. 100 square meters within the dense forest. Work proceeded with trowels, with each level (2-5 cm thick) documented with traditional drawings, orthophotography, and photogrammetry with each artifact measured with a tachymeter. yet the main methodological goal was to challenge the idea that photogrammetric documentation located within virtual reality could be used instead of a tachymeter for taking the measurements. Based on our test of this method, we argue that this methodological replacement would shorten the preparation time of field documentation and in some conditions be more reliable than tachymeter recording. It would also provide new tools for the analysis of archaeological sites.

During the excavations, 325 pieces of pottery, 1408 cremated bone fragments, dozens of flints, and several metal artifacts were found. We applied color markers to each group of the finds so that they could be recognized by the camera, allowing us to place them within photogrammetric models. The usual number of photographs taken for each section was approximately 100, out of which 40 were used for processing. The models created in Agisoft Metashape® were imported to Blender® and placed within a 3D space, that was created analogically to the tachymeter-measured grid, creating virtual reality for the excavations. This way the location of each find visible on the photogrammetric model should match its score from the tachymeter. Creating a new 3D marker within the Blender grid, therefore, would create a three-dimensional planigraphy of the finds, while the photogrammetrical models of each excavated level would provide necessary information about the layers. More generally, this type of photogrammetric documentation gathering within Blender®, would create a useful database for future analysis, especially if the excavation works were to be continued.

Results

Photogrammetry as a tool in archaeology has already been proven and in recent years has become more of a regular practice during excavations (Marín-Buzón, Pérez-Romero, López-Castro Ben Jerbania and Manzano-Agugliaro 2021). Yet its advantage has mostly been found in creating orthophotographical images for traditional style drawings. However, work at different sites has already demonstrated that more can be done with three-dimensional data and more should be done with such data (Forte, Dell'Unto, Issavi, Onsurez and Lercari 2012). Our study has shown just that and constituted yet another case study. More specifically, we have found that even during regular excavations of burial mounds more information can be gathered just by amassing photogrammetric documentation of each level. Further, in certain conditions, photogrammetric documentation shortens the time spent on tachymeter data collection and precise traditional documentation. As an example, saving the location of 100 bone fragments would take approximately 30 minutes, while creating a working 3D model of the area using photogrammetry could be several times faster in the field. Finally, the added value is larger coverage with photographic documentation, allowing investigations of any anomalies found below after evidence collection.

Discussion

The method applied in our excavations does not exceed the time spent on creating drawings and capturing 3d points during scientific excavations and provides more ways to use documentation afterward. However, in order for it to be useful, certain conditions have to be met. Firstly, the field methods must match the idea of documentation. The field markers of the artifact locations must be placed where the artifacts were found therefore very shallow layers could be explored each time. Secondly, a proper methodology of photogrammetry must be maintained, which can present an issue in different light and weather conditions. Thirdly, the most proper and organized field methods are essential for its application to be mistake-free.

Photogrammetric methods of field documentation, such as those employed by us, should not exclude the use of more traditional methods - tachymeter and traditional drawings. However, their simplicity and usefulness as secondary tools should be stated. Further, there can be many different circumstances, in which a tachymeter is not available or physically can not be used, and in such cases, archaeologists should not dismiss gathering the 3D measurement data from the site. Lastly, this method makes more widespread application of 3D techniques possible, as the costs of a high-quality camera are significantly lower than those of advanced surveying equipment.

In terms of small-scale excavations, the method can be used as a Blender database for photogrammetry, additionally enabling measurements, presentation of data, and analysis of archaeological contexts, as well as further reconstruction of the site based on all of the records taken at it. What is more, the amount of gathered data for future analysis in itself makes the more frequent conduct of photogrammetric documentation during excavations worth it.

Bibliography:

Forte, Maurizio, Dell'Unto Nicolo, Issavi, Justine, Onsurez, Lionel, Lercari, Nicola. 2012. "3D Archaeology at Çatalhöyük." International Journal of Heritage in the Digital Era. 1(3), 351–378. https://doi.org/10.13140/2.1.5120.0649.

Marín-Buzón, Carmen, Antonio Pérez-Romero, José Luis López-Castro, Imed Ben Jerbania, and Francisco Manzano-Agugliaro. 2021. "Photogrammetry as a New Scientific Tool in Archaeology: Worldwide Research Trends." Sustainability 13 (9): 5319. https://doi.org/10.3390/su13095319.

Miechowicz, Łukasz. 2018. "Wczesnośredniowieczne grody nad Chodelką i ich zaplecze osadnicze." Historia Slavorum Occidentis 17 (2): 11–41. https://doi.org/10.15804/hso180201.

377. Building and using an integrated 3D database

Rosie Campbell, University of Cambridge
Michael Boyd, The Cyprus Institute
James Herbst, The American School of Classical Studies in Athens
Hallvard R Indgjerd, Museum of Cultural History, University of Oslo
Nathan Meyer, University of California, Berkeley

While modelling techniques such as structure-from-motion photogrammetry are becoming more and more common in archaeological practices, rarely has it been used for more than visualisation purposes or to support the process of manual field drawings (Magnani et al., 2020). It is important to move past the phase of record keeping and visualisation, toward that of significant interpretative value. The improved capacity of computer specifications, normalisation of photogrammetric and 3D modelling as means of archaeological recording, and the increased capacities of current 3D GIS software, have created an ideal environment to develop and expand the use of the third dimension in archaeological analysis.

This paper presents an example of a 3D GIS environment that incorporates site data in synthesis with image-based 3D models of each stratigraphic context and structure excavated at the site. Such a 'true 3D GIS system', encapsulating all the abilities of a traditional GIS, including data entry, database management, data analysis and manipulation, gives access to all excavation data within a single platform, making the tool data-driven and research-oriented. This is built as an interface for running comparative queries across the trenches and aiding site interpretation by way of spatial analysis. Furthermore, it will act as an interactive database, where site data, photographs, and specialist data and interpretations can be accessed in a single environment. The overarching goal is to improve the integration of separate classes of archaeological data – 3D, 2D GIS, tabular finds data and measurements, photographs, and descriptions – through the creation of a unified system that streamlines interpretation and analysis into a single project centred around 3D models.

Data from the most recent excavations of the Early Bronze Age (EBA) site of Dhaskalio, Greece, excavated in the 2016 - 2018 field seasons are used in the current presentation. The recording strategy employed in the field is discussed in detail in Boyd et al. (2020). It included an extensive photogrammetry program, which created the basis for this project. While UAV was used for site-wide image-based models, DEMs and orthomosaics, the 3D models were mainly based on hand-held terrestrial cameras. Both intra-site and micro-level recordings were made of the architecture, stratigraphic units and layers, and other features, giving a three-dimensional representation of each taphonomic event. Finds and samples, including structured chemical sampling of all surfaces, was also recorded in three dimensions.

The authors will discuss the experiences and challenges encountered when implementing the system and opening it for use by project participants with varying use cases and levels of technical know-how in the post excavation analysis and write-up phase. We aim highlight the areas where the system added analytical value, but also pinpoint pitfalls and propose workarounds for future implementations.

References

Boyd, M.J., Campbell, R., Doonan, R., Douglas, C., Gavalas, G., Gkouma, M.,Halley, C., Hatzler, B., Herbst, J., Indgjerd, H., Krijnen, A., Legaki, I.,Margaritis, E., Myer, N., Moutafi, I., Piree Iliou, N., Wylie, D. & Renfrew,C. 2021. Open Area, Open Data: Advances in Reflexive Archaeological Practice. Journal of Field Archaeology, 46:2, 62-80. https://doi.org/10.1080/00934690.2020.1859780

Magnani, M., Douglass, M., Schroder, W., Reeves, J. & Braun, D.R. 2020. The Digital Revolution to Come: Photogrammetry in Archaeological Practice. American Antiquity, 85(4), 737–760. https://doi.org/10.1017/aaq.2020.59

33. All datasets are Meshes: Towards a new Ontology for 3D GIS

Paul Harwood, Runette Software Ltd

Context

Over a number of years there has been some discussion about an epistemology of three-dimensional GIS and various foundational ontologies for higher-dimensional GIS have been proposed and discussed.

This paper proposes a fundamental change to the ontological basis of multidimensional GIS: that 'all multidimensional geographic data sets are meshes'.

Main Argument

The paper will argue the following:

- That all of the data sets are useful in GIS can be represented using "meshes", also known as spatial networks or geometric graphs, and
- That in most cases such a definition brings real benefits over the current practices (noting that in the case of points, point processes and point clouds although they can be defined as zero-dimensional graphs this definition is trivial and brings no benefit), and
- That the current ontologies based on a division between raster and vector types are based on an invalid dichotomy and bring negative utility that becomes more difficult as the number of dimensions increases.

The paper will argue from first principles of graph theory and network science as well as using practical examples of multi-dimensional data analysis in Python using MDAL to demonstrate the value of the approach.

Implications

It has been argued in an Archeological context that Network Science "provides the natural framework to transcend the dualism between physical and relational space"[Rivers et al 2013 p129]. It has also been said that "Complexity scientists argue that a scientific method is needed to bridge the gap between "the reductionist study of parts...to the constructionist study of the related whole", and this is exactly what a networks perspective allows us to do." [Brughmans 2013, p3].

Basing GIS analysis on a more correct mesh/network based ontology both improves the analytical mechanisms that can be used and removes methodological barriers to a better understanding of the data.

References

Bevan, Andrew, & Lake, Mark. (2013). Computational approaches to archaeological spaces / edited by Andrew Bevan, Mark Lake. (Publications of the Institute of Archaeology, University College London; 60). Oxford: Routledge (ebook retrieved from Google Play July 2018)

Brughmans, Tom (2013) Thinking through networks: a review of formal network methods in archaeology. Journal of Archaeological Method and Theory, 20 (4), 623-662. (https://doi.org/10.1007/s10816-012-9133-8).

Rivers, Ray, Knappett, Carl & Evans, Tim(2013) "Network Models and Archeological Space" in Bevan & Lake 2013.

07. Open Analytical Workflows and Quantitative Data Integration in Archaeological Prospection

Karsten Lambers, Leiden University (NL – Dept. of Archaeological Sciences, Faculty of Archaeology)
Jitte Waagen – University of Amsterdam (NL – Faculty of Humanities)
Philippe De Smedt – Ghent University (BE – Faculty of Bioscience Engineering; Faculty of Arts and Philosophy)
Martijn van Leusen – University of Groningen (NL – Faculty of Arts, Groningen Institute of Archaeology)

Location: E103

This session invites contributions from the field of prospective archaeology that address the design of open, reproducible, and transferable workflows for archaeological and environmental data processing, analysis and interpretation and/or quantitative data integration across different sensors, modalities and scales for the study or archaeological landscapes.

In recent years, archaeological prospection has benefited enormously from the increasing quantity, quality and availability of digital data from remote sensing and geophysics that record selected environmental parameters across space, often at high resolution. This wealth of data now allows archaeologists to go beyond the traditional remit of archaeological prospection, namely the detection and mapping of traces of past human activity, and to study landscapes and the ecological and anthropogenic processes that formed them over time from a holistic perspective.

However, the full potential of this approach is often not realized in the practice of archaeological research and heritage management due to a limited availability of skills, tools and protocols. Many projects focus on specific data types or analytical methods, without making use of additional sources of information that would also be available and might be able to add important interpretative dimensions. Often, the choice of data and methods is motivated by practical constraints rather than analytical potential. Also, the joint analysis of remote sensing or geophysics data and data from field observations (e.g., surface survey, corings, excavations) is often performed on a qualitative level only, due to a lack of suitable protocols for a combined quantitative analysis.

Another common problem is that many projects create ad hoc solutions for their analytical and interpretative workflow that are not easily reproducible or transferable to other projects. There is still a lack of open, standardized protocols and workflows that can be applied to a variety of cases, even though promising approaches exist (e.g., Lozić & Štular 2021). Further inspiration may be drawn from other domains that often use the same environmental data, e.g. ecology, geomorphology or soil science. Here, the development of open analytical and interpretative workflows that allow the integration and joint quantitative analysis and interpretation of data from remote sensing and field observations is further advanced than in archaeology (see, for instance, Ghamisi et al. 2019; Chatterjee et at. 2021).

In this session, we welcome papers that showcase and evaluate novel approaches to analytical workflows and data integration in archaeological prospection. Alongside case-studies that offer concrete examples of these issues in archaeology and presentations of workflows and theoretical frameworks, we encourage contributions on best practices in associated fields and their relevance for archaeological applications.

References

Ghamisi, P.; Rasti, B.; Yokoya, N.; Wang, Q.; Hofle, B.; Bruzzone, L.; Bovolo, F. et al. 2019. Multisource and Multitemporal Data Fusion in Remote Sensing: A Comprehensive Review of the State of the Art. IEEE Geoscience and Remote Sensing Magazine 7, 6–39. https://doi.org/10.1109/MGRS.2018.2890023.
Chatterjee, S.; Hartemink, A. E.; Triantafilis, J.; Desai, A. R.; Soldat, D.; Zhu, J.; Townsend, P.; Zhang, Y. and Huang, J. 2021. Characterization of Field-Scale Soil Variation Using a Stepwise Multi-Sensor Fusion Approach and a Cost-Benefit Analysis. CATENA 201, 105190. https://doi.org/10.1016/j.catena.2021.105190
Lozić , E.; Štular, B. 2021. Documentation of Archaeology-Specific Workflow for Airborne LiDAR Data Processing. Geosciences 11, 26. https://doi.org/10.3390/geosciences11010026

SLOT 3	
13:00	331. Conducting soil surveys – orchestrating change: developing practices to enable an integrated approach to agricultural and archaeological management *Eamonn Baldwin (University of Glasgow)*; Rachel Opitz (University of Glasgow); Philippe De Smedt (BE); Stefano Campana (University of Siena); Victorino Mayoral (Merida Institute of Archaeology); Marco Vieri (University of Florence); Carolina Perna (University of Florence); Daniele Sarri (University of Florence)*
13:20	353. Taming Complexity: the rocky road from qualitatively accurate to quantitatively precise data analysis and interpretation in archaeo-geophysical survey *Agnes Schneider (Leiden University)**

13:40	109. Documenting drone remote sensing: a virtual reconstruction approach *Jitte Waagen (Universiteit van Amsterdam)**
14:00 - 14:20	18. Survey Planning, Allocation, Costing and Evaluation (SPACE) Project: Developing a Tool to Help Archaeologists Conduct More Effective Surveys *Edward B Banning (University of Toronto)*; Steven Edwards (Nova Scotia Community College); Isaac IT Ullah (San Diego State University)*
14:20 - 14:40	343. Field survey and environmental proxy data to asses the Roman Rural world in Lusitania. *Jesus Garcia Sanchez (Instituto de Arqueología, Mérida (IAM) CSIC)**
14:40 - 15:00	264. Machine Learning approaches for a multi-scale and multi-source detection and characterization of archaeological sites: the case of the funerary tumuli at Abdera (Thrace, Greece, 6th – 2nd C. BCE, aprox.) *Arnau Garcia-Molsosa (Landscape Archaeology Research Group, Catalan Institute of Classical Archaeology)*; Hector A. Orengo (Landscape Archaeology Research Group, Catalan Institute of Classical Archaeology); Mercouris Georgiadis (Landscape Archaeology Research Group, Catalan Institute of Classical Archaeology); Nikolas Dimakis (National & Kapodistrian University of Athens); Paraskevi Motsiou (National & Kapodistrian University of Athens); Alfredo Mayoral (Landscape Archaeology Research Group, Catalan Institute of Classical Archaeology); Eurydice Kefalidou (National & Kapodistrian University of Athens); Konstantina Kallintzi (Eforate for Antiquities of Xanthi, Greek Ministry of Culture)*

331. Conducting soil surveys – orchestrating change: developing practices to enable an integrated approach to agricultural and archaeological management

Eamonn Baldwin, University of Glasgow
Rachel Opitz, University of Glasgow
Philippe De Smedt, BE
Stefano Campana, University of Siena
Victorino Mayoral, Merida Institute of Archaeology
Marco Vieri, University of Florence
Carolina Perna, University of Florence
Daniele Sarri, University of Florence

Precision agriculture is transforming the practice of agricultural land management. This strongly digitalised approach to farming makes use of remote and proximal sensing technologies and digital data to collect data on soil and crop systems to inform their management. Common applications of sensing data include establishing a baseline and monitoring indicators of soil health, mapping erosion rates, and for modelling carbon sequestration potential (Weiss, Jacob and Duveiller 2020). The remote and near-surface sensing technologies used in precision agriculture, including multi- and hyper-spectral imaging and diverse geophysical survey techniques are widely used by archaeologists to investigate buried evidence of past human activities (Cowley, Verhoeven and Traviglia 2021). The shared use of these sensing technologies is unsurprising, as practitioners and researchers in both domains aim to understand better local variations in soils, their impacts on plant development, and the implications of these for land management (Webber 2019).

Despite the close relationship between the techniques used to collect data, similar analytical methods, and interest in related soil properties, data sharing and collaboration on analysis and interpretation between practitioners working in agricultural and archaeological domains remains limited. Technical differences in how the data are collected, standard analytical workflows, and typical outputs are all perceived as barriers to cross-domain data reuse or joint planning of surveys. This paper presents approaches to the reanalysis of agricultural and archaeological sensing data designed to move beyond these perceived barriers and realise co-benefits in both archaeology and agriculture.

We focus on one geophysical technique, electromagnetic induction (EMI) as an example of the challenges and advantages involved in a coordinated cross-domain approach to sensing data collection, analysis, and interpretation. EMI techniques are widely used in agriculture to produce maps of a range of soil properties and to predict soil types. These data are routinely analysed to inform land management decisions. Consequently, there is a growing collection of data held by farmers and agricultural service providers. Commercial agricultural interest in these data is promoting the development of improved analytical and modelling methods. EMI techniques are also commonly employed in archaeological prospection, typically to detect potential archaeological features and inform their characterisation and interpretation by analysing and modelling closely related soil properties.

Through a case study from Wiltshire, UK this paper illustrates how data collected for agriculture can be re-analysed for use in archaeological applications. It addresses the impacts of differences in data collection parameters including instrument configuration, spatial resolution, and collection timing on the archaeological interpretability of the data and considers where adjustments might feasibly be made to enable data reuse.

EMI soil measurements are presented which were collected following typical agricultural domain protocols at two approximate depths (topsoil and subsoil levels) by an agricultural service provider over a large area of arable farmland for the purpose of everyday soil and crop management. Data comprise both electrical conductivity and magnetic susceptibility measurements, of which, only the former are typically used in current agricultural practice. The uses of these multi-depth measurements in archaeological workflows are illustrated, emphasising where they can complement other forms of archaeological and environmental information already used in archaeological research and heritage management, despite the relatively coarse resolution of the agricultural data in comparison to typical archaeological datasets. Specific applications of the data discussed include: • The use of coarse resolution conductivity maps to help delineate soil-type deposits horizontally over larger areas, providing wider contextual information for known archaeological features.

- The application of multi-depth data for modelling of top and subsoil thickness, aiding in identifying areas of soil erosion or soil preservation, which can inform environmental soil sampling strategies.
- Modelling concentrations of higher magnetic susceptibility over larger areas to indicate potential areas of past human activities. • Identification of large archaeological features or concentrations of features at a landscape scale, where these may only be discernible through contiguous mapping over extensive areas. Building on the data reuse demonstrated in this case study, working practices in both domains are considered and recommendations for how collaboration on protocols could result in more useful data for all parties are discussed. The paper concludes by emphasizing the wider potential benefits of coordinated planning, data sharing and interpretation of the data, which go beyond transactional exchange, to create a forum around integrated sustainable agricultural land management, bringing together archaeology and cultural heritage with agricultural, environmental and natural heritage.

References

Cowley, Dave, Geert Verhoeven, and Arianna Traviglia. 2021. 'Editorial for Special Issue: "Archaeological Remote Sensing in the 21st Century: (Re)Defining Practice and Theory"'. Remote Sensing 13 (8): 1431. https://doi.org/10.3390/rs13081431.

Webber, Henry, Volker Heyd, Mark Horton, Martin Bell, Wendy Matthews, and Amanda Chadburn. 2019. 'Precision Farming and Archaeology'. Archaeological and Anthropological Sciences 11 (2): 727–34. https://doi.org/10.1007/s12520-017-0564-8.

Weiss, M., F. Jacob, and G. Duveiller. 2020. 'Remote Sensing for Agricultural Applications: A Meta-Review'. Remote Sensing of Environment 236 (January): 111402. https://doi.org/10.1016/j.rse.2019.111402.

353. Taming Complexity: the rocky road from qualitatively accurate to quantitatively precise data analysis and interpretation in archaeo-geophysical survey

Agnes Schneider, Leiden University

Context

This paper presents a workflow for a quantitatively consistent, formalised learning data set for the automated analysis of magnetometer data from qualitative expert knowledge, which aims to be reproducible and replicable.

For almost two decades, there has been a trend in Archaeological Remote Sensing (ARS) towards (semi-)automated data analysis. With the continuous development of sensors (satellite, LiDAR, multispectral, hyperspectral) and platforms (UAV, cube satellites) the sensor size is getting smaller, but the quality, resolution, and amount of data is becoming larger, meaning that ARS is dealing with Big Data in archaeological terms.

In the last decade, with the development of multi-sensor systems and their suspension to vehicles, geophysical prospection has started to collect data at large scale as well. The increasing amount of archaeo-geophysical survey data requires analytical methods that can deal with this: namely automated analysis methods. These are already established for air- and spaceborne data but cannot be transferred directly to geophysical data due to the specific character and complexity of geophysical data.

Main argument

The main data types to which (semi-)automated analysis methods are applied are satellite imagery, LiDAR data, aerial imagery and drone imagery. These data types are usually treated as 2D images. The (semi-)automated methods applied to them predominantly work on pixel (Pixel-based Image Analysis and Geometric Knowledge-based analysis) or object level (Object Based Image Analysis, OBIA). In the last decade Computer Vision (CV) applications have become more common in ARS. Deep Learning (DL), in contrast to pixel or object-based methods, addresses images on scene-level and uses mainly Neural Networks (mainly different versions of Convolutional Neural Networks, CNNs) to classify images.

Geophysical datasets - especially magnetometer data have been mainly investigated on pixel (Geometric Knowledge-based: GPR data & Magnetometry; Machine Learning: EGPR, Magnetometry and Magnetic Susceptibility) or object level (OBIA: Magnetometry, GPR, Magnetometry). Recently U-nets were applied to magnetometer data (Wolf 2020) to perform a binary classification: to classify archaeological anomalies against a non-archaeological background.

Magnetometers record anomalies of the Earth's magnetic field which emerge due to the contrast in the magnetic properties between objects in the ground and the surrounding matrix. Magnetic anomalies can be very complex because various sources of magnetic anomalies might be in superposition, and will be registered additively as a single signal of mixed origin. According to the principle of equifinality small near-surface objects and larger, more deeply buried objects may lead to similar anomalies, so the exact relation between objects in the ground and the related magnetic anomaly cannot be clearly determined without excavation. Furthermore, several natural and artificial factors influence how anomalies are represented in the data set. This creates ambiguity and uncertainty on data, interpretation, and analysis level.

The case study presented is magnetometer survey data from al-Ḥīra, Iraq, currently investigated as part of Agnes Schneider's PhD project at Leiden University under the supervision of Karsten Lambers. The data were collected in the framework of the project "The Late Antique and Early Islamic Hira - Urbanistic Transformation Processes of a Transregional Contact Zone" funded by DFG: a collaboration between the Museum for Islamic Art Berlin (M. Müller-Wiener), the German Archaeological Institute (DAI) – Oriental Department (M. van Ess and I. Salman), the Technical University Berlin (M. Gussone), Eastern Atlas GmbH (B. Ullrich) and Leiden University (K. Lambers), as well as the SBAH (Iraqi State Board of Antiquities and Heritage) as local partner. The aim of the PhD project is to develop a reproducible and replicable (semi-)automated workflow, based on transparent quantitative criteria.

Particular attention will be paid to the mindful creation of learning data sets, in order to avoid the Gi-Go effect (garbage in = garbage out). In the case of al-Ḥīra, in the first data set acquired in 2016, 9 classes of anomalies have been identified manually. This scheme was extended to 16 classes when applied to the second data set acquired in 2021. Four classes represent the principal settlement structure of the site, but the first goal is to detect just the most common class 3, that is, anomalies interpreted as mudbrick walls.

Manual interpretation is based on implicit, qualitatively accurate, reconstructive, and subjective expert knowledge. If such classes are to be used as learning data sets for automated data analysis, they have to be converted to explicit, qualitatively precise, semantically consistent, and objective context information. Based on the specific character and complexity of magnetometer data, any such formalised, semantically consistent framework has to be generalised with certain trade-offs to be able to replicate it for other data sets with similar factor influence.

Although since 2004 more than 250 papers deal with the automated analysis of ARS data, a complete workflow, let alone data and code, is rarely published. Thus in terms of reproducibility and replicability there is a lot of room for improvement. Lacking open, standardised protocols, workflows and best practices, scientific studies start from scratch, leading to a multitude of highly specialised ad hoc solutions (Schneider 2021). In the case of geophysical datasets, the existing EAC guidelines (Schmidt et al. 2015) do not disseminate how to interpret data sets specifically, due to the specific character and complexity of geophysical data.

Applications and implications

Solutions developed for air- and spaceborne data sets cannot be transferred directly to geophysical data if the complex nature of geophysical data sets is taken into account. To use automated analysis methods and to achieve reproducible, replicable, and comparable results, a consistent, quantitatively precise, semantically consistent, objective, reproducible and replicable interpretation scheme of mindful learning data is needed.

Such an interpretation scheme and learning data set has to be generalised to be transferable to data sets with similar factor influence. Optimally such datasets can be used as reference data sets for future research. The expression 'learning dataset' targets both manual interpretation and automated analysis: in a feedback loop the expert knowledge controls what is to be detected, which is then critically tested by the context information of the automated analysis. In the case of unsatisfactory learning, the learning data set can be updated and vice-versa. This way, feedback loops ensure that expert knowledge and the context information learn from each other to create a learning data set with a high detection rate.

References

Schmidt, Armin, Paul Linford, Neil Linford, Andrew David, Chris Gaffney, Apostolos Sarris, and Jörg W. E. Fassbinder. 2015. EAC GUIDELINES FOR THE USE OF GEOPHYSICS IN ARCHAEOLOGY. Questions to Ask and Points to Consider. EAC GUIDELINES 2. Europae Archaeologia Concilium. https://www.europae-archaeologiae-consilium.org/_files/ugd/881a59_fdb1636e95f64813a65178895aea87cf.pdf.

Schneider, Agnes. 2021. 'ISEGMound. A ReproducibleWorkflowforMoundDetection inLiDAR-Derived DTMs.' Master Thesis in partial fulfillment of the requirement for the degree of Master of Science in Physical Geography, Marburg: Philipps-Universität Marburg.

Wolf, Julien. 2020. 'These Are Not the Ring Ditches You Are Looking For: Some Early Results of Semantic Segmentation on Magnetometer Data'. ISAPNews, no. 60 (September): 11–17.

109. Documenting drone remote sensing: a virtual reconstruction approach

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This paper addresses the design of open, reproducible, and transferable workflows for remote sensing data processing in archaeology. In the field of virtual reconstruction the need for transparent workflows is much recognized, and various approaches exist, which may serve as an example for the field of archaeological prospection (Lozić & Štular 2021). In the 4D Research Lab at the University of Amsterdam, both virtual reconstruction techniques as well as RPA remote sensing techniques are applied in the context of projects concerning material heritage. Examples are the capturing of high resolution 3D geometry and texture data of archaeological or historical structures, sites and landscapes, but for example also deploy drone remote sensing tools such as thermal cameras and multispectral cameras to trace buried archaeological remains through crop- and soil marks, earthworks or spectral signals. In order to justify the choices made during the reconstruction process, the 4D Research Lab developed its own documentation workflow, and projects are published through the Open Access 4D Research Lab Report Series (Lanjouw & Waagen 2021, https://uvaauas.figshare.com/collections/4DRL_Report_Series/5503110). The template of the report ensures that 3D (visualisation) projects are executed and documented to generally accepted academic standards. The standards adhere to the "The London Charter for the computer-based visualization of cultural heritage" (Denard 2012) and the "Principles of Seville, international principles of virtual archaeology" (Bendicho & Grande 2011). Given this context, the 4D Research Lab seeks to integrate the drone remote sensing techniques in these standardized reports, elucidating and specifying the photogrammetrical, LiDAR, thermal and multispectral workflows, even in cases where a prospection project is not part of a virtual reconstruction. This paper will explore how the RPA remote sensing workflows may be integrated into the template and standards of the 4D Research Lab Report Series and thus can adhere to the London Charter and the Principles of Seville. The paper will also explore how they can match other approaches, such as that of the documentation workflow for airborne LiDAR data processing which has recently been proposed (Lozić & Štular 2021). Finally, the proposed paper also links the conclusions to the E-RIHS ArcFieldLab project that has just been started by the author of this abstract (https://e-rihs.nl/project-innovatieve-technieken-archeologisch-veldwerk/). The ArcFieldLab project is aimed at bolstering sensor-based expertise networks and knowledge exchange in the Dutch field archaeological context. In this project, awareness of good practices, including the publication of transparent workflows, is encouraged. In this way, this paper aims to contribute to the insights about potentially successful approaches to creating and communicating transparent workflows for archaeological remote sensing data.

Bendicho, V.M. and Grande, A. 2011. "The principles of the Seville Charter." XXIIrd CIPA Symposium. 2-6.

Denard, H. 2012. "A new introduction to the London Charter." In Paradata and Transparency in Virtual Heritage edited by Bentkowska-Kafel, A., Denard, H. and Baker, D, 57-72. Routledge, London.

Lanjouw, T.J.R. and Waagen, J. 2021. "Making 4D: principles and standards for virtual reconstruction in the humanities by the 4D Research Lab." 4D Research Lab Report Series 1, 1-31. https://doi.org/10.21942/uva.14932461.v3

Lozić, E. and Štular, B. 2021. "Documentation of Archaeology-Specific Workflow for Airborne LiDAR Data Processing." Geosciences 11, 26. https://doi.org/10.3390/geosciences11010026

18. Survey Planning, Allocation, Costing and Evaluation (SPACE) Project: Developing a Tool to Help Archaeologists Conduct More Effective Surveys

Edward B Banning, University of Toronto
Steven Edwards, Nova Scotia Community College
Isaac IT Ullah, San Diego State University

Designing an effective archaeological survey can be complicated and confidence that it was effective requires post-survey evaluation. The goal of SPACE is to develop software to facilitate survey designers' decisions and partially automate tools that depend on mathematical models so that archaeologists can conduct surveys that accomplish their goals and evaluate their results more easily. We aim for SPACE to be a modular and accessible web-based platform for survey planning and quality

assurance, with a "front end" that has a non-threatening, question-and-answer format. Its several interacting modules will ultimately include ones for evaluating visibility, estimating sweep widths and coverage, costing, determining sample sizes, transect and test-pit intervals, allocating effort optimally for stratified samples and predictive surveys, and quality assurance. In this paper, we focus on the module for estimating fieldwalkers' sweep widths on the basis of "calibrations" on fields seeded with artifacts, while also reviewing the overall structure of the project. Sweep widths are critical for estimating coverage, evaluating survey effectiveness and quality, and planning transect intervals.

343. Field survey and environmental proxy data to asses the Roman Rural world in Lusitania.

Jesus Garcia Sanchez, Instituto de Arqueología, Mérida, IAM CSIC

In this paper, I will present the field survey workflow designed to study off-site record and settlement patterns in the Iberian Southwest, focusing on three study cases, the territory of Roman capital Emerita Augusta, the mid-Guadiana river valley and the Upper Alentejo. The workflow employed in these surveys combines qualitative assessment of survey areas, and the documentation of site boundaries with quantitative approaches to off-site archaeological record using hand-held GPS to document complex background scatters.

Moreover, other data has been used to spot archaeological sites, chiefly historical aerial imagery and LiDAR data. These methods proved helpful; however, there are substantial differences on data accessibility across the modern boundaries of Spain and Portugal. Remote Sensing is allowing us to acquire data about site preservation and also about certain elements, such as river dams, that could be of potential interest to study the impact of past populations on the management of the landscape and water.

Another data proxy that could provide valuable information is a bioarchaeological approach to excavated sites. Some key sites in Portugal and around Augusta Emerita (Mérida) are currently under investigation using palynological and carpological analysis to reconstruct the dynamics of the Mediterranean sclerophyllous forest (Dehesa), an anthropogenic ecosystem created in the 4th-3rd millennium BC through human pressure and deforestation using fire. Environmental dynamics could be compared to the pre-Roman, Roman and post-Roman settlement patterns, as human activity is one of the main factors in the creation, management and eventual destruction of this landscape.

The paper will try to demonstrate how field survey is a valid methodological approach to shed light on the human dynamics of this critical ecosystem.

264. Machine Learning approaches for a multi-scale and multi-source detection and characterization of archaeological sites: the case of the funerary tumuli at Abdera (Thrace, Greece, 6th – 2nd C. BCE, aprox.)

Arnau Garcia-Molsosa, Landscape Archaeology Research Group, Catalan Institute of Classical Archaeology
Hector A. Orengo, Landscape Archaeology Research Group, Catalan Institute of Classical Archaeology
Mercouris Georgiadis, Landscape Archaeology Research Group, Catalan Institute of Classical Archaeology
Nikolas Dimakis, National & Kapodistrian University of Athens
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Machine and Deep Learning methods are being successfully applied for the detection of topographic anomalies of anthropogenic origin. After the publication of initial proofs of concept, applications addressing different study cases are quickly growing during the last years. First applications tend to focus on the analysis of a single source (usually a EO product of a particular LIDAR dataset), but the potential of multi-source analysis is being explored in recent works. In most of the examples, ML and DL have been implemented as a "brute force" instrument, particularly suited to analyse very extensive areas which would be impossible to cover by traditional manual means (both on field and on computer image analysis), but providing little value for local-scale analysis. As a consequence, the target of these analyses are dependent of the availability and resolution of the sources employed. That has directed most of the analysis towards metric-resolution LIDAR national or regional datasets (where those are available), while global satellite-based sensors have been employed to locate large mounded-sites in areas such the Middle-East or the Indus Valley. The potential of higher resolution imagery for targeting all sorts of archaeological features (from potsherds to little mounds or crop-marks), is being tested with success using UAS-mounted sensors in limited areas.

Results obtained through automatic site-detection address also a unique characteristic, most commonly the topographical anomaly. Multi-source analyses have incorporated other factors, but employed basically to distinguish sites of other similar signatures. Although the indisputable value of the location of hundreds or thousands of potential new sites, it represents only a very first step on the research, with very limited historic-archaeological interpretative value.

In this paper we will address the potential of integrating multi-source and multi-scale approaches to provide information beyond the location of potential archaeological sites including some elements of its historic-archaeological character. To achieve this objective, we will use the study case of the funerary tumuli spread on the hinterland of the Greek colony of Abdera (Thrace), founded in the 7th c. BCE and occupied until the Byzantine period. The area is nowadays under intensive cultivation, which has involved the levelling of the tumuli, resulting in few of them still standing, and most of them recognisable only by as small elevations in the fields associated to remains of sarcophagi and stones. Funerary tumuli in this area had been the focus of previous works, including some recent work lead by the authors of the paper, and its distribution is well-known. That made it a particular adequate case to test our workflow.

The specific objectives of the work presented here are: first locate the mounds, including those almost disappeared, secondly, to distinguish them of other archaeological contexts and, third, to contextualise them within their landscape and preservation history.

For the experiments presented here, we have used UAS-mounted sensors to obtain a high-resolution (1 m/px) DEM of a sample area of ca. 3 square km, and very high-resolution (1mm/px) images of selected fields. Algorithms previously developed by the authors (Berganzo-Besga et al 2021; Orengo & Garcia-Molsosa 2019; Orengo et al. 2020) have been adapted and trained here to target specifically 1) circular topographic anomalies; 2) potsherds and other burnt clay fragments; and 3) Stone blocks that are not part of the local soil.

Training and validation data has been provided by field data coming from intensive survey complemented by information about disappeared tumuli collected from local memory and archive work, including several series of historical aerial imagery. For the intensive survey, the area has been object of systematic pedestrian survey since 2015 in the context of the Archaeological Project of Abdera and Xanthi (APAX), (Georgiadis et al. on press). The study area is divided in a grid of 40x40m squares in which archaeological objects are counted, a selection picked-up and then classified by specialists. Remains of architectural elements and stone sarcophagus are also documented on the field. Fieldwork also included the assessment of the detected topographic anomalies.

Current efforts are identifying around 90% of the 116 funerary tumuli detected by the combination of previous fieldwork, local memory, and archive work. Previously unknown sites have been located and assessed during the development of the study. After discarding clear false positives, it results in an increasing of at least 15% the number of funerary tumuli known in this well studied area. Size-based filters of the distribution of material culture and stone blocks shows that former tumuli are associated also to the presence of big fragments, with its size tending to increase at the centre of the former levelled monument. Comparing the distribution of the fragments, former tumuli also show differences respect other archaeological features, particularly settlement areas.

These preliminary results pointed to the potential of the integration of multi-source and multi-scale analysis to locate archaeological mounded sites in Northern Greece, including sites that cannot be detected in lower resolution EO imagery.

Beyond the detection itself, the paper will focus on the potential of the workflow developed in Abdera to provide information about the character of the sites, in our particular case, its funerary character and how these might be differentiated from other types of sites. We will discuss up to which point these types of workflows can represent an advance with respect to the applications developed up to now, and how the new information can be exploited for the interpretation of distribution patterns and for Heritage management strategies. Finally, the paper will address the current limitations for scaling-up the analysis towards regional and supra-regional levels, and potential future strategies to overcome these.

References:

- Orengo, Hector A., Francesc C. Conesa, Arnau Garcia-Molsosa, Agustín Lobo, Adam S. Green, Marco Madella, and Cameron A. Petrie. 'Automated Detection of Archaeological Mounds Using Machine-Learning Classification of Multisensor and Multitemporal Satellite Data'. Proceedings of the National Academy of Sciences 117, no. 31 (4 August 2020): 18240–50. https://doi.org/10.1073/pnas.2005583117.
- Orengo, Hector A., and Arnau Garcia-Molsosa. 'A Brave New World for Archaeological Survey: Automated Machine Learning-Based Potsherd Detection Using High-Resolution Drone Imagery'. Journal of Archaeological Science 112 (December 2019): 105013. https://doi.org/10.1016/j.jas.2019.105013.
- Georgiadis, Mercourios, Constantina Kallintzi, Arnau Garcia-Molsosa, Hector A. Orengo, Eurydice Kefalidou, and Paraskevi Motsiou. 2022. "The Archaeological Survey at Abdera and Xanthi 2015–2019: Long-Term Analysis of Colonial Relations in Thrace." Archaeological and Anthropological Sciences 14 (9): 167. https://doi.org/10.1007/s12520-022-01635-x.

18. Modelling Ancient Cities: methods, theories and tools

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Iza Romanowska, Aarhus Institute of Advanced Studies, Aarhus University, Denmark
Dries Daems, Middle East Technical University, Turkey

Location: E104

The city has been a major topic of interest for archaeologists from the early days of the discipline until now (Woolf 2020; Childe 1950). In recent years, scholars have increasingly come to see cities as inherently complex systems requiring a wide range of tools and specialist methods to study their functioning, evolution and transformations (Batty 2007; Shi et al. 2021; Ortman, Lobo, and Smith 2020). The application of quantitative methods for the study of ancient cities and settlement networks has likewise seen increased interest in recent years (Lobo et al. 2019; Ortman et al. 2014). Increased accessibility to large scale datasets, due to advancements in data collection, has resulted in an increasingly diverse number of studies looking at past cities from new perspectives, focusing both on their idiosyncrasies and cross-cultural comparative dimensions (Smith 2020; Baumanova and Vis 2019). At the same time, recent developments in excavation, recording and analysis techniques have enabled archaeologists to dive deep into the past of individual cities, reconstructing their built environment (Fletcher 2020), infrastructure (Crouch 1993), social-economic interactions (Smith et al. 2014) or even their inhabitant's diets (Rowan 2017). These advancements in methods, data and theory have opened new possibilities for the study of cities and settlement systems at different scales.

This session invites papers that deal with the applications of computational and digital methods, grounded in population-level systemic thinking, but also coming from the individual perspective, that investigate the structural properties and mechanisms driving complex socio-natural urban systems. The goal is to showcase the potential of using systematically collected data on urban systems and formal analytical methods to broaden our understanding of the general mechanisms driving urban dynamics. These may include but are not limited to: agent-based modelling, network analysis, urban scaling, gravity and spatial interaction models, space syntax, GIS, and data mining applied to such topics as settlement persistence, urban social complexity, multi-scale spatial patterns within urban complexes and across settlements, inter and intra- settlement dynamics, urban-environmental processes, and city historical trajectories including urban formation and abandonment.

We look for a diverse range of studies on the interactions between cities, simulations of social and socio-natural activities, as well as analyses of groups of cities and their environment. We are especially interested in papers that adopt a large-scale comparative and diachronic perspective to studying transformations and transitions of urban and settlement systems.

References:

Batty, Michael. 2007. Cities and Complexity: Understanding Cities with Cellular Automata, Agent-Based Models, and Fractals, Michael Batty. (version 1st MIT press paperback ed.). 1st MIT press paperback ed. Cambridge: MIT press.

Baumanova, Monika, and Benjamin N. Vis. 2019. "Comparative Urbanism in Archaeology." In Encyclopedia of Global Archaeology, 1–11. Cham: Springer International Publishing. https://doi.org/10.1007/978-3-319-51726-1_3478-1.

Childe, V. Gordon. 1950. "The Urban Revolution." The Town Planning Review 21 (1): 3–17.

Crouch, Dora P. 1993. Water Management in Ancient Greek Cities. Oxford University Press.

Fletcher, Roland. 2020. "Urban Labels and Settlement Trajectories." Journal of Urban Archaeology 1 (January): 31–48. https://doi.org/10.1484/J.JUA.5.120908.

Lobo, Jose, Luis MA Bettencourt, Michael E Smith, and Scott Ortman. 2019. "Settlement Scaling Theory: Bridging the Study of Ancient and Contemporary Urban Systems." Urban Studies, October, 0042098019873796. https://doi.org/10.1177/0042098019873796.

Ortman, Scott G., Andrew H. F. Cabaniss, Jennie O. Sturm, and Luís M. A. Bettencourt. 2014. "The Pre-History of Urban Scaling." PLOS ONE 9 (2): e87902. https://doi.org/10.1371/journal.pone.0087902.

Ortman, Scott G., José Lobo, and Michael E. Smith. 2020. "Cities: Complexity, Theory and History." PLOS ONE 15 (12): e0243621. https://doi.org/10.1371/journal.pone.0243621.

Rowan, Erica. 2017. "Bioarchaeological Preservation and Non-Elite Diet in the Bay of Naples: An Analysis of the Food Remains from the Cardo V Sewer at the Roman Site of Herculaneum." Environmental Archaeology 22 (3): 318–36. https://doi.org/10.1080/14614103.2016.1235077.

Shi, Wenzhong, Michael F. Goodchild, Michael Batty, Mei-Po Kwan, and Anshu Zhang, eds. 2021. Urban Informatics. The Urban Book Series. Singapore: Springer Singapore. https://doi.org/10.1007/978-981-15-8983-6.

Smith, Michael E. 2020. "The Comparative Analysis of Early Cities and Urban Deposits." Journal of Urban Archaeology 2 (January): 197–205. https://doi.org/10.1484/J.JUA.5.121537.

Smith, Michael E., Timothy Dennehy, April Kamp-Whittaker, Emily Colon, and Rebecca Harkness. 2014. "Quantitative Measures of Wealth Inequality in Ancient Central Mexican Communities." Advances in Archaeological Practice 2 (4): 311–23. https://doi.org/10.7183/2326-3768.2.4.XX.

Woolf, Director Greg. 2020. The Life and Death of Ancient Cities: A Natural History. New York.

	SLOT 3
13:00	135. Modelling long-term patterns of urbanism in Anatolia: Conceptual and computational approaches *Dries Daems (Middle East Technical University)**
13:20	80. Does economic exchange drive settlement persistence patterns? Simulating patterns between Cyprus and the Levant during the Late Bronze Age *Katherine A. Crawford (The Cyprus Institute)*; Georgios Artopoulos (The Cyprus Institute); Iza Romanowska (Aarhus University)*
13:40	120. Connecting ports and territories: examples from Asia Minor *Maria del Carmen Moreno Escobar (Lund University)**
14:00 - 14:20	323. The part and parcels of a city. The impacts of urbanization on the population of ancient Thessaloniki *Asterios Aidonis (Laboratory of Physical Anthropology, Department of History and Ethnology, Democritus University of Thrace)*; Elissavet Ganiatsou (Laboratory of Physical Anthropology, Department of History and Ethnology, Democritus University of Thrace); Angelos Souleles (Laboratory of Physical Anthropology, Department of History and Ethnology, Democritus University of Thrace); Maria Korelidou (Laboratory of Physical Anthropology, Department of History and Ethnology, Democritus University of Thrace); Panagiota Bantavanou (Laboratory of Physical Anthropology, Department of History and Ethnology, Democritus University of Thrace); Angeliki Georgiadou (Laboratory of Physical Anthropology, Department of History and Ethnology, Democritus University of Thrace); Eleni Kalliga (Laboratory of Physical Anthropology, Department of History and Ethnology, Democritus University of Thrace); Christina Papageorgopoulou (Laboratory of Physical Anthropology, Department of History and Ethnology, Democritus University of Thrace)*
14:20 - 14:40	9. Visual communication on Hellenistic and Roman squares - The public spaces of Priene and Pompeii explored with 3D vector visibility analyses *Alexander Braun (University of Cologne)**
14:40 - 15:00	128. A multi-scale quantitative and transferable approach for the study of hillfort communities. *Giacomo Fontana (University College London)**

	SLOT 4
15:30	378. A GIS approach to morphology and transformations of ancient cities. Some reflections from historical sources to spatial analysis *Angelo Cardone (Università degli Studi di Bari A. Moro)**
15:50	192. Inequality of a townscape. Problem of assessment of living space in preindustrial cities. *Maria M. Legut-Pintal (Institute of Archaeology - University of Wroclaw)*; Mikołaj Grosel (Wrocław University of Science and Technology)*
16:10	207. The urban side of child rearing: application of machine learning on sequential isotopic dentine data for pattern recognition related with weaning and physiological stress *Elissavet Ganiatsou (Laboratory of Physical Anthropology, Department of History and Ethnology, Democritus University of Thrace)*; Angelos Souleles (Laboratory of Physical Anthropology, Department of History and Ethnology, Democritus University of Thrace); Angeliki Georgiadou (Laboratory of Physical Anthropology, Department of History and Ethnology, Democritus University of Thrace); Asterios Aidonis (Laboratory of Physical Anthropology, Department of History and Ethnology, Democritus University of Thrace); Christina Papageorgopoulou (Laboratory of Physical Anthropology, Department of History and Ethnology, Democritus University of Thrace)*

135. Modelling long-term patterns of urbanism in Anatolia: Conceptual and computational approaches

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Recent efforts to set a new agenda for the study of long-term drivers of urbanism have advocated for the application of the methods of urban science in archaeology (Ortman et al. 2020). Urbanism is a complex and multidimensional matter. Cities are not merely aggregates of individuals and houses, but are rather the result of multitudes of dynamics, practices and institutions of social, economic, cultural, political and religious nature. To untangle this complex set of driving factors in long-term urban development, we need rigorous approaches that allow us to formalize theories and test hypotheses regarding the origins of the urban centre, its functioning, and its integration in wider urban networks.

The core research questions addressed in this paper are: (1) "What are the main driving factors shaping long-term patterns of urbanism?", and (2) How do these factors interact to create mutual synergies, positive or negative feedback loops?". To understand complex systems like cities, it is essential to simplify and abstract to focus on its core elements. I will start from a generalized model of social complexity formation (Daems 2021) and apply this general model specifically to the development of cities as hubs of energy, resources and information flows, and urban systems as "networks of networks". In this model, we identify a well-defined set of selection pressures as our starting point: subsistence, cooperation, competition, interaction, distribution, production, governance, and demography. These act as probabilistic, multi-level causal factors for the decision-making processes of social groups that shape the flows of energy, resources and information driving the formation of urban centres and hierarchies. For example, in times of increased competition, cities might initiate a process of increased settlement nucleation, resulting in denser urban centres and decreasing number of rural settlements. This could create a trade-off with the need to exploit sufficient amounts of land to sustain the community or the desire to participate in trade networks. By simulating the synergies and (positive or negative) feedback loops between multiple selection pressures in a probabilistic framework, we generate a number of scenarios that we can then compare to empirical data from the archaeological record to better understand long-term trajectories of urban development. Building computational environments to test the trade-offs between selection pressures will stimulate the integration of theories of past urbanism developed in archaeology and history, with methodological approaches from urban studies, and empirical archaeological data.

I will particularly focus on Bronze Age to Early Roman Imperial times in Anatolia (3000 BCE-200 CE). Anatolia provides the ideal testing ground for studying urbanism as it has a long tradition of urban communities, covering almost 10,000 years, all the way back to early 'urban experiments' at Çatal Höyük in Neolithic times. Ever since, urban or urban-like communities have emerged, developed, and dispersed throughout Anatolia, ranging from cities such as Ephesos on the west coast to Tushpa in the eastern highlands. Recent reference books of urbanism in Anatolia generally focus on a single chronological period (e.g. Willet 2020 for Roman Anatolia). By contrast, diachronic perspectives such as the one pursued here remain rare.

References

Daems, Dries. 2021. Social Complexity and Complex Systems in Archaeology. London: Routledge.

Ortman, Scott G., Michael E. Smith, José Lobo, and Luís M. A. Bettencourt. 2020. 'Why Archaeology Is Necessary for a Theory of Urbanization'. Journal of Urban Archaeology 1 (January): 151–67. https://doi.org/10.1484/J.JUA.5.120914.

Willet, Rinse. 2020. The Geography of Urbanism in Roman Asia Minor. Sheffield: Equinox Publishing Ltd.

80. Does economic exchange drive settlement persistence patterns? Simulating patterns between Cyprus and the Levant during the Late Bronze Age

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Georgios Artopoulos, The Cyprus Institute
Iza Romanowska, Aarhus University

The rapid change in urbanization on Cyprus during the Late Bronze Age is often attributed to an increase in international trading activities. In particular, debates about the role of copper exchange and pottery exports have focused around their importance in contributing to the rise of urban centers in Cyprus during the Bronze Age (Gaber 2018). The extent to which economic exchange during this period served as a driving factor in changing settlement patterns, however, has yet to be formally tested.

The application of agent-based modelling (ABM) is especially well-suited for studying models of economic exchange and its correlation to settlement persistence. Recent years have seen an increase in the development of both large-scale models for studying the development of past urban dynamics (Wilkinson et al. 2007; Cecconi et al. 2015) as well as models that explore the relationship between settlement population change and trade (Hanson and Brughmans 2022).

The project 'EIDOS of a City: simulating the collapse and resilience of ancient Eastern Mediterranean urban environment via agent-based modelling' aims to question why some cities lasted millennia while others collapsed at the first sign of instability within the Eastern Mediterranean. Big data, consisting of over 30,000 settlements from the Levant, Orontes Watershed, and Cyprus, coupled with ABM is used to identify some of the mechanisms that contributed to urban collapse or resilience within the region.

The paper will present a model that investigates the extent to which economic exchange between Cyprus and the Levant played a driving role in settlement pattern changes during the Late Bronze Age. Using the Cypriot and Levant datasets complied for the EIDOS project, the EIDOS-Networks model considers how rising and lowering economies based on the trade of copper and pottery affect settlement population change over time. Economic exchange is studied based on different network connections. If a city's economic standing decreases, then a percentage of the population finds a new place to live. Using a range of diverse parameters, the model results are then compared to the larger settlement persistence measures to explore the extent to which economic exchange affected different settlement patterns within the eastern Mediterranean region.

Sources:

Cecconi, F. et al. (2015) 'simulating the emergence of proto-urban centres in ancient southern etruria', in J.A. Barcelo and I. Bogdanovic (eds) Mathematics and Archaeology. London: Taylor & Francis Group, pp. 449–478. Available at: http://ebookcentral.proquest.com/lib/asulib-ebooks/detail.action?docID=2057677 (Accessed: 21 October 2022).

Gaber, P. (2018) 'Urbanization on Cyprus: The View from Idalion', Global Journal of Archaeology & Anthropology, 6(1), pp. 1–16. Available at: https://doi.org/10.19080/GJAA.2018.06.555680.

Hanson, J.W. and Brughmans, T. (2022) 'Settlement Scale and Economic Networks in the Roman Empire', in T. Brughmans and A. Wilson (eds) Simulating Roman Economies: Theories, Methods, and Computational Models. Oxford University Press, p. 0. Available at: https://doi.org/10.1093/oso/9780192857828.003.0004.

Wilkinson, T. J., J. H. Christiansen, J. Ur, M. Widell, and M. Altaweel. 2007. "Urbanization within a Dynamic Environment: Modeling Bronze Age Communities in Upper Mesopotamia." American Anthropologist 109 (1): 52–68. https://doi.org/10.1525/aa.2007.109.1.52.

120. Connecting ports and territories: examples from Asia Minor

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Connecting with others is a fundamental trait of human nature, and as such connectivity is not only a live concern and trend nowadays (so intimately ingrained in society that has become somewhat normalised), but it was also an imperative in the past. The issue of connectivity is most clearly portrayed in coastal areas, liminal spaces between land and sea whose intense occupation throughout history highlight the importance of multi-modal mobility in defining their territorial organisation and transformations. However, the faster pace of transformations in the Mediterranean coasts in recent times is having profound consequences on both our understanding of the past and on the preservation and loss of the material evidence of the past interactions between people and their surroundings (i.e. archaeological heritage).

These seemingly unrelated aspects (i.e. connectivity and preservation of archaeological heritage in the Mediterranean coasts) converge in the analysis of the Roman Empire, due to articulation of many of its territories around the Mediterranean Sea, and its character as a highly connected entity, a common topos within archaeological and historical research (e.g. Horden and Purcell 2000) that originally focussed on the analysis of roads, and more recently also on ports and navigation (e.g. Feuser 2017). Firstly, research and resources on the connectivity of the Roman Empire have increased and expanded over the last decades (Leidwanger et al. 2014), mainly identifying the notional connections and networks between towns, individuals, etc in different historical periods. However, scholars have yet to explore how mobility and accessibility shaped the territorial organisation of these connectivity networks, in a plausible attempt to stress human agency over geographical factors. This situation is most notable in the case of Mediterranean coasts, due to the major urban and environmental transformations (affecting also the preservation of heritage) combined with a traditional emphasis by research on the archaeological study of individual ports, both in Maritime and Classical archaeology, that only recently is beginning to be contested (e.g. the work by the ERC-project Rome's Mediterranean Ports, Grant agreement ID: 339123). And secondly, in the last decades a growing interest on the aggregation of dispersed datasets has materialised in initiatives like the Digital Atlas of the Roman Empire, Pelagios, and Pleiades, contributing towards the identification and characterisation of the land occupation across the Roman Empire, whereas resources such as Orbis permits to explore the connectivity (as cost and travel time) between places in the Roman Empire. However, these initiatives rely on the identification of individual sites, and are ultimately hindered by the imbalance in the archaeological knowledge across the different Mediterranean regions, hence challenging a full understanding of the territorial organisation of the mobility and connectivity within the Roman Empire.

It is within this context that the project "Beyond ports: Movement and connectivity in the Roman Empire", funded by the Swedish Research Council, develops, seeking to explore the relationships between the Roman connectivity networks and the physical environment as means to deepen our understanding of how communities integrated into the Roman Empire and of the territorial organisation of the Roman provinces. Using a "big data" approach to archaeological research, this project is on the process of gathering geoarchaeological, archaeological and spatial data about the occupation of coastal areas in Roman times in three case studies within the Mediterranean Basin, data that will then be explored through a combination of topographic modelling, archaeological spatial analysis, and simulations.

The present paper will discuss the theoretical and methodological approaches applied within "Beyond ports", that will take as example its preliminary results of its ongoing work in the Roman province of Asia Minor. In doing so, this contribution seeks to highlight how the application of integrated and regional approaches may generate new perspectives and interpretations into the topic of Roman ports and connectivity.

References:

Feuser, Stefan. 2017. 'Die Wirtschaftlichen Beziehungen Vormoderner Hafenstädte in Lokaler, Regionaler Und Überregionaler Perspektive'. In Wirtschaft Als Machtbasis: Beiträge Zur Rekonstruktion Vormoderner Wirtschaftssysteme in Anatolien, edited by Katja Piesker, 22:1–20. BYZAS. Istanbul: Deutsches Archäologisches Institut Abteilung Istanbul.

Horden, Peregrine, and Nicholas Purcell. 2000. The Corrupting Sea: A Study of Mediterranean History. Oxford: Blackwell.

Leidwanger, Justin, Carl Knappett, Pascal Arnaud, Paul Arthur, Emma Blake, Cyprian Broodbank, Tom Brughmans, et al. 2014. 'A Manifesto for the Study of Ancient Mediterranean Maritime Networks'. Antiquity Project Gallery 88 (342). https://www.antiquity.ac.uk/projgall/leidwanger342.

323. The part and parcels of a city. The impacts of urbanization on the population of ancient Thessaloniki

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Introduction

Studies in urban archaeology incorporate a variety of conceptual toolboxes for reconstructing life in urban centers. The present study investigates the secular changes in the population of ancient Thessaloniki. The city was founded in 315 BC and due to its strategic position on maritime and land routes of the Balkans turned into a significant economic and political hub. The archaeological record supports that during its historical transitions from Hellenistic to Roman and then to the Byzantine period, the city grew and became a multicultural urban center, attracting immigrants of different origins. However, it remains unclear how these economic and cultural transitions influenced living conditions and if there was continuity among the city's inhabitants or major population influxes. We use different lines of evidence to reconstruct the impacts of urbanization on the population of ancient Thessaloniki based on the skeletal material of the ca. .4000 graves that have been excavated during the construction of the metropolitan subway.

Methods and materials

We analyzed human skeletal remains spanning from the Hellenistic (323 BC) to the post-Byzantine period (15th c AD). To reconstruct the secular patterns of the population, we developed a sequence of research modules for the study of population mobility, diet, and living conditions. For investigating population differences among chrono-cultural groups, we targeted the morphological variation of the temporal bone with the use of geometric morphometrics (Harvati and Weaver 2006). The temporal bones of 98 individuals were digitized with a 3D scanner and thirteen anatomical landmarks were collected. Procrustes ANOVA was used to test landmark measurement error. A Generalized Procrustes Analysis (GPA) was conducted to extract the geometric shape from the overall size. Principal components analysis (PCA) and Canonical variate analysis (CVA) were performed to examine shape differences among individuals and chrono-cultural groups respectively. MANOVA was used to determine the statistical significance of the shape differences between population subsamples. In addition, the skeletal material of 30 individuals from Mavropigi, a rural settlement of the late Roman period (4^{th} c AD) where no migration influence was expected, was included in the analysis for comparison. Furthermore, a multi-tissue isotopic approach was employed to reconstruct the infant and adult diets of the population We measured the δ13C and δ15N ratios of 240 individuals (315 BC-4^{th} c. AD) and examined intra-site differences between historical periods, sex, and cultural context. The infant diet (birth-7 years old) was based on the measurement of 1000 dentinal collagen samples obtained from the sequential sampling of 100 first permanent molars (Beaumont et al. 2013). Adult diets were reconstructed from 140 collagen samples from femurs. The analysis of genome-wide data from 60 individuals is in progress to gain insight into the genetic composition of the population leveraging population genomics analyses (Clemente et al. 2021).

Results

The test of landmark measurement error showed that variation among individuals exceeds significantly the error due to digitizing ($p<0.05$) and thus measurement error was not a source of variation within the sample. The geometric morphometric analysis of the temporal bone underlines shape variation among groups. While PCA resulted in the overlapping of the chronological groups, the CVA suggests a separation between them with the first two CVs expressing 87,8% of the variance. MANOVA shows significant variation in the shape of temporal bone between the Hellenistic, the Roman, and the Post-byzantine group ($p<0.05$), while the Byzantine group does not show a statistically significant difference. Comparison of the urban Roman group from Thessaloniki with the rural from Mavropigi suggests also significant variation.

Isotopic analysis suggests infant feeding practices varied greatly: breastfeeding initiates after birth and completes between the ages of 2.0 and 3.5 for half of the dataset. Twenty infants were breastfed for less than two years and eight were breastfed for an even shorter period or were never breastfed. The long-term averaged adult diets consisted of animal protein and C3 plants. The consumption of C4 plants/small fish was detected during infancy and was less frequent during adulthood.

To date, we have sequenced 30 ancient individuals from the site to perform population genomics analyses (PCA, ADMIXTURE, f- statistics) and investigate the genetic intra- and inter-population differences. Our intent is to uncover changes in allelic and genotypic frequencies and detect traces of dynamic population processes such as admixture between populations, genetic drift, and bottleneck effects. Furthermore, we investigate the phenotypic variability of the ancient populations and possible selective evolutionary advantages in relation to the constantly shifting environmental and social conditions.

Discussion

Urbanization is often associated with migration. The archaeological record reveals that Thessaloniki during the roman period attracted persons of foreign origin. This is evident in inscriptions related to grave stelae, sarcophagi, professional and religious associations. The results of the geometric morphometric analysis so far suggest morphological variation among chrono-cultural groups and are consistent with this view. The results of the ongoing aDNA analysis will highlight the deep population dynamics of the city. Isotopic compositions have uncovered dietary breadth reflecting the urban character of the city, adding to our understanding of diachronic trends. Our in-progress interdisciplinary study demonstrates the importance of employing multiple lines of research to generate a deeper understanding of complex ancient urban lives.

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References

Beaumont, J., A. Gledhill, J. Lee-Thorp, and J. Montgomery. 2013. "Childhood Diet: A Closer Examination of the Evidence from Dental Tissues Using Stable Isotope Analysis of Incremental Human Dentine*." Archaeometry 55 (2). https://doi.org/10.1111/j.1475-4754.2012.00682.x.

Clemente, Florian, Martina Unterländer, Olga Dolgova, Carlos Eduardo G. Amorim, Francisco Coroado-Santos, Samuel Neuenschwander, Elissavet Ganiatsou, et al. 2021. "The Genomic History of the Aegean Palatial Civilizations." Cell 184 (10): 2565-2586.e21. https://doi.org/10.1016/J.CELL.2021.03.039.

Harvati, Katerina, and Timothy D. Weaver. 2006. "Human Cranial Anatomy and the Differential Preservation of Population History and Climate Signatures." Anatomical Record - Part A Discoveries in Molecular, Cellular, and Evolutionary Biology 288 (12). https://doi.org/10.1002/ar.a.20395.

9. Visual communication on Hellenistic and Roman squares - The public spaces of Priene and Pompeii explored with 3D vector visibility analyses

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Visual communication is one of the essential tools of ancient Greek and Roman representation strategies. Especially the elites had a distinct interest in presenting themselves within a group and to outsiders. Further, the community as a whole had an interest in communicating its internal organisation and prowess to its members and to outsiders, friends or rivals.

This might be no more prevalent than in the build environment of the public squares: A community or individual wishing to present itself, to reinforce and reiterate its internal organisation to its citizens and not political participating residents, as well as to outsiders, did this in their public spaces. Simultaneously, the actors responsible for the build environment had to strike a balance between the community's benefactors, who were in constant competition with each other, and the community with an invested interest in keeping equality in the body of citizens.

The public square, the agora, or the forum, was thus the central communication nexus of the ancient city: meeting place, centre of administration, public cults, mercantile strife, justice and the stage of the elites to compete amongst themselves to negotiate them the right to a monument on the public land of the square for eternity. In short, it was the place to interact with everyone.

The planners of the build environment of a square had a lot of messages to communicate visually to visitors. An outside guest of the city, it had to impress and show the grandness, history and stability of the community. For the residents of the city it had to reiterate their own societal organisation and history. In addition, the demands of its benefactors for representation had to be balanced, and they had to juggle the expectations of more powerful political entities from outside. (Ma 2013; Sielhorst 2015)

The wish and need to communicate and balance these messages of so many different interests created and developed different strategies on how to achieve that. The Goal of the PhD project "Visual communication strategies on Hellenistic and Roman squares" is it to research these different strategies and their development for the Hellenistic and in comparison the Roman world in a diachronic approach. In order to do so, quantitative 3D vector visibility analyses are employed. In this contribution the workflow for the analyses and preliminary results for the agora of Priene and the forum of Pompeii are to be presented.

The 3D vector visibility analysis is a GIS based tool created for large scale urban planning. However, it can be adapted to function in small scale spaces. It allows a quantitative analysis and comparisons between the visibility distributions of the build environment of a given space. (Braun 2019/20)

The first step and hurdle for such an approach is the need for a 3D reconstruction of the target space. This adds a level of uncertainty, which has to be assessed and discussed in the scope of the research question. In this first step the level of detail for the reconstruction is also to be addressed, because of limitations of the software and cost-benefit concerns regarding time and computer resources.

In order to prepare the 3D reconstruction vector points have to be defined along the models geometry in a grid system (Target Points) as well as a second set of vector points, to represent the eyes of potential observers in the environment (Observer Points).

For the analysis, indexed vector lines can then be created between Observer Points and Target Points to represent potential sightlines a human observer might have from their position in space. These sightlines can then be tested against the geometry of the 3D model and intersecting lines defined as being blocked by the geometry.

The results can then be summarized and visualised on the geometry of the 3D model to show the quantitative distribution of Observer Points with an uninterrupted view to the Target Points and as such the potential visibility to the feature in comparison to the potential visibility of others inside the build environment.

In the case of agorai and fora this approach allows to answer the question of prominence inside the complex, planned ensemble of buildings and statues. These computational results must in a next step, be interpreted with the help of the knowledge of the build environment and which messages different parts were meant to communicate: Questions concerning if the administrative building was more prominent than economic building, or if the frieze of a temple was more prominent than the frieze of a stoa. In the case of statues, the questions resolve around the modus of their placements: Are statues that were placed in groups or lines really equal in their visibility or not? These are a few of the questions that can be asked on how the actors responsible for the build environment organised their charge. How the different interests of constantly interacting parties were addressed. But it also allows to see interaction on the squares itself, how the visibility changes allowed to discern different functions of space. How the group and the individual interacted in planning and building the square.

This method is a way to understand how different societies with the intent to communicate certain messages visually developed their strategies, as well as to approach the question on what they wanted to communicate like that. In addition, it allows to test theories made by scholars before.

References:

Braun, Alexander. 2019/20. “Schau Augustus(?): Visuelle Kommunikation und politische Veränderungen auf dem Forum Romanum zwischen der späten Republik und der frühen Kaiserzeit mit einem computergestützten Ansatz.“ Kölner und Bonner Archaeologica 9/10: 189 - 202

Ma, John. 2013. Statues and Cities: Honorific Portraits and Civic Identity in the Hellenistic World. Oxford: Oxford University Press.

Sielhorst, Barbara. 2015. Hellenistische Agorai: Gestaltung, Rezeption und Semantik eines urbanen Raumes. Berlin: De Gruyter.

128. A multi-scale quantitative and transferable approach for the study of hillfort communities.

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The definition of city is quite problematic when applied to hillfort sites. Although they are a common phenomenon in Europe and beyond, we still lack a robust understanding of how these sites can be characterised as urban or non-urban (Moore and Fernández-Götz, 2022). Debates on the degree of urbanism on hillforts are shared across several regions, with interpretations that range from urban centres to places of refuge and seasonal occupation, even within the same local cultural context. This is the case of the Samnites, a mountain society of South-Central Italy that became famous in history for its military and political confrontation with the emerging Roman Republic in the later part of the first millennium BCE. Archaeological research focused on identifying urban models, considering them as the only possible explanation of Samnite resilience to attack and co-option over the several centuries of war with Rome. While focusing on identifying cities, research failed to investigate the actual function of hillfort sites in the landscape and how they supported a resilient complex society.

Computational archaeology provides a robust method to move away from the urban or non-urban dichotomy. Instead, it allows examining the broader spectrum of settlement types present in the archaeological record without prior labels. This paper discusses a multi-scale transferable quantitative approach to studying hillfort communities, using Samnite society as a case study. This approach integrates a range of spatial and non-spatial computational methods, and combines both qualitative and quantitative data, to address long-standing debates on the nature of these sites and the society that constructed them.

The dataset on Samnite hillforts was highly biased and fragmented due to the tendency of archaeological surveys to focus on easily accessible areas and ignore sites hidden beneath forests or located high in the mountains. This was addressed by using LiDAR-based remote sensing and ground-truthing to create a new, more representative dataset of hillfort sites across 15,300 sq.km of south-central Italy (Fontana 2022).

The dataset was subsequently applied in spatial and multivariate mixed-data cluster analyses to investigate the role and impact of architectural and fortification investment at hillfort sites. This involved the creation of a novel labour-cost model of polygonal masonry that was used to investigate building as an energy investment. By producing this type of quantitative models, it is possible to integrate past architecture, whether urban or not, into a range of historical questions, from socioeconomic impacts to labour organisation and political power. This allowed for differentiating the hillfort sites into formal typologies substantiated by variations in labour and occupied surface types.

Complementing this work about on-site energetics, point process models were used to trace how the broader system of settlements and other sites were organised across the whole Samnite landscape and territory. This work identified first-order patterns derived from a range of environmental priorities behind the choices of Samnite communities, as well as second-order effects originating from processes of aggregation or dispersion that vary depending on cultural and military context across Samnium. In doing so, it highlighted generative patterns for different typologies of sites, among which some sites could have functioned similarly to urban centres.

In combination, such techniques and fresh evidence shed new light on the character of hillfort sites and Samnite society. The overall approach was designed to be replicable and suitable for cross-regional and cross-cultural analysis of hillfort and other settlement communities. Entirely written in Python and R and subsequently integrated in Quarto, it provides a transferable method that could be used to test the occurrence of the same organisational models in different societies.

References:

Fontana, Giacomo. 2022. “Italy’s Hidden Hillforts: A Large-Scale Lidar-Based Mapping of Samnium.”Journal of Field Archaeology 47 (4): 1–17. https://doi.org/10.1080/00934690.2022.2031465.

Moore, Tom, and Manuel Fernández-Götz. 2022. “Bringing the Country to Town: ‘Rurban’ Landscapes in Iron Age Europe.” Journal of Urban Archaeology 5: 101–25. https://doi.org/10.1484/J.JUA.5.129845

378. A GIS approach to morphology and transformations of ancient cities. Some reflections from historical sources to spatial analysis

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Introduction

This proposal represents a synthesis starting from several case studies on post-classical cities carried out by the author and related to GIS approach.

A common procedure affects examined contexts. A georeferenced dataset containing data from different sources was implemented; collected data was subsequently integrated to obtain a preliminary, diachronic summary; finally, spatial analysis was carried out to go beyond traditional outcomes. Main goal is a reconstruction of topography and urban transformations between the Middle Ages and the Early Modern Era. A long-term study between classical and post-classical age is enabled for the few cases in which the data available on the Roman phase are more consistent.

The cities examined belong to two different geographical areas. The first case is that of Monselice (northern Italy, near Padua; Cardone 2017); the nineteenth-century cadastre (1810) was the cartographic basis for this work. Other contexts are located in northern Apulia (southeastern Italy); here the research concerns some smaller centers as part of an ongoing Phd, both abandoned -Montecorvino, Salapia-Salpi, Siponto (archaeological excavations by the University of Bari, the University of Foggia, McGill University of Montreal- are ongoing; magnetic survey have returned ancient topography) and existing centers (Pietramontecorvino, Motta Montecorvino, S. Marco in Lamis, Rignano, S. Giovanni Rotondo, Monte S. Angelo).

Preliminary data are published for Montecorvino (Favia, Cardone, D'Altilia 2021) and Salpi (Goffredo, Cardone 2021).

Methods and materials

Above all, the setting of the research depends on the project about medieval Padua developped a few years ago (ARMEP Project, University of Padua).

As first level, a geodatabase was created; it contains the data available for each urban center. In addition to contemporary cartography (maps, DTM, aerial photos), data from historical cartography (both georeferenceable maps and drawings), iconographic sources, archaeological data - emergency excavations, occasional finds -, written sources - houses and dimensions, roads, infrastructures, production structures, etc. - data on historical buildings still existing (residential, religious buildings, fortifications), toponymy.

The geodatabase lets a first, integrated and 'global' consideration starting from the superposition of the features, useful for evaluating the relationship between the elements of the city. An exhaustive study of these urban centers was indeed missing. Previous searches had interested just some elements of theese cities (religious sanctuaries, urban excavations).

Spatial analysis was then set up. The main tools are listed below:

a) Kernel density to evaluate areas of parcels concentration.

b) Orientation of the parcel to evaluate the development of the urban fabric, especially the "transformission" according with archeogeography research.

c) Morphological analysis of the parcels to identify anomalies related to missing elements / constraints or to evaluate the structure of the urban fabric (dimensions, shape of the parcels in the various districts), e.g. for traformations, planned divisions.

d) Distribution analysis of categories (e.g. residential spaces in written sources); space syntax analysis to evaluate the main paths Thesee data are related to other elements (e.g. churches).

This step helps to formulate hypotheses about urban center development by combining a regressive and predictive approach.

The consistency of the data is quite different and various factors partially limit the potential of discussed tools. Unfortunately, in general the written sources are not very consistent for these contexts; the quantitative level is not representative from a statistical perspective and often the data on the social life of the city are almost non-existent (for example, we know very little about the location of commercial premises or spaces with public functions). In addition, urban archeology has not provided significant news in the continuity of life centers.

Results

In general, the work carried out aims to formulate a series of hypotheses to guide future research. In fact, at the moment the characteristics of the datasets are not always favorable for complex analysis.

However, new factors on topography and urban development have been detected.

The distribution of the surviving fortifications and historic buildings gives the shape of the original medieval settlements and partly of the internal structure (road routes related to medieval structures). Various ideas suggest the development of the centers. The origin of the particle agglomerates is often evident; they developped around the oldest churches or in specific road nodes (for example, as seen in Monselice and

Salpi). Specific modules of the houses (side facing the street) show the subdivision of the land and the expansion of the city (for example Salpi); the building expansion finds partial reflections in contemporary written sources, where social mobility transpires between the 13th and 14th centuries.

Elsewhere, the passage to a concentrated settlement is visible: for example, early Christian churches are outside the late medieval walls (S. Giovanni Rotondo).

The relationship with pre-existing and geomorphological factors is noted. For example, the medieval city of Salpi is very much bound by the Roman structures of Salapia, although it seemed that the creation of a 'motta' had involved the total obliteration of the Roman and late antiquity phases. Furthermore, various cases show the progressive management of the hydrological elements; the mentions of "dead rivers", canals and reclamation (a sign of water regulation works) indicate the arrangement of the territory until the current cancellation of these elements.

Discussion

The work confirms an advantageous result for an analysis based on integrated systems of sources.

Specifically for the geographical area of interest, this work allows us to start thinking about the models and processes of the city between the post-classical and Modern Era. For example, new data about urban fabric or about adaption to orography and enviromental factors (above all hydrography and swamps) shed light on foundations in 11th cent.

References

Cardone Angelo. 2017. "La lettura dell'impianto urbano di Monselice fra fonti scritte e GIS analysis." In Monselice. Archeologia e architetture dai Longobardi ai Carraresi, edited by Brogiolo Gian Pietro, Chavarria Arnau Alexandra, 231-255. Mantova: SAP.

Favia, Pasquale. Cardone, Angelo. D'Altilia, Luca. 2021. "Spazio urbano e relazioni territoriali di un insediamento della Puglia settentrionale medievale: applicazioni digitali nell'indagine archeologica in corso a Montecorvino." In Tiziano Mannoni. Attualità e sviluppi di metodi e idee, edited by Iscum, 412–419. Firenze: All'insegna del giglio.

Goffedo, Roberto. Cardone, Angelo. 2021. "Salpi in Capitanata. Fonti, dati archeologici, dati spaziali per la restituzione di un paesaggio urbano sepolto" In Archeologia Medievale, XLVIII, 301-322. Bari: Edipuglia.

192. Inequality of a townscape. Problem of assessment of living space in preindustrial cities.

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The structure of medieval towns in Central Europe depends on their genesis and factors influencing development. From the time of establishment of a town, it was changing and transforming, creating a constantly evolving palimpsest (Bailey 2007). It was shaped by both environmental and economical factors, as well as individual historical events and long-term trends. Under their influence, the socal topography of a city changed over time (Hilier, Hanson 1984). Some city zones accumulated positive factors and got more prestigious. Zones where negative factors dominated developed a bad reputation. The value of land and living space in different parts of a city began to diversify. What factors generated this inequality? We would like to answer the question of whether we can observe and measure the increase in inequality in the context of the architectural and urban space of the city.

Working on a historical city we usually deal with limited sources of information (incomplete archaeological research, unpreserved written documents). Despite the incomplete source base, are we able to create a model that evaluates the space in the city? Can we compare different timelines and cities with each other?

We want to propose a method of assessing living space (houses) in terms of its utility value. The approach we propose is inspired by contemporary methods of assessing the attractiveness of space, used in regional studies and multivariate analysis for real estate appraisal. The assessment of space is made on the basis of iconographic, cartographic and archaeological data, historical sources and architectural documentation. We used the scoring method to combine quantitative and qualitative components. We selected evaluation criteria and conducted an assessment of individual blocks of building, referring to the idea of neighborhoods in the city (Michael 2010). The analyzes were carried out with the use of GIS tools. The obtained model was confronted with the available tax sources and data on real estate prices. The results allowed for the identification of prestigious and degraded locations within the city. The method allows assessment of changes in different time periods and comparisons between different cities.

We discuss the method on the examples of two early modern cities: Prague in Bohemia and Wrocław, Silesia (today's Poland) in the 16th and 18th Century. We believe that it can also be applied to studies of other cities, at various periods. The method is constantly being developed and refined. Attempts are made to use modern classification methods, such as neural networks, to improve the method.

Bailey Geoff, Time perspectives, palimpsests and the archaeology of time, „Journal of Anthropological Archaeology", 2007, 26, 198-223, https://doi.org/10.1016/j.jaa.2006.08.002

Hillier Bill, Hanson Julienne, The Social Logic of Space, Cambridge 1984.

Smith Michael E., The archaeological study of neighborhoods and districts in ancient cities, "Journal of Anthropological Archaeology", 2010, t. 29, s. 137–154.

207. The urban side of child rearing: application of machine learning on sequential isotopic dentine data for pattern recognition related with weaning and physiological stress

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1 Introduction

The city of Thessaloniki, founded in 315 BC, is one of the first large urban centers of the Graeco-Roman world. The urban and multicultural element of large centers is usually reflected in the upbringing of children since subsistence strategies interfere with breastfeeding practices and parental investment. However, the completion of breastfeeding before the age of two and/ or the introduction of supplementary foods prior to 6 months, have been associated with elevated risks of infant morbidity and mortality, since breastfeeding and weaning are powerful mediators of infant health and survival.

The recent development of sequential isotopic analysis of dentine allows the reconstruction of breastfeeding and weaning leveraging the formation of dentine in subsequent layers and its ability to retain isotopic signatures during its formation period. This method has been used to differentiate the effects of diet and physiological stress due to weaning with the examination of isotopic patterns. An isotopic pattern compatible with weaning is characterized by a sustained decrease in isotopic ratios of nitrogen (δ15N) and carbon (δ13C). An isotopic pattern indicating physiological stress is characterized by an increase in δ15N and a probable decrease in δ13C values (Craig-Atkins, Towers, and Beaumont 2018).

In this study, we applied a machine learning approach to identify isotopic patterns associated with weaning and physiological stress in ancient Thessaloniki. The intent of this study is twofold: first, to measure the suitability of machine learning on isotopic data as a new method to investigate early life nutritional conditions, second, to investigate the developmental origins of infant health in ancient urban societies.

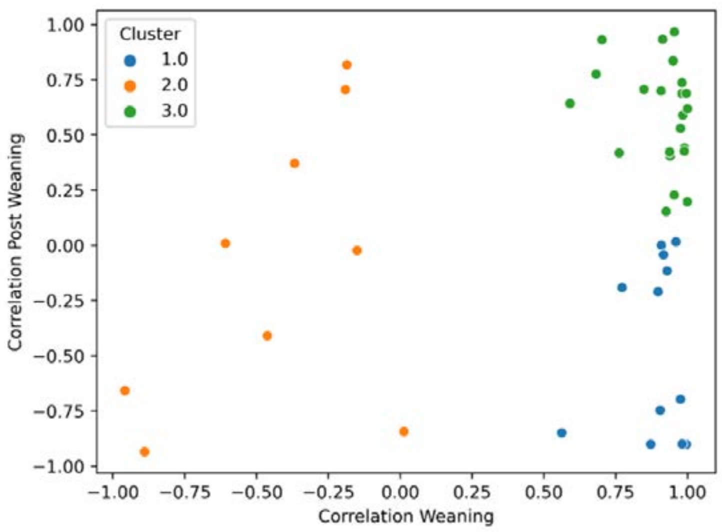
2 Materials and Methods

Sample preparation and age-at-increment assignment are described in Ganiatsou, Vika, et al (2022), and weaning duration was estimated with the application WEAN.

For the pattern recognition, we used the k-means algorithm to measure the correlation of δ15N and δ13C values in individual isotopic profiles produced from incremental dentine collagen of first permanent molars (Ganiatsou, Vika, et al. 2022; Ganiatsou, Georgiadou, et al. 2022). To increase the resolution, we divided the paired measurements of isotopic ratios by using the median weaning age of the population (2.1 years) and discriminate them into those corresponding to the period of weaning and to those corresponding to the period afterwards. Therefore, we created two variables (correlation weaning and post-weaning) that the algorithm compared. We excluded the individuals with no breastfeeding-associated values, as these profiles are characterized by insignificant, but concominant changes in isotopic ratios and this would potentially interfere with the algorithm's calculations.

3 Results

To assess different isotopic patterns in our dataset with the k-means algorithm, we selected the number of three clusters after plotting the Sum of Squares Error (SSE) against the number of clusters (k) (Figure 1). Cluster 1.0 consists of 12 individuals whose values have positive correlation during the weaning process. Six individuals have negative correlation during post-weaning and six individuals have no correlation after the completion of weaning. Cluster 2.0 includes nine individuals whose ratios show no or negative correlation during weaning and post-weaning. Cluster 3.0 includes 22 individuals whose values exhibit positive correlation before the weaning age and after the completion of weaning.



4 Discussion

In our dataset, the Clusters 1.0 and 3.0 include individuals who were breastfed and do not show evidence of stress, at least during weaning. The individuals of Cluster 1.0 are characterized during the post-weaning phase by numerous changes in their isotopic ratios, which could have resulted from radical dietary shifts, i.e., the abrupt consumption of C4 plants/ fish or animal protein for a short period. On the contrary, individuals in Cluster 3.0 are characterized by fewer isotopic ratio changes, which point to smaller dietary shifts during their life.

Cluster 2.0 includes the individuals whose isotopic values are related to physiological stress due to the early cessation of breastfeeding or the consumption of foods, low in nutritional content

Taking into consideration that Cluster 2.0 represents almost 10% of the total examined dataset and also six individuals did not breastfeed or breastfed for a limited period, these results hint that maladaptive breastfeeding patterns were present in the site.

This study shows diachronic trends in infant feeding practices in a large ancient urban center. Based on our results, the k-means algorithm can be used to assess early life nutritional conditions, which served as key to mitigate or exacerbate the health status of infants. These findings were obtained by the amalgamation of isotopic evidence with mathematical and machine learning methods with the intent to lay a new foundation in the treatment of isotopic data.

Funding

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References

Craig-Atkins, Elizabeth, Jacqueline Towers, and Julia Beaumont. 2018. “The Role of Infant Life Histories in the Construction of Identities in Death: An Incremental Isotope Study of Dietary and Physiological Status among Children Afforded Differential Burial.” American Journal of Physical Anthropology 167 (3): 644–55.

Ganiatsou, Elissavet, Angeliki Georgiadou, Angelos Souleles, Asterios Aidonis, Tania Protopsalti, Stavroula Tzevreni, Krino Konstantinidou, Stella Vasileiadou, Frank Siegmund, and Christina Papageorgopoulou. 2022. “Application of Machine Learning on Isotopic Data from Tooth Microsections for Reconstructing Weaning Patterns and Physiological Stress.” Https://Papers.Ssrn.Com › p...Https://Papers.Ssrn.Com › p... https://doi.org/10.2139/ssrn.4186545.

Ganiatsou, Elissavet, Efrossini Vika, Aggeliki Georgiadou, Tania Protopsalti, and Christina Papageorgopoulou. 2022. “Breastfeeding and Weaning in Roman Thessaloniki. An Investigation of Infant Diet Based on Incremental Analysis of Human Dentine.” Environmental Archaeology.

12. Chronological modelling: formal methods and research software

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Location: E107

Time and its analysis are at the heart of archaeology: one of the main objectives of the archaeologist is the establishment of a temporal framework for a given layer, site or material culture. But archaeology covers such a wide range of cultures, dispersed both in time and space, that contextual chronological assessments are constructed using very different tools, languages and techniques. It creates as many different temporal and cultural frameworks as there are specialties, with notable differences in approaches depending on whether one is dealing with absolute or relative chronology, laboratory techniques or cultural approaches, deterministic or statistical methods (Buck and Millard 2004). The aim of this session is to explore a wide variety of research tools and techniques related to (semantic) chronological modelling in archaeology in order to identify common methodological frameworks and to build bridges between specialties. This also invites approaches from CAA Special Interest Groups (SIG), e.g. on Scientific Scripting Languages in Archaeology (SSLA) and Semantics and LOUD in Archaeology (Data Dragon) as well as from the CAA Little Minions on chronological modelling. These SIGs are following the FAIR (Bahin et al. 2020) and FAIR4RS (Hong et al. 2022) principles in the idea of Open Science, including Open Access, Open (Research) Data and Open Source (Research) Software.

We invite papers in all fields related to time/chronology research, including:

Bayesian modelling. Bayesian modelling has revolutionized the way radiocarbon dating is practised nowadays (Buck et al. 1991; Bronk Ramsey 2009). The introduction of known priors (e.g., stratigraphic sequences, termini post/ante quem) into the radiocarbon calibration process enables researchers to obtain much more precise dating intervals than previously, when radiocarbon samples were individually calibrated rather than incorporated into a model. Many software tools are currently available for Bayesian modelling in archaeology, such as OxCal, BCal, ChronoModel, as well as R and Python packages.

Stratigraphic modelling. The most famous tool for stratigraphic modelling is the Harris matrix (Harris 1989), which has been the focus of much software development (Harris Matrix Composer, Stratify, Stratifiant, …). Originally designed as a tool restricted to relative chronology, the Harris matrix has also seen developments aimed at extending this formalism to include absolute dating elements (see for example Desachy 2016). Similar efforts have extended the model's power to be able to automatically detect temporal relations between stratigraphic units (see for example the Phaser tool).

Temporal logics. Temporal logics is an important field of mathematical and computer science research (Demri et al. 2016), which has up to now found too little applications in archaeological research, probably due to a lack of communication between the relevant research communities. The main results of temporal logics widely applied and cited by archaeologists (see for example Holst 2004; May 2020) are the fundamental, but old, Allen relations (Allen 1984, 1991). The archaeological research community has otherwise only brought too little attention to recent research results in temporal logics.

Seriation techniques. A classical way to provide relative chronology between artifacts, even in the absence of stratigraphic information, is seriation (O'Brien and Lyman 1999). In its variant called frequency seriation, the relative frequencies of each type of artifacts found within the same layer are computed and presented in chart form. The relative order between these layers (possibly coming from different sites, thus not featuring a relative stratigraphic order with each other) can then be established using the hypothesis of unimodality of artifact production. Seriation is an old but powerful method, which seems to have fallen out of fashion in many fields of Old World archaeology, but that still saw significant advances in the last decades (see for example Lipo, Madsen and Dunnell 2015).

Chronological networks. Until recently, little attention had been brought to the application of deterministic (i.e. non-statistical) techniques to building wide regional chronologies, based on historical data and cultural synchronisms. The goal of such techniques is to automate the archaeological cross-dating process by encoding a network of chronological relationships between temporal entities, and using algorithms to build the global chronology by propagating along the network a set of absolute dates located at specific nodes of the network. This approach has recently been implemented by two software tools: Groundhog (Falk 2016, 2017, 2020) and ChronoLog (Levy et al. 2021a, 2021b), relying on different techniques (exhaustive search and graph-theoretic techniques, respectively).

Linked Open Time Data (LOTD). Chronological Linked Open Data provides chronological space-time-gazetteers, e.g. PeriodO, GODOT and ChronOntology, and standard formats and ontologies, e.g. RDF, OWL TIME, EDTF, and CIDOC CRM, Alligator Ontology, AMT Time Ontology. LOTD and open source research tools allow for reproducible research, the unveiling of "hidden assumptions" in archaeological data and the semantic modelling of fuzziness and wobbliness. An example could be statistical approaches such as the horseshoe paradigm using correspondence analysis and the application of temporal logics to do temporal reasoning (Madsen 1998; Thiery and Mees 2018).

Other approaches. A host of other formal approaches to chronological modelling and computation have been explored in the recent years, such as fuzzy logics (Niccolucci and Hermon 2015), aoristic analysis (Crema 2012), and evidence density estimation (Demján and Dreslerová 2016).

We welcome papers dealing with new theoretical, methodological and research software developments in any of the above fields, in order to promote shared practices and the discovery of new ideas and paradigms.

References

Allen, J.F. 1984. Towards a general theory of action and time. Artificial Intelligence 23: 123–154.

Allen, J.F. 1991. Time and time again: the many ways to represent time. International Journal of Intelligent Systems 6(4): 341–355.

Bahim, C., Casorrán-Amilburu, C., Dekkers, M., Herczog, E., Loozen, N., Repanas, K., Russell, K. and Stall, S., 2020. The FAIR Data Maturity Model: An Approach to Harmonise FAIR Assessments. Data Science Journal 19(1): 41. DOI: http://doi.org/10.5334/dsj-2020-041

Bronk Ramsey, C. 2009. Bayesian analysis of radiocarbon dates. Radiocarbon 51: 337–360.

Buck, C.E., Kenworthy, J.B., Litton, C.D. and Smith, A.F.M. 1991. Combining archaeological and radiocarbon information: a Bayesian approach to calibration. Antiquity 65: 808–21.

Buck, C.E. and Millard, A. 2004. Tools for Constructing Chronologies: Crossing Disciplinary Boundaries. London.

Chue Hong, N. P., Katz, D. S., Barker, M., Lamprecht, A-L, Martinez, C., Psomopoulos, F. E., Harrow, J., Castro, L. J., Gruenpeter, M., Martinez, P. A., Honeyman, T., et al. (2022). FAIR Principles for Research Software version 1.0. (FAIR4RS Principles v1.0). Research Data Alliance. DOI: https://doi.org/10.15497/RDA00068

Crema, E.R. 2012. Modelling temporal uncertainty in archaeological analysis. Journal of Archaeological Methods and Theory 19: 440–461.

Demján, P. and Dreslerová, D. 2016. Modelling distribution of archaeological settlement evidence based on heterogeneous spatial and temporal data. Journal of Archaeological Science 69: 100–109.

Demri, S., Goranko, V. and Lange, M. 2016. Temporal Logics in Computer Science: Finite-State Systems (Cambridge Tracts in Theoretical Computer Science). Cambridge.

Desachy, B. 2016. From observed successions to quantified time: formalizing the basic steps of chronological reasoning. Acta Imeko 5: 4–13.

Falk, D.A. 2016. Groundhog: A Computer test laboratory to validate chronological hypotheses. Research poster presented at the 2016 Annual Meeting of the American Schools of Oriental Research (ASOR). http://www.groundhogchronology.com/poster.pdf (accessed 23/9/2021).

Falk, D.A. 2017. Evaluating chronological hypotheses by computer analysis in light of low and middle chronological frameworks. Abstract of a paper presented at the 2017 Annual Meeting of the American Schools of Oriental Research (ASOR). https://www.asor.org/wp-content/uploads/2019/01/ASOR-Program-2017.pdf (accessed 23/9/2021).

Falk, D.A. 2020. Computer analytics in chronology testing and its implications for the date of the Exodus. In: Averbeck, R.E., Younger Jr, K.L., eds. “An Excellent Fortress for His Armies, a Refuge for the People”, Egyptological, Archaeological, and Biblical Studies in Honor of James K. Hoffmeier. University Park, PA: 99–111.

Harris, E. 1989. Principles of Archaeological Stratigraphy (second edition). London.

Holst, M.K. 2004. Complicated relations and blind dating: formal analysis of relative chronological structures. In: Buck, C.E. and Millard, A.R., eds. Tools for Constructing Chronologies. London: 129–147.

Levy, E., Geeraerts, G., Pluquet, F., Piasetzky, E. and Fantalkin, A. 2021a. Chronological networks in archaeology: a formalised scheme. Journal of Archaeological Science 127: article 105225.

Levy, E., Piasetzky, E. and Fantalkin, A. 2021b. Archaeological cross dating: a formalized scheme. Archaeological and Anthropological Sciences 13: article 184.

Lipo, C.P., Madsen, M.E. and Dunnell, R.C. 2015. A Theoretically-Sufficient and Computationally- Practical Technique for Deterministic Frequency Seriation. PLoS ONE, 10(4): 1–31.

Madsen, T. 1988. Multivariate statistics and archaeology. In: Madsen, T. (ed.), Multivariate Archaeology. Numerical Approaches in Scandinavian Archaeology. Jutland Archaeological Society Publications 21, 7-28.

May, K. 2020. The Matrix: Connecting Time and Space in Archaeological Stratigraphic Records and Archives. Internet Archaeology 55. https://doi.org/10.11141/ia.55.8 (accessed 3/10/2021).

Niccolucci, F. and Hermon, S. 2015. Time, chronology and classification. In: Barcelo, J.A. and Bogdanovic, I., eds. Mathematics and Archaeology. Boca Raton: 257–271.

O'Brien, M.J. and Lyman, R. L. 1999. Seriation, stratigraphy, and index fossils: the backbone of archaeological dating. New York.

Thiery, F. and Mees, A. 2018. Taming the chronology of South Gaulish Samian found at Hadrian's Wall and the German Limes using Linked Open Data, UK Chapter of Computer Applications and Quantitative Methods in Archaeology (CAA-UK 2018), Edinburgh, Scotland, 26th October 2018. https://doi.org/10.5281/zenodo.1469298.

SLOT 3	
13:00	**Introduction**
13:20	105. Aoristic temporal study of heterogeneous amphora data in Roman Germania reveals centuries-long change in regional patterns of production and consumption *Tom Brughmans (Classical Archaeology and Centre for Urban Network Evolutions (UrbNet), Aarhus University)*; Tyler Franconi (Joukowsky Institute for Archaeology & the Ancient World, Brown University); Ekaterina Borisova (Center for Humanities Computing Aarhus, Aarhus University); Laura Paulsen (Center for Humanities Computing Aarhus, Aarhus University)*
13:40	124. Temporal Modelling of the Roman Marble Trade *Devi Taelman (Vrije Universiteit Brussel)**
14:00 - 14:20	123. Beyond chronological networks: a comparison of formal models for archaeological chronology *Eythan Levy (Bern University)**
14:20 - 14:40	189. Dendrochronological networks: from time series to networks and back to spatio-temporal patterns again *Ronald Visser (Saxion University of Applied Sciences)**
14:40 - 15:00	70. Conventions for Archaeological Stratigraphic and Chronological Data *Keith May (Historic England)*; James Taylor (Department of Archaeology, University of York)*

SLOT 4	
15:30	57. Automating chronology construction and archiving (FAIR)ly along the way *Bryony Moody (University of Sheffield)*; Keith May (Historic England); Thomas Dye (University of Hawaii); Caitlin E Buck (University of Sheffield)*
15:50	285. ChronOntology for periodisations in Entangled Africa *Wolfgang Schmidle (DAI)*; Eymard Fäder (Universität zu Köln); Johanna Sigl (KAAK); Eva Reinke (Universität zu Köln); Lukas Lammers (Universität zu Köln); Florian Lukas (KAAK)*
16:10	283. Discussing the need for a new CAA Special Interest Group on chronological modelling *Thomas Huet (University of Oxford, School of Archaeology)*; Eythan Levy (Bern University); Florian Thiery (LEIZA); Allard Mees (RGZM)*

105. Aoristic temporal study of heterogeneous amphora data in Roman Germania reveals centuries-long change in regional patterns of production and consumption

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Ekaterina Borisova, Center for Humanities Computing Aarhus, Aarhus University
Laura Paulsen, Center for Humanities Computing Aarhus, Aarhus University

We apply probabilistic aoristic temporal methods to obtain novel insights into trade in amphorae-borne products over a 550-year period in Germania along the frontier of the Roman Empire.

We present an exploratory temporal data analysis of the RAAD database, which includes highly heterogeneous published amphorae assemblages from 79 different archaeological sites in the region of ancient Roman Germany, roughly equivalent with the parts of The Netherlands, Germany, France, and Switzerland that border the Rhine River in western Europe. Chronological information is derived from site occupation dates (some of which are temporary military forts and were occupied for extremely short periods) and from typo-chronological information of 260 individual ceramic forms. We will explore the strong impacts of using different temporal information on data patterns generated by aoristic methods. Specifically, the differences between using production and consumption dates (respectively amphora type and site dates). Moreover, we will present the differences in data patterns between ceramic quantification methods (Minimum Number of Individuals (MNI), Maximum Number of Individuals (MAX), and diagnostic Rim, Base, and Handles count (RBH)). We will additionally trace temporal patterns of amphorae from different regions (Iberian Peninsula, Italy, Gaul, Eastern Mediterranean, North Africa, and Germania), with different typical prime-use contents (wine, olive oil, fish sauce, fruit). Finally, we will explore differences between amphora data patterns at different site types (military, settlement, villa), explore the exceptional case of Augustan period sites with a short occupation span, and closely examine the data pattern of the site of Augst that has a particularly rich, published material record. All analyses were performed using Python, documented in open iPython notebooks, using an open deposited dataset.

Our data analysis reveals highly detailed differential patterns of consumption and production within the German market. We show how connections to far-flung regions such as the Eastern Mediterranean or the Iberian Peninsula wax and wane through time, and how the local German producers start to compete with these imported products. These chronological patterns provide important insight into a regional market within the larger Roman economy and provide an important case study in changing economic connections over a long period, demonstrating in a transparent and reproducible way a geographical and chronological pulsation in market activity that was otherwise unknown and undemonstrated. We will conclude with a reflection on the methodological decisions made when dealing with chronological archaeological information, focusing in particular on the potential and challenges of aoristic methods. Temporal probabilistic approaches are highly uncommon in Roman archaeology, the field this study belongs to, and aoristic methods are considered most intuitive and more common within the field. However, there is a need for educational resources and easy-to-use tools to make other approaches to temporal uncertainty more common in fields like Roman archaeology.

124. Temporal Modelling of the Roman Marble Trade

Devi Taelman, Vrije Universiteit Brussel

Recent decades have witnessed a growing importance of archaeological data in studies of how past economies functioned and evolved through time. Much of this progress results from advances in scientific (provenancing) techniques, the application of (geo-)statistical methods, and an increased interest of archaeologists and historians in what the material record can tell us about past socio-economical systems. Commonly used archaeological proxies for the economy of the Roman period include amphorae, various kinds of fineware pottery, shipwrecks, wine and olive presses, and fish salting infrastructure.

While studies of high-quality raw materials, such as marbles, are not uncommon in archaeology, the full potential of this material category as proxy data for the Roman economy has not yet been fully explored in the field of economic archaeology/history. The importance of marble for Roman society, combined with its durability, provenancing potential, and chronological resolution—marble objects (e.g., building elements, sculpture, sarcophagi) are generally well-dated—make it a very promising subject of research for archaeologists and historians interested in the economy of Antiquity. Provenance determinations for white marble can serve as a meaningful proxy indicator for studying long-distance trade, changes in urbanization and elite urban investment in the Roman world, as well as for examining the structure, behavior and performance of the wider Roman economy. Quantitative analysis of marble provenance data permits revealing and visualizing general trends, patterns and associations in the rise and fall of market shares and distribution of individual marble resources across the Mediterranean. Without ignoring the effect of taphonomic processes, changes in consumption and distribution patterns can charted with the aim of identifying relative changes in the volume of marble traded throughout the Roman Mediterranean.

In this paper, I focus on published white marble provenance data of the quarry districts that exported on a supra-regional scale in the Roman Mediterranean (200 BCE – 500 CE). Data from 417 publications with provenance determinations for archaeological white marble have been collected, resulting in a corpus of 7,017 records of individual white marble artefacts from 350 archaeological sites around the Mediterranean Sea. Chronology of the studied marble objects is derived either from their stratigraphical context, or, in case the objects originated from open contexts or secondary depositions, from stylistic characteristics. Regardless of their depositional context, exact dates of production and/or consumption are generally not available. Like in most archaeological material studies, chronology for objects are normally given using date ranges. Apart from this intrinsic temporal uncertainty of the collected archaeological material, we are confronted with objects that have different levels of temporal uncertainty. While some marble objects can be dated very narrowly (e.g., Imperial portraits, inscriptions), others can only be assigned to specific cultural periods (e.g., Early Empire, Late Roman, Hadrianic) or centuries (e.g., 1st c. CE).

Different, simple visualisations are used to illustrate the temporal resolution of the studied marble objects and to assess their value for styding diachronic trends in marble distribution. Using midpoint-radius diagrams (Kulpa 2006, Van De Weghe et al. 2007), the relation between the temporal resolution of the marble objects included in the study and their distribution over time is presented . Here, every marble object is represented as a point in time on the basis of its date range and temporal resolution. Using this method, it is possible to represent visually how many objects are dated to a particular time period, but also what objects have relatively higher or lower temporal reliability.

The problem of temporal diagnosticity remains, however, pressing when looking at middle- and long-term trends in the rise and fall of market shares of marble resources and when aiming to compare the trade of marble with that of other (archaeological) proxies for the Roman economy. To deal with the issue of temporal uncertainty, and to allow for graphing the variability in distribution over time of objects with different levels of chronological resolution, a chronological distribution method has been applied to the objects in the marble dataset. For this paper, marble objects were chronologically assigned to a particular period using aoristic weighting with a linear distribution. This method was chosen to reduce introducing to much interpretational difficulties as we generally have very little or no archaeological indication of the probability distribution of the production/distribution of marble objects within their date ranges. The timeline was divided into time blocks of 25 yr, a choice that was based on and can be justified by the chronological resolutions of the objects under study. However, instead of summing the aoristic weighting results per time block, a simulation approach was applied to the distribution method, with the goal of accounting for the probabilistic nature of the temporal distribution (Crema 2012). This approach involves the creation of multiple possible 'scenarios' of the results, in this case 10,000 simulation runs, with the probability of occurrence for each trajectory being defined by the aoristic probabilities.

References

Crema, E.R. 2012. "Modelling temporal uncertainty in archaeological analysis." Journal of Archaeological Method and Theory 19: 440–461.

Kulpa, Z. 2006. "A diagrammatic approach to investigate interval relations." Journal of Visual Languages & Computing 17: 466–502.

Van De Weghe, N., Docter, R., De Maeyer, P., Bechtold, B. and Ryckbosch, K. 2007. "The triangular model as an instrument for visualising and analysing residuality." Journal of Archaeological Science 34: 649–655.

123. Beyond chronological networks: a comparison of formal models for archaeological chronology

Eythan Levy, Bern University

This paper compares the recent "Chronological Networks" model (Levy et al. 2021) used by the ChronoLog software (chrono.ulb.be), to several other chronological models in archaeology. Chronological networks constitute a versatile formalism for building complex chronological models featuring stratigraphic data, historical data, ceramic types, and more. They allow to encode both exact dates and durations, as well as uncertain ones (expressed as bounds or ranges). They also features a wide array of synchronisms, modelling the different types of relations that temporal entities can share with each other. The model is backed by fast graph-theoretic algorithms, that allow to build and check chronologies interactively.

This paper discusses the similarities and differences between the chronological networks model and several other chronological formalisms, such as Harris matrices, Pert & Gantt charts (Kromholz 1987), and OxCal Bayesian models (Bronk Ramsey 2009). We discuss how chronological networks can be used to generalize—or to simulate—some of the above models, and we highlight the advantages and limitations of this approach.

Finally, we discuss some perspectives on future works, regarding the evolution of ChronoLog and its relevance for applications beyond chronological networks, hoping to trigger discussions and possible new collaborations with other members of the CAA community.

References

Bronk Ramsey, Christopher. 2009. Bayesian analysis of radiocarbon dates. Radiocarbon 51: 337–360. https://doi.org/10.1017/S0033822200033865

Kromholz, Alfred H. 1987. "Business and industry in archaeology." In High, Middle or Low? (Part 1), edited by P. Åström, 119–137. Gothenburg: P. Åström Forlag.

Levy, Eythan, Gilles Geeraerts, Frédéric Pluquet, Eli Piasetzky, and Alexander Fantalkin. 2021. "Chronological networks in archaeology: a formalised scheme." Journal of Archaeological Science 127: article 105225. https://doi.org/10.1016/j.jas.2020.105225

189. Dendrochronological networks: from time series to networks and back to spatio-temporal patterns again

Ronald Visser, Saxion University of Applied Sciences

Dendrochronology and archaeology are strongly connected disciplines and both deal with time, time series and spatio-temporal patterns. Dendroarchaeology uses dendrochronological material from archaeological context and results not only in dated contexts, but also enhances our insight into the provenance of wood and patterns of wood use (Sands 2022; Visser 2021). While for some the dating of the context is the most important result of dendrochronological research, the spatio-temporal patterns that can be made visible using a large dataset of tree-ring material is an important part of dendroarchaeology. Interestingly, there is no formal framework to do this kind op modelling. Some people use dots on the maps to discern the spatial distribution of the matching site-chronologies (Daly 2007; Daly and Tyers 2022), which is perfect for building the argument to determine the provenance the wood. The temporal modelling is not as strongly expressed. It is also possible to present matching tree-ring material in a network (Visser 2021b), with the nodes representing the tree-ring series (e.g. single series or chronologies) and the edges showing the relation based on the statistical similarity (Pearson's correlation coefficient, number of overlapping years, synchronous growth changes (SGC: Visser 2021a) and its related probability of exceedence). These networks strongly help to understand the patterns that exist between the tree ring material. These tree-ring patterns and patterns in the network are strongly influenced by various factors, such as climate, soil, disturbances (Cook 1990). These have a strong spatial and temporal character, but up until now the interpretation has been mainly focused on the spatial interpretation. In this paper, I will focus on the temporal patterns in the dendrochronological networks and explore how a network of time series can be used for chronological interpretation and modelling to enhance our understanding of patterns in the past.

References

Cook, E. R. 1990. 'A Conceptual Linear Aggregate Model for Tree Rings'. In Methods of Dendrochronology: Applications in the Environmental Sciences, edited by E. R. Cook and L. A. Kariukstis, 98–104. Dordrecht: Kluwer Academic Publishers.

Daly, Aoife. 2007. 'Timber, Trade and Tree-Rings. A Dendrochronological Analysis of Structural Oak Timber in Northern Europe, c. AD 1000 to c. AD 1650.' PhD Thesis, University of Southern Denmark. http://www.humaniora.sdu.dk/phd/dokumenter/filer/Afhandlinger-101.pdf.

Daly, Aoife, and Ian Tyers. 2022. 'The Sources of Baltic Oak'. Journal of Archaeological Science 139 (March): 105550. https://doi.org/10.1016/j.jas.2022.105550.

Sands, Rob. 2022. 'Life beyond Life: Repair, Reuse, and Recycle—the Many Lives of Wooden Objects and the Mutability of Trees'. Archaeometry 64 (S1): 168–86. https://doi.org/10.1111/arcm.12708.

Visser, Ronald M. 2021a. 'On the Similarity of Tree-Ring Patterns: Assessing the Influence of Semi-Synchronous Growth Changes on the Gleichläufigkeitskoeffizient for Big Tree-Ring Data Sets'. Archaeometry 63 (1): 204–15. https://doi.org/10.1111/arcm.12600.

Visser, Ronald M.. 2021b. 'Dendrochronological Provenance Patterns. Network Analysis of Tree-Ring Material Reveals Spatial and Economic Relations of Roman Timber in the Continental North-Western Provinces'. Journal of Computer Applications in Archaeology 4 (1): 230–53. https://doi.org/10.5334/jcaa.79.

70. Conventions for Archaeological Stratigraphic and Chronological Data

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The chronological modelling of archaeological data is dependent upon access to, and re-use of, primary stratigraphic data and associated dating evidence, which should form a principle component of archaeological datasets. However current practice for archiving of digital records of the stratigraphic data from excavations is still very variable internationally, and in many cases lacking, particularly for commercially excavated sites. Experience in the UK shows "comparison of the number of archives deposited with the ADS against an estimated number of projects found that, at best, 2-3% of all commercial projects have been digitally archived with the ADS." (Tsang 2021). There is also no commonly accepted consistent practice for making sure that the primary stratigraphic data from excavations is included in the digital archive. Although there are valuable initiatives currently being undertaken to address what is included in the digital archive from excavations, such as the "Dig Digital Think Archive" project, the actual processes used in the analysis stage of projects varies quite markedly and therefore the by-products from that stage of the process are far less consistent in the resulting digital archives.

For projects that do archive primary stratigraphic records from an excavation, in most cases the grouping and phasing information from the analysis of stratigraphy is not associated with the primary stratigraphic data. This creates an hiatus in the stratigraphic record, whereby it is not possible to follow the stratigraphic sequences through from the primary records made on the excavation, to the interpretive phasing of the stratigraphic matrix based on the associated finds assemblages and dating evidence. Most significantly the actual chronology for sites derived from the dating of stratigraphic units from finds objects and scientific dating of samples is not available unless the evidence from such analysis records are incorporated into the site grouping and phasing and these records are the least prevalent in the digital archives.

In current practice often only a PDF image of a matrix diagram is included in an archived report. Where primary stratigraphic relationships are archived these may be recorded as separate columns in spread sheets and archived in Comma Separated Value (CSV) format, which is substantially better for preservation and reuse purposes. In other cases, the stratigraphic relationships will be held as part of the site database and will then be archived in a format that such database software enables to be digitally preserved and migrated as necessary, again most commonly in .csv format. Even so, and in either case, that does not necessarily guarantee commonality in how the stratigraphic information within the data are represented and preserved and does not incorporate chronological data from the analysis of associated finds.

For stratigraphic modelling it has been proposed by Edward Harris that an International Convention is needed to re-visit, re-affirm and advance as necessary the existing laws and Principles of Stratigraphy (Harris 1989). To do so, a first step could be a working group on stratigraphic and chronological methods be created as part of the work to investigate the best practice documentation for post-excavation analysis practice. To be able to fully manage FAIR stratigraphic and related chronological data and its archiving we may need to take a new approach to data packaging and how it could help in making stratigraphic data more re-usable, and interoperable across different site records. The objective would be to improve data packaging to cover the range of archaeological processes that use stratigraphy and chronological data with related data sign-posting in digital archives. The aim would be to better reflect data characterization of most common examples of re-use (or re-mixing, or re-cycling of data) based upon analysis of common use case scenarios, informed by "action mapping" of typical user journeys through digital archives. Stratigraphic and chronological re-use examples provide a good basis for case studies. One proposal would be to combine existing resources and develop new exemplars along the lines of the FAIR Cookbook for life sciences (FAIR Cookbook 2022).

The Matrix project has investigated the re-use of stratigraphic data in archives and found a number of issues that impact on the re-use of data for stratigraphic and chronological modelling. The Phaser application developed as part of the Matrix project is a prototype designed to address some of the key elements that are needed to help harmonize the processes of data analysis and its deposition for archiving. This paper will consider a number of these proposals and options for improving the records and re-use of stratigraphic data e.g. for chronological modelling, including developing an online handbook for post-excavation practices in stratigraphic analysis.

References:

Harris, Edward. 1989. Principles of Archaeological Stratigraphy (2nd Edition). London: Academic Press. https://harrismatrix.com/

The FAIR Cookbook. 2022.https://faircookbook.elixir-europe.org/content/recipes/introduction/FAIR-cookbook-audience.html

Tsang, Claire. 2021 Red Sky at Night: digital archiving in England 2020, Internet Archaeology 58. https://doi.org/10.11141/ia.58.6

57. Automating chronology construction and archiving (FAIR)ly along the way

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Thomas Dye, University of Hawaii

Caitlin E Buck, University of Sheffield

A key goal of archivists is ensuring that digital archaeological data are archived in a way that satisfies the FAIR principles (https://www.go-fair.org/fair-principles/). These principles ensure that the archaeological data, and especially scientific archaeological data, are Findable, Accessible, Interoperable and Reusable. Unfortunately, there is a lack of standardised software for managing and archiving relative and absolute dating evidence. Consequently, digital archaeological data that should be comparable in archives such as the Archaeology Data Service (ADS) in the UK, are inconsistent, often incomplete and, thus, are not reusable. This paper will discuss prototype software for managing and interpreting absolute and relative dating evidence, allowing FAIR archiving along the way.

We postulate that one cause for the lack of dating evidence within archives such as ADS is that no free, open-source software is available to manage such data. The process of chronology construction has multiple steps in which the data might be augmented and analysis carried out: from data collected during an excavation, to obtaining calendar date estimates for many different finds and samples, to adjustments on proposed date ranges for phases. Our prototype software seeks to ensure that all changes to the data are automatically archived while ensuring the user provides a rationale for any modifications to the data or chronological models they make.

285. ChronOntology for periodisations in Entangled Africa

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Lukas Lammers, Universität zu Köln
Florian Lukas, KAAK

ChronOntology is a time gazetteer, i.e. a gazetteer for periodisations such as "neolithic" or "Hadrianic". It is based on a rich semantic data model that is compatible with CIDOC CRM. Periods typically have a geographical and temporal extent, but the extent is not part of their definition. Instead, researchers can provide a timespan based on the definition and different researchers can disagree on the dating information even if they agree on the definition. Thus, a record in ChronOntology represents a period in the sense of CIDOC CRM, a different approach than in e.g. PeriodO, a time gazetteer where records represent opinions of individual researchers or organisations.

ChronOntology comprises more than 10,000 records that were either taken from other electronic sources and enriched for its more complex data model or extracted from the literature. Each period has a type, such as "political" or "material culture". Types have subtypes such as "pottery style". The periods are strongly connected with each other via relations such as "is part of" or "follows". Geographical information is stored in a separate place gazetteer. The geographical and temporal extents are visualised in a timeline widget and a geo widget.

In this talk we focus on the experience of creating new records in Entangled Africa. The research groups within this DFG-financed "collaborative research centre" have agreed on a set of so far ca. 200 periodisations, which have been very carefully curated and added to ChronOntology. We will describe the process (and limits) of extracting definitions from the literature, creating connections within the Entangled Africa periods as well as with existing periods and situating the cultural periods in larger geological periods. For Egypt we describe our ongoing effort of correcting the existing records without invalidating existing links to these gazetteer entries. We are also modelling different approaches to the Ptolemaic dynasty, where the usual periodisation neglects the role of female co-rulers.

The data is connected to Arachne, a large database of archaeological objects. Where the geographic information was missing in the place gazetteer, new records have been created there as well. It has also proven useful to create a test server in addition to the live system. Based on our experience we are currently creating extensive documentation and best practices for using ChronOntology.

So far the original data model can keep up with the new records but a round of tweaks and changes is planned. For example, we are working on the formalisation of definitions by type, starting with the example of the Handessi Complex, situated in the southern Libyan Desert and part of a wider northeast African technocomplex of the 3rd and 2nd millennia BC that is characterised by pottery decorated with geometric ornaments. New subtypes such as "pottery decoration pattern" are being added as needed to the type hierarchy.

For the future we are planning to extend ChronOntology in several directions, most of which will require further changes to the data model. Just to mention a few: Within Entangled Africa we will add records whose definitions are based on methods like dendrochronology and carbon dating. Gazetteers shine when they are connected with each other, so we want to improve the alignment especially with PeriodO. We will complement the modern periodisation systems with events and contemporary periodisations, i.e. period names that were used in historic times. We will add the possibility to specify and reason over dates more precise than whole years. And finally, we will complement the explicitly stated geographical and temporal extents of periods with the individual datings of the objects that are connected with the period.

283. Discussing the need for a new CAA Special Interest Group on chronological modelling

Thomas Huet, University of Oxford, School of Archaeology
Eythan Levy, Bern University
Florian Thiery, LEIZA
Allard Mees, RGZM

Chronological modelling in history comes from a need to approach temporal continuity through its formalisation (Le Goff 2014). Archaeologists have long been interested in the processes of change that occurred in the past and have wondered how to formally represent such processes using formal models and graphical representations. Archaeologists have long been interested in the processes of change that occurred in the past, representing them using formal and graphical models (for an overview, see O'Brien and Lyman 2002). Archaeological times cover a wide range of periods and cultures, leading to a great diversity of such models. In order to build bridges between the different periods of history - from the earliest prehistory, some 8 million years ago, to the Modern era - the archaeological community needs an agora to formalise and share good practice and research tools for dealing with the chronological dimension of archaeology.

Methods and tools available to archaeologists working on chronology are indeed diverse. They include Bayesian modelling, stratigraphic modelling (e.g. Harris matrices), temporal logics, seriation techniques, chronological networks, Linked Open Time Data , fuzzy logics, aoristic analysis, evidence density estimation, among others. But works that would discuss how to weave together these different threads are scarce. To the best of our knowledge, no monograph or edited volume surveyed the existing techniques since Buck and Millard's "Tools for Constructing Chronologies: Crossing Disciplinary Boundaries", published almost twenty years ago (Buck and Millard 2004). We feel that their idea of "crossing disciplinary boundaries" still reflects a real need in current chronological studies in archaeology.

Indeed, people working within one specific subfield of chronological modelling are often little aware of recent advances in other subfields. Chronological studies are often siloed, both in terms of methods and chrono-cultural focus. Yet, we believe that many techniques used in one domain could benefit others, if more synergy existed between the relevant research communities. We also feel that software tools could be made to better communicate with each other, through better standardisation of inputs and outputs, more precise formalisation and comparison between the underlying data models, as well as shared open access platforms for IT development.

In order to achieve such objectives, there is a need to create an international, interdisciplinary community dedicated to chronological modelling. This community must be data-driven, community-driven and compliant with Open Science principles such as Open Data, Open Access, Open Source, FAIR, and LOD.

In particular, we will discuss the opportunity of an SIG dedicated to chronological modelling, formal methods and domain-specific research software, entitled "Chronological Modelling" (working title). This SIG would be linked to two other SIGs, thus ensuring capacity building through research software engineering (Scientific Scripting Languages in Archaeology, SIG SSLA) and being compliant with semantic community standards (Semantics and LOUD in Archaeology, SIG Data-Dragon). The SIG will provide a persistent platform for discussing the integration of existing tools and methods, and also for planning the development of new research software.

This paper is seen as a dialogue guided by the authors to encourage participation and exchange with the audience. It will give an overview of the current state of the art on chronological modelling, focusing on formal methods and their implementation in research software. It will also show how these can be embedded and connected into the digital archaeology landscape, e.g. CAA SIGs or Digital Humanities networks such as Pelagios (https://pelagios.org).

References

Buck, C.E. and Millard, A. 2004. Tools for Constructing Chronologies: Crossing Disciplinary Boundaries. London: Springer-Verlag. Le Goff, J. 2014. Faut-il vraiment découper l'histoire en tranches ? Paris: Éditions du Seuil. O'Brien, M.J. and Lyman, R.L.. 2002. Seriation, Stratigraphy, and Index Fossils: The Backbone of Archaeological Dating. New York: Kluwer Academic Publishers.

13. An inventory of the Sea: our shared marine heritage challenges and opportunities

Peter McKeague, Historic Environment Scotland
Professor Julian Richards, Archaeology Data Service, University of York
Dr Clare Postlethwaite, MEDIN Coordinator, National Oceanography Centre

Location: E105

The marine environment is a vast resource, covering over 70% of the Earth's surface. Our seas provide an exceptional record of human activity from the seabed to the shore; from iconic wrecks through submerged landscapes and inter-tidal archaeology to the ports and harbours providing the onshore infrastructure supporting fishing and trade. Despite the richness of our marine heritage, accessing, re-using and presenting information about that heritage can be challenging – much more so than for terrestrial archaeology. Marine data are expensive to collect but have considerable reuse potential to increase our knowledge. The multi-disciplinary character of marine data, including commercially or scientifically sensitive data, pose particular challenges to ensuring that data conform to the FAIR Data principles (https://www.go-fair.org/fair-principles/). Of course, there is a large international dimension to marine and maritime data, with trading connections, ships logs and manifests adding rich detail to our understanding of maritime traffic. Our marine heritage is more than ships and wrecks. Intertidal archaeology offers opportunities for public engagement and citizen science but is particularly at threat from coastal erosion and climate change. Offshore infrastructure projects offer the opportunity for multidisciplinary research into submerged landscapes. The opportunities for new discoveries on the seabed have increased significantly through large scale seabed remote sensing data undertaken for the offshore renewables industry and national mapping. Application of machine learning and artificial intelligence to these massive survey datasets can assess seabed survey data to identify potential wreck sites and other obstructions. In the United Kingdom some of the challenges presented in working with the historic marine environment are being addressed in the Towards a National Collection funded 'Unpath'd Waters': Marine and Maritime Collections in the UK (https://unpathdwaters.org.uk/). By developing data standards, including key controlled vocabularies, and cataloguing practices Unpath'd Waters aims to improve interoperability across national heritage agency resources and unlock opportunities to work more closely with museums and archives. This session will explore:

- Solutions to harmonising marine data from across the heritage sector with the broader marine data landscape, in ways that enhance their Findability, Accessibility. Interoperability and Reusability.
- Visualisations and simulations that promote our understanding of submerged landscapes and wrecks.
- Applications of artificial intelligence and machine learning to explore marine heritage data and paleaolandscapes.

Whilst not an unknown frontier, our marine past is an underexplored frontier providing significant opportunities to apply a range of computer applications to improve the quality of the archaeological record. This session will explore how computer applications can be applied to the broad range of marine datasets to improve our knowledge and understanding of our maritime heritage and to communicate a difficult to access environment more broadly through novel techniques.

SLOT 3	
13:00	12. Aggregating the UK's maritime data in Unpath'd Waters *Julian Richards (GB)*; Jamie Bradley (Archaeology Data Service); Jamie G Geddes (Archaeology Data Service); Holly Wright (University of York)*
13:20	210. Embedding heritage data within a broader marine context *Clare F Postlethwaite (Marine Enviornmental Data and Information Network (MEDIN))**
13:40	273. Shifting Sands: a review of the marine archaeological record in Scotland. *Peter McKeague (Historic Environment Scotland)**
14:00 - 14:20	34. Recording Davy Jones' Locker: Reimagining the National Marine Heritage Record for England *Phil Carlisle (Historic England); Hefin Meara (Historic England)**
14:20 - 14:40	**Discussion**
SLOT 4	
15:30	248. Modest Doubt: Enabling Discovery Across Maritime Heritage Records *Jack W F Pink (University of Southampton)*; Shrikriti Singh (University of Southampton); Adriane Chapman (University of Southampton); Fraser Sturt (University of Southampton)*
15:50	345. The CHERISH Project: Integrated survey of the marine historic environment *Anthony Corns (The Discovery Programme)*; Robert Shaw (The Discovery Programme); Edward Pollard (The Discovery Programme); Sandra Henry (The Discovery Programme); Louise Barker (RCAHMW); Toby Driver (RCAHMW); Hannah Genders Boyd (RCAHMW); Kieran Craven (Techworks/GSI); Sean Cullen (GSI)*

16:10	229. Unpath'd Waters: Values and co-design in large scale maritime immersives *Stuart Jeffrey (GB)*; Sara Perry (Museum of London Archaeology); Katrina Foxton (Museum of London Archaeology); Lawrence Northall (National Maritime Museum)*
16:30 - 16:50	94. Photogrammetry As An Accurate Tool To Document Our Hidden Submerged Heritage: Methodological Approach And Examples From Swiss Lakes *Florence Gilliard (CH)**
16:50 - 17:10	6. Dealing with data about, but not from, Doggerland *Philip Murgatroyd (University of Bradford)*; Vincent Gaffney (University of Bradford); Simon Fitch (University of Bradford)*
17:10 - 17:30	**Discussion**

12. Aggregating the UK's maritime data in Unpath'd Waters

Julian Richards, GB
Jamie Bradley, Archaeology Data Service
Jamie G Geddes, Archaeology Data Service
Holly Wright, University of York

Unpath'd Waters is a ground-breaking 3-year research project funded by the AHRC's Towards a National Collection programme, that aims to unite the UK's maritime collections. Within the project the Archaeology Data Service (ADS) is responsible for identifying what marine data collections are available, and defining the core information about them. We can then develop a shared and cross-searchable online catalogue of marine data across the UK. This catalogue will be made freely available so that the same information can be displayed in existing online search systems, without duplicating it.

In order to construct the catalogue we have adapted the proven ontology developed within the European ARIADNE consortium, which is itself mapped to the CIDOC-CRM. Data is aggregated as Linked Open Data by loading it to a GraphDB triplestore and then enhanced by mapping individual controlled vocabularies to the Getty AAT, and publishing period terms with PeriodO, achieving interoperability

The information from this catalogue will be available:

(a) on the websites of the Archaeology Data Service

(b) in the national records of each of the UK nations, in England, Scotland, Wales and Northern Ireland

(c) as a shop window for UK marine data in European heritage portals, such as ARIADNE.

This paper will introduce some of the challenges we have faced in aggregating marine data, and present some of the research opportunities it enables. We will demonstrate how the ARIADNE infrastructure architecture has been adapted to construct a specific portal for maritime data, based upon the same underpinning Linked Data triplestore. Our research also provides lessons for the aggregation of heterogeneous data sets at a national scale, and pointers for how fragmented national digital collections of the future can be integrated and curated, connecting analogue and digital resources.

References

Aloia, N., Binding, C., Cuy, S., Doerr, M., Fanini, B., Felicetti, A., Fihn, J., Gavrilis, D., Geser, G., Hollander, H., Meghini, C., Niccolucci, F., Nurra, F., Papatheodorou, C., Richards, J., Ronzino, P., Scopigno, R., Theodoridou, M., Tudhope, D., Vlachidis, A. and Wright, H. "ARIADNE: A European Research E-Infrastructure for Archaeology", Journal of Computing and Cultural Heritage 10.3, https://doi.org/10.1145/3064527

https://unpathdwaters.org.uk/data-catalogue-launched/

https://portal.ariadne-infrastructure.eu

210. Embedding heritage data within a broader marine context

Clare F Postlethwaite, Marine Enviornmental Data and Information Network, MEDIN

The historic marine environment does not exist in isolation. Wrecks and other underwater archaeology form one part of a complex system, interacting with the underlying seafloor and surrounding water, as well as with the species that subsequently make historic structures their home. The Marine Environmental Data and Information Network (MEDIN) provides the national framework for managing marine environmental data in the United Kingdom, allowing historic environment data to be put into a broader marine context. A key component of MEDIN is a network of specialist, accredited Data Archive Centres. Currently the network encompasses a broad range of marine data: meteorology, oceanography, fisheries, species and habitats, geology and geophysics, bathymetry and the historic environment. The MEDIN Historic Environment Data Archive Centre is delivered by the Archaeology

Data Service, Historic Environment Scotland and the Royal Commission on the Ancient and Historic Monuments of Wales. New collaborations as part of the Unpath'd Waters (https://unpathdwaters.org.uk/) project will extend the breadth of underwater archaeology data available via the MEDIN portal by incorporating information and records held by the wider marine historic environment including museums and archives.

The ebb and flow of the tides and changing currents coupled to variations in the properties of the seawater, seafloor and weather all create a complex and challenging environment in which to collect any type of marine data. Moreover, the equipment and vessels required to collect marine data can be expensive to operate. The cost and challenge of collecting marine data increases the urgency of ensuring that these data are Findable, Accessible, Interoperable, and Reusable (FAIR). Doing so increases the scientific, economic, societal and environmental value of these data, far beyond the purpose for which they were originally collected. MEDIN was established in 2008 to realise just such benefits. A recent collaboration between MEDIN and the Organisation for Economic Cooperation and Development (OECD) and Global Ocean Observing System (GOOS) explored the value chains of marine data made available from public data repositories and highlighting the significant reuse value of such data (Jolly et al, 2021).

MEDIN enables users to find marine data via an online portal (the MEDIN portal https://portal.medin.org.uk/portal/start.php). This portal is underpinned by a marine specific profile and implementation of an international discovery metadata standard (ISO19115). Widespread adoption of this standard across the UK marine community means the MEDIN portal currently signposts over 17,000 datasets collected or managed by over 600 different organisations. Each metadata record includes marine specific keywords defined using interoperable controlled vocabularies, supporting linked data.

MEDIN is exploring ways to complement its standardised approach to metadata by considering standardised approaches to accessing data using Application Programming Interfaces (APIs). This is not an easy task considering how varied marine data are. Three of MEDIN's Data Archive Centres have recently trialled the Open Geospatial Consortium's Environmental Data Retrieval API standard for some of their marine data holdings. We believe this is the first time that this standard has been trialled on marine data. This may be a significant development for marine heritage organisations to consider adopting and is certainly one to keep an eye on.

References

Jolly, C., et al. (2021), "Value chains in public marine data: A UK case study", OECD Science, Technology and Industry Working Papers, No. 2021/11, OECD Publishing, Paris, https://doi.org/10.1787/d8bbdcfa-en.

273. Shifting Sands: a review of the marine archaeological record in Scotland.

Peter McKeague, Historic Environment Scotland

The marine environment presents a number of challenges to recording the past from inaccessibility, to the dynamic forces that impact and damage fragile resources. The nature of investigation of the marine environment is considerably different from terrestrial archaeology. Much of the evidence is drawn from outside archaeology – through bathymetric survey and increasingly from commercial surveys in advance of large scale infrastructure projects. How Historic Environment Scotland addresses, or intends to address these challenges is explored in this presentation.

With approximately 18,743 km of coastline along the high water line, 462,315 km2 of sea and over 900 islands Scotland has a rich and diverse, though under recorded marine heritage. There are over 4,000 wreck sites and some 26,000 documented losses in the National Record of the Historic Environment (NRHE) at Historic Environment Scotland (HES) but the archaeological potential of submerged landscapes is yet to be fully researched and recorded. If the volume of professional and academic research archaeology is small in comparison to other parts of the United Kingdom, community focused archaeology projects have significantly increased our understanding of the archaeology of the inter-tidal zone this century. It is all information and knowledge that contributes our understanding of Scotland's marine heritage presented through Canmore – the online catalogue of the National Record of the Historic Environment. Separately, a small number of wreck sites were formally protected through designation as Scheduled Monuments and latterly as Historic Marine Protected Areas.

HES digital archives gained Core Trust Seat status in 2020. Together with the Archaeology Data Service and the Royal Commission on the Ancient and Historical Monuments of Wales, HES forms part of a Marine Environment Data Information Network (MEDIN) accredited Data Archive Centre for the Historic Environment. MEDIN accreditation helps ensure that the marine historic environment data is promoted within the wider marine industry.

The character of the marine record is informed by established terrestrial approaches to site recording in Scotland. Before 1995 there was no systematic record of marine archaeology from Scotland's waters. Publication of a Code of Practice for Seabed Developers by the Joint Nautical Archaeology Policy Committee (1995, revised 2006) in that year acted as a catalyst for developing a marine component to the national record. It's purpose was to provide the information base to encourage commercial operators to seek advice on the possible archaeological potential of their proposed development at the earliest opportunity. The record was initially populated by importing wreck data from the United Kingdom Hydrographic Office (Groome and Murray 1998), supplemented by information collated from third party research. For the marine record emphasis was firmly placed on documenting the location with a single note field documenting the entire history of investigation.

Incremental development of the database in the early 2000s introduced an event – monument -archive model to provide more structure to the database. This model allows users to document the events (activities) that lead to the discovery or subsequent re-investigation of a site or vessel but also manages the relationship between individual records in the database with large area surveys supported by links to associated project archives when deposited at HES. Through this model HES is well placed to document data from submerged landscape research going forward.

One of the strengths of the NRHE is the integrated nature of the inventory and event data with the associated archives. Record locations act as finding aids for associated collections material from our own and external projects. This tight relationship is challenged through the multidisciplinary character and scale of research in the marine environment, particularly through the offshore renewables industry. Fortunately, a robust distributed infrastructure to ensure preservation and access to specialist datasets, including offshore remote sensing surveys, exists through the MEDIN DAC network leaving HES with the easier task of managing links to those related datasets.

Through participation in the United Kingdom Research Institute, Towards a National Collection funded Unpath'd Waters, HES is able to contribute to a virtual atlas of the marine historic environment of Great Britain and Northern Ireland. The project presents a unique opportunity to harmonise terminologies across participating resources from national heritage agencies to maritime museums. Unpath'd Waters will open up opportunities for further developing data about the marine historic environment.

Groome, D, and D Murray. "The Creation of the NMRS Maritime Record." Edited by RCAHMS. RCAHMS: Monuments on Record: Annual Review, 1995-1996, 1996, 38. Accessed October 31, 2022. https://canmore.org.uk/collection/1471305.

Joint Nautical Archaeology Policy Committee. Code of Practice for Seabed Developers., 1995. Accessed October 31, 2022. https://jnapc.org.uk/Code%20of%20Practice%201995.pdf.

Joint Nautical Archaeology Policy Committee. JNAPC Code of Practice for Seabed Development. Accessed October 31, 2022. https://www.jnapc.org.uk/jnapc_brochure_may_2006.pdf.

Marine Environment Data and Information Network. "MEDIN," n.d. Accessed October 31, 2022. https://medin.org.uk/

Unpath'd Water. "Unpath'd Waters." Accessed October 31, 2022. https://unpathdwaters.org.uk/.

34. Recording Davy Jones' Locker: Reimagining the National Marine Heritage Record for England

Phil Carlisle, Historic England
Hefin Meara, Historic England

The National Marine Heritage Record was established in the late 1990s to provide an overview of archaeological remains on the seabed around England. The dataset forms part of the Historic England inventory system Warden which is the latest incarnation of the various National Monuments Record databases. Alongside the terrestrial records, Warden currently holds over 55,000 records relating to the marine environment including 39,000 known wreck or casualty records. Under the Heritage Information Access Strategy the Local Authority HERs are the primary trusted source of investigative research data and knowledge (Principle 1) whereas Historic England are the primary trusted source of national datasets, such as the National Heritage List for England and National Marine Heritage Record (Principle 2). This has resulted in the opportunity to reimagine the National Marine Heritage Record and bring together a variety of datasets covering the coastal, intertidal and underwater landscapes. This paper will present an overview of the policies behind the National Marine Heritage Record and detail some of the current thinking surrounding the semantic modelling.

Historic England views the redevelopment of the National Marine Heritage Record as fundamental to improving the delivery of the organisation's marine services. The National Marine Heritage Record will be the principal online interface for public access to marine historic environment records, and a key means of actively engaging the public in enhancing our knowledge and understanding. The National Marine Heritage Record is vital to informing assessments of significance for heritage assets under consideration for designation under the Protection of Wrecks Act 1973, or for scheduling under the Ancient Monuments and Archaeological Areas Act 1979. In addition, the National Marine Heritage Record informs the advice provided by Historic England to the Marine Management Organisation, the Planning Inspectorate, seabed developers and other partner organisations. High quality and accurate marine historic environment records are essential to ensure the early identification of heritage assets and associated features so that they can be protected appropriately. The need for a dependable and up to date marine record is demonstrated by the unprecedented scale of change to the seabed that is currently taking place. Production of electricity from offshore wind has risen from an operational capacity of under 700MW in 2009 to more than 10,000MW by the end of 2020. Proposals for decarbonising all sectors of the UK economy to meet our net zero target by 2050 includes 50GW of offshore wind delivery by 2030.

The National Marine Heritage Record will be delivered using the Arches Software platform. The new system, currently called Mariner, will allow a shift in focus from the previous model where the vessel and the wreck were perceived as a single entity to one where the vessel and its physical remains are separate but linked entities allowing for a more accurate representation of our understanding. The development of a dedicated marine resource will also allow for diverse datasets to be brought together in an integrated way. Over many years Historic England and its predecessors have commissioned projects looking at various aspects of the marine environment and maritime heritage and these have produced detailed datasets. The Mariner platform will allow for the incorporation of broad scale thematic projects, such as the strategic assessment of submarines in English waters undertaken to mark the centenary of the First World War. We will also be able to incorporate detailed site-specific data, such as the assessments of artefact assemblages from shipwrecks designated under the Protection of Wrecks Act 1973, including the Stirling Castle, lost on the Goodwin Sands during the Great Storm of 1703, and the Schiedam, stranded at Jangye-run, Cornwall during a gale in 1684. By providing a home for that data it is hoped Mariner will enable us to increase our understanding of the marine historic environment and provide a single port of call for all marine historic environment data for the sea around England. Historic England is developing Mariner alongside the Unpath'd Waters project, and the new system will contribute directly to the ambitions of the 'Towards a National Collection' programme.

The development of Mariner using the free open source Arches software platform will allow the sharing of models and ideas with other partner organisations already using the software or looking to move to it. It is hoped that Mariner could become the model for systems focusing on the marine historic environment whether relating to wreck sites, coastal peat deposits, submerged landscapes or seascape characterisation.

References:

Historic England. 2021. National Marine Heritage Record. Last modified July 1, 2021. https://historicengland.org.uk/research/support-and-collaboration/heritage-information-access-simplified/national-marine-heritage-record/

Landward Research Ltd and Wessex Archaeology. (Forthcoming). North Sea Prehistory Research and Management Framework, 2nd Edition.

Trow, S & Roberts, P. 2002. Taking to the Water: English Heritage's Initial Policy for The Management of Maritime Archaeology in England. Swindon: RCHME

248. Modest Doubt: Enabling Discovery Across Maritime Heritage Records

Jack W F Pink, University of Southampton
Shrikriti Singh, University of Southampton
Adriane Chapman, University of Southampton
Fraser Sturt, University of Southampton

Maritime Heritage Records in the United Kingdom represent essential datasets for multiple stakeholders. From facilitating investigation of our past, through heritage management to improved understandings of anthropogenic impacts on the environment and climate change. These crucial records, however, are often static, vary in structure, quality and degree of compliance with FAIR principles. Very few permit detailed search or linking. This limits our ability to capture this information and transform it into the knowledge we need. Recent developments in Machine Learning (ML) approaches to complex datasets have created routes to solving these problems.

This paper presents initial results from the AHRC funded Unpath'd Waters project on application of ML tools to enable search, discovery, and linkage within and across datasets. The focus is on the successes (and failures) in application of Zero and Low Shot Learning techniques, as well as Named Entity Recognition and computer vision to these datasets. In reflecting on this we will discuss what potential this holds for the future, not just in terms of data discovery but also the generation of new knowledge.

345. The CHERISH Project: Integrated survey of the marine historic environment

Anthony Corns, The Discovery Programme
Robert Shaw, The Discovery Programme
Edward Pollard, The Discovery Programme
Sandra Henry, The Discovery Programme
Louise Barker, RCAHMW
Toby Driver, RCAHMW
Hannah Genders Boyd, RCAHMW
Kieran Craven, Techworks/GSI
Sean Cullen, GSI

The CHERISH (Climate, Heritage and Environments of Reefs, Islands, and Headlands) Project is a six and a half year research project which began in January 2017 and has involved the survey and investigation of some of the most iconic coastal locations in Ireland and Wales. A variety of methods were employed by the CHERISH team to monitor and understand the past, present and near-future impacts of climate change on the rich cultural heritage of our sea and coast, with the aim of developing experience and practice to assist in the monitoring of the coastal historic environment into the future. By combining these methods, the CHERISH 'toolkit' was established which represents an integrated and multidisciplinary approach where individual methods were rarely used in isolation.

This paper focuses on several of the methodologies within the 'toolkit' which aim to improve our understanding of the historic intertidal and marine environment specifically in the recording and monitoring of shipwrecks. Each methodology employed within the project will be explored through integrated case studies that highlights:

- the relative benefits and challenges in their application
- the different datasets created and how they assist in the identification and monitoring analysis of marine archaeological structures and features
- how archaeological marine survey data is visualised to aid assessment and communication
- how archaeological marine survey data is managed with the aim of making access open and integrated and ensuring future assessment of current baselines can be carried out.

CHERISH 'toolkit' methods explored include:

Marine bathymetric surveying, which has been used by CHERISH at sites in both Ireland and Wales to provide local context to coastal sites and to generate high-resolution baseline data of shipwrecks. By leveraging the equipment and experience of the INFOMAR (INtegrated Mapping FOr the Sustainable Development of Ireland's MARine Resource) programme, vessels have acquired data from Counties Dublin, Wexford, Waterford and Kerry in Ireland, and the Isle of Anglesey and Cardigan Bay in Wales. This data has provided detailed site-specific bathymetric maps (down to 0.1 m resolution) of historic sites. Many of the Irish shipwrecks, including the Manchester Merchant and City of London have been surveyed over successive years to permit change detection. Surveys on a local scale provide bathymetric maps (down to 0.5 m resolution) that can be integrated with terrestrial LiDAR or UAV elevation models to provide seamless onshore-offshore maps.

Structure from Motion (SfM) Photogrammetric survey has been carried out on several intertidal (The Sunbeam) and submerged wreck sites (Bronze Bell & Manchester Merchant). Photographic and video Imagery captured by terrestrial survey, diver lead survey, and underwater ROV (Remotely Operated Vehicles) has enabled the production of accurate 3-dimensional models which have enabled the baseline documentation and monitoring of these historic structures to be carried out. In addition, digital video footage has enabled the creation of environmental wreck survey analysis including biological faunal audits, often valuable in identifying invasive species associated with climate change. Considerations for data delivery and archiving are explored including online delivery of 3D models and the archiving of raw video and photographic imagery to ensure baseline comparison is achievable for future condition surveys.

Magnetic gradiometry geophysical survey has been utilized on intertidal and beach environments with the aim of locating and identifying buried wreck sites. Through the analysis of anomalies in the magnetometry data caused through the strong signatures created by buried ferrous remains or the subtle remains of deteriorating wooden structures, the location of often wrecks often recorded within historic documentary evidence has been achieved.

As much of the described data captured within the CHERISH Project is to act as the first baseline metric survey against which future change will be assessed, it is essential that the correct management, archiving and access policies are established. Ensuring that future researchers can effectively find, understand and utilise the data sets created as part of the CHERISH Project is essential when developing evidence-based policy and management tools for the marine historic environment.

229. Unpath'd Waters: Values and co-design in large scale maritime immersives

Stuart Jeffrey, GB
Sara Perry, Museum of London Archaeology
Katrina Foxton, Museum of London Archaeology
Lawrence Northall, National Maritime Museum

The Unpath'd Waters project is a large AHRC funded multi-partner project building towards a national collection of maritime heritage datasets in the UK (AH/W003384/1)(Sloane et al 2022). The project focusses on the meaningful integration of diverse maritime data, held by multiple partners in the UK, and is committed to identifying and engaging new audiences for these data through novel means. This includes a large scale immersive system, 'Unpath Explorer', for the exploration and interrogation of the project's datasets, including data holdings in audio, video and 3D formats. Underpinning our work, and fundamental to the ethos of the project, is cooperation across the partners in the development of a statement of values that reflects our shared position across a range of topics including equitable working, collaboration, reliability and sustainability.

The statement of values has been the foundation on which a rigorous co-design process has been developed which brings audiences into the heart of the immersive development process. In order to develop a User Interface (UI) for the Unpath Explorer a co-design approach has been adopted which responds to a key plank of the values statement by shifting design focus from data holders to their proposed audiences and working equitably and collaboratively with them in the development process. Building on previous work that has successfully collaborated with community and stakeholder groups in the co-design and co-production of Digital Heritage Objects (e.g. McKinney et al 2020, Jeffrey 2020), this project extends the co-design process further, by bringing it to bear on the development of the UI through which these records and objects are engaged with by the audiences. The design takes advantage of novel UI affordances such as gaze activation, spatialised audio and gesture recognition. This has offered an opportunity to think afresh about modes of interaction without relying only on existing visual vernacular, cues or standard interface controls. Through the co-design process key design decisions, notably on user interfaces and interaction, but also on design aesthetic and storytelling through the development of 'curated pathways', have been taken in direct collaboration with the ultimate users of the immersive system.

This paper elaborates on and critically examines the values definition and co-design methods as they are being iteratively applied together with three core case-study audiences; inter-disciplinary researchers, visually impaired users and non-maritime communities (i.e. communities who do not traditionally identify with maritime heritage). We report on the challenges and successes of the approaches we have adopted, including design evaluation, and reflect on the benefits of both values definition and co-design and how these can be adopted to enhance other, similar projects in the digital heritage domain. Working together with audiences to develop meaningful, useful and creative interfaces in heritage data is a key step in thinking about systems that can further explore both how the underlying datasets are themselves constructed and how communities (and communities of interest) can work with these data to tell their own stories alongside and in tandem with the grander narratives of the UK's national maritime heritage.

Stuart Jeffrey, Siân Jones, Mhairi Maxwell, Alex Hale & Cara Jones (2020) 3D visualisation, communities and the production of significance, International Journal of Heritage Studies, 26:9, 885-900, DOI: https://doi.org/10.1080/13527258.2020.1731703

Sierra McKinney, Sara Perry, Akrivi Katifori, Vassilis Kourtis. 2020. Developing Digital Archaeology for Young People : A Model for Fostering Empathy and Dialogue in Formal and Informal Learning Environments. In: Hageneuer, S (ed.), Communicating the Past in the Digital Age. London: Ubiquity Press. DOI: https://doi.org/10.5334/bch.n

Barney Sloane, Julian Richards, Fraser Sturt, Ann Coats, Michael Roberts, Vince Gaffney, Stuart Jeffrey, & Sara Perry. (2022). Unpath'd Waters: Marine and Maritime Collections in the UK. Zenodo. https://doi.org/10.5281/zenodo.7152083

94. Photogrammetry As An Accurate Tool To Document Our Hidden Submerged Heritage: Methodological Approach And Examples From Swiss Lakes

Florence Gilliard, CH

Underwater photogrammetry is often used -as on land- to recreate a precise 3D model for visualization or simulation purposes. While diving in bad conditions, photogrammetry is as a matter of fact an amazing tool to use, since it allows the underwater archaeologists to show something that wouldn't be seen otherwise: mostly because of the visibility or because the size of the documented items is too important to be observed at once. However, by doing this, the researchers only take advantage of a small part of the software functions. In fact, many different applications are possible, besides having an accurate reconstitution of an archaeological site or artefact.

Frequent and regular records of an interesting archaeological site may be employed to calculate the changes that occurred between the captures. This strategy to track any transformation can be exploited among other things to calculate the volume of what was excavated and to monitor pile dwelling sites, endangered by erosion. In this context, photogrammetry allows the scientists to analyze and document what can only hardly be physically seen or measured.

During this talk, the methodology to get this documentation will be explained in detail. Moreover, specific examples from different projects accomplished in swiss lakes will be used to show the efficiency of this method. These cases will also help clarify the actual exceptional possibilities that photogrammetry offers to archaeologists in order to document places or objects of underwater cultural heritage interest.

6. Dealing with data about, but not from, Doggerland

Philip Murgatroyd, University of Bradford
Vincent Gaffney, University of Bradford
Simon Fitch, University of Bradford

As part of the Towards a National Collection funded 'Unpath'd Waters' project, the work package titled 'Lands Beneath the Sea' needs to take an innovative approach to the idea of a data collection in areas of sparse or unusual data. Doggerland, the land under the southern North Sea, was inundated between around 15,000 - 7,000 years ago. Since then, our knowledge of Doggerland has largely relied on a patchwork of seismic data from the oil and gas industries, a relatively small number of cores, few of which contain deposits from prehistoric land surfaces, and chance finds dredged from the seabed during commercial fishing expeditions. Yet our understanding of the processes which operated within the landscape of Doggerland are more extensive than just those which could be derived from these data (Gaffney and Fitch 2022).

Sea level and climate data, Landscape Evolution Models, comparable terrestrial archaeology and environmental reconstruction all combine to allow us to start to understand the processes which formed Doggerland and which contribute to the limited archaeological record we currently have access to. Yet these data sources fit awkwardly into standard methods of spatial data integration. How can we build a spatial database of Doggerland when much of the data comes from elsewhere?

One approach is to create not a collection of data but a collection of the processes behind the data. The most practical method of collecting and presenting processes is via computer simulation. With simulation, we can make the processes which are likely to have operated in and on Doggerland accessible to both specialists and members of the general public. Our sandbox simulation will allow the user to explore a Doggerland of processes, in which the implications of the data we do have can be easily seen. It will allow the user to experience sea level change and climate variation at human scales and grant access to a landscape which is currently inaccessible. This will allow users to generate a sense of significance and context around a series of landscape features which no one has seen for thousands of years. It will also act as a research tool, allowing specialists to see the differences between, and implications behind, the many competing sea level models.

In making this simulation accessible via an easy install process with no other software requirements, a comprehensive suite of documentation and an accessible user interface, we aim for the numbers of users typical of entertainment software, albeit with niche subject matter, rather than those typical of archaeological simulations. This approach will stand in sharp contrast to the rest of the ‘Unpath’d Waters’ project, and allow us to asses the advantages and disadvantages of presenting the data via the processes as opposed to presenting the processes via the data.

References

Gaffney, Vincent, and Simon Fitch. 2022. Europe’s Lost Frontiers: Volume 1. Archaeopress.

19. Building a Collaborative & Interoperable Information Ecosystem: A conversation to bridge archaeological data systems and infrastructures

Annabel Lee, Enriquez Getty Conservation Institute
Alison Dalgity, Getty Conservation Institute
David Myers, Getty Conservation Institute

Location: E106

Roundtable

The session will explore ways to foster a richer and more collaborative information ecosystem in archaeology. This landscape encompasses commercial information services and software applications, academic and nonprofit information services, and multiple open-source projects. Some of these information systems are general purpose, and some are specifically designed to meet unique information management needs in archaeology and cultural heritage.

For example, the Arches project develops open-source software to support cultural heritage data management needs and has built a strong community of organizations and people who actively use the application worldwide to document and conserve cultural heritage, including numerous implementations dealing with archaeological recording, risk assessment, and research. The project's goal is to ensure improved data management to support effective heritage conservation and management, and ultimately to improve understanding and stewardship of cultural heritage resources by providing researchers with tools for creating, sharing, and exploring data.

But Arches is only one of a constellation of software systems and services used in archaeology. Cultural heritage professionals have many and diverse information needs that extend beyond areas that Arches currently supports. KoboToolBox, FAIMS, and others provide field data collection tools, while Pelagios offers a number of software applications and online services that help researchers use and create Linked Open Data. Besides these tools, other online data systems, including various gazetteers and collections databases, as well as digital repositories play critical roles.

The success and vibrancy of archaeological information systems depends upon a collaborative community that builds upon each other's contributions. We are hosting a round table session including key panelists and an open discussion to explore how this diversity of applications and services can better work in concert. Questions to be explored include:

- Where might there be areas of complementarity that can be further developed?
- Can we promote workable more modular design practices so we can develop and share useful components across different projects? Would this help address "not invented here" disincentives to build upon each other's efforts?
- What roadblocks may exist in establishing greater interoperability?
- What opportunities can be explored for collaborative partnerships?
- What lessons can we learn from one another? And, how can we collaborate and leverage the strengths and roles of each system to better serve archeological management and research, and cultural heritage in general?

The discussants present at this roundtable will be:

Annabel Lee Enriquez, Arches Project, Getty Conservation Institute, Los Angeles

Mike Heyworth, Cultural Heritage Programmes, Arcadia Fund, London

Andy Jones, Software Development Team, Historic England

Eric Kansa, Open Context and consultant to Arches Project, San Francisco (Moderator)

Adela Sobotkova, FAIMS Project, Australia

Koen Van Daele, Flanders Heritage, Brussels

Holly Wright, Archaeology Data Service (ADS), York, England

Dennis Wuthrich, Farallon Geographics Inc., San Francisco

32. A Bridge too Far. Heritage, Historical and Criminal Network Research

Lena Tambs, University of Helsinki
Marta Lorenzon (University of Helsinki)
Arianna Traviglia (Centre for Cultural Heritage Technology-Istituto Italiano di Tecnologia)
Michela De Bernardin (Centre for Cultural Heritage Technology-Istituto Italiano di Tecnologia)

Location: E108

Over the last decades, ancient historians and archaeologists have slowly realised the potential network science holds for studying past phenomena and better understanding the relationships that connect entities under study. By now, we have employed diverse network perspectives to explore a variety of sources and datasets that help us shed light on the past (for overviews, see e.g. Brughmans 2013; Collar et al. 2015; Crabtree & Borck 2019; Knappett 2013; Knappett 2020; Peeples 2019; Rollinger 2020). We have built and analysed networks to answer questions about social and interpersonal networks, trade routes, production and consumption patterns, group behaviour, diffusion of ideas and technologies, social mobility, and other complex phenomena (Brughmans 2021; Cline and Cline 2015; Verhagen 2018).

Networks have been popular in diverse disciplines such as biology and physics, and their application and full implementation to archaeology emphasises the structural representation of the relationship between objects, people and places, guiding recent discovery on land use, ancient demography, past economies and trade (Brughmans 2013, 2021; Graham 2006; Verhagen et al. 2019). While not yet fully explored in the area of art-related crimes and in connection with issues of illicit trafficking in cultural heritage (Tsirogiannis and Tsirogiannis 2016), network analysis has also been successfully used to study degrees and manner of relations among criminal individuals and groups, and to investigate other forms of criminal organised trades, such as human (Vivrette 2022), drugs (Tsai et al. 2019) and wildlife trafficking (Costa 2021). It is, therefore, interesting to survey further intersections of network analytical applications to multiple fields, both in micro and macro perspectives.

Network science offers a plethora of conceptual and digital tools that allow networks to be measured and explored with formal methods, and archaeologists, historians and digital humanists have found aspects of Social Network Analysis (SNA) particularly useful (for an introduction to SNA, see e.g. Graham et al. 2016: 195-234. For handbooks, e.g. Borgatti et al. 2013; Scott 2017; Wasserman and Faust 1994). Learning to handle the uncertainty of the data and refining network modelling techniques are, however, paramount for a correct and scientific reconstruction of past interactions (Birch and Hart 2021; Carreras et al. 2019; Verhagen et al. 2019).

Even within the subfield of SNA, a range of methods and software packages are available for researchers and they provide analytical tools for exploratory as well as descriptive analysis (links below). Their relevance depends on the researchers' topic, source material, dataset, financial means, technical skills, etc. – all of which may be decisive factors when choosing ones software (Graham et al. 2016: 237-240). For small datasets, the MS Excel extension NodeXL might suffice, but Gephi – which is freely available, works on all platforms, offers a variety of tools and plugins, is relatively easy to learn and has buttons to press (in exchange for code to be written) – quickly became popular in historical and archaeological network studies. For larger datasets or more complex statistical and network analysis, UCINET, Pajek or R might be more appropriate, but they require the researcher to engage more directly in the calculations and thus have steeper learning curves. For visualising and analysing networks that are dynamic, multivariable, longue durée or have a particularly strong emphasis on spatial data, yet other applications – like Nodegoat or the Vistorian, which are more specialised towards archaeological and/or historical data – might be the preferred choice. And often, the best solution might be to form interdisciplinary research teams (Verhagen et al. 2019: 237-238).

Since archaeologists and historians tend to work with different source materials and research questions, they are likely to utilise different software or apply different tools offered by them. The fields of historical network research and archaeological network analysis have thus developed in different directions – with historians more commonly exploring social whole or ego networks and particularly central figures in them, and archaeologists e.g. placing a larger emphasis on spatial data and compatibility with Geographical Information System (GIS), Least-Cost Path (LCP) analysis and other types of modelling (Benvan and Wilson 2013, Carreras et al. 2019; Groenhuijzen and Verhagen 2016; Lewis 2021; Verhagen 2018; Verhagen et al. 2019: 233ff.). Scholars who routinely employ network analysis to study archaeological and historical data nevertheless have a lot of common ground, in that they strive to increase our knowledge of the past through distinct network approaches and face many of the same challenges in the process (Brughmans et al. 2016; Ryan and Ahnert 2021: 61f.).

Roughly a decade ago, Lemercier (2012) and Brughmans (2013) reported general unawareness of the history, underlying sociological theories, and diversity of existing network approaches in history and archaeology respectively. That many new and creative studies have since seen the light of day is for instance reflected in the events of the flourishing Connected Past community and the online bibliography and newly launched Journal of Historical Network Research (links below). Studies critically testing the performance and robustness of formal measures on network models of the past further indicate that the fields have matured and progressed (Groenhuijzen and Verhagen 2016; Ryan and Ahnert 2021; de Valeriola 2021).

Despite an increasing number of network studies in archaeology and history, Holland-Lulewicz and Thompson (2021: 2) recently reported, that "such applications remain limited to cases employing either solely archaeological evidence or solely documentary evidence". Acknowledging that increased dialogue between the two communities can help raise awareness of relevant (combinations of) tools and inspire new projects, methodologies and collaborations, this session aims to strengthen the ties between historically, archaeologically and cultural heritage oriented network researchers by bringing them together to discuss, share experiences and showcase relevant methods. In doing so, it welcomes papers that integrate the communities, studying both written and archaeological evidence, reflecting on the directions one or both subfields are taking, presenting research from collaborative teams, etc.

In striving to create an interdisciplinary, inclusive and diverse platform for such discussions, we encourage scholars working on all periods and geographical regions – regardless of background, identity, field and affiliation – to submit an abstract on active case studies. Research topics could include (but are not limited to):

- skills transfer in archaeology;
- modern use of archaeological data in the political discourse;
- illicit trafficking of cultural heritage;
- past and contemporary trade networks;
- interpersonal relations of individuals and groups;
- linguistic and semantic networks;
- dynamic network models;
- software and methods for studying historical and archaeological data.

References:

Bevan, A., and Wilson, A. 2013. Models of Settlement Hierarchy Based on Partial Evidence. Journal of Archaeological Science 40: 2415–2427. https://doi.org/10.1016/j.jas.2012.12.025.

Birch, J., and Hart, J.P. 2021. Conflict, Population Movement, and Microscale Social Networks in Northern Iroquoian Archaeology. American Antiquity 86 (2): 350–367. https://doi.org/10.1017/aaq.2021.5.

Borgatti, S.P., Everett, M.G., and Johnson, J.C. 2013. Analyzing Social Networks. Los Angeles: Sage.

Brughmans, T. 2013. Thinking through Networks: A Review of Formal Network Methods in Archaeology. Journal of Archaeological Method and Theory 20 (4): 623–662. https://doi.org/10.1007/s10816-012-9133-8.

Brughmans, T. 2021. Evaluating the potential of computational modelling for informing debates on Roman economic integration. In: Koenraad Verboven (ed.), Complexity Economics: Building a New Approach to Ancient Economic History: 105–123. Cham: Palgrave Macmillan. https://doi.org/10.1007/978-3-030-47898-8_4.

Brughmans, T., Collar, A., and Coward, F. (eds.). 2016. The Connected Past: Challenges to Network Studies in Archaeology and History. Oxford: Oxford University Press. https://doi.org/10.1093/oso/9780198748519.001.0001.

Collar, A., Coward, F., Brughmans, T., and Mills, B.J. 2015. Networks in Archaeology: Phenomena, Abstraction, Representation. Journal of Archaeological Method and Theory 22: 1–32. https://doi.org/10.1007/s10816-014-9235-6.

Costa, J. 2021. Working Paper 35: Social Network Analysis Applied to Illegal Wildlife Trade between East Africa and Southeast Asia. https://baselgovernance.org/publications/SNA_IWT [last accessed 2022-08-26].

Carreras, C., De Soto, P., and Munoz, A. 2019. Land Transport in Mountainous Regions in the Roman Empire: Network Analysis in the Case of the Alps and Pyrenees. Journal of Archaeological Science: Reports 25: 280–293. https://doi.org/10.1016/j.jasrep.2019.04.011.

Cline, D., and Cline, E. 2015. Text Messages, Tablets, and Social Networks: The "Small World" of the Amarna Letters. In: Mynářová, J., Onderka, P., and Pavúk, P. (eds.), There and Back Again—The Crossroads II: 17–44. Prague: Charles University.

Crabtree, S.A., and Borck, L. 2019. Social Networks for Archaeological Research. In: Encyclopedia of Global Archaeology: 1–12. Cham: Springer. https://doi.org/10.1007/978-3-319-51726-1_2631-2.

De Valeriola, S. 2021. Can Historians Trust Centrality? Historical Network Analysis and Centrality Metrics Robustness. Journal of Historical Network Research 6 (1): 85–125. https://doi.org/10.25517/jhnr.v6i1.105.

Graham, S. 2006. Networks, Agent-based Models and the Antonine Itineraries: Implications for Roman Archaeology. Journal of Mediterranean Archaeology 19 (1): 45–64. https://doi.org/10.1558/jmea.2006.19.1.45.

Graham, S., Milligan I., and Weingart, S. 2016. Exploring Big Historical Data: The Historian's Macroscope. London: Imperial College Press.

Groenhuijzen, M.R., and Verhagen, P. 2016. Testing the Robustness of Local Network Metrics in Research on Archaeological Local Transport Networks. Frontiers in Digital Humanities 3:6. https://doi.org/10.3389/fdigh.2016.00006.

Holland-Lulewicz, J., and Thompson, A.D.R. 2021. Incomplete Histories and Hidden Lives: The Case for Social Network Analysis in Historical Archaeology. International Journal of Historical Archaeology. https://doi.org/10.1007/s10761-021-00638-z.

Knappett, C. (ed.). 2013. Network Analysis in Archaeology: New Approaches to Regional Interaction. Oxford: Oxford University Press. https://doi.org/10.1093/acprof:oso/9780199697090.001.0001.

Knappett, C. 2020. Relational Concepts and Challenges to Network Analysis in Social Archaeology. In: Donnellan, L. (ed.), Archaeological Networks and Social Interaction: 20–37. Routledge.

Lemercier, C. 2012. Formale Methoden der Netzwerkanalyse in den Geschichtswissenschaften: Warum und Wie? Österreichische Zeitschrift Für Geschichtswissenschaft 23 (1): 16–41. https://doi.org/10.25365/oezg-2012-23-1-2.

Lewis, J. 2021. Probabilistic Modelling for Incorporating Uncertainty in Least Cost Path Results: A Postdictive Roman Road Case Study. Journal of Archaeological Method and Theory 28 (3): 911–924. https://doi.org/10.1007/s10816-021-09522-w.

Peeples, M.A. 2019. Finding a Place for Networks in Archaeology. Journal of Archaeological Research 27 (4): 451–499. https://doi.org/10.1007/s10814-019-09127-8.

Rollinger, C. 2020. Prolegomena. Problems and Perspectives of Historical Network Research and Ancient History. Journal of Historical Network Research 4: 1–35. https://doi.org/10.25517/jhnr.v4i0.72.

Ryan, Y.C., and Ahnert, S.E. 2021. The Measure of the Archive: The Robustness of Network Analysis in Early Modern Correspondence. Journal of Cultural Analytics 6 (3): 57–88. https://doi.org/10.22148/001c.25943.

Scott, J. 2017. Social Network Analysis. 4th ed. Los Angeles: Sage.

Tsai, F.C., Hsu, M.C, Chen, C.T., and Kao, D.Y. 2019. Exploring Drug-related Crimes with Social Network Analysis. Procedia Computer Science 159: 1907-1917. https://doi.org/10.1016/J.procs.2019.09.363.

Tsirogiannis, C., and Tsirogiannis, C. 2016. Uncovering the Hidden Routes: Algorithms for Identifying Paths and Missing Links in Trade Networks. In: Brughmans, T., Collar, A., and Coward, F. (eds.), The Connected Past: Challenges to Network Studies in Archaeology and History: 103-120. Oxford: Oxford University Press. https://doi.org/10.1093/9780198748519.003.0012.

Verhagen, P. 2018. Spatial Analysis in Archaeology: Moving into New Territories. In: Siart, C., Forbriger, M., and Bubenzer, O. (eds.), Digital Geoarchaeology. Natural Science in Archaeology: 11–25. Cham: Springer. https://doi.org/10.1007/978-3-319-25316-9_2.

Verhagen, P., Nuninger, L., and Groenhuijzen, M.R., 2019. Modelling of Pathways and Movement Networks in Archaeology: An Overview of Current Approaches. In: Verhagen, P., Joyce, J., and Groenhuijzen, M. (eds.), Finding the Limits of the Limes. Computational Social Sciences: 217–249. Computational Social Sciences. https://doi.org/10.1007/978-3-030-04576-0_11.

Vivrette, A.T. 2022. Approach to the Global Human Trafficking Crisis: Analyzing Applications of Social Network Analysis. PhD Dissertation. http://hdl.handle.net/1803/17435 [last accessed 2022-08-26].

Wasserman, S., and Faust, K. 1994. Social Network Analysis. Methods and Applications. Structural Analysis in the Social Sciences 8. Cambridge: Cambridge University Press.

Cited Network Analytical Software:

- Gephi (https://gephi.org/)
- R (https://www.r-project.org/)
- UCINET (https://sites.google.com/site/ucinetsoftware/home)
- Pajek (http://mrvar.fdv.uni-lj.si/pajek/)
- The Vistorian (https://vistorian.net/)
- Nodegoat (https://nodegoat.net/)
- NodeXL (https://www.smrfoundation.org/nodexl/)

Communities and Blogs of Archaeological and Historical Network Researchers:

- The Connected Past (https://connectedpast.net/)
- Historical Network Research (https://historicalnetworkresearch.org/)
- Archaeological Networks (https://archaeologicalnetworks.wordpress.com/

SLOT 4	
15:30	141. Networks of Hittites: Rivers, Mountains, and Cities *Ali Akman (Bilkent University)**
15:50	121. Challenges in Building Akkadian Co-Occurence Networks for Comparative Research *Ellie Bennett (University of Helsinki)**
16:10	257. Characterising Peasant Economies in the north of Roman Spain through Network Science *Fernando Moreno-Navarro (Universidad Carlos III de Madrid)**

16:30 - 16:50	242. Travelling the wine dark sea – Networks of Mobility in the Late Bronze Age Mediterranean *Paula Gheorghiade (University of Helsinki)*; Henry C. W. Price (Imperial College London); Ray Rivers (Imperial College London)*
16:50 - 17:10	78. Why did cities evolve in Gharb Al-Andalus? Network analysis as a potential method for charting city growth *Joel Santos (University of Leicester)**
17:10 - 17:30	112. The impact of Levantine transit trade on 16th century Transylvania, Wallachia and Moldova *Daria Stefan (TU Wien)**
17:30 - 17:50	279. Disentangle the Net: How Social Network Analysis Can Help Understand and Fight the Illicit Trafficking in Antiquities *Riccardo Giovanelli (Ca' Foscari University of Venice); Michela De Bernardin (Istituto Italiano di Tecnologia)*; Arianna Traviglia (Istituto Italiano di Tecnologia (IIT))*

141. Networks of Hittites: Rivers, Mountains, and Cities

M. Ali Akman, Bilkent University

Introduction

The present paper presents a quantitative methodology based on network analysis for studying Hittite historical geography. The Hittites, which ruled Anatolia during the late Bronze Age between 1650 BCE and 1200 BCE, used cuneiform writing for administrative and cultural purposes. So far, nearly 30.000 cuneiform tablets, mainly from the capital, have been discovered. In these tablets, more than 2000 toponyms are identified (Kryszeń 2019)—however, a lack of financial, personal, and geographical records made studying Hittite historical geography challenging. Additionally, most tablets come from a single site, further complicating the study.

Because of the sheer number of attested toponyms, researchers often isolate a region or a toponym to conduct their studies. These studies often rely on critical reading of texts. The present paper suggests a quantitative approach that provides a consistent and comprehensive analysis of attested toponyms. Quantitative analysis of texts is hoped to bring new perceptions to the study of Hittite historical geography.

Aim

This research aims to respond to the scholarly demand for a holistic approach to studying Hittite historical geography without imposing arbitrary limitations on the studied regions or texts. (Barjamovic 2011, 66). The study employs network analysis tools to gain meaningful insights into the relationships between toponyms to achieve this goal. By constructing relative geography and expressing it quantitatively, this research enables integrating quantitative analysis of archaeological findings and geographical information with textual analysis.

Data

The data for this research includes a digital database of attested toponyms in Hittite texts created by Dr. Adam Kryszen through the project "Toponyme der Hethiter." The database contains 20,361 instances belonging to over 2000 unique toponyms. In order to evaluate the validity of the proposed methodology, 30,000 news articles published between 2021-2022 were also used to rediscover geographical relations among 81 Turkish provinces.

Method

The research is based on Tobler's first law of geography, which states that geographically close places are more related to each other than distant places (Tobler and Wineburg 1971). The study hypothesizes that the co-occurrence of toponyms in Hittite texts reflects the relatedness of toponyms. Therefore, the detected communities of the co-occurrence network are expected to correspond to geographical regions.

The force-directed graph is visually analyzed using known geographical anchors to suggest localizations for disputed toponyms. Although this model cannot provide the exact location of a place, it can be used to challenge and support existing ideas constructed through traditional methods. By analyzing the network, the researchers aim to understand the relational geography of Bronze Age Anatolia, the interactions between the regions from the Hittite state's perspective, and comment on the settlement hierarchies within the regions.

Results

Preliminary results and example studies show that the proposed methodology can recognize geographically meaningful clusters by analyzing texts that do not contain direct geographical information. Detected communities are primarily parallel with the current understanding of Hittite political geography. The methodology shows the potential to recognize homonymy, which is often addressed as a challenge within the field.

Barjamovic, Gojko. 2011. Historical Geography of Anatolia in the Old Assyrian Colony Period. Copenhagen, Denmark: Museum Tusculanum Press.

Kryszeń, Adam. 2019. "Hittite Toponymy: An Overview." Altorientalische Forschungen 46 (1): 1–14. https://doi.org/10.1515/aofo-2019-0001.

Tobler, W., and S. Wineburg. 1971. "A Cappadocian Speculation." Nature 231 (5297): 39–41. https://doi.org/10.1038/231039a0.

121. Challenges in Building Akkadian Co-Occurence Networks for Comparative Research

Ellie Bennett, University of Helsinki

The Embodied Emotions project will explore how Akkadian, (modern) English, and (modern) Finnish use parts of the body to express different emotions. The comparison of embodied emotions in languages spanning three different language families and thousands of years will aid in the understanding of whether there are any 'basic' emotions that are experienced the same way across human cultures.

One of the goals of the project is to produce co-occurence networks for these three languages and compare the results. The need for comparison has highlighted interesting issues. In order for our results to truly be comparable, we had to address the following issues with the Akkadian dataset:

- The size and type of dataset
- Which linguistic methods can be used
- How to select our 'target' words

This paper will explain how we addressed these issues and made our Akkadian dataset as comparable as possible to the modern languages. I will discuss each of the three problems, and outline the decisions we made for our project. I will end with outlining the preliminary results and the co-occurence networks generated from this stage of the project.

Problem 1: the dataset

The paper will begin with the decisions made in the data collection stage. We restricted ourselves to collecting digitised texts that date from the Neo-Assyrian period (c. 934-612 BCE) in order to make our Akkadian dataset comparable to the modern language corpora. This resulted in a relatively small corpus (just over 900,000 words and 7,000 texts). Restricting ourselves any further (such as according to genre or century) would have resulted in an even smaller corpus, which would not have been appropriate for our computational methods.

We also had to be mindful of the types of texts in this dataset. The vast majority of our texts are either royal inscriptions or correspondence texts from across the Neo-Assyrian empire. We have made a note of this so we can construct a dataset for modern English and Finnish that has texts similar in genre to the Akkadian one.

Problem 2: selecting the method

The small Akkadian dataset has meant we had to be careful with which method we use to measure the co-occurences. Ideally, we needed the same or similar method across all three datasets.

Pointwise Mutual Information (PMI) was developed for large corpora, and has been fine-tuned for usage on the smaller Akkadian datasets. PMI gives a numerical score to pairs of words that refers to how likely these pairs will occur within the dataset. There are several versions of PMI, but Aleksi Sahala and Krister Lindén have developed a version that takes into account the very formulaic and repetitive nature of many of the Akkadian texts (Sahala and Lindén 2020). The tailoring of this measure for Akkadian corpora and the options available for the much larger modern language corpora meant PMI was the best option for acquiring co-occurences for emotion and body words.

Problem 3: selecting target words

In order to measure the co-occurences, we needed to collect a list of 'target words'. These are the words we are interested in for the project: words relating to emotions and body part words. The study of emotions in the ancient Near East is still new, and there have been very few projects that have collated a list of such words. We have therefore used the work of Ulrike Steinert to curate such a list (Steinert 2022). The list includes the Akkadian word, and its broader semantic field according to current Assyriological literature (for example, joy, schadenfreude, and fear). The list is as comprehensive as possible in order to capture nuances and allow for comparison of wider emotional concepts with other languages.

Assyriological research has demonstrated there are only a few parts of the body that are related to emotions (Steinert 2022). However, restricting ourselves to a few body parts limits the comparative potential of such a project. The target list therefore includes as many body parts as possible as well as their Akkadian translation. The list also includes the broader category of the body the word relates to (for example, eyes, face, and mouth are part of the wider category 'head').

The co-occurence networks

Once we had the dataset, selected a method, and created a list of target words, we were able to create node and edge lists that were imported to Gephi (Bastian, Heymann, and Jacomy 2009).

The node lists included: the Akkadian word; whether it is a word relating to emotion, the body, or neither; the broader emotional field it is part of according to previous literature; the part of the body the word is connected to. This attributional data will allow for analysis as to whether the patterns in the data correspond to previous Assyriological research.

The edge list has the co-occurence pairs as the source and target, and the PMI score as the edge weight.

The resulting networks will allow us to use several Network Analysis approaches to identify patterns in the co-occurences of emotion and body words. This paper will briefly outline our results and preliminary analysis on an ego and network-wide level.

Broader implications

This paper will highlight the ongoing challenges of applying computational linguistic techniques to ancient texts. It will be of interest to those interested in co-occurences in ancient texts, but also those interested in the application of comparative methods to the ancient Near East.

Citations

Bastian, Mathieu, Sebastien Heymann, and Mathieu Jacomy. 2009. 'Gephi: An Open Source Software for Exploring and Manipulating Networks'. Proceedings of the International AAAI Conference on Web and Social Media 3 (1): 361–62.

Sahala, Aleksi, and Krister Lindén. 2020. 'Improving Word Association Measures in Repetitive Corpora with Context Similarity Weighting': In Proceedings of the 12th International Joint Conference on Knowledge Discovery, Knowledge Engineering and Knowledge Management, 48–58. Budapest, Hungary: SCITEPRESS - Science and Technology Publications. https://doi.org/10.5220/0010106800480058.

Steinert, Ulrike. 2022. 'Emotion and the Body'. In The Routledge Handbook of Emotions in the Ancient Near East, by Karen Sonik and Ulrike Steinert, 1st ed., 51–87. London: Routledge. https://doi.org/10.4324/9780367822873-5.

257. Characterising Peasant Economies in the north of Roman Spain through Network Science

Fernando Moreno-Navarro, Universidad Carlos III de Madrid

Introduction

The archaeological analysis of rural areas in the Roman world has traditionally focused on the study of villae and other elite settlements as centres for the articulation of economic and social life. The application of this perspective to the study of the archaeological record and settlement patterns in the rural areas of Roman Hispania has served to overshadow other models of rural habitat. The principal objective of this paper is the analysis of the domestic economies of several rural settlements from the north of Roman Carpetania (Spain) through network science. The application of these methods has allowed us to characterise the consumption patterns of the inhabitants of these settlements. In this way, we have been able to analyse in greater detail the material repertoire used in these places. The results show consumption patterns like those traditionally associated with peasant communities across history. Furthermore, the application of this type of methods has also allowed us to measure the level of integration or segregation of these settlements into the Roman market economy and between the peasant settlements.

Our case study is framed in a region located in the centre of the Iberian Peninsula that mainly coincides with the Madrid basin. This region is known as the north of Roman Carpetania and is traditionally characterised as an eminently rural area. Historiography about this region has centred his attention on the discovering and study of several monumental villae and elite settlements. However, a large number of archaeological rural sites have been discovered thanks to several systematic survey projects and preventive excavations performed in relation to the exponential urbanistic development of the metropolitan areas. These new discoveries cannot be attributed to the traditional framework of the Roman villa.

Methods

Based on the systematic analysis of all this archaeological evidence, this work aims to address the study and characterisation of the domestic economies of these peasant settlements. In the context of our project, we sampled the material contexts of a series of archaeological deposits documented at 9 different sites in the study area with at least 1500 findings following a behavioural archaeology methodology (Wilk and Rathje 1982).

We choose network science due to its versatility and its ability to characterise complex systems as a whole. These are tools that can analyse any kind of relationships between different elements such as those existing between the various components of the archaeological record. Our work is based on an exploratory analysis which has enabled us to detect some patterns about the peasant settlements' archaeological networks. For our analysis we have created co-presence networks between the analysed archaeological sites and different types that we have ascribed for the archaeological finds. Subsequently, in addition to the visual analysis of the networks created, we have used different tools derived from network analysis such as centrality measures. These analyses will help us to check the similarities and differences between the archaeological sites, as well as the importance of the find typologies in each of the sites. On the other hand, we have also used community detection tools such as modularity analysis. This type of analysis will allow us to glimpse the levels of integration or segregation of the peasant settlements into the Roman markets diachronically and at different scales.

Results

The results show a complexity in the data that does not allow a clear choice to be made in favour of any of the hypotheses put forward before the analyses were carried out. The peasant settlements in this region mainly used objects from a regional market. There was also a significant presence of objects produced in the surroundings of the domestic spaces. The presence of imported objects is merely testimonial, but may be indicative of some level of integration of these settlements into large trade networks. Centrality analyses have also shown us an expected approximate hierarchy of settlements in which larger and more architecturally complex sites have higher values. On the other hand, it is also indicative of the differences between the settlements despite the fact that many of them share the same chronological range and geographical framework.

Thanks to the complexity of the graphs we can see results from a diachronic perspective and the chronological evolution by century. The results provide a weak integration pattern during the first two centuries and a radical change towards a stronger integration in the 3rd century AD.

Discussion

Network science allows us to discuss the models with which historiography has traditionally conceived the Roman economy. For this reason, we also analysed how the networks established at a local scale between household economies could be integrated into interprovincial economic networks. In the case that the networks show mostly local exchange patterns, we can deduce that the economy of these settlements was dominated by local families and associations that controlled information and supply flows, similar to a 'bazaar economy' model (Bang 2008). On the other hand, in the case that the patterns tend towards interregional scale exchange, we can deduce that these economies were part of a wider, interconnected market. As analyses often do not yield such conclusive results towards a certain position it will be necessary to explore new frameworks.

Despite the pattern of segregation shown by some parts of the graphs, we definitely cannot speak of isolated economies or settlements. The homogenisation pattern shown from the 3rd century AD coincides mainly with a change in the settlement patterns when we can see an increase in the number of monumental villae and the abandonment of most of the peasant sites. The differences in the type of settlements may correspond to an expanded settlement pattern where the different units collaborate depending on the needs of their inhabitants, similar to the pattern found in other case studies (Bowes 2021).

References

Bang, Peter Fibiger. 2008. The Roman Bazaar. A Comparative Study of Trade and Markets in a Tributary Empire. Cambridge: Cambridge University Press.

Bowes, Kim, ed. 2021. The Roman Peasant Project 2009-2014: Excavating the Roman Rural Poor. Philadelphia: University of Pennsylvania Press.

Wilk, Richard, and William Rathje. 1982. "Household Archaeology." American Behavioral Scientist 25 (6): 617–39. https://doi.org/10.1177/000276482025006003.

242. Travelling the wine dark sea – Networks of Mobility in the Late Bronze Age Mediterranean

Paula Gheorghiade, University of Helsinki
Henry C. W. Price, Imperial College London
Ray Rivers, Imperial College London
Ray Rivers, Imperial College London

As a peninsula in reverse the geography of the Mediterranean played a significant role in structuring and supporting connectivity and mobility in the region. While connectivity can be thought of as a property of the environment – in this instance, the sea as a facilitator and connector between larger landmasses – mobility should be thought of as a property of the people living in this landscape. In other words, "connectivity is a potential, while mobility is the actualization of that potential" (Woolf 2016, 447). Consequently, exploring connectivity requires theory and spatial modelling, while mobility should build on and rely on archaeological evidence best approached through material networks or data models.

In this paper we explore potential maritime mobility in the LBA east Mediterranean. Similar approaches have been discussed by Leidwanger (2013), Safadi (2016), and Safadi & Sturt (2019) for the east Mediterranean. Here our focus shifts on the largest island in the Mediterranean, Crete, where the mobility of people and things regardless of terrain can be considered a necessity for survival. As the largest island in the Mediterranean, Crete was highly connected during the Late Bronze Age (LBA). Ceramic evidence highlights connections with Egypt, the Levant, Italy, and even Sardinia. Whether these connections were direct or indirect, they highlight a complex network trade across the larger Mediterranean basin. In this paper, we are concerned with possibilities for mobility when distance, travel time, and sea currents are taken into consideration. Our paper utilizes a collected set of spatial data points across the Mediterranean collated from known archaeological sites active during the LBA. We first discuss a null model (see also Gheorghiade 2022) that only regards Euclidean distance for connecting coastal Cretan sites with those across the larger Mediterranean. Second, we augment our approach by integrating maritime currents as a second layer of complexity to consider potential mobility (distance) from various sites on Crete based on seasonality. Our conclusions show that a multi-method approach for modelling mobility is far more fruitful, even if the results require further refinement.

References

Gheorghiade, P., Price, H. and Rivers, R. J. (2022) "The importance of geography to the networked Late Bronze Age Aegean", published in Mediterranean connections. How the sea links people and transforms identities. Edited by Schmidt, L.; Rutter, A.; Käppel, L.; Nakoinz, O. Sidestone Press, Leiden.

Leidwanger, J. (2013). "Modeling distance with time in ancient Mediterranean seafaring: A GIS application for the interpretation of maritime connectivity." Journal of Archaeological Science 40(8): 3302–3308.

Safadi C. (2016). Wind and wave modelling for the evaluation of the maritime accessibility and protection afforded by ancient harbours." Journal of Archaeological Science: Reports, 5: 348-360.

Safadi, C., and Sturt, F. (2019). "The warped sea of sailing: Maritime topographies of space and time for the Bronze Age eastern Mediterranean." Journal of Archaeological Science 103: 1-15.

Woolf, G. (2016) "Movers and Stayers." In Migration and Mobility in the Early Roman Empire, edited by Luuk de Ligt and Laurens Ernst Tacoma, 438-462. Boston: Brill Publishing.

78. Why did cities evolve in Gharb Al-Andalus? Network analysis as a potential method for charting city growth

Joel Santos, University of Leicester

Since the 8th century that the Muslim presence in the Iberian Peninsula was highly connected with urban centres. The purpose of this presentation is to understand and debate, using an approach based on Network Theory, the influence that various cities exerted on each other through communication routes during the Islamic presence in the Gharb Al-Andalus – mostly nowadays Portugal - and how this influence impacted on those cities' growth.

This study intends to use statistical analysis based on Network theory and on its centrality measures, in order to build a network of geographical relationships between the cities of the Gharb Al-Andalus. The study of these centrality measures (mainly betweenness and eigenvector) indicates that mutation in the importance of such cities might be due to their geographic location, but, as well, by the influence that each city had over the nearest ones. Our theory states that, by measuring the centrality value of a city on a certain moment, it would be possible to indicate the probability of a city to grow or to decline in the successive period. This influence to grow was surely due to political, military, religious or commercial contacts but, likewise, by the different ways cities were connected (terrestrial, fluvial, and maritime).

The combination between archaeological and historical data, together with a network theory approach will allow to validate our theory proposal, which allow us to think in future applications in different case studies.

112. The impact of Levantine transit trade on 16th century Transylvania, Wallachia and Moldova

Daria Stefan, TU Wien

After losing Zadar to the king of Naples, Sigismund de Luxembourg, together with allied Genoa started a campaign against Republic of Venice. As a result, Hungary was cut off from the supply of Levantine wares.

An alternative supply chain took shape: Genoan merchants supplied Levantine wares in the ports of the Black Sea, which merchants then transported across Wallachia, Transylvania and Moldova towards Buda, Cracow and Lviv.

At the end of the 16th century, the imports documented in Sibiu and Brasov amount to 7-8% of Venice's imports at the time and are five times as large as imports from the Adriatic Coast.

In this paper I investigate the impact of Levantine transit trade on these regions - Were certain cities more likely to turn into trading centres? Can certain cities exert control over and profit from the flow of goods? How could this have influenced the behaviour of the locals?

Written sources from the 15th and 16th century, like trading registers and letters providing merchants with passage rights and toll exemptions, document both the officially endorsed itineraries and the quantity of wares crossing the border between Wallachia, Transylvania, and Moldova.

Basing on those sources, Willcocks compiled a map of the trading routes, (Nagy, Schmieder, and Vadas 2018), which I used as the starting point of my analysis.

Encoding the cities on the map as nodes, their region as attributes, the road segments connecting them as edges and a general SE-NW direction for the edges allowed me to analyse the flow of Levantine goods through the network.

For measures that do not take direction into account, or for describing general trade in this region, the undirected counterpart of the network was used.

Describing the network in terms of density, transitivity, centralization, and degree distribution provides context for the measures at neighbourhood and node level.

When interpreting betweenness and brokerage roles, the possibility of flow splitting across different ties – given by density, the probability of intermediaries being excluded – given by transitivity and the proportion of interregional ties – given by the E/I index are relevant.

Centralization is related to the movement of flow - it shows if a single node dominates the system, as opposed to flow moving freely and can reveal funneling or dispersion effects in directed networks.

The degree distribution can reveal the presence of power imbalance, prompting closer investigation at neighbourhood level.

At neighborhood level, a competitive environment like international trade, gives rise to the possibility of dyadic constraint.

On node level, the degree-centrality and closeness measures can be used to identify trading centres: easily reachable cities with numerous trading partners.

In a directed network, high out-degree in combination with high out-closeness indicates a distribution centre, a city that can reach a variety of clients easily.

The combination of in-degree and in-closeness fits the profile of a meeting point, a convenient destination for vendors from different cities.

The Freeman betweenness was used to identify the nodes that can potentially profit from their position as part of a trading route, by restricting, taxing, or directing the flow of goods. In combination with brokerage roles and the E/I index, this measure helps identify the influent nodes in the system.

The edge betweenness was used to identify central, well used roads and the cities adjacent to them.

Using these methods, I identified likely trading centres, cities occupying influent network positions and cities which benefited indirectly from the flow of goods through the analysed region.

The network is decentralized, indicating that flow was likely to move according to economic principles like supply and demand.

The directed network displays a higher out-degree centralization than in-degree centralisation, indicating a dispersion effect. I identified the Wallachian cities Craiova and Buzau as likely distribution centres, and the Transylvanian city Oradea and the Moldavian city Baia as likely meeting points.

For the bidirectional network, these cities belong to the top 10% nodes with high Closeness, alongside Transylvanian cities Brasov and Targu Mures, occupying favourable positions for trade in both Levantine and European wares.

The degree distribution hints at inequality in the system, the network is sparse, with low transitivity, which may give cities with high betweenness the opportunity to control, redirect and profit from the flow of goods.

The E/I index reveals a clear preference for intra-regional ties, meaning that the cross-border connections supplying cities with foreign wares are rare.

Brasov scores highest for betweenness and degree and lowest for constraint and enjoys staple and toll-collection rights, these factors indicate a strong economic position. Staple rights also indicate the possibility of local consumption. Additionally, this node has the most cross-border connections and fulfils the roles of Gatekeeper and Liaison most often, which indicates relevance on an international level.

Medias on the other hand enjoys none of these benefits and has no cross-border connections, but it is adjacent to the road segment with the highest betweenness in the system. Even if the locals might not have been directly involved in trade, they might have offered other services, such as hospitality, guidance, or cartage.

The edge betweenness reveals a South-East to North-West corridor, which passes through Brasov, as well as a separate segment, crossing the Carpathians through Sibiu. Both cities occupy similar network and geographical positions, being adjacent to highly used roads.

Given its connection to the Black Sea and the constraint exercises over the other two ports, Chilia and Tulcea, Braila is also a noteworthy node. This city has a direct connection to Brasov and Buzau, acting as a distributor, a representative of its own region and a liaison between Moldova and Transylvania and the Genoan merchants.

These results provide a quantitative basis for discussion regarding the roles of the individual cities in Levantine trade.

Additionally, they may be used to better understand the economic and political position of these cities and offer insight into the relationship of the locals with the Levantine items– be it directly, as wares for trade and consumption, or indirectly, as a phenomenon that encouraged certain behaviours.

Nagy, Balázs, Felicitas Schmieder, and András Vadas. 2018. The Medieval Networks in East Central Europe: Commerce, Contacts, Communication. Edited by Balazs Nagy, András Vadas, and Felicitas Schmieder. 1st ed. Abingdon, Oxon; New York, NY : Routledge, 2019.: Routledge. https://doi.org/10.4324/9781315149219.

279. Disentangle the Net: How Social Network Analysis Can Help Understand and Fight the Illicit Trafficking in Antiquities

Riccardo Giovanelli, Ca' Foscari University of Venice
Michela De Bernardin, Istituto Italiano di Tecnologia
Arianna Traviglia, Istituto Italiano di Tecnologia, IIT

The pursuit and the trade of ancient valuables are both human behaviours with (extremely) old roots. They have been recursively deemed as illegal/forbidden or rightful/permitted deeds, with noticeable differences depending on places and historical periods. Nowadays, the constant ambiguity of the status and provenance of archaeological items has been generating the so-called 'grey market': here, the boundaries between licit and illicit trade are so nuanced that it is extremely easy to let recently looted objects or robbed artworks slip into the sales of the biggest auction houses or into the showcases of renowned museums.

Despite the huge progress that the international community has made, especially since the 1970 UNESCO and 1992 UNIDROIT Conventions, the extent and ramifications of this market, the relationships between all the entities involved and the actual movements (and present whereabouts) of the antiquities are still mostly uncertain (Brodie et al. 2022).

Tsirogiannis (Tsiriogiannis and Tsiriogiannis 2016) was among the first to show how Social Network Analysis may be applied to cultural heritage crime, to study and describe the illicit trafficking network displayed in the famous "Medici Conspiracy" case (Watson and Todeschini 2006). His research designed and tested different algorithms to explore the capabilities of network analysis both in estimating transaction paths and predicting the missing links between entities.

Drawing from this pioneer application of network theories to illicit trade in antiquities, this paper presents a new SNA method based on Python, NLP Machine Learning, and Neo4j. The system aims to detect and gather data from the websites of the most notorious auction houses in an automatic and unsupervised way and to visualise the resulting network connecting items, trading entities, exhibitions, and publications.

In order to automatically organise the data as soon as they are collected, an ontology is previously defined in accordance with the topic specifics. Quantitative measures to evaluate the "quality"/"reliability" of the declared provenance are also proposed and integrated into the system.

The original scraping scripts are developed in Python language, while the items database is based on Neo4j (cypher language), an open-source knowledge graph platform that combines native graph storage with built-in algorithms that allow you to study a given database through the lenses of several network analysis measures.

The network derived from the auctions scraping is then checked against the one originating from past and ongoing investigations. The overall public data, gathered, organised, re-structured and analysed through such SNA-system, will show critical distribution patterns of the nodes and cliques packed around specific actors (auction houses, art galleries, museums, cultural institutions), thus raising red flags on those objects still on the market, passed through or handed out by the very actors.

This SNA system applied to the study of illicit trafficking in antiquities will be boosted and implemented on a broader scale once it is integrated into the complex and multi-datasets platform to be developed in the framework of the new European project RITHMS: Research, Intelligence and Technology for Heritage and Market Security (GA 101073932).

References

Brodie, Neil, Kersel, Morag, Mackenzie, Simon, Sabrine, Isber, Smith, Emiline and Yates, Donna. 2022. "Why There is Still an Illicit Trade in Cultural Objects and What We Can Do About It." Journal of Field Archaeology 47, no. 2: 117-130, https://doi.org/10.1080/00934690.2021.1996.

Tsiriogiannis, Constantinos and Tsiriogiannis, Christos. 2016. "Uncovering the Hidden Routes: Algorithms for Identifying Paths and Missing Links in Trade Networks." In The Connected Past Challenges to Network Studies in Archaeology and History edited by Tom Brughmans, Anna Collar, and Fiona Coward, 103–122. Oxford: Oxford University Press.

Watson, Peter and Todeschini, Cecilia. 2006. The Medici Conspiracy: The Illicit Journey of Looted Antiquities.

22. Machine and deep learning methods in archaeological research – creating an integrated community (Part 1)

Alex Brandsen, Leiden University
Wouter Verschoof-van der Vaart, Leiden University
Daniella Vos, University of Groningen
Daniël Paul van Helden, University of Leicester

Location: E103

We are witnessing an increase of papers, sessions and discussion on Machine Learning (ML) and Deep Learning, both within CAA and outside of the conference, and it is apparent that there is plenty of interest in the application of these methods in archaeology [1]. This interest might be partly ascribed to advances made in Deep Learning – in particular Convolution Neural Networks – across various disciplines. Applications using these methods now show high performance and in some cases exceed humans on challenging tasks ranging from computer vision to natural language processing. In digital archaeology we have seen and foresee applications of these techniques including automated object detection in remote sensing data, artefact image classification, use-wear analysis, text mining, paleography, predictive modelling, 3D shape analysis and recognition, and typology development.

The diversity of AI-based procedures, methods and archaeological applications results in a certain lack of standardised approaches, comparable accuracy metrics, and reusable workflows, leading to a "reproducibility crisis" [2]. If we want to learn from each other, avoid common pitfalls, and together push this topic forwards within archaeology, we need to move beyond isolated case studies, and look into how we can best combine our efforts.

This session aims to: 1) offer a space for comparing methods, algorithms, code, APIs and workflows; 2) discuss the problems related to their application and; 3) offer insights into best practices including sources of error and validation methods. The ultimate aim is that the combination of approaches and the ensuing discussion will help to further build an integrated community of practitioners.

We specifically invite authors to submit papers relating to the creation of (annotated) datasets & the sharing of developed methods, data (or data structures) and code, but also welcome papers on the more broad subject of Machine Learning, relating to the following themes:

- Using small, incomplete and noisy datasets for ML;
- Choosing and tuning specific ML techniques;
- Evaluation of ML and conventions for performance metrics;
- Interpretation and validation of ML results;
- Collaboration and insights from ML fields outside of archaeology;
- Ethics of ML in archaeology;
- Education of ML in archaeology;
- Case studies on the application of ML to the analysis of texts, artistic representations, bioarchaeological remains, material culture, archaeological sites, etc. Combinations of such approaches will be particularly welcome.

For practical approaches we would encourage a critical dialogue to identify individual and shared problems, opportunities, and solutions. We invite authors to provide a thorough explanation and evaluation on their methods.

References:

[1] Mantovan, L., & Nanni, L. (2020). The Computerization of Archaeology: Survey on Artificial Intelligence Techniques. SN Computer Science, 1, 267. https://doi.org/10.1007/s42979-020-00286-w

[2] Kapoor, S., & Narayanan, A. (2022). Leakage and the Reproducibility Crisis in ML-based Science. arXiv preprint. https://doi.org/10.48550/arxiv.2207.07048

SLOT 1	
08:30 - 08:50	217. From unsupervised to supervised: Supporting the analysis of a large coin hoard with AI-based methods. Part 2 *Chrisowalandis Deligio (Goethe Universität Frankfurt am Main)*; Karsten Tolle (Goethe-University); Dr. David Wigg-Wolf (Römisch-Germanische Kommission, Frankfurt am Main)*
08:50 - 09:10	3. From Fragment to Reconstruction using Neural Networks and Associative memories *Joan Anton Barcelo (UAB, Spain)*; DENIZ KAYIKCI (Universitat Autònoma de Barcelona); Borja Urbistondo (Universitat Autonoma de Barcelona)*
09:10 - 09:30	53. Chasing social complexity through body ornaments in the recent prehistory of Iberia. Implemantation of an archaeochemical tool for prehistoric data analysis and predictive modelling *Daniel Sánchez Gómez (University of Seville)*; Galo Romero-García (Universidad de Sevilla); José Angel Garrido (University of Seville); Carlos P Odriozola (University of Seville)*
09:30 - 09:50	198. Characterizing stylistic evolution via Approximate Bayesian Computation and Random Forest Adjustment *Simon Carrignon (McDonald Institute for Archaeological Research, University of Cambridge)*; R. Alexander Bentley (University of Tennessee, Knoxville); Michael J. O'Brien (Texas A&M University, San Antonio)*
09:50 - 10:10	328. Amphoraefinder - Roman amphorae identification through Convolutional Neural Networks *Diogo Nunes (Instituto Superior Técnico); Joel Santos (University of Leicester)**
10:10 - 10:30	233. A comparison of machine learning and rule-based approaches for text mining in the archaeology domain, across three languages *Alex Brandsen (Universiteit Leiden)*; Andreas Vlachidis (UCL); Alphaeus G W Lien-Talks (University of York, Historic England, Archaeology Data Service)*
SLOT 2	
11:00 - 11:20	330. Creating an accurate, well-defined and documented Assyriological Dataset for ML applications: is it for all? *Diego Chinellato (Ca' Foscari University); Sara Ferro (Istituto Italiano di Tecnologia (IIT))*; Homa Davoudi (Istituto Italiano di Tecnologia (IIT)); Arianna Traviglia (Istituto Italiano di Tecnologia (IIT))*
11:20 - 11:40	47. Machine Learning for archaeological site detection: An Irish case study *Susan Curran (The Discovery Programme)*; Anthony Corns (The Discovery Programme); Žiga Kokalj (ZRC SAZU); Dragi Kocev (Bias Variance Labs, d.o.o); Nejc Čož (ZRC SAZU); Ivica Dimitrovski (Bias Variance Labs, d.o.o); Stephen Davis (UCD); Rob Shaw (The Discovery Programme); John O'Keeffe (The Discovery Programme); Ana Kostovska (Bias Variance Labs)*
11:40 - 12:00	58. Automated detection of archaeological sites using LiDAR - addressing False Positives *Fabricio Botelho (Universidade de Aveiro); Daniel D Canedo (University of Aveiro)*; Petia Georgieva (University of Aveiro); Joao Fonte (Universidade da Maia); Luis Seco (Universidade da Maia); Marta Vázquez (Universidade da Maia); Rita Dias (ERA Arqueologia); Tiago Pereiro (ERA Arqueologia); João Hipólito (ERA Arqueologia); José Machado (ERA Arqueologia); António Neves (Universidade de Aveiro)*
12:00 - 12:20	113. HillfortFinderApp and site detection across Europe – latest results from a Deep Learning based hillfort search *Jürgen Landauer (Landauer Research)*; Giacomo Fontana (University College London); Simon Maddison (University College London); Axel G. Posluschny (Keltenwelt am Glauberg)*
12:20 - 12:40	238. Automated Recognition of Archaeological Traces in Southeast Asia from Airborne Lidar *Damian Evans (EFEO)*; Vladyslav Sydorov (EFEO); Tommaso Pappagallo (EFEO); Ladislas Letourneur (EFEO); Sarah Klassen (University of Toronto)*
12:40 - 13:00	68. Automated Archaeological Feature Detection Using Artificial Intelligence on UAV Imagery: Preliminary Results *ARGYRO ARGYROU (Cyprus University of Technology)*; Athos Agapiou (Cyprus University of Technology)*
SLOT 3	
14:00 - 14:20	59. The Chaînes that Bind Us: Why the Chaîne Opératoire is Not Enough for Digital Artefacts *Katie M Biittner (MacEwan University)*; John Aycock (University of Calgary)*
14:20 - 14:40	376. Machine learning for UAV-captured imagery: an outgrowth of XRchaeology 2019-2022 *Brooklyn Christofis (Northern Arizona University)*; Kayeleigh Sharp (Northern Arizona University); Hossein Eslamiat (Southern Illinois University); Carlos Osores Mendives (Pontificia Universidad Católica del Perú); Bijay Raj Paudel (Southern Illinois University)*

14:40 - 15:00	*351. Generalisation Capability of Semantic Segmentation Methods for the Identification of Archaeo-logical Structures on Remote Sensing Data* *Gregory Sech (Italian Institute of Technology); Paolo Soleni (Italian Institute of Technology); Marco Fiorucci (Istituto Italiano di Tecnologia); Arianna Traviglia (Istituto Italiano di Tecnologia (IIT); Sara Ferro (Italian Institute of Technology / University of Venece)*
15:00 - 15:20	*155. Building a toolkit for ML-integrated archaeological workflows: the contribution of human-centred approaches* *Lucy Killoran (University of Glasgow)**
15:20 - 15:40	*17. AI-on-Demand (AIOD) platform and its uses for cultural heritage* *Edisa Lozić (ZRC SAZU)*; Benjamin Štular (ZRC SAZU); Gabriel Gonzalez Castane (Insight SFI Research Centre for Data Analytics)*
15:40 - 16:00	160. Creating an additional class layer with machine learning to counter overfitting in an unbalanced ancient coin dataset *Sebastian Gampe (Goethe-Universität Frankfurt am Main)*; Karsten Tolle (Goethe-University)*

217. From unsupervised to supervised: Supporting the analysis of a large coin hoard with AI-based methods. Part 2

Chrisowalandis Deligio, Goethe Universität Frankfurt am Main
Karsten Tolle, Goethe-University
Dr. David Wigg-Wolf, Römisch-Germanische Kommission, Frankfurt am Main

In our project "Classifications and Representations for Networks: From types and characteristics to linked open data for Celtic coinages" (ClaReNet), we have image data for one of the largest Celtic coin hoards: Le Câtillon II containing nearly 70,000 coins. At the last CAA 2022 in Oxford, where we demonstrated our approach, the focus was mainly on how to handle the dataset without having any information about it. We showed how to separate the dataset into groups of coins of different sizes using object detection in combination with the scale included in the images. The main approach was to treat the coins independently from the underlying classification and to analyze how an unsupervised method could group them. We decided to use the method presented in the paper "Deep Clustering for Unsupervised Learning of Visual Features" (Caron et al. 2018). The method combines a convolutional neural network (CNN) with unsupervised clustering algorithms, such as k-Means, to create pseudo-labels for the CNN with a predetermined number of clusters. After applying the method, we found that the algorithm:

- successfully separated obverse motif (head) and reverse motif (horse)
- separated coins in a good condition – i.e. where the motif was still well recognizable – and other broken, corroded or worn coins into different groups
- grouped similar coins together.

Some of the generated clusters were mixed, meaning there was no observed similarity based on the motifs, and so less helpful. Clusters which showed a high degree of similarity between the coins also showed good correlation with the classification by the domain experts.

While in that presentation we focused on the analysis of the hoard, in this one we will summarize what we learned, and show how we then proceeded. We double checked the classifications of the domain experts in order to improve the ground truth, but also to better understand the way experts do the classification, particularly when dealing with poorly preserved coins. One main question in this respect is:

How far can coins in poor condition be recognised by a supervised CNN approach based "only" on coins in good condition? Would the addition of coins in poorer condition harm the performance for good coins?

Coins from a hoard can come in various states of preservation (corroded or worn). Not only are important features missing or not fully visible, the corrosion and wear add also a layer of noise to the dataset. With the presorting based on an unsupervised approach as presented at the CAA 2022, we could find clusters of coins in good condition. As noted, some of those clusters showed a high correlation with the underlying assignments by the domain expert and were used as a starting point to train a supervised model. The goal is now to redetermine the poorly preserved coins that were not included, and the question here is how to evaluate the result of the prediction where it does not match the ground truth, in particular how to involve the domain expert in discussing problematic decisions.

Figure 1: Here it is possible to see that the nose sometimes disappears depending on the condition of the coin, but that the centre, the eye, remains visible. Coin images: Jersey Heritage

While discussing the results of our AI system with the domain experts, we also realized that the domain expert has a prioritization of features when classifying a coin. With the help of the visualization tools we used (GradCam, XRAI) it was possible to identify features and regions that led to the decision of the AI model. One surprise was that a feature that is relevant from the numismatists' point of view, in this case the "nose", was rarely marked as an important region. In the case of this coin series, our model focuses on the centre of the image (the "eye" region), as this is often present and recognizable throughout the data set. The feature "nose" is often located at the edge and is therefore sometimes not completely present or not visible at all, as shown in Figure 1 for the two coins on the right. To deal with this, we want to apply methods such as "Hide-and-Seek: Forcing a Network to be Meticulous for Weakly-supervised Object and Action Localization" (Krishna Kumar Singh, Yong Jae Lee, 2017), as well as other ways of affecting the training process, for example augmenting the dataset to extend the learned features. The idea is to see if it is possible to shift the model towards the expert's prioritization of features and combinations of them.

To summarize:

- At the CAA 2022 in Oxford we demonstrated how to presort huge amounts of coins and to filter out coins of good condition.
- Based on the good coins, we trained a supervised network for identifying coin types. Our presentation will cover:
- To what extent coins of less good condition are recognised.
- How to integrate the domain expert into our process.
- Ways to influence the model (by adjusting the training set) in order to boost features that are more important for domain experts, and to analyze the effects.

References:

Jersey Heritage: https://www.jerseyheritage.org/learn/jerseys-celtic-coin-hoard/

3. From Fragment to Reconstruction using Neural Networks and Associative memories

Joan Anton Barcelo, UAB, Spain
DENIZ KAYIKCI, Universitat Autònoma de Barcelona
Borja Urbistondo, Universitat Autonoma de Barcelona

In this paper, we present how to use a supervised Machine learning approach to archaeological reconstruction. Feed Forward neural networks are used to build an associative memory where complete pottery vessels are represented and we use it to associate different fragments to the most probable complete form they may come from.

Because the objective of the paper is basically theoretical, we use a simulated data base where pottery shapes are represented using six quantitative measurements (diameters and heights) and six qualitative attributes (decoration, surface characteristics). Simulated fragments are represented using the same measurements and attributes when available, and as missing values when the sherd appears to be too small to measure. Statistical classification and numerical taxonomy methods are used in a preliminary step, and results are compared with different algorithms of neural networks. Finally, the concept of induction and generalization is critically debated.

A key aspect in our approach is a critical evaluation of the very idea of object similarity: Two entities are similar because they have many properties in common. According to this view (Medin 1989):

- similarity between two entities increases as a function of the number of properties they share;
- properties can be treated as independent and additive;
- the properties determining similarity are all roughly the same level of abstractness;
- these similarities are sufficient to describe a conceptual structure: a concept would be then equivalent to a list of the properties shared by most of its instances.

The problem is that fragments are not "similar" in shape, even though they come from the same pot or from pots with the same general shape. We need a form of supervised learning, because some known instances of a particular fragment-to-complete shape relationship should be used. In this paradigm, an agent learns to classify fragments as members of generalized shapes through trial and error with corrective feedback (prior knowledge) (Baxter 2006, Barceló 2009). Known examples of a particular input-output mapping may be experimental replications and/or ethno-historical data. In other words, the idea is to look for common features between positive examples of the fragment-to-pot relationship to be predicted, and common differences between its negative examples. For best generalization, we need an algorithm able to match the complexity of the hypothesis with the complexity of the function underlying the data. If the hypothesis is less complex that the function, the resulting model will be underfitted. If the hypothesis is too complex, or the data is not enough to constrain it, we will end up with a bad hypothesis. If there is noise, the resulting model will be over¬fitted because it is not only based on the underlying function but also on the noise in the data. In such a case, having more examples, or known instances helps but only to a certain point (Alpaydin 2004).

Neural networks are a special kind of algorithm able to learn non-linear and non-monotone input-output relationships. They have three main characteristics that have contributed to the wrong idea that they mimic the way the human brain operates: they work in a distributed and parallel way; they are also the result of adaptive process of learning. 'Distributed' means that calculations are decomposed into thousands of basic calculations between some basic computational units. 'Parallel' means that all those calculations are made simultaneously and all of them contribute to the final solution. 'Adaptive' means that they learn through reinforcement of rewards in successive 'evolutive' steps.

The most known learning algorithm to solve this kind of problem was invented in 1986 by David Rummelhart, Geoffrey E. Hinton and others, and it is called Backpropagation (Rumelhart et al. 1995; Kishore, Kaur 2012). Once learned, a neural network can be used as associative memory, and therefore it assigns to new unseen inputs, the output that probably corresponds. It is a distributed representation of scientific knowledge because causal and other explanatory associations are stored throughout all the connections in the network, and because one set of connections can store several different associations. After learning, when using the network to categorize a new input, if the associative mechanism runs properly, then the pattern of activation in the output neurons will be the pattern that was originally associated with the cue pattern.

An artificial neural network for multi-label classification predicts the probabilities of each out¬put node independently of all other nodes. In this way, it allows information to be simultaneously classified into multiple categories, which distinguishes this classification algorithm from others, such as discriminant analysis, because the neural network does not compute the probabilities of outputs in conjunction with or in opposition to any other output (Lin 2021).

The advantages of this way of learning what archaeological elements may be – the concept to which they probably belong – are obvious. First of all, the relationship between input and output, between description and explanation can be non-linear, when classical statistical classifiers are limited by the intrinsic linearity of distinctions they can reproduce. Second, qualitative attributes can be added to quantitative ones. Parametric assumptions, normality or symmetry are not required.

REFERENCES:

E. ALPAYDIN 2004, Introduction to Machine Lear¬ning, Cambridge (MA).

BARCELÓ, J.A, 2009, Computational intelligence in Archaeology. New Ror: IGI Group Press

BAXTER, M. 2006, A review of supervised and unsupervised pattern recognition in ar¬chaeometry, "Archaeometry", 48(4), pp. 671-694.

R. KISHORE, T. KAUR 2012, Backpropagation algorithm: an artificial neural network ap¬proach for pattern recognition, "International Journal of Scientific & Engineering Research", 3(6), pp. 1-4.

J.W. LIN 2021, Is the algorithm of artificial neural network a deduction or induction? Discussion between natural sciences, ma¬thematics and philosophy, "European Journal of Information Technologies and Computer Science", 1(4), pp. 6-8.

D.L. MEDIN 1989, Concepts and conceptual structure, "American Psychologist", 44(12), pp. 1469

D.E. RUMELHART, R. DURBIN, R. GOLDEN, Y. CHAU¬VIN 1995, Backpropagation: The basic theory, "Backpropagation: Theory, archi¬tectures and applications", pp. 1-34.

53. Chasing social complexity through body ornaments in the recent prehistory of Iberia. Implemantation of an archaeochemical tool for prehistoric data analysis and predictive modelling

Daniel Sánchez Gómez, University of Seville
Galo Romero-García, Universidad de Sevilla
José Angel Garrido, University of Seville
Carlos P Odriozola, University of Seville

1. Introduction

Since the expansion of the Neolithic across the Mediterranean, with the arrival and consolidation of village life and agriculture, long-distance exchange experiences unusual growth, and exotic items become an important means of displaying new roles and social differences within and between communities. The use and association of exotic items with specific individuals increase as social complexity grows and it becomes more necessary to enhance social differences and exhibit the status of the bearer. The study of the geographical origin and the Spatio-temporal distribution patterns of exotic raw materials and their products are trending topics in European archaeological research since they are considered key to understanding social interaction and the mobility patterns of individuals and goods at different scales. Variscite-like minerals are some of the most used materials for the elaboration of body adornments in prehistory that have both, an important weight in the archaeological record and a relevant research tradition in the Iberian Peninsula context. Thanks to the development of novel chemical analytical techniques, which are both portable and non-destructive, in the last ten years it has been possible to record data of thousands of items of personal adornment made out of different minerals from more than 900 archaeological sites on the Iberian Peninsula through different projects, which represents a first-rate experimental data set for the study of these subjects. Despite the existence of such relevant data sets, to date, there are both methodological and theoretical challenges in extracting knowledge from this type of resource due to the lack of comprehensive studies with a data-driven approach. It is still necessary to make exhaustive inventories of Iberian sources, mineralogical characterisation of items, and systematisation of scattered and unpublished data among other urgent tasks that will improve or reconsider provenance models used to explain the socio-economic dynamics in late prehistory. Through the use of different techniques of Computational archaeology such as Data mining and Machine Learning, this project aims to explore a data-driven approach to solve some of the main methodological challenges in the study of the socio-economic complexity in the late prehistory of the Iberian Peninsula and develop an Open Access approach for the publication of results by the necessity of digitalization of humanities.

2. Methods and Materials

A Machine Learning pipeline that involved several data preparation techniques and algorithm experimentation routines has been developed to predict the mineral Group and Subgroup to which a sample obtained from p-XRF belongs using open-source tools (Ali, 2020; pandas development team, 2020; Pedregosa et al., 2011; Pérez & Granger, 2007)

To train our model we have used a real-world dataset that comprises more than two thousand records of items of personal adornment made out of more than 25 different mineral classes from more than 900 archaeological sites on the Iberian Peninsula. The shape of our original dataset comprised 46 numerical features and one target with 26 categories.

A total of 16050 data points were reached after the implementation of a mixed technique of case deletion, undersampling and oversampling to create synthetic data for minority classes(Carlson, 2017; Thai-Nghe, Gantner, & Schmidt-Thieme, 2010). Different models were developed using ten different algorithms and its performance was evaluated with a k=10 cross-validation procedure. After choosing the best model, an hyperparameter optimization routine was implemented and evaluated through different metrics (accuracy, F1 score, recall and precision). Finally, we validated our model using a real-world case and deployed it in a general-purpose web application.

3. Results and Discussion

We have developed a model as complex as necessary but as simple as possible.

From a technical point of view, our problem is quite simple once the modelling of the problem has allowed us to use machine learning algorithms whose performance is optimal and does not represent high computational costs.

Our model reached 87-95% of scores in different metrics (Precision, Recall and F1) and we have deployed it in a web app for public use. However, high scores on various metrics achieved through various training and testing routines aside, our model, as an ongoing project, has been re-evaluated as our data set grows and new questions arise. The challenges of using AI-derived techniques and a data-driven approach to solve archaeological questions still raise several issues. Our results remain open questions

- How do AI-derived methods reconfigure archaeological research?
- How to present final results when the data continue to grow?
- How is the workflow of an archaeological research team transformed when the core of the research is an AI and data-driven approach?

4. References

Ali, M. (2020). PyCaret: An open-source, low-code machine learning library in Python. Retrieved from https://www.pycaret.org

Carlson, D. L. (2017). Quantitative Methods in Archaeology using R (1st ed.). Cambridge: CAMBRIDGE UNIVERSITY PRESS. https://doi.org/10.1017/9781139628730

pandas development team, T. (2020). pandas-dev/pandas: Pandas. Zenodo. https://doi.org/10.5281/zenodo.3509134

Pedregosa, F., Varoquaux, G., Gramfort, A., Michel, V., Thirion, B., Grisel, O., … Duchesnay, E. (2011). Scikit-learn: Machine Learning in {P}ython. Journal of Machine Learning Research, 12, 2825–2830.

Pérez, F., & Granger, B. E. (2007). {IP}ython: a System for Interactive Scientific Computing. Computing in Science and Engineering, 9(3), 21–29. https://doi.org/10.1109/MCSE.2007.53

Thai-Nghe, N., Gantner, Z., & Schmidt-Thieme, L. (2010). Cost-sensitive learning methods for imbalanced data. In The 2010 International Joint Conference on Neural Networks (IJCNN) (pp. 1–8). https://doi.org/10.1109/IJCNN.2010.5596486

198. Characterizing stylistic evolution via Approximate Bayesian Computation and Random Forest Adjustment

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Evolutionary theory, as the science of how attributes are transmitted and modified through time, is ideally suited to investigating cultural change (Creanza et al. 2017). Its application to human social and cultural production has propelled fruitful debates over what units of culture are transmitted, and how and why. As models addressing these questions are adapted from evolutionary biology and ecology, they must be adapted appropriately to explain changes in frequencies of cultural traits and artifacts (Shennan 2008).

A key variable is the frequencies (popularity) of cultural elements, which affect the evolution of their future frequencies. In its simplest form, pure frequency-dependent effects have been explored through the neutral model, where random choices are made among a different set of equally useful variants. The parsimony of the neutral model provides a useful null hypothesis against which deviations can be measured and interpretation subsequently made. As a null model for appropriate case studies (e.g., archaeological pottery decorations, cattle brands, dog breeds, baby names, pop songs, online memes) the neutral model has helped researchers hypothesize about additional factors–specific events, cognitive biases, or functional aspects of the variants–that underlie observed deviations from the neutral model.

Besides differences in utility of the variants themselves, among the most important reasons for non-neutrality are the various biases in social learning, such as conformity or anti-conformity, and many others (Kendal et al. 2018). As a simplification, these various biases have been usefully categorized as either context- or content bias. Context bias refers to the human capacity to discern the value of a variant in terms of its payoff –what we refer to as the "utility" of the variant. We expect that human cognition has evolved to detect and select cultural variants (tools) that maximize utility. This ability has its limits, however, and whether an agent can recognise the utility of a variant is what we call "transparency", which can depend on environmental factors and human cognitive abilities.

Context versus content biases, or what we parameterize as popularity bias versus transparency of utility, are essential to how frequencies and the function of cultural artifacts co-evolve. From an empirical perspective, however, this coevolution can be hard to untangle, especially if one is focused on the archaeological record. In the sparse archaeological record, causal mechanisms have been lost, and only fragmented proxies of the original processes are left behind. To address this, we propose to:

1. Combine computer simulations with archaeological data to optimize the available data while accounting for missing information.

2. Use a model that combines context- and content-dependent mechanisms to navigate the different dimensions of cultural evolution.

The model we use arrays context and function-driven mechanisms in two dimensions, J and *beta*, where J tracks the degree of popularity bias in social learning, and *beta* tracks the transparency of information about the variants (Figure). We have shown in a recent study (Videilla et al. in press) how this can reproduce a wide range of already well-known and observed dynamics, including steady changes and punctuated jumps in mean utility.

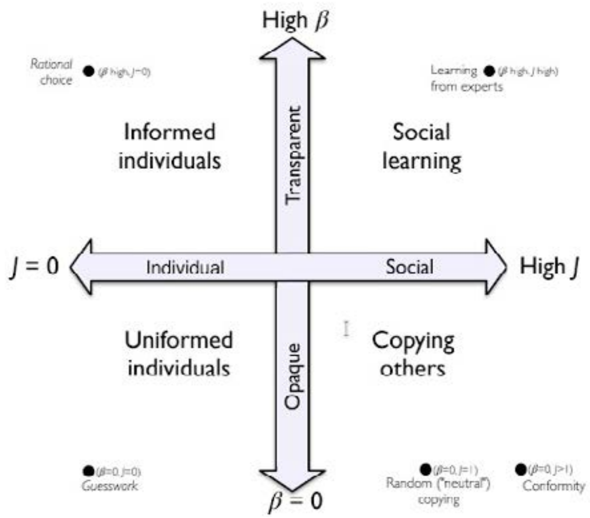

Figure: A four-quadrant map showing different domains of human decision making, based on whether a decision is made individually or socially (horizontal axis) and the transparency of options and payoffs that inform a decision (vertical axis)

As our case study, we use this model to explore Neolithic social interactions and infer what drove them. To do so we combine the Linearbandkeramik (LBK) pottery decorative motifs with Bayesian inference. The latter allows us to extract the mechanisms—combinations of J and *beta*— that have most likely generated the observed LBK patterns. In other words, it will allow us to understand if changes in Neolithic pottery decoration were driven by popularity of style or by expert knowledge.

Since archaeological data are sparse, the dimension and richness available to archaeologists is limited with respect to the richness of possible outcomes of any given model. We address this by using Approximate Bayesian Computation (ABC), which compares the range of possible outcomes of a model with known situations (Beaumont 2010). In addition, we use a random-forest machine-learning algorithm, called Random Forest Adjustment (Bi et al. 2022), which allows us to use multiple metrics at once, rather than the single summary metric typically used in classic ABC. In the limited-information context of archaeology, the combination of random forest and ABC methods allows us to use multiple metrics to compute a regression between model parameters and the data. We find that use of multiple metrics adds precision to the ABC estimates. This is likely because the complex interaction of function and popularity cannot be captured by any single metric on its own. We illustrate how this works with tactical simulation and then apply our method with the LBK dataset to bring a new light on the understanding of Neolithic social interactions.

Creanza, N., Kolodny, O., & Feldman, M. W. (2017). Cultural evolutionary theory: How culture evolves and why it matters. Proceedings of the National Academy of Sciences 114, 7782–7789.

Beaumont, M. A. (2010). Approximate Bayesian computation in evolution and ecology. Annual Review of Ecology, Evolution, and Systematics 41, 379–406.

Bi, J., Shen, W., & Zhu, W. (2022). Random forest adjustment for approximate Bayesian computation. Journal of Computational and Graphical Statistics 31, 64–73.

Kendal R.L., et al. (2018). Social learning strategies: Bridge-building between fields. Trends in Cognitive Sciences 22(7): 651–665.

Shennan, S.J. (2008). Evolution in archaeology. Annual Review of Anthropology 37:75–91.

Vidiella, B., Carrignon, S., Bentley, R. A., O'Brien, M. J., & Valverde, S. (2002). A unified framework for cumulative cultural evolution. Journal of the Royal Society Interface (in press).

328. Amphoraefinder - Roman amphorae identification through Convolutional Neural Networks

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Archeology, and more specifically the field of fragment identification, has traditionally relied on human expertise, which comes at a very high cost, in time-consuming and human errors. The development of Deep Learning algorithms, access to data, and improved computing power, have allowed for the development of recognition models that very accurately classify a plethora of inputs and if applied to fragment classification will probably have a positive impact on archaeologists' work.

In this paper, we propose to apply one of these algorithms, specifically Convolutional Neural Networks (CNN), for the automatic identification of archeological fragments of 4 types of Iberic roman amphorae (i.e., formally defined as a multi-class classification problem). Our proposition is solely based on the captured images of fragments, whereas other similar works may be dependent on additional information, such as the expected outline of the full object (C Cintas, et al., 2019), or the manual introduction of points along the fragment's profile (ML Gualandi, et al., 2021). These profiles might be difficult to obtain during the excavation and sometimes imply that the sherd must be drawn. Additionally, we exported our machine learning model to an Android mobile app, which we designed and developed to be used without the necessity of laboratory work and can be used even on archaeological sites. This mobile app allows the user to take photos of unidentified archeological fragments and automatically classify them with a given probability. The app is also connected to a knowledge-base, which offers additional information for the classification results.

For this work, we developed a dataset composed of 7608 images of amphorae fragments of 4 types, which was randomly split into training (90%), validation (10% of training), and test (10%) sets in a stratified manner, i.e., maintaining the relative frequency of each class in each set. The CNN model was trained for 50 epochs, which was the cut-off point for avoiding overfitting, according to the validation performed on each epoch. Our model obtained an overall accuracy of 89.5% on the test set, and a balanced accuracy of 87%, which is a performance metric designed for imbalanced datasets, such as ours.

References

C Cintas, et al., Automatic feature extraction and classification of Iberian ceramics based on deep convolutional networks, Journal of Cultural Heritage (2019).

ML Gualandi, G Gattiglia, F Anichini, An Open System for Collection and Automatic Recognition of Pottery through Neural Network Algorithms, Heritage (2021). 4(1):140-159

233. A comparison of machine learning and rule-based approaches for text mining in the archaeology domain, across three languages

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Archaeology is a destructive process in which the evidence primarily becomes written documentation. As such, the archaeological domain creates huge amounts of text, from books and scholarly articles to unpublished 'grey literature' fieldwork reports. We are experiencing a significant increase in archaeological investigations and easy access to the information hidden in these texts is a substantial problem for the archaeological field, which has been identified as early as 2005 (Falkingham

2005). In the Netherlands alone, it is estimated that 4,000 new grey literature reports are being created each year, as well as numerous books, papers and monographs. Furthermore, as research – such as desk based assessments – are increasingly being carried out online remotely, these documents need to be made more easily Findable, Accessible, Interoperable and Reusable. Making these documents searchable and analysing them is a time consuming task when done by hand, and will often lack consistency. Text mining provides methods for disclosing information in large text collections, allowing researchers to locate (parts of) texts relevant to their research questions, as well as being able to identify patterns of past behaviour in these reports. Furthermore, it enables resources to be searched in meaningful ways using semantic interoperable vocabularies and domain ontologies to answer questions on what, where and when.

The EXALT project at Leiden University is working on creating a semantic search engine for archaeology in and around the Netherlands, indexing all available, open-access texts, which includes Dutch, English and German language documents.

In this context, we are systematically researching and comparing different methods for extracting information from archaeological texts, in these 3 languages. The specific task we are looking at is Named Entity Recognition (NER), which is to find and recognise certain concepts in text, e.g. artefacts, time periods, places, etc. In the archaeology domain, the task of entity recognition is particularly specialised and determined by domain semantics that pose challenges to conventional NER. We develop text mining applications tailored to the archaeological domain and in this process we will compare a rule-based knowledge driven approach (using GATE), a 'traditional' machine learning method (Conditional Random Fields), and a deep learning method (BERT).

Previous studies have investigated different applications of text mining in archaeological literature (Richards et al. 2015), but this often occurred at a relatively small scale, in isolated case studies, or as proof-of-concept type work. With this study, we are comparing multiple methods in multiple languages, and we aim to contribute to guidelines and good practice for text mining in archaeology. Specifically, we will compare not only the overall accuracy of each approach, but also the time, digital literacy, hardware, and labelled data needed to run each method. We also pay attention to the energy usage and CO2 output of these machine learning models and the impact on climate change, something that's particularly poignant during the ongoing energy crisis. Besides these more practical aspects, we also aim to describe some general properties of the way we write about archaeology, and how writing in a particular language can make knowledge transfer (and by extension, NER) easier or more difficult.

References

Falkingham, G. (2005). A whiter shade of grey: a new approach to archaeological grey literature using the XML version of the TEI guidelines. Internet Archaeology, 17. https://doi.org/10.11141/ia.17.5

Richards, J., Tudhope, D., & Vlachidis, A. (2015). Text Mining in Archaeology: Extracting Information from Archaeological Reports. In J. A. Barcelo & I. Bogdanovic (Eds.), Mathematics and Archaeology (pp. 240–254). CRC Press. https://doi.org/10.1201/b18530-15

330. Creating an accurate, well-defined and documented Assyriological Dataset for ML applications: is it for all?

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Machine learning models, as well known, depend on data. Without a foundation of properly labelled, high-quality data, even the most high-performing algorithm can be ineffective. The annotation process, a challenging and time-consuming activity, is especially complex in disciplines like archaeology or epigraphy where specialised expertise is required to label the dataset (Bogacz and Hubert 2022). In these as well in similar cases, expedients like crowdsourced data collection are clearly not an option to obtain a sufficient number of labelled data in a relative short time given the high level of domain knowledge required. The applications used to annotate the data, on the other hand, need to be as intuitive and flexible as possible for users not accustomed to a labelling activity in order to minimise the risk of importing errors and inaccuracies. In addition to this, documenting how to use the data must be properly defined in order not to run into reproducibility problems (Bell and Onno 2021).

These considerations have underpinned the creation of an epigraphic dataset assembled for LIBER, an Assyriology project focused on deciphering the meaning of specific epigraphic signs called 'firing holes', appearing in cuneiform tablets, whose function, purpose and use still escape scholars. Approaching the problem from a Machine Learning point of view has required the creation of a dataset formed by the segmentation of cuneiform tablets' epigraphic plates, paragraphs, lines of text, drawing lines, inked parts, sealings and firing-holes.

This paper aims to share some considerations about the problems afforded during the creation of the dataset and about the procedures implemented, pointing to the methodological aspects and the specific constrains taken into account during the building phase. The attempt was to create a high-quality dataset both in terms of labelling accuracy and in terms of documentation, respectively to ensure first-class performance of the algorithms and to avoid misunderstanding and inappropriate use of the dataset once the dataset is released.

Due to specific needs of the project and the copyright sensitivity of the images depicting the cuneiform tablets, a custom web application was developed to have full control of the dataset creation affording sufficient flexibility to add new features as required.

The annotation process was undertaken in two phases: a first phase in which Assyriologists involved in the project labelled the images creating polygons/bounding boxes/lines to pixel-wise label the cuneiform tablet's layout elements; a second one consisting of validating or adjusting the annotations, which meant correcting wrong labels and/or modifying the shape/extent of polygons/bounding boxes/lines to increase the labelling accuracy. This two-phase workflow has proven to be necessary as human error is always present. The continuous interaction in both phases between computer scientists and Assyriologists was fundamental to understand if the labelling software was suitable to the purpose: only while using the software scholars figured out its limitations and were able to suggest integrations and corrections. For example, users requested to add an option to discard images that did not offer sufficient resolution or quality to be properly annotated, in order not to increase the noise in the data by introducing misreading or flawed transcriptions. While creating the dataset, other meta-information was deemed to be necessary and therefore added, e.g., normalisation parameters (means and standard deviations) for the different set splits.

Many limitations arose also during the project design and development phases, which required at times revising much of what had already been accomplished. Quite a lot of time, for example, was used to design and implement a suitable interface. There is already a considerable choice of software freely available to label datasets for ML purposes; only a few software, however, can be easily integrated into custom applications and have enough features to be sufficiently flexible to adapt to specific requirements.

The high-quality dataset obtained through the accurate annotation process is now unique in that it includes epigraphic signs that are not recorded in other existing datasets. The accuracy of the labelling has been ensured by two-phase workflow, where validating has been undertaken from top experts of Assyriology. The training, validation and test sets have been explicitly and properly defined in separate files. All this would not have been possible without the strong and persistent collaboration of domain experts that have in many cases led the development of new software features and functionalities, based on their deep understanding of the epigraphic documents being annotated. While the collaboration between such diverse disciplines is not always easy, it is only a full cooperation and a co-design approach in the development of Machine Learning applications that will be able to ensure that meaningful advances in scholarship can be achieved.

References

Bell, Samuel J., and Onno P. Kampman. 2021. 'Perspectives on Machine Learning from Psychology's Reproducibility Crisis'. arXiv. https://doi.org/10.48550/arXiv.2104.08878.

Bogacz, Bartosz, and Hubert Mara. 2022. 'Digital Assyriology—Advances in Visual Cuneiform Analysis'. Journal on Computing and Cultural Heritage 15 (2): 38:1-38:22. https://doi.org/10.1145/3491239.

47. Machine Learning for archaeological site detection: An Irish case study

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Introduction

The need for using machine learning in archaeology is ever-growing with rapid developments in image analysis techniques. With a European-wide interdisciplinary team comprising experts from archaeology, remote sensing, earth sciences and machine learning, the TII (Transport Infrastructure Ireland) ALS Machine Learning Research Project aims to develop a user-friendly software tool capable of automatically detecting archaeological features from airborne laser scanning (ALS) data using deep learning algorithms. This includes the development of a 'trained' machine learning model that can automatically detect three classes of archaeological earthwork monuments from ALS data. The software tool is initially being designed for TII staff and archaeological consultants appointed to TII projects. It is hoped that it can subsequently be made more widely available as free and opensource software to provide opportunities for future collaboration and development. The software is envisioned to be either standalone or based on a QGIS plugin, with clear inputs and outputs and with minimal interaction needed by the user.

This paper presents the up-to-date findings of this project; discussing the overall approach, methods, and challenges faced through the application of machine learning to the analysis of archaeological sites across the island of Ireland.

Methods

The project comprises three major technical steps: Pre-processing, Detection, and Post-processing. The primary interest of the machine learning model (MLM) is the detection of archaeological remains across the entire dataset as discrete spatial objects. The whole process has to create information that is systematic and well-documented (i.e. with thorough metadata). The pre-processing phase involves the creation of suitable surface models in order to achieve some standardisation of diverse data quality and formats. Steps include re-processing the data, DEM creation (either a DTM, or where possible, a digital feature model (DFM), that includes buildings), and assessment and identification of appropriate visualisation(s) to produce the best results with Irish topography and the selected archaeological site types.

Within the detection phase, two machine learning tasks were employed: object detection and object segmentation. Object detection provides a labelled bounding box that locates the monument within the image (DEM), whereas object segmentation places a labelled footprint that locates and delineates the monument within the image. These were created for each of the monuments specified under the chosen monument classifications. In line with the definitions proposed by Ripley (1996, 354), the creation of the dataset was split into three sub-datasets: the training (learning) set, the validation set, and the test set. The selection of archaeological sites was based on Ireland's Sites and Monuments Record, a complete listing of recorded monuments classified according to typology and chronology. With c. 480 individual monument classifications, it was necessary to identify those monument types which would be most appropriate for a machine-learning project. Careful consideration was given to select those monument types that would have – among other criteria - sufficient topographic expression and a sufficiently large volume of recorded examples. Following a thorough selection process, this was narrowed down to three overall monument classifications: Ringforts, Enclosures, and barrows; each comprising further sub-groups within each overall classification. This dataset only contained archaeological sites whose topographic characteristics were identifiable on the DTM. Due to the relatively low numbers of surviving barrows in Ireland, supplementary data were incorporated from recorded UK barrows in order to augment the training datasets. The selection of monument classifications posed its own challenges, particularly in terms of sub-divisions within each classification and the varied quality of monument survival. Testing was conducted using a wide range of data augmentation techniques including rotation, horizontal and vertical flipping, scaling, blurring and sharpening, brightness and contrast alterations, translation, truncation, and noise injection (e.g. Guyot, Lennon, and Hubert-Moy 2021, 5).

Post-processing can improve the results by reducing the false positive detections and provides more readable, understandable, and usable results, e.g. geo-referenced vector maps equipped with detection confidence. Where possible, historic land-use assessment and historic landscape characterisation datasets will be evaluated as an indicator for different zone ranks. The project also tests the effectiveness of applying a feedback loop through the initial labelling of archaeological objects on the performance of the model; this follows Verschoof-van der Vaart and Landauer (2021) who implemented a feedback loop between the archaeological interpreter and the classification algorithm to enhance the quality of the training dataset and the classification model.

Discussion

The purpose of the project is to carry out research leading to the development of a user-friendly software tool capable of automatically detecting archaeological features from ALS data using machine learning, specifically deep learning algorithms. This paper will present the findings of this European multi-disciplinary case study, discussing the development of the machine learning model for the purposes of archaeological feature detection within the Irish landscape. It will present the methods and processes which were designed and implemented in order to develop the model, from the initial selection and identification of potential archaeological sites It will present the methods and processes which were designed and implemented in order to develop the model, from the initial selection and identification of potential archaeological sites through to the present stage of the project.

References

Guyot, Alexandre, Marc Lennon, and Laurence Hubert-Moy. 2021. 'Objective Comparison of Relief Visualisation Techniques with Deep CNN for Archaeology'. Journal of Archaeological Science: Reports 38:103027. https://doi.org/10.1016/j.jasrep.2021.103027.

Ripley, Brian D. 1996. Pattern Recognition and Neural Networks. Cambridge: Cambridge University Press. https://doi.org/10.1017/CBO9780511812651.

Verschoof-van der Vaart, Wouter B., and Juergen Landauer. 2021. 'Using CarcassonNet to Automatically Detect and Trace Hollow Roads in LiDAR Data from the Netherlands'. Journal of Cultural Heritage 47 (January): 143-54. https://doi.org/10.1016/j.culher.2020.10.009.

58. Automated detection of archaeological sites using LiDAR - addressing False Positives

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The fieldwork and manpower required for the mapping of archaeological sites is costly. Efforts have been put into automating this process by using remote sensing data (in particular, LiDAR) and artificial intelligence. However, the top-down nature of LiDAR data leads to a recurrent problem in automated detection, namely many false positives. The morphology of several archaeological features is commonly mistaken by other similar natural and artificial shapes. This naturally results in many false positives which invalidates the usefulness of this automation. The detection of archaeological sites must be reliable so that it can provide valuable information regarding their location to expert archaeologists. To solve this problem, this paper proposes a novel data-centric approach. Firstly, the data is pre-processed with a visualization technique, namely the Local Relief Model (LRM). According to (Guyot 2021, 103027), this visualization technique alone is the fourth top-performing one, and if combined with the Multi-scale Topographic Position (MSTP) and the Red Relief Image Map (RRIM), it achieves the top-performing visualization technique. For this reason, LRM was chosen for this work. Secondly, the data is augmented with several image transformations. This is done with a tool called Albumentations (Buslaev 2020, 125). This tool deals with partially visible objects resulting from geometric transformations with a minimum visibility threshold. For any object that does not meet this threshold, the corresponding annotation is deleted. However, deleting annotations is not desired for this work, because if the annotations are deleted there is no way of handling partially visible archaeological sites. The minimum visibility threshold was set to 100% so that no annotations are deleted after a perspective transformation. However, this did not work since this calculation is done using the original bounding box area and the bounding box area after the transformation. This means that if the transformed bounding box area is smaller than the original, this annotation is deleted. Therefore, this tool was adapted to always return the annotations independently of the visibility, so that it is possible to match the original bounding boxes with the transformed ones and handle them independently. Consequently, if a transformed image has any partially visible archaeological site, the image is immediately discarded. This is done in a loop until there is a successful transformation. The explored image transformation ranged from flipping either horizontally, vertically, or both horizontally and vertically; randomly change hue, saturation, and value, or randomly change gamma, or randomly change brightness and contrast; randomly shift values for each channel of the image; perform a random four-point perspective transform. Additionally, a copy-paste algorithm based on image segmentation is done to increase the number of annotated archaeological sites. This algorithm segments the data to find regions where archaeological sites are more likely to appear and copy-pastes annotated sites to those regions. Due to the high resolution of the data, it needs to be cropped into a dataset that can be used by Deep Learning algorithms. However, the data cannot be randomly cropped since it would inevitably result in images where archaeological sites can be partially visible. To avoid this problem, an algorithm was developed to iterate over the data to generate images containing fully visible and unique archaeological sites. Thirdly, the generated dataset is used to train a Deep Learning model based on object detection. Deep Learning approaches have been increasingly used in Archaeology to detect archaeological sites. One of them is the state-of-the-art object detector YOLO (You Only Look Once) that has been used to detect several archaeological sites, such as burial mounds (Berganzo-Besga 2021, 4181). For this reason, the latest iteration of YOLO up until the writing of this document was used in this work (YOLOv5). Fourthly, the same image segmentation of the copy-paste algorithm is also applied in the test data to identify regions of interest which are then used in the inference. Finally, a post-processing technique using the raw LiDAR data is used to validate the inferences. The third dimension, namely the elevation, is lost when applying the visualization technique. However, by converting the location of the detections from pixels to real-world coordinates, it is possible to compare the elevation data contained in the raw LiDAR data with the elevation of the detected objects to validate inferences. The real-world coordinates of validated inferences are provided to the expert archaeologists. This gives them clear locations to search for during the ground-truthing phase. The classification performance can then be improved based on the ground validations by retraining the Deep Learning model using the new information.

References:

Guyot, Alexandre, Marc Lennon, and Laurence Hubert-Moy. 2021. "Objective comparison of relief visualization techniques with deep CNN for archaeology." Journal of Archaeological Science: Reports 38 (August): 103027.

Buslaev, Alexander, Vladimir I. Iglovikov, Eugene Khvedchenya, Alex Parinov, Mikhail Druzhinin, and Alexandr A. Kalinin. 2020. "Albumentations: fast and flexible image augmentations." Information 11, no. 2 (February): 125.

Berganzo-Besga, Iban, Hector A. Orengo, Felipe Lumbreras, Miguel Carrero-Pazos, João Fonte, and Benito Vilas-Estévez. 2021. "Hybrid MSRM-based deep learning and multitemporal sentinel 2-based machine learning algorithm detects near 10k archaeological tumuli in North-Western Iberia." Remote Sensing 13, no. 20 (October): 4181.

113. HillfortFinderApp and site detection across Europe – latest results from a Deep Learning based hillfort search

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Keywords: Landscape Archaeology; Site detection; Hillforts; LiDAR; Deep Learning.

Introduction

The widely increasing availability and improving resolution of LiDAR data are revolutionising landscape archaeology, allowing the identification of previously unknown archaeological features and thus aiding heritage protection strategies. This can be achieved even on a countrywide scale by using effective automation techniques. Our work aims at developing an approach to automatically detect hillfort sites cross-regionally, using Britain to train a neural network tool and Italy and Germany to test its transferability to different regions and landscapes.

Hillforts are amongst the most evident and iconic archaeological sites in Europe. Usually associated with the Iron Age, they can date from the Neolithic to early Medieval times. The Atlas of Hillforts (Lock and Ralston 2017) provides a comprehensive and up-to-date record of these sites, over 4000 in total, and an invaluable database for further research (e.g., Maddison (2022)).

The large number of hillforts known in Britain constitutes the best training dataset available to date for developing effective automation for recognising hillforts in remotely sensed data. The variety of landscapes present in Italy and Germany, on the other hand, makes this area an optimal case study for testing the transferability of this type of automation in different regions.

Detection in Britain

Since 2020 we have been developing a neural network to detect hillforts in Britain from LiDAR data automatically. The methodology and the workflow have already been presented at various conferences (e.g. Landauer and Verschoof-van der Vaart 2022) but, since then, they have been substantially improved using an extended database of sites. Despite still being a work-in-progress, the approach has shown to be effective in a substantial part of Britain.

Transferability to Italy and Germany

The application of the tool in Italy highlighted both the potential and the limitation of transferring the neural network to different landscapes. The neural network trained on British hillforts was initially tested on selected small Italian areas where hillfort locations were known, to see whether its output was - in principle - applicable to landscapes with rather different characteristics. The result of this limited test was promising, confirming the tool's ability to detect hillfort sites in diverse landscapes. However, many locations were falsely classified as hillforts, and the majority of these turned out to be in those types of landscape that are not present in Britain, such as the heavily terraced hilly areas of the Italian Apennines. These areas were affected by large-scale terracing works across the centuries, with the latest dated to just a few decades ago when large areas were modified for arboriculture. For this reason, the linear features characteristic of hillforts are often in between similar ones, namely the terraces, creating a stratified landscape of walled enclosures that is challenging to interpret.

The neural network had difficulties with terrace data as it had never "seen" this terrain type before. To address this, we decided to re-train the neural network, including many LiDAR samples with terraces (10% of the training data). This neural network training technique, called "transfer learning", means that a network trained on one domain is re-trained to also deal with a slightly different domain. The preliminary results obtained from this approach are promising, showcasing the flexibility of the neural network in detecting hillfort sites in areas which would be already challenging for the human interpreter. In a test region in Molise some 70% of the hillforts known there were detected without further measures.

To verify that the approach presented here is in principle applicable to all landscape types, we have also obtained the Lidar data from the German state of Hesse. Whilsti a full-scale analysis is still ongoing, initial results point towards a similar detection quality, although other terrain types causing false positives need to be dealt with as well.

Overcoming limitations

When processing large areas, the number of false positives is currently too high for human verification. Although we are satisfied with the relatively low number per km², it easily reaches several thousand when applied to an entire country. Our approach to overcome this limitation is twofold: First, we try to identify large "clusters" of detections in terrain types which cause false positives, then re-train the neural network using Lidar patches from that terrain as negative examples.

The HillfortFinderApp

Second, we follow a crowdsourcing approach by providing a web application named "HillfortFinderApp". Archaeologists are invited to upload LiDAR tiles from their region and get a list of possible hillfort sites and their probabilities in return. Optionally, they can provide feedback on the detection quality by indicating false positives. These are then in turn used to fine-tune the neural network, thus contributing to a stepwise improvement process.

Conclusion and further work

This research contributes to automating the detection of previously unknown archaeological sites in three ways. First, we have shown that a suitable database of existing sites can be used to train a state-of-the-art deep learning system to accurately find numerous possible new sites of that type (with a high likelihood of success). This comes with a high degree of automation and reasonable processing times, even at a countrywide scale. Second, we showed that these results are – at least in principle – transferable to other landscape types, in this case from Britain to both Italy and Germany. This works well even if the nature of the landscape is significantly different, as shown with the example of terraces in Italy, when specific transfer learning techniques are applied.

Third, with the HillfortFinderApp we present a novel way to make our research results accessible to other archaeologists as a trained neural network, simultaneously inviting them to cooperate online.

We believe that the quality of results obtained for hillfort detection are also likely to be applicable to other types of archaeological feature. As a long-term objective, the findings of this project (and similar automatic detection projects) could serve as the basis of a future quality benchmark for the automated identification of archaeological feature using remote sensing data across multiple regions.

References

- Fontana, G., 2022, Italy's Hidden Hillforts: A Large-Scale Lidar-Based Mapping of Samnium, Journal of Field Archaeology, 47:4, 245-261, https://doi.org/10.1080/00934690.2022.2031465
- Landauer, J., Verschoof-van der Vaart, W.B. 2022 "Find 'em all: Large-scale automation to detect complex archaeological objects with Deep Learning - a case study on English Hillforts", submitted to CAA2021, Limassol. Preprint available at https://www.researchgate.net/publication/358736419_CAA_2021_-Digital_Crossroads_Find_'em_all_Large-scale_automation_to_detect_complex_archaeological_objects_with_Deep_Learning_-_a_case_study_on_English_Hillforts
- Maddison, S. (2022) Using Atlas data: the recognition and significance of selected clusters of hillforts in Britain. In: Ralston, I. & Lock, G. (Eds.) The Atlas of Hillforts of Britain and Ireland. Edinburgh, Edinburgh University Press

238. Automated Recognition of Archaeological Traces in Southeast Asia from Airborne Lidar

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Introduction

Over the last thirty years, researchers have mapped traces of pre-modern urban, industrial and agricultural networks that are inscribed into the surface of the landscape across Southeast Asia. For the most part this work was done manually, by hand-tracing vectors over imagery in a GIS environment, and has resulted in a consolidated database describing tens of thousands of traces as polygons, over a combined area of several thousand square kilometres. Recently, this process has been streamlined with the arrival of lidar imagery, which allows researchers to efficiently and precisely map very subtle traces even in areas that are covered by dense tropical vegetation (Evans 2016).

Now, however, the amount of lidar imagery coming online from various projects threatens to outpace our capacity to identify and inventorize archaeological traces by hand. In this paper, we provide an overview of ongoing efforts to help resolve this problem using automation. We apply and assess techniques drawn from computer vision and other domains with a view to identifying archaeological traces in derivative lidar image products. We also leverage thirty years of hand-crafted archaeological mapping data to create a web-based infrastructure for serving tiles of annotated raster and vector data in geographic space, which can be used as inputs for training and validation, and which provide a framework for data visualisation and research collaboration in a web-map-based environment.

Background

The durable masonry monuments of the classic period in mainland Southeast Asia (ca. 500-1500 CE) have been intensively studied for a century and a half. However, these architectural remains, impressive as they are, represent only a small fraction of the built environments of the period, in which almost all dwellings were made of non-durable materials such as thatch and wood that have long since degraded and disappeared. Nonetheless, traces of past human activity remain identifiable today in the form of microtopographic traces of features such as paths, roads, ponds, temple platforms and moats, occupation mounds, canals, field walls, quarries, kilns, and other features.

Since the 1990s, a centralised project of archaeological mapping involving numerous projects and researchers has been devoted to aggregating, cleaning and consolidating cartographic work from as early as the 1800s in a GIS environment, and also to extending the archaeological maps using new inputs such as lidar. Initial lidar coverages were on the order of tens of square kilometres, but we now routinely produce coverages of several thousand km2 in countries such as Laos and Cambodia, complemented by smaller acquisitions using UAV-mounted lidar systems. The consolidated mapping database consists of around 50,000 individual polygons over around 5000 km2 describing archaeological traces classified into around 20 different categories.

Methods

Our work related to automation has focused on three main areas:

Firstly, we have focused on creating the infrastructure necessary for creating pipelines for automation directly in geographic space, over multiple scales, in a robust and reproducible way – in particular, making our archive of vector annotations accessible for training and validation. This has involved translating the hand-drawn GIS polygons to annotations of point cloud data, and the creation of a web service that is able to deliver tiles of vector annotations at various scales that can be related, in geographic space, to geospatial imagery. We have also implemented a service that allows lidar point data, and derivative image products, to be delivered over the web as tiles across multiple scales of geographic space, including derivative lidar image products (visualisations) that can be generated on-the-fly according to user-defined parameters. The ensemble of services provides the basis for a collaborative testbed for automation that is accessible though web-based mapping interfaces.

Secondly, we have sought to leverage this infrastructure to reproduce and extend the various approaches that have been used to automatically identify archaeological traces in lidar imagery, in particular approaches revolving around deep learning and convolutional neural networks, which are these days relatively widespread in archaeology (Kocev et al. 2022). We provide an overview of the results of this work, in which we compare applications of different deep learning models to the Southeast Asian archaeological data, and evaluate the quality of the results. We discuss some of the benefits and drawbacks of these approaches in our specific context, given the scale, variability, and other characteristics of the archaeological traces we seek to identify.

Thirdly, we explore some of the potential of working directly with three-dimensional point cloud data (Richards-Rissetto, Newton, and Al Zadjali 2021), in an effort to attenuate some of the methodological and interpretive difficulties involved in using derivative image products and visualisations, which improve the human-readability of elevation data but which have various assumptions embedded in their production, and which may be poorly adapted to specific local geographic/archaeological circumstances. We assess the utility of different approaches to the problem of segmentation, classification and object detection in unstructured and unordered point datasets, including point-based methods (e.g. PointNet ++), multi-view methods that map point clouds into 2D space to perform pixel-wise labelling, and volumetric/voxel-based approaches.

Conclusion

As a result of this work we have arrived at a series of insights and solutions related to working with a diversity of cultural traces that manifest at different scales and orientations in different geographical contexts, from flooded lowland plains to mountainous terrain with significant background topographic relief. Efforts to create robust and reproducible workflows within dedicated spatial data infrastructure will allow us to scale up this work across the Southeast Asian region, as new lidar data comes online. Overall, our work strongly affirms the potential of automated approaches to identifying archaeological traces in lidar data acquired in Southeast Asia, which offers us a path towards rapid documentation and effective preservation of heritage landscapes currently under threat from urbanisation, deforestation, and agricultural extensification.

Citations

Evans, Damian. 2016. 'Airborne Laser Scanning as a Method for Exploring Long-Term Socio-Ecological Dynamics in Cambodia'. Journal of Archaeological Science 74 (October): 164–75. https://doi.org/10.1016/j.jas.2016.05.009.

Kocev, Dragi, Nikola Simidjievski, Ana Kostovska, Ivica Dimitrovski, and Ziga Kokalj, eds. 2022. Discover the Mysteries of the Maya: Selected Contributions from the Machine Learning Challenge & the Discovery Challenge Workshop, ECML PKDD 2021. Ljubljana, Slovenia: Jožef Stefan Institute. https://arxiv.org/ftp/arxiv/papers/2208/2208.03163.pdf.

Richards-Rissetto, H., D. Newton, and A. Al Zadjali. 2021. 'A 3D Point Cloud Deep Learning Approach Using LIDAR to Identify Ancient Maya Archaeological Sites'. ISPRS Annals of the Photogrammetry, Remote Sensing and Spatial Information Sciences VIII-M-1–2021 (August): 133–39. https://doi.org/10.5194/isprs-annals-VIII-M-1-2021-133-2021.

68. Automated Archaeological Feature Detection Using Artificial Intelligence on UAV Imagery: Preliminary Results

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Introduction

Archaeological remains can be found either on top of the surface or hidden below the ground. As stated in their article Orengo H.A. and Garcia-Molsosa A. (2019) the analysis of the dispersion of surface remains, provide to researcher's information related to changes of the landscape use or the destruction or disappearance of sites. Over the last decade, we have seen an evolution in analytical tools, including the use of techniques such as machine learning (ML) combined with geometric morphometry and, more recently, computer vision techniques with artificial intelligence (AI) through deep learning (DL) as referred by Domínguez-Rodrigo et al in 2020 for supporting archaeological research.

Nevertheless, traditional pattern recognition methods (i.e., through photointerpretation) may have limited applicability for archaeological research for covering large areas or looking into an extensive archival dataset. A significant factor that affects the success of surface research is the methodology itself that is followed during the research, which may not be sufficient or less reliable. Therefore, there is a difficulty regarding the correct evaluation of the results and the validity in their interpretation to consider the research objectives successful. Jamil et al. in recent research (2022) refer that in archaeology field, most of the ML and DL algorithm are used for classification and identification of artifacts, nevertheless the detection of archaeological structure using DL algorithm especially using aerial imaging the results are still insufficient.

Thus, conclude that surface survey is a relatively straightforward survey method but at the same time its success and correctness is multifactorial. To improve both the design of the survey itself and the results themselves, we may integrate other complementary methods into the surface survey, such as earth observation methods, remote sensing, artificial intelligence etc. Consequently, by combining all these methods together we will be able to come closer to locating archaeological remains, information, and try to understand how the environment in the past affected the oldest populations and their interaction with the landscape.

The aim of our study is to investigate whether automated archaeological feature detection using Artificial Intelligence on UAV imagery could be developed and furthermore answer research questions for a more efficient approach in terms of time and accuracy compared also to traditional fieldwalking archaeological surveys.

Methods and materials

In this study different Artificial Intelligence (AI) image processing methods were implemented. The workflow included drone-based image acquisitions, using (a) the DJI P4 Multispectral system with the following spectral bands: Blue (B): 450 nm ± 16 nm; Green (G): 560 nm ± 16 nm; Red ®: 650 nm ± 16 nm; Red edge (RE): 730 nm ± 16 nm and Near-infrared (NIR): 840 nm ± 26 nm and (b) using DJI Phantom 4 Pro system with the following spectral bands: Blue (B): 468 nm ± 47 nm; Green (G): 532 nm ± 58 nm; Red ®: 594 nm ± 32.5 nm. Flight height was set to approximately 20m above ground level (AGL), providing orthophotos with a spatial resolution of a few centimeters, and sufficient to clearly identify ceramics over the study area.

Next process included standard photogrammetric processing to combine all these photographs into a single orthophoto-mosaic. Finally, two steps included computational processing (AI techniques) and geospatial analyses (GIS software) as illustrated in figure 1 below.

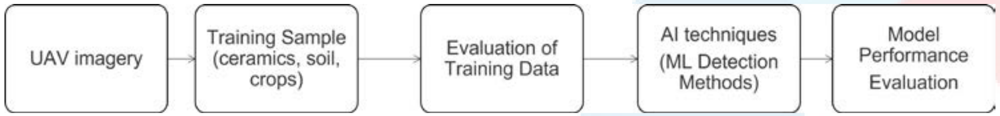

Figure 1: Framework of the processing steps using UAV images beyond the visible part of the spectrum.

Results

Various AI techniques like machine learning algorithms (Random Forest classifiers) have been implemented and compared along with the results from foot surveys. Overall accuracy and relative accuracy were estimated. First steps of computational processing included RGB images in which supervised classification like Random Forest in was applied using the Snap software. The results show significant correct prediction (more than 85% overall accuracy). Other algorithms were also tested, like Maximum Likelihood Classifier with also quite significant results of correct predictions. The overall results were compared with the in-situ survey records showing that automatic AI methods using UAV high resolution imagery can be used as a first proxy indicator for the detection of surface archaeological ceramics (figure 2).

Despite the above results the classification resulted many soil pixels as ceramic fragments. To remove false cases of ceramics, morphologic filters were developed in GIS environment, that eliminated isolated high-value pixels without affecting large groups of these belonging to sherds. Same algorithms are in process of testing using multispectral images and the results will be evaluated and compared with those from the RGB images.

Discussion

Generally, results and accuracy can vary, depending on variety of factors like the type of soil, the conditions of the plot, the period of flight, the visibility and quantity of the material culture but also the number and experience of the inspectors. Further improvements are expected such us more sophisticated remote sensing algorithms will be tested, even larger areas will be tested to cover with a higher success rate, improve classification, using techniques to clean up random noise, improvements including filtering, smoothing class boundaries, and removing small, isolated regions.

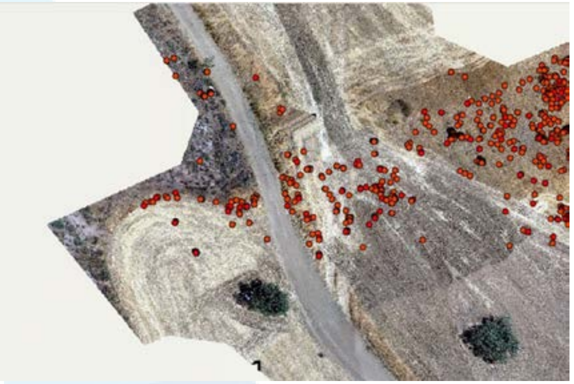

Figure 2: The classification resulting from the process identifying ceramic fragments

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References

Agapiou A., Vionis A. and Papantoniou G. (2021). Detection of Archaeological Surface Ceramics Using Deep Learning Image-Based Methods and Very High-Resolution UAV Imageries. https://doi.org/10.3390/land10121365 Land 2021, 10,1365.

Czajlik, Z., Črešnar, M., Doneus, M., Fera, M, Kramberger, A.H.,Mele, M. Researching archaeological landscapes across borders Strategies, methods and decisions for the 21st century Graz – Budapest 2019. [https://www.academia.edu/40373820]

Jamil A. H., Yakub F., Azizan A., Roslan S. A., Zaki S. A., Ahmad S. A. (2022). A Review on Deep Learning Application for Detection of Archaeological Structures. Journal of Advanced Research in Applied Sciences and Engineering Technology 26, Issue 1, 7-14

Manuel Domínguez-Rodrigo M., Gabriel Cifuentes-Alcobendas, G., Jiménez-García, B., Abellán, N., Pizarro-Monzo, M., Organista, E., Baquedano, E. Artificial intelligence provides greater accuracy in the classification of modern and ancient bone surface modifications. Scientific Reports, 2020, 10, 18862. [https://doi.org/10.1038/s41598-020-75994-7]

Orengo H.A, Garcia-Molsosa A. (2019). A brave new world for archaeological survey: Automated machine learning based potsherd detection using high-resolution drone imagery. Journal of Archaeological Science 112, 105013

376. Machine learning for UAV-captured imagery: an outgrowth of XRchaeology 2019-2022

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Our collaborative XRchaeology works began in 2019 with the intent to overcome obstacles that arise from the inability to access museum and remote archaeological collections from various parts of the world, and the more specific aim to emphasize the contextual associations of systematically excavated objects residing in those collections using web-based VR technology. In 2021, we expanded our work to incorporate a new AI assistant using natural language processing techniques known to the computer sciences and engineering to advance our understanding of in situ phenomena to promote creative inquiry on artifact collections under study. These combined techniques have become part of our standard information dissemination repertoire. This year, we began development of a neural network to help overcome site recording and accessibility issues we will will face during future site survey and recording operations. With this range of experience an our most recent advances, our successes and failures, it is our primary aim to contribute to the dialogue at this transformational moment in archaeology.

Recent advances in UAV-remote sensing technologies allowed us to begin collecting a range of data survey teams might encounter on the ground, in order to train an algorithm to detect objects and features in remote sensing data obtained by our UAV. While we expected the quality of data to improve dramatically using these superior techniques, we were also concerned about the feasibility of our proposed long-term research that relies on its success. With primary aims to collect high-quality data and reduce the time normally spent doing exploratory survey work in difficult terrain to permit more advanced studies in the short amount of time available, we also became aware of the technique's applicability in the context of improving the safety of our field crews who work at the margins of what has become a hotly contested quarry and mining zone. We also recognized the advantage of being able to collect high-resolution, accurate information in ways previously unimaginable which contributed greatly to the quality of this and other research data sets.

With the incorporation of: (1) combined 2D and 3D visual imagery of both artifacts and terrain for sharing virtual heritage (Diáz et al. 2015), (2) the automated object detecting algorithm for detecting material culture with UAVs (Orengo et al. 2021), and (3) the development of an AI assistant that helps us to explore refined nuances of our data using natural language processing (Liddy 2001), our ability to both study and share high-quality immersive information across international boundaries is greatly improved. The ability to weed out non-essential data and focus on the essential has proven to be another a key advantage. Like their in situ archaeological counterparts, our high-resolution spatial data and material culture have been rendered informative and experiential.

Yet with our new-found ability to detect, analyze, interpret and share, we find ourselves ever at the cross-roads of experimentation, trial and error. Although creative and thought provoking, we want for standardized methodologies to lend credibility, longevity and repeatability to our approach. With this paper and our shared insights, it is our aim to contribute to the dialogue on combining such approaches, helping to further integrate this innovative and trans-disciplinary community of digital archaeological practitioners.

References:

Gómez, Francisco Díaz, Josué Jiménez Peiró, Amparo Barreda Benavent, Bárbara Asensi Recuenco, and Juan Hervás Juan. "3D modeling for the generation of virtual heritage." Virtual Archaeology Review 6, no. 12 (2015): 29-37.

Liddy, Elizabeth D. "Natural language processing." (2001).

Orengo, Hector A., Arnau Garcia-Molsosa, Iban Berganzo-Besga, Juergen Landauer, Paloma Aliende, and Sergi Tres-Martínez. "New developments in drone-based automated surface survey: towards a functional and effective survey system." Archaeological Prospection 28, no. 4 (2021): 519-526.

351. Generalisation Capability of Semantic Segmentation Methods for the Identification of Archaeological Structures on Remote Sensing Data

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Machine Learning-based workflows are being progressively applied for the identification of hidden archaeological structures (buried under soil or covered by vegetation) on remote sensing imagery [1]. Automated detections will be increasingly necessary for archaeological research given the extraordinary amount of airborne and spaceborne data collected every year for any area of interest and the fact that more and more accurate imagery will be available in the next decades.

Although the development of object detection and semantic segmentation-based workflows offers already promising results [1,2,3], the current methods are usually tailored to the detection of specific categories of archaeological objects, located in definite geomorphological contexts (e.g., desert, forest, urban) [1,2,3] and their effectiveness is often evaluated either using customised semi-automatic measures or by applying a range of different evaluation procedures [1].

This paper presents the first study on the capability of a semantic segmentation deep neural network of identifying various categories of archaeological features placed in two different geomorphological contexts. The proposed methodology entails the comparison of the performance obtained by training the 'U-Net' network on two datasets containing different types of archaeological objects (ranging from prehistoric site to Maya settlements) located one in the Veluwe (Netherlands), which is predominantly covered by forests interspersed with agricultural fields and variously sized areas of habitation [2], and the other in Chactún (Campeche, Mexico), which is covered by tropical semi-deciduous forest [3]. Three training strategies were performed to assess the generalisation capability of the U-Net. First, the strategy of independently training and testing the U-Net on each of the two datasets was adopted to obtain an experimental baseline where no generalisation capability is tested. The second strategy consisted of training and testing the U-Net on one dataset and fine-tuning the trained network on the second dataset. A transfer learning approach was applied in this step to evaluate if the features learned by the first layers of the network were similar to the ones learned from the second dataset. The last approach was designed to test the full generalisation capability of the U-Net by using the pre-trained network on one dataset to directly identify archaeological sites located in the other dataset. As expected, the first strategy obtained the best results, followed by the second and third. Although less successful in terms of efficiency, the transfer learning between two archaeological datasets appears to offer promising perspectives for tackling the lack of labelled data and ensuring that pre-trained features capture the shapes and the textures of archaeological structures, which are different from those characterising other types of images (e.g., the ImageNet images).

The paper also introduces an image-enhanced method to increase the spatial resolution of ASI (Italian Space Agency) PRISMA hyperspectral data to make them suitable for identification of archaeological objects. Hyperspectral PRISMA images, while possessing rich spectral information and wide geographical and time coverage, lack spatial resolution and often contain camera-induced blurring degradation and noise, evident especially in some spectral bands. The approach here presented exploits two well-known properties of hyperspectral images: low-rank and non-local similarity of image patches (i.e., small image parts). The image fusion process is enabled by the exploitation of available co-registered panchromatic data that facilitate a priori knowledge imposed on the underlying sharp image. An object detection method is used to test the effectiveness of the super-resolution approach in improving the identification of archaeological sites through the comparison of the results obtained on the not super-resolved PRISMA images with the ones obtained on the super-resolved images. The experimental results show the effectiveness of super-resolved remote sensing images in reducing the number of false negatives enabling the discovery of new archaeological sites.

This work underlines the importance of developing novel machine learning methods that can satisfy as much as possible the generalisation property that will enable the effective re-use of pre-trained networks on multiple geographic locations. It will save the time and resources needed to label a dataset for each geographical area of interest. At the same time, this presentation will highlight the fundamental roles played by archaeologists in providing domain knowledge to the machine that can produce reliable results only if it is fed by high-quality data that are representative of objects of interest, and the necessity of interaction between archaeologists and machine learning researchers to obtain satisfactory results across both the disciplines, crucial for the development of the next generation automatic methods for the identification of undiscovered archaeological structures.

Acknowledgements

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References

[1] Fiorucci, Marco, Wouter B. Verschoof-van der Vaart, Paolo Soleni, Bertrand Le Saux, and Arianna Traviglia. 2022. “Deep Learning for Archaeological Object Detection on LiDAR: New Evaluation Measures and Insights” Remote Sensing 14, no. 7: 1694.

[2] Verschoof-van der Vaart, W., Lambers, K., Bourgeois, Q. Quentin, P.J. 2020. Integrating Remote Sensing, Machine Learning, and Citizen Science in Dutch Archaeological Prospection. ISPRS International Journal of Geo-Information, 9, 293.

[3] Somrak, Maja, Sašo Džeroski, and Žiga Kokalj. 2020. “Learning to Classify Structures in ALS-Derived Visualizations of Ancient Maya Settlements with CNN” Remote Sensing 12, no. 14: 2215.

155. Building a toolkit for ML-integrated archaeological workflows: the contribution of human-centred approaches

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Introduction

What does success or failure look like when using machine learning (ML) in archaeology? In the technical literature, the success of ML methods are typically assessed through metrics such as accuracy scores; but this represents only one part of the picture when ML is applied in practice within a workflow to accomplish a task. A human-centred approach to archaeological ML development presents a definition of success which can be measured through better effectiveness and acceptability of developed tools, reduced error, higher ethical standards, and more sustainable systems with better longevity (Benyon 2018).

To utilise these new measures of success requires ML tools to be tested by potential future users. Research is just starting to design workflow components specific to the needs of the end user, such as model output evaluation measures designed specifically for archaeological use cases (Fiorucci et al. 2022). However, methods to help bridge the gap between model development research and the application of ML in professional practice remain largely missing. This paper brings together analysis of key parts of archaeological topographic survey practice and research on how users interact with ML to propose a set of features essential to the design of successful ML-integrated topographic survey toolkits and workflows for archaeology.

Methods

Building on work presented at CAA 2022, this paper will present an in-depth qualitative analysis of the testing of a prototype user interface for ML-augmented archaeological survey and prospection. Prototyping software user interfaces is a key part of workflow design because it focuses on what people want to achieve using technological tools, rather than focusing on what the technology can do (Benyon

2018). A low fidelity prototype interface was designed based on interviews with professional archaeological surveyors working in heritage management. The design was also informed by a rapid review of existing ML-powered tools. The prototype was tested in two online workshops with aerial archaeology specialists. The resulting data was analysed using qualitative coding to produce insights grounded in stakeholder feedback.

Results

Key findings of the prototype testing show that trust, accountability, and the provenance of outputs are significant issues for the integration of ML tools into professional practice. For example, an essential requirement for heritage management applications of ML is an audit trail which documents all stages of analysis and interpretation. The prototype testing also presents GIS as a key site of focus for the development of ML-augmented archaeological topographic survey practice. This is in contrast to research which situates automated workflows outside of GIS in notebooks or other code development locations.

Discussion and Conclusions

The implications of these results are that human-centred research is beginning to build a set of features essential to the design of successful ML-integrated topographic survey toolkits and workflows for archaeology.

To develop these resources, insights from the prototype testing will be mapped against an a framework for human-centred ML system design which is based on a synthesis of 30 published guidelines from across communities who research human-centred and social computing (human-computer interaction and computer-supported cooperative work) as well as technological implementation and deployment in real-world scenarios (MLOps). These guidelines are applicable to the archaeological use case because they consider applied ML from a domain-agnostic standpoint.

The ML systems design framework can be used as a basis to produce joined-up understandings of the challenges related to ML tool design, which will help the archaeological ML community make progress by providing practical steps on how to approach solving common problems in human-centred ML. A shared understanding of the challenges of developing ML tools from across disciplines and applications will help to define what problems have common solutions, and what problems are specific to archaeological or wider cultural heritage use cases.

Work-in-progress on future elements of the development of this toolkit will be presented, specifically the development of an open source catalogue of models and datasets as a trust- and accountability-building resource for the archaeological ML community and stakeholders.

References

Benyon, David. 2018. Designing User Experience: A Guide to Hci, Ux and Interaction Design. Harlow, United Kingdom: Pearson Education, Limited. http://ebookcentral.proquest.com/lib/gla/detail.action?docID=5632313.

Fiorucci, Marco, Wouter B. Verschoof-van der Vaart, Paolo Soleni, Bertrand Le Saux, and Arianna Traviglia. 2022. 'Deep Learning for Archaeological Object Detection on LiDAR: New Evaluation Measures and Insights'. Remote Sensing 14 (7): 1694. https://doi.org/10.3390/rs14071694.

17. AI-on-Demand (AIOD) platform and its uses for cultural heritage

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Theme: Education of ML in archaeology

Archaeologists' interest in artificial intelligence (AI) and its subfield of machine learning (ML) is growing exponentially, e.g., (Bickler 2021; Fiorucci et al. 2020; 2022). We agree with the session authors that as archaeologists using ML we need to move beyond isolated case studies and explore how best to combine our efforts. We also share the ultimate goal of building an integrated community of practitioners. This session offers a bottom-up approach to community building, which is almost always the best approach. However, the top-down approach also has its benefits, for example, in providing infrastructure and other resources. We are convinced that the best results are achieved when the bottom-up and top-down approaches can be combined.

One such top-down approach to building an AI community in Europe is the AI-on-Demand (AIOD) platform (https://www.ai4europe.eu). It has been under development since 2019 and has just started a new development cycle under the AI4Europe project (Horizon Europe CORDIS ID 101070000; https://www.ai4europe.eu.), whose mission is to further drive the technical development of the platform and build a supportive community to add value to the AI research community.

The AIOD is intended to serve as a resource to promote European research and innovation in AI. The objective of the platform is to support all solutions and tools that contribute to the ecosystem of excellence and the ecosystem of trust. It will mature to add AI assets and tools that can be used by the wider community to upskill and share knowledge with innovation sectors. It will provide new services and a marketplace for non-experts to experiment with and use AI solutions in their own work.

The AIOD platform is a community resource and its success depends on the active engagement of end users. The platform is therefore open to any individual or organisation interested in technically developing aspects of the platform, leading or contributing to various components, sharing research outputs or simply sharing news updates or information about upcoming events. There are many opportunities to contribute and help shape the direction and features of the AIOD platform in the years to come.

Cultural heritage, and by extension archaeology, was envisaged from the outset as one of the eleven 'industrial verticals' (user domains) of AIOD. However, this is the first time that it has been included as one of the "model verticals" (case studies). The goal of the cultural heritage model vertical is to showcase success stories and how content can be presented most effectively. In addition, we want to identify the needs of cultural heritage in general and archaeology in particular, to identify where new research can be applied, and to help AI researchers to understand the specific challenges of archaeological applications. Ultimately, the aim is to build and foster a cultural heritage community within the AIOD platform.

In the first part of our presentation, we will introduce the AIOD platform and the plans for its development over the next four years. In the second part of the presentation we will focus on the services most suited to archaeology and how they can be used by archaeologists. The key goal of our presentation is to support the aim of the authors of this session, which is to continue building an integrated community of practitioners.

Bickler, Simon H. 2021. 'Machine Learning Arrives in Archaeology'. Advances in Archaeological Practice 9 (2): 186–91. https://doi.org/10.1017/aap.2021.6.

Fiorucci, Marco, Marina Khoroshiltseva, Massimiliano Pontil, Arianna Traviglia, Alessio Del Bue, and Stuart James. 2020. 'Machine Learning for Cultural Heritage: A Survey'. Pattern Recognition Letters. http://dx.doi.org/10.1016/j.patrec.2020.02.017.

Fiorucci, Marco, Wouter B. Verschoof-van der Vaart, Paolo Soleni, Bertrand Le Saux, and Arianna Traviglia. 2022. 'Deep Learning for Archaeological Object Detection on LiDAR: New Evaluation Measures and Insights'. Remote Sensing 14 (7): 1694. https://doi.org/10.3390/rs14071694.

160. Creating an additional class layer with machine learning to counter overfitting in an unbalanced ancient coin dataset

Gampe, Sebastian
Tolle, Karsten

Machine Learning (ML) applied to ancient coin data brings different challenges. We have discussed some of them already at our talk at CAA 2022 in Oxford. In this paper we want to focus on the problem of dealing with an extremely unbalanced dataset for training a convolutional neural network (CNN) and the progress we have made since then.

One aim of our current project Data quality for Numismatics based on Natural language processing and Neural Networks (D4N4) is to train and improve a supervised CNN in order to recognize types and/or mints for the "Corpus Nummorum" (CN) dataset. This dataset features about 19,000 different coin types and more than 40,000 coin images from four different ancient landscapes ("Thrace", "Moesia Inferior", "Troas" and "Mysia"). One of our main problems is the coin per type ratio which is approximately two coins per type. Our previous tests have shown that a CNN based model cannot learn a type properly without a threshold of about twenty coins. By applying this threshold less than 200 types remain for training (Gampe 2021) (Gampe and Tolle 2019). So, we established another recognition model based on the coins' mints. Every mint class includes all corresponding coin types which increases our training set by a large number of coins (about 5,700 for the coin types and about 37,000 for the mints). This way we cover 94 of our 120 mints in the dataset.

Although we have achieved good results with the mint approach (78% Top-1 Accuracy) new problems have emerged. Some of our mint classes are too dominant due to a high amount of coin images in the dataset. Mints like "Pergamon" and "Perinthos" come with about 3,000 images while other mint classes just passed the 20 picture threshold. Hence, we discovered an overfitting in the model's results. So our idea was to split these "big" classes into an additional class layer without reducing the number of training images in the dataset. The goal is to create a dataset with a better balance between the classes. In addition, these new classes might be potentially interesting for the domain experts as well. Currently, we work on three approaches for generating the additional class layer:

- The first method is the use of the unsupervised "Deep Clustering" (DC) method (Caron et al. 2019) for the distribution of images to smaller classes of the same mint. DC incorporates a k-means approach which creates pseudo-labels for a CNN. It also needs a predetermined number of clusters which has to be found in several experiments. However, a manual filtering for clusters with images that are as homogeneous as possible will still be necessary.

- Our Natural Language Processing (NLP) method can find entities like “head” or “Apollo” in a coin’s design. A grouping of with the help of the combination of obverse and reverse entities and their number can produce an additional class layer based on the similarity of types. The results of this grouping have to be filtered by hand.

- The third approach is an object detection model which was trained to detect frequently occurring subjects like “head” or “owl” on both sides of a coin. As with the NLP approach, we want to find frequently occurring combinations of subjects which will form our additional class layer.

After the creation of these new classes with the different methods we will run the mint training again in order to check if the overfitting problem has decreased.

Creating the additional class layer provides another opportunity for the CN coin typology: Currently, the types are defined by the domain experts on a very granular level, based normally with good preserved coins. As one can see by the number of over 19.000 types. Introducing an additional, less granular level on top, can help to assign coins of less good preservation. This means beside the performance of the trained CNN, the usability to serve as a second less granular communication layer is a second goal we want to discuss with the domain experts and currently also thinking of ways to evaluate the usefulness of this goal.

Summary:

- We want to present the progress we made since CAA2022 in creating an additional class layer for mint classes which cause overfitting.

- We use three different approaches: unsupervised Deep Clustering, natural language processing and object detection.

- We think of two possible benefits with our approach: 1. Reducing overfitting for classes with many images and thus increasing our accuracy metrics for the mint recognition. 2. Doing a first step into establishing a parent-typology for the fine-granular coin typology with our numismatists.

References:

Caron, Mathilde, Piotr Bojanowski, Armand Joulin, and Matthijs Douze. 2019. “Deep Clustering for Unsupervised Learning of Visual Features.” ArXiv:1807.05520 [Cs], March. http://arxiv.org/abs/1807.05520.

Gampe, Sebastian. 2021. “Neuronale Netze zur Bestimmung römischer Kaiser auf Bildern antiker Münzen.” Master thesis, Goethe-Universität Frankfurt am Main.

Gampe, Sebastian, Karsten Tolle. 2019. “Combination of machine learning methods of image and natural language recognition on ancient coin data.” Check Object Integrity. Proceedings of the 47th Conference on Computer Applications and Quantitative Methods in Archaeology (not yet published).

08. Where do you draw your lines? Mapping transformation of archaeological practice in the digital age

Nicolò Dell'Unto, Lund University
James Stuart Taylor, University of York

Location: E108

Archaeology has always had a close relationship with emerging digital technologies, and the last ten years have seen a dramatic uptick in the application of these technologies across the discipline ('The Digital Turn?'). From the refinement of database management systems, ontologies, and the principles that guide them (F.A.I.R.), to experimentation with computational approaches like Network Analysis and Agent Based Modelling, to the almost universal adoption of spatial technologies and the current golden age of 3D data acquisition and VR. From our perspective, the impact upon our fieldwork has been profound. The question of where you draw your lines has a literal gravitas these days (on paper, in a GIS, in your simulation, or straight into your 3D environment?). But what about the discipline more broadly? We have recently argued that digital practice that consumes emergent technologies often emulates an analogue counterpart as a skeuomorph of practice, as part of a process of testing the affordances and limitations of new technologies. In doing so, these technologies are socialised as we become comfortable with them, so that we can ultimately use them to transform our practice (Taylor & Dell'Unto 2021). Increasingly these transformations may be more fluid, with archaeologists potentially shifting their practice from analogue to digital, digital to digital, and even digital to analogue. In this session, we would like to explore these transformations, no matter how great or small; where do you draw the line? [~your lines?]. How has your archaeological practice been affected by new and emergent technologies? In the field? In the lab? In the museum? And across the years? We invite you to literally map or diagram these transformations, reflect upon them in the example of your own practice and together, perhaps we will explore emerging digital trends and future disciplinary directions. Session Structure This will be a standard session focused upon a series of 20-minute papers in which we literally encourage you to 'map', 'chart' or visualise your transformative practice. We encourage collaborative papers that include or foreground the work of junior researchers. The last part of the session will be set aside for a round table discussion of some of the themes that emerge throughout the day.

References:

Taylor, J., & Dell'Unto, N. (2021). Skeuomorphism in digital archaeological practice: A barrier to progress, or a vital cog in the wheels of change? Open Archaeology, 7(1), 482-498. https://doi.org/10.1515/opar-2020-0145

SLOT 1	
09:10 - 09:30	333. Current approaches to computational archaeology at GIAP-ICAC *Hector A. Orengo (Landscape Archaeology Research Group, Catalan Institute of Classical Archaeology)**
09:30 - 09:50	110. With great power comes great responsibility: rethinking the role of new technologies in the archaeological recording workflow *Bet Mallofré López (LAM-UB); Sabina Batlle Baró (Universitat de Barcelona)**
09:50 - 10:10	307. The transformation of an archaeological community and its resulting representations in the context of the co-developpement of open Archaeological Information Systems *Eric Lacombe (MICA - Bordeaux-Montaigne University)*; Dominik A Lukas (University of Chicago)*
10:10 - 10:30	151. Body Mapping the Digital: visually representing the impact of technology on archaeological practice *Leila Araar (The University of York)*; Colleen Morgan (GB); Louise Fowler (MOLA)*
SLOT 2	
11:00 - 11:20	173. Aligning procedures to map archaeological practice: the Tradition in Transition methodology *Loes Opgenhaffen (Saxion University)**
11:20 - 11:40	142. Cultural significance assessment of archaeological sites for Heritage Management in the Digital Age: from text to spatial networks of meanings *Yael Alef (Israel Antiquities Authority)**

11:40 - 12:00	234. Mapping transformation of archaeological practice through digital data curation by using the Archaeological Interactive Report (AIR) *Paola Derudas (Lund University)*; Federico Nurra (Institut national d'histoire de l'art (INHA))*
12:00 - 12:20	246. The gap in the line - digital impact on fieldwork practices *Åsa Berggren (Lund University)**
12:20 - 12:40	225. Using In-Person and Remote Methods of Co-Design to Build Research-Oriented VR Programs. *Cole Juckette (University of Glasgow)**
12:40 - 13:00	361. Re-thinking Our Digital Archaeological Practice through 3D Data-driven Analysis and Interpretative Visualization: Lessons Learned at Çatalhöyük and Palenque *Nicola Lercari (Institute for Digital Cultural Heritage Studies - LMU Munich)*; Arianna Campiani (Dipartimento di Scienze dell'Antichità - Sapienza University of Rome)*
SLOT 3	
14:00 - 14:20	84. Mapping the impacts of photogrammetry on workflow and dataflow in archaeological excavation *Eric E Poehler (University of Massachusetts Amherst)**
14:20 - 14:40	170. Landscape Heterogeneity at the Acheulean Site of Rodafnidia (Lesbos, NE Aegean): Connecting sites and continental models through intermediary scales *Patrick Cuthbertson (PADMAC Unit, Oxford)*; Peny Tsakanikou (Department of History and Archaeology, University of Crete); Simon Kübler (Ludwig Maximilians University Dept of Earth and Environmental Sciences, Munich); Nena Galanidou (Department of History and Archaeology, University of Crete)*
14:40 - 15:00	247. 1-Draw And 3-Dimensions: A Methodological Proposal For The Recovery Of Archaeological Finds *Veronica Venco (University of Sassari)*; Elena Griggio (University of Padova)*
15:00 - 15:20	263. Complexity science as a way of thinking *Iza Romanowska (Aarhus Institute of Advanced Studies)**

333. Current approaches to computational archaeology at GIAP-ICAC

Hector A. Orengo, Landscape Archaeology Research Group, Catalan Institute of Classical Archaeology

Introduction

This paper will present current development strategies, theoretical approaches, and practical workflows currently in use at the Landscape Archaeology Research Group, Catalan Institute of Classical Archaeology.

Methods and materials

Development strategies will be explained as an evolving compromise between group development and the career development of the researchers within the group. These will showcase the strategies followed to keep the members' work integrated through collaborative work in complementary projects. These projects cover specific research areas within the main computational research lines promoted by the group leaders.

Theoretical approaches adopted by the group will be explained in relation to the group development strategies, the research lines promoted and the practical approaches adopted for each specific project.

Lastly, practical workflows will be explained in relation to specific research projects. The different toolboxes and workflows available to members of the group are combined, expanded and complemented in order to achieve the specific objectives of each project. Several specific workflows characteristic of our research group in areas such as landscape archaeology, archaeological survey, site detection and monitoring, machine learning and 3D object analysis will be showcased in certain detail.

The presentation will make extensive use of maps, flow diagrams and other charts as recommended by the session organisers to illustrate the current approaches to computational archaeology by the GIAP.

Conclusions

This paper will discuss the theoretical assumptions, practical approaches and the research environment that underpin and frame current approaches to computational archaeology at GIAP. As such it will be both subjective and explicit in geolocating current computational research within the frame of the current academic market, funding landscape, and emerging digital trends in archaeology and the humanities.

110. With great power comes great responsibility: rethinking the role of new technologies in the archaeological recording workflow

Bet Mallofré López, LAM-UB
Sabina Batlle Baró, Universitat de Barcelona

Our team, the archaeological section of the Medieval Art, History, Paleography and Archaeology research group (MAHPA) and part of the Laboratory of Medieval Archaeology of the University of Barcelona (LAM-UB), has been working on the field in the Tremp-Montsec area (an important part of the Orígens UNESCO Global Geopark in Lleida, Catalonia) for more than 25 years now (Alegría et al., 2019). Since some years ago, other sites from around Catalonia have been added, and we now have three undergoing intervention projects that include 13 archaeological sites with chronologies that range from the 7th to the 17th century, most of them located in the Catalan Pre-Pyrenees.

Since the early 2000 this team has been eager to implement and use emerging technologies. Our main motivations have been ameliorating data analysis and interpretation, fostering dissemination and public engagement, but also overcoming the challenges that our work implies: mountain sites that are difficult to access, lack of time and, especially, short funding. With these goals in mind, we have been using for some years 3D reconstruction tools, GIS, databases and 3D digital recording methods. These new techniques and methods, applied both to our field and laboratory work, have profoundly changed our workflow. The use of new tools to process and work with those data are also fostering the interpretation exercise and helping build archaeological and historical knowledge (Costa & Sancho, in press). However, their implementation by fits and starts, the lack of funding to provide proper training to our team (or to have a specialist on the matter), and the dramatic growth our site set has undergone in the last few years (from 2 active sites in 2014 to 11 excavation and 4 survey sites in 2022) left in result a slightly chaotic, Frankenstein-like flow that combines both digital and analogic processes, with a lack of standard procedures (differences in the recording and processing methodology amongst the different sites), high risk of miscommunication, and redundant data.

The field data is currently recorded mostly on paper (stratigraphic context information) or by digital means or tools (topographic data, graphic data). For some specific excavations, a database (running on a tablet) is updated on-site. The finds and artifacts are later studied in the Medieval Archaeology Laboratory (LAM-UB) and the data collected from their analysis is normally registered in internal simple databases or Excel files. In 2018, a new recording methodology was introduced to all site excavations within the project. Since then, all stratigraphic contexts are being recorded with georeferenced photogrammetry, creating 3D models that are the core of the documentation of those contexts that are now already destroyed. This new methodology is giving great results in terms of accuracy and efficiency, and is now opening a great deal of possibilities, even though it is now mostly used to produce 2D recording traditional results, such as archaeological planimetries and sections (Batlle et al., 2022). However, it also highlights the need to better document the digital data (which is more easily decontextualized) and to link it with all the related archaeological, landscape and historical data.

The new technologies implemented have been game-changing for our team, and the workflow described is giving us good results, as it allows us to work in a more efficient way and to record more and better data. However, we are aware it is not perfect: sometimes the data are not centralized nor interconnected, and, as they are processed, stored and managed by the site directors only, they end up in silos of information corresponding to each site. This hinders data integration and makes it difficult to analyze and understand the data in their completeness, which could prevent the main project goals from being properly reached. Currently, there are multiple and heterogeneous datasets created and managed within the project (which include field data from different sites, 3D models, artifacts' data, etc.) scattered across multiple locations, with or without proper backups and lacking an updated tracking or recording system. We are now facing a new problem: the management and preservation of a big (and growing) amount of data.

We know positively that digital tools, techniques, and methods, although they may have been one of the causes of our current problems, are also the answer. However, it is clearer than ever that with great power comes great responsibility; an inappropriate implementation or a misunderstanding of their potential can do more harm than good, and the need to train ourselves to be able to adapt to the current challenges, and those yet to come, is becoming a crucial matter.

In our presentation, we will describe and map our current workflow(s) exploring how this slow implementation of the emerging digital technologies has been shaping it during the past decade and reassessing it. We will also evaluate all the positive and negative aspects that the digitization of the archaeological recording methods have brought us, pondering over the experience accumulated during these years, trying to extract valuable lessons from our (both good and bad) experiences, and drawing some future improvement lines –either on paper or on digital tools.

References

Alegría, Walter; Sancho i Planas, Marta; Soler, Maria. (2019) "Mountain communities in the Catalan Pyrenees: 25 years of archaeological research". In: Brady, N.; Teune, C. (eds.) Settlement Change Across Medieval Europe Old Paradigms and New Vistas (Ruralia XII). Leiden: Sideston Press, pp. 81–90.

Costa, Xavier & Sancho, Marta [in press]. "La cartografía digital como herramienta dinámica e integrativa para el estudio del poblamiento medieval. La propuesta metodológica del proyecto Muntanya Viva". Cuadernos de Arqueología de la Universidad de Navarra.

Batlle, Sabina; Coso, Júlia & Vallverdú, Jordi (2022). "Fotogrametria aplicada al registre arqueològic d'època medieval. Avantatges i limitacions" [Conference presentation]. II Congrés Internacional IRCVM: Digitalitzar l'edat mitjana, Barcelona, Spain.

307. The transformation of an archaeological community and its resulting representations in the context of the co-developpement of open Archaeological Information Systems

Eric Lacombe, MICA - Bordeaux-Montaigne University
Dominik A Lukas, University of Chicago

The adoption of Archaeological Information Systems (AIS) evolves according to multiple factors, both human and technical, as well as endogenous and exogenous. These developpements can be induced by the introduction of new tools (e.g. DBMS, GIS at Çatalhöyük), they can be a consequence of generational change following the retirement of the initiators of the initial systems (e.g. Michel Py for Syslat, Dominique Joly for SysDA), or they can be imposed by technological breaks (e.g. non backward compatibility of Python 3 with Python 2 which requires a rewriting of the applications in the long term). In this context, an initial set of tables for recording reference data on an excavation might have gradually eveolved into complex management systems. In consequence the ever increasing scope of digital tools, which allow for the organization of information in order to understand the transformations of the site, at the same time transforms the organizations that generate or manage these data.

This relationship between the organization of information and the simultaneous transformation of the organization is obviously not restricted to archaeology or even to digital technology, but their coupling has its own specificities. First, archaeology has an ethical duty to preserve its archives, resulting from the obligation to render their primary records durable following the destruction of the sources during the act of excavation. Nevertheless archaeologists are open to experimentation, making use of what Christophe Tuffery in the most noble sense of the terms calls "braconnage" (i.e. poaching) and "bricolage". Yet, the obligation remains so that "[t]echnology must be tested [...] and challenged [...] through implementation and critiqued reflexively so that the epistemological framework of the project remains intact, albeit augmented, despite the new effects of the new technology on digital practice." (Taylor, Dell'Unto, 2021). In consequence, the transformations induced by digital methods are carriers of an antagonism of continuity and discontinuity, which leads to permanent reorganization. The pace of change imposed by the digitalization of the world and the obligation to uninterrupted usability of our systems, have led to the emergence of new concepts such as agility in development methods and the urbanization of information systems. The city metaphor inspiring the latter concept, reflects on an initially static and functional approach (by block, district, etc.) that is now dynamic and centered on flow management. In the same way, Web 2.0 (collaborative) and design (centered on and with the user) lead to open access to data (open data), to code (open source) and to make the design process accessible to the greatest number (low-code, no-code), as is the case with platforms like Heurist for example. In this spirit, archaeology seeks interoperability and reusability (e.g. FAIR principles, LOUD data), which in return, leads to the emergence of new organizations of information, as for example, the definition of criteria for interoperability (ministerial decrees in France), data models dedicated to data exchange (CIDOC CRM, Linked Art Data Model...), dissemination platforms (Nakala on HumaNum), the scripting of treatments in order to make these reproducible, or the sharing of terminologies.

In response to these issues, the SIAMOIS project, "Mutualized and Open Archaeological Information System based on Semantic Intelligence" aspires to master the relationship between the organization of information and the transformation of the organization as one of its main goals. Supported by the EPCC (i.e. Public Establishment for Cultural Cooperation) Bibracte, the project brings together approximately fifty actors in French archaeology who share in a common understanding of the need for evolution and interoperability of their dedictated AIS. Beyond the mere choice and sharing of the modules that constitute these systems, models used for the construction of archaeological representations are themselves based on a paradigm and an underlying logic. The representation of reality is moreover specific to the civilization studied, which makes it necessary to take different paradigms into account in order to further the interoperability of data and the sharing of tools. Therefore the objective of our research is to study the emergence of these paradigms in a collaborative context.

Our starting point is the construction of a representation of the organization of an archaeological community, in order to analyze the transformation of this community and especially the impact on the information produced. This representation will be enriched and updated throughout the lifetime of the project.

Methodologically we use a conceptualized analysis model, formalized in the T!O (Transformation, Information, Organization) framework, which is based on Stéphane Lupasco's logic of energy (Lacombe, 2021). Lupasco's approach to logic attempts to mitigate the principle of "Tertium non datur" in classical logic to extend the conventional binary logic. He identifies two contrasting movements of heterogenization and homogenization, and understands their conjunction as a source of dynamic equilibrium. In this approach the actualization of one state is simultaneous with the potentialization of the other. The conditions of these changes of state are hereby the object of particular attention. It is a matter of observing a phase transition, possibly in the order of a metamorphosis. What is at stake here, is the development of a new writing - the writing of code following that of the language and that of the number (Herrenschmidt, 2007). This phase transition, which could be qualified as post-skeuomorphic, is today carried by a new generation, born in an environment where the digital is omnipresent, and for which its use is more fluid.

The chosen methodology is based on elementary units of meaning, called information seeds, which are being treated by making use of a set of three tools to deal with the lexical, syntactic and semantic dimensions of the study. Opentheso, the first of these tools, is a multilingual and multi-hierarchical thesaurus manager, which allows for the definition and sharing of reference vocabularies, specific to each archaeologist. In bidirectional relation with Opentheso, as a second tool we used Stemic for the generation of organizational maps to link these vocabularies. These representations reflect different points of view, personal or shared, as well as their evolution. The third tool is a graph database (Neo4j) ingested with the different representations processed and analyzed using graph theory algorithms and allowing for the generation of new representations. These views are exploitable in return on the organizational maps and can be directly modified by the archaeologists involved. These tools have already been partially tested during a study on ceramics typologies (Durost et al., to be published).

Our paper will examine several phenomena to investigate the creation on the one hand and command, control and surveillance on the other hand - a double evolution that is brought about by digital technology and which is the signature of any organic development.

Durost, S. Reich, G., Girard, J.-P. (to be published). Terminologies, modèles de données archéologiques et thésaurus documentaires : réflexion à partir d'une typologie de céramique. https://hal.archives-ouvertes.fr/hal-03278684

Herrenschmidt, C. (2007). Les trois écritures. Langue, nombre, code. Gallimard, Paris.

Lacombe, E. (2021). Transformation numérique des organisations en réseau : les potentiels d'une schématisation dynamique de l'information, Sciences de l'information et de la communication, Université Michel de Montaigne - Bordeaux III. https://www.theses.fr/2021BOR30016

151. Body Mapping the Digital: visually representing the impact of technology on archaeological practice

Leila Araar, The University of York
Colleen Morgan, GB
Louise Fowler, MOLA

Recording during archaeological fieldwork has developed from diaries and notes during antiquarian excavations to more routinised pro forma, developed in part in the United Kingdom as a response to large, urban excavations. Digital systems have also been embedded within post-excavation processes for many years, and most finds and environmental recording work is now born digital. Recent years have seen the pace of the so-called 'digital turn' accelerate, as mobile computing has expedited the full digitalization of archaeological workflows. With the promise of accuracy, speed, and novel ways of viewing archaeology, the application of technological tools has often overshadowed meaningful critique of their implications. Digital recording has been introduced in archaeological fieldwork, and while there have been studies regarding their proposed utility in increased speed, fidelity, and even reflexivity (Berggren et al. 2015; Roosevelt et al. 2015; Taylor et al. 2018, among others), there has been little examination of the impact of digital recording in the commercial sector.

There are many questions raised by the mass adoption of digital archaeological recording techniques, including: Do digital recording strategies impact the interpretation of archaeological remains? Can digital recording be used to improve working conditions and enskilling of archaeologists? To gain insight into these particular problems and knowledge production in archaeology as a whole, this collaborative project will provide the background to understand digital workflows with particular attention to how digital recording impacts the enskilling of archaeologists, the non-alienation of archaeological labour, and the interpretation and dissemination of archaeological remains.

To achieve these aims we use a creative, art-based methodology to empower archaeologists to consider the changing relationships between mind, body and practice brought about by digital technologies. Art-based research (ABR) has gained increasing recognition within research communities as an approach that extends beyond the limitations of words in conveying the complexities of embodied experiences (Skop 2016). In recent years, body mapping has become an increasingly popular form of ABR that employs storytelling to illustrate social, political and economic processes. Body mapping involves the co-creation of life-sized drawings and narratives representing individuals' lived experiences, perceptions and meanings within their social context.

With data gathered during an initial series of focus groups, this paper will explore body mapping as a visual research method in understanding the lived experiences of archaeologists with respect to changes brought about by digital technology. While still ongoing, this research aims to encourage archaeologists to consider their evolving relationships with technology.

173. Aligning procedures to map archaeological practice: the Tradition in Transition methodology

Loes Opgenhaffen, Saxion University

The archeological technical tradition is a stage of transition. New technologies are implemented in a familiar way, its potential to change archaeological practice wholesale not yet fully deployed. This skeuomorphism of existing practice may actually be a means to "socialize" new technologies (Taylor and Dell'Unto 2021), to get all practitioners of a community to gradually embrace the technology. As in all traditions, an innovation is followed by a process of negotiation in order to be finally reproduced, albeit perhaps in a different way than archaeologists are used to. Notwithstanding the explanation of the processes of adoption and adaptation of technology into existing traditions, we are "all working in the same process" (Taylor and Dell'Unto 2021, 496). And to assess this stage of transformation of archaeological practice, a shared framework is required to map and analyze current practice, improving the comparison of such practices when they have been documented in a similar fashion.

The Tradition in Transition methodology provides such a guidance. It responds to recent calls for an introspective digital archaeology, with an awareness of the impact of the deployment of digital 3D technology on practice and inherent skills, the archaeologists' interaction with their tools and archaeological material in a given social environment, and subsequent knowledge construction. As technical tradition warrants knowledge production (Roux and Courty 2019, 6), only strong technical motives and prevalent social conditions determine the adoption or rejection of digital innovations in existing visualization strategies. This notion of ensured knowledge generation is demonstrated in the example of the automation of a particular process with 3D technology (replacing manual drawing practice and classification of pottery shapes), which did not automatically lead to new knowledge, despite the production of increased quantities of familiar-looking (digital) data (conventional 2D section drawings). The emulation of traditional practice with cutting-edge 3D technology did not convince the community to adopt the technique and transform practice altogether. This furthermore implies that the archaeological (visualization) tradition is in motion due to digital innovations, but did not change as the theoretical foundations are not yet decided by the community.

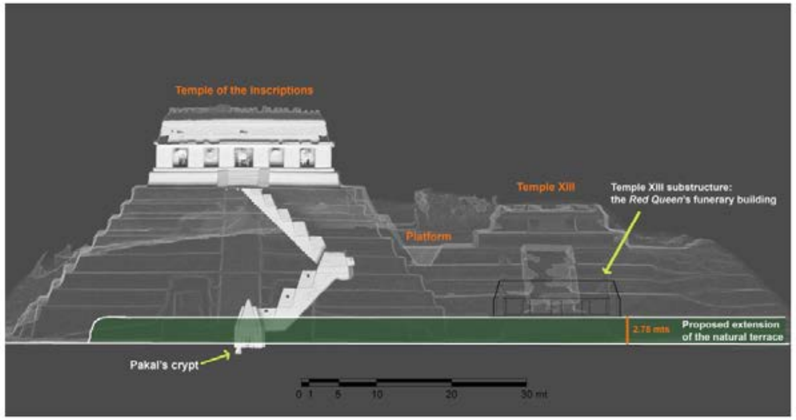

Fig. 1. Composite visualization of the northern façades of the Temple of the Inscriptions and surrounding buildings. The integration of 3D renders and digitized drawings highlights the natural terrace (green area) beneath the buildings. Temple XIII's inner chambers' elevation digitized from González Cruz 2011. 3D models and drawings by Campiani and Lercari.

Tradition in Transition has been developed to provide the theoretical underpinnings to guide the mapping, analysis and identification of current visualization and archiving practice, and functions as a framework to assess the proposed methods which constitute these practices. Tradition in Transition draws from profoundly archaeological theoretical approaches, rather than computationally-informed approaches, and combines praxeological theory derived from sociology, particularly the chaîne opératoire approach and the concept of communities of practice, with reflexivity, enabling the interrogation of the incremental creative steps within technological processes that occur within a social environment. The chaîne opératoire conceptualises archaeologists as making choices, a choice to adopt new technology and learn how to use it in order to enhance any given practice.

The framework provides diagrams to guide the mapping process of practice and to demonstrate visually and promptly the similarities and differences of archaeological operational sequences. As an example of its effectiveness, I have applied the framework to assess to what extent my own visualization practice has changed due to 3D technology, and how I transferred these new methods and skills to students (Opgenhaffen 2021). To further illustrate the importance of a shared methodology to map, compare and assess transforming practices, I will elaborate in this paper on this latter aspect of knowledge transfer in a collaborative working environment. The similarly produced diagrams and descriptive testimonies gathered from colleagues in the same consecutive approach, allow to assess to what extent teaching archaeological practice has been affected by digital 3D technology.

References

Opgenhaffen, L. 2021. "Tradition in Transition: Technology and Change in Archaeological Visualisation Practice." Open Archaeology 7 (1): 1685–1708. https://doi.org/10.1515/opar-2020-0218.

Roux, V., and M. A Courty. 2019. Ceramics and society: a technological approach to archaeological assemblages. New York: Springer.

Taylor, J.S., and N. Dell'Unto. 2021. "Skeuomorphism in Digital Archeological Practice: A Barrier to Progress, or a Vital Cog in the Wheels of Change?" Open Archaeology 7 (1): 482–98. https://doi.org/10.1515/opar-2020-0145.

142. Cultural significance assessment of archaeological sites for Heritage Management in the Digital Age: from text to spatial networks of meanings

Yael Alef, Israel Antiquities Authority

The shift in Archaeological Resource Management (ARM) to a value-based approach placed the cultural values of the sites at the heart of decisions about their future research, protection, and conservation. Accordingly, the question changed from "how important is the site?" to "which kind of values does the site represent, and where do they come from?". The problem is that until now, "…assessing significance has proven to be one of the most difficult chores facing the conservation archaeologist…" (Schiffer & Gumerman 1977, 240). It is context-dependent, reliant on expert assessment, overly complex, and time-consuming. Given that significance assessment is a central information category in the ARM inventory, it is only logical to ask how new technologies could support its generation and what is required to transform ARM inventories in this direction. The paper will explore new ways of representing cultural significance in ARM inventories through a case study that analyzed ancient synagogues in the Galilee.

In the past, significance assessment was written in inventories on paper site records. With the transition to digital systems, it was converted to a text field, and later on, the text was linked to geographical coordinates in GIS. In most ARM inventories today, cultural significance information still emulates the analog record with no relation to other resources and limited computational capabilities. Digital inventories still mainly function as lists of sites with better accessibility online. Nevertheless, heritage assets are currently being digitized rapidly, providing new opportunities to understand the cultural significance of these assets through semantic and spatial representations. Using Linked Open Data and especially the rise of AI abilities may provide even deeper insights from a single site record and large data sets. These new affordances may transform how we assess the significance and turn our inventory system into an effective value-based management tool (Carlisle et al., 2014) see Table 1.

	From		To	
ARM approach	Isolated monuments 'How important is the site?' Inventory as a list		Value-based, holistic management 'Which values the site represents?' Spatial networks of meanings	
Representation of Cultural Significance	Analog Textual content	Digital Textual content	Digital Textual content linked to coordinates	Digital Context: Related entities, linked open data
Inventory technology	Paper	Database	GIS	Semantic

Table 1. interrelationships between developments in ARM concepts and digital transformation and their effect on the representation of significance assessment.

The greater weight of values in ARM requires a change in the inventory knowledge model that will help understand and communicate them. While spatial and semantic tools already exist to some extent, the practice still lacks principles for informed use regarding cultural assessment information. Therefore, the study seeks to identify the relevant information characteristics to support and represent cultural significance assessment in an ARM inventory system. Consequently, the question is, what are the building blocks of the values of the sites, and how can they be implemented in a digital system?

The research analyzed texts of significance assessments of synagogues from the roman -byzantine period. The texts were composed according to accepted assessment formats in ARM and archaeological publications. Using qualitative methods, the study extracted and refined the information components of the values that could be represented digitally.

The prominent information characteristic found is the need to express the contexts as entities in the ARM inventory. The components of the contexts emerged from the 'context-effect' phenomenon. In other words, the meanings of the resources' context impart value to the resource, while the resources' meanings impart value to that context. For example, the community's values reflected in the village or town impart value to the synagogue's remains and vice versa.

This analysis suggests that the resource values are constructed from the components of the context. These include information on the structural-spatial contexts associated with the resource, i.e., artefacts, architecture, site, and area, and the thematic context, including its type, uses, narratives, and traditions, as well as historical evidence. For example, the Huqoq synagogue is a building in the Huqoq village adorned with a mosaic of Samson from the Bible, which can also be found in the nearby Vadi Hamam synagogue. Samson is associated with eschatological traditions that flourished around the Sea of Galilee. These relate to eschatological narratives rooted in the area associated with Jesus (see fig. 1).

Figure 1. The spatial and semantic relations graph in the Arches platform demonstrates the context components of the Huqoq synagogue. The colors represent the entities in the knowledge model based on CIDOC-CRM ontology.

Representing the contexts with spatial and semantic tools enhances the understanding of the site's cultural significance with its deep meanings. This representation creates a network of associations that becomes richer with every new entity added.

Representation of the context in the inventory system raises several issues. The site record in the inventory isolates the resource from its broad cultural context, e.g., its historical landscape and finds, which makes it more difficult to understand as a real and unique place with multifaced cultural and physical qualities. (Carman 2015). The spatial representation raises another issue regarding the definition of archaeological sites as heritage resources and their mapping. That is, how to move from a site-based approach to a holistic understanding of the remains as part of the entire historic environment.

The research on implementing these affordances, especially when combining these tools for significance assessment, is still in its infancy. The same goes for investigating AI assistance in extracting meanings from that information. To answer the question of what is required to transform ARM inventories, the research suggests that transformation towards new ways of generating significance assessment should begin with formulating the building blocks of the digital significance object. This transformation may eventually change how we assess significance and represent it. That is, focusing more on 'context' and relationships between places, objects, and people rather than the mere textual description of values as 'content' in books. Moreover, the focus on context may also change the policy regarding what we assess and which archaeological resources to include in the inventory.

References

Carlisle, Philip, Ioannis Avramides, Alison Dalgity, and David Myers. 2014. "The Arches Heritage Inventory and Management System: A Standards-Based Approach to the Management of Cultural Heritage Information." International Committee for Documentation of the International Council of Museums (CIDOC) Conference: Access and Understanding – Networking in the Digital Era.

Carman, John. 2015. "Inventory." In Archaeological Resource Management: An International Perspective, 79–104. Cambridge: Cambridge University Press. https://doi.org/10.1017/CBO9781139020473.

Schiffer, Michael B., and George J. Gumerman. 1977. "Assessing Significance." In Conservation Archaeology: A Guide for Cultural Resource Management Studies, edited by Michael B. Schiffer and George J. Gumerman, 239–47. New York: Academic Press.

234. Mapping transformation of archaeological practice through digital data curation by using the Archaeological Interactive Report (AIR)

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Introduction

In archaeological practice, data acquisition has become fully digital or digitally born (Campana, 2014; Dell'Unto & Landeschi, 2022; Dell'Unto, 2018) in order to record geometrical and spatial data by performing topographical, laser scanning, and photogrammetric acquisition and to produce documentation through digital devices used in the field, such as digital photo cameras, and tablets. Data collection and data publication in the form of reports and other types of editorializations represent two different phases within the archaeological practice and are usually performed using separate tools and software.

According to this issue, we believe it is necessary for archaeologists to develop a consistent workflow, keeping in mind the principles of archaeological digital curation proposed by Costis Dallas (Dallas, 2015).

Archaeological Digital data curation refers to the use of formal data representation and available technologies and implies the need to publish compilations (e.g., archaeological datasets) and explanations, maintaining the existing interdependence between data constitution and scholarly argumentation (Dallas, 2016: 16).

Our paper shows how using the Archaeological Interactive Report (AIR) to manage and publish archaeological data impacted and affected our current archaeological practice. AIR allows inserting the archaeological data in an online publication workflow from its capture and to follow it throughout its life cycle.

AIR is the final result of a Ph.D. research and of a fruitful collaboration between two institutions: Lund University and the French National Institute of Art History (INHA).

Methods and materials

AIR is a web platform for recording archaeological investigations in real-time or legacy data from previous investigations through entity templates (for contexts, artifacts, and 3D models, to list a few) that ease the recording process. AIR is an online archive that can incorporate the complete documentation dataset of the investigations: geographical data used to localize features and artifacts and their metadata registered through texts and tables, images and video, and 3D models. AIR is also a multimedia visualization system that embeds the 3D environment used for exploring data and performing basic analysis and multimedia assemblages for testing interpretation hypotheses. Furthermore, AIR is an editing platform where constructing and publishing archaeological reports and other editorialization forms, exploiting archaeological data previously archived.

During the last two years, AIR has been tested in several investigation projects; however, here we will present its use within two archaeological projects, the terrestrial excavation at Västra Vång and the maritime one at Gribshunden, where it was used as the main recording and management system.

Using AIR as a daily working tool produced changes in the archaeological practice in terrestrial and maritime excavations. The online availability and accessibility of 3D contents and linked metadata concerning contexts and artifacts at the end of the working day made it possible to engage in discussions, multivocal interpretation hypotheses, and to plan digging activities.

It also favored collaborations with colleagues and specialists from other disciplines not in the field through the same user-friendly interface.

Results and Discussion

Archaeologists at Västra Vång and Gribshundend needed to familiarize themselves with AIR, which implied a different approach to data recording without upsetting the archaeological practice standard methods; they were briefly trained in using AIR and implementing it. Such a task was facilitated by AIR characteristics, being it an online platform and archaeologists accustomed to using web browsers and online forms.

Excavators changed the recording tool, but the recording media and formats remained the same. In contrast, a relevant change affected the way of accessing the information: data is simultaneously accessed as soon as it is recorded and can be queried and interrogated. The way data can be used for reviewing the stratigraphical records and building interpretation also changed: the interpretation, which starts the moment we start excavating, can either be supported and reinforced or undermined and weakened by instant accessibility to the dataset. Data is not only reachable as a showcase on the website but retrievable by people not involved in the investigations as it is exposed semantically through standard ontologies such as CIDOC-CRM and standard formats such as json-LD.

In our study, we experimented with and tested new technologies; we got familiar with them during the archaeological practices. We challenged them and bent them to the needs of the stakeholders: archaeologists working in the field and in the lab (Taylor and Dell'Unto, 2021: 486).

By paying attention to the needs of the multiple stakeholders involved in archaeological research, we considered our investigation as an experimentation and sharing workshop to develop a scalable and adaptive tool over time.

By using this approach of continuous dialogue between archaeologists, and research and development engineers, we could also map how archaeological practice has evolved thanks to the provided tools, which evolved as well functionally to the archaeologists' needs.

Conclusions

Digital data management of archaeological excavations has proved to be successful in terms of data archiving, online publications, and sharing by exploiting multiple tools and platforms.

For this reason, archaeological data curation cannot be performed, as archaeological datasets are separated from scholarly argumentation and scientific publications (Dallas, 2016: 16). Furthermore, the multiplication of platforms hinders adherence to FAIR principles due to the lack of standards in languages and formats.

The tool described in this study allows deploying archaeologists and any researcher involved in the investigations a unique "sketchbook" where they can draw their own "lines" simultaneously.

Providing archaeologists with such new digital tools throughout the whole archaeological process allowed us to map the evolution of the archaeological practice and to achieve a new integrated approach to archaeological data curation.

References

Campana, S. 2014. "3D Modeling in Archaeology and Cultural Heritage–Theory and Best Practice." In 3D Surveying and Modeling in Archaeology and Cultural Heritage Theory and Best Practices, edited by S. Campana, and F. Remondino, 151–158. Oxford: BAR international series.

Dallas, C. 2015. "Curating Archaeological Knowledge in the Digital Continuum: From Practice to Infrastructure." Open Archaeology 1 (1), https://doi.org/10.1515/opar-2015-0011.

Costis Dallas. 2016. Jean-Claude Gardin on Archaeological Data, Representation and Knowledge: Implications for Digital Archaeology. Journal of Archaeological Method and Theory 23, 1 (March 2016), 305–330. https://doi.org/10.1007/s10816-015-9241-3

Dell'Unto, N., & Landeschi, G. (2022). Archaeological 3D GIS (1st ed.). Routledge. https://doi.org/10.4324/9781003034131

Dell'Unto, N. (2018). "3D Models and Knowledge Production." Included in: Archaeology and Archaeological Information in the Digital Society. Huvila, I. (ed.). Oxon: Routledge. pp. 54–69. (15 p.)

Derudas, P., Nurra, F., & Svensson, A. (forthcoming). "New AIR for the archaeological process: the use of 3D web semantic for publishing archaeological reports". Journal of Computing and Cultural Heritage JOCCH. ACM

Taylor, J., & Dell'Unto, N. (2021). Skeuomorphism in digital archaeological practice: A barrier to progress, or a vital cog in the wheels of change? Open Archaeology, 7(1), 482-498. https://doi.org/10.1515/opar-2020-0145

246. The gap in the line - digital impact on fieldwork practices

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The questions posed is "where do I draw my lines?" regarding the impact of digital methods on archaeological practice. I think it could be interesting to discuss the length of this "impact-line". It is my opinion that this line can be drawn longer today than previously, as the discussion of the digital impact has shifted from separate parts of archaeological investigations (documentation, point of discovery, analyses etc) to a more coherent and continuous line as awareness has grown of the digital impact, from the planning of an investigation to the archiving of the material, is profound during this whole process. Moreover, an awareness of how (digital) archiving will be implemented at the end of a project has to be a part of the initial research plan is also growing. Planning and handling the digital data have to be a part of the whole process.

However, the line would not be continuous, if we regard fieldwork as both documentation and excavation. There would be a gap in the line. There is no doubt archaeological documentation has been profoundly changed through the introduction of digital methods, and is still changing/developing at an ever increasing pace. But, how have excavation techniques and practices been impacted and changed by digital methods? If at all? (Here I do not mean digital excavation techniques per se, e.g. excavation performed by digital tools or robots, which some may see coming in the future, but rather how the shift to digital documentation techniques has impacted the way we excavate.) Compared to explicit shifts of archaeological fieldwork methods, such as the introduction of single context recording that was accompanied by a certain excavation method in the 1970s, or the even earlier introductions of open area excavation, box-grid excavations or excavation by sections, that all were driven by a preference to document the remains in a certain way, the digital documentation methods seem to have had very little impact on the way we excavate. In fact, most still excavate according to a single context method, or an open area method in combination with sections of features.

We expect digital methods to impact archaeological interpretation processes and we try to understand how this effects archaeological knowledge. There are several aspects of interpretation that are effected, among them the possibility to engage with digital documentation in 3D. It changes how we can visualise, analyse and understand the material, in comparison to 2D documentation. In fact, the 3D documentation may be regarded as mimicking the actual remains, and the actual excavation situation. We do excavate material in three dimensions and perhaps it can be said that archaeological documentation now is in line with this. Is this one reason why excavation practice have changes so little while documentation methods have changed so greatly, i.e. that the documentation has caught up with excavation? There are suggestions to this effect (Mickleburgh et al 2021).

In this paper I would like to outline the relation between archaeological fieldwork practices, i.e. both excavation and documentation, the impact of digital methods and how the presence or lack of impact may influence the interpretation process.

Reference:

Mickleburgh, H., Nilsson Stutz, L. & Fokkens, H. 2021. Virtual Archaeology of Death and Burial: A Procedure for Integrating 3D Visualization and Analysis in Archaeothanatology, Open Archaeology 2021; 7: 540–555

225. Using In-Person and Remote Methods of Co-Design to Build Research-Oriented VR Programs.

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Background

The use of Virtual Reality in Archaeology has evolved through multiple eras of archaeological methods design, from its early use in "virtual archaeology" through the embodied intentions of "cyber archaeology" (Forte 2016, 277-285; Reilly 133-135, 1991). Now VR is more popular and accessible than ever with the advent of consumer grade head mounted systems that have normalized the use of VR as a medium in fields including psychology, education, and history. While it is an established technology in archaeology, its applications are primarily in the creation of archaeological "products", finished interpretations that need to be transmitted. Consequently, to date, the impact of VR on archaeology is overwhelmingly through projects that use VR to translate their findings to an audience, in other words projects and designs that are "public facing". Many VR supported projects use the technology in presenting their analysis of the data to show the public a slice of the past or an experience of the past according to "experts". What is lacking is an understanding of ways archaeologists themselves might use VR to explore their own data and assist or alter how they arrive at interpretations. This paper explores ways VR can be used to interpret archaeological data by identifying the specific characteristics or potential uses which position it well to change how we interact with that data. In doing so, it asks: How should it look and function? What does it need, to be useful for experts and practitioners with years of experience conducting archaeology in well evaluated ways? How can a program be designed to address the various needs present in diverse situations?

Methods

This paper introduces two case studies developed in collaboration with projects in Italy, where the teams are excavating sites with materials dating from the Iron Age to the 4th century AD and early medieval period. Both have strong potential for incorporating VR into their workflows because of their adoption of digital recording methods. The projects represent very different contexts, require the representation of different levels of uncertainty, and are largely dissimilar in size and thematic areas of interest. To determine what design elements were crucial to developing a new VR program between such diverse projects, I used participatory design methods to assess the needs of the different teams as collectives. Activities were carried out in the form of in person and Minecraft based workshops and prototyping. Each activity evaluated aspects of what a research-oriented system for VR might look like. The workshop method encouraged the use of collective imagination and synthesis among users to produce positive outcomes in terms of the team's overall satisfaction with and assessment of the utility of final designs (Zamenopoulos and Alexiou 2018, 25-41). The workshops were recorded, and comments were transcribed and analysed to identify the key design elements for each project. These design elements were then categorised to identify the key aspects of the overall design related to the appearance, function, and focus of these potential virtual projects.

Results and Discussion

While there is much diversity in the desired functions archaeologists participating in this project expressed, the pilot study presented here revealed patterns of similarity. Evaluation of participant responses and observation suggests that a few functions constitute the essential design elements for research-oriented VR and must be present to drive its function in a capacity that connects with current archaeological questions and leverages data in 3D to answer them. First among these is a social element; archaeologists in the field often apply a level of collective thinking that needs to be present for them to engage with the interpretive process. The program also needs robust tools for visualizing large collections of data, in other words, a digital whiteboard for compiling and organizing relevant visual information. Finally, using the flexibility afforded in a virtual program, users must be able to build off their data, creating reconstructions and visual hypotheses to translate their ideas to one another outside of the imagination. These functions form the core of a research-oriented VR system which could be adapted for use by teams interpreting archaeological data in diverse contexts.

This requirements for research-oriented VR emerging from this assessment are quite different from those for public-facing VR. Research-oriented designs need to convey uncertainty and display raw data to an expert user, concepts with unnecessary depth for public facing exhibits. Programs built for a non-expert public must be careful about how they represent concepts about which we are uncertain. For example, because 3D representation is intrinsically very powerful for conveying the certainty of interpretations, its use to represent areas that lack evidence is problematic. Programs designed for experts who are interpreting data don't need to worry about actively misleading those users, since they have control over the content they are creating. Finally, when designing VR research tools, special consideration should be given to the ways archaeologists currently engage with research, excavation, and interpretive activities. These activities rely heavily on interpersonal and collective communication, an element not commonly prioritised in designing virtual site tours and reconstructive visualizations.

Conclusions

Based on this pilot study, I argue that public facing VR projects and the research behind them have very different methods and intended outcomes than a program oriented for archaeological research, and thus there are different design requirements when attempting to develop these systems. While primarily used in public facing applications to date, VR can be a powerful tool for research when designed and implemented through collaborative development. Designed well, VR should create a medium where archaeological reasoning and interpretation are facilitated by technology.

361. Re-thinking Our Digital Archaeological Practice through 3D Data-driven Analysis and Interpretative Visualization: Lessons Learned at Çatalhöyük and Palenque

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Introduction:

Digital archaeologists have long speculated on the effects of computation, digital, and geospatial techniques on their practice. For instance, the application of Image-based modeling (IBM), widely known as digital photogrammetry, terrestrial laser scanning (TLS), and airborne Light Detection and Ranging (LiDAR) to archaeological investigation has revolutionized how we capture, fuse, analyze, understand, and share our data and how we discover and monitor archaeological sites. In the past decade, our digital scholarship has focused on developing new methods and workflows for 3D and GIS applications in archaeology, which we employed in two major research projects, namely the Çatalhöyük Research Project and the Palenque Regional Project. In this paper, we discuss how, within these decade-long archaeological projects, the analysis and visualization of 3D data transformed our practice, highlighting our successes and shortfalls and mapping major shifts in our workflows and understanding of the archeological record. We argue that 3D data-driven architectural analysis allowed us to overcome the lack of primary data, like in the case of Palenque's Temple of the Inscriptions (Figure 1). We also contend that archaeological visualization, or the process of creating a visual representation of the archaeological record based on spatial logic and inference, allowed us to propose new interpretations of the repetitive use of space in complex contexts, such as Çatalhöyük's Shrine 10 sequence.

Methods and Materials:

Since the early 2010s, the increasing availability of airborne LiDAR technology, also known as Aerial Laser Scanning (ALS), has revolutionized the archaeological investigation of Mesoamerica's densely forested regions (Chase et al. 2016). ALS enables remote measurements of the underlying elevation of the Earth's surface and human-made structures on the landscape. This capability produces detailed topographic data for mapping and site reconnaissance purposes or investigating land use and landscape modification in antiquity. However, alternative close-range LiDAR techniques, such as TLS, are much more effective in delivering ultra-precise measurements of the morphology of stratigraphic layers and high-fidelity 3D point representations of archaeological surfaces and built structures. Most significantly for archaeologists, TLS is capable of recording building substructures uncovered through tunnel excavations and capturing archaeological features retrieved in caves, buildings, and plazas with millimeter-level accuracy. Besides enabling multi-temporal building monitoring, TLS 3D data also provide the basis for the virtual reconstruction or reassembling of monuments in GIS and virtual reality. Since the 2010s, drone-based IBM has proven very effective in documenting entire excavations and enabling low-cost investigation of the archaeological built environment and landscape. Most significantly, LiDAR and IBM data can be combined in the same analytical environment to contextualize ancient buildings and relate them to their immediate surroundings (Campiani, Liendo Stuardo, and Lercari 2021). This data fusion technique enables a new way to investigate ancient structures from different perspectives, generate drawings extrapolated from the 3D models, and spatially relate archaeological findings. However, capturing and fusing the data is not enough for digital archaeologists. We utilize archaeological visualization as a visual-analytical practice able to render and reconstruct places of the past successfully. The significance of a virtual reconstruction depends on how the underlying cognitive processes and interpretative choices are recorded and made available to other scholars. For these reasons, in our work, we utilize the recommendations of the London Charter and Seville Principles to guarantee the intellectual integrity, reliability, and scientific rigor of our multi-temporal reconstructions and compile extensive collections of associated metadata and paradata, which help us capture the critical arguments and inference choices we made during our visualization or virtual reconstruction work.

Results:

This paper re-examined the results we obtained in the Çatalhöyük Research Project and the Palenque Regional Project as previously published in 2020 and 2021 (Campiani, Liendo Stuardo, and Lercari 2021; Lercari and Busacca 2020). These results show session participants and readers where we recently drew the line that changed our digital archaeology practice.

Discussion:

Within the Palenque Regional Project, we went beyond digital documentation by taking advantage of 3D data's potential to answer archaeological questions related to architectural analysis. Building on our expertise in drone-based IBM and TLS survey techniques, we proposed a new interpretation of a group of important funerary buildings at Palenque, including the Temple of the Inscriptions and adjacent structures. We achieved this goal by successfully combining 3D data with legacy archaeological information and anthropological knowledge to tackle unanswered archaeological questions regarding the construction of the Temple of the Inscriptions as part of a larger mausoleum architectural project. In the Çatalhöyük's Shrine 10 case study, we utilized archaeological visualization to contextualize and nuance spatial understanding of stratigraphic continuities and discontinuities in a sequence of several buildings. For instance, we created a VR reconstruction of this sequence. Archaeologists using this VR app could see through the 3-D data and ponder connections that are not identifiable in their 2-D representation (e.g., a plan or photograph). We also created interpretative infographics of the Shrine 10 sequence to ease the analysis of continuity and history making in this case study. By presenting multiple layers of information at a glance (e.g., plans, 3-D renderings, and graphic spatial/temporal connectors), our archaeological visualizations spatially connected repeated architectural features or burial locations in superimposed buildings, de facto providing unambiguous synoptic representation of the archaeological record. We conclude that 3D data-driven analysis and interpretative archaeological visualization transformed our digital archaeology practice. We look forward to further discussing these topics with the session's organizers and participants.

References:

Campiani, Arianna, Rodrigo Liendo Stuardo, and Nicola Lercari. 2021. "THE MAUSOLEUM ARCHITECTURAL PROJECT: REINTERPRETING PALENQUE'S TEMPLE OF THE INSCRIPTIONS THROUGH 3D DATA-DRIVEN ARCHITECTURAL ANALYSIS." Ancient Mesoamerica, 1–16. https://doi.org/10.1017/S0956536120000498.

Chase, Arlen F., Kathryn Reese-Taylor, Juan C. Fernandez-Diaz, and Diane Z. Chase. 2016. "Progression and Issues in the Mesoamerican Geospatial Revolution: An Introduction." Advances in Archaeological Practice 4 (3): 219–31. https://doi.org/10.7183/2326-3768.4.3.219.

Lercari, Nicola, and Gesualdo Busacca. 2020. "A Glimpse through Time and Space: Visualizing Spatial Continuity and History Making at Çatalhöyük, Turkey." Journal of Eastern Mediterranean Archaeology and Heritage Studies 8 (2): 99–122.

84. Mapping the impacts of photogrammetry on workflow and dataflow in archaeological excavation

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The creation of three-dimensional models by means of digital photography and commercial software, especially Agisoft's Metashape program, has become increasingly more common over the last decade in archaeological fieldwork. Although the computational barriers to implementing photogrammetric modeling have been greatly reduced, such that little to no specialized hardware is now required, these barriers have been replaced by new organizational and infrastructural challenges. Specifically, full integration of photogrammetric modeling into archaeological excavation projects requires dedicated personnel, demands new on-site workflows, generates massive new digital datasets, and anticipates new forms of dissemination and sharing both within the project and with the public. This paper discusses a map of the changes to excavation practice on the University of Cincinnati's Tharros Archaeological Research Project that have been the result of adopting a dedicated regime of photogrammetric capture for each stratigraphic unit encountered (Ellis et al., 2019). These changes include instances of "upstream" impacts (i.e., changes to the way the project is run and the way excavation is undertaken) as well as "downstream impacts (i.e., the changes to the kind, number, and shape of the project's outputs).

Ellis, Steven, Eric Poehler, Leigh Lieberman, Sarah Wenner, Alex Marko, Christopher Motz, Angela Trentacoste, and Jane Millar Tully. (2021). "New Excavations at the Punic-Roman City of Tharros, Sardinia." The Journal of Fasti Online 516. www.fastionline.org/docs/FOLDER-it-2021-516.pdf.

170. Landscape Heterogeneity at the Acheulean Site of Rodafnidia (Lesbos, NE Aegean): Connecting sites and continental models through intermediary scales

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Palaeolithic sites are not discrete, but represent partial windows into wider, continuous behavioural systems. However, Palaeolithic archaeologists have still struggled in practice to avoid drawing their lines as discrete boundaries. The obverse of this has been to contextualise individual sites by cementing them within wider, continental-scale models of hominin dispersal and occupation. In practice, this has allowed a disconnect to grow between the immediate landscape of individual sites and the larger-scale models that are supposed to contextualise them. Although Geographic Information Systems (GIS) have been a transformative tool in spatial approaches to the Palaeolithic, it still remains a challenge to bridge this conceptual gap between site-based archaeology and continental-scale models. In particular, practice in this area has struggled to access intermediary scales in between, where behavioural questions can be approached and the mechanisms that link individual sites to larger-scale models can be interrogated.

The Lower Palaeolithic site of Rodafnidia (Galanidou et al. 2013), on the Aegean island of Lesbos, is the focus of the current analysis. It is an Acheulean open-air site located in a tectonically active area of complex topography, with a large number of local landscape attractors for hominins, including diverse water and raw material sources. Tectonic activity is directly connected to the expression of these resources in the form of hot springs and hydrothermal chert. The situation at the site closely resembles the hypothetical one described in King & Bailey's (2006) Complex Topography Hypothesis (A.K.A. Tectonic Trail model), which posits a relationship between hominin occupation and tectonically active areas of complex topography. Subsequent elaboration on this hypothesis has identified a number of plausible reasons that topographically complex regions might concentrate resources that attract hominins. One possible attraction of these environments is the ecological diversity and/or richness fostered by a heterogeneous mix of elevations and landforms. This prediction about features of site location made by the continental-scale Complex Topography Hypothesis should be testable at intermediary scales around sites, but exactly at what scale are these features and effects expressed?

Landform and slope position classification techniques have a long history of use in geography, and provide an obvious first step in identifying and assessing landform heterogeneity. Topographic Position Index (TPI) and Deviation from Mean Elevation (DEV) are both methods of landform classification that have seen some limited adoption by archaeologists working with GIS. Although their adoption has been even more muted within Palaeolithic applications of GIS when compared to other methods of spatial analysis. A number of possible reasons can be suggested for this:

1) Landform classification is not specifically addressed in-depth in spatial archaeology introductory textbooks.

2) Although limited versions of landform classification might be included in some GIS as 'push button' analyses, to use the technique effectively in a flexible way for research requires third-party plugins or individually tailored workflows.

3) Perhaps most significantly, framing research questions using landform classification to target hominin behaviour may be more conceptually difficult than with comparatively more popular methods with clearer behavioural relevance, such as least-cost or visibility analyses.

In the few instances where landform classification has been used in Palaeolithic applications of GIS, scale is 'intuited' and rarely are the effects of changing scale explored. Results from these analyses are mostly interpreted visually, and the conclusions are correspondingly not much more than what can be deduced from observation of a Digital Elevation Model (DEM) alone. This situation shows that integration with the methods of geography via GIS adoption is partial, incomplete, and ongoing. Palaeolithic researchers have significant groundwork to do in order to develop a truly integrated practice with well-defined, sub-discipline specific concerns and research agendas.

In this analysis, both TPI and DEV were generated at multiple scales for the area around Rodafnidia from a DEM, and classified into basic slope classes following a similar system to that detailed by Weiss (2001). The goal was to understand in what sense and at what scale the site location can be considered heterogeneous through slope classification of the results of these two analyses, and also how expression of heterogeneity changes through different scales. Through the results of this analysis, we argue it is possible to assess to what extent Rodafnidia and its surrounding area fit the Complex Topography hypothesis, and also narrow down the intermediary scales at which its localised heterogeneity articulates with the wider model. The study doesn't draw lines so much as it erases them, specifically deconstructing a conceptual boundary inherited from analogue practice by opening up examination of intermediary scales.

References:

Galanidou, Nena, James Cole, Giorgos Iliopoulos, and John McNabb. 2013. 'East Meets West: The Middle Pleistocene Site of Rodafnidia on Lesvos, Greece'. Antiquity 87 (336).

King, Geoffrey, and Geoff Bailey. 2006. 'Tectonics and Human Evolution'. Tectonics and Human Evolution 80 (308): 265–86.

Weiss, Andrew. 2001. 'Topographic Position and Landforms Analysis'. Poster presented at the ESRI user conference, San Diego, CA, July.

247. 1-Draw And 3-Dimensions: A Methodological Proposal For The Recovery Of Archaeological Finds

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Elena Griggio, University of Padova

Introduction

Archaeological drawing, with its scientific rules and standards, has been an established practice for years. Drawing and its characterisation help to understand the archaeological record. Publications dealing with archaeological finds include numerous drawing boards and scale drawings. The approach to the drawing of artefacts began in historical times with the first publications on excavations and the various assemblages of artefacts in private collections.

But in recent years, with the advent of the information technology revolution and the implementation of technology in archaeology, techniques such as photography, Structure from Motion and Laser scanning have contributed to the dissemination of images and 3D models on the web. This new way of disseminating material culture in scientific publications or in online catalogs allows freer access to information and more effective comparison.

All of it is organized under principles of visualization and communication of these data (Denard 2012, 57-71).

Methods and Materials

Every year, destructive events, whether man-made or environmental, lead to the disappearance of many archaeological finds. The only traces that often remain are photographs or drawings of them. In recent years, thanks to technology, it is possible to obtain accurate 3D replicas that allow the preservation of a digital copy of the artefacts. However, not all remains are scanned or digitally processed and what we possess today are only fragments of an already incomplete culture. The aim of this work is to recover, from unique images of certain artefacts, not only their third dimension, but also their integrity. Starting from drawings of archaeological finds that have been lost (due to events of various kinds), we intend to return the object to the present time. The workflow provides the use of 3D modelling combined with the methodological rules of archaeological drawing. The characterisation of drawing, usually used for 2D graphics, is here applied directly on the three-dimensional surface.

This methodology was applied on two different archaeological collections. The first case study selected comes from the protohistoric site of Bostel di Rotzo (Vicenza, Italy). In 1912, the archaeologist Giuseppe Pellegrini excavated at this 'pre-Roman station', investigating the entire plateau. During the excavations, he found countless ceramic, faunal and metal materials. Some of those finds were graphically reported in a board inside a publication. Many years later, Giovanni Leonardi and Angela Ruta Serafini made new drawings of them according to modern methodological standards (Leonardi, Ruta Serafini 1981). Of the materials unearthed in 1912, some are still preserved in the Museo Nazionale Atestino, while others have not been found.

The second case study concerns some finds stolen in 2003 from the National Museum of Iraq. Although a few years later some of these artefacts were recovered and returned to the Nation, many others are still missing (http://oi-archive.uchicago.edu/OI/IRAQ/dbfiles/categories/c110_1.htm). For these artefacts, not only drawings were available in scientific publications, but also photographs, which were useful for a better characterisation of the surface and an attempt to restore the colour rendering.

Results

The artefacts were reconstructed through 3D modelling. Using the description and information retrieved from the drawings, it was possible to reconstruct the objects. In addition, the comparison with materials belonging to the same typology was useful for reconstructing the average dimensions that could not be deduced from the archaeological drawing.

Once the 3Dsurface was obtained, the characterisation of the object was applied using archaeological drawing standards. This procedure can be carried out in two ways. In the first one, drawing and characterisation is done directly on the 3D model, allowing control and management of any hidden parts of the surface. The second method involves an initial phase of 2D drawing and characterisation. Subsequently, the image file is applied as a texture on the 3D surface. This practice can also be developed by directly modifying the 3D shape, thus interacting directly on the vertices of which the model is composed.

The three-dimensional characterisation follows the standards of 2D archaeological drawing, maintaining in this case, a white background and black lines (fig. 1).

A step forward for the complete restitution of the archaeological finds was possible for objects for which colour information was available from photographs (as in the case of material from the National Museum of Iraq) or from the description in text (if according to international standards - Munsell).

For some artefacts still preserved, a check was made between the real and the digital copy that served as a test to determine the accuracy of the reproduction and to identify any criticalities of the operations.

Although this is a digital reconstruction that is sometimes approximate in size, it is nevertheless processed according to the scientific methods of the discipline of archaeology.

The final model presented is therefore a 3D reconstruction described according to international standards of realisation and interpretation, complete with all its necessary graphic information to be easily usable and exploitable.

Fig. 1: The different work procedures. 2D drawing – characterisation – 3D model

Discussion

The methodology presented here for archaeological material that is no longer preserved, but of which we have graphic and/or photographic traces, makes it possible to recover information. This information could be of morphological and typological nature. The application of this practice to lost or dispersed archaeological collections is indispensable for the conservation and recovery of material culture. The scientificity of the reproduction itself, as dictated by the principles of the London Charter 2009, is implemented through the conjugation of 2D graphic rendering in a 3D environment.

The entire process has revealed certain features necessary for a correct interpretation of the archaeological drawing. In the profile view, it is important to accurately report the pattern as it highlights the type of workmanship (e.g. for ceramics, it is possible to note the undulations due to lathe work).

The realisation, through this method, of reconstructions of archaeological artefacts allows the reproduction, the analysis and the dissemination of cultural heritage. This is achieved through an all-round graphical schematisation of them, which is useful for further comparisons and studies. Compared to the usual methods using Structure from Motion, this allows the operator, or the graphic source he refers to, to choose what information to outline. The retrieval of archaeological assets allows, in a future perspective, their dissemination in both museum institutions and online platforms. This would allow researchers to have new and more accurate data by reconstructing the third dimension.

References

Denard, Hugh. 2012. "A New Introduction to the London Charter" in Paradata and Transparency in Virtual Heritage, edited by Anna Bentkowska-Kafel, Drew Baker, Hugh Denard, 57-71. Digital Research in the Arts and Humanities Series. Ashgate 2012

Leonardi, Giuseppe, and Ruta Serafini, Angela. 1981." L'abitato protostorico del Bostel di Rotzo (Altipiano di Asiago)". In Preistoria Alpina, 17, 7-75. Trento

Strommenger, Eva, and Hirmer, Max. 1963. L'Arte della Mesopotamia dal 5000 a. C. ad Alessandro Magno. G. C. Sansoni Editore

263. Complexity science as a way of thinking

Iza Romanowska, Aarhus Institute of Advanced Studies

Complexity science is a cross-disciplinary theoretical paradigm concerned with studying complex systems, that is, systems where non-linear local interactions of many elements lead to non-trivial structures at higher scales. Such systems are inherently difficult to study and their behaviour is notoriously hard to predict. A whole suite of tools have been devised to deal with this challenge - among them my tool of choice - computer simulation. At the same time, a large community of practitioners work across disciplines to uncover laws that go so deep into the fabric of reality that they govern all complex systems - regardless of whether they are social, natural or physical.

In this talk, I'll map the lessons from complexity science that have influenced my practice as an archaeologist and which provide insights that are relevant for all researchers dealing with complex systems.

11. The Age of #Archaeogaming: The Past and Future of Archaeology + Video Games

Aris Politopoulos, Leiden University & VALUE Foundation
Sebastian Hageneuer, University of Cologne
Csilla E. Ariese, VALUE Foundation & Reinwardt Academy

Location: Forum

The last decade has seen the exciting development of a new field in digital archaeology: archaeology and video games. The field, commonly known as archaeogaming, deals with such concepts as the use of video games for archaeological research, the archaeological study of video games, and the implementation of video games for heritage and outreach. Popularised initially on social media and in blogs, #Archaeogaming has brought together researchers from diverse disciplinary backgrounds. In this session we will celebrate the origins of the field, consider its current inter- and intra-disciplinary synergies, and dream together to envision its futures.

ORIGINS

The engagement of archaeologists with video games has no singular point of origin, neither in time nor in place. Although archaeologists have used computer applications for half a century, and the first historical video game dates to the era of the earliest computer games, Archaeogaming as a field of study is significantly younger. The first publications on the topic appeared in the 2000s, dealing with a variety of topics, from exploratory (Gardner 2007), to experimental (Morgan 2009), to heritage (Champion 2011). It was in the early 2010s however, when the term 'archaeogaming' was coined, after the namesake blog by Andrew Reinhard, and the field started taking shape. The origins of the field were characterised by a great freedom of exploration. In part, this was due to the fact that the new area of study had no set boundaries, nor any clear research agenda (Mol et al. 2021). Additionally, significant research was carried out outside of formal academic settings, by researchers in their own free time or at least on the side lines of grant projects. This freedom enabled a wide-spread exploration of all aspects and angles of Archaeogaming and also drew people from different disciplines and, notably, many early career scientists. Entering #Archaeogaming's second decade, we are ready to reflect on our origins. What qualities characterise the field and set it apart from other research strands in computational archaeology? Which milestones, perhaps outside the Anglophone, should be included in its origin story? We welcome any papers that delve into the (brief as it may be) history of #A rchaeogaming.

INTER-/INTRA- DISCIPLINARY SYNERGIES

Over the years, the field's popularity has drawn increasingly more participants, especially appealing to those whose gaming at home has taken on extra meaning. With openness and innovation at its core, there seems to be no end to the themes and potential avenues for research. Archaeogaming studies have included a wide variety of topics like decolonizing and ethical movements, collaborative digital survey projects, and game making experiments. The fluidity of the field has allowed for a richness of synergies that fearlessly cross disciplinary and sub-disciplinary boundaries. Despite archaeogaming's growth and the enthusiasm of its participants, the field has struggled to gain a secure foothold in academia. With play as a core component of its practice, archaeogaming has often been disregarded as frivolous or non-serious. While universities have been quick to showcase archaeogaming endeavours to attract new students, they have been slow to formalise archaeogaming in terms of funding, teaching positions, or long-term support. As a result, archaeogaming projects have mostly been incidental and there is a lack of sustainability. Conferences and an exponential increase in academic publications have helped to formalise archaeogaming as a 'real' or 'legitimate' strand of research, but this struggle for understanding has taken time and effort away from further expanding the field. Where does archaeogaming stand at the beginning of its second decade? What is the actuality of its practice – and is this what the field should indeed be focusing on? We welcome papers that reflect on the current state of the field of Archaeogaming and any areas that remain un- or under-explored. We also welcome presentations about ongoing or recent Archaeogaming projects, particularly those discussing current methods and practices.

ENVISIONING THE FUTURE

Although not a completely blank slate anymore, the future of archaeogaming is still malleable and open. From our perspective, we expect three major influences on how this future will take shape. Fundamentally, the future of video games and the video game industry, including technological developments such as AR and VR, will significantly impact the source materials that we can work and play with. Secondly, we anticipate that established and new scholars will build upon previous research: celebrating past achievements while also correcting our course to compensate for omissions, gaps, and weaknesses. Finally, Archaeogaming's future will also be dependent on structural and institutional support both from within academia as well as the game development industry. In this session we would like to welcome all archaeogaming scholars, enthusiasts, or people curious about the field to envision its future together. We are curious to hear about new avenues to explore, but equally interested in how tried and tested methods can be applied to future games. Please share your dreams or future realities.

PAST AND FUTURE

This session is both about celebrating archaeogaming's origins and about envisioning the exciting opportunities that lie ahead. We welcome students and scholars whether you are new to the field or have been following and contributing over the years. We welcome traditional paper presentations as well as playful projects and game demonstrations.

References:

Champion, E. 2011. Playing with the Past. London: Springer. Gardner, A. 2007. Playing with the Past: A Review of Three 'Archaeological' PC Games. European Journal of Archaeology 10(1), 74-77.

Mol, A.A.A., A. Politopoulos, C.E. Ariese, B. van den Hout and K.H.J. Boom, 2021. Introduction. In C.E. Ariese, K.H.J. Boom, B. van den Hout, A.A.A. Mol and A. Politopoulos (eds), Return to the Interactive Past: The Interplay of Video Games and Histories (7-18). Leiden: Sidestone Press.

Morgan, C. 2009. Re-building Çatalhöyük: Changing Virtual Reality in Archaeology. Archaeologies: Journal of the World Archaeological Congress 5(3), 468-487.

SLOT 1	
08:50 - 09:10	340. 10 years of Archaeogaming; Good Hits & Bad Misses Aris Politopoulos (Leiden University)*; Angus Mol (Leiden University); Csilla E Ariese (Reinwardt Academy)
09:10 - 09:30	19. Creating Archaeogames – Experiences and results of a joint course in digital archaeology and digital humanities Valentina Hiseni (University of Cologne); Sebastian Hageneuer (University of Cologne)*
09:30 - 09:50	22. Student Feedback on Archaeogaming: Perspectives from a Classics' Classroom Robert P Stephan (University of Arizona)*
09:50 - 10:10	228. Designing Stories from the Grave: Reviving the History of a city through Human Remains and Serious Games Electra Tsaknaki (Centre for Research & Technology Hellas (CERTH))*; Eleftherios Anastasovitis (Centre for Research & Technology Hellas (CERTH)); Georgia Georgiou (Centre for Research & Technology Hellas (CERTH)); Kleopatra Alagialoglou (Tetragon S.A.); Maria Mavrokostidou (Tetragon S.A.); Asterios Aidonis (Laboratory of Physical Anthropology, Department of History and Ethnology, Democritus University of Thrace); Vasiliki Kartsiakli (dot2dot Social Cooperative Enterprise); Tania Protopsalti (Ephorate of Antiquities of Thessaloniki City); Spiros Nikolopoulos (ITI-CERTH); Yiannis Kompatsiaris (CERTH-ITI)
10:10 - 10:30	147. Transforming the Archaeological Record Into a Digital Playground: a Critical Analysis of The Living Hill Project Samanta Mariotti (University of Bari)*

SLOT 2	
11:00 - 11:20	317. Archaeology And Technology: The Development Of An Archaeogame Amanda Pina (University of São Paulo)*
11:20 - 11:40	60. Assessing digital methods of communicating archaeological research to the public: storytelling, interaction and immersion Despoina V Sampatakou (University of York)*
11:40 - 12:00	184. Gamifying Ancient Transcaucasia: Prototyping the Creation of Digital Cultural Heritage Robert C Bryant (UPenn)*
12:00 - 12:20	211. Performing Glencoe - Creative Digital Archaeology and the Living Landscape Elizabeth Robertson (University of Glasgow)*

12:20 - 12:40	91. Archaeology as Worldbuilding Colleen Morgan (GB)*
12:40 - 13:00	350. Gaming as a Guide to the Past Environments: A Gentle Assistance to Landscape Archaeology in Palaepaphos, Cyprus. Efstratios Mavros (National and Kapodistrian University of Athens)*
	SLOT 3
14:00 - 14:20	201. Archives (Not) Of Our Own: Procedurally Generating Object Biographies Florence Smith Nicholls (Queen Mary University of London)*
14:20 - 14:40	215. Playing for high stakes. Archaeogaming and the deconstruction of populist conservative appropriations of the past Mara Visonà (University of Salento - Lecce)*; Vincenzo Idone Cassone (Ritsumeikan University - Kyoto)
14:40 - 15:00	8. The unwritten presence of emotions in archaeological research and their future in archaeo-gaming. Luca Ottonello (University of Glasgow)*
15:00 - 15:20	294. Cultural Gaming in the Metaverse: what potentialities for future applications? Margo Lengua (Entertainment Game Apps, Ltd.); Michela De Bernardin (Istituto Italiano di Tecnologia)*

340. 10 years of Archaeogaming; Good Hits & Bad Misses

Aris Politopoulos, Leiden University
Angus Mol, Leiden University
Csilla E Ariese, Reinwardt Academy

10 Years of Playful Digital Archaeological Scholarship

This paper reviews 10 years of archaeogaming, a movement born in and out of playful and digital scholarship that is itself constructed or built on the digital playgrounds of games (Politopoulos et al. 2019). Kicking off in 2013 (Reinhard 2018), archaeogaming has in a sense only 'just been released' as a form of digital archaeology. In its very early stages, archaeogaming was popularised as a grassroots initiative through the blog and Twitter spheres. Pioneered mainly by students and early career researchers, these blogs introduced several archaeogaming concepts and ideas that would fledge into substantiated research projects. Many blogs, such Archaeogaming, Gamingarchaeo, Electric Archaeology, and Gingerygamer, produced substantial research, on topics such as the interactivity and storytelling potential of games, how archaeology is portrayed in and perceived through video games, and digital methodologies such as Agent-Based Modelling that could be in conjunction with video games for archaeological research.

In many respects the archaeogaming field was on a trajectory of constant growth. Several PhD projects began on archaeogaming topics and major gaming outlets featured archaeogaming projects. Major book publications, as well as several research articles paved the way for various other projects to come to life like the ARISE group in Brazil. In addition, archaeogaming sessions became mainstays in major archaeological conferences (EAA, SAA, CAA) and there was the Interactive Pasts conference, a dedicated archaeogaming conference that included scholars from around the world. In a way it felt like archaeogaming was at the top of the (archaeological) world.

It is exactly because archaeogaming is still so 'young', at least academically speaking, that the field uses this anniversary, not only to discuss our critical hits as well as its fumbles. This is important, because archaeogaming is at an inflection point: after big successes during the early development of the field, culminating in the publication of Andrew Reinhard's Archaeogaming in 2018, archaeogaming has lost some of its aforementioned momentum.

Hits and Misses

We have been involved with archaeogaming, as individuals, researchers, and founding members of the VALUE Foundation from very early on, and have developed more than a few archaeogaming projects. As such, we first and foremost feel that it is important to be reflective and critical of our own work. This is important, as it is not our goal to be destructively critical of this budding field of research, let alone of upcoming scholars in it, but rather be reflective of what has been done so far and can be considered as 'established' within archaeogaming. For each different point of critique we will also be offering a best practice from other individuals or groups that we think have been or will be particularly fruitful or promising in their approaches. The vectors of our review will be on archaeogaming as a tool for:

The archaeological study of games

One of the main starting points for archaeogaming was, and still is, whether archaeology can be useful for the study of games and vice-versa. In particular this strand of archaeogaming looks into whether archaeological concepts and methods can be used in virtual playful environments. Such perspectives include the use of digital methodologies like agent-based modelling, or the conceptualization of video games as archaeological sites. Yet, despite the enthusiasm that such projects have generated, there has been relatively little work done that explicitly connects to archaeological theory or method that is also sustainable or groundbreaking.

Archaeological outreach

Outreach, or science communication has always been the obvious application of video games in archaeology. As the largest entertainment medium with reach of hundreds of millions of people, and with thousands of games set in or around the past, it is not surprising that archaeologists see a potential in them for outreach projects. The connection seems so self-evident that one would then expect not only a lot of archaeogaming outreach projects, but a relatively high success rate of such projects. The unfortunate reality is that, for reasons that we will explore, this facet has also remained unrealized.

Building bridges between disciplines

One particular aim that archaeogaming is very suitable for, is for building bridges between (sub)disciplines that archaeology traditionally has not had many collaborations with, such as games studies, media archaeology, education studies, museology, and more. In addition, archaeogaming is not the only field that deals with video games and the past. Historians, for example, have also extensively engaged with video games and the representation of history. We believe that the insights of archaeogaming and other scholarship at the intersection of the past and play can benefit how global citizens engage with the past through games.

Failing Gloriously as a Play for Future Success

Play is messy and almost any research or outreach project we have been part of has failed in minor (or sometimes major) ways. Yet if playing games has taught us anything it is that failing is not fun, but failing gloriously, by learning from past misses and sharing their lessons, is (Graham 2019). In archaeogaming, and digital archaeology in general, we should thus use failure as a potential for change, and commit to discuss it with an attentive and caring stance, in an effort to be our own and others' critical friends.

In this presentation we do not want to dwell in what we, maybe uncharitably, call bad misses. We want to delve into archaeogaming's past hits and misses in order to imagine a better future. A future that would lead to sustainable scholarship, and one that embraces the open, diverse, accessible, and fun fuelled practices that have defined early archaeogaming because, at the core of it, archaeogaming is about collectively making, exploring, and playing in this wild new, digital playground.

Graham, S., 2019. Failing Gloriously and Other Essays, North Dakota.

Politopoulos, A, C.E. Ariese, K.J.H. Boom and A.A.A. Mol 2019. Romans and rollercoasters: Scholarship in the digital Playground. Journal of Computer Applications in Archaeology 2(1), 163–175.

Reinhard, A. 2018. Archaeogaming. An introduction to archaeology in and of video games, New York.

19. Creating Archaeogames – Experiences and results of a joint course in digital archaeology and digital humanities

Valentina Hiseni, University of Cologne
Sebastian Hageneuer, University of Cologne

Roundtable

During the summer semester of 2022 the Institute of Archaeology and the Institute of Digital Humanities of the University of Cologne were offering a joint course on Archaeogaming (Reinhard 2018) to BA and MA students of Archaeology, Digital Archaeology, and Digital Humanities. The aim of this course was to evaluate in what capacity student groups were capable to not only discuss, but also to create Archaeogames within one semester (about a half year) in mixed groups of four to six students from idea to release. There were no restrictions in technologies or game mechanics to enable total creative flexibility.

The task was to create a game discussing the past or the profession of Archaeology (or both) in a thoughtful way that challenges predetermined stereotypes of already known games about the topic (e.g. Hageneuer 2021). Students were therefore only given a basic introduction into Archaeogaming, and the challenges current research is facing within the discipline (e.g. Chapman 2016). The introduction focused on two topics: 1) The colonial past of nations producing the games and the relationship to the depicted cultures in the games themselves and 2) The unethical archaeological practices depicted in these games representing the profession of Archaeology (in the widest sense) as it is communicated by video games today. After that, the individual groups were tasked to come up with a game mechanic and a theme that discusses the depiction of the past and/or the profession of Archaeology. They were also tasked to come up with a project plan that utilises the individual backgrounds of Archaeology, Digital Archaeology, and Digital Humanities. Beside this challenge, the students had to learn how to communicate and how to structure the workload in the group due to the limited time.

After one semester, eight groups have created games which are published on a university website to download. While not every game was finished flawlessly, the basic concept of each game is tangible. While some games try to give an understanding of the process of excavation itself, others are educating in ancient mythology or archaeological pasts. One game also discusses current debates on the restitution of stolen cultural artefacts, currently displayed in museums worldwide.

In our presentation, we want to showcase parts of these games and discuss the challenges and possibilities of creating Archaeogames within a university curriculum, but also what students learned from each other while creating these games in mixed groups. Our conclusion of the course was that the creation of Archaeogames is far more valuable than talking about or analysing them, because by virtualising own ideas, students came up with creative ways of debating current problems in the depiction of the past or the profession of Archaeology.

Literature cited

Chapman, Adam. 2016. Digital Games as History - How Videogames Represent the Past and Offer Access to Historical Practice. Routledge Advances in Game Studies 7. New York: Routledge.

Hageneuer, Sebastian. 2021. "Archaeogaming: How Heaven's Vault Changes the 'Game.'" In Pearls, Politics and Pistachios. Essays in Anthropology and Memories on the Occasion of Susan Pollock's 65th Birthday, edited by Herausgeber*innenkollektiv, 631–42. Berlin: ex oriente. https://doi.org/10.11588/propylaeum.837.c10771.

Reinhard, Andrew. 2018. Archaeogaming - An Introduction to Archaeology in and of Video Games. New York - Oxford: Berghahn.

22. Student Feedback on Archaeogaming: Perspectives from a Classics' Classroom

Robert P Stephan, University of Arizona

INTRODUCTION

Several years ago, I gave my first presentation on archaeogaming as part of the 2019 CAA conference in Krakow, Poland. In that original presentation, I presented a series of pedagogical activities that were based on the blockbuster video game Assassin's Creed: Odyssey. While the feedback from that initial presentation was relatively positive, the comment put forth repeatedly was, "sounds great, now go do the study!"

This project is the evidence-based follow-up to that preliminary presentation. The goal of this study was to get a sense for the way in which students respond to video game-based assignments and for the way in which those responses compare to feedback regarding more traditional text and writing based activities. Developing a better sense for the way in which students perceive archaeogaming, both their perceived strengths and weaknesses of gaming as a learning modality, provides the potential to illuminate new teaching methodologies to improve archaeology and history course enrollments, major declarations, and achievement of learning outcomes.

METHODOLOGY

This IRB-approved case study took place during the Fall 2021 semester within my asynchronous online course, Classics 160B1: Meet the Ancients: Gateway to Greece and Rome. The goal was twofold. First, it aimed at gathering qualitative and quantitative student feedback regarding the use of video games as a teaching tool in the college classroom. Second, the study aimed to evaluate the relative strength of this new teaching method by comparing it to more traditional pedagogical methods.

To accomplish this, I gave the 266 students enrolled in this course the option to complete one of two assignment sequences. The video-game based sequence asked students to complete a series of 6 assignments In which they would explore some component of the game, read an excerpt from an ancient text, and write a 300+ word essay. The traditional sequence asked students to complete a series of 6 assignments in which they focused solely on reading an ancient text and writing a 300+ word response. Thus, in both sequences students were asked to engage with ancient texts and produce 300+ word written responses. By running parallel assignment sequences within a single course, and constructing similar assignment deliverables, the aim was to better isolate the impact of video games on student perceptions of the teaching and learning process.

After completing the course, students were sent an IRB-approved survey that consisted of 10 questions, including yes/no, Likert scale, and free response questions. These questions were meant to get a sense for prior video game experience, assignment sequence enjoyment, and specific characteristics of each assignment that increased student learning.

RESULTS

Out of the 266 students in the course, only 26 students completed the survey. Fortunately, these responses were relatively evenly split between students who completed the video game assignment sequence (n=14) and the traditional assignment sequence (n=12). The first clear takeaway from these responses was that students appear to have selected their assignment sequence strongly based on their previous gaming experience. Nearly all students who chose the video game sequence (93%) played video games recreationally outside of class, while only about half (58%) of students who chose the traditional sequence played games for fun. Likewise, more than 1/3 of students (36%) who chose the video game sequence had played Assassin's Creed: Odyssey, while none of the students who chose the traditional sequence had played the game. In short, previous gaming experience appears to have a big impact on the appeal of the modality.

Quantitative student responses suggest strong levels of student satisfaction and self-perceived learning from those who opted for the video game assignment sequence. The question regarding the degree to which students enjoyed their respective assignment sequences led to an average score of 9.1 from the video game students and an average of 6.8 from the traditional assignment sequence students. Average scores regarding students' self-perceptions of learning led to similar results, with video game students producing a score of rated the amount they learned from the assignments as a 9.1 out of 10, while the traditional assignment students felt like they learned a 7.7 out of 10. It's important to reiterate that these are self-perceptions of student learning rather than differences in the actual achievement of learning outcomes, but nonetheless the differences seem significant in scale.

The free responses questions help illuminate the specific aspects of the video game assignments that help. The two aspects of the video game assignments that came up most frequently as positive contributors to student learning were the visualization of the ancient Greek natural and built environment (5 of 9 students), and the interactivity of the activities (3 of 9 students). In terms of drawbacks, students highlighted difficulties in finding correct locations within the game and disjuncture between some of the assignments and the course content.

DISCUSSION

The preliminary results from this study align well with previous studies on the use of video games as teaching tools, especially the conclusion that students appear to find video games as useful for building interest in and satisfaction with the course (Mol et al. eds. 2017). Clark et al's 2016 meta-analysis, for example, noted similar trends with student feedback with regard to these characteristics. One of the major directions moving forward would be to test the impact of video game integration on the actual achievement of student learning outcomes, rather than student perceptions of learning. Slobodan et al. 2021's study suggests that this may, indeed, produce similar results, but running a similar study using these assignments would be a useful next step. Finally, given the substantial difference in gaming experience within the two groups of this study, it would be useful assess the way in which students who do not regularly play video games respond to video game-based assignments.

There is certainly room for far more robust research on the topic. The preliminary results of this study, however, suggest that integrating gaming into the history classroom has the potential to dramatically impact students' perceptions of both enjoyment and learning of the course material.

REFERENCES

Clark, D., Tanner-Smith, E., and S. Killingsworth. 2014. Digital games, design, and learning: A systematic review and meta-analysis. Menlo Park: SRI Education.

Mol, A., Ariese-Vandemeulebroucke, C., Boom, K., and Politopoulos, A., eds. 2017. The Interactive Past: Archaeology, heritage, and video games. Leiden: Sidestone Press.

Slobodan, A., Al-Mansour, J., Naqvi, H., and S. Stambolic. 2021. "The impact of video games on students' educational outcomes." Entertainment Computing 38, 1-6.

228. Designing Stories from the Grave: Reviving the History of a city through Human Remains and Serious Games

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1 Introduction

Recent technological advances have led the industry to a new era where the narration of archaeo-anthropological research outcomes through Serious Games (SGs) and Archaeogaming is more attainable than ever. Though the archaeogaming ecosystem is relatively new (Derfoufi 2019), the whole "games and learning" field could be traced back to the work of Plato, who stated that play can be utilized to guide the development of a child, while also serving educational purposes (Wilkinson 2016). This particular statement can find fertile ground in our century, given the exploitation of the advanced technology in the fields of Virtual and Augmented Reality (VR and AR, respectively).

In this project, the main purpose is to reinforce the knowledge-sharing related to the ancient citizens of the city, through a fully immersive and interactive environment. This will be achieved by creating photorealistic virtual surroundings and game-mechanics that will combine the archaeo-anthropological research with SGs theory.

The scope of this contribution is to analyze the design process of gamified experiences being developed in alignment with archaeogaming framework and on the basis of inter-disciplinary approach.

2 Methods and materials

The proposed methodology is divided into three steps (described in 2.1-2.3), in order to highlight the human past of the city through a key factor of social expression: the biographies of its inhabitants.

2.1 Questionnaire

First, in order to define the user needs and preferences regarding the VR and AR technologies, a questionnaire was distributed to three (3) main groups of people: (1) Citizens (188 answers), (2) Tourists (103 answers), and (3) Educators (98 answers). The questionnaire contained several generic questions regarding the level of familiarization of the respondents with the aforementioned technologies, as well as questions about the VR and AR environments and the information that will be communicated within the game. While analyzing the results, it was clearly observed that nearly half of the respondents (55%) were not familiar with and had not used these technologies, but the most encouraging fact is that they are willing to attempt to familiarize with them, and that they are interested in SGs for cultural heritage.

2.2 Game scenarios

The preliminary phase of the production process is the formulation of the scenarios and the reward system embedded in both the AR and VR SGs. The purpose of the AR environment is to introduce a different approach by which users can perceive the city. On the first screen, a map of the historical center with predefined points of interest will appear. The user will be able to choose between those locations in order to augment the projection of 3D cultural assets that once existed in this place, and play through the interaction with them combined with the information regarding the specific asset and short animations.

Subsequently, the VR SG will be divided into unique environments. At the first virtual environment, the user will be witnessing the internal part of the city's metropolitan subway, while on the inside of a wagon from the subway, the first acquaintance with the ancient citizens of the city will be achieved. The subway passengers will initially appear as blurred forms, with the goal being the user/player to learn about their stories and unblur their forms. Each passenger, as an avatar, will lead the player to his/her own VR environment related to his/her biography. The player will be transferred to virtually reconstructed historical sites, which will operate as the games spaces. The player will be able to interact with cultural assets in a gamified mode.

Before the closure of the narration related to each virtual experience, a reward in the form of information will be presented to the player. When the learning goal is achieved, the user will be additionally rewarded with the phenotypic characteristics of the ancient citizen of the city who had virtually transported him/her to the specific environment. The passenger/avatar will gradually acquire and present its physical characteristics, its eye color, hair color, skin color, and other anthropological findings. The aforementioned reward system, will also be implemented in the remaining environments.

2.3 AR and VR experiences

The next step in the methodology is the creation of the AR and VR environments. For this process, four key objectives were taken into account in order to design the experiences: (1) Interaction within the game, (2) Immersion level, (3) User participation, and (4) Photorealism of the environment.

The AR application for Android devices will be created using the Unity game-engine and the ARCore platform, while for iOS devices, ARKit will be combined with the Unity game-engine. Those powerful tools will provide the application with useful user interfaces that will be utilized to contribute to an interactive AR-tour to the historical center of the city.

The VR environments will be designed using Unity 3D. This cross-platform game-engine creates scenes consisting of various objects and defines the interaction of objects with one another, with the environment, and with the player, while the photo-realistic scenes will provide the desired level of immersion. Within the environments, the user will be able to interact with 3D objects related to the chosen biographer and his personal story.

The archeological findings from the graves like vessels, figurines jewelry, and the archaeo-anthropological research, are a crucial and interesting part of the story. These could provide valuable information about the communities, the individuals, and the observed social inequalities. The user will extract the desired information from these objects that will be digitalized using 3D modeling tools like Cinema 4D to recreate decayed findings, or the photogrammetry technique for intact preserved objects.

3 Discussion

This methodology could be adopted by researchers who are searching for a way to communicate their research outcomes to a wider audience through SGs technology.

Finally, due to the fact that the project is currently in progress, there are several steps regarding the future work. The most crucial part is the user experience and gained knowledge evaluation through a distributed post-game questionnaire, which is the most popular method for documenting the users' prior and gained knowledge (Catalano 2014).

4 References

Derfoufi, Mehdi. 2019. "Archaeology and the Archaeologist on Screen." In "Masters" and "Natives" , 255-287.

Wilkinson, Phil. 2016. "A Brief History of Serious Games" Entertainment Computing and Serious Games, (Springer) 17–41. https://doi.org/10.1007/978-3-319-46152-6_2

Catalano, Chiara Eva, Angelo Marco Luccini, and Michela Mortara. 2014. "Guide-lines for an Effective Design of Serious Games". International Journal of Serious Games 1 (1). https://doi.org/10.17083/ijsg.v1i1.8.

147. Transforming the Archaeological Record Into a Digital Playground: a Critical Analysis of The Living Hill Project

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The use of digital applications has been an essential tool to help archaeologists in the study of archaeological sites and records, and in the last decades, it has also provided new methods of use (AR, VR, video games), able to fascinate new audiences and therefore promote the heritage of a territory. In recent years, the academic community, including archaeology professionals, has shown great interest in the relationship between digital games, research, education, and outreach. As pointed out by Erik Champion (2015), these digital products offer a learning potential through tools focused on non-textual visualization, in addition to their ability to convey stories and meanings.

The path, especially in Italy where these topics are still in the experimental stage, hasn't been easy due to a severe amount of compelling issues: first of all the tendency of academics to consider commercial products as a belittling form of knowledge; secondary the common misconception towards video games and interactive entertainment, in general, that has always been viewed as a somewhat childish pastime; thirdly, one of the most obvious problems is that archaeologists are often ignorant of the dynamic of the commercial interactive industry. However, the recent development of institutionalized Public Archaeology programs has had the potential not only to face the interactive entertainment industry's increasing encroachment into archaeology but also to change the sentiments that many archaeologists hold toward interactive entertainment.

In this regard, this paper aims at presenting a video game project, The Living Hill, dedicated to the excavation site located on the Poggio Imperiale hill of Poggibonsi (Siena, Italy) which has been an emblematic case study for digital application to an archaeological project since its initial phases in the 1990s and the case study chosen to experiment with new dissemination methodologies such as VR and gaming applied to archaeological heritage in the last two years (Bertoldi and Mariotti 2022). The Living Hill was developed starting from the scientific results of the Poggibonsi excavation and through the collaboration between academia and industry in the framework of a project whose aim was the digital enhancement of the archaeological heritage on the site. What is extraordinary in this case study is the nature of the archaeological context (spanning from Late Antiquity to the First Renaissance period) and the very clear intentions in terms of public outreach and technological experimentation that characterized the excavation project since the earliest approaches.

At the beginning f the project and after many years of research and interpretations a major issue had to be addressed: how can complex archaeological data (often referred to small and negative evidence and poorly preserved structures) be used in a video game to engage a broad range of public and learners in accessible ways?

The workflow adopted for the video game project started with a 3D survey of the hill through the use of a drone and the subsequent elaboration of the photographs in Agisoft Metashape to obtain the model of the terrain and the correct position of archaeological evidence. Next, the three-dimensional modelling of the three levels scenarios (dedicated respectively to the Early Medieval village, the Late Medieval castle and the Early Renaissance fortress), characters, buildings, and objects was carried out using the Blender software. At the same time a deep study of the dense and specialized historical and archaeological literature related to the archaeological record, finds, and historical sources allowed the writing of the narrative, the multiple-choice dialogues between the characters, and the additional information that players can access at their discretion. The narrative framework storyline was developed on the basis of a major quest. To solve the quest, players are encouraged to freely explore the space and interact with other characters. Finally, scenes and interactions were programmed using the Unity 3D software.

The project wanted to explore the acknowledged benefits of a gaming experience and put them at the service of archaeological heritage enhancement purposes: video games are e a potential for public outreach and education because they can strongly motivate learners and create awareness about a topic; they can also provide immersive environments where a large variety of users can practice knowledge and skills in an engaging way since the thrill of discovery and exploration combined with the opportunity to relive the past is something that appeals both on an instinctive and emotional level; moreover, they can be used as an asset to promote tourism and sustainable cultural heritage development.

However, many issues also emerged and needed to be critically addressed during the two years of development. They involved: the need to remodel the project due to the Covid-19 pandemic that affected the activities' timeline and the planned users' involvement; the level of accuracy (Copplestone 2017; Di Giuseppantonio Di Franco, Galeazzi, and Vassallo 2018) in both 3D reconstructions and narrative design: the initial strategy adopted for the modelling of the scenario in Unity 3D software; the management of the file size that led to the creation of a double version (pc and mobile devices) but affected the processing and the release time of the game.

Entering Archaeogaming's second decade, it is, therefore, necessary to reflect on the possibilities presented by this tool at the convergence between the production of academic and scientific knowledge (specifically, the interpretations and representations of the past and its material culture) and specific practices of development of these games guided by interdisciplinarity.

References

Bertoldi, Stefano, and Samanta Mariotti, eds. 2022. The Past as a Digital Playground. Archaeology, Virtual Reality and Video Games. Oxford: Archaeopress.

Champion, Erik. 2015. Critical gaming: interactive history and virtual heritage. Surrey: Ashgate.

Copplestone, Tara Jane. 2017. "But that's not accurate: the differing perceptions of accuracy in cultural-heritage videogames between creators, consumers and critics". Rethinking History, 21(3): 415-438

Di Giuseppantonio Di Franco, Paola, Fabrizio Galeazzi, and Valentina Vassallo, eds. 2018. Authenticity and cultural heritage in the age of 3D digital reproductions. Cambridge: McDonald Institute for Archaeological Research.

317. Archaeology And Technology: The Development Of An Archaeogame

Amanda Pina, University of São Paulo

This research made part of a doctoral thesis in Archaeology under development at the Museum of Archaeology and Ethnology at the University of São Paulo in Brazil and has the support of Leiden University in the Netherlands. The work exposed here evolves the creation of a tridimensional simulator for students in the last years of elementary school and the first years of high school who want to learn concepts about Archaeology and Heritage in a playful way. It is based on specialized bibliography on Archaeogaming and Cyberarcheology, in addition to having photographic databases of archaeological sites. These resources will be necessary for the creation of a learning tool characterized by a product marked as an "archaeogame". The principal purpose of this research is the development of a tridimensional simulator both in your bibliographic and practical parts. The result will be the combination of research and model approaches that can offer new parameters for archaeological interpretation and application of teaching strategies.

Technology can be considered one of the significant impacts of the change of habits in contemporary society. Electronic and technological devices can be found in abundance in everyone's daily life. It can't be different if we talk about video games. Data demonstrate that this industry is one of the most rentable in the market, trespassing the cinema segment. According to Newzoo, a specialist in videogame analysis and marketing research, the ten biggest videogame companies generated a revenue of 126 billion dollars in 2021. Newzoo expects an increase of at least 2.1% for 2022, with an estimated 196 billion dollars of revenue. This number is the result of a booming industry and directly affects the strategies developed by decision-makers, both inside and outside the market.

What is the reflection of technologies on professions? How will technology impact archaeological work? Archaeologists cannot just stick to the vestiges of the past, it is necessary to insert this professional in areas related to technology (Morgan, 2016).

One of the ways to insert the archeologist in this niche is based on the making of electronic games aimed at education. Teaching and informing about heritage and Archeology cannot be limited to writing scientific articles and academic books. It is known that the public does not have access to these works, therefore, spreading this knowledge is a valuable strategy for reaching qualified and scientific information, translated into simpler terms and in an interactive way.

It is proposed in this work the creation of an interactive simulator (an archaeogame), developed by Blender and Unity software. For its making, it will be necessary to listen to students and teachers, both from public and private schools, in the North and Southeast of Brazil, to improve the intrinsic and extrinsic characteristics of the game produced. The semi-structured interviews will have a qualitative emphasis on analysis and will consider an anthropological approach, using ethnographic concepts aimed at making the digital game allied to Archaeogaming (Reinhard, 2018).

Based on archaeogaming, it is necessary to exemplify the archaeological study of digital games. The VALUE Foundation is an excellent example of how to apply archaeogaming studies both in an academic context and for audiences outside the academy, aiming to democratize access to the different types of knowledge produced through science with the use of new technologies (Mol, Ariese & Politopoulos, 2017).

Methodologically, the research will be divided into three parts: 1) Theoretical: presentation of the concepts of Archaeogaming, Cyberarcheology, and Digital Archeology; 2) Interviews: transcription and analysis of semi-structured qualitative interviews with free and paid schools in the North (Belém – PA) and Southeast (São Paulo – SP) of Brazil; and 3) Practice: the creation of the archaeological simulator, which will be developed based on a database of images recovered from archaeological sites, combined with Blender (version 3.2.1) and Unity.

Through the assistance of the CAPES (Coordination for the Improvement of Higher Education Personnel) funding agency in Brazil, through the Sandwich Doctorate Program Abroad, part of this research will be carried out at Leiden University, located in the Netherlands. The Leiden University laboratories and spaces will provide both the physical apparatus and updated theoretical references on Digital Archeology and Archaeogaming. The use of innovative technology through hi-tech equipment will be essential for the development of this research. In addition to access, theoretical and technical deepening on the operation of specific programs to develop digital products is necessary.

For the development, the computer programs Blender 3.2.1 and Unity will be used. Initially, it will be a digital program aimed at cell phones (IOS and Android), later being able to be adapted for the web (PC). It will be in 3D (three-dimensional) and will not have ultra-realistic graphics, given the scope of the program to the cellular devices that will run it. The chosen format will probably be lowpoly, which consists of reducing the existing number of polygons for greater optimization and better functioning for devices that do not need a lot of power to run the program.

It is worth mentioning that the idea of the product may (and probably will) undergo some changes, because of the result of the analysis of the interviews and the opinions generated by teachers and students.

This research will deal with a topic related to an unconventional archaeological praxis; therefore, I believe it is an even more fruitful field for the debate of ideas and methodologies (Reinhard, 2018). The small sketch proposed here is the embryo of a discussion about how technologies can impact both the discussions focused on the field of Archeology and the field of Heritage, with a practical example to be developed (the interactive simulator - or archaeogame). Thinking wildly is opening doors to a critical, analytical, and disruptive look. This is doing Archeology, it is knowing the past, and it is shaping the future.

REFERENCES

Reinhard, A. 2018. Archaeogaming: An Introduction to Archaeology in and of Video Games. Oxford: Berghahn Books.

Morgan, C. 2016. Video Games and Archaeology. The SAA Archaeological Record, 16(5): 9-10.

Mol, A; Ariese, C; Politopoulos, A. 2017. The Interactive Past: A book on archaeology and videogames. Sidestone Press, Leiden.

60. Assessing digital methods of communicating archaeological research to the public: storytelling, interaction and immersion

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Introduction

Archaeologists are keen to try digital media and cutting-edge technology to study the past or to present their research to the wider public. Digital archaeology is an established field of archaeology usually focused on using digital technology to study or communicate the past (Morgan 2022). Interactivity and immersion along with archaeological storytelling are often used to create digital heritage experiences, such as Virtual Reality (VR) installations, to communicate archaeological research to the public and to attract more visitors to the museums and cultural institutions. However, the suitability, limitations, and results of these techniques have not been widely assessed and discussed, neither has the overall relationship between digital archaeology and public engagement (Richardson 2018).

In this paper I will present my current doctoral research, where I am looking into different media and techniques of communicating archaeological research. The aim of my research is to assess the impact and implications of the use of different forms of archaeological storytelling in communicating archaeological research to the wider public. In addition, I am examining whether and to what degree can an archaeologist employ such digital tools to communicate their research without hiring professionals, undergoing long training, or using extra funds. Finally, I want to assess which digital tools would offer the best options for archaeologists to develop such heritage experience.

For this reason, I have looked into two widely used digital media: videogames and VR. Archaeogaming and games in archaeology in general is an established and growing field (Politopoulos and Mol 2021), while VR has already been used in some museum settings.

Methods and Materials

A key aspect of my research is that archaeologists can create such media themselves, thus I am trying to test how feasible it is for an archaeologist to create meaningful and impactful stories using digital techniques and media. As such, I have created the media that I am using for this research myself: a textual story, an interactive story which has more game-like characteristics and is based on interaction of the user with the medium using Twine, and an 3D version of the story in VR which takes advantage of the immersion element rather than interaction or passive reading of a text.

The case study that the story is based on is a Bronze Age cemetery in Mycenae, in South Greece, the so-called 'Grave Circle A' (GCA). I have attempted to recreate the life and death of the individual MYC1V from the grave number five of the GCA based on recent osteological reports, archaeological data from the excavation, as well as artefacts and materials from the Bronze Age and the Homeric epics.

Lastly, an important aspect of the project is to contribute to the decolonisation of the history of the excavations and discuss the immense effort and work of an important Greek archaeologist, Panayiotis Stamatakis, who was appointed by the Greek government to supervise the excavations in Mycenae conducted by Heinrich Schliemann in the 19th century.

In order to study the impact of the stories and to assess whether and in what degree the research questions were covered, I have created an experiment as an assessing methodology which combines qualitative and qualitative research tools;

The experiment made use of groups of individuals across three different countries: the UK, Malta, and Greece.

The design of the experiment is focused on assessing any previous knowledge on the subject via pre-questionnaires, as well as the knowledge obtained after the experience via post-questionnaires. The quantitative data from the questionnaires were processed using Qualtrics and analysed using Excel. Moreover, qualitative data have also been collected during follow up interviews with the individuals, which will also be analysed and studied using Thematic and Discourse Analyses. Hence, the final datasets are a combination of quantitative and qualitative data aiming to help to better understand the impact of the stories as well as to answer the research questions.

Results and Implications

As this is still an ongoing research the data are currently under analysis. However, the study will be completed by January, and as such I aim to present and discuss the complete results during the CAA conference in April.

References:

Morgan, Colleen. 2022. "Current Digital Archaeology". Annual Review of Anthropology 51: 213-231. https://doi.org/10.1146/annurev-anthro-041320-114101.

Politopoulos, Aris, and Angus Mol. 2021. "Video Games as Concepts and Experiences of the Past." In Virtual Heritage: A Guide, edited by Erik Malcolm Champion, 81-91. London: Ubiquity Press.

Richardson, Lorna-Jane. 2018. "Ethical Challenges in Digital Public Archaeology". Journal of Computer Applications in Archaeology, no. 1: 64–73. http://doi.org/10.5334/jcaa.13.

184. Gamifying Ancient Transcaucasia: Prototyping the Creation of Digital Cultural Heritage

Robert C Bryant, UPenn

Gamification, in general, has the potential to transform how we typically use archaeological data (Bryant 2015). Archaeological works sitting idly in digital repositories, physical archives, and academic journals rarely promote true public access to information, and are not usually built with the goal of praxis and civic engagement in mind.

John Doe from Hahira, Georgia in the U.S. or Elvin Aliyev from Dize, Naxchivan may not be interested in scouring a complex database of archaeological material to ask research questions. They might, however, be interested in the data if it is made more accessible through a gamified experience that promotes and rewards behavioral engagement and learning. Games and entertainment have had a generally childish, negative connotation, yet they are increasingly becoming a predominant focus of economic and social behavior in the 21st century (McGonigal 2011). Understanding why games and gaming increasingly intersect with social-economic and political interaction is key to leveraging game play within the humanities.

Can a simple game using this growing body of digital data problematize ongoing political and cultural arguments over cultural heritage? Furthermore–can it also provide access to the definition and creation of that heritage to stakeholder groups typically left out of these discourses? I believe this can be achieved through the roleplaying scaffolding within a game where a player is allowed to follow their bias of the ancient past and watch how those biases play out in their decisions within the game world as they confront the reality of the contextual data we have: the ceramic traditions, the climate, the environment, interregional warfare, massive shifts in demographics, and sudden changes in the exploitation of the ancient landscape through time. Confrontations with bias in the non-judgmental context of a game are not intended to indoctrinate players into a set narrative, but rather encourage them to explore their own narrative through their interactions with this distant world, and through that exploration, form both a mental and digital form of cultural heritage.

This paper will explore my own research on this application of games within archaeology, while also sharing on-going work on the creation of an "Archaeo-Game" that gamifies the ancient Bronze and Iron Ages of Transcaucasia. This region serves as useful scaffolding for this project, because it was an ever shifting mélange of human settlement patterns and ideas through time and space (Smith and Rubinson 2003), and this rich fabric asks the potential player to contribute to its diversity with their own experiences, rather than define it simply within the bounds of a textbook or through the established political discourse. Its ancient positionality at the center of several cultural shifts–from the Early Bronze Kura-Araxes period to the warring Urartian and Neo-Assyrian Empires in the Iron Age(Smith and Rubinson 2003), and finally to the center of a contested space within the modern political reality involving Iran, Turkey, Armenia, Georgia, and Azerbaijan–offers a foundation to build an engaging, gamified experience for players to attempt to replicate their ancient success or failure against the changing nodal influences surrounding them, as well as explore, learn, and challenge pre-existing notions of political borders and problematize the efficacy of cultural heritage-bound demarcations in the landscape used in the past as well as in modern political discourse.

The player is expected to engage with the archaeological record and historical materials to attempt to predict as best as possible how they should develop their small settlement in a simplified and familiar turn-based strategy genre of gaming, e.g., Civilization, albeit not as expansive. Making this process 'fun' is the primary goal of the engagement. The player will be provided with an opportunity through indirect engagement with other players to add their experiences. Because player accomplishments and engagements will be stored in a low cost online database, they can then be asynchronously redirected to indirectly interact with other players in their own gameplay. For example, one player may discover a mine in the hills that another player has discovered in a previous run of the game, and they would be presented with information left by that player–perhaps an omen of what not to do by a non-player character or erected stelae and why.

An ever expanding list of these indirect player interactions will be integral to the co-production of narratives across the landscape. The gamification of these indirect engagements remains the goal of the project: to create a context for moderated interaction between anonymous players to discuss the landscape through player generated and established archaeological content outside the lens of modern political boundaries. This style of indirect engagement has been popularized by modern games from FromSoft, such as the Dark Souls series or Elden Ring, where players are allowed to leave cryptic, humorous, concise, or intentionally misleading information to other players within a predetermined textual scaffolding. Different groups of players choosing different settlements, for example, may choose to align themselves as ephemeral factions to influence other players who choose other starting settlements in order to promote their own success on planned leaderboards. The ability for players to vote positively or negatively on these textual engagements provides motivation to engage with the system if rewards for highly rated player generated interactions are provided.

This paper's primary aim is to help in the overall discussion over gamification and its promotion in archaeology, and its secondary aims are to provide insights from my own work in understanding another example of how it can be applied to our field, and graciously receive any feedback from peers on what aspects of the project seem fruitful, and which are potential deadends or pitfalls.

Bryant, Robert, "The Atlanta Phoenix Project: Applications of Gamification for Online Civic Engagement." M.A. Thesis, Georgia State University, 2015.

McGonigal, J. 2012. Reality is Broken: Why Games Make Us Better and How They Can Change the World. London: Vintage.

Smith, Adam T and Karen Sydney Rubinson. 2003. Archaeology in the Borderlands : Investigations in Caucasia and Beyond. Los Angeles: Cotsen Institute of Archaeology University of California.

211. Performing Glencoe - Creative Digital Archaeology and the Living Landscape

Elizabeth Robertson, University of Glasgow

Building on areas of game design, sound design and sensory archaeology studies, in this paper I will present some of the methodologies I've been developing and my creative practice as a digital archaeologist. The setting and subject of my research has been Glencoe in the Scottish Highlands. Through the use of immersive, interactive soundscapes, my research is about creating new forms of interaction with Scottish Highland landscapes through their archaeological, historical and geographical dimensions. By creating and designing various immersive experiences, it is my aim to demonstrate how digital creativity can enhance an audience's experience of cultural heritage landscapes. These contemporary digital interventions can create a more nuanced interpretation of highland life.

Representations of the Scottish Highlands have often been subject to Romantic notions of the sublime – with landscapes being perceived as empty, wild, and rugged. Memorialised pasts have become the focus of many narratives about the Highland experience. Such perceptions have a tendency to overlook the archaeological past and present realities of Highland life, where landscapes were busy with the activity of human and non-human actors and supported a rich tradition of Gaelic language and culture. Using the Scottish audio archive collections on Tobar an Dualchais, as well as my own field-recordings and compositions, I've been creating sound works inspired by the archaeology of Glencoe. By placing/performing Gaelic voices back into these landscapes, its my aim to facilitate connections to place, folklore and the archaeology of the region for audiences.

Creative and innovative approaches to immersive experience and game design show exciting potential for the way we can engage people with archaeological and heritage. Work by Mona Bozdog has shown how elements of performance can be used to create experiences that hybridise game elements and exploration of heritage spaces, and the potential to play with the traditional boundaries of AR, VR and XR (Bozdog and Galloway 2020). In thinking about creating feelings of immersion, I've also been looking at the work of sound artists and those in the performing arts. The way that sound artists deal with spatiality when creating sound installations and other works can help us think about similar themes and connections when creating mixed and augmented reality-type experiences. Using landscapes as settings for these types of experiences has precedence in site-specific performance – a topic that has long been explored by archaeologists (Pearson and Shanks 2001).

Through the course of my PhD, I have been exploring the ways in which creative audio experiences, experiments and acoustic reconstructions can engage audiences with the past in emotional, meaningful ways. As part of this presentation, I will present three of these experiments – one a headphone-based, spatialised audio experience that is set in the remains of the post-medieval township of Achtriachtan; one an interactive sound installation based around some recently excavated shielings in Gleann Leac na Muidhe; the final one, a radio-based interactive experience around a 19th cent ruined cottage in Rannoch Moor.

For this headphone experience, I designed a prototype application in Unity that tracked the orientation of the user to provide a spatialised soundscape for the participant to explore. With spatialised audio becoming more accessible through consumer brands of headphones, I wanted to explore the potential of this in a heritage context. However, what I hope to demonstrate through this initial prototype is that creativity and storytelling remains highly integral in creating feelings of immersivity and presence.

In creating the interactive installation based at Gleann Leac na Muidhe, I used influences from interactive game design and sensory archaeological methodologies. Based on Hamilton et al's phenomenological methodologies, I've tried to understand the connections between shielings and associated structures through their inter-audibility from one another (2006). Not only can this provide interesting discussions about the role of community up in the summer pastures of early modern highland townships, but it has provided a key tool in designing these site-specific sound installations as well. Being able to understand how the landscape works to project/hide certain sounds from certain locations, I've been designing an interactive experience that will lead participants around the different structures. The side of the valley becomes the interface for the audience's immersive experience as they move around and place portable speakers in amongst the archaeology.

The third experience that I will discuss in the context of this talk is the radio-based interactive experience, trialled at both Achtriachtan and Rannoch Moor. This used aux-to-fm broadcasters attached to devices that were placed around the site in question. The devices played audio at a set frequency and participants were given a radio to walk around the site and discover the different parts of the sonic composition being broadcast. Following the same sort of functionality as a geo-located-type experience, the analogue element created an effective level of unpredictability that allowed for each performance to be unique, created by the relationship between participants, radio, and landscape.

Reflecting on where my research lies in the context of session – over the course of my studies in archaeology, I have been interested in the interdisciplinary nature of Archaeogaming, its use in heritage outreach, public engagement and interpretation of archaeology. Its emphasis on storytelling, immersion, and consideration of "realities" has shaped the current direction of my research, and I think there is exciting potential to further explore our interdisciplinary connections; to embrace our roles as digital creators and to bring our digital skills into other non-digital settings.

References

Bozdog, Mona, and Dayna Galloway. 2020. "Performing walking Sims: from Dear Esther to Inchcolm Project." Journal of Gaming and Virtual Worlds 12, no. 1 (March): 23-47. https://doi.org/10.1386/jgvw_00003_1

Hamilton, Sue, Ruth Whitehouse, Keri Brown, Pamela Combes, Edward Herring, and Mike S. Thomas. 2006. "Phenomenology in practice: towards a methodology for a 'subjective' approach." European journal of archaeology 9, no. 1 (January): 31-71. https://doi.org/10.1177/1461957107077704

Pearson, Mike, and Michael Shanks. 2001. Theatre/archaeology: Disciplinary Dialogues. London: Routledge.

91. Archaeology as Worldbuilding

Colleen Morgan, GB

Within fiction and game creation, worldbuilding is the act of integrating history, ecology, geology to bring an imaginary world to life. I argue that as archaeologists we are intimately involved in our own worldbuilding, using archaeological remains to try to understand past lives. We bring together environmental data, zooarchaeological assemblages, evidence of trade and foodways, osteobiographies, architectural remains, and all other textual and material traces to holistically generate tableaux, our own snapshots and postcards from the past. The characterisation of archaeological interpretation as worldbuilding stands in contrast to the ubiquitous trope of archaeologists as storytellers, those who weave a narrative with a beginning and end, motivated by specific actors or event. Further, when we build past worlds, we can invite others to play in this world, to be the multiple storytellers of the past.

In this paper I develop worldbuilding as a primary, critical mode of archaeological inquiry. I follow on from Tara Copplestone's (2017) work to argue that metaphors of game creation can be powerful heuristics for changing how we collect, consider and reuse archaeological data. As she argued, game developers "tended to describe the past as systems, interactions, agency, and multilinear narratives" (2017, 85). This is in contrast to archaeologists who describe the past as "physical things, linear narratives, and the known outcomes of a process (ibid). By shifting from storytelling approaches we can move away from grand narratives to craft open-ended past landscapes to think and play in. As such, archaeogaming has considerable potential to intersect with existing theory-laden archaeologies inspired by new materialism and posthumanism and perhaps lead toward a new digital imaginary. To think through the implications of this provocation, I examine my previous work with the OKAPI team in rebuilding Çatalhöyük in the virtual open world of Second Life (Morgan 2009) and in my current work in creating avatars based on bioarchaelogical evidence in the UKRI-funded OTHER EYES project (Morgan 2022). In both projects we generated virtual worlds from multiple strands of archaeological data for others to play and inhabit, to create their own stories. While stories emerged, they were plural and crafted by participants. As Politopoulos and Mol (in press) argue, "archaeogaming is about collectively making, exploring, and playing in this wild new, digital playground." By engaging in virtual world creation engendered by archaeologaming we think through archaeological data in new and exciting ways, but also leave room for others to intervene, play, and create their own stories inspired by the past.

Copplestone, T. J. (2017). Designing and developing a playful past in video games. The Interactive Past: Archaeology, Heritage & Video Games, 85–98.

Morgan, C. L. (2009). (Re)Building Çatalhöyük: Changing Virtual Reality in Archaeology. Archaeologies, 5(3), 468–487.

Morgan, C. (2022). Current Digital Archaeology. Annual Review of Anthropology. https://doi.org/10.1146/annurev-anthro-041320-114101

Politopoulos A. and A.A.A. Mol, in press. Critical Miss?: Archaeogaming as a Playful tool for archaeological research and outereach. In K. Lambers and T. Kalayci (eds.) Promises and Impasses of Digital Archaeology.

350. Gaming as a Guide to the Past Environments: A Gentle Assistance to Landscape Archaeology in Palaepaphos, Cyprus.

Efstratios Mavros, National and Kapodistrian University of Athens

In the last decades, landscape archaeology is an evolving area of archaeological research. More and more archaeologists turn to landscape archaeology to answer questions about the perception of the environment and the ways that people exploited it in the past and organized their societies. However, this kind of research has some serious problems to face. First of all, the non-ending change of environment and landscape, combined with the estranged relationship present people have with it. Urban landscape and way of life make it more difficult to understand the way people of past societies perceived the environment and tried to adapt to it. Luckily, most archaeologists during their studies have the opportunity to interact with non-urban landscapes and understand them better. This gap could be bridged thanks to Game development and Augmented reality.

Through gaming, people have the chance to experience landscapes and environments that are not so easily accessible in real life. People have the chance not only to observe them through a photo or even a 3D model but to interact with a drastic environment. Their choices, movement, and actions give them different outcomes and create different experiences. Strategy games specifically, combine ideally human action in a certain environment. The players can understand the main factors that cause a society to be developed, a settlement to be established, and an empire to be expanded.

This presentation aims to present the way that gaming could help a researcher, or a student complete his research. During my master's thesis, I did a spatial analysis of the site of Palaepaphos in western Cyprus from the Late Bronze Age to the end of the Roman Period. One of the many questions I had to answer is the reason why people chose Palaepaphos as the exact site to establish their long-live settlement. Strategy games like Age of Empires II, made me understand that certain demands have to be fulfilled, while building and organizing a settlement. These demands can be separated into two different tiers. The basic tier is the one that ensures the survival of the population. This tier includes sufficient water and food resources. The second tier includes tributary -although basic- advantages, such as the existence of natural fortifications, the exploitation of minerals or other resources, and the ability to control the land and the sea, that could bring prosperity, safety, and power to the settlement.

As proved through GIS analyses, Palaepaphos was an ideal position that fulfilled not only the basic demands, but its landscape allowed to become one major site, as many scholars support. Its adjacency to the sea, combined with the ground of the site, allows Palaepaphos to have immediate control of the SW seafront and coastline. Also, it has water sources and rich coastal alluvial fertile land. Slope analysis showed that the ground around Palaepaphos was very steep, making the site penetrable only from the south slopes, in which archaeologists found defensive wall structures. By combining the way of thinking used during the gameplay of a strategic game with the GIS and archaeological perspective and knowledge, one can understand the way people chose the best location for their establishment and the ways that they exploited the landscape and its benefits.

Gaming and AR are tools that can provide better visual information about archaeological research. It will be helpful to understand the differences in the landscape not only on a theoretical level but also through an interactive environment. Another chance that those tools can provide is easy access to a controlled environment based on each demand. For example, it will be easier if any researcher has easy access to a VR environment or landscape that he/she wants to study than to travel there. Also, it will be safer for them, in case of dangerous places, harsh weather conditions, and inaccessible places. All those, are the reasons that landscape archaeology has to combine its benefits with gaming and give all this piece of information that gaming needs to be accurate and real-life based. Landscape archaeologists who are using new methods of studying the environment and landscapes such as remote sensing, orthophotos of wide areas, 3D modeling, and GIS tools, have to think about sharing those data with game developers to make a real-life based game which will be great for the next generations to understand their landscape and its evolutions through time.

References:

Hanussek, Benjamin. "Designing the Past (Together): On the Gaming Industry's Contribution to Archaeology and What We Can Contribute to the Gaming Industry." Proceedings of the 24th International Conference on Cultural Heritage and New Technologies, 2021.

Mol A., Ariese C.E. and Politopoulos A.: The Interactive Past Archaeology Heritage and Video Games, 2017.

Mavros E., Spatial Analysis of Palaepaphos Archaeological Site from Late Bronze Age to the Late Roman Period, MA Thesis, Forthcoming.

201. Archives (Not) Of Our Own: Procedurally Generating Object Biographies

Florence Smith Nicholls, Queen Mary University of London

Context

The field of archaeogaming has been notoriously hard to define, straddling reception studies, ethics, game development and digital fieldwork. A considerable bibliography of work under the 'archaeogaming' brand has explored how the past has been represented in the video game medium, but somewhat less work has been conducted on the creation of games from an archaeological perspective. In this talk, we will demonstrate how we modified a game with procedural content generation in order to highlight the inherent subjectivity of archaeological interpretation, specifically through object biographies.

Broadly speaking, procedural content generation is the creation of content algorithmically, as opposed to by hand. It is a technique with broad applications in the game industry, often cited as a way to create a large amount of content or enhance the replayability of a game through unpredictable outcomes. Rather than simply engaging with procedural generation as a way to automate content creation, we are interested in what Mark Johnson calls qualitative procedural generation (2016); generating abstract concepts like religion that in turn affect the material culture of a virtual world. Johnson is the developer of Ultima Ratio Regum, a game which procedurally generates the culture of its game world at both the macro and micro scale.

The term object biography has been used in archaeology to refer to the practice of tracing an artefact's life cycle through its interactions with people and other objects. The concept has gained traction since the 1980s, and more recently has been employed to counter linear narratives of artefact history and to understand the management of poorly documented museum collections. Linking back with video games, there are several examples of games which arguably have procedurally generated object biographies, such as Caves of Qud and Dwarf Fortress. Like Ultima Ratio Regum, both simulate the histories of their fantasy worlds, including artefacts.

This paper presents a system description of the short game Nothing Beside Remains (Cook 2018), modified by the author to include procedurally generated object biographies. Nothing Beside Remains simulates a ruined village that has been destroyed by one of three factors: predators, environmental factors or overpopulation. The material culture generated in the village reflects these stressors. The game has no fail state, instead encouraging exploration and interpretation by the player. Though there has been archaeogaming research into the recording of procedurally generated content, to the author's knowledge, no games have been developed by archaeologists which engage with the affordances of procedural generation to create object biographies.

Argument

This paper argues that the affordances of procedural generation allow for productive reflection on simulating the archaeological record. As mentioned above, one feature of procedural generation is randomness, though within set parameters. This controlled randomness is analogous to the analogue archaeological record which may be subject to known disturbance or environmental factors, but which is unlikely to be predicted in its entirety prior to analysis. In short, procedurally generated object biographies allow for an exploration of archaeology as process. The argument that the video game medium can affect how we construct archaeological knowledge builds on Tara Copplestone's chapter "Designing and Developing a Playful Past in Games", in which she states "video games have the potential to not just be viewed as a tool or an entertainment medium to be tacked on after all the research has been done, but as a part of the process itself" (Copplestone 2017, 95).

This paper also argues that the development of games such as Nothing Beside Remains explores the inherent subjectivity of archaeological interpretation. Our modified game mechanises subjectivity through different player 'classes', such as a tourist or curator, who each have different perspectives on the material culture encountered in the game. Furthermore, the textual descriptions generated for objects function as unreliable narration. Objects become actors with their own perspectives on events.

Implications

This research forms part of a wider doctoral project on "generative archaeology games", a term coined by the author to refer to games with procedurally generated material culture that a player interprets to understand past events. The wider implications of this research involve future user studies into how players react to and interpret the procedurally generated content in Nothing Beside Remains.

This paper also functions as a call for archaeogaming and computational archaeology to engage more with video game development as a creative practice. There is great potential for future collaborations between game developers, narrative designers, computer scientists and archaeogamers, who are all in one way or another rewriting the procedural rhetoric of video games.

References

Cook, Mike. 2018. "Nothing Beside Remains." itch.io. Online game. https://www.possibilityspace.org/nbr/

Copplestone, Tara. 2017. "Designing and Developing a Playful Past in Video-Games." In The Interactive Past, edited by Csilla E. Ariese-Vandemeulebroucke, Krijn H.J. Boom, Bram van den Hout, Angus A.A. Mol, and Aris Politopoulos, 85-97. Sidestone Press.

Johnson, Mark R. 2016. "Towards qualitative procedural generation." Computation Creativity and Games Workshop.

59. The Chaînes that Bind Us: Why the Chaîne Opératoire is Not Enough for Digital Artefacts

Katie M Biittner, MacEwan University
John Aycock, University of Calgary

Digital artefacts like video games present theoretical challenges to traditional archaeological frameworks. For example, a game programmer does not directly create the video game the player experiences; the programmer crafts instructions for the computer to create the video game experience. Even this process is not direct because multiple software tools and code libraries may be involved that are themselves digital artefacts. Grappling with the complexity and levels of indirection involved demands updated archaeological thinking.

Here we focus on the chaîne opératoire, a concept introduced to archaeology by André Leroi-Gourhan (1964) as a sequence of operations from acquiring and preparing raw materials through to finishing a product. Adapted from the works of French sociologists and cultural anthropologists, the chaîne opératoire was adopted by archaeologists – largely those studying lithics – and ethnoarchaeologists as a framework for approaching the study of technologies. Through the use of the chaîne opératoire, archaeologists have captured not only the operational sequence involving the transformation of raw materials into objects but addressed the technological knowledge and technological choices that affect other social behaviours and result in artefacts that transmit cultural knowledge (Lemmonier 1993). The use of this approach also signalled a shift away from focusing on the style or function of artefacts and on linear sequences of production towards developing artefact biographies and agency-based approaches. Today the chaîne opératoire sees varied applications including those that step beyond the materiality of artefacts, and while broad usage of the chaîne opératoire demonstrates its utility and strengths, there are known limitations to the approach.

Applying the chaîne opératoire to archaeogaming, in particular, leaves us with many questions. For example: How do we use it for technologies comprised of or containing immaterial or digital culture, instead of only material culture? How can the chaîne opératoire be used for a technology where the concepts of a singular archaeological site or of a tangible raw material are restrictive? How do we address the contextual limitations of digital artefacts that exist in no singular physical "place" but across often innumerable disks and in a variety of versions and formats? How should archaeogamers capture the non-linear interrelationship between the digital and the material, i.e., how can we address the interconnected chaînes of code and computer? What does it mean to have artefacts that exist in a context that is neither systemic nor archaeological, but both? Our response to these questions is to propose an adaptation of the chaîne opératoire that addresses its limitations with respect to digital artefacts in the broader praxis of archaeogaming. This revision to the chaîne opératoire follows Buob et al. (2019) who argue that the model's strength is in how it allows for shared notions of technological organization and modes of documentation and representation of it, but who caution against applying it without adjustment. Our model permits an adjustment of the chaînes that currently bind our analysis of digital games and which serve as a barrier to further development of theory in and of archaeogaming.

Our new model is illustrated using case studies drawn from the analysis of video game code - wherein we define code as the raw material of digital artefacts. Our model redefines the core subsystems of the chaîne opératoire to address the complex interplay of the digital with the material (the hardware, the paratext) in the video game technological system. It distinguishes the various forms of communication, inputs and outputs, and technological knowledge that are part of the design, implementation, and use of digital games.

REFERENCES:

Buob, B., Chevallier, D., and Gosselain, O. 2019. Technographies: Dans la trousse a outlis de celles et ceux qui travaillent sur la technique. Techniques & Culture 71:10-25.

Lemonnier, P. (ed.). 1993. Technological Choices. Transformation in Material Cultures Since the Neolithic. London and New York: Routledge.

Leroi-Gourhan, A. 1964. Le Geste et la Parole I - Technique et Langage. Paris: Albin Michel.

215. Playing for high stakes. Archaeogaming and the deconstruction of populist conservative appropriations of the past

Mara Visonà, University of Salento - Lecce
Vincenzo Idone Cassone, Ritsumeikan University - Kyoto

PREMISE

Over the last two decades, a combination of social, political and economical factors are driving the rise of the far-right and conservative movements and parties. Despite the different socio-political contexts across the world and their different characteristics, these political realities have several elements in common, and amongst them the use of propaganda that constantly employs instrumental (and distorted) use of historical, archaeological and anthropological arguments and narratives in order to legitimize and support extremely conservative social policies (Hoffman et al. 2021).

While this kind of rhetoric is not new, as it was already employed in the totalitarian regimes of the 20th century, it has recently gained traction and has become relevant in its relationships with the new forms of communication and media.

Not surprisingly, game studies and historical disciplines, over the course of twenty years, have reflected the sociocultural dynamics involved in the representation/interaction with the past in ludic settings (Kapell and Elliott 2013), highlighting two inter-related dimensions:

Several studies pointed out how many games involved in the representation of the past end up (more or less explicitly) reiterating colonialist, nationalist or capitalist dynamics, by means of game narratives and gameplay dynamics (e.g.: focus on exploiting resources, accumulating goods, war against other nations etc);

Many studies showed the potential of games in subverting and/or critically approaching the medium itself, historical narrations, as well as the potential of interactive ludic systems to communicate the dynamics of the past to a different audience, in a systemic and engaging way.

The rise of populist narratives based on assumed historical arguments in the ludic medium has a potential high impact on society; for this reason it is particularly relevant for the present (and future) debate on the archaeogaming. On the one hand, it is linked to the already existing investigations into the representation of archaeology and the use of its findings; on the other, to its belief that the ludic medium may make people get closer to historical and cultural heritage topics, promoting engagement and awareness of the past in its many forms, help in reducing the gap between scientific community and the broader public (Moll et al. 2017).

In light of the above-mentioned insights, it seems possible and useful to develop the debate on the ludic appropriations of the past in archaeogaming, by focusing on the (relatively unexplored) discussion on the potential of archaeogaming for addressing and deconstructing populist and conservative propaganda.

OBJECTIVES AND METHODS

Our proposal plans to reflect on the potential for archaeogaming to deconstruct the populist conservative appropriations of the past, by focusing on the relationships between archaeological and historical contents, game dynamics, and conservative populist rhetoric.

This is done under the belief that the ludic medium is increasingly relevant for the communication, awareness and engagement of present and future generations, and that certain representations of the past in the medium may be easily (mis)used by populist propaganda to diffuse their reinterpretations of past events.

To do so, the proposal will compare the well-known dynamics of conservative populist reinterpretation of the past, with examples of game dynamics and narratives that may facilitate those rhetorics, or viceversa that can be used to deconstruct or contrast them.

In relation to the former, the common elements of far-right propaganda have been identified as: the centrality of religious sentiment, the ancestral bond between the community and national territory, patriotism, social conservatism and the strict division of gender roles. These elements are proposed as universal values based on assumed historicity and traditionality. The past is thus reconstructed according to two related dynamics:

1. The coexistence and syncretism of elements and phenomena that are chronologically very distant from each other (such as the coexistence of a pagan and neo-pagan symbology of protohistoric Italo-Celtic origin with the Christian Catholic faith, as in the case of the Lega Nord in Italy);

2. A monolithic and static vision of the past and of social structures, seen as universal and immutable (supporting, for example, the 'nuclear family' model as universal or refusing the idea of the current societies as the result of a long-term cultural and ethnical hybridisation).

The perspective of a past thus reconstructed is then used to support the preservation of social structures seen as the direct heritage of a 'natural' order, universally recognized by all 'civilized' human communities and unchanged over time.

In relation to the latter, the analysis will focus around three main topics, which frames and interpret game dynamics and narrative in terms of archaeology key concepts:

1. Evenementiality: on the one hand, games may represent past peoples, lands, and fragments of cultures only in terms of histoire evenementielle (e.g. representing only well known historical characters, events and cultures), which may favour a nationalist, top-down perspective on the past as the never-ending history of national development. On the other hand, game dynamics provide the possibility to represent and act as voiceless subjects of history (e.g. marginalised groups), as well as to simulate long-term historical development of groups or of the environment, moving away from the "foundational" moments of History;

2. Resources and materiality: recurrent game systems often provide only functional models of interaction with the landscape, other human groups, or the past itself, translating everything into game resources (e.g. looting and resource exploitation, goods accumulation) used for the national development. These dynamics not only reiterates colonialists rhetorics, but the populist belief of identity as owning (place, people, cultural heritage) itself. Beside that, games have also developed forms of play not based on resources accumulation, that de-functionalise the past and its traces, and disconnect it from the logic of accumulation;

3. Historical development: many games risk presenting the historical development of societies in terms of linear and necessary progress, flattened on the rhetorics of Western scientific development, as well as the narratives of National development as a necessary conflict between us and them. Simultaneously, historical simulations may also provide forms of systemic counterfactualism, providing explorations of alternative historical developments, as well as representing the dynamic identities shifting and changes in the groups and collectives over time.

References

Hofmann, Daniela, Emily Hanscam, Martin Furholt, Martin Bača, Samantha S. Reiter, Alessandro Vanzetti, Kostas Kotsakis, et al. 2021. Forum: Populism, Identity Politics, and the Archaeology of Europe. European Journal of Archaeology 24, Nr. 4: 519–555. https://doi.org/10.1017/eaa.2021.29, .

Kapell, Matthew Wilhelm, and Andrew BR Elliott, eds. 2013. Playing with the past: Digital games and the simulation of history. Bloomsbury Publishing USA.

Mol, Angus A.A., Csilla E. Ariese-Vandemeulebroucke, Krijn H.J. Boom and Aris Politopoulos, eds. 2017. The interactive past: Archaeology, heritage & video games. Sidestone Press.

8. The unwritten presence of emotions in archaeological research and their future in archaeo-gaming.

Luca Ottonello, University of Glasgow

Introduction:

Emotion is an integral part of the human experience and is therefore present in archaeology and history, as these disciplines study humans as well as things. It is surprising, therefore, that there is little work on emotion within archaeological scholarship. Its limited treatment within digital archaeology is particularly striking because much digital work in archaeology involves images and interactions, and these creative and artistic media are often designed to provoke emotions, or their reception is emotional.

Research by Katifori et al. 2019 (EMOTIVE Project) identifies the importance of emotion in archaeological storytelling. There is a wider range of research (e.g., work by Tringham, Morgan, and Watterson) that addresses the role of emotion in storytelling indirectly, but where it is not a central or explicit focus of the research. However, none of this research investigates in detail how the design of visual storytelling provokes emotions in the people who engage with it.

This paper presents an investigation of the implicit role of emotion in the work of different practitioners active in archaeological research as they designed their storytelling media. Through an analysis of published literature and media, together with author and creator interviews, it demonstrates that emotion is a key element in the work of both researchers and practitioners, even when they do not intentionally and directly discuss it.

Methods and materials:

To discover how practitioners implicitly work with emotion in mind, I began by critically reviewing several pieces of research focussed on emotive contexts such as "Avatars, Monsters and Machines" by Morgan (2019), where the emotive association to the avatar representing the user and the emotional attachment to the physical characteristics of the avatar itself transcended the actual physical user's looks, or the emotive empathy described by Perry, exploring the way in which people experience history distinguished from the emotionally limited and controlled way professionals in archaeology describe it.

I then identified unexplored aspects of work on emotions described in the literature, such as the decision to simply describe emotional reactions without any attempt to try an explain the reasons behind them, or aspects about negative emotions that seemed to be avoided completely in fear of the difficulty of exploring emotions such as fear, suffering and despair.

I also identified areas where there were emotional elements which were partly explained but not fully engaged and explored in context of design decisions and motivations behind the development of the projects in question, such as the intricate area of nostalgia. In some instances, more difficult emotions may have been treated in the study, but did not take center stage in the published analysis or the final publications.

I contacted authors of published work, and asked them to identify areas that needed clarification or were important for understanding the role of emotions in their work but were not further investigated. Several semi-structured interviews with a selection of these authors were subsequently conducted. These interviews involved eight researchers, interviewed for approximately one hour each.

The in depth nature of these interviews generated a large pool of data, despite the limited number of interviewees. Several analytical techniques were considered and narrative analysis was chosen to focus on the most salient parts of the interview and to restructure their content in the context of emotion. Framework analysis (familiarization; identifying a thematic framework; indexing; charting; and mapping and interpretation) was also used to further structure and organise the interview data. This allowed me to identify key issues and areas of interest within the narrative and make a well-defined interpretation.

Results:

The analysis of the interviews revealed that emotion played a central role in how the practitioners interviewed carried out their work. A range of emotions were raised through the interviews. Nostalgia, frustration, and regret were prominent in their influence, rather than simple reactions such as fear, hate, or anger. This initial finding prompted further investigation into the role of these multi-faceted emotions.

Further analysis showed how these complex emotions often combine or integrate other emotions, for example, the mixture of nostalgia, regret, and frustration, and can be a product of previous experiences.

The analysis also highlighted how practitioners used the emotional references associated with a range of media, such as literature, film, game design, and art, to convey emotion, because archaeological media lacked the tools to convey the emotional aspects of visual media.

The approach used here, combining analysis of practitioner interviews and critical reading of literature, allows us to better understand the importance of emotive presence "behind the curtains" of all research done incorporating digital depictions in archaeology.

Discussion and implications for future practice:

The results of this research should have wide-ranging effects on the way archaeology sees emotion and the design of digital media, encouraging more attention to it. This is not to say that realism and accurate data should be disregarded, but that interpretations are constantly shifting and there is space for emotions and feelings in the very human process of interpreting the past.

In particular, despite their unpredictability and unreliability, emotions can and should be used to enhance the storytelling and create more realistic and immersive environments using digital technology in archaeology.

To do so requires a shift from emphasis on precision to affording fuller immersion, including emotional engagement. This step-change requires not only accepting emotions as part of archaeology but welcoming yet more multidisciplinary approaches to the archaeological mix, such as media studies, creative writing, and sociology, to generate new approaches, building on established ones across multiple fields.

References:

Katifori, Akrivi. Roussou, Maria. Perry, Sara. Drettakis, George. Vizcay, Sebastien. Philip, Julien. Palma, Gianpaolo. 2019. The EMOTIVE Project – Emotive Virtual Cultural Experiences through Personalized Storytelling. CIRA@EuroMed 2018. Ireland: IEEE.

Morgan, Colleen. 2019. Avatars, Monsters, and Machines: A Cyborg Archaeology. European Journal of Archaeology. 22(3).

Watterson, Alice. 2014. Engaging with the Visual: Re-Thinking Interpretive Archaeological Visualisation. Digital design studio: Glasgow School of Art.

294. Cultural Gaming in the Metaverse: what potentialities for future applications?

Margo Lengua, Entertainment Game Apps, Ltd.
Michela De Bernardin, Istituto Italiano di Tecnologia

Video games development, meant as a tool for enhancing cultural heritage through game design strategies with specific educational and narrative objectives, is one of the modern digital technologies commonly applied to cultural heritage. Conceptually, the gaming experience can vary from simple to complex: from video games conceived for smartphones/tablets to applications installed directly in the museums to experiences exploiting gaming elements in virtual environments.

Over time, the digital gaming language has shown great effectiveness in achieving valorisation purposes by developing new and interesting interpretations of cultural heritage, tailored for the target audience (Georgopoulos et al. 2017). The ever-increasing versatility and performativity of gaming software and technologies disclose various new possibilities for experimentation in heritage enhancement. As a matter of fact, the power of gaming technologies in virtual production is leading to their adoption in multiple fields and today, it represents a pivotal element in the development of the metaverse (Ivanova and Watson 2021). This perspective makes researchers and developers explore new relationships between the processes of interactive gaming related to cultural heritage and the potentialities of the metaverse.

This paper will analyse the main features of the video games recently developed with the purpose of cultural heritage valorisation by several software companies specialized in the field. Then, by contrast, it will outline the potential digital applications of the advanced virtual world of the metaverse, highlighting novelties, such as the interoperability of multiple elements, the special focus on social interactions, the connection and persistence of the metaverse, and the essential role of the user within it.

The work will then aim to evaluate how the characteristics of the metaverse can represent a tool for the development of new experiences of cultural heritage enhancement through interactive forms of participation, digital community, sharing, learning, and exchanging. This field also opens up to future experiments that overcome the limits of physical places connected to the “traditional” video games (for example, the links to museums’ itineraries), which usually do not entail the direct participation of the users in their creation.

Finally, the research will focus on the potential limits of the metaverse embedded in the cultural panorama, especially for its economic structure which can represent an obstacle to the implementation of sustainable initiatives for public cultural institutions.

References

Georgopoulos, A., Kontogianni, G., Koutsaftis, C. and Skamantzari, M. 2017. “Serious Games at the Service of Cultural Heritage and Tourism.” In Tourism, Culture and Heritage in a Smart Economy edited by V. Katsoni, A. Upadhya and A. Stratigea. Springer: Springer Proceedings in Business and Economics. https://doi.org/10.1007/978-3-319-47732-9_1

Ivanova, V. and Watson, K. 2021. Future Art Ecosystems: Art x Metaverse, Londra: Serpentine Gallery.

Ball, Matthew. “The Metaverse: What It Is, Where to Find it, and Who Will Build It.” Matthew Ball Webpage. 1 December 2021, https://www.matthewball.vc/all/themetaverse.

15. Reproducing, Reusing, and Revising Code and Data in Archaeology

James R. Allison, Brigham Young University
Sophie C. Schmidt Berlin Graduate School of Ancient Studies, Freie Universität Berlin
Florian Thiery M.Sc., Römisch-Germanisches Zentralmuseum, Department of Scientific Computing and Research Software Engineering, Mainz, Germany

Location: E107

This session aims at evaluating how reproducible research in archaeology is actually faring. It has been argued that reproducible research techniques such as publishing and sharing code as well as data speed up scientific progress (Marwick 2017, Schmidt & Marwick 2020). With the FAIR movement and the rise of (Linked) Open Data approaches there seem to be more and more archaeological data sets available. Code used for archaeological analysis is also increasingly published online. There are a growing number of openly available code examples that have been used for articles (see for R https://github.com/benmarwick/ctv-archaeology, or for Netlogo https://www.comses.net/codebases/?query=archaeology). In some cases, this shared code may be adapted into "little helpers", small modules of research software, aka Little Minions (Thiery et al. 2021), that can be reused and individually adapted. The community of Research Software Engineers (RSE), people who create software applications for research, is growing. For better dissemination of these programs, they created the FAIR4RS principles (Hong et al. 2022). RSEs are fighting for scientific recognition by e.g. implementing the CFF format to cite software (Anzt et al. 2020). But despite this general progress, published articles reusing or adapting open data or code are rare in archaeology. It is difficult to assess how often code and data are reused for research, but the rate of reuse appears to be low (Huggett 2018, Marwick and Birch 2018). Open data and code may be reused more often for teaching (Cook et al. 2018, Gartski 2022, Marwick et al. 2019), but it is not clear how often this happens. In this session we would like to ask the following questions

- How often does it happen that archaeologists try to reproduce each others' analysis, or borrow code from each other?
- Can fruitful examples be shown?
- Are there examples of replication or reproduction of analyses failing?
- Which techniques are needed to successfully reuse data and code from other persons – on the side of the provider as well as the reuser (forking, data papers, ...) ?
- Are these methods taught to students and how are they taught?
- What reproducibility techniques should be focused on in the future?
- What problems arise in trying to re-use data (not just tabular, but also eg 3D and geophysical data)

By discussing these topics we want to encourage the re-use of openly available data sets and published code in archaeology. We particularly welcome papers that reuse or adapt openly available code to analyze new datasets, or papers that reanalyze existing open data in new ways. We would very much like to see contributions that generate open code to replicate previous analyses or create newly open data sets from existing data that is currently difficult to access (e.g., data found only in printed tables in reports or articles). Papers that examine the use of open data and code in teaching are also very welcome. We hope to fuel a debate about the usefulness and worthwhileness of creating open data and code. Reproducibility needs to be evaluated not just from a theoretical viewpoint but also in practice.

References:

Anzt H., Bach F., Druskat S. et al. (2021). An Environment for Sustainable Research Software in Germany and Beyond: Current State, Open Challenges, and Call for Action [version 2; peer review: 2 approved]. F1000Research, 9:295 (https://doi.org/10.12688/f1000research.23224.2)

Chue Hong, N. P., Katz, D. S., Barker, M., Lamprecht, A-L, Martinez, C., Psomopoulos, F. E., Harrow, J., Castro, L. J., Gruenpeter, M., Martinez, P. A., Honeyman, T., et al. (2022). FAIR Principles for Research Software version 1.0. (FAIR4RS Principles v1.0). Research Data Alliance. DOI: https://doi.org/10.15497/RDA00068

Cook, K., Çakirlar, C., Goddard, T., DeMuth, R. C., and Wells, J. (2018). Teaching Open Science: Published Data and Digital Literacy in Archaeology Classrooms. Advances in Archaeological Practice, 6(2), 144–156. DOI: https://doi.org/10.1017/aap.2018.5

Garstki, K. (2022). Teaching for Data Reuse and Working toward Digital Literacy in Archaeology. Advances in Archaeological Practice, 10(2), 177-186. DOI: https://doi.org/10.1017/aap.2022.3

Huggett, J. (2018). Reuse Remix Recycle: Repurposing Archaeological Digital Data. Advances in Archaeological Practice, 6(2), 93-104. DOI: https://doi.org/10.1017/aap.2018.1

Marwick, B. (2017). Computational reproducibility in archaeological research: Basic principles and a case study of their implementation. Journal of Archaeological Method and Theory 24(2), 424-450. http://doi.org/10.1007/s10816-015-9272-9

Marwick, B., & Birch, S. (2018). A Standard for the Scholarly Citation of Archaeological Data as an Incentive to Data Sharing. Advances in Archaeological Practice 1-19, https://doi.org/10.1017/aap.2018.3

Marwick, B., Wang, L.-Y., Robinson, R., & Loiselle, H. (2019). How to Use Replication Assignments for Teaching Integrity in Empirical Archaeology. Advances in Archaeological Practice, 1–9. https://doi.org/10.1017/aap.2019.38

Schmidt, S. C., & Marwick, B. (2020). Tool-Driven Revolutions in Archaeological Science. Journal of Computer Applications in Archaeology, 3(1), 18–32. DOI: http://doi.org/10.5334/jcaa.29

F. Thiery, Visser, R. & Mennenga, M. (2021). Little Minions in Archaeology: An Open Space for RSE Software and Small Scripts in Digital Archaeology. SORSE – International Series of Online Research Software Events (SORSE), virtual. DOI: https://doi.org/10.5281/zenodo.4575168

SLOT 1	
08:30 - 08:50	188. Statistics, Data, and the History of the New Archaeology *James R Allison (Brigham Young University)**
08:50 - 09:10	197. Percolation Package - From script sharing to package publication *Sophie C. Schmidt (Free University Berlin)*; Simon Maddison (University College London)*
09:10 - 09:30	204. XRONOS: a global open repository enhancing reproducible research with chronometric data *Martin Hinz (CH)*; Joe Roe (University of Bern)*
09:30 - 09:50	276. Detection of Temporal Changes of the Omega House at the Athenian Agora *Antigoni Panagiotopoulou (Information Management Systems Institute, Athena Research Center); Lemonia Ragia (Hellenic Open University); Dorina Moullou (GR)*; Colin Wallace (University of Waterloo)*
09:50 - 10:10	232. Implementing a Database and Information System in a Heavily Heterogeneous Research Data Environment *Steffen Strohm (Kiel University)**
10:10 - 10:30	127. Efforts and outcomes to making the ROAD database reusable *Christian Sommer (Heidelberg Academy of Sciences and Humanities)*; Volker Hochschild (Uni Tübingen)*

SLOT 2	
11:00 - 11:20	370. An Example of Data Integration Using the ArchaMap Application *Robert Bischoff (Arizona State University)*; Matthew Peeples (Arizona State University); Daniel Hruschka (Arizona State University)*
11:20 - 11:40	154. OpenHistoryMap - A case of reuse and refactoring *Silvia Bernardoni (Open History Map); Lucia Marsicano (Open History Map); Marco Montanari (Open History Map)*; Raffaele Trojanis (Open History Map)*
11:40 - 12:00	13. Citizen science supports megalithic research - virtual reconstructions through old photographs *Louise Tharandt (University of Cologne)**
12:00 - 12:20	50. PyREnArA – Spatio-temporal analysis of artefact morphology with multivariate approaches *Robin John (University of Cologne – Department of Prehistoric Archaeology)*; Florian Linsel (Martin Luther University of Halle-Wittenberg, Institute of Computer Science); Hubert Mara (MLU - Instiut für Informatik); Georg Roth (Freie Universität Berlin – Institute of Prehistoric Archaeology); Isabell Schmidt (University of Cologne – Department of Prehistoric Archaeology); Andreas Maier (Universität zu Köln)*

188. Statistics, Data, and the History of the New Archaeology

James R Allison, Brigham Young University

Beginning in the 1960s, archaeologists associated with the "New Archaeology" movement published several important studies using multivariate statistics. The best known of these (Binford and Binford 1966; Hill 1970; Longacre 1970) examined topics as diverse as identifying Paleolithic toolkits, inferring kinship systems from the intrasite distribution of painted design elements on ceramics, or the distribution of ceramic types.

The publications by Binford and Binford, Hill, and Longacre were important in setting the theoretical agenda for the New Archaeology. Along with several slightly earlier, but less-known studies they are among the earliest attempts to use multivariate statistics in archaeology, and the authors strongly promoted methods they used (mainly factor analysis and multiple regression).

These studies predate the open science movement by several decades, but in most cases the authors did try to make their data available for other researchers by publishing data in tabular form. Sometimes the published data tables include all the information necessary to try to replicate the analyses, but in most cases the data are incomplete or not organized in the same way as in the published analysis. Even where the data are complete, they are not in digital format, making reanalysis difficult. Even though the data from these studies have great importance to the history of the New Archaeology movement in general, as well as the history of the turn towards quantitative methodology that accompanied the New Archaeology, they have not been generally available.

My paper reports on a project to better understand these early uses of multivariate analyses statistics in archaeology by recovering as much of the data as possible, compiling and organizing that data, reanalyzing it, and making it openly available for research and teaching. Making the data available for reanalysis by researchers using modern methods (correspondence analysis, for instance, which is better suited to the artifact count data used than either factor analysis or multiple regression) promises to reveal new insights about the successes and failures of these foundational studies.

Assembling the data has required starting with data tables and graphs in the original publications, then tracing back through earlier publications, unpublished doctoral dissertations, museum archives, and the Archives of Archaeology (an early attempt at open data publication and preservation originally on microfiche, images of which are now available on tDAR). Most, but probably not all, of the data is recoverable, but the search is ongoing.

References

Binford, Lewis R., and Sally R. Binford. 1966. "A Preliminary Analysis of Functional Variability in the Mousterian of Levallois Facies." American Anthropologist 68 (2): 238–95.

Hill, James N. 1970. Broken K Pueblo: Prehistoric Social Organization in the American Southwest. Anthropological Papers of the University of Arizona 18. Tucson: University of Arizona Press.

Longacre, William A. 1970. Archaeology as Anthropology; a Case Study. Anthropological Papers of the University of Arizona 17. Tucson: University of Arizona Press.

204. XRONOS: a global open repository enhancing reproducible research with chronometric data

Martin Hinz, CH
Joe Roe, University of Bern

Radiocarbon data has been at the forefront of archaeologists' recent embrace of open data and open science. Comprehensive compilations of radiocarbon dates have become available for many parts of the world in the last decade and, as natural next step, there are now several initiatives to collate this data globally, including the retrieval tool c14bazAAR (Schmid, Seidensticker, and Hinz 2019), the IntChron exchange format (Bronk Ramsey et al. 2019), and the synthetic database p3kc14 (Bird et al. 2022). Here, building on a complementing these initiatives, we present XRONOS <https://xronos.ch>: a new web-based platform for chronometric data from archaeological contexts worldwide, combin- ing an open data repository with tools for importing, curating and analysing chronometric information from diverse sources. The development of XRONOS has raised a number of challenges. Conventions for sharing radiocarbon data are relatively well-established, but integrating other classes of chronological information—dendrochronology, typochronology, Bayesian priors, etc.—demands a more sophisticated technical infrastructure. The scale of the dataset, and our aim of "one date, one record", also requires new systems for the continuous ingestion, synthesis and curation of data from multiple sources; systems that should be scientifically robust and sustainable in the long term. Finally, beyond the technical, we must acknowledge several ethical and practical limitations on the how 'open' archaeological data can be, building tools that respect these limits, but also continue to foster an appreciation of the ethical imperatives for data-sharing within our discipline. In this talk, we present our progress towards meeting this challenges in the development of XRONOS so far, and invite discussion with the community of practioners who produce, compile, and use chronometric data on the future direction of the project.

Bird, Darcy, Lux Miranda, Marc Vander Linden, Erick Robinson, R. Kyle Bocinsky, Chris Nicholson, José M. Capriles, et al. 2022. "p3k14c, a Synthetic Global Database of Archaeological Radiocarbon Dates." Scientific Data 9 (1): 27. https://doi.org/10.1038/s41597-022-01118-7.

Bronk Ramsey, Christopher, Maarten Blaauw, Rebecca Kearney, and Richard A Staff. 2019. "The Importance of Open Access to Chronological Information: The IntChron Initiative." Radiocarbon 61 (5): 1121–31. https://doi.org/10. 1017/RDC.2019.21.

Schmid, Clemens, Dirk Seidensticker, and Martin Hinz. 2019. "c14bazAAR: An R Package for Downloading and Preparing C14 Dates from Different Source Databases." Journal of Open Source Software 4 (43): 1914. https: //doi.org/10.21105/joss.01914.

276. Detection of Temporal Changes of the Omega House at the Athenian Agora

Antigoni Panagiotopoulou, Information Management Systems Institute, Athena Research Center
Lemonia Ragia, Hellenic Open University
Dorina Moullou, GR
Colin Wallace, University of Waterloo

This work is presenting the role of 3D visualization and analysis of monuments and archaeological sites in producing useful data for regarding their preservation condition. The progress made in 3D digitization technologies, in combination with finding new data processing algorithms, have enabled reliable and highly detailed digitization of the characteristics of different parts of the monuments. Due to both the effects of nature and human intervention, monuments and sites all over the world have changed over time. The use of analog documentation data can help significantly towards this direction. In this work, we use as case study a luxurious residential complex in the Athenian Agora, known as Omega house. We use a retrospective 3D model, created with photographs taken in the late 60's and early 70's, in comparison with a 3D model made with contemporary digital photos, taken in 2017.All models are georeferenced. The old model is produced using analog terrestrial photographs and aerial photos taken by a blimp. The new one is created by terrestrial digital photographs in combination with images taken by unmanned aerial vehicle commonly known as a drone. The 3D models have been divided into smaller parts so that we can analyze them with greater accuracy separately, and then the whole models were compared between them too. The Constructive Solid Geometry (CSG) modeling scheme is used and Boolean operations are applied to find the difference and intersection of the models. The comparison that is carried out in the current work elaborates on legacy data usefulness and utility for monitoring the Omega House condition. The type of investigation proposed in this work proves that legacy data can be repurposed and attain a new role through change detection techniques.

232. Implementing a Database and Information System in a Heavily Heterogeneous Research Data Environment

Steffen Strohm, Kiel University

Recent advances in digital technologies provide researchers with powerful means to improve and accelerate their research activity by sharing and fusing their data and results effectively. However, new technologies often add new layers of complexity that need to be dealt with. Otherwise, using these tools and approaches becomes impractical for every day research. In the context of larger interdisciplinary projects, challenges on the single project level are enriched with additional issues only occurring in collaborative work. Among other things, these challenges arise from different perspectives, vocabularies, and the need for a common understanding. This work focusses on the technical implications for data management and analysis.

Within the Collaborative Research Center 1266 "Scales of Transformation", researchers from various domains such as archaeology, archaeobotany, biology, ecology, geophysics, geography, computer science and more aim to provide research data to maintain reproducible research workflows and satisfy today's FAIR requirements by implementing an information system called LandMan.

While planning and implementing the system, a rich variety of challenges in project management, every day processes, data quality, data organization, data sparsity and data fusion occurred. Combined with a socio-technical perspective on the process of developing and implementing the LandMan repository and data integration system, specific examples of research in geophysics, archaeology and others will be used to illustrate present and upcoming challenges.

In the overall process a significant shift from a full integration goal towards a more practical solution had to be undertaken to align the system with scientific work requirements and ensure its usability. The current goals of the system will be compared to other existing systems to provide a broader picture of the usability constraints appearing.

Based on the DAMA Data Management Framework a modified approach will be presented, where aspects less relevant to the archaeological research data environment are deprioritized and domain specific characteristics like data sparsity are added. This systematic approach will be linked to other example solutions of archaeology-focused CRCs to evaluate their FAIR solutions with respect to the DAMA framework.

Final questions this implementation process is working towards are: Who is the audience of this? Which people should be addressed here? Who is a part of the solution to implement FAIR principles in a reproducible research workflow? What are the limits of interdisciplinary or transdisciplinary work between computer scientists and archaeologists? These will be tackled - and to the degree possible answered - with the exemplary data analyses, reproducible workflows and socio-technical design constraints in mind.

DAMA International. 2017. DAMA-DMBOK: Data Management Body of Knowledge (2nd Edition). Technics Publications, LLC, Denville, NJ, USA.

Marwick, Ben. 2017. "Computational Reproducibility in Archaeological Research: Basic Principles and a Case Study of Their Implementation." J Archaeol Method Theory 24, 424–450 (2017). https://doi.org/10.1007/s10816-015-9272-9.

Renz, Matthias, Strohm, Steffen, Kempf, Michael, and Nakoinz, Oliver. 2022. „Cross Domain Fusion in der Archäologie – Interview mit Dr. Michael Kempf und Prof. Dr. Oliver Nakoinz". Informatik Spektrum (2022). https://doi.org/10.1007/s00287-022-01488-7.

Willmes, Christian. 2016. "CRC806-Database: A semantic e-Science infrastructure for an interdisciplinary research centre". Dissertation, Universität zu Köln.

127. Efforts and outcomes to making the ROAD database reusable

Christian Sommer, Heidelberg Academy of Sciences and Humanities
Volker Hochschild, Uni Tübingen

We present our long-term experiences of (1) structuring and filling an interdisciplinary database about prehistory sourced from literature, (2) redirecting this database after 10 years to the FAIR principles, and (3) report some positive and sometimes unexpected cases of reuse that have evolved since.

The research project "The Role of Culture in Early Expansions of Humans" (ROCEEH, www.roceeh.net/) aims to develop a systemic understanding of the process to become "human" in Africa and Eurasia in the time frame from 20 thousand to 3 million years before present. As a long-term project, funded between 2008 and 2027 by the Heidelberg Academy of Sciences and Humanities, it has the necessary capacities to experiment, develop methods and assemble time-intensive datasets. But it also requires to go with fast-paced developments in science and IT.

The ROCEEH Out of Africa Database (ROAD) is at the core of the project and aims to address two challenges in the current research landscape. One is to enable a holistic and interdisciplinary view on prehistoric life by integrating archaeological, paleoanthropological, paleofaunal, palynological and geographical information in a common place. The process took about two years, during which the scientists exchanged concepts, taxonomies and structures of their diverse disciplines in order to develop a synthesis that could be formalized and implemented as a database model. The other challenge is to combine legacy data from diverse sources of literature with existing databases. More than 4,600 publications (comprising articles, books, theses, excavation reports and own research) in more than ten languages were manually screened by the project members and student assistants to excerpt relevant information. From the archaeological side, these include e.g. geographical coordinates of sites, stratigraphic layers, chronometric dates, archaeological finds, taxonomic interpretations, etc.. The use of forms for data entry and self-developed thesauri helped to do this in a systematic way and review circles ensure data quality. As a result, information about more than 2,200 archaeological sites with more than 20,000 archaeological assemblages were digitalized and are now available in a structured and machine-actionable way. Furthermore, the project developed tools to retrieve data through SQL queries, visualize results together with auxiliary data in a web GIS, perform time series analysis and export handy, human-readable site portraits. All are available through the user interface at www.roceeh.uni-tuebingen.de/roadweb/.

During the project's lifetime, developments like the Panton Principles, FAIR Principles and Open Science revolutionized scientific practice. These concepts were also taken up by ROCEEH and from 2018, ROAD was expanded and in some cases readjusted. A major step was a cooperation starting 2020 with the ARIADNE+ project (https://ariadne-infrastructure.eu/), which had already gained experience as a data aggregator and served frameworks for standardization. We extended our SQL database through a RDF triple store, mapped relevant information to ARIADNE+ using the Getty Arts and Architecture Thesaurus (https://www.getty.edu/research/tools/vocabularies/aat/) and Periodo (https://perio.do). As a result, considerable parts of ROAD are available in a standardized ontology and findable through the ARIADNE Portal (https://portal.ariadne-infrastructure.eu/). As another step to promote the reuse of ROAD, we replaced the former, rather restrictive license with an open CC By-SA 4.0 license. Furthermore, the use of ROAD is taught in regular workshops, conferences and seminars. This has not only broadened the user base, but also allowed us to invite international scientists to complete the database. Nevertheless, there are open challenges, like the standardization of paleolithic data beyond the granularity of ARIADNE's data scheme, a deeper integration into linked open data and the long-term maintenance of ROCEEH's research environment after project funding.

These efforts made ROAD more accessible and visible to the scientific community and resulted in a number of collaborations and scientific publications covering fields like prehistoric demography (Schmidt et al., 2021), lithic studies (Archer, 2021), the emergence of ochre use or past human-environment interactions. A form of reuse that reached a public audience was the exhibition "Being human" at the archaeological museum of Frankfurt (https://www.na-verlag.de/programm/n/nh/nht/nhtb/being-human/). One of the main attractions was a digital table, where visitors could explore the spread of ancient human species or cultures through a touch-enabled digital map sourced through ROAD. In another attempt to inform the public, we feed interactive web maps into prehistory-related sites on Wikipedia (e.g. https://en.wikipedia.org/wiki/Uluzzian). The web map engine called "Kartograph" allows to display customized GeoJSON files exported from ROAD to Wikimedia Commons. And finally, we highlight a creative way of reuse that resulted from the cultural hackathon "Coding da Vinci". Florian Diller created a computer game, where you can explore human origins by flying over the African landscape (https://www.roceeh.uni-tuebingen.de/cdv/TimeFlies/).

We summarize that the development of our database in the sense of FAIR principles was time-consuming and sometimes seen as a burden in the beginning. Since data stewardship was still unusual at that time, all project members had to familiarize themselves with aspects of data management that were previously foreign to them. However, through the involvement of all participants, a democratic consensus could be reached that strengthens the further sustainable development of the project. Furthermore, we could increase our scientific network considerably and thus hosted a virtual conference entitled "Human Origins – Digital Future" in 2020 (Kandel et al., 2022), that brought many people together that supported us on this way.

Archer, W. (2021). Carrying capacity, population density and the later Pleistocene expression of backed artefact manufacturing traditions in Africa. Philosophical Transactions of the Royal Society B: Biological Sciences, 376(1816), 20190716. https://doi.org/10.1098/rstb.2019.0716

Kandel, A. W., Haidle, M. N., & Sommer, C. (Eds.). (2022). Human Origins – Digital Future: An International Conference about the Future of Archaeological and Paleoanthropological Databases. Propylaeum. https://doi.org/10.11588/PROPYLAEUM.882

Schmidt, I., Hilpert, J., Kretschmer, I., Peters, R., Broich, M., Schiesberg, S., Vogels, O., Wendt, K. P., Zimmermann, A., & Maier, A. (2021). Approaching prehistoric demography: Proxies, scales and scope of the Cologne Protocol in European contexts. Philosophical Transactions of the Royal Society B: Biological Sciences, 376(1816), 20190714. https://doi.org/10.1098/rstb.2019.0714

370. An Example of Data Integration Using the ArchaMap Application

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Matthew Peeples, Arizona State University
Daniel Hruschka, Arizona State University

Introduction

Archaeological data are complicated and rarely highly standardized between projects. Using data from multiple sources often requires a time-consuming and difficult process of mapping data ontologies, categories, recording schema, and contextual information among projects manually. This work is error prone, and it is difficult to document substantive decisions and translations made. In this paper we present ArchaMap, an open-source tool designed to aid in the integration of multiple complex data sets with different sources, data ontologies, and resolutions. ArchaMap is an R Shiny Application and graphical user interface designed to save time, increase consistency, and document complex data merging processes among multiple sources. Importantly, this online platform stores and suggests past translations to build an ever-expanding list of associations to aid in connecting categorical data across different sources. In this paper, we use data from two large projects conducted simultaneously around Roosevelt Lake, Arizona (Roosevelt Community Development Project [Doelle et al. 1992] and Roosevelt Platform Mound Study [Rice 1998]) to demonstrate the tremendous time-saving potential for standardizations of material culture data. These projects were conducted in the same region at the same time, but they were conducted by different institutions with different procedures and data structures, so the data have not previously been compatible.

Methods and materials

ArchaMap uses previously uploaded categories to build a database of potential category names and includes contextual information to help users find the appropriate match. For example, a generic pottery type named Unclassified Black-on-white could match several types of pottery. It would not be appropriate to combine these pottery types. However, by including hierarchical classifications to ceramic wares and including basic location information, the user has enough information to determine which of several identical names is the appropriate match.

The following is a summary of the process:

7. Access the application at https://catmapper.org/archamap
8. Select the TRANSLATE CATEGORIES option
    a. Upload the categories that need to be matched to existing categories in ArchaMap
    b. Select the appropriate properties and search
    c. Confirm the correct matches and correct any errors
9. Once the categories have been translated to match ArchaMap's category names, then select UPLOAD TRANSLATION
    d. The user logs in (required to track changes made to the database itself)
    e. Appropriate metadata on the dataset and categories being uploaded are collected (of note are any unique keys the dataset uses to identify a category, if none exist then the name of the category is used)
    f. The dataset is uploaded to ArchaMap
10. Once all datasets to be merged are uploaded the user selects the MERGE option and selects the desired datasets

g. Once the datasets are chosen, this function returns all necessary information to merge the datasets

This process can be repeated to translate and merge as many datasets as required. An important note is that ArchaMap is not designed to store information about the categories (such as how many ceramic sherds are found at a site). This will be stored with the original dataset. What ArchaMap is designed to do is to store how datasets connect to each other. This is done by translating the terms used in each dataset into a common ID. Each unique category is given an ArchaMapID and ArchaMapName that can be referred to. With this common ID and the unique name or key for each dataset, common merges (i.e., joins) can be done in Excel, R, Python, SPSS, Stata or whichever tool is preferred. Future upgrades of ArchaMap will provide additional tools to aid this process.

The following categories are integrated in this case study:

- Site designations
- Ceramics
- Chipped stone
- Shell
- Fauna
- Ground Stone
- Macrobotanical

Results

Table 1. Example of Integrated Ceramic Categories from Roosevelt Platform Mound Study (RPMS) and Roosevelt Community Development Study (RCDS)

ArchaMapName	ArchaMapID	RPMS	RCDS
Black Mesa Black-on-white	21734	Black Mesa B/W	Black Mesa Black-on-white
Casa Grande Red-on-buff	21095	Casa Grande R/buff	CasaGrande Red-on-buff
Cedar Creek Polychrome	21829	Cedar Creek Poly	Cedar Creek Polychrome
Chevelon Black-on-white	20998	Chevelon B/W	
Cibola White Ware, Undifferentiated	20743	Cibola White Ware	Cibola Whiteware
Flagstaff Black-on-white	21738	Flagstaff B/W	
Fourmile Polychrome	21831	Fourmile Poly	Fourmile Polychrome
Gila Black-on-red	21516	Gila B/R	Gila Black-on-red
Gila/Tonto Polychrome	21519	Gila or Tonto Poly	
Gila Polychrome	21517	Gila Poly	Gila Polychrome

Gila Butte/Santa Cruz/Sacaton Red-on-buff	21124	Hohokam Buff Ware	

Table 1 shows the results of several ceramic categories integrated between the two studies. Not all ceramic categories had corresponding types. This is a simple data integration, as the names are easy to recognize and not much expertise is needed; however, a computer would struggle to make the merge even using string distance matching due to the many abbreviations used. There are a total of 99 ceramic categories between the two databases. Manually translating the categories and double checking the translations took approximately 15 minutes. The same process using ArchaMap with a manual checking of each category took only 5 minutes. This same process provides significant time-savings for each harmonized category, and a 66% reduction in time with large datasets is a substantial savings in time, and with each dataset added, matching further improves.

Conclusion

ArchaMap provides substantial savings in time for integrating datasets. Furthermore, every dataset that is integrated provides additional alternate names to further improve matching and provides a permanent record showing how the datasets were integrated. This follows open science principles and reduces work for future researchers. An additional benefit is that each category is linked to a dataset. ArchaMap has an explore feature that allows users to find categories through a full text search and then identify all datasets that use that category. This can help tie datasets whether they be publications, online datasets, or archived collections.

References

Doelle, William H., Henry D. Wallace, Mark D. Elson, and Douglas B. Craig 1992 Research Design for the Roosevelt Community Development Study. Vol. Anthropological Papers ,12. Center for Desert Archaeology, Tucson, Arizona.

Rice, Glen E. (editor) 1998 A Synthesis of Tonto Basin Prehistory: The Roosevelt Archaeology Studies, 1989 to 1998. Roosevelt Monograph Series 10 Anthropological Field Studies 40. Arizona State University, Office of Cultural Resource Management, Dept. of Anthropology, Tempe.

154. OpenHistoryMap - A case of reuse and refactoring

Silvia Bernardoni, Open History Map
Lucia Marsicano, Open History Map
Marco Montanari, Open History Map
Raffaele Trojanis, Open History Map

OpenHistoryMap is a project that tires to reuse, normalize and reorganize public and research data in order to create a navigable and explorable map of the past. This opens a whole lot of issues in data quality, data availability and research depth on several dimensions. For this reason in the last 5 years we have been working on several indexes exploring the various measures that a single dataset can have, but also on the other main vector for the creation of data quality: Processes. The processes we started defining are based around the software development processes and publicly available data repositories, such as Github and Zenodo, and on the usage of (at most, slightly more expressive but still completely compatible) standards, both on a data format level (csv, geojson, tsv) as well as a data structure level, where available (GTFS, GTFS-RIDE, OSRM, OSM). This simplifies the reuse of the data in several processes, both in research and in education.

197. Percolation Package - From script sharing to package publication

Sophie C. Schmidt, Free University Berlin
Simon Maddison, University College London

In this paper we will trace the development of an R-package starting with the adaptation of code from a different field, via scripts shared between colleagues, to a published package that is being used by researchers world-wide.

The percolation package (Maddison and Schmidt 2020) evolved from work undertaken at UCL by Simon on the distribution of Hillforts, seeking an approach to identify regional groupings independent of geographical and political boundaries of any period. Percolation Analysis provided a conceptually simple approach and had recently been used in geography by Elsa Arcaute at UCL for identifying urban density through road junctions (Arcaute, E., Molinero, C., Hatna, E. et al. 2016). This had been adopted within the Institute of Archaeology for identifying clusters of Domesday settlements in England, and from that was taken up for the study of Hillforts. The geographical work was undertaken using a C program to efficiently manage the very large databases involved. Elsa kindly produced a simple program in R that could be readily adapted and developed for the exploratory work on other, smaller archaeological datasets. This adapted program suite was written to be readily used by others and the work was published and presented at various conferences, where it caught Sophie’s interest for a project she was working on.

A meeting of the co-authors at the CAA 2018 conference in Tübingen spurred the next phase in development of the package. Simon shared his four scripts with Sophie, who was able to re-use the code to analyse her own data. At this point the code had some comments and a three page description that enabled an understanding of the program within a couple of hours. In re-using the code on a dataset of a very different geographic scale, some problems arose that needed to be addressed in order to extend the program's range of application. During the next two years a paper was prepared, in which the performance of the code applied to differing data sets and in comparison to different clustering methods was evaluated. During this time, versions of the R scripts were sent between the collaborators via email, while at the same time documented via Git and private GitHub on Sophie's side; this was released upon publication of the package and a paper in JCAA in 2020 (https://github.com/SCSchmidt/percopackage). For publication of the code, the scripts were converted into functions and the R-package {percopackage} was developed. For the package the functions were properly documented with {roxygen2}, as well as an explanatory vignette and an example dataset added. An early version of the package was part of the peer-review of the paper and linked to the paper via an DOI derived from osf.io (https://osf.io/7extc/).

This process exemplifies how script sharing and co-creation "traditionally" works: A personal contact between researchers leads to a collaboration, in which different versions are emailed back and forth. The script adaptation for own use requires communication between the script author and the person implementing. In our case this led to a discussion of flexibility of input and use cases, which inspired the creation of the package. The package creation was a time costly endeavour, especially the documentation. After publication of the package, however, the code is now much easier to use and no contact with the authors is needed, which means time is saved by the person using the code. This supports the thesis by Schmidt and Marwick (2020), that code sharing may speed up scientific progress in archaeology. Also, the contribution is citable and there is no need to ask permission to re-use the program. This greatly improves usability, as can be seen by its application in different papers since 2020. We therefore strongly suggest, that though sharing of scripts is a valid approach that already speeds up the adoption and adaptation of new methods, once the code is developed further, it should be distributed in a structured and easy to implement format suited to the environment it is run in (e.g. R package, QGIS plugin or similar).

Bibliography

Arcaute, E, Molinero, C, Hatna, E, Murcio, R, Vargas-Ruiz, C, Masucci, AP and Batty, M. (2016). Cities and regions in Britain through hierarchical percolation. Royal Society Open Science, 3(4): 150691. DOI: https://doi.org/10.1098/rsos.150691

Maddison, M.S. and Schmidt, S.C. (2020). Percolation Analysis – Archaeological Applications at Widely Different Spatial Scales. Journal of Computer Applications in Archaeology, 3(1), 269–287. DOI: http://doi.org/10.5334/jcaa.54

Schmidt, S. C., & Marwick, B. (2020). Tool-Driven Revolutions in Archaeological Science. Journal of Computer Applications in Archaeology, 3(1), 18–32. DOI: http://doi.org/10.5334/jcaa.29

13. Citizen science supports megalithic research - virtual reconstructions through old photographs

Louise Tharandt, University of Cologne

The Düwelsteene, one of the southernmost sites of a megalithic tomb of the Funnel Beaker culture in Westphalia, western Germany, has been a place of interest for archaeological research since the early modern period and are now the foundation for new digital research methods. This megalithic tomb holds special interest for a study project because of its reconstruction history. The Düwelsteene is a restored archaeological structure and the current positioning of the megaliths dates to 1932. At that time the megalithic tomb was restored and the stones that had been in situ were relocated to recreate the structure as it was believed to have been in antiquity.

This study compares the extensive impact that such an intrusive restoration had, in contrast to the contact-less method of virtual reconstructions. By integrating the citizen science project, using digital research methods and creating virtual reconstructions, the advantages and disadvantages of digital reconstructions and public outreach in archaeology are examined.

Collecting old photographs through a citizen science project in the region of the Düwelsteene, allowed the virtual reconstruction of the megalithic tomb from before the tangible restoration in 1932 with the open source software Blender. This virtual reconstruction also provided more informative sources for the creation of a digital reconstruction of the original Düwelsteene structure of around 3000 BC. The initiative started as a top-down citizen science project engaging the public to collect data. But it resulted in a community driven, bottom-up project with the subsequent reconstructions being built with open source programs and shared online.

The website to display the virtual reconstructions and 3D model of the current structure was built with Bootstrap and is hosted on GitHub. The advantage of GitHub is the integrated version control and open access to the data and code used for the website. To display the virtual models, the 3D viewer 3DHOP (3D Heritage Online Presenter) was used. The basic 3DHOP viewer has a number of features already integrated, which are helpful for displaying cultural heritage content. It is possible to change the lighting, zoom in and out of the model and measure the 3D models in the viewer. The 3D objects can be cut into sections to see inside and a basic code for annotations is provided. For this website even more features were built, like the visualisation of the certainty with which the reconstructed megaliths were positioned. On the website it is also possible to toggle the reconstructed hill on and off and view the metadata for each model.

The resulting digital reconstruction was not only visually educating, but there also was actual scientific knowledge gained from the reconstruction. Through the comparison of the orthographic floor-plan of the current megalithic grave structure with the 3D reconstruction model it was possible to detect a change in the alignment of the grave that occurred during the restoration work. The megalithic tomb was rotated around 3 to 4 degrees further along the North axis when it was restored in 1932.

The digital reconstruction work of the Düwelsteene would have been much harder without the photographs collected through the citizen science project. Needing to rely on data from outside of archaeology shows the impact of hands-on restoration work on tangible cultural heritage sites, especially when such work is not documented enough. This also emphasises the benefits of virtual reconstructions, where hypotheses can be tested and comparisons between structures are much easier implemented.

Using digital methods and three-dimensional models can help visualise the changes and lead on to new findings. Especially with many archaeological sites presently being excavated and documented using digital methods in surveys, it is much easier to use the resulting data for further research. Even without prior excavation or documentation work, many cultural heritage sites can easily be turned into digital models due to new image-based modelling techniques, that don't require time consuming methods and expensive equipment.

For this project digital archaeological research and virtual visualisations was combined to also benefit the general public. It was demonstrated, that projects using 3D reconstruction modelling as a research environment can be published and help spread awareness and information on cultural heritage sites to the general public. Most programs and software that were used, were open-source. The publication of the 3D models on the website can be tracked and downloaded, which means the workflow and features can be used and applied to other cultural heritage projects.

Hageneuer, Sebastian. 2020. "The Challenges of Archaeological Reconstruction: Back Then, Now and Tomorrow" In Communicating the Past in the Digital Age: Proceedings of the International Conference on Digital Methods in Teaching and Learning in Archaeology (12–13 October 2018) edited by Sebastian Hageneuer, 101–112. London: Ubiquity Press. DOI: https://doi.org/10.5334/bch.h.

Klinke, Leo. 2021. "Virtuelle Massen-Bewegung. Die digitale 3-D-Rekonstruktion des Megalithgrabes Große Sloopsteene bei Lotte-Wersen, Kreis Steinfurt." Ausgrabungen und Funde in Westfalen-Lippe 15: 257-326. LWL-Archäologie für Westfalen.

Potenziani, Marco, Marco Callieri, Matteo Dellepiane, Massimiliano Corsini, Federico Ponchio, and Roberto Scopigno. 2015. "3DHOP: 3D Heritage Online Presenter" Computers & Graphics 52: 129–141. https://doi.org/10.1016/j.cag.2015.07.001.

50. PyREnArA – Spatio-temporal analysis of artefact morphology with multivariate approaches

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Hubert Mara, MLU - Instiut für Informatik
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Andreas Maier, Universität zu Köln

Traditionally, most of the archaeological record is described in terms of typologies. While typologies have a long history of use in Palaeolithic archaeology and capture artefact diversity comparatively well, artefact variability, i.e., the differences in shape and size within a single type, is insufficiently reflected. To overcome this inherent problem of typologies, a new trait-based recording system for lithic tools, tuned to analytical methods that allow for a quantitative analysis of morphometric change was developed within a pilot study at the universities of Erlangen-Nürnberg and Cologne and gradually improved over the last years by four of us (AM, FL, GR, RJ) (Maier et al. in prep.).

To this end, we apply a semi-automatic system for recording and analysing morphometric data. Instead of taking individual measurements on one artefact after the other and subsequently feeding the data into special computer programs for statistical analysis (e.g. Microsoft Excel) – a process both error-prone and time-consuming – we integrated these steps into a single implementation named PyREnArA (Python-R-Environment for Artefact Analysis). Starting with a standardised way of orientating multiple artefacts on one image and afterwards recording standard properties, such as size, shape, or the position of retouches of each artefact, PyREnArA also records properties, which are difficult to measure manually, such as the surface area, fractal dimension (Seidel 2018), or the position of the centre of mass. The data recorded can be easily fed into a variety of quantitative methods like Geometric Morphometrics (GMM) or Redundancy Analysis (RDA). Given additional chronological data the latter can e.g., detect variability in the data which is related to the progress of time (Maier et al. in prep.).

In this talk we present our extended analysis approach, in which we investigate morphometric variability related to geographical location. We hence make use of the adespatial-package in R to generate spatial weighting matrices and compute

Moran´s Eigenvector Maps (MEM (Dray, Legendre, and Peres-Neto 2006)). As spatial predictors, MEM are used in multivariate statistical methods to provide a spatially-explicit multiscale tool that allows us the calculation of the relationship between measured variability and geographical location.

A dataset of 353 lithic Solutrean points derived from 12 well-dated sites located across the Iberian Peninsula is used as our test-case. The morphology of Solutrean points is characterized by a high degree of regionalisation (cf. Schmidt 2015). Therefore, it is well suited as proof of concept for MEM. We thus can test the null-hypothesis that neighbouring sites should show higher morphometric similarities than more distant ones. In addition, we will analyse the potential of chronological trends within each investigated region, since supra-regional trends seem to be masked by regional variability.

30. Crossing Landscapes of the Past: Developments in Modelling Mobility and Connectivity in Archaeology

Andrew McLean, University of Edinburgh
Xavier Rubio-Campillo, Universitat de Barcelona

Location: E106

Recent trends show that the variety of computational approaches available for modelling mobility and connectivity across past societies are numerous and diverse. In the past employing techniques such as network analysis agent based modelling simulations or GIS to shine far greater light on the cost mobility and connectivity associated with the movement of goods and people across ancient landscapes. Advances in simulations network analysis and more complex GIS based connectivity models can be clearly noted in disciplines such as ecology but many of these new perspectives have yet to be widely adopted or discussed in archaeological contexts. Fairly well established techniques such as Least Cost Path (LCP) analysis remain the most common approaches and can provide insight into routes and journey times. However LCP is limited in the data it can provide beyond optimal routes between two fixed points. Furthermore while maritime movement was of major importance across the ancient world applying such analyses to these more complex contexts is an arduous undertaking. There have been attempts to address the difficulties with LCP but these need to be more widely discussed and understood. Innovative new methodologies have the potential to offer greater scope for improving quantitative studies. The aim of this session is to bring together scholars and researchers utilising the most cutting edge techniques for understanding movement across past landscapes. These techniques can be aimed at modelling new and more complex scenarios or presenting methods for overcoming some of the issues with the more well established techniques. It is especially hoped that researchers working with methods for understanding movement that are less widely understood in archaeology will contribute and help to improve our overall understanding of this ever evolving subject matter. We welcome speakers studying traditional LCP or network analysis for terrain beyond the purely terrestrial such as maritime or fluvial. Beyond this we are particularly eager for papers that discuss new techniques that are not necessarily well known in archaeology (or beyond) but which have a strong focus on quantitatively modelling mobility and/or connectivity across ancient landscapes. With all of this we hope to foster discussion of the most current and promising approaches to modelling mobility and connectivity available to archaeologists.

References:

Arcenas S. (2015). 'ORBIS and the Sea: a model for maritime transportation under the Roman Empire' Stanford ORBIS Project

Brodie J.F. Mohd-Azlan J. and Schnell J.K. (2016). 'How individual links affect network stability in a large-scale heterogeneous metacommunity' Ecology 97.7: 1658–1667.
Gustas R. and Supernant K. (2017). 'Least cost path analysis of early maritime movement on the Pacific Northwest Coast' Journal of Archaeological Science 78: 40–56.

Hazell L.C. and Brodie G. (2012). 'Applying GIS tools to define prehistoric megalith transport route corridors: Olmec megalith transport routes: a case study' Journal of Archaeological Science 39.11: 3475–3479.

Herzog I. (2014). 'Least-cost Paths – Some Methodological Issues' IA .36:

Indruszewski G. and Barton C.M. (2008). 'Cost surface DEM modelling of Viking Age seafaring in the Baltic Sea' in B. Frischer and A. Dakouri-Hild (eds.) Beyond Illustration: 2D and 3D Digital Tools for Discovery in Archaeology (BAR International Series 1805). Oxford

Llobera M. Fábrega-Álvarez P. and Parcero-Oubiña C. (2011). 'Order in movement: a GIS approach to accessibility' Journal of Archaeological Science 38.4: 843–851.

McLean A. and Rubio-Campillo X. (2022). 'Beyond Least Cost Paths: Circuit theory maritime mobility and patterns of urbanism in the Roman Adriatic' Journal of Archaeological Science 138: McRae B. Shah V. and Edelman A. (2016). Circuitscape: modeling landscape connectivity to promote conservation and human health.

Pelletier D. Clark M. Anderson M.G. Rayfield B. and Wulder M.A. (2014). 'Applying Circuit Theory for Corridor Expansion and Management at Regional Scales: Tiling Pinch Points and Omnidirectional Connectivity' PLoS ONE 9.1: 1–11.

Rubio-Campillo X. Ble E. Pujol À. Sala R. and Tamba R. (2022). 'A Spatial Connectivity Approach to Landscapes of Conflict: Julius Caesar and the Assault to Puig Ciutat (NE Iberian Peninsula)' J Archaeol Method Theory

Yubero-Gómez M. Rubio-Campillo X. and López-Cachero J. (2016). 'The Study of Spatiotemporal Patterns Integrating Temporal Uncertainty in Late Prehistoric Settlements in Northeastern Spain' Archaeological and Anthropological Sciences 8.3: 477–490."

SLOT 1	
08:30 - 08:50	**Introduction**
08:50 - 09:10	14. Where the grass is greener – large-scale phenological patterns and their explanatory potential for the distribution of Paleolithic hunter-gatherers in Europe *Andreas Maier (Universität zu Köln)*; Vlad Krakov (Simon Fraser University); Florian Linsel (Martin Luther University of Halle-Wittenberg, Institute of Computer Science); Patrick Ludwig (Karlsruhe Institute of Technology); Louise Tharandt (University of Cologne)*
09:10 - 09:30	322. Informing hunter-gatherer LCP models through indigenous knowledge *Oliver Vogels (University of Cologne)*; Tilman Lenssen-Erz (University of Cologne); Eleftheria Paliou (University of Cologne)*
09:30 - 09:50	290. MADO applications in the FBA-EIA transition in the Portuguese Beira Interior and the Spanish Alta Extremadura: a multi-scalar analysis of the Iberian warrior stelae *Pedro Baptista (Albert-Ludwigs-Universität Freiburg)**
09:50 - 10:10	29. Mobility as evidence of the cultural in the natural: The complexity of the transhumant landscape in the Sierra de Cebollera Natural Park (La Rioja, Spain) *Andrea Solana-Muñoz (Incipit-CSIC)**
10:10	272. Rivers vs. Roads? Assessing accuracy in route network models of transport in the Roman period. *James R. Page (University of Edinburgh)**

SLOT 2	
11:00 - 11:20	101. Putting the donkey before the cart: exploring Roman roads using large digital road dataset *Adam Pažout (Centre for Urban Network Evolutions)*; Tom Brughmans (Aarhus University)*
11:20 - 11:40	357. Modelling connectivity in ancient regions through the application of Beta-Skeletons *Diego Jimenez-Badillo, National Institute of Anthropology and History of Mexico*
11:40 - 12:00	199. A connecting sea: circuit theory and maritime exchange and mobility in the Roman Adriatic *Andrew McLean (University of Edinburgh)**
12:00 - 12:20	55. “It’s fine on a good day!” - Perceived risk and route choice among Viking Age seafarers. Potentials of digital mapping and experimental archaeology. *Greer K Jarrett (Lund University)**
12:20 - 12:40	136. Convolutional multi-factor probabilistic time-aware corridors: a new approach to the analysis of past long-distance mobility *Hector A. Orengo (Landscape Archaeology Research Group, Catalan Institute of Classical Archaeology)*; Toby C Wilkinson (Catalan Institute of Classical Archaeology)*
12:40 - 13:00	319. Identifying Reasons for Lack of Least-cost path success: A case study from Germany *Irmela Herzog (LVR-Amt für Bodendenkmalpflege im Rheinland)**

14. Where the grass is greener – large-scale phenological patterns and their explanatory potential for the distribution of Paleolithic hunter-gatherers in Europe

Andreas Maier, Universität zu Köln
Vlad Krakov, Simon Fraser University
Florian Linsel, Martin Luther University of Halle-Wittenberg, Institute of Computer Science
Patrick Ludwig, Karlsruhe Institute of Technology
Louise Tharandt, University of Cologne

Migrating animals often follow the greening of the landscape during the onset of the vegetation period. Such movements likely have been of interest for prehistoric hunter-gatherers and thus may have affected long-distance migrations as well as seasonal land-use patterns and location of foraging areas. Timing and length of the vegetation period may thus have been an important driver in long-term trends of spatial patterning of populations. Consequently, shifting patterns of the greening and productivity of the landscape might reveal ecological pull factors with different directionality that might hold explanatory potential for the patterns we observe in the archaeological record.

In this paper, we present a protocol for estimating the timing and length of the vegetation period and explore its explanatory potential in two case studies, comparing differences between stadial and interstadial conditions. Since temperatures play a vital role in the timing of the vegetation period, estimating diachronic changes requires spatial information on daily temperatures throughout the year. For this study, the regional climate model WRF (Weather and Weather Research and Forecasting Model), was nested into the coarse gridded LGM simulation of the Max Planck Institute (MPI-ESM-P). The 30 year-long regional climate simulation provides the average daily temperature of 2m above the ground at 50 km grid spacing, which were used for the two case studies. The WRF model was also adjusted to palaeoclimatic settings for 21 ka to consider the glacial environmental boundary conditions. Our method consists of estimating the growing season by calculating the vegetation period, which was automated by using the programming language R, and producing images showing vegetation patterns with Python and QGIS. This means that our method and the results are reproducible.

First, we look at a dynamic phase of population expansion related to the arrival of anatomically modern humans in Europe (i.e., the Aurignacian between 43 and 33 ka) and discuss to what extent our results match the archaeological observable distribution of sites and the hypotheses of migration corridors, such as the 'Danube corridor'. Our results show, that for the expansion of Anatomically Modern Humans into Europe, we see strong gradients along the coasts, whereas the route along the Danube shows only weak or no phenological pull-factors. For most parts of Europe, stronger incentives for movement appear during interstadial phases, while the southern parts of the Italian and Iberian Peninsula provide stronger phenological gradients during stadials.

Second, we explore the spatial patterning of hunter-gatherer populations in the topographically homogeneous landscape of the East European Plain between 40 and 27 ka. Despite the uniformitarian landscape, a comparatively large number of taxonomic units is reported from this region. Here, we evaluate to what extent the observed phenological gradients may have fostered a segregation of population in certain regions and thus the development of regional differences in the material culture. One of our main results for this case study is that the East European Plain is phenologically divided in an eastern and a western part, so that it is more likely that networks form within than between these two areas.

Based on our results, we conclude that differences in the estimated timing of the vegetation period in different parts of the East European Plain as well as Western Europe are indeed helpful to understand the large-scale structure of the archaeological record in these areas. It would also be interesting to compare other regions with a particularly rich archaeological record, as we found that several regions such as Franco-Cantabria, Moravia and southern Poland, or Kostenki, are located in areas where special phenological settings foster a kind of self-contained sub-system, more or less decoupled from the remaining mesh of gradients.

Because our method was deliberately built to be reproducible and will be openly available, other geographical areas and other time periods can be explored and their vegetation period can be calculated.

Ludwig, Patrick, Joaquim G. Pinto, Christoph C. Raible,and Yaping Shao. 2017. "Impacts of surface boundary conditions on regional climate model simulations of European climate during the Last Glacial Maximum." Geophysical Research Letters 44: 5086–5095. https://doi.org/10.1002/2017GL073622.

Maier, Andreas, Patrick Ludwig, Andreas Zimmermann, and Isabell Schmidt. 2022. "The sunny side of the Ice Age: Solar insolation as a potential long-term pacemaker for demographic developments in Europe between 43 and 15 ka ago." PaleoAnthropology, Preprint. https://doi.org/10.13140/RG.2.2.19046.55367.

322. Informing hunter-gatherer LCP models through indigenous knowledge

Oliver Vogels, University of Cologne
Tilman Lenssen-Erz, University of Cologne
Eleftheria Paliou, University of Cologne

Introduction

One of the concerns in modelling mobility of past societies is the lack of a methodology for testing the goodness of fit of LCP models statistically, as well as their relevance for past societies (Kantner 2012). Another concern is that least-cost strategies are basic intuitive capabilities that people neglect whenever its necessary. So how do we know the models we create would have any relevance for past societies? We suggest that least-cost modelling has a lot to gain from quantitative and qualitative data on mobility from more traditional activities: where do people go and why? And what does traditional mobility today tell us about the past?

The project "Indigenous Knowledge and Archaeo¬informatics" (IKAi) brings together archaeologists and indigenous hunting experts for a better understanding of human mobility during traditional hunting – one of the oldest human activities related to food procurement and social status. The project takes advantage of a rare opportunity to capture the movements of Ju/'hoansi and Hei//kom San game tracking experts during non-lethal hunting using geo¬spatial technologies. The study region is the Doro !nawas, a topo-graphically highly contoured landscape adjoining the hyper-arid Namib desert in north-western Central Namibia. The area is rich in prehistoric rock that depicts a typical hunter's talk – animals and their foot-prints. The project's objective is to collect quantitative and qualitative data that allow to contextualize and to better understand traditional hunting mobility. A variety of georeferenced quantitative data (in-cluding movement, heartrate, wind speed, landcover, vegetation, topography and direction measure-ments), as well as qualitative information on decision-making during hunting are collected during field-work.

Methods and materials

Traditional hunters in the IKAi project were accompanied by a one- or two-person team documenting environmental information and the decision-making process during hunting for a more holistic data col-lection. The aim was to better understand the relationships between hunter, vegetation, landcover, wind and hunting game. In this research scheme smartwatches were used to collect GPS coordinates, barometric height and heartrate (via ECG chest belt) per 1 second of the Ju/'hoan and Hei//om hunting experts. More objective data on landcover and vegetation in the hyper-arid landscape of the Doro !nawas (land-cover, i.e. rocks, gravel, sand and more open areas vs. more vegetated areas such as dry riverbeds) were collected using GoPro cameras in 10 s picture mode. Hunter's decisions and more subjective data on land-cover (e.g. soft ground, hard ground, slippery ground) were collected with smartphones, using the open-source software Cybertracker (cybertracker.org) that is widely used in monitoring hunting skills and biodi-versity. Mobile ultrasonic wind measurement devices were used to collect data on wind-speed and wind direction, as there is a strong relationship between the behaviour of the hunters, the hunting game and the wind.

The resulting data sets were analysed regarding their fit to existing linear, exponential and polynomial cost functions that have been used and discussed in archaeological contexts (see e.g. Herzog 2014),

Results

Results show that with a median speed of ca. 2.5 km/h the San hunters walked slightly slower during their hunts than most LCP cost functions suggest. Moreover, the collected data show that whether the San hunters followed cost-benefit strategies was highly influenced by their aim during hunting: searching game, tracking game, approaching game, and finding the way back to the camp.

San hunting mobility data also show that differences in speed while walking up- and down-slope are also less pronounced than existing cost functions suggest. This can be explained – to some degree – with the particular landcover in the study region. Due to the lack of vegetation, slopes are often scattered with gravel, rocks, or boulders. Hence, slopes are often slippery and care is needed to avoid falling particularly while walking down slopes.

Some authors also argued that landcover (e.g. sand vs. paved roads) can influence costs of walking (Her-zog 2014). This assumption was irrelevant in our study, as the San hunters were adapted to walk on soft sand without decrease in walking speed or increase in heartrate, just by adjusting their walking technique.

Discussion

Differences in walking speeds suggested by existing cost functions and data recorded in the IKAi project can be explained to a large extent by their contexts. Most existing cost functions are based on data that were recorded from hikers walking on prepared roads or hiking trails, military recruits, sports experts or subjects walking on treadmills (Herzog 2004). Data recorded from San hunters shows that such kinds of mobility do not fit well to more traditional mobility, particularly that of hunter-gatherers. In hunter-gatherer societies a much higher degree of mental and physical elaboration is needed for orientation, navigation (see also Irmischer and Clarke 2018), and the interaction between humans and the landscape (e.g. searching plant food or game, reading animal tracks, keeping track of the location of the camp and hunted game) on the way, which requires time and can cause slower travel rates. Moreover, the San hunters sometimes consciously neglected least-costly routes in the hot and arid landscape in favour of a successful hunt, without major influences on their physical fitness (pronounced increase in heartrate).

In summary, quantitative and qualitative data on indigenous San hunting mobility show that existing cost functions used for modelling least-cost-paths in archaeological contexts are restricted when it comes to explaining the patterns they produce. Including indigenous knowledge in LCP modelling is thus important for enhancing models of human-landscape interaction related to hunter gatherer societies, and for testing their fit to traditional activities, such as hunting.

References

Herzog, Irmela. "Least-Cost Paths—Some Methodological Issues." Internet Archaeology 36 (2014). https://doi.org/10.11141/ia.36.5.

Irmischer, Ian J., and Keith C. Clarke. "Measuring and Modeling the Speed of Human Navigation." Cartog-raphy and Geographic Information Science 45, no. 2 (2018): 177--186. https://doi.org/10.1080/15230406.2017.1292150 .

Kantner, John. "Geographical Approaches for Reconstructing Past Human Behavior from Prehistoric Roadways." In Spatially Integrated Social Science, by Donald G. Janelle and Michael F. Goodchild, edited by Donald G. Janelle and Michael F. Goodchild. Oxford: Oxford University Press, 2004.

290. MADO applications in the FBA-EIA transition in the Portuguese Beira Interior and the Spanish Alta Extremadura: a multi-scalar analysis of the Iberian warrior stelae

Pedro Baptista, Albert-Ludwigs-Universität Freiburg

Introduction

Warrior stelae are among the most interesting testimonies left by Final Bronze Age (FBA) – Early Iron Age (EIA) communities in the Southwest of the Iberian Peninsula. These monuments correspond to stone slabs engraved with motifs depicting objects from Atlantic, Mediterranean, and Central European influence. Despite evoking wide-spread connectivity, they anchor these references in specific places of their landscape, often related to pathways and water sources; and while being somewhat standardized, geographic regionalisms can be identified, with basic formats more recurrent in the North and anthropomorphic and Mediterranean representations in the South.

In this sense, warrior stelae are prime examples of multi-scaled mobility and connectivity for the FBA-EIA, the understanding of which can greatly be enhanced through GIS-based analyses and landscape studies - something previously shown, for instance, regarding statue-menhirs in Northern Portugal and Southern Galicia (Fábrega-Álvarez et al. 2011). As such, in the scope of an international and interdisciplinary ongoing research project focused on the Iberian warrior stelae, we propose to present a practical case study by exploring the application of least-cost analyses (LCA), focusing on the MADO (Spanish acronym for Modelo de Acumulación del Desplazamiento Óptimo [Optimal accumulation model of movement from a given origin]) (Fábrega-Álvarez 2008). Our objective is to model a mobility network for the FBA – EIA transition in the neighbouring regions of the Portuguese Beira Interior and the Spanish Alta Extremadura, that allows us to investigate the role(s) of the warrior stelae in the landscape.

Methods and materials

LCA have become a staple in GIS-based archaeological approaches to mobility and connectivity in the past decades, with isochrones and least-cost paths (LCP) being just the first of a vast array of analyses enabled by least-cost surfaces (LCS).

Unlike LCP, which require both a starting and destination point, MADO creates a flow accumulation model from a single starting point (Fábrega-Álvarez 2008, 9), resulting in a less conditioned analysis that doesn't assume direct connectivity between different archaeological sites. A single MADO can provide extensive information regarding how mobility is structured to and from a given site. However, by processing the sum of the MADO from a series of coetaneous sites from a given study area, one can create an accumulated flow model (Fábrega-Álvarez 2008, 10), that can serve as a base for a potential mobility network.

Here, the MADO were calculated based on the known FBA-EIA archaeological occurrences – settlements, warrior stelae, metallic hoards, and funerary monuments – which correspond to our cultural variables. On the other hand, the LCS was calculated based on a modified version of the SRTM GDEM in which recent and significant constructions (such as dams) were edited out, based on the altimetric information from older cartographic series – which correspond to our natural variables, by modelling this past landscape through its major geomorphological elements absent more recent interferences.

Results

The resulting sum of the MADO can be used as a potential mobility network that accounts for both natural and cultural variables, highlighting from the get-go a given territory's optimal paths, its connections to neighbouring regions, and mountain and river passes where flux is concentrated. This allows us to understand how movement was preferably practiced inside the territory, but also how it relates to the territories around it; in a sense, it's possible to represent the means through which people, goods, ideas, and technologies were shared among communities. Further, and even if it's just based on the current state of the art, it's possible to discern areas with a higher flux intensity, whether due to the concentration of sites, or due to corresponding to key passes in the landscape, thus becoming important nodes in it.

In the scope of the ongoing project, the MADO served as an important bridging element to investigate, through GIS-based accessibility and visibility analysis, as well as fieldwork, warrior stelae's position in the landscape in relation to:

- Coetaneous archaeological occurrences (settlements, metallic hoards, and funerary monuments);
- Older ones (rock art, statue-menhirs, and funerary monuments);
- Natural features (rock outcrops, mining resources, and river and mountain passes);
- The mobility network itself.

Discussion

In the scope of pre and proto historic studies, and in the absence of built roads for these periods, a potential mobility network generated through the application of GIS-based analysis is of particular importance as it can be used for several distinct kind of follow-up studies.

For starters, it can be examined from the perspective of the evolution of the territory's road systems, comparing it to historically recorded tracks.

Further, it can serve as the base for GIS-based visibility and accessibility analyses, through which the relationship between several archaeological (e.g. settlements, funerary monuments, rock art, etc.) and natural elements (e.g. resources, passes, etc) can be evaluated. In the case of transnational study areas, MADO also helps bridge each country's research traditions and "blur" the current administrative border – often irrelevant or completely inexistent in the analysed chronological periods.

In the end, it signifies a contribution to the study of human mobility, fundamental to understand the distribution of different archaeological sites in the landscape (Murrieta-Flores 2011, 34).

References

Fábrega-Álvarez, Pastor. 2006. "Moving without destination. A theoretical, GIS-based determination of routes (optimal accumulation model of movement from a given origin)". Archaeological Computing Newsletter, 64: 7-11.

Fábrega-Álvarez, Pastor, João Fonte, Francisco Javier González García. 2011. "Mobilidade e materialidade: uma aproximação à análise da localização das estátuas-menir transfronteiriças (Norte de Portugal e Sul da Galiza)". In Estelas e estátuas-menires: da Pré à Proto-história. Actas das IV Jornadas Raianas, edited by Raquel Vilaça, 245-270. Sabugal.

Murrieta-Flores, Patricia. 2011. "Travelling through past landscapes - Analysing the dynamics of movement during Late Prehistory in Southern Iberia with spatial technologies." PhD Diss., University of Southampton.

29. Mobility as evidence of the cultural in the natural: The complexity of the transhumant landscape in the Sierra de Cebollera Natural Park (La Rioja, Spain)

Andrea Solana-Muñoz, Incipit-CSIC

1. Introduction

Transhumance is one of the most widely analysed forms of recurrent mobility in some areas of Europe, such as in the Iberian Peninsula. Until a few decades ago, the Iberian Peninsula was crossed by transhumant livestock routes. However, the decadence of their transit led to the decline of their cultural manifestations, becoming practices and places that are little present in our collective memory. Architectural elements are in a poor state of conservation, and the vestiges of livestock mobility are relegated to the protection and documentation of large cattle tracks, while local routes have been lost in the forests.

This contribution will analyse the complexity and dynamism of transhumance cultural landscapes focusing on the study of the Sierra de Cebollera Natural Park, an area of great historical significance for transhumance located in Northern Spain (Moreno 1996). It does so by combining the use of remote sensing tools and Geographic Information Systems (GIS) to identify material remains of ancient tracks and to unlock the logics behind those routes, through digital modelling. The main aim of these analyses is to analyse livestock mobility at a detailed scale, beyond the examination of long-distance routes that have been typically the focus of transhumance studies (see figure 1). By doing so, we will approach practices that are related not so much to the movement of livestock over long distances as to more local practices that support these large seasonal movements on a daily basis. To this end, the aim is to reconstruct a network of possible routes connecting transhumant sites in and with the landscape, and to examine the wider implications of that.

The results will show how long-distance and local movement have been guided by different logics and imply different forms of engagement with the landscape. In this way, transhumance becomes a complex, multiscale and dynamic form of mobility, far from the static visions that have been typical of analyses based on the study of written documentation.

2. Methods and materials

2.1. Materials

- Points of origin and destination for optimal route analyses (LCP):
    - Stone enclosures related to transhumant practice. Many of them are not documented, so remote sensing techniques have been used to locate them (comparison of historical orthoimages and Lidar data).
    - Centres of manufacturing activity: the villages of Villoslada de Cameros and Lumbreras.
- Digital Elevation Model (DEM) of 5 metres pixel cell resolution obtained from the Download Centre of the National Geographic Institute. This DEM has been processed taking into account the energy cost of human displacement according to the degree and steepness of the slope; and water courses. Regarding the slope, the function used to calculate the cost of displacement has been the one proposed by Llobera and Sluckin (2007), which differentiates the energy cost (kJ/m) according to the degree of slope and whether it is ascending or descending. To ensure that the optimal routes did not coincide with the riverbeds, a distance of 4 metres was established on each side of the lines that represent them in order to avoid distorting the possible routes if they had coincided with the watercourses, which would not have been practicable in reality.

2.2. Methods

In the first analysis, a MADO (Fábrega-Álvarez 2016) was developed, i.e., the creation of optimal routes to a destination point taking into account the land area (DEM). The objective is to explore which would be the natural corridors that would connect the main centres of manufacturing activity derived from the transhumant practice with the valleys of the study area, understanding that this can bring us closer to understanding the forms of short-distance local mobility, which would complement the large displacements through the ravines. For the second, a layer of routes was made according to the optimal cost of displacement, with the point of origin being the production nuclei and the point of destination being the stone enclosures located by remote sensing.

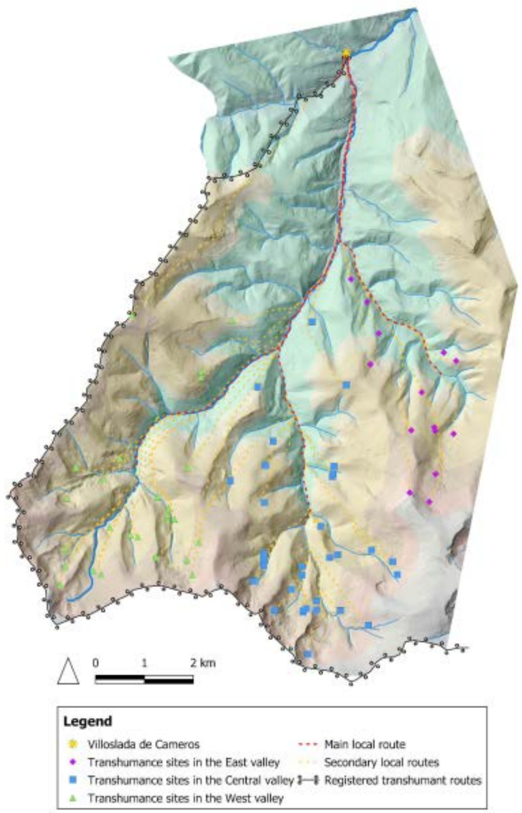

Figure 1. Example of the results obtained from the analysis of optimal routes in the area around Villoslada de Cameros. Figure made by the author.

3. Results

- The registered transhumant routes run through a different space from the one occupied by all the structures identified, which indicates that there must have been other levels of paths connecting these spaces, probably on a more local scale of movement.
- In most of their sections, the optimal routes run at a higher altitude than the valley bottoms, sometimes running along the mountain ridges. This proximity and similarity of path to the registered routes shows that cattle were moved at higher altitudes than the valley bottoms, except where the secondary valleys and the main valley widen considerably, facilitating mobility.
- Local movements do not seem to differ from general seasonal movements in terms of areas of movement. In other words, the registered routes and optimal routes do not necessarily run along the valley bottoms, but are maintained at altitude. This variable could be due to the need to make use of high-altitude

pastures.

4. Discussion

Mobility analyses show that valleys played an essential role in livestock movements. This demonstrates that the mobility of transhumant herds was not dependent solely on the main cattle track, but that mobility at local scales played an essential role and was complemented by the mobility of large cattle tracks for seasonal movements.

The study of transhumant practice through the use of mobility analysis (LCP) has made it possible to rediscover a complex and dynamic cultural landscape, recognising its cultural importance for the development of the environment of the current Sierra de Cebollera Natural Park, as well as recalling the role that local communities played in shaping it.

5. References

Fábrega-Álvarez, Pastor. "Un alto en el camino: notas acerca del uso del SIG en los análisis de movilidad en arqueología". In Manual de Tecnologías de la Información Geográfica aplicadas a la Arqueología, edited by María del Carmen Mínguez García, Enrique Capdevila Montes, 159-182. Madrid: Comunidad de Madrid, 2016.

Llobera, Marcos, Sluckin, Timothy. J. "Zigzagging: Theoretical insights on climbing strategies". Journal of Theoretical Biology, no. 249 (2007): 206-217.

Moreno, José Ramón. "La ganadería trashumante en La Rioja (1752-1865). Una revisión Bibliográfica y cuantitativa". Brocar, no. 20 (1996): 277-302.

357. Modelling connectivity in ancient regions through the application of Beta-Skeletons

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Reflecting on how particular configurations of interlink networks articulated transport, communications, and social relationships in ancient societies has been an important research subject in archaeology (Brughmans 2013). A basic approach involves elucidating why certain inter-site links exist and why others are missing in an actual archaeological system.

When enough empirical evidence of a road network exists, it is useful to apply standard measures of connectivity, such as ringness, circuitness, and webness to answer questions related to movement potential (Xie and Levinson 2007). However, when there is little information on the actual physical links articulating the communication between places -a situation quite common in archaeology, it is desirable to assess several possible networks, which provide hypotheses on the articulation of a region.

This paper applies the notions of Relative Neighbourhood Graph (RNG) and β-Skeleton for the generation of such hypothetical networks. The Relative Neighbourhood Graph (RNG) links two points if they are as close to each other as they are to any other point (Lankford 1969; Toussaint 1980). Retrieving an RNG involves testing, for each pair combination of sites, the emptiness of a region of influence that resembles a "lune". The neighbourhood extension depends on the specific distance of each pair-combination of sites and varies accordingly, while its shape is determined by certain geometric functions like a circle whose circumference passes through the pair of sites, the intersection of two circles centred at the sites, a conical function, or more complex forms (see Cardinal et al. 2009). In all cases, two nodes are considered relative neighbours -and therefore a link is drawn between them- if and only if their area of influence is empty.

The introduction of a parameter to enlarge or reduce such area of influence generate the so-called β-Skeletons (Radke 1982). Given a set of nodes N = {n1, n2, …, nn} there is a family of regions of influence, whose extensions and shapes are controlled by a positive real number called beta (β). According to Kirkpatrick and Radke (1985), when β is close to zero, it delimits a small region whose emptiness is a necessary condition for the pair to be neighbours. As β increases, the region delimits a relatively large neighbourhood whose emptiness defines a sufficient condition for the pair {ni, nj} to be neighbours. Thus, β-neighbourliness occurs within the range of these minimum and maximum bounds.

By applying different values of β, one can obtain a spectrum of networks whose edge density varies from very sparse to very dense (Kirkptarick and Radke 1985; Radke 1988), which in itself reveals subtle transitions in the spatial links of the sites under study and provide a series of hypothetical links between the sites under study.

Computing several β-Skeletons allows labelling each pair of sites with the largest β value for which they are connected. This is useful to identify edges that appear or disappear unexpectedly from the spectrum, which in turn could reveal important aspects of an empirical network (Radke 1982; Kirkpatrick and Radke 1985). By observing the progressive change in the edge density of the network, archaeologists could explore, for example, how different values of β affect inter-site links to assess how and why an actual archaeological network deviates from the β-networks. The power of β-Skeletons for revealing connectivity patterns at different resolutions can be used in this context.

To illustrate the application of the method, we emulate and develop an approach, originally proposed by Radke (1982) and Kirkpatrick and Radke (1985) in their study of road networks in Canada, to elucidate the connectivity of the region of Zempoala

(Hidalgo, Mexico) during the sixteenth century (Valadez Vázquez et. al. 2021). The analysis starts with the null hypothesis that (a) all sites were equally important, and (b) spatial distribution was the only factor determining inter-site relationships. Then, we label the edges with the highest value of β for which each pair of towns remained connected. Afterwards, we identify the links that conflicted more with the null hypothesis, either because the connections were not predictable but appear in the empirical road network as described by historical sources, or vice versa, were highly expected but did not exist in reality. Through this simple procedure, it has been possible to discover non-spatial factors (cultural and natural barriers) governing the connectivity of the most likely road network.

References

Brughmans, Tom. 2013. Thinking through Networks: A Review of Formal Network Methods in Archaeology. Journal of Archaeological Method and Theory 20(4): 623-666.

Cardinal, Jean, Sébastien Collette, and Stefan Langerman. 2009. Empty Region Graphs. Computational Geometry 42: 183-195. https://doi.org/10.1016/j.comgeo.2008.09.003

Kirkpatrick, David G., and John D. Radke. 1985. A Framework for Computational Morphology. Machine Intelligence and Pattern Recognition 2:217-248. https://doi.org/10.1016/B978-0-444-87806-9.50013-X

Lankford, Philip M. 1969. Regionalization: Theory and Alternative Algorithms. Geographical Analysis 1:196-212. https://doi.org/10.1111/j.1538-4632.1969.tb00615.x

Radke, John D. 1982. Pattern Recognition in Circuit Networks. PhD dissertation, Department of Geography, University of British Columbia, Canada. Available at: https://open.library.ubc.ca/cIRcle/collections/ubctheses/831/items/1.0095874#downloadfiles

Radke, John D. 1988. On the Shape of a Set of Points. Machine Intelligence and Pattern Recognition 6:105-136. Available at https://doi.org/10.1016/B978-0-444-70467-2.50014-X

Toussaint, Godfried T. 1980. The Relative Neighbourhood Graph of a Finite Planar Set. Pattern Recognition 12(4):261-268. https://doi.org/10.1016/0031-3203(80)90066-7

Xie, Feng, and David Levinson. 2007. Measuring the Structure of Road Networks. Geographical Analysis 39:336-356. https://doi.org/10.1111/j.1538-4632.2007.00707.x

Valadez Vázquez, Ricardo, Castañeda de la Paz, María, and Jiménez-Badillo, Diego. 2021. Zempoala. Historia y Paisaje de un Corregimiento en el Estado de Hidalgo. México: UNAM-Instituto de Investigaciones Jurídicas.

101. Putting the donkey before the cart: exploring Roman roads using large digital road dataset

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Tom Brughmans, Aarhus University

Roman roads are one of the best preserved and documented examples of pre-modern road infrastructure that has drawn the attention of both “classical” and computational archaeologists. Attempts were made to explain the layout of Roman roads using least-cost path (LCP) methodologies (e.g., Parcero-Oubiña et al. 2019), or recently combining LCP with probabilistic modelling (Lewis 2020). These applications are undertaken within a predictive-postdictive framework, where existing road segments are analysed and used for reconstruction (prediction) of the uncertain segments of the road. In most cases, the analysis is limited to individual roads, exploring methodological possibilities and limitations, and no large-scale region-wide application generalizing the results of the postdictive (explanatory) phase has been attempted.

In this talk, a way forward for more large-scale regional analysis of Roman roads is proposed that combines both qualitative and quantitative approaches. It will draw on the MINERVA dataset of spatially precise Roman roads, presenting a case study for the Southern Levant, and raising a number of issues.

In the context of the MINERVA project a large dataset of Roman roads, covering the Eastern Mediterranean, is being digitized using a combination of archaeological, and cartographical sources, and remote-sensing methods (satellite imagery). Out of tens of thousands of kilometres of digitized roads, only ca. 8% are spatially precisely located roads. In the Levant this amounts to more than 3,000 km of roads, but the precision in other regions of the Roman East tends to be much lower. This large dataset offers unique opportunities to analyse road data across diverse environments. We will present the analysis of road data taking the southern Levant as a case study, focusing mainly on a) slope, b) drainage, c) topographic position index, d) geology and soil. An attempt is made to generate a set of environmental characteristics that most influence the location of the roads on a regional scale.

The issues that are raised in connection with this research are: a) availability and reusability of large digital road datasets, b) potential of large road datasets for quantitative and qualitative analysis and their limitations, c) incorporating human elements into the analysis, especially social and economic processes that shaped the direction and intensity of human movement.

References:

Lewis, Joseph. 2020. “Probabilistic Modelling using Monte Carlo Simulation for Incorporating Uncertainty in Least Cost Path Results: a Postdictive Roman Road Case Study.” SocArXiv, mxas2, ver. 17 peer-reviewed and recommended by PCI Archaeology. https://doi.org/10.31235/osf.io/mxas2

Parcero-Oubiña, César et al. 2019. “Footprints and Cartwheels on a Pixel Road: On the Applicability of GIS for the Modelling of Ancient (Roman) Routes.” In Finding the Limits of the Limes: Modelling Demography, Economy and Transport on the Edge of the Roman Empire, edited by Philip Verhagen, Jamie Joyce and Mark R. Groenhuijzen, 291-312. Computational Social Sciences, https://doi.org/10.1007/978-3-030-04576-0_14

272. Rivers vs. Roads? Assessing accuracy in route network models of transport in the Roman period.

James R. Page, University of Edinburgh

Context:

Over the past two decades, spatial network modelling has seen increased application to the study of ancient transport systems, especially those of the Roman world (Collar et al.: 2015). Many of these studies have used network modelling to measure connectivity and accessibility across and between regions, especially in regard to transport costs. Theoretically, the lower the cost in time and money to reach one place from another, the greater the level of that region’s connectivity, and the greater the scope for goods and people to access it from further afield. For inland regions, sites located on a navigable river are considered the most accessible, while those that could only be reached via overland routes are viewed as isolated and prohibitively expensive to travel to. This picture is supported by many route network models of transport during the Roman period (Scheidel 2014).

While route network models form an important tool when studying ancient transport, many models fail to test the validity of their conclusions against other ancient evidence. This risks reinforcing old orthodoxies on transport and trade. Within this paper, the results of route network analysis based on a methodology developed by Pau de Soto (de Soto 2019) are outlined for the transport network of the Po valley, Italy, in the Roman period, mapping the incremental cost of transport across the canals, lakes, rivers, and roads of the region. The results of the network model are then compared and contrasted against the distribution of a quantified dataset of amphorae from twenty-six urban sites to explore the accuracy of the model’s conclusions. The Po valley forms a geographically contained region within which to explore the dynamics of inland transport and trade during the Roman period. Furthermore, the region is located away from the frontiers and the city of Rome, two areas where state action might serve to overcome obstacles to cost, making it well-suited to act as a case study for this analysis.

Main Argument:

The results of the route network model demonstrate that the extensive water network within Northern Italy substantially lowered transport costs from the Adriatic coast to inland sites, providing a cheaper alternative to overland routes. Costs rapidly increased as transport moved away from navigable rivers and trans-mountain routes were amongst the most expensive, supporting the established orthodoxies around transport in the Roman period.

To act as a comparison to the results of the network model, the provenance of twenty-six amphora assemblages dated to the first-second centuries AD were measured and hierarchically clustered using the UPGMA algorithm (Unweighted Pair Group Method with Arithmetic mean). This was used to calculate the pairwise distance between each site assemblage based on the provenance of the vessels within it, grouping sites that showed the greatest similarity in their assemblage composition together. By clustering the assemblages in this way, patterns in how amphorae provenance changed across the region were highlighted.

Changes in the provenance of amphorae were clearly observed as distance from the Adriatic coast increased and suggested that imported amphora-borne goods were able to travel significant distances inland before transport costs affected their distribution. However, the results also suggested that sites furthest inland, those closest towards the navigable endpoints of rivers or only accessible via overland routes, had greater diversity in both the provenance and type of amphorae than sites in the coastal hinterland. Indeed, many of these sites contained goods that entered the region via trans-mountain routes, despite the network model suggesting this would cost significantly more than the equivalent upriver transport. The distribution of the clusters identified via the UPGMA algorithm and their lack of alignment with network model consequently suggest that factors beyond cost influenced the distribution of goods within the Po valley.

Applications/Implications:

Although network models are useful tools when thinking about transport in the Roman era, their simplicity and the incompleteness of the ancient dataset means that there will inevitably be a level of inaccuracy in the picture they present. The cost surfaces generated by models represent an idealised scenario, assuming that the maximum price was charged for carriage, that transport would always take the cheapest route, and that all cargo was of the same value. The overlay of the material evidence over the network model shows a more complex situation. Although transport cost was certainly an important factor in the distribution of material within inland regions, the paper's analysis demonstrates that a multitude of other factors influenced ancient trade and transport which network models struggle to account for. Models form important heuristic devices but are, out of necessity, a simplification of real-world conditions. The comparisons outlined in this paper demonstrate the importance of combining and contrasting models with ancient material evidence to test the validity of their conclusions, alongside providing a framework for future studies to use.

References:

Collar, Anna., Coward, Fiona., Brughmans, Tom., and Mills, Barbara. "Networks in Archaeology: Phenomena, Abstraction, Representation." Journal of Archaeological Method and Theory 22, no. 1 (2015): 1-32.

De Soto, Pau. "Network Analysis to Model and Analyse Roman Transport and Mobility." In Finding the Limits of the Limes. Modelling Demography, Economy and Transport on the Edge of the Roman Empire, edited by P. Verhagen, J. Joyce and M.R. Groenhuijzen, 271-90. Springer Open Access, 2019.

Scheidel, Walter. "The Shape of the Roman World: Modelling Imperial Connectivity." Journal of Roman Archaeology 27 (2014): 7-32.

199. A connecting sea: circuit theory and maritime exchange and mobility in the Roman Adriatic

Andrew McLean, University of Edinburgh

Introduction

Reconstructing past economies is a complex and daunting undertaking, particularly for societies and periods with limited written evidence. One of the main methods of large scale economic exchange in the ancient world was maritime exchange, utilising the so called highways of the ancient world. As such, a particularly promising avenue of research is the analysis of maritime mobility. This movement and maritime exchange can be understood archaeologically, in part, through the shipwreck data. However, these data are notoriously difficult to interpret and to draw concrete conclusions from. As such, new methods, and additional archaeological markers, such as patterns of urbanisation, must be used to fully understand maritime exchange in the ancient world. Quantitative analyses are gradually being applied more frequently to research in the ancient world, particularly in understanding these data with regard to ancient economies. It is against this background that this paper is framed. The research questions are:

- How can Circuit Theory be used to model ancient mobility?
- Does potential mobility have an impact on shipwreck distributions or patterns of urbanisation in the Roman Adriatic?
- How can patterns of exchange be reconstructed using Circuit Theory and archaeological economic proxies?

Methods and materials

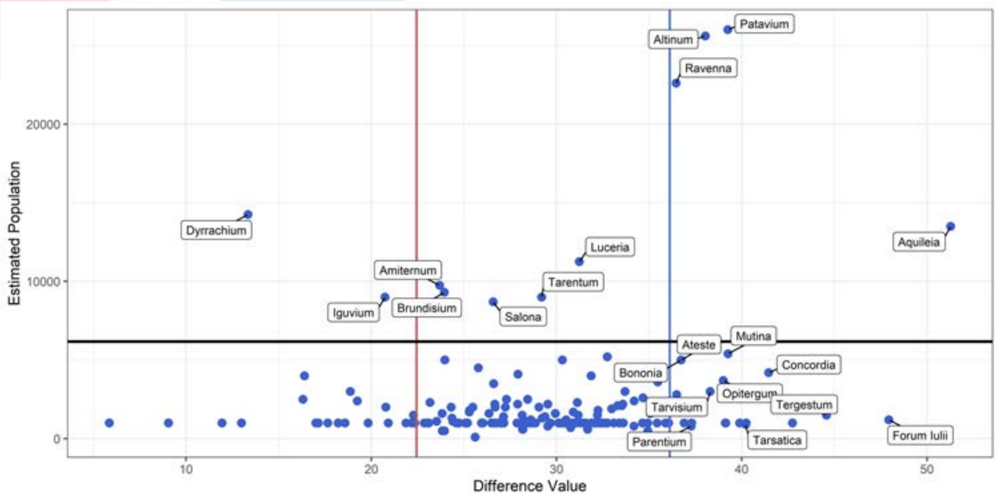
The methodology builds upon a series of current theoretical and methodological innovations. Recent scholarship has trended towards more quantitative approaches employing network analysis, statistics and GIS. Least Cost Path analysis has provided insight into the routes and journey times, but is limited in the data it can provide beyond optimal routes between two fixed points. In this paper, I seek to outline developments in approaches to modelling mobility across the sea, and specifically, the potential of Circuit Theory for archaeologists attempting to understand mobility in past societies in a maritime setting. Based on historic wind patterns and ancient sailing speeds, a dynamic proxy for potential mobility is produced. Rather than being limited to optimal routes, with Circuit Theory we can begin to identify entire regions of high potential mobility and connectivity within wider landscapes.

Circuit Theory is based on Ohm's Law outlining the electrical relationship between current I, resistance R and voltage V under the formula ($V = IR$). Current I flows across a circuit with varying resistance R values; these resistance values result in greater or lesser current values. The inclusion of specific archaeological sites is not necessary at the outset of the model. Instead, user-defined areas of any size can be used as sources between which current flows. Therefore, the results of the model are not impacted by the choice of case study itself; rather the case study, and specific sites, can be compared to the final CT output independently.

The case study used is the Adriatic during the Roman period. The Adriatic is a semi-enclosed sea in the middle of the Mediterranean, often seen as a border between east and west and the gateway between the Mediterranean and central Europe. Only during the Roman Empire was the Adriatic entirely under the control of a single unified political entity. During the early Empire, the pax Romana ushered in an age of economic stability and increased exchange. As such, the Adriatic under the Roman Empire represents a particularly useful case study to better understand ancient mobility and exchange.

Results

Overall, the potential of Circuit Theory is clear. Providing far more detail of the landscape of mobility than any traditional LCP analyses could produce, clearly highlighting funnel points and a spectrum of viable routes across this landscape, from the primary routes, through to secondary, tertiary and beyond, down to the those that would be particularly limited in their viability. Additionally, the early results of the archaeological data against these Circuit Theory outputs study show that urban centres are consistently located in areas of high potential mobility. However, the relationship between the population of an urban centre and the potential mobility value are less clear, with some large urban centres having relatively low potential mobility values (see Figure). In terms of shipwreck data, the most striking result is that the colder wetter months appear to have higher overall mobility values, and is particularly apparent when infrastructure such as ports and roads are included.



Discussion

It is clear that the inclusion of the seascape has a significant impact on the terrestrial landscape of mobility. As such, it should be acknowledged that terrestrial studies in isolation offer, at best, an incomplete picture of mobility, and at worst, an inaccurate or misleading representations of these landscapes. Furthermore, while high potential mobility appears to have been necessary for the development of an urban centre, the level of development of individual urban centres is not directly tied to this value of potential mobility. A variety of other factors must have been at play, including local ecology, proximity to other urban centres and other less tangible cultural or political factors, the provincial capital of Salona is a clear example of this. Potential mobility is linked to all of these, but this research shows that potential mobility alone does not drive the development of individual urban centres.

The shipwreck data is somewhat more complicated. It may appear, at first, to suggest that more maritime exchange likely took place during colder wetter months. However, what this shows in reality, is that more ships sank during these colder months. Nevertheless, what is emphatically clear, is that large scale intra-regional, as well as smaller scale inter-regional, maritime exchange regularly took place during the winter months. The idea that the ancient sailing season was overwhelmingly restricted to the summer months should be discounted, and a more dynamic model for ancient maritime exchange can begin to be formulated.

Ultimately, this research highlights current innovations employing Circuit Theory to better understand mobility in archaeological landscapes. It allows us to begin to build on more traditional LCP analyses and move beyond some of their limitations. While the case study is particularly useful for showcasing and testing this methodology, the methodology itself is in no way restricted temporally or geographically to the Roman Adriatic.

References

Herzog, Irmela. 2014. "Least-Cost Paths – Some Methodological Issues." Internet Archaeology, no. 36.

McLean, Andrew, and Xavier Rubio-Campillo. 2022. "Beyond Least Cost Paths: Circuit Theory, Maritime Mobility and Patterns of Urbanism in the Roman Adriatic." Journal of Archaeological Science 138.

McRae, Brad, Viral Shah, and Alan Edelman. 2016. Circuitscape: Modeling Landscape Connectivity to Promote Conservation and Human Health. https://doi.org/10.13140/RG.2.1.4265.1126.

55. "It's fine on a good day!" - Perceived risk and route choice among Viking Age seafarers. Potentials of digital mapping and experimental archaeology.

Greer K Jarrett, Lund University

The maritime communities of Viking Age Scandinavia are enjoying great popularity in and beyond academia, thanks to frequent appearances in popular culture, a growing body of archaeological evidence, and UNESCO's recent designation of Nordic clinker boat traditions as intangible heritage of humanity. These communities were part of a complex and lively network of interaction and exchange spanning the seas and oceans of the Viking world involving frequent maritime travel over vast distances. Unfortunately, most of the surviving evidence for this network provides us only with a point of origin and a point of burial, deposition, or diffusion. We still know very little about the journeys in between, that brought people, goods, ideas, and beliefs across the water. Both the nature of these routes (geographical itinerary, duration, seasonality, cost) and the ontological implications of mobility and discovery (consequent mental maps and worldviews) remain hard to reconstruct and characterise with current research methods. This presentation will examine a methodological approach that might provide us with new insights into maritime mobility and connectivity in the Viking Age. In this approach, digital mapping methods from a range of cartographic traditions are used to record, represent and re-process field data from experimental archaeology. These data are then used as the basis for a digital model of Viking Age seafaring that may answer some of our questions about these iconic voyages.

In this presentation I will summarise the results of recent experimental fieldwork, which aimed to identify the most important factors for determining route choice for Viking Age mariners. The results indicate that the main factor in this choice is a multi-faceted judgement of the perceived risk to vessel and crew. These results allow us to hypothesise about which routes would have been preferred, but how best to model and represent such a subjective, contextual and dynamic concept as risk judgement? To answer this, a range of digital methods will be explored and evaluated, such as isochronic cartography and deep maps. It is hoped that these will trigger discussion and feedback surrounding the representation and reconstruction of maritime route choices in the past, and provide inspiration for new approaches and methodologies.

136. Convolutional multi-factor probabilistic time-aware corridors: a new approach to the analysis of past long-distance mobility

Hector A. Orengo, Landscape Archaeology Research Group, Catalan Institute of Classical Archaeology
Toby C Wilkinson, Catalan Institute of Classical Archaeology

Introduction

Mobility has been essential for the development of communications and relationships between different human groups. Transcontinental routes, formed by the continuous adjoining of intra-cultural roads, played an essential role in the development of a common knowledge of the world as early as the Bronze Age with clear evidence of cultural interchange between lands so distant as Crete in the Mediterranean and India. These are shaped by interlinked settlements and extend over territories surpassing the regional scale. When approached at a large scale routes join forming transport networks forming a continuous web of movement possibilities, which expands in space and time.

Despite the importance of movement to comprehend the origins and development of human relationships little is understood of how people moved in the past, how environmental conditions affected movement and how the domestication of animals and the evolving technologies of transport extended human connectivity to different ecological zones. This is particularly pressing when considering long-distance and transcontinental routes, where factors affecting movement can greatly vary along the route and the mobility network tend to reflect seasonal variations and socio-economic factors.

In this paper we address these problems by developing a network of high resolution transcontinental, multi-factor probabilistic temporal corridors using high performance computing that can be statistically related to multitemporal settlement data and queried using common statistical approaches.

Methods and materials

The preparation of the cost surface, which measures the cost of traversing each raster cell, presented the most complex part of the workflow. It was developed combining a series of satellite-based sources modified to adapt to different cost values. The first of those was the slope cost for humans, which was derived using the sixth degree polynomial developed by Herzog (2013) from ethnographic data from Minetti et al. (2002) using ALOS (30 m/px). This raster forms the basis of the cost surface to which all other factors are multipliers (except for the sea mask, which is summed).

The Global Water Mask (250 m/px), a global map of surface water was used to identify large water bodies with a cost value of 50 to discourage transit over water. However, these not include temporary or even perennial water bodies such as rivers that can hinder movement. For this we used the JRC Monthly Water Recurrence dataset, cost values were set to range between 1 and 4 depending on the quantity of water documented in each 30 m pixel for the specific month. Snow costs were derived from the MODIS MOD10A1 V6 Snow Cover Daily Global 500m product were also included.

Another important factor to take into account is the lack of water. However, this is a very complex cost to factor as how the lack of water affect movement is dependent upon a multiplicity of factors. The most important of these factors is temperature, which was derived from TerraClimate. Temperature data was limited to user-selected values in ˚C (default, min:28, max:50), distributed in a 0-2 range and used as an exponent where the base was the value of dryness. Dryness values were extracted from a multiyear monthly series of Landsat 5-derived EVI values thresholded at 0.05, which is a common value to define desertic conditions, and ranged from 1 to 2.

We also created a layer factoring the attraction to areas with higher presence of water. However, the attraction factor of this layer is should be weighted by the local environmental conditions. Therefore this attractor (reduced costs) layer is only implemented in areas with high aridity and temperature. Taking this into account and, given the capacity of humans to carry water we created a focal mean convolution of the previous 'lack of water' cost layer with a 7 km radius to provide a sense of distance for the areas where desert and temperature are high and, therefore, the presence of water can be considered an attracting factor. The convolution was included as an exponent in a where the base was the same Landsat 5-derived EVI multi-year monthly values thresholded at 0.2 (minimum EVI healthy vegetation value).

Lastly, a layer aiming to measure the cost of traversing high mountain areas was derived using the function f = 0.00345*e^0.000845h (where h is the DSM value for each cell thresholded at 2000 m.a.s.l.). This function derives a curve intersecting the two values for which we have data on how altitude affects walking performance (Minetti et al. 2006).

All cost derivates were cropped to the user-defined area of interest (AoI) and averaged by user-selected periods, which allowed us to extract cost surfaces for different seasons or months. All these cost layers were multiplied between them and the sea mask was added.

The next steps in the production of corridors was the generation of cost distance rasters from specific points of interest. For this the knight move algorithm was employed. Despite being more computationally costly, the knight's move doubles possibilities for radial movement from any given raster cell compared with traditional algorithms, which provide much more natural results. Different cost distance rasters can be combined to create corridors between two or more points of interest using cell stats.

Results

We have employed the code described above to generate probabilistic corridors modelling the historical Silk Route from Istanbul to Xi'an. To test the significance of the resulting corridors we have employed a distribution of selected sites and artifacts related to the Silk Route.

Discussion

The corridors presented here provide a unique tool for the analysis of long-distance movement. They are multi-factor, which allows them to take into account multiple factors affecting movement over large distances that are usually not significant on the calculation of local or regional routes. They also introduce convolutional costs, which allow changes in costs according to local conditions, they incorporate time-aware datasets that allow users to produce best routes according to seasonal variations. The nature of the corridors (including a range or values rather that a single best route) together with the possibility to join several corridors from multiple start-destination points allows probabilistic modelling of distributions along the route and exploratory analysis, which adapt much better to the nature of hypothesis-based archaeological enquiry and the fact that costs are based on modern data.

References

Herzog, I. 2013. Theory and Practice of Cost Functions. In F. Contreras, M. Farjas and F.J. Melero (eds.) Proceedings of the 38th Annual Conference on Computer Applications and Quantitative Methods in Archaeology, CAA2010. Archaeopress, Oxford: 375-82.

Minetti, A.E.; Moia, C.; Roi, G.S.; Susta, D. and Ferretti, G. 2002. Energy cost of walking and running at extreme uphill and downhill slopes. Journal of Applied Physiology, 93: 1039-46.

Minetti, A.E.; Formenti, F. and Ardigò, L.P. 2006. Himalayan porter's specialization: metabolic power, economy, efficiency and skill. Proceedings of the Royal Society on Biological Sciences, 273: 2791-7.

319. Identifying Reasons for Lack of Least-cost path success: A case study from Germany

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Evidence of past routes is often sparse or does not exist. Computational approaches such as least-cost path (LCP) algorithms implemented in GIS procedures seem to provide an objective methodology for reliable route reconstruction. For this reason, archaeological LCP studies frequently do not include a ground-truthing section. If the ground truth is known, the cost parameters can be adjusted iteratively until the LCPs reconstruct the known routes successfully. For the study region considered, this provides an adequate model of mobility for the routes reconstructed successfully and allows assessing the accuracy of the LCP approach in the study region. These reflections were the basis of the case study to be presented in this paper.

The hilly study region east of Cologne is mostly rural and is covered by a dense network of small water courses. The ground truth is provided by detailed publications by Herbert Nicke who describes the main old trade routes in the study area. Modern highly accurate elevation and hydrology data form the basis of the LCP computations. In a first step, the outcomes of a set of slope-dependent cost functions were compared with the known trade routes. The slope-dependent cost function generating the best fit was integrated in refined models that include penalties for traversing water courses and also take possible bridge or ford locations into account.

The best cost model achieved this way reconstructed about two thirds of the past trade routes quite successfully (Herzog 2022). The aim of this paper is to analyse why several of the LCPs fail to reconstruct the known old routes. As expected, some of these issues can be attributed to landscape change, mainly due to dam construction. Sometimes, including another important waypoint in the set of targets improved the reconstruction by LCPs considerably. But in general, the distance between two targets to be connected by LCPs was not correlated with the LCP performance.

Moreover, it turned out that the ground truth was not as reliable as assumed in the first place. Some of the digitized "ground truth" route sections were corrected after rereading the publications by Nicke as well as comparing the digitisation by the author, by another person and the old roads recorded in the Viabundus project. A small portion of the Viabundus road sections are not included in Nicke's descriptions, and several routes included in Nicke's publication do not coincide with Viabundus roads. This observation inspired a classification of Nicke's routes. Route sections are considered reliable if they are also recorded in Viabundus or depicted on an old map created in 1715 or before. It turned out that nearly all reliable route sections could be reconstructed quite successfully by the LCPs based on the cost model derived by successive refinement.

References:

Herzog I. (2022). 'Issues in Replication and Stability of Least-cost Path Calculations' Studies in Digital Heritage 5(2): 131–155.

Holterman B. et al. (ed.). 'Viabundus Pre-modern Street Map 1.2' (released 21-9-2022), https://www.viabundus.eu

33. Bayesian Inference in Archaeology: new applications and challenges

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The archaeological record provides a unique opportunity to study past human behaviour . Its record, nonetheless, is not straightforward to analyse — it is scarce, noisy, biased, incomplete and unevenly distributed over space and time. Bayesian statistics offers a inferential framework that is well suited for tackling these problems, offering ways to quantify uncertainties arising from these limitations and providing means to take them into account when drawing our conclusions. Bayesian inference has made great advances recently. While initial applications in archaeology were limited within the confines of chronological modelling and few dedicated softwares packages (e.f. OxCal and BCal). The last decade saw a major change – with applications including faunal analyses, diet reconstructions, paleodemography, past economy, and cultural evolution to name a few examples. This major change in archaeological practice was made possible thanks to the increased computational power of desktop machines , a the availability of a large number of probabilistic programing languages (e.g. JAGS, Stan, Nimble,etc.) , a growing number of "hands-on" literature on Bayesian methods (McElreath 2020), and the increased number of scholars across disciplines sharing their scripts and code to ensure their work is fully transparent and reproducible..

With this session we want to capture this momentum by proposing a showcase of how archaeologists face their own specific problems using formal inference and probability theory, but also a broader reflection of where we are and where can we go using these types of techniques. In order to do so, we raise a series of questions:

- How can Bayesian statistics and probability theory help understanding the archaeological record?
- What are the specific archaeological challenges in applying techniques designed to handle measurement error and missing data?
- What probabilistic methods can/are being applied within archaeology?
- What are the specific challenges in re-using inferential models developed in other fields within archaeology?

By bringing together archeologists who already apply Bayesian inferential techniques to their work or are interested to do so, we hope to increase the awareness and visibility of such methods in the larger field of archaeology. By showcasing successful examples of application of probabilistic inference in archaeology, we hope to convince people of the power of such an approach. Finally, we also want to offer a platform where researchers using Bayesian approaches can share knowledge and keep themselves up to date with the latest techniques in use.

We invite proposals of any applications of Bayesian statistics in archaeology, with particular interest in the following areas:

- Hierarchical Modelling
- Gaussian Process Modelling in Spatial and Temporal Analyses
- Bayesian Networks
- Phylogeography and phylogenetic Analyses
- Inference with missing Data and measurement errors
- Mixture Models
- Likelihood-free methods (e.g. Approximate Bayesian Computation, Bayesian Synthetic Likelihood)

The session is not limited to any chronology or geographical area and may include case studies, theoretical reflections, methodological innovation and assessment, etc. Innovative approaches and novel insights are particularly welcome as well as students and early career researchers who want to present preliminary results.

References:

McElreath, R. (2020). Statistical Rethinking: A Bayesian Course with Examples in R and Stan. CRC Press, Boca Raton.

SLOT 1	
08:30 - 08:50	125. Variation in Archaeology and Osteoarchaeology: using Bayesian Hierarchical Modelling to explore variation in dental tissues *Christianne L Fernee (University of Bristol)*; Kate Robson Brown (University of Bristol)*
08:50 - 09:10	176. Modelling Roman Roads in Roman Britain *Joseph Lewis (University of Cambridge)**

09:10 - 09:30	302. Bayesian mixing models as a tool to explore the Bronze Age bitumen trade. *Adrià Breu (Autonomous University of Barcelona)*; Anna Bach (Autonomous University of Barcelona); Zidan Bradosty (Salahaddin University); Aziz Zebari (Salahaddin University); Hawkar Abdullrahman (Salahaddin University); Miquel Molist (Autonomous University of Barcelona)*
09:30 - 09:50	205. Spatial Autocorrelation and Cultural Boundaries: detecting Japanese burial tradition areas during the Jomon-Yayoi transition *Simon Carrignon (McDonald Institute for Archaeological Research, University of Cambridge)*; Shinya Shoda (Nara National Research Institute for Cultural Properties); Mariko Yamamoto-Wilkins (University of Cambridge); Enrico R Crema (University of Cambridge)*
09:50 - 10:10	280. How do you cultivate? The ecological niche for rice in Yayoi period Japan via multi-proxy species distribution modelling *Leah Brainerd (University of Cambridge)*; Simon Carrignon (McDonald Institute for Archaeological Research, University of Cambridge); Marco Madella (Universitat Pompeu Fabra); Akihiro Yoshida (Kagoshima University); Enrico R Crema (University of Cambridge)*
10:10 - 10:30	289. Inequality in prehistoric Japan: estimating Gini coefficients from pit dwellings using a Bayesian hierarchical model *Charles Simmons (University of Cambridge)*; Enrico R Crema (University of Cambridge)*

125. Variation in Archaeology and Osteoarchaeology: using Bayesian Hierarchical Modelling to explore variation in dental tissues

Christianne L Fernee, University of Bristol
Kate Robson Brown, University of Bristol

Introduction

Data in archaeology, and more specifically osteoarchaeology, is inherently nested. Identifying variation at the different levels of this data is often at the heart of archaeological inquiry. In recent years, Bayesian models have been increasingly used in archaeology (Otárola-Castillo & Torquato 2018). Bayesian multilevel models are able to a variety of questions, regarding both the levels in the respective model and associated predictors (Fernée and Trimmis 2021). They are, however, yet to be fully exploited in archaeology.

This paper will explore inter- and intra-individual variation in dental tissues and proportions using Bayesian multilevel modelling. The durability of dental tissues means that teeth often outlast any other skeletal remains in many contexts, from paleoanthropology to forensic. Dental variation can be used as a source of information for a range of genetic, epigenetic and environmental factors. This variation is multi-layered and multifaceted, occurring within and between individuals and involving the entire or a specific aspect of a tooth. Dental variation within populations and, even more so, within individuals is far less well understood than variation between populations in both archaeological and clinical research. Existing intra-population studies, as with inter-population studies, of tooth variation have relied largely on metric crown measurements. Alternative dental measurements, such as tooth tissue proportions, may provide interesting new insights.

Materials and Methods

A sample of 300 teeth were studied from 30 archaeological individuals. Individuals were obtained from 3 sites from the south of the UK: 1) the Early Medieval (5^{th} – 7^{th} century AD) cemetery at Great Chesterford, Essex (n=10), 2) the middle Medieval (7^{th} – 11^{th} century AD) monastic cemetery at Llandough, South Wales (n=10), and 3) the Late Medieval priory cemetery of St Peter and Paul, Taunton, Somerset (n=10). Teeth were scanned using micro-computed tomography (micro-CT), from these scans tooth tissue volumes, surface areas and proportions were obtained for each tooth.

Dental variation on an intra and inter individual level was studied using Bayesian Multilevel Modelling. For each dental measurement a two-level model was constructed: tooth (level 1) and individual (level 2). Specifically, this included 300 teeth, first incisor to second premolar, from 30 individuals. Tooth and individual level predictors were included. At a tooth level: tooth type, isomere (upper or lower), position in field and degree of dental wear were included. At the individual level: sex and age were included. The proportion of residual variance attributed to each level of the model can be determined by calculating the Variance Partition Coefficient (VPC). The effect of the fixed predictor variables on the outcome variable was interrogated using the posterior distributions, particularly the credible intervals.

Results and Discussion

The results give an insight into the variability of these dental measurements and the impact of the predictors. A greater proportion of variation occurs between teeth, however more variation occurs at an individual level than first thought. This is indicative of considerable variability in tooth dimensions between individuals and has important repercussions on past, present and future research in terms of sample composition. The potential of using Bayesian multilevel models will be discussed in the context of this research, alongside its use for other measurements and different types of data. This includes its use for 'new' measurements, with non-informative priors, and 'old' measurements, with informative priors.

References

Fernée, C. L. & Trimmis, K. P. (2021) Detecting variability: A study on the application of bayesian multilevel modelling to archaeological data. Evidence from the Neolithic Adriatic and the Bronze Age Aegean. Journal of Archaeological Science. 128:105346

Otárola-Castillo, E. & Torquato, M. G. (2018). Bayesian Statistics in Archaeology. Annual Review of Anthropology. 47:435-453

176. Modelling Roman Roads in Roman Britain

Joseph Lewis, University of Cambridge

With an estimated total length of 300,000 km and spanning across seven ecological zones, Roman roads were fundamental for the expansion, consolidation, and economic development of the Roman empire.

With a long history of interest, the study of Roman roads can be classified into two defining groups: (1) roads themselves as evidence through which the Roman world is understood, and (2) the social impact of Roman roads on how space and society is organised. Whilst the latter is more recent and continues in its prominence (e.g. Laurence 1999), the study of Roman roads under the former has received comparatively little theoretical or methodological attention since Raymond Chevallier's Roman Roads in 1976. This is particularly true with regards to the use of computational methods, which this paper will address.

Focusing on Roman roads deduced from the Antonine Itinerary (a collection of itineraries compiled from publicly displayed lists accumulated over time until around A.D 300), this study uses least-cost path analysis and Approximate Bayesian Computation (ABC) to infer the factors that might have influenced the route of these roads in Roman Britain. For this, a generative model representing the rationale used when constructing a Roman road through the landscape is developed, with simulations from this model compared against the route of the known Roman roads.

Although still preliminary, the results show that the construction of Roman roads in Roman Britain did not share a single shared decision-making rule. Instead, it is suggested that the factors influencing the route of each road reflects the topographical considerations present for each road. By using ABC as the method, these factors and the uncertainty in their value are quantified. The inability to model all Roman roads is also discussed, with this challenge linked to model misspecification and a mismatch between observation scale and process scale.

References

Beaumont, M. A. (2019). Approximate Bayesian Computation. Annual Review of Statistics and Its Application, 6(1), 379–403. https://doi.org/10.1146/annurev-statistics-030718-105212

Chevallier, R. (1976). Roman roads. London: Batsford

Laurence, R. (1999). The roads of Roman Italy: mobility and cultural change. London: Routledge

Lewis, J. (2021). Probabilistic Modelling for Incorporating Uncertainty in Least Cost Path Results: a Postdictive Roman Road Case Study. Journal of Archaeological Method and Theory. https://doi.org/10.1007/s10816-021-09522-w

302. Bayesian mixing models as a tool to explore the Bronze Age bitumen trade.

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In ancient times, bitumen was a valuable commodity used for its stickiness, ignition, and waterproofing properties. It was widely traded across south-west Asia from early prehistory to medieval times and played a significant role in the economic and political developments of the Bronze Age. Bitumen was used in monumental architecture, shipbuilding, water management, art pieces, magic, and medicine, and its use in boat construction facilitated trade itself (Forbes, 1964; Stol, 2012). The study of ancient bitumen trade thus can provide insights into the origins of this resource and the networks of exchange that were established during the Bronze Age (Connan, 1999; Connan and Van de Velde, 2010).

Bayesian mixing models have been successfully applied to quantify the proportions of different foodstuffs in archaeological pottery residues (Fernandes et al., 2018; Lucquin et al., 2018; Courel et al., 2020) and to study the composition of past human diets (Fernandes et al., 2015). In this study our purpose is to evaluate the effectiveness of Bayesian models in distinguishing and apportioning bitumen remains of different geographic origins found in pottery from the Bronze Age layers of Tell Lashkir, an archaeological site located in Erbil, Iraq. The validity of the models have been tested using a corpus of published modern references and previously identified archaeological samples.

In this case, a series of non-weighted concentration-independent Bayesian mixing models were built using the FRUITS v3.1beta software to identify the types and sources of bitumen found at an archaeological site. The model used geochemical ratios as proxies for the different bitumen types, and applied a Monte Carlo Markov Chain to calculate the relative amounts of each bitumen type in the mixture.

A first model was used to detect variations within the bitumen samples from the site, while the second model was used to evaluate the similarity of the samples to those found at other contemporary archaeological sites. The third model was used to explore the possible geographic location of the bitumen sources.

To test the accuracy of the third model, it was applied to a set of known modern reference samples and previously published archaeological samples. In the first case, 76.8% of the results were found to be in agreement with the literature, while in the second case, the rate of success rose to 83.7%. The main sources of error were samples from southern and central Mesopotamia that were mistakenly attributed to north-eastern sources. To take them into account, a Linear Discriminant Analysis was used to consider biases undervaluing or overvaluing the probability that certain regions were the main source of bitumen in the mixture. Furthermore, a posteriori aggregation of model results (Phillips et al 2005) combining data from samples located in the same archaeological contexts provided more constrained and interpretable results.

Given the high degree of agreement between the reference samples and the outputs of the model, well-preserved bitumen residues from the archaeological site were submitted to the third model. The results indicated that the bitumen at the site had a predominantly north-eastern Mesopotamian origin, with a smaller contribution from central Mesopotamia.

The use of Bayesian mixing models in the study of archaeological bitumen has thus been successful in helping to identify the sources of various mixtures. As the analysis of bitumen from northeastern Mesopotamia in the early third millennium suggests, the people living in Tell Lashkir were part of exchange networks that extended to southern Mesopotamia. It is likely that they traded with bitumen from both nearby and distant sources, including central Mesopotamia. The results also support the widespread use of central Mesopotamian bitumen at this time (Connan and Van de Velde, 2010), while also indicating the presence of bitumen from the northeast.

Bitumen was instrumental to the origin of the first civilizations and states, as well as the development of the first global trade networks. The use of robust statistical techniques to interpret chemical data on archaeological bitumen allows deciphering in exceptional detail the apportionment of ancient bitumen trade in south-western Asia. Thus, the combined biomarker and Bayesian approach offers new insights into the origin of civilisation and the first states, one of the defining periods in the history of humankind.

References:

Stol, M., 2012. Bitumen in ancient mesopotamia. The textual evidence. Bibl. Orient. 48–60.

Phillips, D.L., Newsome, S.D., Gregg, J.W., 2005. Combining sources in stable isotope mixing models: Alternative methods. Oecologia 144, 520–527. https://doi.org/10.1007/s00442-004-1816-8

Lucquin, A., Robson, H.K., Eley, Y., Shoda, S., Veltcheva, D., Gibbs, K., Heron, C.P., Isaksson, S., Nishida, Y., Taniguchi, Y., Nakajima, S., Kobayashi, K., Jordan, P., Kaner, S., Craig, O.E., 2018. The impact of environmental change on the use of early pottery by East Asian hunter-gatherers. Proc. Natl. Acad. Sci. 201803782. https://doi.org/10.1073/pnas.1803782115

Forbes, R.J., 1964. Studies in Ancient Technology. Brill, Leiden.

Fernandes, R., Grootes, P., Nadeau, M.-J., Nehlich, O., 2015. Quantitative diet reconstruction of a Neolithic population using a Bayesian mixing model (FRUITS): The case study of Ostorf (Germany). Am. J. Phys. Anthropol. 158, 325–340. https://doi.org/10.1002/ajpa.22788

Fernandes, R., Eley, Y., Brabec, M., Lucquin, A., Millard, A., Craig, O.E., 2018. Reconstruction of prehistoric pottery use from fatty acid carbon isotope signatures using Bayesian inference. Org. Geochem. 117, 31–42. https://doi.org/10.1016/j.orggeochem.2017.11.014

Courel, B., Robson, H.K., Lucquin, A., Dolbunova, E., Oras, E., Adamczak, K., Andersen, S.H., Astrup, P.M., Charniauski, M., Czekaj-Zastawny, A., Ezepenko, I., Hartz, S., Kabaciński, J., Kotula, A., Kukawka, S., Loze, I., Mazurkevich, A., Piezonka, H., Piličiauskas, G., Sørensen, S.A., Talbot, H.M., Tkachou, A., Tkachova, M., Wawrusiewicz, A., Meadows, J., Heron, C.P., Craig, O.E., 2020. Organic residue analysis shows sub-regional patterns in the use of pottery by Northern European hunter–gatherers. R. Soc. Open Sci. 7, 192016. https://doi.org/10.1098/rsos.192016

Connan, J., 1999. Use and trade of bitumen in antiquity and prehistory: molecular archaeology reveals secrets of past civilizations. Philos. Trans. R. Soc. B Biol. Sci. 354, 33–50. https://doi.org/10.1098/rstb.1999.0358

205. Spatial Autocorrelation and Cultural Boundaries: detecting Japanese burial tradition areas during the Jomon-Yayoi transition

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Japan's transition to farming started around 1000 BCE and was triggered by the diffusion of a new cultural package brought in by migrants from the Korean peninsula. The spread of individual elements of this package did not happen uniformly: some were adopted by the local populations, others only travelled where the migrants settled. Variations on these diffusion processes led to geographical and temporal patterns that provide unvaluable hints on how different geographical, ecological and cultural areas responded to these novel cultural traits. Nonetheless, the identification of these cultural boundaries and clines have so far been limited to simple visualisation of the evidence at hand or subjectively drawn lines on maps, which hinders our ability to assess the impact of sampling error or to formally assess hypotheses that might explain the observed patterns of cultural diversity .

Here we attempt to overcome these issues by:

1. Creating a new dataset recording the presence and absence of multiple categorical data for which precise geographical locations are available and with known and as uniform as possible sample size.

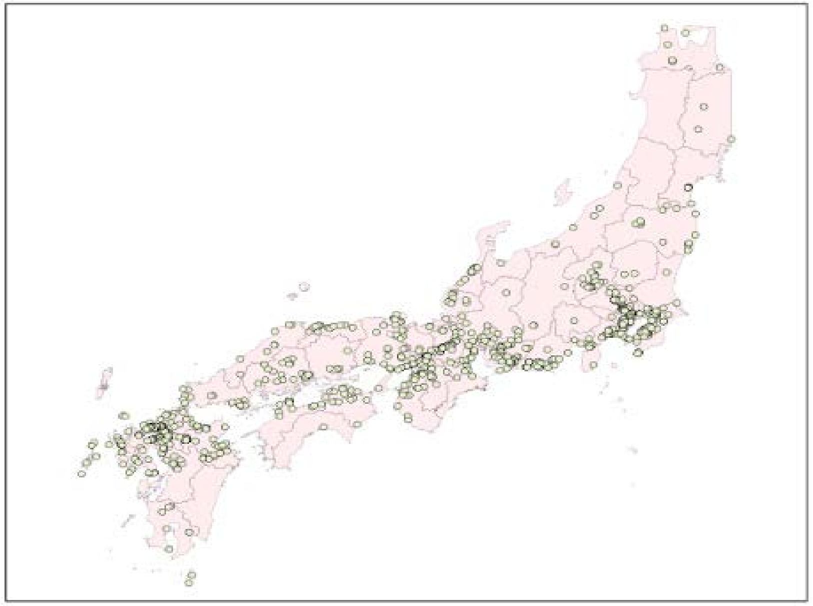
2. Estimating with as much accuracy as possible the real distribution of the observed categorical data.

3. Detecting statistically significant between adjacent areas and finding covariates that may explain these abrupt variations in the composition of cultural traits .

In this paper we explore the distribution of different types of burial present in the Honshu, Kyushu and Shikoku islands of the Japanese archipelago during the Yayoi period. We gathered together data from archaeological reports and books, to create a database listing 13 different categories of burials found in almost 3000 sites distributed over 45 of the 47 Japanese prefectures (cf Fig. 1) during the Yayoi period.

This dataset still suffers from multiple issues: each prefecture has its own policies and follow different procedures regarding how archaeological excavations are made and how the information is stored. Some are less populated than others, thus have less archaeological activities, etc… Overall, this leads to an uneven data distribution with differences in the relative frequencies of each variant that are potentially confounded and biased by sampling error and research design. To circumvent this, statisticians have developed models that use available geographical information to infer likely values where data is limited or missing (Besag et al. 1991). These methods often rely on Conditional Autoregressive (CAR) processes and Bayesian techniques that account for how spatially auto-corellated the data are. This allows us to a) handle smaller sample sizes and noisy records and b) detect when the spatial variation in the proportion of cultural variants are not simply due to spatial autocorrelation.

Here we follow Dean et al. (2019), who adapted such methods to detect frontiers and social segregation in neighbourhoods in the city of Sheffield. We used the INLA (Integrated Nested Laplace Approximation) implementation of an Intrinsic Conditional Autoregressive model (ICAR) to estimate the proportion of our 13 categories of burials in all prefectures of Japan where information is available. We then used these estimates to automatically and systematically detect frontiers, defined as statistically significant differences and unexpected drop of proportion between adjacent prefectures. We then compare the frontiers detected for each category and contrast them with different geological and ecological characteristics to determine if some spatial or environmental regularity and correlations could be found to explain the observed patterns.



Dean, N., Dong, G., Piekut, A., & Pryce, G. (2019). Frontiers in residential segregation: understanding neighbourhood boundaries and their impacts. Tijdschrift voor economische en sociale geografie, 110(3), 271-288.

Besag, J., York, J., & Mollié, A. (1991). Bayesian image restoration, with two applications in spatial statistics. Annals of the institute of statistical mathematics, 43(1), 1-20.

280. How do you cultivate? The ecological niche for rice in Yayoi period Japan via multi-proxy species distribution modelling

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The introduction of rice and millet agriculture into Japan during the 1st millennium BCE led to significant changes in lifestyle within the archipelago. Rice and millet agriculture were proliferated by migrant communities from mainland Asia; these communities spread into the Japanese islands interacting with the incumbent population of complex hunter-gatherers, the Jomon people. However, its adoption was not uniform across Japan, with some areas showing limited to no reliance on the new subsistence strategy and others, after an initial adoption, even reverting to a predominantly hunting and gathering economy. The geographically diverse response to the continental subsistence economy is generally assumed to reflect the underlying variation in the environmental and climatic settings of the Japanese islands. However, this assumption remains untested, and further exploration of the relationship between environmental and social factors is required to elucidate the diversity of local responses. This paper contributes to this research agenda by exploring how environmental suitability for rice agriculture impacted the spatial distribution of archaeological sites in the Yayoi period. To explore this topic, we employ Bayesian species distribution modelling (SDM) to estimate the realised ecological niches for Japonica rice using multiple proxies for its presence. The exploration of different proxies for rice subsistence will allow for discussion of the effectiveness of different proxies to represent subsistence and the impact they have upon species distribution modelling.

SDM is a suite of statistical techniques that originates within ecology and whose use has exponentially increased over the past two decades along with some limited applications within archaeology. The popularity comes from its relative ease of use computationally and lower data requirements compared to extant models. Typically, SDMs require two types of data as input: observed spatial data (e.g presence data at archaeological sites) and environmental information (e.g. paleoclimatic information). The relationship between the observed data and the environment is obtained using a chosen algorithm to predict the realised niche of the 'species'. In this paper, we will use several proxies spanning across the entirety of Japan for rice subsistence as our observed spatial data. These datasets include archaeological sites with evidence of paddy fields, lithic toolsets suited for rice cultivation (i.e. stone sickles), and rice macrofossils. The mix of different proxies is necessary as true 'presence' of rice cultivation is very difficult to determine and each suffers from different drawbacks. Paddy fields, while definite in certainty of cultivation, are more nebulous in chronological certainty due to only relative dating means. Macrofossils have much more certainty in timing but do not necessarily imply cultivation. Finally, stone tools have been shown to be used for rice cultivation in some cases,but that may not be their only purpose at these sites. This research will provide valuable insight into the benefits of multi-proxy techniques and the effectiveness of these individual proxies.

For environmental suitability to rice cultivation, we will be focusing on temperature and soil, both known as key variables that deeply impact the growth of rice and are accessible from paleo-environmental reconstructions. To explore temperature we employed ecological thermal niche modelling, which provides a measure of accumulated heat required during growing season. Parameters of the thermal niche model have been obtained from experimental cultivation of historic Japanese red rice , a variety with characteristics similar to oryza rufipogon and that has ungone limited pressure for hybridization, and by adapting it to account for rice transplanting. We will use maps of soil and geology across Japan to highlight areas that are better and worse suited for rice production. In particular, highlighting those with well drained and phosphorus deficient soils having a negative impact on rice production.

With our data, we will fit a model using individual proxies both separately and jointly to explore the effects the individual proxies have on the resulting niche. We have elected to treat the proxies as different species at this point in time as it is likely that they have differing, but related signals, (e.g. lithics can be used for rice cultivation but also can have other possible functions) treating them combined together similarly to an "ecological community" (Fauth et al., 1996). For both separate and joint proxy models, we will be relying on the Hierarchical Modelling of Species Communities (HMSC) framework, using the R package Hmsc (Tikhonov et al., 2022). HMSC is a multivariate hierarchical generalised linear mixed model fitted with Bayesian inference. While HMSC is a class of Joint SDM, it can also be applied to single species data as well and the framework overall has performed well when compared with many other algorithms. Thus, through this research, we hope not only to elucidate on the relationship between environment and the spread of the Yayoi cultural package, but to contribute meaningful information about how different types of SDMs can be used within archaeology and how utilisation and evaluation of multiple proxies is incredibly important to archaeological research.

References:

Fauth, J.E., Bernardo, J., Camara, M., Resetarits, W.J., Van Buskirk, J., McCollum, S.A., 1996. Simplifying the Jargon of Community Ecology: A Conceptual Approach. Am. Nat. 147, 282–286.

Tikhonov, G., Ovaskainen, O., Oksanen, J., Jonge, M. de, Opedal, O., Dallas, T., 2022. Hmsc: Hierarchical Model of Species Communities.

289. Inequality in prehistoric Japan: estimating Gini coefficients from pit dwellings using a Bayesian hierarchical model

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The Jomon Period of Japan (16,000 to 2800 cal BP) is often characterized as an egalitarian hunter-gatherer society. Still, only a few studies have been conducted to assess the level of inequality present throughout the period. The analysis of grave goods, ritual objects, prestige items, and settlement layouts suggest that the levels of inequality in the Jomon increased in the Late (4400 - 3200 cal BP) and Final (3200 - 2800 cal BP) Periods. The Yayoi Period (2800 - 1700 cal BP) that follows the Jomon sees the introduction of agriculture to the Japanese Archipelago and a considerable increase in inequality. To investigate the long-term social and economic changes that occurred in Japan within these two very different periods, it is necessary to have a quantitative measure of wealth inequality that is robust against significant cultural differences. Gini coefficients derived from house size data, while acknowledging the criticisms of their reliability as an accurate proxy, allow for this type of cross-cultural comparison. This paper analyzes data from over 100 sites across the archipelago's main islands representing over 5000 pit dwellings from the Jomon and Yayoi periods. With this approach, we can quantitatively assess changes in inequality towards the end of the Jomon period and determine if the different responses in eastern and western Japan to the introduction of agriculture also lead to different socio-economic trajectories, as suggested by the household data. We introduce a hierarchical Bayesian approach that incorporates measurement error and uncertainty from sampling into the subsequent level of analysis that compares multiple sites and geographic regions. Using a log-logistic distribution model, we can calculate the Gini coefficient throughout these comparisons as the reciprocal of the shape function of the model.

39. Web-database solutions for the excavation datasets

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Contemporary field archaeology can be characterised as a rush into use more and more digital research methods. The consequence of this is the collection of a wide variety of data: beginning with digitised paper documentation, through spreadsheets such as Excel, Access, photographs and drawings, to very specialised data such as 3D models, microscopic images, non-invasive prospection data or imagery acquired from a variety of platforms like UAVs or satellites. This diversity and volume of data generate several problems facing modern field archaeologists. These problems can be put into a few key points:

1) The storage of collected data in a single environment, which should allow the active use of this information, both at the fieldwork and study levels.

2) The accessibility of the acquired data so that it can be viewed, edited, or used by as wide an audience as possible, in the first instance by expedition members, more widely by the public.

3) The state of existing database solutions. Many emerging open databases are the result of scientific or development projects, and often after the end of their implementation and amortisation period, such solutions are no longer developed or supported. It causes a decrease in their usability, reliability, and significantly hinders their development. This last problem is especially relevant from the point of view of archaeologists who in such a case have to bear the costs for the maintenance and development of their chosen software.

We would like to ask a question and discuss the following issue: Is the rapid development of web-based data solutions for archaeologists an answer to a growing number of data gathered during excavations and a need for its digitization?

For our session, we would like to invite researchers who could share their experience with implementing and using both commercial and open-source databases based on web-based solutions in their excavation practice. From initial excavation recording, surveys, through advanced studies, post-excavation analysis, research and dissemination or archiving. Both small or time-limited projects and large, long term projects with a complex structure will be a point of interest.

If you are using databases solutions like Arches (The Getty Conservation Institute), Portable Antiquities Scheme (the British Museum and Amgueddfa Cymru – National Museum Wales), Open Atlas, FAIMS (Macquarie University), The Archaeological Recording Kit (ARK), HEURIST (University of Sydney) or any other specially designed web-database, we would like to encourage you to talk about your experiences.

References:

Doerr M.; Theodoridou M., Aspöck E., Masur A., Mapping Archaeological Databases to CIDOC-CRM, [in:] Campana S., Scopigno R., Carpentiero G., Cirillo M. (eds.), Proceedings of the 43rd Conference on Computer Applications and Quantitative Methods in Archaeology Keep The Revolution Going CAA, Siena, Italy, 30 March–2 April 2015, p. 443–452.

Filzwieser R., Eichert S., Towards an Online Database for Archaeological Landscapes. Using the Web Based, Open Source Software OpenAtlas for the Acquisition, Analysis and Dissemination of Archaeological and Historical Data on a Landscape Basis, Heritage 3, p. 1385-1401, 2020. https://doi.org/10.3390/heritage3040077

Mafredas T., Malaperdas G., Archaeological Databases and GIS: Working with Databases, European Journal of Information Technologies and Computer Science 1 (3), p. 1-7, 2021. https://doi.org/10.24018/compute.2021.1.3.20

Roosevelt C.H., Cobb P., Moss E., Olson B.R., Ünlüsoy S., Excavation is Destruction Digitization: Advances in Archaeological Practice, Journal of Field Archaeology 40 (3), p. 325-346, 2015. https://doi.org/ 10.1179/2042458215Y.0000000004.

SLOT 1	
08:30 - 08:50	239. AIR: a web-based data management solution for (multiple) archaeological excavations *Paola Derudas (Lund University)*; Federico Nurra (Institut national d'histoire de l'art (INHA))*
08:50 - 09:10	303. DAISY 2.0: A field database solution for an archaeological institution *Adrian Chlebowski (The Polish Centre of Mediterranean Archaeology, University of Warsaw); Maciej Krawczyk (Faculty of History, University of Warsaw); Robert Mahler (Polish Centre of Mediterranean Archaeology, University of Warsaw)**

09:10 - 09:30	373. Back to DIY: Beyond turnkey web solutions *Hallvard R Indgjerd (Museum of Cultural History, University of Oslo)**
09:30 - 09:50	28. Excavation Databases and Numismatic Needs: Case of Marea Archaeological Project *Szymon P Jellonek (University of Warsaw)*; Barbara Zając (National Museum in Kraków)*
09:50 - 10:10	382. Dealing with old and new excavation datasets: the TiMMA web-database *Bastien Rueff (Ecole française d'Athènes)**
10:10 - 10:30	301. MA-P vs. Arches. An open source data management platform for MA-P ("Maloutena and Agora in the layout of Paphos: modeling the cityscape of the Hellenistic and Roman capital of Cyprus") project (Nea Paphos, Cyprus) *Pawel PL Lech (Polish Centre of Mediterranean Archaeology)*; Łukasz Miszk (Jagiellonian University in Kraków); Wojciech Ostrowski (Warsaw University of Technology)*

239. AIR: a web-based data management solution for (multiple) archaeological excavations

Paola Derudas, Lund University
Federico Nurra, Institut national d'histoire de l'art, INHA

Introduction

Excavation data management and publication imply the production of huge datasets composed of multiple formats and different sizes. Most archaeological investigations exploit advanced technologies to handle data using 3D documentation and data management. Solutions such as 3D GIS are commonly used for analyzing and archiving spatial data and metadata of archaeological features; and for several years now, online platforms for the publication and sharing of 3D models have spread.

Such documentation and management approach, even if can be considered successful, demand the use of multiple tools and systems and have some limitations, like data fragmentation (Bauer-Clapp and Kirakosian, 2017) and lack of standards.

The first attempt to overcome data fragmentation we made about the report publication was the development of the Interactive Reporting System (IRS) (Derudas et al., 2021), an online archaeology reporting platform based on 3DHOP (Potenziani et al., 2015). IRS allowed the integration of 3D models with description and interpretation, the spatial location of archaeological features, and artifacts. It combined fragmented data into a unique system that was oriented to constructing dynamic narratives like archaeological reports, thus enriching the user experience. Nevertheless, the data kept being ingested in the 3D GIS for archival and analysis purposes. It implied a dualistic system for managing the excavation data again. Furthermore, the inaccessibility of the local 3D GIS data prevented the reuse by actual and potential users.

A possible solution to address such issues was to design a unique tool able to manage the whole archaeological data lifecycle, from its acquisition in the field to its editorialization.

Methods and materials

In order to create a unique tool for archaeological data acquisition, management, and publication, in adherence with FAIR principles (Wilkinsons et al., 2017), we identified a three-step process:

Gathering legacy data from previous excavations, combining these heterogeneous media and formats ranging from handwritten documentation (like fieldnotes, contexts sheets, and find-list) to matrix diagrams and pictures of archaeological features and finds, which are necessary to the archaeologists and the specialists working with them.

Defining a data model and structuring the whole data according to standard languages and formats; on the one hand, ontologies like the CIDOC-CRM and its extensions, on the other hand, interoperable formats like json-LD: this was paramount to have a queryable overarching dataset.

Finding the right tool capable of managing a robust database and an editorialization platform directly linked to the source data. Such a tool should be able to expose data online via the website but also as standard data (according to FAIR principles), responding to the archaeologists' needs of basic analysis, 3D, and GIS visualization.

These were the premises for the design and development of the Archaeological Interactive Report (AIR).

Results and Discussion

The most suitable solution to create a unique tool for managing the archaeological process was the combination of 3D visualization aspects with data structured in a robust way and the possibility to design customized websites. Thanks to a fruitful collaboration between Lund University and the Digital Research Service of the National Institute of Art History (INHA) in Paris, we were able to make such an integration possible.

Our output is the Archaeological Interactive Report (AIR) (https://omeka.ht.lu.se/s/reports/page/home) obtained by merging the 3D visualization platform 3DHOP with a powerful Content Management System (CMS), Omeka S (https://omeka.org/s/), specifically designed for Cultural Heritage and oriented towards the semantic web data exposition.

The elements of the GIS database and Interactive Reporting System became the AIR core entities. Such entities were identified by ontological classes inherited from standard ontologies like Dublin Core, CIDOC-CRM (Doerr et al., 2015), and its extensions, the most diffuse for exposing Cultural Heritage data.

This further development results in the logical database model, where all the elements are linked and entangled. Our excavation data model comprises 14 entities interlaced among themselves through semantic properties.

To create it, we considered the whole dataset of excavation data collected and produced during and after the fieldwork in any format, including data collected and implemented in the 3D GIS system, commonly used as an archive and an analysis tool, and used this data as a skeleton for the new system.

Besides the archaeological data management aspects, we also focused on editorialization to allow archaeologists to build and publish their reports in the same environment by directly recalling their own archived data.

AIR was tested and validated with legacy and real-time excavation data within three long-term projects in terrestrial and maritime archaeology: Västra Vång (Derudas, Nurra, and Svensson, submitted), Gribshunden (Derudas and Foley, submitted) and Kämpinge.

The results of using AIR as a daily working tool were successful: archaeologists in the field quickly learned how to use it; furthermore, its employment allowed us to achieve our primary goal to overcome the fragmentation of the archaeological data and combine it into a unique system. Another extraordinary result is to have real-time online availability and accessibility of 3D contents and linked metadata, fostering collaborations among colleagues and specialists remotely by using the same interface.

Conclusions

In our study, we intended to develop a system for the documentation, management, and publication of data from archaeological excavations to address the issue of archaeological data silos caused by the fact that archaeological data, composed of multiple formats and sizes, is scattered in multiple archives. We also intended to define a "working model" for publishing interactive archaeological reports as a solution to address the specific needs of field archaeologists to include in the archaeological practice workflow all aspects of data management and publication (Kansa and Kansa, 2021, 81-82).

AIR represents a suitable tool for archaeologists working in the field to manage all data, including 3D ones (from recording to publishing and archiving), within a unique system that allows archaeological report writing.

In conclusion, in our experience, designing a comprehensive web-based data solution helped manage the massive datasets usually gathered during excavations. Moreover, it goes beyond: thanks to such an overarching solution, the archaeological data lifecycle is preserved, and data is accessible, interoperable, and reusable throughout the entire archaeological process.

References

Bauer-Clapp H., & Kirakosian, K. (2017). Archaeologists and Archives: Revisiting an Old Challenge. Advances in Archaeological Practice 5, 3 (2017), 220–226. https://doi.org/10.1017/aap.2017.16

Dallas, C.(2015). Curating Archaeological Knowledge in the Digital Continuum: from Practice to Infrastructure. Open Archaeology 1, 1 (2015). https://doi.org/10.1515/opar-2015-0011

Derudas, P., Dell'Unto, N., Callieri, & Apel, J. (2021). Sharing Archaeological Knowledge: The Interactive Reporting System. Journal of Field Archaeology 46, 5 (2021), 303–315. https://doi.org/10.1080/00934690.2021.1911132

Derudas, P., Nurra, F., & Svensson, A. (submitted). New AIR for the archaeological process: the use of 3D web semantic for publishing archaeological reports. Journal of Computing and Cultural Heritage JOCCH. ACM

Derudas, P. & Foley, BP. (submitted). Managing data from maritime archaeology investigations: AIR at Gribshunden

Doerr M.; Theodoridou M., Aspöck E., Masur A. (2015). Mapping Archaeological Databases to CIDOC-CRM, [in:] Campana S., Scopigno R., Carpentiero G., Cirillo M. (eds.), Proceedings of the 43rd Conference on Computer Applications and Quantitative Methods in Archaeology Keep The Revolution Going CAA, Siena, Italy, 30 March–2 April 2015, p. 443–452.

Kansa, E., & Whitcher Kansa, S. 2021. Digital Data and Data Literacy in Archaeology Now and in the New Decade. Advances in Archaeological Practice 9, 1 (2021), 81–85. https://doi.org/10.1017/aap.2020.55

Potenziani, M., Callieri, M., Dellepiane, M., Corsini, M., Ponchio, F., & Scopigno, R. (2015). 3DHOP: 3D Heritage Online Presenter. Computers & Graphics, 52, 129–141. https://doi.org/10.1016/j.cag.2015.07.001.

Wilkinson M.D., Dumontier, M., Aalbersberg I.J., Appleton, G., Axton, M., Baak, A., Blomberg, N., Boiten, J.W., Bonino da Silva Santos, L., Bourne, P.E., et al. (2016). The FAIR Guiding Principles for scientific data management and stewardship. Scientific data 3, 1 (2016), 1–9. https://doi.org/10.1038/sdata.2016.18

303. DAISY 2.0: A field database solution for an archaeological institution

Adrian Chlebowski, The Polish Centre of Mediterranean Archaeology, University of Warsaw
Maciej Krawczyk, Faculty of History, University of Warsaw
Robert Mahler, Polish Centre of Mediterranean Archaeology, University of Warsaw

Collecting and storing data is one of the biggest challenges facing archaeology today. It begins with planning an archaeological project and culminates in the field, when it is of crucial importance to find a way to safely store and process the large amounts of data produced. In the end, this data is the most concrete result of our work. While there are a wide variety of digital solutions available out there, the specificity of the Polish Centre of Mediterranean Archaeology (PCMA) and its expeditions has called for a dedicated approach.

The Digital Archaeological Information System (DAISY) was created for the UMMA ERC Old Dongola archaeological project but, from the very outset, the aim of this web-based database was to create a field data management solution that could also be easily adopted by other expeditions run under the umbrella of the PCMA. Although the idea was not new, the first attempts at creating such a solution failed. Furthermore, the first main version of DAISY did not prove to be universal and easy to maintain. To meet our needs, a second version of the database was built from scratch – with three main principles being brought to the forefront, namely: simplicity, flexibility, and two-way communication with GIS.

In this paper we would like to present not only the results but also the history of our struggle with this matter. The rationale behind this particular solution will be discussed taking into account the multiple aspects that played a role in the development process. Particular attention will be given to formulating the requirements for the system but alongside the technical and practical usability issues, we would also like to address the administrative, organizational, and financial circumstances that influenced our project. The results will be illustrated with two real life use cases based on one expedition in Sudan (Old Dongola) and one in Egypt (Naqlun).

The future of such a database depends on many factors which we would like to discuss, as well as our roadmap in which we try to anticipate the development of the DAISY solution in the coming years.

References:

Kadar, Manuella. 2002. "Data modeling and relational database design in archaeology." Acta Universitatis Apulensis 3: 73–80.

Mafredas, Thomas, and George Malaperdas. 2021. "Archaeological Databases and GIS: Working with Databases." European Journal of Information Technologies and Computer Science 1 (3): 1–7.

Scherr, Nathaniel. 2012. "Archaeology Database Management: A Case Study in the Solution of Incompatibility Issues between Different Archaeological Databases." Student Theses, Dissertations, & Professional Papers, 52.

373. Back to DIY: Beyond turnkey web solutions

Hallvard R Indgjerd, Museum of Cultural History, University of Oslo

Archaeologists working in the field are met with a particular set of challenges different from most other web-based database users. These include the need for mobile, battery powered recording devices, lack of network connectivity in remote areas, and the wide range of data types being collected. The paper takes the author's experience with setting up and implementing both general purpose proprietary DBMS solutions and specially designed web-based systems for archaeological survey and excavation research projects in the Mediterranean as a starting point for discussing typical advantages and challenges inherent in the available alternatives. It then moves on to look into how the system might be developed going forward, attempting to address some of the issues encountered.

While collector apps, such as FileMaker Go and ODK Collect, sets the user free from the need of server connectivity during data capture, they introduce potential issues synchronising the data back at the base, and can't provide immediate updates on other teams' work. iDig attempts to alleviate this by allowing for a flat, mesh-like structure of devices that can synchronise with each other in the field, but not without introducing its own 'syncing headaches'. Most web- and browser-based solutions, like ARK, rely on a central web server storing and sending the data to each connected client device. This ensures every client sees the most up-to-date information, but requires constant network connection. A workaround for remote areas is a 'field server' running on a laptop or battery powered SBC, for example a Raspberry Pi.

Ready-made web-based platforms offer a welcoming user experience, but they can't (and can't be expected to) cater for the variety of use cases and differing expectations across archaeological research projects. While customisation is certainly possible, especially in the case of open-source systems, it often requires a high degree of technical skill and understanding. Then the gap to a fully custom made solution is not so far.

Instead of ready-made all-in-one solutions, the author argues it's time (again) to consider dividing up the tasks and using multiple pieces of software that 'does one thing, but does it well'. Increasingly user-friendly entrances to advanced and often Free/Open-Source Software packages means more of us have access to enterprise-level tools. Similarly, the recent rise of low- and no-code solution for developing (JavaScript-based) browser based apps has lowered the bar for custom development considerably, further facilitating the creation of custom user interfaces.

Decoupling the database and file storage (backend) from the user interface (frontend) introduces a new level of flexibility for users and developers, but may also contribute to better data preservation and FAIR compliance. This allows for multiple routes of access to a single source of data depending on needs during recording, analysis, visualisation and outreach – or simply based on user preference. Rather than keeping data separated in different software, saved in incompatible, and sometimes proprietary file formats, the same familiar software packages can be used as frontends accessing the same data. Automated data processing, data integrity rules and safety measures can be done on the database level or within the user facing software, depending on whether it's specific for one route of access, or it should apply to all data.

In the paper, one such example will be presented. Here, a PostgreSQL with PostGIS database stores the majority of the produced datasets, and provides links to media file types. Having been set up with transparency in mind, the table structure is kept simple and naming schema human readable, ensuring that the data and links can easily be reconstructed by someone new to the system. A number of user interfaces have been set up for data recording and access, all of which can be used in parallel, and immediately see the latest state of the data. For field recording, a web-based interface (LAPP) with modules adapted to the project's needs is accessed with mobile devices. While the web-app provides a 2D GIS with vector recording options and a simple 3D visualisation feature, more advanced GIS tasks and analysis are done in a dedicated GIS suite. For QGIS, also the project files and layer styles are stored in the PostgreSQL database, providing a file-less solution with minimal configuration for the user. As some users prefer data entry through pre-existing forms in Access or in a spreadsheet-like interface, an ODBC connection has been set up for opening the tables in Access – LibreOffice's equivalent database software comes with PostgreSQL support pre-installed. Permissions and user management, audit trails and automated backups are all conducted within the database, ensuring a uniform security policy regardless of the user interface, and thus giving a higher level of control over e.g. GIS data creation than is typically seen.

28. Excavation Databases and Numismatic Needs: Case of Marea Archaeological Project

Szymon P Jellonek, University of Warsaw
Barbara Zając, National Museum in Kraków

Approximately 7.700 coin finds have been registered during comprehensive archaeological research conducted by University of Warsaw in cooperation with Archaeological Museum in Kraków since 2000. Coins as other categories of finds are consequently registered in a database created for the purpose of project Is 'Marea' indeed Marea? Roman industrial centre and Byzantine city in the region of Mareotis directed by T. Derda and available on webpage http://mapdatabase.uw.edu.pl.

However a specificity of numismatics requires peculiar adjustments, that are not generally included in excavation databases (obverse and reverse descriptions; axis; etc.). Furthermore, among almost 8.000 coins there are issues struck between Hellenistic and Umayyad periods. Therefore different fonts, features such as countermarks, monograms etc. shall be implemented. Consequently, one of the first step of ongoing project Coin circulation in the Byzantine and Umayyad Marea/North Hawwariya: studies in the monetary economy of Mareotis region in the hinterland of Alexandria directed by P. Jaworski is to create a comprehensive web database containing all of the coins. The main challenge is to integrate excavation database with numismatic one, without any loss of data and/or transparency.

382. Dealing with old and new excavation datasets: the TiMMA web-database

Bastien Rueff, Ecole française d'Athènes

The TiMMA project, an international and multidisciplinary project funded by the French National Research Agency, aims to investigate the role of timber in Minoan and Mycenaean architecture. Gathering more than twenty scholars stemming from institutions based in five different countries, it deals with old and new excavation datasets, and therefore encompasses data of various nature: architectural evidence, archives study, material culture and environmental analysis. In order to handle this variety, we chose to use Omeka S, a web-publishing platform linked to a MySQL database. In this paper, we intend to present the advantages of the solution retained with emphasis on storage, accessibility, usability and reliability. Omeka S gives the possibility to every user to fill the database in its own language, from its own computer, and to publish data in open access as the work goes on. It is user-friendly and promotes the use of open data. The TiMMA database thus uses standards and interoperability vocabularies such as the Art & Architecture Getty Museum vocabulary, particularly suitable to excavation datasets, as we shall demonstrate. Moreover, the TiMMA vocabulary, designed for the purposes of this project, is exportable in Json-LD format and made available to any other project related to archaeological timber and wood resources. The possibility to import digital images with their metadata in IIIF format and bibliographical references from collective Zotero libraries fosters the use of online digital archives and referenced fieldwork notebooks. It is possible to export all the metadata in Json-LD or in xml in order to guarantee their reusability. Finally, Omeka S offers a unified web platform combining data of different nature and periods, that makes it easier for the researcher to synthesize architectural, textual and visual data. This platform is equipped with a research engine that allows simple and advanced requests. It is therefore a particularly suitable solution to handle old and new excavation datasets related to architecture and wood studies in archaeology.

301. MA-P vs. Arches. An open source data management platform for MA-P ("Maloutena and Agora in the layout of Paphos: modeling the cityscape of the Hellenistic and Roman capital of Cyprus") project (Nea Paphos, Cyprus)

Pawel PL Lech, Polish Centre of Mediterranean Archaeology
Łukasz Miszk, Jagiellonian University in Kraków
Wojciech Ostrowski, Warsaw University of Technology

Aim of this paper is to present the process of implementation of the open source data management platform for "The Maloutena and Agora in the Paphos urban plan (MA-P)" project.

The ancient city of Nea Paphos was situated in south-western shore of Cyprus, on the picturesque peninsula. Founded in the late 4th or early 3rd centuries BCE, the city was the capital of the island during the Hellenistic-Roman period. The archaeological project MA-P is focused on reconstruction of the ancient cityscape. Almost 30 years ago, one of the first city plan which included all key features of the city – harbors, agora, theater and temples placed on two independent street grids, which were connected together but differently orientated. The results of archaeological investigations carried out at a number of sites in the ancient city, have shown that the proposed reconstruction needs to be recapitulated.

However, with new tools new problems arose. The need to integrate spatial information, acquired permanently since the 1960s, resulted in the emergence of a problem related to data integration and data storage. When we started the project in 2020, one of the first tasks we faced was to find and implement a tool suitable for handling such a large amount of data. In addition to data gathered during over 55 years of the Polish excavations in Nea Paphos, we also had to process information collected during the new project (MA-P). In just two years, we were able to open 14 survey trenches, generate various data for the entire site (including inter alia whole site orthophoto map, alternative street grids, results of geophysics prospections), hundreds of orthophotos of single contexts, and thousands of newly collected findings.

Nowadays, one of the most effective solutions to this problem seems to be the use of database software that allows you to comprehensively gather, store, validate and administer data. The modern IT market offers many solutions of this type, but only a small part of them are universal tools with characteristics that include the ability to work online/offline, spatial data processing (GIS), support for ontologies, international standards and finally, data access control at any level. An important element is also the use of open-source tools (published source code).

Our speech aims to present the experiences of members of the MA-P project collected during the search for a solution to this problem, which led to the selection of an open, online and geospatial environment – the Arches. Solution which was designed by The Getty Conservation Institute.

The presented experiences include the implementation of the Arches environment, and then collecting, editing and processing data with its help. The lecture will discuss the possibilities of this software and its limitations. The speech will be presented from three points of view: a data steward - responsible for managing the database environment, an archaeologist/supervisor collecting data during fieldwork and an archaeologist - head of excavation works, responsible for processing all information in final form.

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Citations:

Filzwieser, Roland, and Eichert, Stefan. 2020. "Towards an Online Database for Archaeological Landscapes. Using the Web Based, Open Source Software OpenAtlas for the Acquisition, Analysis and Dissemination of Archaeological and Historical Data on a Landscape Basis", Heritage, no. 3, p. 1385-1401. https://doi.org/10.3390/heritage3040077

Miszk, Łukasz. 2020. “Stratigraphy and Architecture of the Agora, w: E. Papuci-Władyka (ed.), Paphos Agora Project (PAP) - volume 1. Interdisciplinary research of the Jagiellonian University in Nea Paphos UNESCO World Heritage Site (2011–2015) — First Results” Historia Iagiellonica, Kraków, p. 127 – 184.

Młynarczyk, Joanna. 1990. Nea Paphos III, Nea Paphos in the Hellenistic Period, Varsovie.

02. Studying uncertainties in archaeology: A new research agenda

Eduardo Herrera Malatesta, Center for Urban Networking Evolutions, Aarhus University
Tom Brughmans, Center for Urban Networking Evolutions, Aarhus University

Location: E105

Archaeology and landscape research have greatly benefited from the increasing application of computational methods over the past decades. Geographical Information Systems (GIS) and spatial statistical methods such as point patterns have been revolutionary for the discipline. Furthermore, the analytical power of studying spatial relationships between objects has been enhanced through the use of network science for archaeological landscape research. However, the results obtained from these techniques can be greatly affected by the many uncertainties imposed by the fragmentary nature of archaeological data, particularly when they are derived from non-systematic surveys. Since the 1960s, archaeologists have tried to solve this by developing more systematic fieldwork methodologies such as total-area survey strategies. Yet, this methodology cannot be applied to every region; therefore, non-systematic survey strategies must be followed. This poses methodological challenges when attempting to apply GIS, spatial statistics and network analysis methods to such fragmentary and uncertain datasets.

For example, while in archaeology it is common to use statistical methods to deal with partial data in point pattern analysis to study regional patterns, this does not provide information to assess the actual levels of uncertainty of a particular regional dataset. Furthermore, at the moment there is no formal study of the uncertainty levels for the computational models resulting from applying the mentioned methods to a non-systematic regional dataset. While the study of uncertainties has seen recent debates in archaeology, it is still an underdeveloped topic. Particularly, previous attempts of quantifying uncertainties for archaeological data have not aimed at creating overarching solutions or resources tailored for the discipline, i.e., a protocol or software.

This session aims at bringing together contributions that present concrete and original research on the quantification of archaeological uncertainties from any archaeological spatial and temporal perspective. Contributions should look towards the creation of overarching solutions for archaeological uncertainties and for the formal application of uncertainty methods and analysis. For this, each presentation should contain 1) a concrete research problem and case study, 2) a concrete description of the used methods, 3) a clear walkthrough of the application of the methods (with accompanying code when available), 4) concrete results, and 5) a concrete discussion on the interoperability of their methods and results for other case studies. Paper topics of particular interest to this session include but are not limited to:

- Systematic description of sources of and types of uncertainties in archaeological data,
- Uncertainty in landscape archaeology,
- Uncertainty in network research,
- Methods for quantifying uncertainties,
- Sensitivity analysis approaches,
- Protocols, methodological pipelines or standards for uncertainty quantification,
- Coded implementation of uncertainty quantification methods,
- Aggregation of uncertainty quantification methods in toolboxes for our community,
- Case studies addressing the above for any region or time period.

This session will provide a platform for sharing experiences, strategies, and methods for archaeological research on uncertainties. Our ultimate aim is, together with the participants, to outline a new research agenda for the formal application of uncertainty quantification methods, for both non-systematic survey data and computational models, in archaeology.

SLOT 2	
11:00 - 11:20	132. Modelling past land use and settlement patterns in a fragmented landscape. A case study from the SW Baltic region *Giacomo Bilotti (University of Kiel, CRC 1266)*; Michael Kempf (University of Kiel, CRC 1266); Julian Laabs (University of Kiel, CRC 1266)*
11:20 - 11:40	175. If you can't beat vagueness, use it: exploiting uncertainty to gain confidence in a biased archaeological record *Manuela Ritondale (University of Groningen)*; Daniella Vos (University of Groningen)*

11:40 - 12:00	83. Challenges and Limits of an Archaeological Dataset - Case Study of the Middle Danube Germanic Society during the Roman Period *Marek Vlach (Institute of Archaeology of the Czech Academy of Sciences Brno)*; Balázs Komoróczy (Institute of Archaeology of the Czech Academy of Sciences, Brno)*
12:00 - 12:20	295. Archaeoriddle: A collaborative game to improve archaeological inference *Alfredo Cortell-Nicolau (University of Cambridge)*; Simon Carrignon (McDonald Institute for Archaeological Research, University of Cambridge); Leah Brainerd (University of Cambridge); Charles Simmons (University of Cambridge); Joseph Lewis (University of Cambridge); Enrico R Crema (University of Cambridge)*
12:20 - 12:40	237. Degrees of certainty in historical and archaeological 3D reconstructions: classifying certainty in the context of the Virtual Interiors Project and 4D Research Lab projects *Tijm Lanjouw (UvA)*; Chiara Piccoli (UvA)*
12:40 - 13:00	46. Ambiguous Landscapes: Quantifying uncertainty in non-systematic regional survey data *Eduardo Herrera Malatesta (Aarhus University)**

132. Modelling past land use and settlement patterns in a fragmented landscape. A case study from the SW Baltic region

Giacomo Bilotti, University of Kiel, CRC 1266
Michael Kempf, University of Kiel, CRC 1266
Julian Laabs, University of Kiel, CRC 1266

In this contribution we model past land-use and settlement dynamics in a multi-regional analysis using large archaeological datasets coming from national databases, with a focus on the South Western Baltic region during the Neolithic and the Bronze Age.

Regional and national databases are an invaluable source in the hands of a modeller because of the very large amount of available data. However, they also have serious issues in terms of homogeneity and data uncertainty. Here, we will focus on how to overcome these issues when modelling past population and land-use pattern in archaeological spatial analysis.

All the analysis will be carried out in a fully documented approach, using only FOSS (Free and Open Source Software).

Because of the nature of archaeological databases, product of different traditions and collection practices, each entry in an archaeological database has three different types of possible uncertainty:

1. Chronological uncertainty, with many undated or poorly dated sites. In some cases, chronology cannot be easily determined using simple queries;
2. Spatial uncertainty. Many sites lack precise information of their original location due to the circumstances of their discovery;
3. Typological uncertainty, due to different standards in recording information and confidence in its reliability. This in turn can impact the previous two types of uncertainty.

In addition to these three layers of uncertainty, we also have to consider uncertainty of representativeness. In some areas, research intensity and post-depositional factors (soil erosion, human activities, etc.) create a strong bias, which is sometimes very difficult to disentangle from past human choices. This in turn contributes to spatial uncertainty, although at a different scale.

In order to overcome these uncertainties, we model land-use and population patterns using probabilistic intensity areas. The workflow is divided into two main parts, the first dealing with chronological and representativeness uncertainty and the second with population modelling.

The first part is structured as follows:

- Definition of key areas. The choice will be a combination between intensity of archaeological investigations or archaeological knowledge and an intensity-based approach. This can be done performing a Nonparametric Estimate of Intensity as function of different covariates representing the distance of our observations from modern biases (cities, roads, etc.).
- Chronological uncertainty. Well dated sites are binned into time windows of 200 years, that represents the average duration of a relative chronological period of the Nordic Bronze Age. The remaining sites with no precise date (e.g. labelled as “Bronze Age”) are assigned a simulated date with a varying probability

depending on the summed density of locally available radiocarbon dates;

- The simulation is then reiterated and the output used to create a probabilistic surface of past human activity for each time window. The surface is calculated interpolating the assigned dating probability using a distance decay function. For instance, the 100% surface only represents the area around the well dated sites at a given window, not different from a "traditional" catchment calculation. On the other hand, the 0% surface is equivalent to the key area identified in the first step.

The output is used to create the final model for each time window. Different covariates (e.g. elevation, slope, soil, proximity to resources, etc.) will be used as a predictive model for potential site distribution. Additionally, second order effects will be studied using Point Pattern Analysis.

The results have a double function: they allow to grasp the drivers of settlement choice and how they changed through time. As a further step they allow to predict site intensity based on the predictive model on poorly investigated areas, allowing a regional reconstruction of settlement patterns. These two aspects are a great advantage compared to traditional models because they maximize the information gain both for the key areas and for the entire region, adding a quantified value of the underlying uncertainty. The gain of each probabilistic surface over another and the choice of the best fitting one can be calculated using a slight modification of the already established methods used for predictive models (1988).

The results will then be compared to the current literature, in particular the comparison to a traditional model (not accounting or not handling uncertainty in the same way as we do) and with other well-established methods to assess human occupation intensity, such as the SPD curves available for the area.

175. If you can't beat vagueness, use it: exploiting uncertainty to gain confidence in a biased archaeological record

Manuela Ritondale, University of Groningen
Daniella Vos, University of Groningen

In an interview in the Guardian published in 2013, the archaeologist Stephen Dean said that "archaeology is like a jigsaw puzzle, except that you cannot cheat and look at the box, and not all the pieces are there". The partial and fragmentary nature of archaeological datasets represents both a limitation and an opportunity in archaeological studies, particularly when employing computational methods or big-data approaches. Indeed, on the one hand, data limitations affect the produced results to an extent, which is rarely formally evaluated, thus undermining their relevance and reliability. On the other hand, by formally investigating data biases and developing methods to assess the level of uncertainty they produce in archaeological models, it is possible to enhance the reliability of the otherwise scant archaeological evidence while fostering our understanding of past phenomena. To further complicate the matter, the partial and fragmentary nature of archaeological datasets is just one of the many sources of uncertainty affecting computational approaches in archaeological science (Evans 2012).

This contribution aims to put together experience, methods and theoretical reflections on handling uncertainty in archaeological computational approaches based on three different research projects. The first dealt with the application of network science for inferring connectivity patterns and commercial contacts from Classical antiquity to the Middle Ages based on shipwrecks cargo assemblages. Whilst the overall research line is not unique, the project specifically aimed at addressing the effects of data incompleteness and data biases by devising an ad hoc resampling technique and a probabilistic approach, which enables to extract relevant information from the partial, biased evidence. Since the above method was developed to suit a particular archaeological context, this presentation will specifically discuss the potential and limitations of interoperability. The second project dealt with spatial analysis and GIS-based archaeological predictive modelling; here, the major challenge has been to identify the multiple factors of uncertainty impacting the model results that included but were not limited to data incompleteness and that may be grouped in: a) input data uncertainty, b) model choice uncertainty, c) model mechanics uncertainty (Evans 2012). The 'One-factor At a Time' (OAT) approach to sensitivity analysis (Brouwer Burg, Peeters, and A. Lovis 2016) was utilised to explore different model scenarios and identify to which variation the model was more sensitive. After discussing the types of uncertainties associated with a highly problematic set of data gathered from a combination of systematic and unsystematic underwater surveys, this presentation will focus on the limits of the OAT method (Saltelli et al. 2019), thus introducing the third ongoing project, which just started. The latter aims to employ Bayesian inference and machine learning algorithms to address the uncertainty embodied in the above-mentioned model and its equifinality. Since this method was first developed and applied to a completely different archaeological context, it represents a suitable ground for discussing the potential and challenges of interoperability: how can we best adapt methodologies borrowed from other disciplines and solutions tailored to specific research questions for applications in various contexts?

Works Cited

Brouwer Burg, Marieka, Hans Peeters, and William A. Lovis. 2016. Uncertainty and Sensitivity Analysis in Archaeological Computational Modeling. Edited by Marieka Brouwer Burg, Hans Peeters, and William A. Lovis. Cham: Springer International Publishing. https://doi.org/10.1007/978-3-319-27833-9.

Evans, Andrew. 2012. “Uncertainty and Error.” In Agent-Based Models of Geographical Systems, edited by Alison J. Heppenstall, Andrew T. Crooks, Linda M. See, and Michael Batty, 309–46. Dordrecht: Springer Netherlands. https://doi.org/10.1007/978-90-481-8927-4.

Saltelli, Andrea, Ksenia Aleksankina, William Becker, Pamela Fennell, Federico Ferretti, Niels Holst, Sushan Li, and Qiongli Wu. 2019. “Why so Many Published Sensitivity Analyses Are False: A Systematic Review of Sensitivity Analysis Practices.” Environmental Modelling & Software 114 (April): 29–39. https://doi.org/10.1016/j.envsoft.2019.01.012.

83. Challenges and Limits of an Archaeological Dataset - Case Study of the Middle Danube Germanic Society during the Roman Period

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Balázs Komoróczy, Institute of Archaeology of the Czech Academy of Sciences, Brno

The presently ongoing project the „Protohistoric Communities of the ‘Marcomannic’ Settlement Zone in the Middle Danube Region – Structure and Dynamics on the Basis of Digital Modelling“ (Czech Research Foundation) aims - amongst other objectives - the quantitatively oriented view on the wide array of social, demographic and economic aspects of the chiefdom type Germanic societies of the Middle Danube. During the primary phase, a heuristics of the available published sources of archaeological information has been conducted. They are inherently and distinctively variable in qualitative characteristics containing all sorts of information sources ranging from scant preliminary reports to thoroughly excavated and published archaeological components. This results in significantly varied representation within individual regions of the settlement zone, where the state of research and archaeological knowledge has been conditioned by different aspects and drivers. Therefore, the state of input data poses a challenge to put them into appropriate perspective regarding their representativeness. The paper deals with testing various ways of assigning a representativeness value, which would affect both generally and locally oriented proxies. Evaluation of their interpretation possibilities has been approached through a quantitatively oriented assessment based on dataset hierarchical structuring (site/location – component/type of activity – action/way of procurement – context/feature – artefact/ecofact) and quality and credibility of the respective sources. The temporal effect based on their revaluation will also be considered through the available aoristic weighting of potential chronological distribution.

295. Archaeoriddle: A collaborative game to improve archaeological inference

Alfredo Cortell-Nicolau, University of Cambridge
Simon Carrignon, McDonald Institute for Archaeological Research, University of Cambridge
Leah Brainerd, University of Cambridge
Charles Simmons, University of Cambridge
Joseph Lewis, University of Cambridge
Enrico R Crema, University of Cambridge

Archaeoriddle is a collaborative research project aimed to improve archaeological hypothesis building by comparing different methodological proposals within a crowd-sourced and interactive working framework. To achieve this, we created a virtual world through computational simulation, emulating an interaction process between a hypothetical group of incumbent hunter-gatherers and a group of spreading farmers. This virtual world and its associated virtual archaeological datasets have been developed by members of the Computational and Digital Archaeology Laboratory (CDAL) of the University of Cambridge and can be consulted here (https://acortell3.shinyapps.io/Archaeo_riddle/).

Archaeologists are well aware of the problems and limitations posed by its data. Methodological and theoretical advances have been made to tackle these challenges over the years. These include a wide range of multidisciplinary approaches, where key insights from chemistry or geology, but also mathematics and data science, are employed in order to improve and transcend the current limitations posed by the archaeological record. In particular, techniques based on statistical modelling and computational simulation, have known an exponential growth during these last years. Nevertheless, the robustness of these techniques are rarely evaluated formally, and their effective ability to reconstruct the human past is unknown. The limited samples available, and the destructive process of archaeological excavation further limits our ability to properly evaluate confounding factors such as research design and post-depositional processes, all of this contributing to archaeological uncertainty.

In short, archaeologists are constrained by the data they have, and are very rarely able to reproduce large scale studies with significant sample sizes, able to offer a data poll where the development of current formal inferential methods can be reliably applied and contrasted.

But this awareness is not enough. If we want to take archaeological formal inference one step further, we must make sure that the methods that are currently being used and developed are effective within our specific research field. This is the key objective of archaeoriddle: to offer a virtual platform and a shared dataset where different methodologies can be compared against each other, with the unique opportunity to be able to assess their ability to reconstruct the human past. This collaborative enterprise will provide an unique chance to (1) help understand and compare different methods applied to archaeology, and (2) propose a general and necessary reflection on archaeological methodology, as a foundation for promoting solid and shared methodological standards.

Since the virtual interaction process has been created virtually, we know the exact parameters behind the farming expansion. However, interested participants are given only a very limited and indirect set of data and information about what happened. Using their preferred methods, we propose a game, following ideas by Axelrod (1980) and Rendell et al. (2010), where participants have to answer a series of questions related to this virtual expansion process. In this way, archaeoriddle is thought of as a game, but which also seeks for international collaboration to understand how different current theoretical and methodological proposals behave under a controlled and testable environment. The project was initially presented in the past CAA (in Oxford) and, therefore, this paper aims at briefly updating the project during a 5 min talk. In this edition of the CAA, we intend to focus on how tactical simulation and collaborative research can help improving methodological approaches to archaeological uncertainty.

References.

Axelrod, R. (1980) "Effective choice in the Prisoner's Dilemma", Journal of Conflict Resolution, 24(1), pp. 3-25. DOI: https://doi.org/10.1177/002200278002400101

Rendell, L., Boyd, R., Cownden, D. Enquist, M., Eriksson, K., Feldman, M. W., Fogarty, L., Ghirlanda, S., Lillicrap, T., Laland, K. N. (2010). "Why copy others? Insights from the Social Learning Strategies tournament", Science, 328(5975), pp. 208-213. DOI: http://doi.org/10.1126/science.1184719

237. Degrees of certainty in historical and archaeological 3D reconstructions: classifying certainty in the context of the Virtual Interiors Project and 4D Research Lab projects

Tijm Lanjouw, UvA
Chiara Piccoli, UvA

The documentation and visualisation of varying levels of certainty in hypothetical historical and archaeological 3D reconstructions is considered an important aspect of transparent science communication. Over the last 25 years various classification schemes and methods have been proposed, but a generally accepted standard is still far off. The challenge lies in developing a classification that does justice to the heterogenous and multimodal nature of the data, sources and types of inference that form the basis of 3D reconstructions. In addition, ce92.rtainty itself is a complex concept that includes definitions of other subordinate concepts such as accuracy, reliability, granularity and should consider different object properties (material, form, dimensions, location and orientation). These must fit into a system that is comprehensive but not too time-consuming to implement and at the same time easy and quick to comprehend for the viewer. Is it possible to develop a single classification scheme that answers all the criteria, or should we aim for a system with multiple classifications varying in complexity depending on the goal and viewership? Moreover, do we need international standardisation, or do the needs of individual projects diverge too much for a single standard? In this paper we will review both existing classifications and our own, developed in the context of the Virtual Interiors Project and 4D Research Lab projects, at the University of Amsterdam. Which criteria are used to classify certainty and what are the strengths and weaknesses of different systems?

46. Ambiguous Landscapes: Quantifying uncertainty in non-systematic regional survey data

Eduardo Herrera Malatesta, Aarhus University

Landscape archaeology, the study of the relationship between past societies and their environments, has increasingly benefited from the application of computational methods to model past dynamics. However, this comes with a challenge that has not been properly explored in archaeology: the inherent uncertainty in archaeological reconstructions of past landscapes as a result of the fragmentary nature of archaeological data. Uncertainty is a part of our degree of knowledge, and as such, its scope needs to be explicitly defined in order to provide a secure basis for the treatment of archaeological data, analyses, and final narratives. Recent approaches to study uncertainty in archaeology have been carried out using probabilistic methods, such as Monte Carlo, for modeling uncertainty in temporal and least cost path analysis. Still, a robust framework for the quantification of uncertainty for spatial data and analysis remains non-existent. While there have been some isolated attempts, long-term research to explicitly quantify the degrees of uncertainty contained in spatial databases, particularly when they come from non-systematic regional surveys, is absent. Furthermore, there are limited examples for the quantification of the uncertainties contained in the computational models created from these non-systematic databases.

In this paper, a new framework to overcome the embedded uncertainty in spatial data and its resulting models will be presented. By defining best practices, identifying optimal methods, and outlining clear protocols for different datasets and spatial analyses, this paper will present a new robust quantitative framework for more accurate computational models of past landscapes, improving their reliability and enhancing their interpretative potential. This framework will be applied to two regional non-systematic survey datasets, one from the north-western Dominican Republic and the second from the Bolivian Amazon. The paper will be divided into three sections. First the assessment of the data uncertainties, where each archaeological case will be presented as well as the degrees of the uncertainty of each dataset. Second, the model uncertainty section where common spatial statistical methods (e.g., point pattern analysis) will be estimated on these datasets, and UQ methods will be applied to assess the degree of uncertainty in the model results. The final section will be devoted to outlining the framework and highlighting its potential use for other archaeological regions in the world.

03. Our Little Minions pt. V: small tools with major impact

Moritz Mennenga, Lower Saxony Institute for Historical Coastal Research, Wilhelmshaven, Germany
Ronald Visser, M.A., Saxion University of Applied Sciences, Deventer, Netherlands
Brigit Danthine, M.A., Austrian Archaeological Institute (Austrian Academy of Science), Austria
Florian Thiery, M.Sc., Römisch-Germanisches Zentralmuseum, Mainz, Germany

Location: E104

In our daily work, small self-made scripts (e.g. Python, R, Bash, Haskell), home-grown small applications (e.g. GIS Plugins) and small hardware devices significantly help us to get work done. These little helpers -"little minions" – often reduce our workload or optimize our workflows, although they are not often presented to the outside world and the research community [1]. Instead, we generally focus on presenting the results of our research and silently use our small tools during our research, without even pointing to them, and especially not to the source code or building instructions. This session will focus on these small helpers – "little minions" – and we invite researchers to share their tools, so that the scientific community may benefit. As we have seen in last year's "minion talks" since 2018 there is a wide range of tools to be shared. This already fifth Little Minion session invites short presentations, lightning talks (max. 10 minutes including very short discussion) – of small coding pieces, software or hardware solutions in any status of completion, not only focusing on fieldwork or excavation technology, associated evaluation or methodical approaches in archaeology. Each talk should explain the innovative character and mode of operation of the digital tool. The only restriction is that the software, source code and/or building instructions are open and are or will be freely available. Proprietary products cannot be presented, but open and freely available tools designed for them. In order to support the subsequent use of the tools, the goal should be that they are openly and available to the scientific community (e.g. GitHub, GitLab). We invite speakers to submit a short abstract including an introduction to the tool, the link to the repository – if possible – to get access to the source code and an explanation of which group of researchers could benefit from the little minion and how. The tools may address the following issues, but are not limited to (you will find an overview of the previous sessions under https://littleminions.link): -data processing tools and algorithms -measuring tools -digital documentation tools -GIS plugins -hands-on digital inventions (e.g. for excavations) -data-driven tools (e.g. Linked Data, CSV, Big Data) After previous years (pt. I CAA 2018 Tübingen, pt. II CAA 2019 Krakow, pt. III CAA 2021 Limassol/virtual, pt. IV CAA 2022 Oxford/hybrid) spontaneous success of "Stand-up-Science", you will also have the opportunity to spontaneously participate and demonstrate what you have on your stick or laptop. If you want to participate without an abstract in the spontaneous section of the session, don't hesitate. Please come and spontaneously introduce your little minion! The minion session is designed for interested researchers of all domains who want to present their small minions with the focus on the technical domain and also for researchers who want to get ideas about what kinds of little minions are available to help in their own research questions. All of us use minions in our daily work, and often tools for the same task are built multiple times. This online session gives these tools that are considered too unimportant to be presented in normal talks, but take important and extensive steps in our research, a home. As an outcome of the session, we try to give support, that all presented tools and links to code repositories will be available for the research community on our website https://littleminions.link.

References:

[1] F. Thiery, R. Visser & M. Mennenga. (2021). Little Minions in Archaeology An open space for RSE software and small scripts in digital archaeology. SORSE – International Series of Online Research Software Events (SORSE), virtual. https://doi.org/10.5281/zenodo.4575167

	SLOT 2
11:00 - 11:20	299. MiGIS – Document, analyse and share your micromorphological observations of archaeological sediment thin sections *Mirijam Zickel (University of Colgne)*; Astrid Röpke (University of Cologne); Martin Kehl (University of Cologne)*
11:20 - 11:40	48. Tachy2GIS and Tachy2GIS_arch – two plugins for direct total station measuring in QGIS. *Christof Schubert (Landesamt für Archäologie Sachsen)*; Jörg Räther (Archäologisches Museum Hamburg)*
11:40 - 12:00	159. CORPUS NUMMORUM – A Digital Research Infrastructure for Ancient Coins *Ulrike Peter (Berlin-Brandenburg Academy of Sciences and Humanities)*; Karsten Tolle (Goethe-University); Jan Köster (Berlin-Brandenburg Academy of Sciences and Humanities); Claus Franke (Berlin-Brandenburg Academy of Sciences and Humanities); Sebastian Gampe (Goethe-Universität Frankfurt am Main); Bernhard Weisser (Münzkabinett. Staatliche Museen zu Berlin)*

12:00 - 12:20	304. The bonestatr: An R package to facilitate choosing the best human stature reconstruction method based on bones *Robert Mahler (Polish Centre of Mediterranean Archaeology, University of Warsaw)**

299. MiGIS – Document, analyse and share your micromorphological observations of archaeological sediment thin sections

Mirijam Zickel, University of Colgne
Astrid Röpke, University of Cologne
Martin Kehl, University of Cologne

The DFG-funded interdisciplinary project 'Living together or apart? Unravelling the development, internal organization and social structure of a complex Bronze Age tell settlement at Toboliu, western Romania' focusses on the investigation of local Bronze Age settlement activities, associated land use, and landscape development. With a geoscientific background, I focus on landscape reconstruction and micromorphological investigations of the archaeological sediments. A specific micromorphological challenge is the extensive, multi-layered tell stratigraphy including the remains of a wide variety of Bronze Age floor coverings. To cope with this task, I started to analyse scanned images (transmitted, reflected, cross-polarised mode) of sediment thin sections in a GIS environment, supported by Machine Learning. Moreover, I am currently developing a Python based MiGIS toolbox for the Open Source GIS software QGIS 3 to provide public access to this tool. A semi-automatic approach enables the implementation of microscopically collected sample observations as a reference to build Regions of Interest (ROI). These ROIs serve as training data for the image classification algorithm. Random Forest algorithm has proven to be particularly stable for this task in terms of the high variability of sediment components and their spectral properties. As a result the amount and distribution of diagnostic components, such as anthropogenic constituents, e.g.charcoal, bones or abundant pedofeatures, can be analysed and quantified at thin section level. This enables the investigation and comparison of horizon- or layer-related spatial relationships in soil and sediment sequences.

48. Tachy2GIS and Tachy2GIS_arch – two plugins for direct total station measuring in QGIS.

Christof Schubert, Landesamt für Archäologie Sachsen
Jörg Räther, Archäologisches Museum Hamburg

Importing coded total station measurements into QGIS is not much of a deal – after you finished your survey and exported the job from your total station. But what if you would like to see "live" what you are doing while measuring?

Tachy2GIS (https://github.com/gbv/Tachy2GIS) provides an interface to Leica total stations and allows you to generate geometries while measuring, using the total station as your digitizing tool. Tachy2GIS uses Leica GeoCOM functions to easily setup a connection to the total station, set reflector height and even control robotic stations. Finally, a 3D-viewer based on VTK has been integrated. Tachy2GIS is not subject-specific, so it is not restricted to archaeology.

Tachy2GIS_arch (https://github.com/Landesamt-fuer-Archaeologie-Sachsen/Tachy2GIS_arch) has been designed to support data acquisition with Tachy2GIS especially on archaeological excavations. Over the last two years of coding and testing, a kind of archaeological application module was developed. The plugin allows easy measurement into a basic data structure that aims at being adaptable to different documentation standards. To speed up the measuring process, attribute values can be preselected. Additional functions like a rigid transformation (e.g. from a local to national projected coordinates) and a tool for rectification of profile images based on the algorithm used by the ProfileAAR plugin (https://github.com/ISAAKiel/profileAAR) close gaps in QGIS functionality.

159. CORPUS NUMMORUM – A Digital Research Infrastructure for Ancient Coins

Ulrike Peter, Berlin-Brandenburg Academy of Sciences and Humanities
Karsten Tolle, Goethe-University
Jan Köster, Berlin-Brandenburg Academy of Sciences and Humanities
Claus Franke, Berlin-Brandenburg Academy of Sciences and Humanities
Sebastian Gampe, Goethe-Universität Frankfurt am Main
Bernhard Weisser, Münzkabinett. Staatliche Museen zu Berlin

Corpus Nummorum (CN) is a joint project of the Berlin-Brandenburg Academy of Sciences and Humanities, the Münzkabinett Berlin and the Big Data Lab of the University of Frankfurt. As part of an overarching international endeavour to create a corpus of Greek coin types based on Linked Open Data, it indexes ancient Greek coins from various landscapes and collections and develops typologies. The coins and types are published in the multilingual web portal www.corpus-nummorum.eu, using numismatic authority data and FAIR principles.

Our poster aims to present the CN-Editor that was developed as a multifunctional open-source web app to manage the project's data regarding coins, types, dies and related information. It provides extensive search and evaluation functions. The backend to store the data consists of a MySQL database and a PHP JSON API. Images are handled via the API and can be stored in a separate IIIF service. Its modular structure allows for a quick functional extension or an adaption to other object types, thus making it attractive for projects beyond numismatics. The CN-Editor represents a digital research infrastructure that enables and encourages the re-use of aggregated data and unrestricted collaboration with other scholars or institutions. It uses the PHP framework Laravel (v. 8) and vue.js (v. 2.6). Upgrades to Laravel v. 9 and vue.js 3 are in progress. The code is licensed under the GNU GPLv3 and can be freely reused and adapted. The CN-Editor and further descriptions how to install and use it are available in Github under: https://github.com/telota/corpus-nummorum-editor.

At present, CN is being further developed within the framework of our projects "Data quality for Numismatics based on Natural language processing and Neural Networks (D4N4)" and "Ikonographie und KI-Methoden in der Numismatik (IKKINUM)" financed by the German Research Foundation and with funds from the State of Berlin. The aim of D4N4 and IKKINUM is to establish AI-research tools for numismatics that can also be used as services separately or integrated as part of the CN-Editor. Our approaches are particularly well applicable for object categories that combine images and text and are available in large quantities. These involve: a) natural language processing (NLP) methods for multilingual and non-standardized coin descriptions and their linking to a hierarchical iconographic thesaurus and b) image recognition of designs and their elements by means of deep learning. The NLP generated data shall allow for more sophisticated semantic searches on the given coin and type data. Furthermore, a new Graphical User Interface shall also allow for semantic searches for users with no SPARQL experience.

Deligio, Chrisowalandis, Karsten Tolle, and Sebastian Gampe. 2022. NLP-on-multilingual-coin-descriptions. GitHub Repository. Link: https://github.com/Frankfurt-BigDataLab/NLP-on-multilingual-coin-datasets

Gampe, Sebastian, and Karsten Tolle. 2019. "Combination of machine learning methods of image and natural language recognition on ancient coin data." In Proceedings of CAA 2019 (in print)

Klinger, Patricia, Sebastian Gampe, Karsten Tolle, and Ulrike Peter. 2018. "Semantic Search based on Natural Language Processing – a Numismatic example." Journal of Ancient History and Archaeology 5 (3): 68–79. https://doi.org/10.14795/j.v5i3.334.

304. The bonestatr: An R package to facilitate choosing the best human stature reconstruction method based on bones

Robert Mahler, Polish Centre of Mediterranean Archaeology, University of Warsaw

Stature is one of the most ecosensitive characteristics of the human body and as such it is widely used as a universal indicator of the well-being of the populations studied. This is the case not only when the actual stature of living subjects is measured. Skeletal remains provide measurement data that can allow a credible reconstruction of the stature of past populations using long bone lengths and regression formulae.

A wide variety of regression-based stature reconstruction formulae are available in the literature but each is based on a different population with different limb to stature proportions. Choosing the best stature reconstruction method for a particular population is therefore crucial for the credibility of the estimations obtained. One way to choose the most appropriate method is to compare the consistency of estimations using different long bones for a number of individuals and compare the results using different formulae. So far, however, such comparisons have rarely been employed. In everyday practice bioarchaeologists either use the most popular method or choose it using an educated guess only as the methods available require a substantial amount of well-preserved skeletons.

The bonestatr package (https://codeberg.org/rmahler/bonestatr) is intended to facilitate the process of choosing the best stature reconstruction method for human skeletal populations also in the case of poorly preserved skeletal series. It is hoped that such automation support in the analysis, not requiring good bone preservation, will encourage researchers to use a more formal way of selecting the stature reconstruction formulae in everyday practice.

The bonestatr is an R implementation of the procedure published in 2022 (Mahler 2022).

References:

Mahler, Robert. 2022. "A formalized approach to choosing the best methods for reconstructing stature in the case of poorly preserved skeletal series", Archaeometry,

64: 265–280. https://doi.org/10.1111/arcm.12700

23. Understanding Archaeological Site Topography: 3D Archaeology of Archaeology

Gert Jan Van Wijngaarden, University Of Amsterdam
Jitte Waagen, University of Amsteram

Location: E107

Roundtable

The current ubiquitous use of 3D recording technologies in archaeological fieldwork, for a large part due to the application of budget-friendly (drone) photogrammetry, has exponentially increased the availability of 3D data of archaeological sites and landscapes. Various applications, such as 3D excavation documentation, prospection, heritage management and of course visualisation/presentation have already advanced beyond the experimental phase. In this round table, we would like to discuss the application of 3D recording for the 'Archaeology of Archaeology' approach, which has been developed at the University of Amsterdam, see: https://www.uva.nl/en/discipline/archaeology/research/troy/troy.html. In this approach, past archaeological activities at a site are studied by archaeological means in order to elucidate how past research questions, designs, results and interpretations have influenced knowledge about a site (cf. Murray & Spriggs 2017). Within this concept, the archaeological site is regarded as a laboratory in which, often for long periods of time, scientific research has taken place that has left its traces on the site. The current geography of a site such as ancient Troy, at which the approach is currently further developed, is determined at least as much by archaeological activities as by ancient habitation (Lucas 2012). Within the Archaeology of Archaeology approach, 3D recording techniques play a key role. They allow for creating a high-resolution and accurate digital twin of the archaeological site in its current state (1), facilitating the understanding of the topography of past excavations at complex sites (i.e. the spatial definition of trenches, dumps, pathways and stratigraphy), thereby contextualizing the old records, plans and photos of past interventions. With the help of such records it will become possible to reconstruct the archaeological site in its past state, before and during successive stages of excavations (2). Perhaps most importantly, a model of the site may serve as a central 4D hub, functioning as a study resource and allowing the interaction of different types of data and archival records (3). Since 2018, these three aims are being pursued at the site of ancient Troy in Turkey, where the Archaeology of Archaeology approach is being developed. However, the conceptualization of the 3D component is still in its early stages. In this round table, we would like to have an open discussion about the potential to combine 3D recording and 3D information systems with geographical and archival information of archaeological activities at a site. Where we have Troy as a case study, we hope to discuss wider implications with the participants of this round table. We invite scholars and students who work with varied datasets at complex archaeological sites and landscapes to share their experiences and ideas.

References:

https://www.uva.nl/en/discipline/archaeology/research/troy/troy.html

Lucas, G. 2012, Understanding the Archaeological Record, Cambridge: Cambridge University Press. Murray, T. & M. Spriggs 2017, The Historiography of Archaeology: Exploring Theory, Contingency and Rationality, World Archaeology 49.2, 151-157

37. Rijckholt in 3D: The role of close-range photogrammetry within the archaeological trajectory of Limburg's Flintmines

Alicia Walsh, Recollection Heritage
Joep Orbons, ArcheoPro
René Haemers, Subterranean Dynamics

Within the Maas river valley in the southeast of the Netherlands, lies the Neolithic flint mine of Rijckholt. Mined between 4200 and 2750 BCE, it remained undocumented until 1881, when Belgian archaeologists began the first excavations. Further excavations were conducted in the 1960s by volunteers from the Dutch Geological Society, who constructed a 130 metre long tunnel, which has since allowed visitors to view the galleries and mining techniques of the Neolithic workers. Today, maintenance and research of the Rijckholt Flint Mine is carried out by the volunteer association, Stichting Ir. D.C. van Schaik. A project has been underway since 2019, nearing its completion in 2023, to consolidate the stability of the prehistoric galleries, modernise the information available to the public, and allow for new future archaeological excavations and research (verbouwing.vuursteenmijn.nl).

3D recording has been used as a partial means in reaching these goals and plays a key role in the archaeological narrative at Rijckholt. Beginning in 2021, close range photogrammetry has been carried out within the mine to determine (1) its practicality in low lighting with limited accessibility, (2) what information can be obtained from the photogrammetric models, and (3) what role 3D recording plays in the 'archaeology of archaeology' at Rijckholt. To answer these questions, seven areas within the mine and one ex-situ artefact were documented using photogrammetry and processed through Agisoft Metashape.

Multiple challenges had to be overcome in order to produce these models, including the appropriate lighting and manoeuvring within the galleries during the image capture stage . Since no natural light reaches into the mine, our own portable light sources had to be carried in. In order to eliminate surrounding shadows, a diffused ring light was used (Rivero et al. 2019). Access to the galleries along with the equipment was achieved through crawling, often through areas 50cm in height. Special care was taken during this process to not touch the surrounding walls with fragile cut marks, or the ceilings which could have been unstable.

Carrying out image capture for photogrammetric models of the mine contributes to the impermanence of certain areas. Gallery 45, the largest area recorded in 3D, exhibited a limestone dust floor that was untouched since the 1960s. The floors had to be documented in their unspoiled state before crawling over them, which can now be seen in 3D but is changed in reality. The 3D model will be used for site management purposes and to visualise the underground mine for the general public. This gallery is inaccessible to visitors; therefore, the 3D visualisation offers an opportunity for the public to visit the underground mine without having to crawl through them. This virtual visit is more desirable due to the physical and mental toll that crawling in tight spaces can take on an individual, and because the mines are very vulnerable, especially in areas with fragile cut marks of archaeological importance.

Since there will be limited future access to this area, the present day human interference on the floors from 3D recording will likely remain a part of the archaeological trajectory of this mine (Appadurai 2006, 15).

The 3D photogrammetric model offers additional values and research questions for the archaeology of the site. While it is possible to compare features visually through 2D images, the 3D models allow greater chances for further analysis, such as being able to accurately scale the model and measure features. Each feature that was 3D-imaged not only gives us information about mining techniques during the Neolithic, but also the archaeological practices during the 1880s and the excavation of the 1960s. In the 1960s and later, some prehistoric tunnels were altered for practical and for safety reasons. Galleries were often closed up with backfill, which have since been removed in order to research the areas. In its place, iron support columns were added in order to stabilise the galleries. By 3D-imaging these areas and digitally removing the columns, we are able to visualise the mine in its former Neolithic state.

A digital visualisation provides opportunities to virtually visit galleries without having to crawl through them. In this way, future research can be prepared by locating specific areas in the model. It is the intention to expand the excavation of the underground galleries into unchartered neolithic mines. These areas will be documented with photogrammetry as well, including the changes to the mines caused by excavation. The knowledge of these new excavations could be used to reversely interpret the 1960 excavation and hopefully add new archaeological knowledge to the extensive mining system. Analyses on Rijckholt flint artefacts prove that the excavated flint mining area does not cover the complete Rijckholt flint species. The new excavations will extend into areas that could expand the knowledge of these flint species by geological methods but also through different mining methods, which will be visualised by close range photogrammetry.

Beyond the scientific research questions that 3D models can assist in answering, photogrammetry can tell the story of Rijckholt's long archaeological trajectory. The action of excavating and restoring break the illusion of permanence (Appadurai 2006, 16) within the mines, which results in a visualisation of labour from the Neolithic to present time. The evidence of the restorations, including iron supports to stabilise the galleries, can be shown or omitted from the 3D models. In this way, we decide which phase of work we wish to highlight in 3D, and determine which areas require further research by visualising them in a safe and virtual manner.

References:

Arjun Appadurai 206. "The Thing Itself." Public Culture 18, no. 1 (Duke University Press): 15-21. https://doi.org/10.1215/08992363-18-1-15.

Orbons, Joep. n.d. "De vuursteenmijnen van Rijckholt." Accessed October 5, 2022. https://verbouwing.vuursteenmijn.nl/index.php?option=com_content&view=featured&Itemid=101

Rivero, Olivia, Juan F. Ruiz-López, Iñaki Intxaurbe, Sergio Salazar, and Diego Garate. 2019. "On the limits of 3D capture: A new method to approach the photogrammetric recording of palaeolithic thin incised engravings in Atxurra Cave (northern Spain)". Digital Applications in Archaeology and Cultural Heritage 14. https://doi.org/10.1016/j.daach.2019.e00106.

71. At The Edge Of A City The Digital Storyline Of The Brontochion Monastery Of Mystras

Vayia V Panagiotidis, University of the Peloponnese
Vasiliki Valantou, University of the Peloponnese
Anastasios Kazolias, University of the Peloponnese
Nikolaos Zacharias, University of the Peloponnese

Introduction:

The Byzantine city of Mystras is situated at the foot of Mt. Taygetos, six kilometres west of the city of Sparta in the Peloponnese Greece. Mystras was established in 1249 when the Frank Commander William II of Villehardouin built a castle fortress on top of Myzithra Hill. The Acropolis fortress provided safety to the population of Medieval Sparta which eventually transferred to the hill settlement. The city expanded outside the Acropolis walls quickly after its surrender to the Byzantines in 1259. The Castle City's location and ties to the Byzantine capital of Constantinople boosted the city's development. Mystras grew and evolved through a number of phases, population changes and rulers (Sinos 2009).

Methods & Materials:

This study focuses on the digital depiction of the storyline of the Monastery of Brontochion of Mystras, located at the southwest edge of the city. The Monastery initially included the church of Hagioi Theodoroi founded by Pachomios, the enterprising abbot of Mystras, and built sometime before 1296 (Ministry of Culture and Sports, 2022). Twenty years later a second instalment to the Monastery was added by Pachomios. The Church of Panagia Hodegetria ("Aphentiko") was built as a prestigious temple to commemorate "the Renaissance" of the Palaiologos dynasty (Arvanitopoulos, 2004).

Results:

The overall study of the history of Mystras has been under development including a digital depiction of the different phases of the city providing a visualization and projection of archaeological data concerning the area of the Byzantine city (Panagiotidis & Zacharias, 2022). The digital recreation of the Monastery, part of this overall study, is implemented using modern spatial technologies, an unmanned aerial system (UAS) for documenting the area, a high accuracy GPS GNSS receiver, control points for georeferencing the drone images and a high resolution DSLR camera for documenting the buildings. Photogrammetry is applied to create the orthophoto of the study area, which works as the basemap for the subsequent analysis via GIS, as well as for the generation of the 3D models of the buildings of the Monastery. The final product is a visualization of the archaeological site and its evolution from the foundation of the Monastery to the present.

Discussion:

The geodatabase developed can act as the building blocks of a variety of digital applications from AR and VR applications to 3D visualization projects, educational games and digital smart guides. Future aims should include discussion for its continuation as a dynamic database for further incorporation and exploitation of data such as laser scanning data, LIDAR point clouds etc.

References:

Arvanitopoulos St., (2004). The City of Mystras: Η Πόλη του Μυστρά: Aspects of the Organization and Operation of a Late Byzantine Urban Complex Based on Sources and Public Buildings. National and Kapodistrian University of Athens, unpublished PhD Thesis

Panagiotidis V. & Zacharias N., 2022, "Digital Mystras: An approach towards understanding the use of an archae-ological space", Scientific Culture Vol. 8 No. 3, pp 85-99

Sinos, St. (2009). The Monuments of Mystras, The work of the Committee for the Restoration of Mystras Monuments. Athens: Credit Management Fund for the Execution of Archaeological Works Committee for the Restoration of Mystras Monuments, 11-22, 80-89 (in Greek)

The Ministry of Culture and Sports, Castle City of Mystras, (2005). History & Character of the Byzantine City [online]. Available at: https://www.culture.gr/mystras-edu/history/index.html# [July 20, 2019].

74. Round table: S23. Understanding Archaeological Site Topography: 3D Archaeology of Archaeology

Teagan K Zoldoske, Archaeology Data Service

I work for the Archaeology Data Service in England. Presently I am the lead archivist in charge of the High Speed 2 project which is England's largest infrastructure project at 330 miles, all of which was scanned with an areal drone which was then converted to DEM and DTM as well as vectors for analysis. We also have specific sites where most of the recording was done through photogrammetry (ranging up to 3000 models for one site). I'd love to discuss the implications of analysis the route as a whole and the sites but can go into details about anything relating to the digital archive of the project.

224. 3D DOCUMENTATION AND PUBLIC ARCHAEOLOGY AT THE EPONIMOUS SITE OF CUCUTENI CULTURE

Radu A Brunchi, Alexandru Ioan Cuza University
Casandra Brasoveanu, UAIC
Andrei Asandulesei, UAIC
Felix Tencariu, UAIC

The Chalcolithic culture Cucuteni is well-known for its fine painted ceramics, of great artistic refinement but, just as spectacular are the remains of the dwelling structures, investigated in the archaeological excavations. The constructions are generally destroyed by fire, often to the point of vitrifying the clay of the walls and floors. However, inside them important vestiges of everyday life and prehistoric spiritual life are preserved. This generates difficulties during the research, related to the correct methods of excavation and accurate documentation of the different levels of destruction.

Fortunately, due to the development and popularization of 3D documentation methods, we are able to record the archaeological information from these sites much faster and also obtain an objective point of view over the archaeological context.

We start the 3D data acquisition on a larger scale in order to get a better view of the landscape surrounding the archaeological site, then we focus our attention on the archaeological trench, and document and create 3D models of all the layers of destruction that are present in the trench.

Although we use the method in all our work, we chose as a case study a dwelling, researched in the eponymous settlement of the Cucuteni culture – Cetăţuia, from NE Romania. It is a construction with heavily burned walls, collapsed over a suspended floor, which in turn overlapped the ground floor, where several features (an agglomeration of loom weights, numerous ceramic vessels etc.) were identified. The ensemble was affected and partially mixed by various post-Chalcolithic disturbances. Under these conditions, without the possibility of photogrammetry, the recording of the material in situ would have been extremely difficult and time consuming. Also, the 3D models that we obtained allowed us their later usage for educational and popularization purposes in a Public Archaeology approach.

231. Photogrammetric terrain model of the San Isidro site in El Salvador. Data processing and archaeological analysis

Joachim Martecki, University of Warsaw

A unique feature of archeology is the extraordinary ability to adapt solutions from other disciplines and use them for its own purposes. Techniques and solutions derived from geodesy, are present in archeology for a long time, but in recent years modern instruments and technologies have become more popular.

Archaeologists use public sources of terrain data, as well as LIDAR or aerial photogrammetry to map the site and its vicinity they intend to study Along with geophysical surveys, these practices become standard research elements during field prospecting, the initial phase of research, which allows you to look at the site from a wider perspective and identify the most interesting fragments for excavation.

By participating in the San Isidro archaeological project in El Salvador, I undertook the task of conducting the spatial analysis of the site. I carried out the entire process, from taking aerial photos using a drone, through selecting the best images, and preparing the photogrammetric model, to conducting spatial analysis such as determining the axis of the urban pattern, comparing the size of mounds, and define the level of density of structures in the center of the site.

It is worth emphasizing that when conducting research in developing countries, such as El Salvador, researchers have to deal with problems that they would not even think about, accustomed to the realities of Western countries. There are no institutions responsible for sharing or even collecting data about the area. In addition, social conditions, influence, for example, safety during the research.

Poster intended to present not only the processes and results of my research in El Salvador, but also challenges that I had to face while gathering and analyzing the data.

Szymański, Jan, Krzysztof Misiewicz, Radosław Mieszkowski, Joachim Martecki. 2022. "Regional Patterns, Local Techniques: Remote Sensing and Archaeology at prehispanic site of San Isidro, El Salvador", Journal of Archaeological Science: Reports 45.

Szymański, Jan. 2020. "Recent Research at San Isidro, El Salvador, in the Context of the Southeastern Mesoamerican Archaeology", Estudios Latinoamericanos 40:1-28.

Kurczyński, Zdzisław. 2014. "Fotogramteria", Warszawa, Wydawnictwo Naukowe PWN SA

274. Interpreting geophysical survey data with the help of old site photography – a case study from acient Napata in northern Sudan

Pawel Wolf, none
Burkart Ullrich, Eastern Atlas

The ancient place name "Napata" refers to the significant political and sacral center of the Kushite kingdom in northern Sudan in the last millennium BC. It is located at the foot of a solitary mountain, the so-called "Jebel Barkal", near the present town of Karima. Extensive archaeological research started here as early as the beginning of the last century by the Harvard-Boston Expedition led by George A. Reisner. Since then, nearly a century of archaeological research at the site has brought to light a number of temples and shrines, as well as some representative civil structures of the Napatan and later Meroitic periods of the kingdom. However, a larger settlement with a clearly identifiable urban center was not discovered until recent fieldwork by the University of Michigan, led by Geoff Emberling.

While magnetometry and large-scale surface clearings revealed major portions of an urban settlement east of the known religious center, a ground penetrating radar survey in the temple complex excavated already by Reisner identified previously unknown urban structures that were densely built and structured by orthogonal streets and roads. For the interpretation of this geophysical data, we were able to reuse site photographs taken by the Harvard-Boston expedition more than a century ago: A set of overviews taken from the hilltop of the 80 m high Jebel Barkal allowed their georeferencing and use as an aid in interpreting the recent geophysical data. In a short contribution to this roundtable, we want to present and discuss our experiences.

327. Archaeology of Archaeology at Heloros: Re-interpreting the Urban Layout of a Complex Greek Settlement in Sicily using Proximal Sensing and Data Fusion

Nicola Lercari, Institute for Digital Cultural Heritage Studies - LMU Munich
Davide Tanasi,
Till Sonnemann, Bonn University
Stephan Hassam, University of South Florida
Dario Calderone, Institute for Digital Cultural Heritage Studies - LMU Munich
Paolino Trapani, Università degli studi di Catania
Lena Ruider, Institute for Digital Cultural Heritage Studies - LMU Munich
Rosa Lanteri, 5Parco Archeologico e Paesaggistico di Siracusa, Eloro, Villa del Tellaro e Akrai

Introduction:

The ancient city of Heloros, founded by Syracuse at the end of the 8th century BCE, is one of the least-known Greek settlements in Sicily. The site is briefly mentioned in ancient literary sources and most often in conjunction with the river after which it was named. Located within the Parco Archeologico e paesaggistico di Siracusa, Eloro, Villa del Tellaro e Akrai, Heloros' archaeological area comprises about 10 hectares of gentle slopes overlooking the sea and beaches to the north and south. Significant archaeological excavations were carried out at the site between the end of the 19th century and the 1980s unearthing a lively Hellenistic-period city with monumental fortification walls, a northern gate complex, a theater, several temples, a sacred area with a two-story stoa, and some of the urban layout (Orsi et al. 1965; Voza 1999). Despite its imposing monuments and fortifications, Heloros was never investigated with modern methodologies and techniques. Its archaeological record is fragmentary and did not yield any significant publication. The site has never been opened to the public. This complex situation relegated Heloros to oblivion. To improve our understanding of Heloros' history and cultural significance, we partnered with the Parco Archeologico and performed a comprehensive re-interpretation of the site's topography using the latest in proximal sensing and 3D documentation and GIS visualization techniques. This paper presents our data capture and integration methodology and the preliminary results of two archaeology of archaeology campaigns we carried out at Heloros in 2021-2022.

Methods and Materials:

To perform our archaeology of archaeology at Heloros in 2021, we employed an ensemble of 3D documentation tools, such as terrestrial laser scanning (TLS), drone-based and ground digital photogrammetry, and satellite imagery to produce new data on the post-Classical phases of occupation, focusing primarily on 3D mapping the hill where the site is located and, at a smaller scale, the Northern Gate district and the south-west sacred area, characterized by the binomial temple of Demeter and Stoa. Using low-altitude aerial photographs of Heloros' archaeological landscape we captured with a UAV, we produced natively digital and derivative data through an Image-based Modeling (IMB) pipeline. We created orthophotos of excavated areas and a Digital Terrain Model (DTM) of the entire site using Agisoft Metashape. Comparing these geospatial data in a GIS with the digitized legacy maps and archaeological drawings generated in the 19th and 20th centuries, we produced new interpretations of the complex architectural development of the northern fortifications, sacred urban area, and agora (Figure 1). Using the DTM and GIS visualization techniques, such as the Local Relief Model (LRM) and Red Relief Image Mapping (RRIM), we identified a series of anomalies in the landscape (Davide Tanasi et al. 2023). In 2022, we went back to Heloros to investigate these anomalies further. We used the same digital archaeology techniques we employed in 2021 to generate additional 3D documentation of two major complexes orbiting around the sacred area, the so-called sanctuary of Asklepion and the Theater, and on the agora and its district, located at the center of the Heloros hill, on the highest ground. Additionally, we carried out geophysical prospection, via ground penetrating radar (GPR), of a large North-South unexplored transect terrain of about 3 hectares, located approximately at the center of the hill, north of the sacred area, and west of the agora. The analysis of our GPR data is still ongoing. Still, preliminary results proved very promising and allowed us to identify unexcavated neighborhoods that most likely belong to the Hellenistic phase of the site.

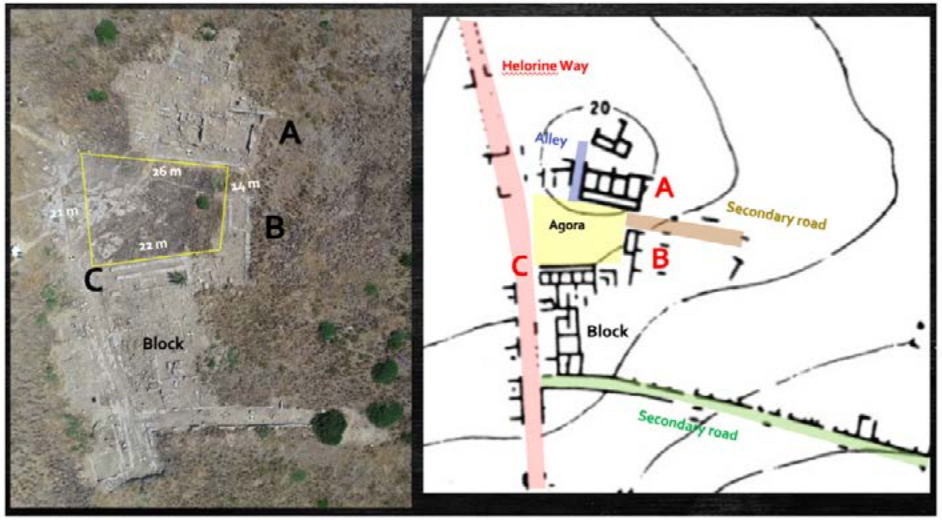

Fig. 1. Heloros agora is seen in the orthophoto we produced by drone-based digital photogrammetry (left) and in legacy documentation (right). The agora's trapezoid shape is delimited to the east by the Elorina way and by three buildings A, B, and C. Legacy documentation identified these buildings but misinterpreted the size and shape of B and C.

Results:

The application of TLS, terrestrial and aerial digital photogrammetry, and GPR produced a cache of important archaeological and topographical data on Heloros that we used to make sense of a complex and fragmentary archaeological record produced over one hundred years. In addition to the 3D documentation of all the excavated areas of the site, including the monumental fortifications, we performed autoptic analysis and cataloging of all their architectural and planimetric feature and produced a 3D collection on the web viewing platform Sketchfab. This collection includes the entire archaeological park, all the excavated areas and part of the fortifications, and dozens of disiecta membra scattered in the sacred area, including column drums, cornices, foundation blocks with mason's marks, and paneled ceiling elements, likely related with the Stoa, the major building of this part of the site, entire areas of the site. In a GIS environment, we transformed the DTM into GIS-based visualizations to improve the visual analysis of spatial features of interest related to archaeological resources. Using hill shading and various manipulations of the original DTM, we produced multiple visualizations emphasizing or smoothing out features such as roads, paths, excavated features, defensive walls and gates, and other archaeological remains. Additionally, we digitized and cataloged over 100 scattered architectural elements in the sacred area and agora using ground digital photogrammetry and TLS. The distribution pattern of those elements, at some distance from the nearby monuments and on the periphery of the sacred area plateau, informs us about the occurrence of major natural and artificial events that took place in the post-classical era and contributed to the current poor conservation state of the monumental areas of the site. The abovementioned Sketchfab platform will be critical for interpreting those patterns and will lay the foundation for tentative virtual reconstructions. Remarkably, the GPR prospection revealed with outstanding clarity previously unknown features of the city, with blocks of houses comprised of roads, that will help us better to understand the urban layout of Heloros via GIS visualization.

Discussion:

The re-interpretation of an archaeological site, especially one as large and complex as Heloros, entails the development of a robust pipeline spanning the digitization of legacy documentation, the acquisition and processing of new digital documentation, GIS analysis, 2D/ 3D visualization, and the curation of data in a digital collection. Our preliminary results led to the creation of extensive digital documentation of previously excavated areas and the verification of new hypotheses about Heloros' fortification system, Temple of Asklepion, and Agora while proving the location of unexplored neighborhoods through geophysical prospections. Integrating the multiple data sources discussed above allowed us to verify the accuracy of the legacy documentation, identify anomalies in the landscape, and discover new neighborhoods and features to be further investigated in future proximal sensing and ground-truthing campaigns. Our future work at Heloros will produce a comprehensive interpretation of the site, nearby necropolis, and quarries by adding new 3D and geospatial layers, including airborne LiDAR data collected with a UAV, and further expanding the GPR prospections. Significantly, our work has generated data that can be used for myriad applications in pattern recognition that can further enhance our GIS and visual analysis of Heloros through automated analyses.

References:

Davide Tanasi, Stephan Hassam, Dario Calderone, Paolo Trapani, Nicola Lercari, Gerardo Jiménez Delgado, and Rosa Lanteri. 2023. "Datafication of an Ancient Greek City: Multi-Sensorial Remote Sensing of Heloros (Sicily)." In ICPR 2022 Workshop Proceedings. Lecture Notes in Computer Science. Montreal: Springer.

Orsi, P., M.T. Currò, E. Militello, and V. Piscione. 1965. "Eloro I-IV." In Monumenti Antichi Dei Lincei, XLVII:203–340. Accademia Nazionale dei Lincei.

Voza, Giuseppe. 1999. Nel segno dell'antico: archeologia nel territorio di Siracusa. Palermo: A. Lombardi.

41. Capacity building for open data persistence in archaeology

Holly Wright, University of York
Edeltraud Aspöck, Austrian Academy of Sciences, Austria

Location: E104

As we work to increase the amount of archaeological data that is freely available online, much of the data that is currently available still cannot be considered to be persistent. In other words, just because something is online, doesn't mean work has been undertaken to ensure it will be available in five or ten years time (and beyond). Even with the best of intentions, data that has been archived for the long term remains the exception, rather than the rule. This has resulted in a myth of persistence; the incorrect assumption that once something is made openly available online, it will continue to be available. An understanding of, and commitment to, the stewardship of our digital archaeological resources for the long-term is still very much lacking.

The European Commission places international collaboration as a central tenet within most of its funding initiatives, and collaboration is the cornerstone of successful digital archaeological data stewardship. Funded by the European Commission's Horizon 2020 research and innovation programme under Grant Agreement 823914, and implemented in parallel with SEADDA, ARIADNEplus consisted of 41 partners representing 23 countries and four international partners, working together to build a data aggregation infrastructure to serve the archaeological community worldwide, through the ARIADNE Portal (https://portal.ariadne-infrastructure.eu/). Data-providing partners in ARIADNEplus encountered challenges in how best to map and organise their metadata in order for it to be incorporated and made discoverable within the ARIADNE Portal, but some partners encountered greater barriers than others. Barriers include lack of technical capacity in preparing their data; lack of background in data stewardship; and lack of an appropriate, persistent repository to house their data. The current development phase of the ARIADNE Portal has recently come to a close, but collaborative work continues and preparations are already underway for the next phase. This will include finding new data providing partners, expanding current collaborations, and enhancing data reuse, but with the added understanding derived from SEADDA around the importance of capacity building for data persistence which has also been an entry point for early career researchers and researchers working outside of academia.

This session invites papers from ARIADNEplus partners and SEADDA members to share their progress in capacity building in their country and/or region, as we seek to raise the visibility of data persistence within the CAA community. This session equally invites submissions from outside SEADDA and ARIADNEplus that discuss issues around data persistence, preservation, stewardship and capacity building in this area, including practical challenges, opportunities, along with ethical and theoretical considerations, such as where individual researchers, who are always pushed to prioritise innovation over preservation in their work, stand in this debate.

References:

Geser, Guntram, Salzburg Research Institute, Julian D. Richards, Flavia Massara, Holly Wright, Archaeology Data Service, Central Institute for the Union Catalogue of Italian Libraries, and Archaeology Data Service. 2022. "Data Management Policies and Practices of Digital Archaeological Repositories." Internet Archaeology, no. 59 (March). https://doi.org/10.11141/ia.59.2.

Richards, Julian D., Ulf Jakobsson, David Novák, Benjamin Štular, and Holly Wright, eds. 2021. "Digital Archiving in Archaeology: The State of the Art" 58 (June). https://doi.org/10.11141/ia.58.23.

SLOT 3	
14:00 - 14:20	107. "But I'm not sure if that's of any interest". Researchers' points of view on archaeological fieldwork data sharing in Catalonia *Sabina Batlle Baró (Universitat de Barcelona)**
14:20 - 14:40	236. Dissemination and sustainable storage of Norwegian archaeological data *Espen Uleberg (NO)*; Mieko Matsumoto (NO)*
14:40 - 15:00	93. Learning from the others: Inrap in the context of European cooperation initiatives in the field of digital archaeological data *Kai Salas Rossenbach (Inrap)*; Amala Marx (Institut national de recherches archéologiques préventives)*
15:00 - 15:20	2. Accessibility And Openness Of Archaeological Heritage Data In Serbia *Milica Tapavicki-Ilic (Institute of Archaeology); Marija Segan-Radonjic (Mathematical Institute SANU)*; Milan Todorovic (Mathematical Institute SANU)*
15:20 - 15:40	92. The state of digital archaeological archiving policies and practice in Europe – a data-based analysis and what to take out of it *David Novák (Institute of Archaeology of the CAS, Prague)*

107. “But I’m not sure if that’s of any interest”. Researchers’ points of view on archaeological fieldwork data sharing in Catalonia

Sabina Batlle Baró, Universitat de Barcelona

The benefits of data opening for both science and society have been widely exposed. Data sharing not only helps making research more sustainable but also accelerates innovation, and Archaeology is not an exception. In fact, the openness of Archaeology in general and of archaeological research data has been seen not only as a beneficial practice but necessary for the advancement of the discipline, practically a sine qua non condition to be able to respond to the big questions that Archaeology has not yet been able to solve (Kintigh, et al., 2014). In this sense, data sharing is seen, by many authors and researchers, as a practically imperative solution to the already destructive nature of the archaeological research method, as well as an ethical obligation for a discipline that studies a public good such as heritage and uses mostly public funding (Marwick et al., 2017).

For many years, the main worries of the literature about archaeological openness were the big transformations this model could bring to the discipline, for better or worse. Apparently, the benefits of open data are now more accepted, as the advantages and disadvantages of this not-so-new model are not the focus of the discussion anymore. Eventually, the debate seems to have shifted to a most practical sphere, from why or whether should we change to how should we make this change possible or how can we overcome the problems we are facing when trying to implement it.

International projects such as ARIADNE and SEADDA have been exploring these technical challenges and got to work to build infrastructures and communities in order to provide European archaeology with a strong network to share not only data but also knowledge and experience in this opening process. These initiatives have been a huge success and a necessary step forward for data managers and curators. However, this whole movement is somehow still lacking the participation of one of the biggest stakeholders: the researchers. The role of the researchers in this play is crucial, and we should include them in the debate, as they are the ones who collect, work and manage the data during most of their lifecycle. Considering this, it feels necessary to assess the points of view of the researchers, to fully understand how and why they are managing and sharing (or not) their data. Understanding the researchers’ perceptions and their current research data management practices can allow us not only to get to know the real starting point and evaluate the implementation of open data, but also to define the challenges this new model must overcome and develop a better strategy to foster its implementation.

This communication will present the preliminary results of a series of interviews conducted with principal investigators of archaeological field projects in Catalonia (Spain), during which the researcher’s data management habits and their feelings on open data were discussed. In Spain, archaeological heritage is managed by the governments of the autonomous regions. Even though there is common ground, there are differences between the regions and their heritage legislation, especially relating to the management of reports and archaeological data, and the funding of archaeological research fieldwork. The different autonomous regions also have different research systems and funding structures.

Huge differences in the way archaeology (and archaeological data) are managed in different countries and regions around the world have been recently highlighted by SEADDA (Jakobsson et al. 2021). For this reason, we feel the need to concentrate our research on a well-defined and well-known frame to minimize the external factors that could affect these practices and points of view. By choosing a specific area of archaeology (fieldwork research) and a delimited geographical context (Catalonia), we make sure that no main differences in funding, legislation or national trends and opportunities are influencing the study set, and all the especial characteristics and nuances of the context can be properly assessed. Moreover, previous knowledge about the shared legal and social framework (impossible when analysing bigger areas) allows for a better understanding of the results.

We have conducted interviews to more than fifteen principal investigators of archaeological fieldwork research projects from Catalan institutions. All projects were funded by the Culture Department of the Generalitat de Catalunya under the same conditions, in a call for fieldwork and research grants that made no mention on data management or publication and were developed for four years (2018-2021). By analysing the preliminary results of these interviews, we try to describe the current data management and sharing practices. Also, we seek to determine the main points of view of the archaeological research community in Catalonia on data sharing, in order to identify the main social barriers and extract useful information that could be used to transform and ameliorate the current model.

References

Marwick, B. (2017). Open science in Archaeology. The SAA Archaeological Record

Jakobsson, U., Novák, D., Richards, J.D., Štular, B. and Wright, H. (eds) (2021). Digital archiving in archaeology: the state of the art. Internet Archaeology, 58. https://doi.org/10.11141/ia.58.23

Kintigh, K.; Altschul, J.; Beaudry, M.; et al. (2014). Grand Challenges for Archaeology. American Antiquity, 79, 5-24.

236. Dissemination and sustainable storage of Norwegian archaeological data

Espen Uleberg, NO
Mieko Matsumoto, NO

This paper will give an overview of the status for dissemination and sustainable storage for archaeological data in Norway. The university museums and NIKU are research institutions. The research at the university museums is primarily based on their collections. Concerning archaeological data from rescue excavations and surveys, there are three main groups – the university museums, NIKU (Norsk Institutt for KUlturminneforskning, niku.no) and the counties.

The Norwegian university museums have a long tradition of collaboration to create common data solutions. The Norwegian law regulating cultural heritage states that all objects older than the reformation (1537) is automatically protected. In addition, numismatic objects older than 1650 and saami sites older than 1917 are also protected. Norway is divided in five university museum districts, and the university museums have been given the responsibility for all archaeological and numismatic objects. Objects and context documentation are therefore kept at the university museums in Oslo, Stavanger, Bergen, Trondheim and Tromsø.

The university museums' collaboration to digitize archive material, creating systems for with cultural historical collections goes back to the Documentation project from 1992 (Matsumoto and Uleberg 2021) and has now the name UniMus:Kultur (https://www.khm.uio.no/english/research/projects/unimus-kultur/). The ongoing work converts the database from oracle to PostgreSQL, and changing from an application written in Delphi to a web-based user interface.

The museum databases, as well as the National Heritage and Environment Register, Askeladden, are used as tools for both research and management. This is related to the fact that they have the same type of information as the museum archives and museum artefact catalogues. In the earlier stages of the projects, the focus was on creating research databases, while in more recent years, the databases have been referred to as a Collection Management System (CMS).

The databases are constantly updated. Collection revisions and new finds from excavations, surveys, metal detecting and other chance occasions coming to the museum are all entered in the same, database. The database model is event based, ensuring that all entries and changes are kept as events linked with time and person as in CIDOC-CRM. The database is a critical system for the museums, and this ensures that the data are sustainable.

The university museums are also responsible for the prehistoric excavations in their districts. Since 2011, the excavations use the Swedish system Intrasis for documentation. The Intrasis projects were for a long time only accessible as separate projects, stored on servers at each museum. The project ADED (Archaeological Digital Excavation Documentation) affords now a National repository for this material. The projects are also migrated to a common platform, facilitating queries across all uploaded projects.

NIKU is responsible for archaeological excavations in mediaeval towns and churches. They will catalogue all finds directly in the Unimus artefact database, and upload images taken for documentation to the Unimus image database. They are also using the Intrasis system, and the Intrasis projects are also sent to the university museums for sustainable storage.

The Norwegian counties are responsible for archaeological surveys in connection with planned construction work. Archaeological finds from the surveys are deposited at a university museum, and reports are distributed to the museums and authorities. The counties also update Askeladden with information from the surveys, but detailed documentation is kept locally. It is a pending question how to improve the accessibility to these data.

Data from the university museums' artefact database are published through unimus.no as API and downloadable datasets. In addition, the Unimusportal (unimus.no/portal) gives a user-friendly access to artefact text data and images of artefacts, monuments, structures at excavations and exhibitions from all the university museums. ADED also provides access to artefacts and documentation photos related to the excavations in ADED.

Each museum has its own solution for archaeological reports and archive material. Some use repositories that provide persistent links, while others just publish reports on their web pages.

The vast majority of excavations in Norway are rescue excavations. The documentation from these projects are stored in a sustainable way, since they become part of the digital archives and databases at the university museums. We could need a better overview of the information collected by the counties, including surveys that do not find new sites. This is potentially important knowledge because it adds to the general understanding of site distribution and use of landscapes.

The Norwegian regulations ensures that also documentation from research excavations will be entered into the common database, and documentation images will be uploaded to the museums' repository. We do have a challenge to provide better solutions for other data that researchers collect and register. It is possible for a researcher to contact us and we will then keep their datasets. However, there is some discussion as to whether data not connected to rescue excavations should be curated by the university museums. All documentation of protected sites should however be regarded as valuable, adding to the collected knowledge of our past.

The issue of open access and sustainable data stewardship receives also in Norway increasing interest. The university museums have worked actively on making information digital and accessible since 1992 (Ore and Uleberg 2019), exchanging knowledge and ideas with the CAA community. International projects like ARIADNE+ and SEADDA are inspiring and important in the process of finding the best possible solutions and ways to make data as FAIR as possible.

Matsumoto, Mieko, and Espen Uleberg (2021). Curation of Digital Archaeological Data in Norway, . Internet Archaeology. https://doi.org/10.11141/ia.58.29.

Ore, Christian-Emil Smith, and Espen Uleberg (2019). “The ADED project - a Norwegian infrastructure for excavation data.” In The ARIADNE impact, edited by Niccolucci, Franco, and Julian Richards, 123–134. Archaeolingua.

93. Learning from the others: Inrap in the context of European cooperation initiatives in the field of digital archaeological data

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INRAP, the French National Institute for Preventive Archaeological Research, was created in 2002 by a French law that constitutes the implementation of the European Convention for the Protection of the Archaeological Heritage of Valletta (Malta). The Institute ensures the detection and study of archaeological heritage affected by development and infrastructure works. It coordinates and disseminates information to the scientific community and promotes archaeological heritage through public awareness and education programmes.

For more than 10 years, Inrap has been participating in several EU projects such as ARIADNE, ARIADNEPlus, ARKWORK or SEADDA. In these cooperation contexts, Inrap has been considered as a potential huge data provider because of the amount of digital data created each year by its 2000 archaeologists in the framework of more than 2000 fieldworks researches. It is interesting to note, in terms of data quality and availability, that most of the data shared by our institution in these projects are archaeological reports. This clearly highlights the lack of maturity and persistence of our data life cycle. The “book” nature of the reports is managed for many years in a digital format and stored for the long term in specific systems. It is therefore interesting to describe and highlight how these projects have provided an opportunity for an entire institution to progress in terms of data management. These skills were acquired through the efforts of the European community/network to provide appropriate and formal capacity building initiatives, but also through the impregnation of our people by high level professionals from different countries. Our paper will describe this process, its concrete achievement and the lessons learned for future programmes.

2. Accessibility And Openness Of Archaeological Heritage Data In Serbia

Milica Tapavicki-Ilic, Institute of Archaeology
Marija Segan-Radonjic, Mathematical Institute SANU
Milan Todorovic, Mathematical Institute SANU

In the Republic of Serbia there is a several decades long practice of documenting archaeological heritage in digital environment. At present, there is also an obligation of institutions responsible for cultural heritage in Serbia to implement the information system defined by law and to send the data to the state center for further management and long-term preservation. Further on, since the Government of Serbia recognized the importance of re-usage of data kept by its public institutions, it highlighted its strategy for making them publicly available and accessible by issuing a row of laws and regulations. However, in reality, even with these laws and instead of the model of full accessibility and open data usage, institutions of protection in Serbia still choose to apply selective accessibility. Thus, the paper reveals the current state of the art regarding accessibility of cultural heritage data in Serbia in 2022 and questions the possibilities of its usage and re-usage.

Two examples of public national repository data re-usage are presented. In the first example, presuming that the data holder guarantees data reliability and also that it shared them on the web in an adequate way and in an adequate form, the authors of this paper tested how a user with a minimum technical knowledge can download them and use them for an individual project. The paper presents how with the help of simple tools, three open data sets of national providers were used for creating digital collections aiming to promote archaeological sites of exceptional importance situated along the National cycling Danube route, this being part of the European cycling route „EuroVelo 6”.

In the second example, the paper deals with advantages of connecting national data sets about cultural heritage with international knowledge bases aiming for their re-usage and preservation. The paper describes the process of integrating data sets of the Mathematical Institute SANU about more than 150 highly important cultural monuments in Serbia with the ARIADNEplus Portal. The here mentioned cultural monuments were initially described within the suggested national metadata format with the goal to incorporate them more easily during a possible establishing of a national information system for management and preservation of data about cultural heritage. The authors further discuss whether this metadata format respected the basic principles regarding interoperability, modularity, refinement, extensibility, multilingualism and flexibility, in order to make the metadata easily mapped and prepared for integration with the ARIADNEplus Portal.

References

Ognjanović, Zoran et al. ,,Cultural Heritage Digitization in Serbia: Standards, Policies, Case Studies". Sustainability 11 (2019):3788. https://doi.org/10.3390/su11143788

Šegan-Radonjić, Marija and Milica Tapavički-Ilić, „Digitisation and Data Management of Archaeological Heritage in Serbia (1991-2020)", Internet Archaeology 58. https://doi.org/10.11141/ia.58.15

Tapavički-Ilić, Milica and Marija Šegan-Radonjić, „Methods and Capacity in Archaeological Data Management in Serbia", Archaeology and Science 17 (2021): 113-134.

354. ARIADNEplus Visual Media Service 3D configurator: toward full guided publication of high-resolution 3D data

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Federico Ponchio, CNR-ISTI
Marco Callieri, CNR-ISTI
Paolo Cignoni, CNR Pisa

Developed in the context of the EC Infra ARIADNE project, the Visual Media Service (VMS) [Ponchio et.al 2016] provides easy publication and presentation on the web of complex visual media assets. It is an automatic service aimed at people working in Cultural Heritage (CH) domain, that allows content creators to upload three different visual media (high-resolution images, RTI, and 3D models) on a server and to transform them into an efficient web format, making them ready for web-based visualization.

To boost the penetration of the service in the CH community, possibly transforming the VMS in a solution exploitable in a more systematic and structured way, the Horizon 2020 ARIADNEplus project aimed at expanding the VMS features, implementing innovative services for users addressed to archaeological data management.

In this context, one of the goals was to design and develop new services for improving the visual organization of 3D archaeological datasets. Initially planned as a simple redesign of the way of linking the 3D model of an artefact or a monument to its archaeological documentation, finally the work has involved not only the 3D data enrichment stage, but also all the other configuration options already provided for customizing the VMS 3D presentation.

The result of this work is a brand new configurator for 3D models, proposed as a complete multi-step wizard able to guide the content creator through the publication process. The current 3D configurator is composed of 5 different configuration steps, appropriately divided according to the type of customization they provide: Alignment, Material & Light, Navigation, Interface, and finally Annotation.

Alignment: the first step allows the content creator to fix the model orientation. One of the more common issues that happens working with 3D models is that the model is often visualized with the wrong orientation. This occurs because the 3D model has not been oriented when created, or because the different tools composing the 3D working pipeline (data acquisition, editing, publication) use different visualization systems. In any case, if the model is not in the correct orientation, in the alignment wizard the content creator can re-orient it using different commands:

- First of all, one can correct the model orientation by rotating the model along an axis; there are 3 different sliders, one for each axis, and one can use them to independently rotate your model on a selected axis;
- Then, one can define the UP of the model; this is another very annoying issue that happens very often, since the software used for creating 3D models follow different notations; so, the UP vector can be defined in 2 different way, and this led to weird behaviour in visualization; since is not possible knowing in advance what is the notation used for the given 3D model, in this panel with a simple button one can switch from a notation to the other;
- Finally, one can use advanced straightening to orient the model to match predefined views directly interacting with it in the 3D scene or by using specifically provided buttons.

Material & Light: the second step allows the content creator to set up the 3D model appearance. More specifically:

- the material wizard provides a set of tools to select the start-up colour of the 3D model (texture or solid colour), define the solid colour used, add or remove a toolbar button for switching between texture and solid colour, and finally customize the glossiness level (dull, low, medium or shiny).
- the lighting setup provides a set of tools to define the start-up lighting of the scene (enabled to use 3D models normal map, or disabled to use just ambient lighting), add or remove a toolbar button for switching between enabled and disabled lighting, and finally add or remove a toolbar button for enabling light direction control.

Navigation: the third step allows the content creator to define the scene navigation setup. In particular, this wizard provides a set of tools to select the trackball paradigm used in the scene for manipulating the 3D model (turntable, that allows tilting and vertical rotating the model, preserving the vertical axis; or sphere, that enables complete and free rotation and panning on all axes), define the initial trackball position, customize the field of view angle of the virtual camera (using a slider or three different buttons with predefined values), specify the type of projection used by the camera at the startup (perspective or orthographic), and finally add or remove a toolbar button for switching between perspective and orthographic projection.

Interface: the fourth step allows the content creator to customize the viewer interface. This specific wizard provides a set of tools to customize the toolbar skin (6 different themes are available: light, dark, minimal light, minimal dark, transparent light, transparent dark), add or remove tool buttons from the toolbar (lighting, light direction, measurement, point picking, sections, solid colour, projection, full screen), define the viewer background (flat colour, linear gradient, radial gradient, predefined images), and finally select which widget provide to the end user (base grid, compass, canonical views, navigation cube).

Annotation: the fifth step allows the content creator to add hotspots (points of interest highlighted by clickable geometries) to the 3D model and link them to some basic annotation. The annotations wizard provides a set of tools to add or remove hotspots (spherical geometries) to the 3D model, define the radius of each sphere associated to a specific hotspot, customize the colour of the hotspot geometry, and finally edit the text information linked to the hotspot. Once at least one hotspot is defined, the wizard automatically add a toolbar button to enable or disable the hotspot visibility. If hotspots are visible, moving the mouse cursor over their geometry recall a popup box showing (in the bottom left of the viewer) the text associated to that specific hotspot.

The VMS 3D wizard represents a first step toward a full guided integration of visual media in the context of archaeological datasets. Initial testing started on selected datasets provided by the partners of the ARIADNEplus project.

References

Ponchio, F., Potenziani, M., Dellepiane, M., Callieri, M., & Scopigno, R. (2016). ARIADNE Visual Media Service: easy web publishing of advanced visual media. CAA 2015 - 43rd Annual Conference on Computer Applications and Quantitative Methods. Siena, Italy.

92. The state of digital archaeological archiving policies and practice in Europe – a data-based analysis and what to take out of it

David Novák, Institute of Archaeology of the CAS, Prague

Many people take the digital transition for granted and consider the process more or less complete. However, if the product of archaeological fieldwork is mainly archaeological data in addition to material finds, is this really true? This topic of digital archiving has long been addressed by both the EAC Working Group for Archaeological Archives and the SEADDA project. These two entities joined forces to produce a special issue of Internet Archaeology journal, bringing together papers on digital archiving practices in more the two dozen countries (Richards et al. 2021). These papers were later analysed both by EAC and SEADDA to compare the international situation in the field. As the results show, there are both shared difficulties associated with the issue of documentary archives worldwide and examples of good practices that help to overcome the shared problems. The papers mainly highlighted that:

- the problems in archiving are primarily organisational (technical level is secondary);
- part of the solution should be to cope with the digital transition, but it is not the only task - the issue is going deeper;
- if digital archaeological archiving is not a matter of legal obligation, it is not working up to the common expectations or best practices;
- the problem lies in the improper handling of archaeology fieldwork data in general;
- there are both shared difficulties and examples of good practice worldwide.

In order to complement the findings resulting from the interpretation of the published articles with supporting data covering the whole European area in a balanced way, a questionnaire survey was also carried out, which allowed compiling an overview of the situation in 27 countries (30 regions) of Europe. All respondents were experts involved in digital archiving and/or heritage data management in individual countries.

Based on the collected information, the disproportion in value of archaeological data and their position within heritage management practice is already proving to be a major shortcoming. There are imbalances in the level of attention – and the resulting level of protection – given to archives of (digital) archaeological documentation. If we want to find a way to improve the situation, it is necessary to initiate systemic changes, which should manifest themselves on a number of levels. However, these changes are conditional on a political decision that will give the whole process legitimacy, the necessary resources, a clear framework, but also the necessary tools. It is needed to formulate general principles and co-create an environment, including a legislative one, in which archaeological archiving can be carried out in a sustainable and meaningful way in order to bring the highest possible social benefit. Compared to other initiatives, we consider it essential to primarily follow the systemic changes (top-down approach) rather than strive for change in the individual practice of researchers. It is the only way to achieve the real persistence of irreplaceable archaeological data. The presentation will summarise the results achieved and present proposed approaches to improve the situation in digital archaeological archiving.

References:

Richards, J.D., Jakobsson, U., Novák, D., Štular, B. and Wright, H. 2021 Digital Archiving in Archaeology: The State of the Art. Introduction, Internet Archaeology 58. https://doi.org/10.11141/ia.58.23

06. Stay connected: Developing Mobile GIS for team-based collaboration in archaeological research

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Adéla Sobotkova, Aarhus University, School of Culture and Society,
Nazarij Buławka, Landscape Archaeology Research Group (GIAP), Catalan Institute of Classical Archaeology
Giuseppe Prospero Cirigliano, University of Siena, Department of History and Cultural Heritage

Location: E104

Mobile GIS Special Interest Group has in its previous CAA conference editions (2017, 2018, 2019, 2021) drawn attention to the importance of mobile GIS in archaeological and other field research, specifically its impact and contribution to fieldwork methodology and data collection (Buławka and Chyla, 2020; Sobotkova et al., 2021). In this edition, we survey how the use of mobile GIS in archaeology has progressed in recent years. In the early phase of COVID pandemic, Scerri et al. argued that sciences working in the field, including archaeology, had to change their ways (2021). The review of the recently published literature partly confirms it. As most international expeditions were canceled, scholars working in the field had to stop their projects. Many projects abandoned field work in favor of office work, for example remote sensing and data analysis. Others, in the late phase of the pandemic, found their way to continue working by novel methods of collaboration (Geser 2021; Magnani et al. 2021; Matte and Ulm 2021). COVID demonstrated the benefit of producing FAIR digital data in the field. Robust toolkit ensured that the collected data were born-digital, complete and consistent upon departure from fieldwork. Having all data shared and accessible by all team-members afterwards meant that work could continue remotely, which was a source of relief during the lockdown (Sobotkova et al., 2021). Additionally, we would like to explore the current differences in collaborative solutions between open-source and commercial software. Do the different OS and commercial software entail a different organization of archaeological fieldwork? What aspects and reasons lead a research team to choose an OS versus a commercial software? What is the range of funding models used to develop or deploy different mobile data capture applications? How should archaeologists prepare for OS updates, changes in hardware compatibility or application funding models so as to retain the ability to use the same workflow in the future? Another aspect that we would like to address at CAA 2023 is the capability to produce standardized results that follow good practice using mobile GIS nowadays. Some archaeologists report increased fieldwork efficiency thanks to the use of mobile devices (Austin 2014; Ames et al. 2020) while others focus on the downsides of the digital medium, such as deskilling, (Caraher 2016; Gordon et al. 2016), or stress the need to manage workplace change and fine-tune daily operation under the new circumstances (Vanvalkenburgh 2018). What makes the difference? Have the mobile devices transformed the entire lifecycle of archaeological research from team-based field data capture to analysis, sharing, and publishing, or affected only the day-to-day working processes in the field? And more specifically: is mobile GIS essential for digital fieldwork? If so, what are the must-have features of mobile GIS and how do you prioritize them? The session invites papers that may concern methodological and technical aspects and will be finished with a moderated discussion.

References:

Ames, Christopher J. H., Matthew Shaw, Corey A. O'Driscoll, and Alex Mackay. 2020. "A Multi-User Mobile GIS Solution for Documenting Large Surface Scatters: An Example from the Doring River, South Africa." Journal of Field Archaeology 45 (6): 394–412. https://doi.org/10.1080/00934690.2020.1753321.

Austin, Anne 2014. 'Mobilizing Archaeologists: Increasing the Quantity and Quality of Data Collected in the Field with Mobile Technology', Advances in Archaeological Practice, 1, 12-23.

Buławka, Nazarij, and Julia Maria Chyla. 2020. "Mobile GIS – Current Possibilities, Future Needs. Position Paper." In Digital Archaeologies, Material Worlds (Past and Present). Proceedings of the 45th Annual Conference on Computer Applications and Quantitative Methods in Archaeology, edited by Jeffrey B. Glover, Jessica Moss, and Dominique Rissolo, 99–113. Tübingen: Tübingen University Press. https://doi.org/10.15496/publikation-43226.

Scerri, Eleanor M. L., Denise Kühnert, James Blinkhorn, Huw S. Groucutt, Patrick Roberts, Kathleen Nicoll, Andrea Zerboni, et al. 2020. "Field-Based Sciences Must Transform in Response to COVID-19." Nature Ecology & Evolution 4 (12): 1571–74. https://doi.org/10.1038/s41559-020-01317-8.

Caraher, William. 2016. "Slow Archaeology: Technology, Efficiency, and Archaeological Work." In Mobilizing the Past for a Digital Future; the Potential of Digital Archaeology, edited by Erin Walcek Averett, Jody Michael Gordon, and Derek B. Counts, 421–42. The Digital Press @ University of North Dakota. http://dc.uwm.edu/arthist_mobilizingthepast/18.

Geser, Guntram. 2021 "Impact of COVID-19 on Archaeology and Cultural Heritage." Salzburg. https://ariadne-infrastructure.eu/wp-content/uploads/2021/11/COVID-19_impact-archaeology-and-cultural-heritage_29Oct2021.pdf.

Gordon, Jody Michael, Erin Walcek Averett, and Derek B. Counts. 2016. "Mobile Computing in Archaeology: Exploring and Interpreting Current Practices." In Mobilizing the Past for a Digital Future; the Potential of Digital Archaeology, edited by Erin Walcek Averett, Jody Michael Gordon, and Derek B. Counts, 1–32. The Digital Press @ University of North Dakota. http://dc.uwm.edu/arthist_mobilizingthepast/2.

Magnani, Matthew, Natalia Magnani, Anatolijs Venovcevs, and Stein Farstadvoll. 2022. "A Contemporary Archaeology of Pandemic." Journal of Social Archaeology 22 (1): 48–81. https://doi.org/10.1177/14696053211043430.

Mate, Geraldine, and Sean Ulm. 2021. "Working in Archaeology in a Changing World: Australian Archaeology at the Beginning of the COVID-19 Pandemic." Australian Archaeology 87 (3): 229–50. https://doi.org/10.1080/03122417.2021.1986651.

Sobotkova, Adela, Shawn A. Ross, Petra Hermankova, Susan Lupack, Christian Nassif-Haynes, Brian Ballsun-Stanton, and Panagiota Kasimi. 2021. "Deploying an Offline, Multi-User, Mobile System for Digital Recording in the Perachora Peninsula, Greece." Journal of Field Archaeology 46 (8): 571–94. https://doi.org/10.1080/00934690.2021.1969837.

VanValkenburgh, Parker, Luiza O. G. Silva, Chiara Repetti-Ludlow, Jake Gardner, Jackson Crook, and Brian Ballsun-Stanton. 2018. "Mobilization as Mediation." Advances in Archaeological Practice. https://doi.org/10.1017/aap.2018.12.

SLOT 1	
08:30 - 08:50	148. Typology of MobileGIS workflow in archaeological prospection: Crowd Data Collection, Volunteer Geographic Information or Geographic Citizen Science? *Julia M. Chyla (Faculty of Archaeology, University of Warsaw)*; Miłosz Giersz (Faculty of Archaeology, University of Warsaw)*
08:50 - 09:10	213. At the interface between GIS mobile applications and reflexive archaeology: using QField app in archaeological surveys *Giordano De Coste (Roma Tre University); Emeri Farinetti (Roma Tre University)*; Matteo Rossi (Roma Tre University)*
09:10 - 09:30	149. (Reading) African Palimpsest – the use of mobileGIS for a team based collaboration: the case study of the rural hinterland of Mustis (Tunisia) *Julia M. Chyla (Faculty of Archaeology, University of Warsaw); Tomasz Waliszewski (Uniwersytet Warszawski)*; Jamel Hajji (The National Heritage Institute, Tunisia); Faouzi Ghozzi (The National Heritage Institute, Tunisia); Ewa Smolska (Faculty of Geography and Regional Studies, University of Warsaw); Jerzy Lechnio (Faculty of Geography and Regional Studies, University of Warsaw); Piotr Szwarczewski (Faculty of Geography and Regional Studies, University of Warsaw); Ouadii El Aroui (CGMED Laboratory, FSHS Tunis, University of Tunis); Piotr Makowski (Institute of Archaeology, Jagiellonian University); Krzysztof Misiewicz (Uniwersytet Warszawski); Radosław Mieszkowski (Faculty of Geology, University of Warsaw); Adrian Ochtyra (Faculty of Geography and Regional Studies, University of Warsaw); Chokri Touihri (Institut National du Patrimoine); Paweł Rongies (Faculty of Archaeology, University of Warsaw); Konstanty Kowalewski (Faculty of Archaeology, University of Warsaw)*
09:30 - 09:50	182. The use of QField in the Ager Rusellanus (Grosseto, Italy), between traditional and experimental methods. *Giuseppe Cirigliano (Università degli studi di Siena)**
09:50 - 10:10	341. In the land of basalt rocks stone and terraces. Use of mobile GIS in documenting the prehistoric megalithic culture of Akkar in northern Lebanon. *Filip Waldoch (IMOC PAS)*; Zuzanna Wygnańska (IMOC PAS)*
10:10	270. Underground Warfare: field survey with mobile GIS app to reconstruct the WWI warscape *Stefano Pedersoli (University of Sassari)*; Giovanni Azzalin (University of Sassari); Anna Michielin (University of Bologna); Marika Cogo (University of Padua); Luigi Magnini (University of Sassari (Italy))*

SLOT 2	
11:00 - 11:20	168. Mobile GIS and Digital Data Collection Workflows on the Kasakh Valley Archaeological Survey (KVAS), Northwestern Armenia *Ian Lindsay (Purdue University)**

11:20 - 11:40	180. Mobile GIS: A Possibility For Commercial Archaeology. The Experience Of Using Qfield On Fieldwork. *Benedetta Baleani (SUNY-University at Buffalo)*; Giuseppe Prospero Cirigliano (Università degli studi di Siena); Edoardo Vanni (University for foreigners of Siena)*
11:40 - 12:00	214. An Android-based freeware solution for field survey and onsite artifact analysis *João Cascalheira (ICArEHB - University of Algarve)*; Joana Belmiro (ICArEHB - Universidade do Algarve); Ana Abrunhosa (CENIEH); Célia Gonçalves (ICArEHB - Universidade do Algarve)*
12:00 - 12:20	100. Implementation of Mobile GIS for Stone Age field survey in southern Botswana *Chris Green (Christian-Albrechts-Universität zu Kiel)*; Sarah Mothulatshipi (University of Botswana); Michaela Ecker (Christian-Albrechts-Universität zu Kiel)*
12:20 - 12:40	380. Transitioning to new FAIMS3.0: to GUI or not to GUI? *Adela Sobotkova (Aarhus University)*; Shawn Ross (Macquarie University); Brian Ballsun-Stanton (Macquarie University); Penny Crook (Macquarie University)*
12:40 - 13:00	**Discussion**

148. Typology of MobileGIS workflow in archaeological prospection: Crowd Data Collection, Volunteer Geographic Information or Geographic Citizen Science?

Julia M. Chyla, Faculty of Archaeology, University of Warsaw
Miłosz Giersz, Faculty of Archaeology, University of Warsaw

Hedges and Dunn, in their book "Academic Crowdsourcing in the Humanities," define crowdsourcing, main method of collection of data via MobileGIS, as "the process of leveraging public participation in or contributions to projects and activities" (Hedges and Dunn 2018). They see crowdsourcing as a methodology similar to 'Citizen Science,' which "is commonly understood to refer to activities whereby members of the public under-take well-defined and (individually) small-scale tasks as part of much larger-scale scientific projects" (Silvertown 2009). However, they argue that, even though crowdsourcing in its fundamental meaning has a similar goal to 'Citizen Science', it differs in its methodology and workflow.

Both Hedges and Dunn, and Hakley in his publication "Citizen Science and Volunteered Geographic Information: Overview and Typology of Participation" (2013) propose typologies and workflows which could be used for the methodology of crowd data collection used in the context of archaeological field prospection with MobileGIS. However, they do not explain the whole process, in terms of the action (or collection of data) itself. Also, Hakley proposes that data collection could be either explicit or implicit, depending on the type of aim with regard to geographical information. However, even traditional archaeological surveys of the sites in the landscape always collected both types of data: a description of the geographical location or morphological aspects of the archaeological site and a non-geographical, or rather archaeological, description of monuments and artifacts visible on the surface.

The paper propose to open much needed theoretical discussion on not so well defined methodology of the use of MobileGIS in archaeological prospection, before, during and after field work and ask whether it is part of Citizen Science or rather should be define as crowd data collection or volunteer GIS.

Bibliography

Goodchild, M. F. 2007. "Citizens as Sensors: The World of Volunteered Geography." GeoJournal 69: 211–21.

Haklay, M. 2013. "Citizen Science and Volunteered Geographic Information: Overview and Typology of Participation." In Crowdsourcing Geographic Knowledge, edited by Sui D., S. Elwood, M. Goodchild: 105–22. Dordrecht: Springer Netherlands. https://doi.org/10.1007/978-94-007-4587-2_7.

Hedges, M., and S. Dunn. 2018. Academic Crowdsourcing in the Humanities. Crowds, Communities and Co-Production. Cambridge, Kidlington: Elsevier Ltd.

Silvertown, J. 2009. "A New Dawn for Citizen Science." Trends in Ecology & Evolution 24 (9): 367–471.

213. At the interface between GIS mobile applications and reflexive archaeology: using QField app in archaeological surveys

Giordano De Coste, Roma Tre University
Emeri Farinetti, Roma Tre University
Matteo Rossi, Roma Tre University

As digital technology progresses, mobile GIS are increasingly becoming more efficient tools for archaeological practice. It is in fact undeniable that nowadays feats of technology stimulate and enrich archaeology debates, theory and methods, particularly in the field of landscape archaeology. Of various applications available for mobile devices, 'QField' stands out as a viable and sound option to manage spatial data. It is a free mobile GIS developed by 'OpenGis.ch' for Android and iOS devices. Based on the popular open-source desktop software 'QGis' (with wich it shares the same libraries), QField provides a simple user interface, yet rich in content, to digitize, collect and browse archaeological data.

Aim of this contribution is to address general pros and cons of this app and practical ways of exploiting it for archaeological surveys. Within the context of various landscape research projects, QField has been tested out during fieldwork and proved to be an effective and time-saving tool, both in actual fieldwork as well as in survey design and strategy. In particular, one of the latest features of the app, 'Qfield Cloud' will be subject of discussion. The possibility of storing a project within a cloud server accessible and editable by research team members only, unlocks new and intriguing opportunities to approach field surveys. Additionally, Qfield excels in topographic and on-site surveys, as well as in off-site surveys, allowing the user to save a lot of time in the logistic issues of organization and fulfillment of the fieldwork. However, being a relatively new app constantly developing, it is often affected by minor bugs and glitches. Moreover, minor limitations are imposed by the device in use (smartphone or tablet), liable to failures and crashes and dependent on internet connection to process WFS layers and cloud actions.

In addition, the implications of the app on archaeological surveys will be addressed from a theoretical and reflexive point of view, pointing out why and how this tool (as well as other mobile GIS) may represent an important aid on the field and could bring practical solutions and new ways of looking at archaeological problems and data analysis and integration.

Chyla, Julia, Nazarij Buławka. 2020. "Mobile GIS in Archaeology: Current Possibilities, Future Needs". Digital Archaeologies, Material Worlds (Past and Present) 99.

Tripcevich, Nicholas. 2004. Interfaces: Mobile GIS in archaeological survey. The SAA Archaeological Record 4, no. 3: 17-22.

Witcher, Robert. 2008. "(Re)surveying Mediterranean Rural Landscapes: GIS and Legacy Survey Data". Internet Archaeology 24.

149. (Reading) African Palimpsest – the use of mobileGIS for a team based collaboration: the case study of the rural hinterland of Mustis (Tunisia)

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One of the main goals of the Mustis Archaeological Project is to investigate the dynamics of spatial transformation of the rural hinterland of the Mustis archaeological site (northern Tunisia). To grasp the tangible picture of long-term evolution of the cultural landscape an interdisciplinary approach combining archeological, geomorphological and geophysical methods has been applied. Various data yielded during such a wide range collaboration require a proper management and integration which was provided by the implementation of mobileGIS.

The process of investigation started with an analysis of satellite images and archival maps. Importantly, the purpose of this activity was to mark not only archaeological, but also geomorphological areas of interest. These initial assessments were later verified during the field reconnaissance using the mobileGIS tools like: Survey123, Tracer and Field Maps. To supplement the overall view during the prospection, the surveyors collected geomorphological samples and documented the most distinctive archaeological structures visible on the surface. Finally, the attention was paid on a detailed, artifact-oriented field prospection and geophysical survey of Sidi Araba – a well-preserved rural settlement located in the close proximity of Mustis. After the completion of field works, the collected material was further documented and analyzed by specialists and later uploaded to already existing mobileGIS datasets. Yielded data were finally implemented into the joined online GIS shared by all members of the project.

This paper aims to present how the mobileGIS application can function as a useful tool for collecting different type of data. After the completion of field works, all members of the team have a constant access and opportunity to analyze and edit the shared data yielded by various specialists working within the project. Our intention is to demonstrate not only survey itself, but also pre- and post-field work procedures of data processing. This point is particularly important one, while until now the discussion concerning the mobileGIS has been focused mostly on the data collection process itself. All these aspects can finally help us to define the successful guidelines for preparation, presentation and publication of the datasets.

Buławka, N., and J. M. Chyla. 2020. "Mobile GIS. Current Possibilities, Future Needs." In Proceedings of the 45rd Annual Conference on Computer Applications and Quantitative Methods in Archaeology, edited by. Glover J.B, J.Moss, and D. Rissolo: 99–113. Tübingen. https://doi.org/https://doi.org/10.15496/publikation-43226.

de Vos Raaijmakers M. and Maurina B. (eds). 2019. "Rus Africum IV. La fattoria Bizantina di Aïn Wassel, Africa Proconsularis (Alto Tell, Tunisia). Lo scavo stratigrafico e i materiali" (=Archeopress Roman Archaeology 58). Summertown: Archaeopress.

Romary L., E. Tóth-Czifra. 2019. Open Access guidelines for the arts and humanities: Recommendations by the DARIAH European research infrastructure consortium. halshs-02106332.

Ames, C. J. H., M. Shaw, C. O'Driscoll, and A. Mackay. 2020. "A Multi-User Mobile GIS Solution for Documenting Large Surface Scatters: An Example from the Doring River, South Africa." Journal of Field Archaeology 45 (6): 394–412.

Lindsay, I., and N. Kong. 2020. "Using the ArcGIS Collector Mobile App for Settlement Survey Data Collection in Armenia." Advances in Archaeological Practice 8 (4): 322–36.

182. The use of QField in the Ager Rusellanus (Grosseto, Italy), between traditional and experimental methods.

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Since 2019, I have conducted archaeological surveys in southern Tuscany, between the ancient city of Roselle and the medieval city of Grosseto. My fieldwork is part of a larger project, "Emptyscapes" (2007 ongoing; http://www.emptyscapes.org), which, for decades, handles a wide variety of datasets collected with new methodologies integrating different survey techniques in QGIS (satellite imagery, aerial survey, historical vertical aerial photographs, drone survey, walking field survey, and magnetic survey). QField has been chosen actually because of its close connection with QGIS desktop software. As part of my experience, I had the opportunity to implement new research methodologies, comparing them with classic field data collection practices; this approach allowed me to substantially improve the quality of data collection. In addition, data that is recorded via Mobile GIS can be shared in real-time with experts around the world in order to obtain feedback and suggestions that could improve survey and data collection strategies.

The fieldwalking practice implemented so far is aimed at the systematic survey of sample areas and remote sensing evidence. I also used QField to survey landscapes characterized by forest and vegetation. Features such as satellite positioning, camera integration, and on-the-go editing were very helpful in effectively guiding and directing searches and ensuring the completeness and correct order of field activities. These features also made collaborative teamwork much easier to accomplish. In these environments, characterized by low visibility (vertical and horizontal) kinds of different kinds of obstacles, it is essential to be efficient and pragmatic reducing as many as possible tools and tasks. QField also allowed us to supplement the research with new questions that arose from direct field observation of the collected data. Indeed, it allowed us to transfer and visualize the GIS layout in real-time on mobile devices (smartphones and tablets), survey allowed us to better understand settlement patterns and productive activities in this area during different periods. QField has allowed us to map surface scatters, kinds of building materials, terraces, and many other evidences.

Some limitations found at the beginning of our work (during 2019) are now already resolved. This is a strong signal that emphasizes how fast and careful is the update of these tools. Currently, you can use this app from all mobile operating systems. Great opportunities also come from the fact that you can work and capture data offline. An example is the QField cloud, although this tool is still being tested by us, as stated above, it is practical in the field.

However, these first results have borne out the potential effectiveness of this approach and the contribution of Mobile GIS to all fieldwork phases has allowed us a substantial improvement.

REFERENCES

Campana, Stefano R.L. "Mapping the Archaeological Continuum." SpringerBriefs in Archaeology, 2018, 1–29. https://doi.org/10.1007/978-3-319-89572-7.

Gordon, Jody Michael, Erin Walcek Averett, and Derek B. Counts. 2016. "Mobile Computing in Archaeology: Exploring and Interpreting Current Practices." In Mobilizing the Past for a Digital Future; the Potential of Digital Archaeology, edited by Erin Walcek Averett, Jody Michael Gordon, and Derek B. Counts, 1–32. The Digital Press @ University of North Dakota. http://dc.uwm.edu/arthist_mobilizingthepast/2.

VanValkenburgh, Parker, Luiza O. G. Silva, Chiara Repetti-Ludlow, Jake Gardner, Jackson Crook, and Brian Ballsun-Stanton. 2018. "Mobilization as Mediation." Advances in Archaeological Practice. https://doi.org/10.1017/aap.2018.12.

341. In the land of basalt rocks stone and terraces. Use of mobile GIS in documenting the prehistoric megalithic culture of Akkar in northern Lebanon.

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Zuzanna Wygnańska, IMOC PAS

In this paper, we will present the use of a mobile GIS during the first season (June-July 2022) of the Polish-Swiss archaeological project "MEG-A: The first megalith builders of the northern Levant. A multidisciplinary investigation of Akkar's archaeological landscape (Lebanon, 4th-3rd millennia BCE)". The main tasks of this project are to document and study megalithic monuments and to reconstruct the paleo-environment in the basaltic uplands of the Akkar province in northern Lebanon. The project aims at exploring who were the mysterious megalith builders and why they appeared specifically in this region at the turn of the 4th and 3rd millenniums B.C.

One of the research methods used in the "MEG-A" project is archaeological prospection in which mobile GIS plays a significant role. We will discuss the choice of software and hardware and the pros and cons of using open-source software such as Qfield. Furthermore, the challenges in the application of mobile GIS we encountered while working in a complicated, hilly landscape dominated by terraces and dense vegetation will be addressed. The summary of our paper is a reflection on the potential of mobile GIS based on our experiences.

The NCN (2020/39/I/HS3/02993) and FNSS-funded project is co-directed by Dr Zuzanna Wygnańska IMOC PAS and Dr Tara Steimer-Herbet, University of Geneva.

270. Underground Warfare: field survey with mobile GIS app to reconstruct the WWI warscape

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In recent years, Mobile GIS systems have simplified field data acquisition in archaeology (Tripcevich and Wernke 2010). Geographic information systems have given a great boost in the last 30 years, but in the last ten these have become smart, increasingly portable and manageable from tablets and smartphones. Tablets and mobile phones became also portable GPS devices, which with the help of an antenna can achieve very precise positioning, the accuracy of antennas being in the order of 1-2 cm (Buławka and Chyla, 2020). In this new smart-world, GIS applications are becoming even more popular, much work has highlighted the potential of this new survey method (Ames et al. 2020). Likewise, the apps now start to be numerous and with different potential. Some are from proprietary software, e.g. Esri's mobile package, others open source e.g. Qfield. Others still allow development of one's own project but with a limit on storage space.

The study area of our project is the front line affecting the municipality of Lusiana Conco and the eastern part of the municipality of Asiago. The area is located in the southern part of the Asiago Plateau, acting as a link between the Veneto plain and the plateau itself, in north-eastern Italy. The militarisation of this area was intensified during the spring of 1916, when the Austro-Hungarian troops, during the Battle of Asiago, forced the Italian troops to retreat to the ephemeral defence line of Monte Paù-Monte Zovetto-Monte Lemerle-Monte Kaberlaba-Monte Valbella-Monte Spil-Monte Miela. The work of entrenchment and defensive arrangement of the territory was also carried out through the excavation of a large number of caves and tunnels. The aim of our project is to recognise, map and catalogue these cavities, whether man-made or natural, created and exploited for war purposes during the First World War.

For the field mapping of military tunnels and the Great War structures, we chose Qfield, the open-source field application from Qgis, and Merging Map, an application developed by a research team in the field of agriculture and biology. The choice fell on Merging Map due to its stability on both operating systems (Android and IOS), Qfield on the other hand is only developed and performs on Android while the application for IOS systems is currently being tested. The possibility offered by both applications to work offline by pre-loading any raster data ensured better survey performance even in areas where the connection is absent or unstable and at a later stage, with a stable internet connection, update the entire project.

The starting data loaded onto the portable GIS project are three shapefiles: a linear one for the mapping of structures such as trenches or access roads, a polygonal one for soldiers' barracks or traces of other buildings, and, finally, a point layer to highlight gallery entrances. The work focused on the creation of an attribute table with the main information of the evidence, i.e. ID number, date of acquisition, area, survey notes and photograph of the trace. In addition to the vector elements, a high-resolution orthophoto of the area were also loaded. This allows us to cross-validate the positioning and interpretation of the traces also during the field operations (FIG.1).

The study area was divided into three sectors (eastern, central and western, and the surveys covered all three areas equally. The data acquisition method required the presence of at least three operators: two for the topographical relief of the structures, one to update the project in real time on the smartphone and another to write a detailed description of the evidence. The positioning accuracy achieved is approximately 1 m and can be considered acceptable given the difficulties of acquisition due to the forest cover and the connection issues. In the post-processing phase, the data acquired were elaborated in a GIS environment and a more complex attribute table was associated with the vector data acquired on the field.

During the surveys, approximately one hundred First World War features were recognized and mapped. Most of them are galleries used as machine gun nests or artillery emplacements, ammunition depots, headquarters troop shelters and connective tunnels. Parts of them are still accessible, but many entrances are obliterated due to depositional processes over the time. Some of these tunnels still have war relics and wooden infrastructure inside them. One machine gun nest carved into the rock is nowadays reused as hunting post. The tunnels are linked to defensive positions and trenches: mapping all the war-related features is useful to understand the military strategy and the spatial distribution of structures in the First World War landscape.

Ames, Christopher J. H., Matthew Shaw, Corey A. O'Driscoll, and Alex Mackay. 2020. "A Multi-User Mobile GIS Solution for Documenting Large Surface Scatters: An Example from the Doring River, South Africa." Journal of Field Archaeology 45 (6): 394–412. https://doi.org/10.1080/00934690.2020.1753321.

Buławka, Nazarij, and Julia Maria Chyla. 2020. "Mobile GIS – Current Possibilities, Future Needs. Position Paper." In Digital Archaeologies, Material Worlds (Past and Present). Proceedings of the 45th Annual Conference on Computer Applications and Quantitative Methods in Archaeology, edited by Jeffrey B. Glover, Jessica Moss, and Dominique Rissolo, 99–113. Tübingen: Tübingen University Press. https://doi.org/10.15496/publikation-43226.

Tripcevich, N., and S. A. Wernke. 2010. "On-Site Recording of Excavation Data Using Mobile GIS," Journal of Field Archaeology 35: 380–397.

168. Mobile GIS and Digital Data Collection Workflows on the Kasakh Valley Archaeological Survey (KVAS), Northwestern Armenia

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The mobile GIS data collection workflow discussed in this paper was developed in the context of the Kasakh Valley Archaeological Survey (KVAS) for investigations of the upper Kasakh River valley of north-central Armenia during 2014-17. The KVAS survey is an initiative of Project ArAGATS, a long-term American-Armenian collaboration that has studied the Bronze and Iron Age fortress-based polities of the South Caucasus region for the past two decades. This paper focuses on the technical, financial, and ethical choices we faced when designing a mobile GIS system from the ground up, taking account of the research context, budget, technical affordances, and the project's prior experience with traditional survey data collection. Collaboration between project members during and between field seasons was a major consideration of the survey data platform and will be given special attention.

The worked described here builds on Project ArAGATS' initial survey of Armenia's Tsaghkahovit Plain in 1998/2000, which provided a detailed map of the region's dense archaeological landscape and a well-developed model of local settlement patterns (Smith et al. 2009). For our more recent phase of survey begun in 2014, the neighboring Kasakh River valley was selected to establish a comparative framework for settlement systems in the region, and because of the valley's strategic position as a prominent transportation and communication corridor to high elevation resources useful to Bronze and Iron Age social groups. Embarking on a new survey also provided the opportunity to design a data collection system that could help us overcome the challenges encountered in using more traditional data collection methods in the prior 1998/2000 survey.

In designing a new mobile GIS data collection system, we identified several parameters to incorporate, including easy and safe data back-up procedures; software that is platform agnostic; a straightforward and efficient workflow for GIS non-specialists; in-field access to reference data within our survey area (e.g., legacy sites, high-resolution satellite imagery, historic maps); and maximizing information flow between surveyors in the field. Esri's then-new Collector for ArcGIS mobile app (now ArcGIS Field Maps), though not widely tested in archaeological field contexts, appeared that it would satisfy many of our survey needs (Lindsay and Kong 2020). The US-based collaborators had licenses to ArcGIS through their university, it was a platform our Armenian collaborators had extensive experience with, and its map-centric interface ideal for survey recording and requiring only intermediate GIS skills to deploy without advanced coding. Collector allows project managers to control which data fields in a GIS are editable to users on their devices to both maximize consistency and minimize entry errors, a feature that had clear value on survey. In addition, though standard in many GIS apps, the ability to pre-program pull-down menus for each field also vastly reduced the inconsistencies in data quality and accuracy in paper forms and notebooks. One of Collector's most uniquely significant features is the ability to transfer data instantly to the project GIS and sync newly recorded information across project devices. This real-time sync feature provided us the ability to (a) facilitate in-field consultation between surveyors, allowing survey leaders to quickly address data collection errors in the field, and (b) avoid burdensome and potentially risky manual syncing of devices to a master database each night.

The improvement in site recording efficiencies between the 2000 survey and the 2014-17 surveys was remarkable. For example, in 2000, sites encountered on transect were recorded in field notebooks with coordinates fixed using hand-held GPS devices. While the hybrid paper/digital method worked well for singular architectural features, such as fortresses and settlements, it was less adept at capturing the redundant, tightly-packed clusters of Bronze Age cromlech burials that stretched along the foothills of the survey area. Faced with such high frequencies of burials using traditional methods, surveyors in the 2000 survey described representative tombs within a “burial cluster” (or cemetery) and then estimated the number of burials within it; in essence, the cluster became the minimum unit of recording a mortuary landscape, since it was impossible to record each individual tomb given the constraints of time and technology. In short, there were lots of untapped data in the mortuary and archaeological landscapes for technologies advanced enough to efficiently capture them in the field.

By contrast, during our 2014-17 survey, using the Collector app we recorded basic size and form attributes of individual burials, of which we documented over 1200 on the eastern Mt. Aragats foothills. One of the features of the Collector app we relied on heavily is the copy/paste function, which reduced data entry redundancies given the high frequency of tombs, minimizing both human error and the time needed to record adequate attributes from each feature. This made analysis of burial densities more nuanced and precise (Lindsay et al 2022).

We are fortunate that even in rural, mountainous portion of Armenia network connectivity is available throughout almost all our project area and outfitting the project iPads with SIM cards and unlimited data plans for the season is very affordable. As a result, we were able to collect survey data in online mode nearly continuously. On the occasions where our survey area fell in a network shadow or dead zone, we were able to download the web map to each device and sync the data when we returned to an area with internet service. Most importantly, having data layers synced across devices opens the door for more equitable access to site data, which in turn allows for meaningful consultations with project personnel on transect, at base camp, or virtually anywhere with an internet connected device or workstation.

Lindsay, Ian, Alan F. Greene, Maureen E. Marshall, Ruben Badalyan, Amy Cromartie, Karen Azatyan, Levon Aghikyan, Arshaluys Mkrtchyan, and Adam T. Smith. 2022. “The Project ArAGATS Kasakh Valley Archaeological Survey, Armenia: Report of the 2014 –2017 Seasons.” American Journal of Archaeology 126 (2): 261-303. https://doi.org/10.1086/718333.

Lindsay, Ian, and Ningning Nicole Kong. 2020. “Using the Arcgis Collector Mobile App for Settlement Survey Data Collection in Armenia.” Advances in Archaeological Practice 8 (4): 322-36. https://doi.org/10.1017/aap.2020.26.

Smith, Adam T., Ruben S. Badalyan, and Pavel Avetisyan. 2009. The Archaeology and Geography of Ancient Transcaucasian Societies I: Regional Survey in the Tsaghkahovit Plain, Armenia. Vol. I. Chicago: Oriental Institute Publications.

180. Mobile GIS: A Possibility For Commercial Archaeology. The Experience Of Using Qfield On Fieldwork.

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Digital tools are becoming increasingly present within the construction and data analysis processes in the world of archaeology. Their contribution to all phases of study has stimulated some changes in fieldwork methodology, so much so that nowadays it is no longer possible to imagine conducting archaeological research without technological supports as their applications become increasingly wider and more varied.

Among the most important technological tools are modern mobile devices. Their increasing affordability and their range of uses mean that they are a constant presence in the daily life of all of us. Mobile devices are an extremely helpful tool for archaeological research because of their high computing capability, the duration and durability of their batteries, and their ability to connect to both satellite navigation systems and the internet in almost any location. Therefore, these technological supports can be extraordinarily helpful in data collection operations in the field. In particular, concerning archaeological research, the availability of the main GIS platforms to transfer their projects directly to each device is fundamental. Through these tools, it is possible for archaeologists to update projects straight from the field, and it is also possible to immediately view some results of our investigations, such as, for example, the spatial distribution of our data.

Mobile GIS also makes a substantial contribution to documentation and monitoring operations in the field of commercial archaeology. We have directly applied Mobile GIS to large public works sites in areas subject to archaeological surveillance. Our particular project concerns a large construction site for the expansion of a landfill located in southern Tuscany, Italy. The archaeological activities in the field were carried out by the association “Archeologia Diffusa”. Several external factors have affected the use of these systems. First of all, during the period following the pandemic, due to regulations in force to limit the spread of the COVID-19 virus, it was necessary to find a way to share updates on the progress of construction sites among multiple operators. On the one hand, homogeneity of documentation depends on the fast and easy sharing of data, but on the other, there could be completely different operators on site on different days. In this situation, the transfer of the project from GIS platforms directly to the mobile devices of each operator was paramount. In addition, the ability to share projects on the cloud meant that real-time sharing of updates was accessible to all members participating in operations. The use of Mobile GIS has facilitated and enriched teamwork, by easy sharing of data. Moreover, it has made possible to make a homogeneous documentation, by the creation of properly constructed attribute tables.

All these factors proved to be particularly important to the type of work that was being carried out. The construction site was large, with many mechanical excavators operating at the same time. As a result, the speed of excavation was high, the appearance of the area was constantly changing, and there were no fixed reference points. We have therefore chosen to use the QGIS software for the creation of the work project, for the retrieval of data, and for the creation of the attribute tables. This project was made readable on mobile devices by means of a "Qfield sync" plugin which makes the files readable by the Qfield application and downloadable from various app stores on the mobile devices of our field operators. Sharing took place through the creation of shared folders within Google Drive. Another positive factor, which has favored our choice of using a Mobile GIS, was the possibility of having free access to these tools for all the operators, without burdening the company's budget.

In conclusion, the use of Mobile GIS for site documentation operations yielded positive results owing to several factors: cost-effectiveness, the possibility of collaboration and teamwork, homogeneity of the documentation produced, and ease of use. This positive experience will push us to increasingly use these tools on construction sites, not only for scientific research.

REFERENCES

Gordon, Jody Michael, Erin Walcek Averett, and Derek B. Counts. 2016. "Mobile Computing in Archaeology: Exploring and Interpreting Current Practices." In Mobilizing the Past for a Digital Future; the Potential of Digital Archaeology, edited by Erin Walcek Averett, Jody Michael Gordon, and Derek B. Counts, 1–32. The Digital Press @ University of North Dakota. http://dc.uwm.edu/arthist_mobilizingthepast/2.

Magnani, Matthew, Natalia Magnani, Anatolijs Venovcevs, and Stein Farstadvoll. 2022. "A Contemporary Archaeology of Pandemic." Journal of Social Archaeology 22 (1): 48–81. https://doi.org/10.1177/14696053211043430.

VanValkenburgh, Parker, Luiza O. G. Silva, Chiara Repetti-Ludlow, Jake Gardner, Jackson Crook, and Brian Ballsun-Stanton. 2018. "Mobilization as Mediation." Advances in Archaeological Practice. https://doi.org/10.1017/aap.2018.12.

214. An Android-based freeware solution for field survey and onsite artifact analysis

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This presentation will focus on a freeware digital system based on Google/Android platforms, designed to be a fully integrated and customizable solution to record, manage, and share archaeological survey data. Our solution is an updated version of the approach McPherron et al. (2008) developed for the Abydos Survey for Paleolithic Sites project in Egypt (Olszewski et al. 2005). The core of the system is two custom smartphone/tablet applications (Archeosurvey and Lithics On-The-Go – available at https://data.mendeley.com/datasets/8r8wh8w92m/1) (Cascalheira et al. 2017), through which surveyors are able to retrieve geographical coordinates and relevant attribute data from archaeological locations, but also perform onsite analysis of artifacts, including taking accurate measurements with digital calipers directly connected to the mobile devices. The system uses devices' digital cameras, GPS chips, and USB ports to record different variables, and saves all data recovered either as text files in the devices' internal memory that can be exported to different software for further analyses or as online spreadsheets that can be easily shared with team members. Using the examples of archaeological and raw material surveys in the context of projects on the Middle Paleolithic of Iberia and the Stone Age of Mozambique, we will provide details on the hardware and software components of our solution and how it can be adapted by other researchers to meet the needs of their own projects.

References

Cascalheira, João, Nuno Bicho, and Célia Gonçalves. 2017. "A Google-Based Freeware Solution for Archaeological Field Survey and Onsite Artifact Analysis." Advances in Archaeological Practice 5: 328–39. https://doi.org/10.1017/aap.2017.21.

McPherron, Shannon R, Harold A Dibble, and Deborah Olszewski. 2007. "GPS Surveying and On-Site Stone Tool Analysis: Equipping Teams for Landscape Analysis in The," 6.

Olszewski, Deborah I., Harold L. Dibble, Utsav A. Schurmans, Shannon P. McPherron, and Jennifer R. Smith. 2005. "High Desert Paleolithic Survey at Abydos, Egypt." Journal of Field Archaeology 30 (3): 283–303. https://doi.org/10.1179/009346905791072233.

100. Implementation of Mobile GIS for Stone Age field survey in southern Botswana

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Introduction

The Kgalagadi Human Origins project (KHO) is studying the southern Kalahari region during a key transition point in the development of humanity: the Early to Middle Stone Age transition during which anatomically modern humans appeared and spread across Africa. KHO is taking a multiple pronged approach, with a particular focus in the early phases on extensive field survey, alongside geoarchaeological and isotopic methods for past climate reconstruction. In the summer of 2022, we undertook our first season of survey in the vicinity of the town of Tsabong in southern Botswana, near the border with South Africa formed by the dry bed of the Molopo River. Located today within the southern Kalahari desert (Kgalagadi is the Tswana word for "dry place", derived into English as Kalahari), this area would have experienced substantial fluctuations in available water at different times during the Pleistocene. The field survey focussed on a series of pans that would potentially have held either seasonal or permanent water during wetter climatic phases, to see how these features might have been used by hominins (including modern humans) in the past.

Implementation of mobile GIS recording system using ESRI Field Maps

In order to undertake our field survey, we needed to devise a methodology that would allow fast and efficient recording in the field but which also minimised the need for extensive data entry and cleaning after the field season. Naturally, mobile GIS appeared the most promising approach. After consideration of alternative options and taking inspiration from the methodology developed by Ames et al. (2020), we implemented our system using ESRI products. After some experimentation, we settled upon Field Maps, the latest field recording application released by ESRI.

The advantage of using Field Maps was that it allowed for fast set up and testing of a recording system and the integrated way in which data was uploaded and stored on ArcGIS Online. Recording was undertaken using Lenovo Tab M8 tablets with external Garmin GLO-2 GPS receivers. Field Maps allowed us to operate within a single application environment (with no need to link applications as with ESRI's older Collector/Survey123 system), that also connected directly to the GPS receivers without needing the integration of any GPS receiver bridging application. Field recording could be undertaken offline and then synced over Wifi or via a mobile data hotspot at basecamp at the end of each day.

Field Maps also enabled us to construct data entry forms that presented different questions according to artefact type, much as with Survey123, but with easier set up and a more user-friendly interface. All set up was undertaken in ArcGIS Online without any need to fill in arcane Excel spreadsheets to produce questionnaires. It was also simple to include multiple data layers with their own survey questionnaires, so as allow the recording also of sites (polygons), test pits and sample locations (point recording), for example. A final advantage of the Field Maps application during the survey was that the results of all previous work were present on each tablet after syncing, so that users could see progress (excluding the work of other teams on the current day) even when they were offline.

Mobile GIS in the field

Following three test runs in Kiel, the system was implemented and run in Botswana with great success. The users were given an afternoon's training, led by the students who had been present for the tests in Kiel, which seemed to provide more than enough experience for them to run the mobile GIS recording system once the survey began. During field survey, the students operated in teams of three to four persons per tablet, with one taking charge of the GPS receiver and tablet and providing a degree of oversight, and with three observers – spaced about 2m apart – looking for finds. Progress was satisfactory and we recorded over 550 lithic objects (including some concentrations of multiple finds) over a period of 18 days in the field, covering a combined survey area of around 500ha, working along pre-defined survey lines which could be viewed in Field Maps in order to aid navigation.

All results from the field season were stored in ArcGIS Online and could then easily be made accessible to any team members who needed access. As the team is spread across the world, with collaborators in Germany, Botswana, South Africa, the UK and the USA, this will make our collaboration effective and efficient, with little need for expert knowledge or sharing of files via alternative file sharing systems.

Future prospects

Following our first season in the field, the team has concluded that the system worked very well and we will be continuing to use Field Maps and ArcGIS Online for our future field seasons and for the production of project outputs. In the future, as we move on to excavation, we will explore linking the tablets to more precise GPS units or total stations, as the current GPS receivers are precise enough for extensive field survey (with a median horizontal precision of around 2.8m) but not for piece plotting of excavated finds. However, the implementation of a recording system for excavated material should also be simple within the same application environment.

The advantages of following the commercial pathway for our field recording are in the efficient and straightforward setting up and operation of the system, which runs in a single application and handles all synchronisation automatically, and in the straightforward way in which spatial data can be shared across the team. Obviously, this is only feasible because we have access to ESRI products through our university, but the solution is a pragmatic one for other people with such access.

Acknowledgments

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References

Ames, Christopher J. H., Matthew Shaw, Corey A. O'Driscoll, and Alex Mackay. 2020. "A Multi-User Mobile GIS Solution for Documenting Large Surface Scatters: An Example from the Doring River, South Africa." Journal of Field Archaeology 45 (6): 394–412. https://doi.org/10.1080/00934690.2020.1753321.

380. Transitioning to new FAIMS3.0: to GUI or not to GUI?

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Brian Ballsun-Stanton, Macquarie University
Penny Crook, Macquarie University

For the last decade of FAIMS, the requirement of scripting has been noted as a major barrier in the adoption and broader use of the field data collection system. This paper presents the graphic user interface of the new cross-platform FAIMS3.0 and discusses the benefits and limitations of GUI on the basis of user feedback from a number of 2022 projects. Compared to a programmable interface, GUI has a limited number of predefined choices for fieldapp design, leaving everything off the screen to 'extra development'. On another hand, the GUI gives users full autonomy. It allows users to tinker with the desired fieldwork schema and simplifies the process of application deployment, thus leading to feeling of empowerment and control.

10. Computer applications in archaeology – Bringing South Asia together

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Location: E103

South Asia (SA) is one of the archaeologically and historically rich geographies in the world. Though archaeology as a domain was initiated and had its founding years during the colonial period, the explorations, excavations, and material studies have reached new heights since then. Being the home of the Buddhist era, Harappan civilisation and several prehistoric phases, SA has brought forward interesting materials for analysis that are closely associated with (i)presence of hominins, (ii) early hunting-gathering communities, (iii)early domestication of plants and animals to (i)social systems, (ii)dynastic rules, (iii)urbanisation, (iv) diverse yet contemporary language and cultural systems and many more which assist in better understanding of multiple aspects of human past in this part of the globe.

In recent decades, the advent of technology and computer applications has touched almost all aspects of life, and archaeology is not an exception at all. In SA, many examples of employing these technologies can be seen: geospatial technologies and GPR surveys to name examples. Analysing quantitative data for ceramics, stone-tools, coins, etc is another discourse as well as 3D modelling of monuments and artefacts for academic studies, museum displays and public education. Furthermore, the use of agent-based modeling to simulate prehistoric environments and human behaviour can be used to shed light on early mobility patterns and socio-cultural systems.

What is interesting in SA, especially India, is that many of these listed examples continue to remain as examples or case-studies but are yet to become main-stream practice or part of the curriculum. Likewise, basic technologies for storing data in structured databases, documenting surveys or explorations using appropriate coordinate systems and formats is yet to become standardised in SA archaeology. It is currently taught, studied, and perceived mostly as a humanities and social science (HSS) subject and has not yet been fully explored for computational research.

Computer applications (CA) help bring data together from several domains, transform it, visualise it and analyse in ways which are otherwise humanly impossible. Recognising its value, ensuring academic training, and implementing standard practices is the need of the time in Indian archaeology. CA should not be seen as one of the outcomes or characteristics of processual archaeology but rather a starting point for pursuing any theoretical approach.

This session aims to bring together scholars from SA who have innovative ways of employing CAs at any stage of archaeological research work. We invite talk abstracts from enthusiastic scholars from diverse academic backgrounds wishing to take archaeological research in SA to the next level by applying computational and theoretical tools to shed light on the rich history of SA. Those who wish to present their ideas for tackling specific problems such as academic divide, lack of training, research bias, budgetary constraints, and historical baggage (to name a few examples) are also more than welcome to submit abstracts.

SLOT 1	
08:30 - 08:50	165. How to survive in a resource rich but unsteady environment? Modelling early hominin subsistence behavior in the Pleistocene Indo-Gangetic floodplains. *Jan-Olaf Reschke (ROCEEH Senckenberg, Senckenberg Research Institute; Goethe University, Dept. Of Biosciences, Paleobiology and Environment)*; Christine Hertler (ROCEEH Senckenberg, Senckenberg Research Institute); Susanne Krueger (ROCEEH Senckenberg, Senckenberg Research Institute)*
08:50 - 09:10	179. Mapping the Indian Palaeolithic *vaneshree vidyarthi (Cambridge Archaeological Unit)**
09:10 - 09:30	164. Exploring pathways between rock art sites in central India using a network approach: Implications for cultural dispersals and social interactions *Ketika Garg (Caltech)*; Parth R. Chauhan (IISER Mohali); Rajesh Poojari (Indian Institute of Science Education and Research Mohali)*
09:30 - 09:50	369. Experimentation of Digital modelling in the Quantification of Lithic Artefacts *Ravindra Devra, Indian Institute of Science Education and Research Mohali, India*
09:50 - 10:10	381. Multilayer Methodologies from Remote Sensing to stone tools: Application of Computation archaeology for Exploration of Barwaniya W1, Jharkhand *Shubham Rajak (Deccan College Postgraduate and Research Institute (Deemed University), Pune)**

10:10 - 10:30	75. Spatially sizing up cleavers: GIS-based perspectives on the Indian Acheulean evidence *Parth Chauhan (Dept of HSS IISER Sec 81 Mohali 140306 Punjab); Pallavee Gokhale (IISER Pune)*; Prabhin Sukumaran (Dr. K.C. Patel Research and Development Centre, Charotar University of Science and Technology (CHARUSAT), Changa, Anand, Gujarat); vaneshree vidyarthi (Cambridge Archaeological Unit)*
SLOT 2	
11:00 - 11:20	51. Mapping paleo-landscape of Harappan port Lothal using cloud-computing and multi platforms *Ekta Gupta (IIT-Gandhinagar)*; V N Prabhakar (IIT-Gandhinagar)*
11:20 - 11:40	76. The Interactive Corpus of Indus Texts (ICIT) as an epigraphical database and online tool for Indus script research *Andreas Fuls (Technische Universität Berlin)**
11:40 - 12:00	286. Mapping Indus archaeology and multi-temporal land cover trends in semi-arid regions *Francesc Conesa (Catalan Institute of Classical Archaeology)*; Hector A. Orengo (Landscape Archaeology Research Group, Catalan Institute of Classical Archaeology); Arnau Garcia-Molsosa (Landscape Archaeology Research Group, Catalan Institute of Classical Archaeology); Abhayan GS (University of Kerala); Rajesh SV (University of Kerala)*
12:00 - 12:20	43. 'Mapping' modalities in archaeological remains - Building GIS of Mohenjo-Daro's DK(G)-S mound *Pallavee Gokhale (IISER Pune)**
12:20 - 12:40	220. Loss of heritage in riverine monsoonal plains: integration of geospatial legacy data and multi-source remote sensing in Jammu, India *Navjot Kour (Institut Català d'Arqueologia Clàssica)*; Francesc Conesa (Catalan Institute of Classical Archaeology); Arnau Garcia-Molsosa (Landscape Archaeology Research Group, Catalan Institute of Classical Archaeology); Hector A. Orengo (Landscape Archaeology Research Group, Catalan Institute of Classical Archaeology)*
12:40 - 13:00	359. Mapping Archaeological Heritage in South Asia: a digital workflow in development *Rebecca C Roberts (University of Cambridge)*; Junaid Abdul Jabbar (University of Cambridge); Iban Berganzo-Besga (Institut Català d'Arqueologia Clàssica (ICAC)); Rosie Campbell (University of Cambridge); Moazzam Durrani (Islamia University Bahawalpur); Arnau Garcia-Molsosa (Landscape Archaeology Research Group, Catalan Institute of Classical Archaeology); Petrus Gerrits (University of Cambridge); Jonas Gregorio (Universitat Pompeu Fabra); Abhayan G.S. (University of Kerala); Muhammed Hameed (University of the Punjab); Afifa Khan (University of Cambridge); Marco Madella (Universitat Pompeu Fabra); Hector A. Orengo (Landscape Archaeology Research Group, Catalan Institute of Classical Archaeology); V.N. Prabhakar (IIT Gandhinagar); Abdul Samad (Directorate Of Archaeology & Museums, Khyber Pakhtunkhwa); Rajesh Sasidharan (University of Kerala); Ravindra Nath Singh (Banaras Hindu University); Vikas K. Singh (Banaras Hindu University); Maria Suarez Moreno (University of Cambridge); Kuili Suganya (University of Cambridge); Jack Tomaney (University of Cambridge); Azadeh Vafadari (University of Cambridge); Muhammed Waqar Mushtaq (Islamia University Bahawalpur); Cameron Petrie (University of Cambridge)*

165. How to survive in a resource rich but unsteady environment? Modelling early hominin subsistence behavior in the Pleistocene Indo-Gangetic floodplains.

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Introduction:The first dispersal of Homo erectus out of Africa still poses many open questions. We do not know what permitted and/or forced H. erectus to leave the African continent and disperse into Europe and Asia. It is proposed they used widespread grasslands as a corridor (Dennell, 2010), but which strategies H. erectus applied to survive in diverse Pleistocene grasslands is still under dispute.

Among the habitats potentially occupied were the extensive floodplains in northwest India (Dennell, 2007). Although archaeological evidence shows that India was already settled by hominins 2.6 to 2 million years ago, the northwestern regions lack hominin fossils. The floodplains in this area provide an abundance of edible resources and thus were attractive. Seasonal changes, however, impose challenges to its inhabitants. This type of landscape undergoes seasonal change caused by the summer monsoon. As a resource rich but unsteady landscape it may be difficult to exploit with the foraging capabilities of an early hominin.

We want to identify how H. erectus interacted with floodplains and which subsistence strategies may have allowed them to thrive in northwest India.

Material & Method: To study the foraging behavior of Homo erectus we used the agent-based model, we already developed to test the impact of different foraging strategies on the spatial behavior of hominins. The ForeGatherer model was developed using models of recent hunter-gatherer behavior and the resulting behavior represents how early hominins exploited stationary resources. In the model, a single group moves around in an environment and individual agents representing adult hominins leave the camp to gather resources in the surroundings. The model offers two different foraging strategies; a simple one with the agents walking in a random direction until resources are found, and a more complex one which involves the collecting and sharing of knowledge about resource occurrences.

The tested environment consists of two different ecosystems, the floodplains and the surrounding slopes and elevated areas. The foraging behavior in our model is mostly suited for the exploitation of stationary resources; therefore we focus on the exploitation of plants and small, less mobile animals which occur in great variety in both resource spaces. The floodplains also offer aquatic resources like fish and mollusks (Brown et al., 2013) but larger areas may become flooded during the summer monsoons (Dennell, 2007). To recreate these conditions in our model, we implemented seasonal floods. Some areas including theirresources become temporarily inaccessible. The extent and quantity of seasonal inaccessibility can be adjusted to create scenarios of floodings of various extents.

Our environment with both resource spaces is exploited by agents following different subsistence scenarios. We created several scenarios with varying compositions of three settings. On the most basic level, they differ in access to resources additional to plants like small animals or fish. Secondly, we tested how they behave if they are restricted to only building camps in floodplains; this allows us to analyze the behavior if they populated the resource space year-round. At last, they may differ in the foraging strategies they use representing the abilities to perform more complex foraging.

To study differences between the subsistence scenarios the model creates several output values. The resulting mobility behavior is observed using several variables which are also used to describe recent hunter-gatherer behavior like counting the number of times the base camp has been moved per year. Furthermore we observed the time spent in the two resource spaces and which resources they exploited throughout the different seasons.

Results:

Our experiment showed how depending on the subsistence scenario and the environmental conditions the group changes their mobility behavior and how they exploit the two resource spaces. The occurrence of floods creates problems for foragers who tend to acquire aquatic resources but if they can utilize the more complex foraging strategy they at least seasonal prefer to exploit floodplains.

Discussion:

Our results show how living in the floodplains probably has been a large challenge for H. erectus. The possibility of acquiring additional resources in times during certain seasons possible resulted in a temporary exploitation of floodplains by H. erectus. But if widespread flooding's occurred repeatedly the resulting stress would probably prevented early H. erectus from thriving in this ecosystem. During periods of widespread flooding they would have needed access to more complex foraging strategies or more advanced tools to not be pushed into the out of the region.

References:

Dennell, Robin William. "The Colonization of 'Savannahstan': Issues of Timing(s) and Patterns of Dispersal across Asia in the Late Pliocene and Early Pleistocene." Asian Paleoanthropology, 2010, 7–30. https://doi.org/10.100/978-90-481-9094-2_2.

Brown, Antony G., Laura S. Basell, Sian Robinson, and Graham C. Burdge. "Site Distribution at the Edge of the Palaeolithic World: A Nutritional Niche Approach." PLoS ONE 8, no. 12 (2013). https://doi.org/10.1371/journal.pone.0081476.

Dennell, Robin William. "The Colonization of 'Savannahstan': Issues of Timing(s) and Patterns of Dispersal across Asia in the Late Pliocene and Early Pleistocene." Asian Paleoanthropology, 2010, 7–30. https://doi.org/10.100/978-90-481-9094-2_2.

179. Mapping the Indian Palaeolithic

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Archaeological research in India has a long and complicated history that is intertwined with the country's political, social, and economic history. While the British Raj largely overshadowed the beginnings of archaeology in the nation, there has been a strong legacy of archaeological investigation carried forth by Indian researchers in the post-colonial age (Misra and Nagar 1973). The immediate post-independence period is especially crucial for understanding how India's various overlapping and conflicting elements contributed to archaeological investigation in the nation. Specifically, geographical area, caste, economic rank, and social position. This paper makes use of data on the Indian Lower Palaeolithic obtained by the author from the Archaeological Survey of India's annual open-access publication called Indian Archaeological Review (IARs) and then geocoded them to dive into some of these post-independence research patterns within archaeological research in India. This paper has a three-fold focus:

h. How a simple GIS process such as geocoding can run into various obstacles when the data set in question is not ideal.

i. How preferential sampling in a region can be understood through an analysis of the social, political and economic realities of the time.

j. The use of GIS as a powerful media tool has great potential to level the playing field of archaeological research in developing nations such as India.

The geocoded locations were projected on a map to see if any spatial trends in the distribution of the sites emerged. This data has also been used to create thematic maps in order to better comprehend the link between lower palaeolithic sites and the surrounding terrain. However, the geocoding process is not straightforward and requires a lot of manual intervention. This is due to the complications arising from using a legacy and non-western data set that is not as naturally compatible with modern GIS software. Some linguistic and political issues impacting geocoding have been explored in this paper.

Mapping of these Lower Palaeolithic sites from the immediate postcolonial era further serves as a vehicle for understanding various aspects of India's social, political, and economic history, which undoubtedly influenced not only who was able to participate in research, but also the places that drew the most interest, potentially leading to preferential sampling. As a result, any emerging patterns must be regarded with caution since they are not simply indicative of genuine geographical connections in the palaeolithic but are also influenced by variables such as study emphasis, sample bias, and selective fieldwork. This paper seeks to untangle these aspects and their impacts, as well as provide viable solutions for archaeological study in India to be more equal playing field with accessible datasets and the use of Geographical Information Systems (GIS) as a tool to overcome language and cost barriers. This data shows that multiple clusters of sites exist. Because a full study of all gaps and clusters in the distribution is beyond the scope of this paper, this section will primarily focus on the following: the enormous cluster of sites in Maharashtra, the absence of sites in the Ganga river basin, and the cluster of sites in Madhya Pradesh. During the concerned timeframe (1950s-1970s), India had to deal with many of the British Empire's legacy, as well as a religiously divided nation, a suffering economy, and a slew of other socio-political challenges. This begs the question of whether the distribution of these sites reflects true geographical links between lower Palaeolithic sites or whether it is the consequence of preferential sampling.

Taking these aspects into account allows for a more in-depth knowledge of the preferential sampling at work during this time period, allowing for a more well-rounded interpretation of the data. Any big clusters or blank spaces are a result of socioeconomic variations as well as educational background, not merely Lower Palaeolithic preference. Archaeological research history varies by state and frequently reflects significant state-level distinctions in economy, social mobility, access to education, and regional politics.

Despite the problems provided by employing a non-local language to capture data, the data may be supplemented using other languages after geocoding to make the record more accessible. While the distant structure and application of GIS make it intrinsically divorced from local reality, including vernacular sensitivity into GIS use would make it far more accurate and useful. It also emphasises the relevance of the human element, which is still essential in geocoding to ensure that the data is valid. This experiment also demonstrates that geocoded sites are not necessarily accurate, but rather indicate the most likely option. GIS can assist narrow down where to devote resources, as well as make educated judgments on where to undertake field explorations or excavate in a cost-effective manner using current resources. It may also be used to remotely examine regions that would otherwise be impossible to access (e.g the Naxal belt). The effective use of GIS as a media tool can lead to making archaeological knowledge and research more accessible throughout the country, and increase participation in general. It would also be an excellent way to align national data sets (ie. IARs) with more on-ground, local realities.

References

Misra, V. N., & Nagar, M. (1973). Twenty-five years of indian prehistory (1947-1972) – A review of research. Man and Soicety, , 1-54.

164. Exploring pathways between rock art sites in central India using a network approach: Implications for cultural dispersals and social interactions

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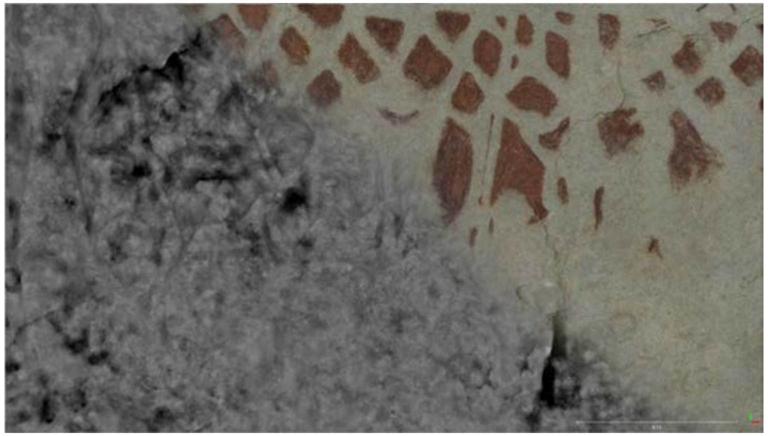
Introduction

Rock art in India comprises paintings, engravings, etchings, cupules or a combination of these, spread across different geographic zones, with the central, eastern and southern ones being the richest. With the exception of the Konkan petroglyphs (Goa and Maharashtra, western coastal India) which are in open-air contexts in a lateritic landscape, almost all other known rock art occurs in rock shelters and on isolated boulders located on hilltops or valley floors. Very few absolute dates are available for this dynamic record and all of them are currently restricted to the Holocene.

However, a recent date of ~44 Ka for the Southeast Asian rock art indirectly hints at a comparable antiquity for the South Asian counterpart. Additionally, the rock art across India shows regionally diverse characteristics in terms of style, context, subject matter and other attributes, suggesting the existence of different cultural groups. Though known for over a century and with hundreds of sites reported comprising thousands of paintings, the rock art of India is known more through descriptive perspectives with very few attempts at scientific studies, and those that have been done have primarily focused on the pigments. Except for publishing broad maps of known site distributions, none of this evidence has ever been investigated systematically and scientifically from spatial perspectives, a lacuna we attempt to address through this paper. The primary focus is on the rock art record near the central part of the Narmada river valley in Madhya Pradesh, central India. One set of evidence is spread across the Vindhyan hills in the northern part of the valley and other set is spread across the Gondwana hills in the southern part of the valley.

Methods and materials

To understand the cultural dispersions and interactions between the diverse rock art, we create a proximity-based network of the rock art sites and analyze various relationships between the sites. Previous works have suggested that social network connectivity and its features can significantly shape the cultural exchange and processes that take place on them (Romano,Lozano and Pablo2022). Here, we attempt to study the effects of spatial connectivity on similarities and variations between rock art styles and motifs, or even on the level of cultural complexity. We analyze network features such as the density, degree of connections, clustering, efficiency to shed light on cultural dispersals and social interactions during prehistoric and younger periods.



The study area includes areas between Salkanpur and Khidiya Kurmi in the Sehore district, which is part of the Vindhyan range, and Mahuadhana, Mandikhoh, and Chichwani in the Narmadapuram (formerly Hoshangabad) district, which is part of the Gondwana range. These are quartzite-rich sandstone hills. Vindhyan has finer geomorphology, while Gondwana has coarser.Around ^100 new painted rock shelters and engravings were discovered and documented in both ranges (Poojari and Chauhan, 2020) and are being studied further to propose suitable methodologies for interpretation and possible conservation, as well as to carry them out for future studies and scientific analysis. While significant work has been done at nearby sites like Bhimbetka, Adamgarh, and Pachmarhi, very little work has been done within the central Narmada Basin. Aside from sites in the Vindhyan and Gondwana regions, the Archaeological Survey of India reported two sites, Adamgarh and Mou Kalan, on the old palaeo-channel. Through systematic surveys, over 2,000 individual paintings were counted, spread across over 80 individual rock art shelters. These painted shelters are deteriorating at an alarming rate due to illegal activities such as deforestation, stone and soil mining, occasional vandalism, and natural factors such as geomorphic degradation and constant exposure to the natural elements. More than 1000 paintings from individual rock shelters have been counted provisionally. They include animals, birds, geometric patterns, x-ray-style figures, social activities, hunting scenes, warriors, horsemen, battle scenes, and other anthropomorphic figures. The paintings are painted in red, yellow, orange, white, and black pigment colours and appear from the Mesolithic, Chalcolithic, and Historical periods, overlapping each other.

Results & Discussion

Preliminary results suggest the use of specific pathways constrained by topographic features of the Vindhyan and Gondwana escarpments. These pathways are most evident in areas with high relief and thus easier to spatially connect specific rock shelters and groups of rock shelters. Our results indicate that multiple topographic routes show potential as past pathways between sites, in addition to the most parsimonious routes currently used today by local villagers and other visitors. At some sites, it is highly probable that multiple routes were used in different directions for multiple purposes including hunting/foraging, social interactions, raw material acquisitions and general exploration for new rock shelter complexes in the past. The diverse patterns of these pathways appear to have had partial impact on the geographic spread of specific themes or subject matter from their (currently unknown) sources of their origin. This method of spatially connecting rock shelter sites based on regional topography, natural resources, painting themes and styles and locations of specific historically known landmarks and sites (particularly due to associated trade routes) is the first step in reconstructing the chronological and geographic movements of regional populations of hunter-gatherer-foragers, farmers and pastoralists.

References

Romano, Valéria, Sergi Lozano, and Javier Fernández-López de Pablo. "Reconstructing social networks of Late Glacial and Holocene hunter–gatherers to understand cultural evolution." Philosophical Transactions of the Royal Society B 377, no. 1843 (2022): 20200318.

Poojari, Rajesh A.,and Parth R. Chauhan. "Preliminary report of a new rock art site complex at Mandikhoh in the Hoshangabad District, Madhya Pradesh." Purakala 24 (2020): 55-62.

Chakravarty, Kalyan Kumar, and Robert G. Bednarik. Indian rock art and its global context. Motilal Banarsidass Publ., (1997).

369. Experimentation of Digital modelling in the Quantification of Lithic Artefacts

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Morphometric analysis is an essential practice in Prehistoric lithic artefact studies. A limited number of researchers only use the advanced technology of digital methods. Notably, underdeveloped countries still have limited lab facilities. In contrast, data are increasing from these regions of the old world. To access the lab facility, large-scale transportation of artefacts to a distant location is usually impossible for analysis purposes. Sometimes, researchers prefer traditional manual methods over digital ones to avoid automated instrument handling and complicated software processes. While considering the benefits and drawbacks of both approaches, this study proposes a set of alternative analytical methods. It comprises multiple manuals and computer-based techniques to quantify the lithic objects. The subjectivity error frequently occurs in the handheld calliper recorded artefact measurements (e.g., length). In order to address this issue, we captured the quality image of each artefact with a reference scale. The images were used for the 2D measurement, including the area cover of any individual artefact. The thickness was measured physically with the calliper (Roe, 1964). Volume was calculated by dipping in the water, and a digital weighing scale was used for measuring mass. Plenty of open sources of computers and smartphone applications provide image measurements with recording. The image provides a stable position of the artefact to record the size attributes. Instead of the traditional methods of handaxe width recording at every quarter, we prefer to measure it within a rectangular frame where the rectangle's height corresponds to the symmetrically orienting length of the object, and the maximum lateral extension represents the width (Iovita & McPherron, 2011).

A coordinate system was created through the intersecting diagonal axis of the rectangle. All four radial line was measured starting from the centre until the intersection of the periphery of the object. The location of the maximum length axis within the rectangle frame was measured from one of the either sides, and the same process was repeated for the width line. Thus we created a criss-cross and plotted another asymmetrically simple cross within the rectangular frame. Each of the three represents different aspects of an artefact (e.g., handaxe) viz., size, elongation, shape and lateral symmetry. When we plot graphs in a concentric position, it shows the variability among the analysed objects. We used the smartphone Google Pixel (4a) and Foxit pdf reader for this exercise. In the second step of the 3D modelling, we used SketchUp Pro2022. Here we mathematically calculated the average thickness of the object using the area cover and volume. The outline of the artefact was filled, and it was given the average height using the Push/Pull tool. This simple model is meant for the size aspect of the artefacts. At the next level, the area cover was raised ½ of the maximum height at the central area, and an attached mirror image of that was curated at the base of the exact figure. There are multiple sets of data generated during these 2D and 3D modelling. The digital measurement in a rectangular frame provides a better precision of the two-dimensional shape. Volume and area provide average height that can use as a fraction of the maximum size to calculate an alternative index of refinement (in the case of handaxe). This method uses basic software and instruments to generate a comparable quantitative data set. Model one experimented with the handaxe analysis, which can be further extended to the other artefact types.

García-Medrano, Paula, Elías Maldonado-Garrido, Nick Ashton, and Andreu Ollé. 2020. "Objectifying Processes: The Use of Geometric Morphometrics and Multivariate Analyses on Acheulean Tools." Journal of Lithic Studies 7 (1). https://doi.org/10.2218/jls.4327.

Iovita, Radu, and Shannon P. McPherron. 2011. "The Handaxe Reloaded: A Morphometric Reassessment of Acheulian and Middle Paleolithic Handaxes." Journal of Human Evolution 61 (1): 61–74. https://doi.org/10.1016/j.jhevol.2011.02.007.

Roe, D. A. 1964. "The British Lower and Middle Palaeolithic: Some Problems, Methods of Study and Preliminary Results." Proceedings of the Prehistoric Society 30: 245–67. https://doi.org/10.1017/s0079497x00015140.

381. Multilayer Methodologies from Remote Sensing to stone tools: Application of Computation archaeology for Exploration of Barwaniya W1, Jharkhand

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Barwaniya W1 is a Late Middle Palaeolithic site/ findspot in North Karanpura Valley (Upper Damodar basin of south Hazaribagh and Chatra districts), Jharkhand. This prehistoric site comes under the colluvial matrix of the tropical dry deciduous forested zone of the Hazaribagh forest range which makes it difficult for primary field exploration. Thus, we have adopted remote sensing techniques including high-resolution FCC imaging and Drone Based LiDAR surveys for the identification of prehistoric sites and their colluvial matrix extension. Lithics were systematically collected by grid sampling and their surface morph-matrix were analyzed with the 3D measurement technique. This morph-matrix measurement data is further statically defined with IBM SPSS statistical software with statically proven prepared core technology and dominance of retouched scrapers. The amalgamation of these Multilayer Methodologies helped us to identify prehistoric sites, their contextual matrix, and material cultural trends.

75. Spatially sizing up cleavers: GIS-based perspectives on the Indian Acheulean evidence

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Geographic Information System (GIS) and Remote Sensing (RS) has become a powerful potential tool for analysis and deriving abundant evidence from spatial and temporal datasets. The Acheulean record of South Asia or the Indian Subcontinent is archaeologically rich, geographically widespread, and chronologically comparable with the African and Levantine records (Chauhan, 2020). The oldest evidence comes from southern India and is ~1.5 Ma in age. At the same time, the youngest Large Flake Acheulean has been reported to be ~120 Ka from central India, indicating a significant overlap with the earliest Middle Paleolithic dated to~385 Ka. After handaxes, cleavers form another significant component of this record and typo-technologically resemble evidence from Africa, Europe, and West Asia, although some regionally distinct technologies have also been reported. However, most studies from South Asia have focused on site-level analysis and interpretations, a regional analysis of these tools in terms of their spatial pattern, and geological and geomorphological controls of such evidence are not yet attempted for the region.

This paper has three main objectives:

1. Spatial distribution and analysis of lithic data (specifically, cleavers) using geographic information system (GIS).
2. Contextualising this information in a broader geospatial framework utilizing geological, geomorphological, and physiographic evidence.
3. 3Demonstrating the utility and the increased importance of GIS as a tool in South Asian Palaeolithic studies.

Methodology

The available artefact information in the reports and literature has several limitations, as it is from relatively older publications (1970s-1990s). Most sites are described in terms of their proximal village or landscape name, and exact coordinates are not reported. Additionally, a large number of the reports mentioning the name of the village are mere conversions of vernacular language pronunciation to English and often fail to capture regional intricacies. In such a situation, even though the sites and their attributes are compiled and documented, it demands a substantial amount of data cleaning and manual intervention to convert these details to a usable data set. To overcome such difficulties, the present study uses ArcGIS Pro GIS software to determine the geocoordinates of the sites. The sites were geocoded through Esri's Online World Geocoding Service, which converts a text-based description of a location to a position on the map. Using such tools, we successfully geocoded the majority of the sites and its accuracy was cross-verified by manual intervention and rematching. Different attributes of the sites were then spatially analyzed with background information such as geology, topography, drainage and watershed parameters of the study area to infer the distribution relation and connection between these sites.

Results

The present research doesn't aim to propose any explicit or final conclusions from the available evidence. Instead, the present study highlights a novel method of lithic analysis using GIS and its implications for better situating contextual and geographic perspectives of a distinct Palaeolithic technology. For instance, the method indicates that different types and sizes of cleaver may have been utilized in different geographic and ecological contexts. The study also highlights potential raw material size and shape constraints, along with other related factors, that may explain the variable distribution of cleavers across the subcontinent including their absence in some zones as well as varying handaxe-to-cleave ratios.

Discussion and future potential

Contextualising artefacts such as handaxes and cleavers needs data at multiple scales, due to the spread of the sites at the subcontinent level. Though the micro-contexts assist in local interpretation of these tools related to the use of raw material, and debitage, there are still significant gaps in our overall understanding of these artefacts. Locating these in a broader context highlights their significance in the overarching study of the stone tool techniques and typologies not only in the Indian Acheulean record but also within the larger South Asian Palaeolithic. Individual descriptions of discrete tools or assemblages with respect to their stratigraphic context, contemporary climatic setting, and geomorphological history of the area provide a very detailed picture of these isolated events. Acknowledging the continuity of changes in geologic and geomorphic settings in regional contexts, and climatic variations and its implications at a more global scale is the first step. Following that, the next step is to bring these isolated events within a single framework. The factors which are building the contexts for these early human artefacts are all 'spatial' in nature. Their combined effects function as a 'location-specific phenomenon' on the entire surface of the earth. However, different factors work at different scales and identifying their possible correlation or impact on the stone tools in the deep past is challenging. GIS provides a powerful set of tools for creating, visualising and analysing these essentially 'spatial' datasets. It thus creates a possibility of building that framework as a starting point. We propose to create this pan-India framework for visualising and analysing the Acheulean record of the Indian subcontinent. Reassessing our existing understanding of these isolated events and making possible additional interpretations in this broader context are one of the aims of this paper. With increasing amounts of data and more precise geospatial data of factors building the framework, we may be able to correlate trends in stone tool techniques and typologies to changing surroundings at the local, regional and continental levels. Future avenues include a) looking at the spatial contexts for other prehistoric techno-chronological phases; b) gaining insights into specific debates in prehistory, especially the relationship between hominins and their landscapes at a larger scale and 3) understanding the role of climate and environment in hominin behaviour and mobility.

General References

Chauhan, P.R. 2020. Human evolution in the center of the Old World: An Updated Review of the South Asian Paleolithic. In R. Ono and A. Pawlik, Eds. Pleistocene Archaeology. IntechOpen. https://doi.org/10.5772/intechopen.94265

Verhagen, P. (2018). Spatial Analysis in Archaeology: Moving into New Territories. In: Siart, C., Forbriger, M., Bubenzer, O. (eds) Digital Geoarchaeology. Natural Science in Archaeology. Springer, Cham. https://doi.org/10.1007/978-3-319-25316-9_2

Shipton C, Blinkhorn J, Breeze PS, Cuthbertson P, Drake N, et al. (2018) Acheulean technology and landscape use at Dawadmi, central Arabia. PLOS ONE 13(7): e0200497. https://doi.org/10.1371/journal.pone.0200497

51. Mapping paleo-landscape of Harappan port Lothal using cloud-computing and multi platforms

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Lothal is one of the most important Harappan maritime trade centers now located at a distance of about 25 km from the Gulf of Khambhat (Gujarat) on the west coast of India. The excavated artifacts from the site attest to their association with maritime activities during the Harappan period. The prominent among them are the Persian Gulf type circular seal and plano-convex copper ingots. It was an active port from around 2200 BCE to 1900 BCE. The site is world famous for its brick-walled dockyard. Different views for and against the dockyard are also available in the archaeological literature. The archaeological, structural, and geomorphological evidence suggest that a sea passage to Lothal approachable at high tide existed during the Harappan period. A previous study based on remote sensing analysis has identified a paleochannel to the north of Lothal. However, the larger context of the paleochannel is not understood so far. In addition, the methods applied were limited to having a holistic understanding of Lothal's surroundings. A wide variety of satellite data is now available, at different spatial, spectral, and temporal resolutions, through open-source satellite data portals and cloud-based geospatial analysis platforms. This paper integrates information extracted from digital early maps, Corona images, multi-spectral and multi-temporal satellite data of different spatial resolutions, and Digital Elevation Models to trace paleochannels and reconstruct the former hydrological network around the Lothal. The study has found the connection of Lothal with river Sabarmati, one of the major rivers in Gujarat, which now flows 20 km east of the Lothal. The study has provided a novel understanding of the paleo-hydrology of the study area and has the potential to throw new insights into the archaeology and geomorphology of the region. Further, the study highlights the importance of a cloud-based geospatial platform to understand past landscapes.

76. The Interactive Corpus of Indus Texts (ICIT) as an epigraphical database and online tool for Indus script research

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The Indus culture (2600 to 1700 BC) is found in Pakistan and NW India, and is one of the earliest ancient civilizations, along with the civilizations of Egypt, Mesopotamia and China. This Bronze Age culture is most famous for its short inscriptions found on different artefacts such as seals, tablets, pots, bangles and sealings. Since the Indus writing system has for the most part remained undeciphered, our knowledge of the Indus culture is based solely on the interpretation of archaeological data. Any decipherment, even a partial one, would provide important information about the Indus people, their social structure, trade and religion.

The basis of successful decipherment is an up-to-date corpus of Indus inscriptions and a comprehensive sign list, which makes it possible to analyse sign patterns and to identify the Indus root language(s). This is the reason why the Interactive Corpus of Indus Texts (ICIT) has been compiled. At present it contains 4665 inscribed objects with 5650 texts and 17966 legible sign occurrences. It is complemented with 16015 images of photos and drawings of the artefacts. Analytical methods have been developed to analyse Indus inscriptions such as Normalized Weighed Sign Position Histograms, Multivariate Segmentation Trees, and a classification method to determine the type of the Indus language.

The Interactive Corpus of Indus Texts (ICIT) is based on a relational database with 29 tables storing more than 1.2 million data entries. It includes the meta data of artefacts such as excavation number, find spot, material, artefact type, status of preservation, etc., the sign coding of Indus texts and its reading direction and completeness, as well as iconographic symbols and cult objects along with facing direction of animals and their completeness. A web-based user interface has been developed in order to make the data accessible. Several tools allow simple and complex search queries and different options to inspect and visualize the archaeological and epigraphical data. Statistical tools give a quick overview of absolute and relative frequencies of signs, texts, artefacts, as well as iconographic elements. It is supplemented with a Chi²-test, a modified Chi²-test and the calculation of the strength of relations between two parameters such as site, artefact type, shape of object, material, colour, boss type of seals, etc.

A statistical method has been developed and implemented to classify the positional behaviour of each sign and to differentiate between various medial positions. The Normalized Weighed Sign Position Histograms give a more detailed analysis and classification of Indus signs for all texts as well as for specific text classes based on the behaviour the sign. The method can also be used to show that often graphically similar signs differ in their preferred positional behaviour and are not stylistic variations (sign variants) but distinct signs (graphemes).

A multivariate segmentation method is developed to compare typical sign patterns with linguistic features such as affixation and other grammatical markers. Segmentation trees are calculated automatically and are based on the current number of complete inscriptions stored in the database and the frequencies of signs, sign pairs, as well as initial and terminal sign positions. They open the posibility of a detailed analysis of sign groupings and search for linguistic pattern represented through the sign sequences of Indus writing. The analysis of segmentation trees makes it clear that we deal with various types of grammatically complex Indus texts.

The spatial distribution of Indus texts and inscribed artefacts of the Indus culture can be mapped with a mapping tool specifically developed for this purpose. It allows the user to choose between several search and drawing options. The map is directly shown in the browser supplemented with a table of the raw data and statistical parameters. Because of the varying number of excavated Indus artefacts at each site, a modified Chi²-test shows the comparison of frequencies with expected frequencies of homogenous distribution. This is especially important because of the many low frequencies of excavated artefacts and published data of Indus archaeology. One of the main implications we can already draw from the spatial distribution and statistical tools is that inscribed Indus artefacts are not homogenously distributed. The archaeological context indicates that inscribed artefacts were used for various purposes and should not be considered as one homogeneous set of data.

The statistical tools allow us to calculate a measure of the homogeneity of a frequency distribution for two parameters. The measure is called Factor of Homogeneous Distribution (FHD) and indicates under- and over-representation of artefacts taking the varying number of excavated artefacts into account. The FHD is similar to the CHI²-test showing, for example, that some Indus signs were used preferably on specific artefacts types.

The goal of the database project is to make all Indus inscriptions accessible to scholars worldwide and to stimulate further research on Indus writing and the Indus culture in general. The database is accessible through a web-based online user interface and will be constantly updated in the future after the publication of new excavated inscriptions of the Indus culture.

Literature

Fuls, Andreas: Entwicklung einer geographisch-epigraphischen Datenbank der Indusschrift. In: Sven Weisbrich and Robert Kaden (Ed.), Entwicklerforum Geodäsie und Geoinformationstechnik 2010, p. 29–45, Shaker Verlag, Aachen 2010.

Viswanathan, Rama and Andreas Fuls: A comparison of digital Indus text corpora: signaries, sign sequences, and statistics. In: Asma Ibrahim, Michael Jansen, Jonathan Mark Kenoyer and Kaleemullah Lashari (eds.), Mohenjodaro Excavations: Centenary Commemoration Volume, Department of Culture, Tourism, Antiquities and Archives, Government of Sindh, Karachi (forthcoming).

Wells, Bryan K.: The Interactive Concordance of Indus Texts and Analytical Methodologies Developed for the ICIT Project. In: Asma Ibrahim, Michael Jansen, Jonathan Mark Kenoyer and Kaleemullah Lashari (eds.), Mohenjodaro Excavations: Centenary Commemoration Volume, Department of Culture, Tourism, Antiquities and Archives, Government of Sindh, Karachi (forthcoming).

286. Mapping Indus archaeology and multi-temporal land cover trends in semi-arid regions

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1. Introduction

This paper will present ongoing remote-based research in a selection of South Asian Indus contexts ranging from the Kachchh region in north-western India to the arid landscapes of the Cholistan Desert in Pakistan. These regions were areas of significant influence for the development of the Indus Civilisation and saw the flourishment of villages, cities and fortified citadels which coexisted with agro-pastoral communities dedicated to the exploitation of local resources. In Kachchh, in particular, newly excavated sites by the University of Kerala, such as the cemetery of Juna Khatiya, attest to the first communities showing Indus traits (c. 3300-2600 BC). Later in historical and medieval times, a network of forts and caravan routes also indicate the long-term relevance of these areas in large-scale mobility and trade connections within the greater Indus region and beyond, towards Central Asia and the Gulf.

In recent years, remote sensing applications for archaeology have seen an unprecedented advance in the application of computational approaches for the remote analysis of archaeological landscapes and features. This progress is mostly related to improvements in availability (i.e. open access), diversity and quality of new satellite missions and the increasing implementation of cloud data catalogues and online computing and visualisation platforms. Within this context, we aim to re-evaluate the archaeological cultural landscapes of South Asian drylands, by 1) expanding the current archaeological data gazetteers with the detection and mapping of mounds and sites, and 2) evaluating the potential risks (from geohazards to anthropic impact) affecting its preservation, and 3) understand its location and position in relation to the potential land use available resources and landscape connectivity through time.

2. Materials and methods

This research integrates historical sources (ranging from historical descriptions and georeferenced maps), open-access geolocation services (such as Global Place Finder and OpenStreetMap) and satellite datasets at multiple scales of analyses (including multi-temporal and multi-source image composites). In particular, and relevant to the general topics discussed in the session, the unique archaeological landscape and physiographical characteristics of Kachchh and Cholistan make those regions an ideal scenario for testing large-scale remote sensing analyses. The analyses explore the combined potential use of Copernicus data (Sentinel 1 and Sentinel 2) coupled with high-resolution elevation models TanDEM-X data and nano-satellite data from the Planet constellations. The cloud computing platform Google Earth Engine is preferred to perform targeted land-cover classifications and multi-temporal change analysis in the area, with a particular focus on testing a set of multi-temporal vegetation spectral indexes (see for example Orengo and Petrie 2018, Garcia-Molsosa et al 2020, Orengo et al 2020).

3. Results and discussion

Multi-temporal vegetation spectral indexes are used as a land proxy for the location of fertile alluvium and soils prone to retain soil moisture in the otherwise arid to semi-arid valleys of Kachchh. The remote mapping of such soil signatures provides a picture of local to regional ecological corridors that are well-aligned with the location of large Indus mounds, thus allowing us to explore past connectivity and spatial relationships between settlements and resources for agricultural and pastoral practices. The close relationships between ephemeral water bodies and exposed dahars (i.e. silt clay depressions in drylands), are also seen in the archaeological landscapes of the Cholistan desert. However, the construction of dams and irrigation canals and the expansion of agriculture is triggering the preservation of many mounds and archaeological surface scatters.

A more methodological discussion will consider current geospatial and remote-based topics in archaeological research, such as the advantages, shortfalls and technological barriers of using mid to high-resolution open access data, especially in contexts when very-high resolution satellite data (such as UAVs) is often unavailable or difficult to access. Overall, our mapping efforts in Kachchh and Cholistan can offer insights -and learn from- other similar South Asian approaches being discussed at this sesison and within the broader CAA comunity. In that regard, the use of cloud data catalogues and code-based algorithms aims at making processing routines open and easily accessible to the growing archaeological and computational community of researchers.

4. References

Orengo, H. A., & Petrie, C. A. (2017). Large-scale, multi-temporal remote sensing of palaeo-river networks: A case study from Northwest India and its implications for the indus civilisation. Remote Sensing, 9(7), 1–20

Garcia, A., Orengo, H. A., Conesa, F. C., Green, A. S., & Petrie, C. A. (2019). Remote sensing and historical morphodynamics of Alluvial plains. The 1909 indus flood and the city of Dera Gazhi Khan (Province of Punjab, Pakistan). Geosciences, 9(1), 21

Orengo, H. A., Conesa, F. C., Garcia-Molsosa, A., Lobo, A., Green, A. S., Madella, M., & Petrie, C. A. (2020). Automated detection of archaeological mounds using machine-learning classification of multisensor and multitemporal satellite data. Proceedings of the National Academy of Sciences, 202005583

43. 'Mapping' modalities in archaeological remains - Building GIS of Mohenjo-Daro's DK(G)-S mound

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Archaeological excavations in South Asia have a legacy of more than 100 years. Till very recent years, site locality documentation has been mostly dependent on rudimentary geospatial data. It mainly involved extracting data from toposheets, open source topographic data such as SRTM/ ASTER, Sketches/ maps created by previous scholars and also data from GoogleEarth for preliminary understanding of the site and its surroundings. Documenting the excavated site by incorporating its total station surveys, drawings of structural remains, stratigraphy and artefacts in digital format - in GIS like systems is yet to become a standard practice. Despite the inevitable relationship of archaeological remains with the underlying landscape, this powerful tool of landscape or spatial studies is still underutilised.

On this background, the case-study of a long excavated site of Mohenjo-Daro opens up possibilities of using GIS, opportunities for more nuanced interpretations of the site and also interrogating the current discourse. This is possible only because of the large-scale and detailed site plans published in the excavation report produced by Ernest J Mackay during 1926-1931. It is a commondable task which was done in the absence of present day technology and tools of mapping. Mackay's ingenuity to visualise and describe the development of the mound by reversing the order of excavation is evident in the excavation report. Based on the then possible stratigraphic and structural analysis, different site plans have been created for then identified cultural periods. We do find changes taking place in structures, house layouts and room sizes over a period of time. Visualisation and quantification of these changes may help interpret this transition. Some efforts in similar direction have been done where 3D modelling of the house layouts has been created using the plans (Green 2018) or estimates of excavated earth has been calculated in order to study the probabilistic distribution of the artefacts (Franke-Vogt 1991).

The present paper employs GIS techniques to analyse these 100 year old site plans and to extract the transitions in architectural and structural phases of the DK(G)-S mound at Mohenjo-Daro. The main aim is to understand how the city layout is transforming over centuries, are there any characteristic features or patterns which can be identified and then can we relate those to understand the cultural transitions in the Indus/ Harappan society. Building a layered spatial database of prehistoric (often referred to as protohistoric in South Asian Archaeology) cityspace can also raise questions about identification of these phases itself, present day understanding about the demarcation of houses and neighbourhoods, their survival or modification across different periods (generally identified as Early, Intermediate/Mature and Late), and the reasons and impacts for these architectural changes.

Surveys conducted in the last few decades have identified problems in methodologies employed by old excavation projects in stratigraphic analysis, periodisation and level identification, and hence in the overall interpretation about the site formation and development. These insights are important in order to improve our understanding of the cultural periods. However, this was carried out only at limited locations and sites hence their applicability to the entire Harppan domain is still under investigation. However this does not diminish the significance of previously produced data. With GIS, we are now in a position to visualise and navigate the ambiguities. The excavation report itself being a historical text, this study of the excavation report becomes an exercise of history.

References

Green, A. 2018. "Mohenjo-Daro's Small Public Structures: Heterarchy, Collective Action and a Re-visitation of Old Interpretations with GIS and 3D Modelling." Cambridge Archaeological Journal, 28. no. 2. (May 2018): 205-223. https://doi.org/10.1017/S0959774317000774

Franke-Vogt, U. 1991. Die Glyptik aus Mohenjo-Daro: Uniformität und Variabilität in der Induskultur: Untersuchungen zur Typologie, Ikonographie und räumlichen Verteilung. Vol. I. Mainz am Rhein: Verlag Philipp von Zaber

Mackay, E.J.H., 1938. Further excavations at Mohenjo-daro (Vol. 2). Manager of publications, Government of India Press, New Delhi

220. Loss of heritage in riverine monsoonal plains: integration of geospatial legacy data and multi-source remote sensing in Jammu, India

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Introduction

Floodplains are one of the most visible and widespread landforms on Earth's surface. Over time they develop and change, and so they continuously reshape their river systems and have a major impact on short- to longer-term human-environment interactions. Most contemporary riverine landscapes, if not all, have been altered by anthropic influence throughout the Holocene. In recent years, however, the intensification of human activities has increased the rate at which natural processes shape the landscape and have severely aggravated the preservation and visibility of many archaeological and cultural heritage sites. In such contexts, remote sensing procedures become an essential tool to remotely investigate large-scale archaeological patterns, land use trends and landscape change at multiple scales of observations.

In recent years, we have witnessed a growing number of geospatial and remote-based applications in South Asian archaeological landscapes (e.g., Conesa et al. 2015, Orengo and Petrie 2017, Orengo et al. 2020, Rajani 2020). This thriving trend is placing South Asian landscapes and in particular the areas within the influence of the Indus Civilisation and the greater Indus Valley (aprox. 3500 BC – 1900 BC), as optimal land laboratories for the development of new methods and workflows that can be exported to and compared with other similar geographical areas with a long-standing tradition of remote-based investigations, such as the Near East (e.g., Rayne et al. 2020).

Here we present the first steps of RIVERINE, a new collaborative project that revolves around the interactions between the archaeology and the hydrological resources of the Jammu alluvial plains in north-western India. We aim to detect and map the location of ancient mounds and re-evaluate their cultural and chronological contexts while also exploring the historical and present-day land use trends and anthropogenic disturbances that put the Cultural Heritage of Jammu at risk.

Materials and methods

Our research draws on similar approaches being developed in Indus contexts that have successfully combined 1) the analysis of geospatial historical legacy data; and 2) the use of satellite imagery from free or open access data missions. The diachronic mapping of archaeological features and land use patterns requires the collection, GIS-based georeferencing and analysis of archived historical data such as historical topographic maps and declassified satellite imagery such as the HEGAXON and CORONA archives, as well as other geospatial data such as published and unpublished archaeological datasets.

We combine the assessment of legacy data with the accurate analysis of the Earth's surface trends using multiple collections of satellite data, such as the Copernicus satellites Sentinel 1-2 and high-resolution digital elevation models such as TanDEM-X (Orengo and Petrie 2018). Data analysis and visualisation are being performed in cloud-computing platforms such as Google Earth Engine, which allows for a smooth and effective implementation of image classification and change detection algorithms while ensuring the reproducibility of code and analysis.

High-resolution satellite imagery collections from Planet are also integrated to validate and map local-scale patterns of the main activities that pose an urgent threat to site preservation and requires rapid evaluation, which includes 1) agricultural development; 2) looting; 3) urban growth; 4) infrastructure development; 5) mining and soil removal and 6) military activities and conflict. The outcomes of the remote-based analysis and land monitoring are then used in systematic field surveys and ground-truthing campaigns to validate the present-day condition of known and new archaeological mounds and other cultural assets in the region.

Results and discussion

Acute landscape modification caused by a variety of environmental and cultural factors is the principal driver of losing tangible archaeological resources. The complex drainage system in the north-western region of the Indian subcontinent is prone to natural hazards such as seasonal flooding and river avulsion, whereas the availability of fertile alluvium soil has triggered a series of anthropogenic developments, such as new irrigation schemes and the expansion of mechanic agriculture at unprecedented rates. The plains of Jammu are not an exception to these processes, and heritage loss is further prompted by other activities such as soil extraction for brick making, dumping grounds, religion structures at the top of mounds and military infrastructure along the international border. In the other hand, a few government-owned lands create a safety pocket that preserves mounds from a certain destruction.

We will present an ongoing categorised assessment (see e.g., Hammer et al. 2017) of the condition of archaeological mounds in Jammu. We will discuss the implementation of our computational approach and its potential implementation in other monsoonal environments, and the opportunities and limitations for the creation of new conservation models. A three-tier blueprint involving various stakeholders is proposed, in which the remote-based mapping and monitoring can help and drive the actions of government agencies towards the effective protection of archaeological assets. In the other hand, promoting the use of geospatial technologies to the broad public at the school, college and even village panchayat level might encourage a much-needed dialogue towards South Asian heritage awareness.

References

Conesa, F. C., Madella, M., Galiatsatos, N., Balbo, A. L., Rajesh S.V., Ajithprasad, P., (2015). CORONA photographs in monsoonal semi-arid environments: addressing archaeological surveys and historic landscape dynamics over North Gujarat, India. Archaeological Prospection, 22

Hammer, E., Seifried, R., Franklin, K., & Lauricella, A. (2018). Remote assessments of the archaeological heritage situation in Afghanistan. Journal of Cultural Heritage, 33, 125–144

Orengo, H. A., & Petrie, C. A. (2017). Large-scale, multi-temporal remote sensing of palaeo-river networks: A case study from Northwest India and its implications for the indus civilisation. Remote Sensing, 9(7), 1–20

Orengo, H. A., & Petrie, C. A. (2018). Multi-scale relief model (MSRM): a new algorithm for the visualization of subtle topographic change of variable size in digital elevation models. Earth Surface Processes and Landforms, 43(6), 1361–1369

Orengo, H. A., Conesa, F. C., Garcia-Molsosa, A., Lobo, A., Green, A. S., Madella, M., & Petrie, C. A. (2020). Automated detection of archaeological mounds using machine-learning classification of multisensor and multitemporal satellite data. Proceedings of the National Academy of Sciences, 202005583

Rajani, M.B, (2021). Patterns in past settlements: geospatial analysis of imprints of Cultural Heritage on landscapes. Springer.

Rayne, L.; Gatto, M.C.; Abdulaati, L.; Al-Haddad, M.; Sterry, M.; Sheldrick, N.; Mattingly, D. (2020). Detecting Change at Archaeological Sites in North Africa Using Open-Source Satellite Imagery. Remote Sensing, 12, 3694

359. Mapping Archaeological Heritage in South Asia: a digital workflow in development

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The Mapping Archaeological Heritage in South Asia (MAHSA) project is developing heritage management tools and expertise that support systematic documentation of archaeological heritage in Pakistan and northwest India. We are developing tools to document the full range of archaeological heritage, which span in date from the earliest villages, through several phases of urbanism, the rise and fall of numerous historical states and empires, and up to the colonial and modern periods. Today, many areas are densely occupied and undergoing rapid development. Many sites are at risk, typically from factors including erosion, large-scale development, looting, and the expansion of extensive irrigation agriculture and the concomitant levelling of large tracts of land. Site destruction has been observed in the field and is ongoing, and at present the level and rate of site loss is not being monitored in many areas. There is thus a clear need for archaeological sites to be documented in a system that also enables monitoring and management (Gupta et al. 2017) This paper explores the work and challenges of the Mapping Archaeological Heritage in South Asia (MAHSA) project in using different technologies and methods to record, digitise, re-interpret, link, and re-use non-digital and born-digital archaeological data into a structured and standardised digital format using a common and unique controlled vocabulary, so that it may become findable, accessible, interoperable, and reusable (FAIR) data.

MAHSA digital workflow

Working with partners in India and Pakistan, the MAHSA project is compiling existing and published data (from published documents, reports, and surveys) which will be published in an Open Access database using the Arches database platform to make such data available for research and preservation. We are also working alongside heritage professionals in both countries to support digital workflows for the documentation of new and previously undocumented sites identified through the analysis of historic maps, remote sensing, automated site detection methods, and field documentation. This documentation will follow the same data standards and recording methodology, and we aim to make data available to the research community, heritage managers, and the public while balancing the needs of sharing data and protecting vulnerable sites. The project includes a training programme of workshops and small-group tailored training courses to ensure the long-term sustainability of the outputs.

Previous research has shown that the maps issued by the Survey of India from the mid nineteenth- mid twentieth centuries document the location of thousands of mound features, and it has now been made clear through ground-truthing that a significant number of these mounds are archaeological sites (Petrie et al. 2019). The MAHSA project is digitising these paper maps, using high-resolution scans to georeference each map sheet. Machine learning is being used to detect possible archaeological mound features from these maps, and these data will be ground-truthed in the field. Map Coordinates are also stored within the image file, and this provides an opportunity to store and structure this information through IIIF standards, making it available in an interoperable and more LOUD-compliant way over the web. This will make the map sheets searchable in the Arches database as geospatial objects, together with their related metadata.

For data collection in the field and ground-truthing data generated through machine learning on historic maps and remote sensing, a customized digital field survey form has been developed using open-source Open Data Kit (ODK) software, building on an initial design developed as part of the TwoRains project. The MAHSA team are working with project partners and collaborators to ensure user requirements are met, and that local fieldwork methodologies are supported. ODK is a low-cost sustainable solution that allows offline data collection using mobile phones or tablets in resource-constrained environments. The collected data is stored locally and can be uploaded to a server when a suitable network or an internet connection is available.

ODK uses the XSLForms standard for developing survey questionnaires, which allows for easy authoring and collaboration on the questionnaire using Microsoft Excel software. XSLForms are then converted to XML structure upon deployment on the server.

The MAHSA team is working with local collaborators to ground-truth a sub-set of data in selected regions using the ODK. The Data is from existing datasets that needs to be groundtruthed and/or automated detected sites using machine learning from historical maps. This step involves training of the collaborators in the survey methodology and use of the ODK to record sites and post processing and analysis of digital data. These born-digital data from the field are then ready for analysis in QGIS and publication, with eventual upload to the Arches database possible once sites have been fully processed and protected at the local level.

Desired outcomes: digital equality and sustainability

Behind all the activities described above lies the context of digital inequality. Issues of digital inequality are often framed as a simple contrast between the Global North with funding and technological and skills capacity, and countries of the Global South, which may be rebuilding economies, healthcare, and education within postcolonial contexts, an issue we tackled during a session at CAA 2022. It is important to acknowledge that digital exclusion is evident for marginalized groups around the world (UN Habitat 2020), and that issues of digital inequality are nuanced in South Asia. In the course of running the MAHSA project, we have discovered a flexible and adaptable approach has been necessary to bridge the digital divide. We are seeking to address traditional imbalances in access to technology, methods and software through its project design, training and methods of dissemination. However, we also engage in an ongoing process of reflection, seeking to improve our approaches and methods to ensure the digital innovations of the project will be truly sustainable in the longer term, and welcome discussion and feedback from the community.

References

Gupta, Ekta, Sonia Das, Kuili Suganya Chittirai Balan, Viraj Kumar, and M. B. Rajani. 2017. 'The Need for a National Archaeological Database'. Current Science 113 (10): 1961–73.

Petrie, Cameron A., Hector A. Orengo, Adam S. Green, Joanna R. Walker, Arnau Garcia, Francesc Conesa, J. Robert Knox, and Ravindra N. Singh. 2019. 'Mapping Archaeology While Mapping an Empire: Using Historical Maps to Reconstruct Ancient Settlement Landscapes in Modern India and Pakistan'. Geosciences 9 (1): 11. https://doi.org/10.3390/geosciences9010011.

UN Habitat. 2020. 'World Cities Report 2020: The Value of Sustainable Urbanization | UN-Habitat'. 2020. https://unhabitat.org/World%20Cities%20Report%202020. [Last accessed 31 October 2022]

20. Simulations for the past, simulations for the future

Isaac Ullah, San Diego State University
Iza Romanowska, Aarhus University
Doug Rocks-MacQueen, Landward Research

Location: Forum

Simulation is the closest tool we have to a time machine. It enables us to investigate past complex social and socio-natural dynamics in a robust scientific manner that overcomes some of the limitations of the archaeological record. This year marks the tenth anniversary of the regular "ABM session" at the CAA conference. In the last decade, over 50 researchers from all continents presented their models ranging in spatio-temporal scope from the earliest hominins' global dispersal to reconstructions of particular building projects in historical times. We have tested hypotheses regarding the origins of cognition, language and art, assessed subsistence strategies of groups across virtually every Earth's biome, looked for mechanisms driving complex human interactions such as exchange, demographics, or warfare and tried to determine what processes shaped human mobility and settlement distributions over various types of landscape or preference for particular products. However, simulation studies also opened up archaeology to bigger and more general research questions that transect the particularities of any one case study. While most models focus on a low-level research question –what has happened in a particular place at a particular time – they also give us insight into general tropes of human behaviour, interactions and response to change. These topics have been of much interest in archaeology since the earliest days, but they are more often simply discussed rather than operationalised, developed, and tested within formal, scientific frameworks. The objective of this session is therefore twofold. First, to showcase the breadth and contribution of archaeological simulation to our understanding of the past and past people. Second, to reflect on the contributions that our models make or could make in the future to addressing the grand societal challenges currently faced by humanity. We invite papers that describe research involving formal simulation modelling methods, such as system dynamics, agent-based modelling, cellular automata, etc., on any topic without restrictions regarding the scope, subject, spatial or temporal aspect, or level of completeness of the model. We ask the authors to dedicate one slide of the presentation to the question of whether and how their model could contribute to one of the UN-defined Global Goals (https://www.globalgoals.org/).

SLOT 1	
08:30 - 08:50	119. Modelling cooperation under climate constraints in the Paleolithic of Kazakhstan *Maria Coto-Sarmiento (University of Tübingen)*; Radu Iovita (New York University - University of Tübingen)*
08:50 - 09:10	114. A Mesolithic Homo Oeconomicus? First steps towards the simulation of Mesolithic Land-use perception *Gerrit Günther (CAU Kiel / CRC1266)**
09:10 - 09:30	292. Human substistence strategies and environmental sustainability in arid ecosystems: simulating Ju/'Hoansi-San traditional hunting practices *Lucía Cobo-Sánchez (University of Cologne)*; Eleftheria Paliou (University of Cologne); Oliver Vogels (University of Cologne); Tilman Lenssen-Erz (University of Cologne)*
09:30 - 09:50	62. Hunter-gatherer impact on interglacial vegetation in Europe: agent-based model and sensitivity analysis *Anastasia Nikulina (Leiden University)*; Fulco Scherjon (NL); Katharine MacDonald (Leiden University); Anhelina Zapolska (Vrije Universiteit Amsterdam); Maria Antonia Serge (University Toulouse Jean Jaurès); Marco Davoli (Aarhus University); Elena Pearce (Aarhus University); Dave van Wees (Vrije Universiteit); Wil Roebroeks (Leiden University)*
09:50 - 10:10	306. Moving through the mountains - An integrated GIS and Agent-based modelling approach to predict the location of Mesolithic sites in the Cairngorms, Scotland *Micheal Butler (University College Dublin)*; Alice Doughty (The University of Maine); Sam Kelley (University College Dublin); Martin Moucheron (University College Dublin); Graeme Warren (University College Dublin)*
10:10 - 10:30	35. AgModel: An Agent-Based Model of the forager-farmer transition. *Isaac IT Ullah (San Diego State University)**

SLOT 2	
11:00 - 11:20	118. An Agent-based model of pre-Columbian land-use in the Monumental Mound Region of Amazonian Bolivia *Joseph Matthew Hirst (University of Reading)*; Joy Singarayer (University of Reading); Umberto Lombardo (Universitat Autònoma de Barcelona); Francis Mayle (University of Reading)*
11:20 - 11:40	31. Was there economic thought in the Roman Empire? A comparison of proxy materials and simulated idealized network theories *Katharina Zerzeropulos (Christian-Albrechts-University Kiel)**
11:40 - 12:00	253. Modelling urban evolution - an agent-based approach to city-hinterland dynamics *Iza Romanowska (Aarhus Institute of Advanced Studies)*; Philip Verhagen (Vrije Universiteit Amsterdam)*
12:00 - 12:20	21. Model transposability: Challenges and implications of transitioning socioecological system models to new regions. *Francesco Carrer (Newcastle University)*; Isaac IT Ullah (San Diego State University)*
12:20 - 12:40	334. Simulation in the age of machine learning *Andreas Angourakis (Ruhr-Universität Bochum)**
12:40 - 13:00	

119. Modelling cooperation under climate constraints in the Paleolithic of Kazakhstan

Maria Coto-Sarmiento, University of Tübingen
Radu Iovita, New York University - University of Tübingen

Modern humans dispersed throughout the entire world during the Pleistocene, completing an important part of our evolutionary history. Central Asia is characterised by extreme environments, and therefore offers an ideal context for testing hypotheses about the role of human behaviour in dispersals under adverse conditions. However, archaeological data in Central Asia is sparse, making precise reconstructions of dispersal routes and their chronology difficult (Iovita et al., 2020).

In such cases, computational models, which provide a powerful tool for simulating behavioural scenarios in the past, will be essential to examine different possible scenarios that can be tested later with new empirical data.

We introduce here an evolutionary theoretical Agent-Based Model exploring the effect of behavioural adaptations in hominin dispersals under different climate scenarios in Central Asia (Kazakhstan) during the Pleistocene. In particular, this study explores human-environment interactions where cooperation plays an important role under climate constraints. Our model uses new survey data from archaeological sites in two different regions (the Altai and Tian Shan (Kazakhstan)) gathered during fieldwork from 2013-2022.

The model uses an evolutionary framework to test cooperation dilemmas in humans (whether to cooperate or not) using an evolutionary model proposed by Henrich and Boyd (Henrich and Boyd, 2001).

This model analyses cooperation strategies based on two social mechanisms: a) the maintenance cost of cooperation in groups and the application of punishment to non-cooperators, and b) cultural transmission where most humans adopt common behaviour (conformist transmission).

These behavioural mechanisms are put to test within four theoretical climate scenarios for each region. These are based on the average temperature (BioClim variables) during glacial and interglacial periods (Glantz et al., 2018): a) a glacial scenario characterised by the annual mean temperature; b) a glacial scenario characterised by the mean temperature of the coldest quarter; c) an interglacial scenario characterised by the mean temperature of the coldest quarter; and finally, d) a glacial scenario characterised by the mean temperature of the warmest quarter. The selection of these climate temperatures corresponds to the reason for testing and comparing examples of temperatures more representative (extreme and non-extreme) during the Glacial and Interglacial periods.

The main idea here is to compare how extreme climate scenarios affect human cooperation depending on the different regions and climates in which hominins are found. Therefore, the model simulates a theoretical environment where groups of humans move to find places with more resources. Meanwhile, they face climate conditions while they compete for these resources.

Preliminarily, the model shows that: a) population size can significantly influence the pressure on the group to adopt cooperative or non-cooperative behaviour, such that a higher population imply more pressure to cooperate, b) cooperative behaviours could be affected by climate change, with a high probability of survival in the harshest conditions only when hominins are mostly cooperative, and c) if the initial probability of non-cooperation is higher, then human groups will tend to be non-cooperative even if a cooperative subgroup pushes them to cooperate.

Our results demonstrate that the degree of cooperation influences survival during periods of extreme climatic deterioration. This may explain why Central Asia was possibly settled later than some other regions in Asia. We believe our methods and results are of interest to a wider human evolution audience, and can also be used for other topics in the study of the human past.

Bibliography

Glantz, M., Van Arsdale, A., Temirbekov, S., & Beeton, T. (2018). How to survive the glacial apocalypse: Hominin mobility strategies in late Pleistocene Central Asia. Quaternary International, 466, 82-92.

Henrich, J., & Boyd, R. (2001). Why people punish defectors: Weak conformist transmission can stabilize costly enforcement of norms in cooperative dilemmas. Journal of theoretical biology, 208(1), 79-89.

Iovita, R., Varis, A., Namen, A., Cuthbertson, P., Taimagambetov, Z., & Miller, C. E. (2020). In search of a Paleolithic silk road in Kazakhstan. Quaternary International, 559, 119-132.

114. A Mesolithic Homo Oeconomicus? First steps towards the simulation of Mesolithic Land-use perception

Gerrit Günther, CAU Kiel / CRC1266

Land-use practices and spatial organization are integral to understand past human-environment interactions. But reconstructing the modes of interaction in times when hardly anything else than material culture is left, is a challenging topic. Thus, it is essential to find ways to interpret the elusive material culture of Mesolithic Hunter-Gatherer societies. Agent-based modelling (ABM) is a distributed Artificial Intelligence method, which enables simulations of an agent's actions and of its interactions with other agents and the environment. The environment is considered as a virtual world, whose characteristics can affect the agent's actions and interactions with it. Due to the flexibility of the agent/agent and agent/environment paradigm, different modelling approaches have evolved.

This paper focuses on Mesolithic Hunter-Gatherer societies in Northern Europe and provides an agent-based simulation tool, written in the Julia programming language. The modelling tool is designed to simulate the landscape perception of Mesolithic Hunter-Gatherers in an abstract, artificially created environment. Our results contribute to the understanding of hunter-gatherer-societies by an integrative perspective of theoretical approaches and empirical data. Thus, first steps towards open and transparent modelling of complex interactions between interrelated components are archived, which can provide valuable tools to discuss hypotheses and to shrink gaps between archaeological data and assumed land-use dynamics.

292. Human substistence strategies and environmental sustainability in arid ecosystems: simulating Ju/'Hoansi-San traditional hunting practices

Lucía Cobo-Sánchez, University of Cologne
Eleftheria Paliou, University of Cologne
Oliver Vogels, University of Cologne
Tilman Lenssen-Erz, University of Cologne

Introduction

Studying prehistoric hunting behavior is essential to understand human subsistence strategies and the social development of past human societies, as well as human resilience, adaptations, and survival in the face of climate change. Many of the dynamic aspects of hunting, such as the relationship between foraging decisions and ecological changes, can be explored through agent-based models and simulations. These computational models are useful to understand complex behavioral patterns that are often the result of the combination of relatively simple rules of interaction among agents (the hunters and their prey) and the environment (Janssen and Hill, 2014). For example, seasonal changes have an effect on the size and resource-richness of vegetation patches, which in turn may alter hunting behavior. In general, the implications of an uneven and shifting distribution of resources on hunting success and prey choice remain poorly understood. Moreover, hunting and gathering are often viewed as rather passive practices, where humans develop behavioral responses and strategies in order to adapt to uncontrollable environmental change. However, frequently, hunter-gatherers also actively influence the environment in order to bring about change to their advantage, for example through fire management practices (Humphrey et al., 2021). We explore how empirical qualitative and quantitative data derived from collaborating with modern Ju/'Hoansi-San hunter-gatherers can be helpful in the conceptualization of models that simulate hunting in arid environments. We take into consideration different types of human-animal and human-environment interactions, which can be used to predict hunting success and behavior under changing environmental conditions.

Methods

This research takes advantage of a rare opportunity to document the movement and decision-making processes of Ju/'hoansi and Hai//kom San hunters during hunting with traditional means (i.e. on foot without firearms, optical aids, or hunting dogs) in arid Namibian landscapes. The collected qualitative and quantitative data includes geospatial information on the trajectories, caloric expenditure, and walking speed of the indigenous tracking experts, as well as information about decisions made during hunting based on their knowledge of the environment and animal behavior. Using logistic and multivariate logistic regression, we analyze and identify the environmental factors or combination thereof that can potentially enhance hunting success or influence hunting behavior, for example, elevation, distance to water sources, distance to vegetated or rainfall. Furthermore, in one of our study areas, the homeland of the tracking experts in the Nyae Nyae Conservancy in northeastern Namibia, we also collect satellite data on fire practices associated with hunting, namely data on human-induced fires partly aimed to generate growth of grass to attract wildlife. It has been argued that such practices have been used in savannas in Africa and Australia for millennia, and, hence, they are relevant to archaeological investigations in such environments (Humphrey et al., 2021; Pyne, 1997). Ultimately, we use the collected qualitative and quantitative data to support the conceptualization, calibration, and/or validation of agent-based model simulations and test different scenarios of human-animal and human-environment interactions. The focus mainly lies in addressing how different environmental and climatic conditions may affect hunting and whether particular arid environmental settings induce different optimal hunting strategies.

Expected results

The empirical data collected during fieldwork shows that some environmental features increase hunting success rates, not only because they affect game distribution, but also because of how hunters interact with or use specific environmental features during hunting, for example through targeting specific areas during the hunt. The outcomes of the preliminary multivariate statistical analysis confirm qualitative observations during fieldwork and support our conceptualization of the agent-based model of hunting behavior. The empirical information is incorporated into the agent-based model to guide agent decision-making. We expect hunting success, prey type selection, and hunting strategies to vary significantly depending on a number of environmental factors, including different types of the spatial distribution of resources and degrees of human influence on the regeneration of vegetation patches through controlled fires.

Discussion

The incorporation of indigenous knowledge in the conceptualization of human behavior models offers valuable new insights into human-animal and human-environment interactions related to foraging and hunting practices. Our study aims to contribute to the growing body of foraging agent-based models and support theoretical model-building efforts in archaeology. Our work explores aspects of environmental sustainability and biodiversity that are relevant to past hunter-gatherer societies, as well as modern populations in our study area, and as such, it has the potential to contribute to the UN Global Goal 15: Life on Land.

References

Humphrey, Glynis Joy, Lindsey Gillson, and Gina Ziervogel. "How Changing Fire Management Policies Affect Fire Seasonality and Livelihoods." Ambio 50, no. 2 (February 2021): 475–91.

Janssen, Marco A., and Kim Hill. "Benefits of Grouping and Cooperative Hunting among Ache Hunter-gatherers: Insights from an Agent-Based Foraging Model." Human Ecology: An Interdisciplinary Journal 42, no. 6 (December 2014): 823–35.

Pyne, Stephen J. World Fire: The Culture of Fire on Earth. University of Washington Press, 1997.

62. Hunter-gatherer impact on interglacial vegetation in Europe: agent-based model and sensitivity analysis

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Passed away in August of 2022

Humans have a long history of landscape modification. Available ethnographic, archaeological and palaeological evidence suggest that anthropogenic impact on vegetation started long before the emergence of agriculture. Human-induced vegetation burning is already visible in a Last Interglacial (Eemian, Middle Palaeolithic, ~ 130,000–116,000 BP) lake-landscape frequented by Neanderthals and in the Early Holocene (Mesolithic, ~ 11,700–8,000 BP) in Europe (Nikulina et al., 2022). Since there are few European Mesolithic studies, and only one high-resolution Eemian case study with evidence of anthropogenic burning (ibid.), the origin, extent and the intensity of these practices conducted by hunter-gatherers are still unclear. In addition to humans, landscape dynamics are determined via other factors such as megafauna activities, climatic fluctuations, and natural fires. It is challenging to distinguish different types of impact on landscapes in proxy-based reconstructions (e.g., palynological datasets). Agent-based modeling (ABM) is commonly used to explore complex systems where multiple factors intertwine and to propose possible scenarios of system functioning (Romanowska et al., 2021). Thus, the primary research question in this work is: what was the role of hunter-gatherer activities in vegetation changes during the Last Interglacial and in the Early Holocene in Europe. Crucial sub-questions are: 1) is it possible to track and to quantify the intensity of different types of impact (anthropogenic and natural fires, megafauna plant consumption, climate) via ABM; 2) what defines the intensity of hunter-gatherer impact on landscapes.

The current study consists of several phases. Firstly, to reconstruct the natural (initial) environment, we used the following datasets: GTOPO30 digital elevation model (DEM) (www.usgs.gov), WISE dataset (https://water.europa.eu/) for distribution of large rivers and lakes, output of a dynamic vegetation model (CARAIB) and pollen-based estimates of plant cover obtained from REVEALS model (Regional Estimates of VEgetation Abundance from Large Sites). The CARAIB model reflects past vegetation openness and distribution of plant functional types (PFT) in Europe before megafauna activities, anthropogenic and natural fires, while REVEALS provides land cover estimations including these impacts. We combined these datasets with megafauna impact on vegetation openness and PFT quantified via CARAIB net primary productivity (NPP) and estimations of megafauna plant consumption (i.e., metabolization of NPP). Except for the DEM and WISE, the rest of the datasets are new results recently obtained within the Terranova project.

Secondly, the continental ABM was implemented in Netlogo 6.2.0. The temporal resolution of the model is one year, and the spatial resolution is 10 km. This model includes four types of impact: megafauna vegetation consumption, climatic impact, anthropogenic fires and thunderstorms (natural burning). Each simulation step starts with climatic impact, which defines vegetation regeneration after fire events or megafauna vegetation consumption. Following this, anthropogenic impact is assessed via five associated parameters: number of hunter-gatherer groups (population size), foraging area (area within which hominins move and burn), openness criteria to burn (humans only burn patches of forest or shrubland with values lower or equal to this criteria), and the percentage of hominin groups that are mobile and their movement frequency (the last two parameters define hominin mobility). After that, natural fires impact vegetation, and the intensity of their impact is determined via the number of thunderstorms per step. The actual natural burning due to thunderstorms and fire spread after that or human-induced fires depend on the probability of ignition, which is calculated by the time passed since the last disturbance event and natural fire return intervals (FRI). These were obtained via 2002-2020 MODIS (MODerate resolution Imaging Spectroradiometer) burned area data from the MCD64A1 C6 product. Finally, megafauna increase vegetation openness and modify PFT distribution via plant consumption.

Constant comparison of the modified vegetation with REVEALS estimations in terms of vegetation openness and distribution of PFT occurs during simulation runs. As a result, parameter values, which led to achieving REVEALS results, are identified. In addition, the number of modifications is calculated for every type of impact to quantify their individual intensity. Regarding anthropogenic burning, sensitivity analysis is conducted to identify the key parameters which influence the intensity of human-induced vegetation changes. The statistical analysis of simulation runs is conducted in R, and the sensitivity analysis is done via the nlrx package.

Our preliminary results of simulation runs and the sensitivity analysis show that it is indeed possible to distinguish between, and qualify and quantify, the different types of impact with the chosen combination of datasets in a continental ABM. As a result, we can begin to clarify the role of hunter-gatherer activities in vegetation changes for both study periods. We plan to produce maps of possible scenarios, which will be obtained by changing the values for the key parameters identified via sensitivity analysis.

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References

Nikulina, Anastasia, Katharine MacDonald, Fulco Scherjon, Elena A. Pearce, Marco Davoli, Jens-Christian Svenning, Emily Vella, Marie-José Gaillard, Anhelina Zapolska, Frank Arthur, Alexandre Martinez, Kailin Hatlestad, Florence Mazier, Maria Antonia Serge, Karl-Johan Lindholm, Ralph Fyfe, Hans Renssen, Didier M. Roche, Sjoerd Kluiving, and Wil Roebroeks. 2022. "Tracking Hunter-Gatherer Impact on Vegetation in Last Interglacial and Holocene Europe: Proxies and Challenges". Journal of Archaeological Method and Theory, 29, 989–1033. https://doi.org/10.1007/s10816-021-09546-2

Romanowska, Iza, Colin D. Wren, and Stefani A. Crabtree. 2021. Agent-Based Modelling for Archaeology: Simulating the Complexity of Societies. The SFI Press Scholar Series

306. Moving through the mountains - An integrated GIS and Agent-based modelling approach to predict the location of Mesolithic sites in the Cairngorms, Scotland

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Martin Moucheron, University College Dublin
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Introduction

Mountains are a prominent feature of the European landscape with approximately 40% of Europe defined as a Mountain municipality (a region where 50% of the area is mountainous). During the Late Glacial and Early Holocene evidence shows that Mountain landscapes saw regular use, especially during the latter (Warren, 2022). However, our knowledge of these landscapes in the past is fragmentary. Adding to the difficulty of access, changes in geomorphology, and glacial dynamics of mountain landscapes, the ephemerality of hunter-gatherer archaeology is easily overlooked during conventional surveying. The majority of these sites remain elusive and what sites we do have are the result of chance finds.

The IRC Coalesce funded 'Looking Up' project (2021-2023) provides an integrated approach to explore human use of mountain landscapes in the past, integrating geochronological techniques, numerical modelling of ice cover, and archaeological simulation modelling. These are used in the context of the Cairngorms, Scotland, and if successful can be applied to other mountain landscapes across Europe to provide guidance for policy makers regarding the management and development of these cultural and natural landscapes.

Methods

In order to aid in the location of sites in these landscapes we employ an integrated GIS and Agent-based modelling framework. This two-fold approach:

Firstly, uses conventional univariate and logistic regression techniques in the generation of probability maps of site location, utilising proxy data from across Europe where greater numbers of sites are known.

Secondly, these are then used to inform decision making processes of human and animal agents in our reconstructed landscapes, predicting their interaction with and movement through the mountains.

Due to the temporality of these landscapes, with changes in glacial extents and geomorphology; geochronological dating and ice cover modelling allow us to simulate these changes at human time scales. This allows us to explore the response to changes in the environment of both humans and animals.

Results and Discussion

We will present a series of generated probability distribution maps generated from the above coupled approach. These maps will be used to inform survey areas during our 2023 summer fieldwork, allowing us to ground proof our models. The employed methodology, generated maps, and ground proofing will provide an iterative approach for continued survey, and site location within this landscape beyond the scope of the 'Looking Up' project. Providing these tools to stakeholders, including state archaeological services and community archaeology groups will allow for continued refinement of distribution maps, while also providing the means for more detailed field survey, and archaeological investigation.

References:

Warren, Graeme. 2022 "Mesolithic Montology" Open Archaeology, vol. 8, no. 1: 132-144. https://doi.org/10.1515/opar-2022-0227

35. AgModel: An Agent-Based Model of the forager-farmer transition.

Isaac IT Ullah, San Diego State University

AgModel is an agent-based model of a potential scenario for the forager-farmer transition. The model consists of a single software agent that, conceptually, can be thought of as a single hunter-gather community (i.e., a co-residential group that shares in subsistence activities and decision making). The agent has several characteristics, including a running population total, intrinsic birth and death rates, and an annual total energy need (measured in kcal), and an available amount of foraging labor. The model assumes a logistic, central-place foraging strategy in a fixed territory for a two-resource economy: millet and deer. The territory has a fixed number of millet patches, and a starting number of deer. While the model is not spatially explicit, it does assume some spatiality of resources by including search times.

Demographic and environmental components of the simulation occur and are updated at an annual temporal resolution, but foraging decisions are "event" based so that many such decisions will be made in each year. Thus, each new year, the foraging agent must undertake a series of optimal foraging decisions based on its current knowledge of the availability of millet and deer. Other resources are not accounted for in the model directly, but can be assumed for by adjusting the total number of required annual energy intake that the foraging agent uses to calculate its millet and deer foraging decisions. The agent proceeds to balance the net benefits of the chance of finding, processing, and consuming a deer, versus that of finding a millet patch, and processing and consuming that millet. These decisions continue until the annual kcal target is reached (balanced on the current human population). If the agent consumes all available resources in a given year, it may “starve”. Starvation will affect birth and death rates, as will foraging success, and so the population will increase or decrease according to a probabilistic function (perturbed by some stochasticity) and the agent’s foraging success or failure. The agent is also constrained by labor caps, set by the modeler at model initialization. If the agent expends its yearly budget of person-hours for hunting or foraging, then the agent can no longer do those activities that year, and it may starve.

Foragers choose to either expend their annual labor budget either harvesting deer or millet patches. If the agent chooses to harvest deer, they will expend energy searching for and processing deer. Deer search times are density dependent, and the number of deer per encounter and handling times can be altered in the model parameterization (e.g. to increase the payoff per encounter). Deer populations are also subject to intrinsic birth and death rates with the addition of additional deaths caused by human predation. A small amount of deer may “migrate” into the territory each year. This prevents deer populations from complete decimation, but also may be used to model increased distances of logistic mobility (or, perhaps, even residential mobility within a larger territory).

If the agent chooses to consume millet, then they extend time searching for a millet patch and processing the millet grains in that patch. Human selection preferences will drive evolutionary processes within the overall millet population, and the selection rate be altered as a parameterization of the simulation. Two characteristics are selected for: plant morphology (which affects both grain size and ease of harvesting), and patch density (reseeding density). These are generalized into two intrinsic populations of millet: “wild type,” and “domestic type.” Human harvesting will increase the overall ratio of domestic type millet plants in utilized patches over time due to artificial selection in patches that are under consistent use. The ratio will begin to decrease in patches that are not used according to a diffusion rate, and the proportion of wild to domesticated millet in all patches. Morphologically wild millet produces fewer kcal per seed, has longer handling times, and produces fewer seeds per patch. Thus, as millet is more frequently used, its desirable traits are enhanced (via selection), and it becomes more profitable. At the same time, however, there is a constant “diffusion” of wild-type characteristics back to patches so that if millet is consumed less frequently, the proportion of wild type millet will begin to increase in patches that are not used. Currently, millet patches are accessed in the same order every year, so humans are assumed to consistently choose the “best” patches first, if/when they decide to consume millet in a given year. The “size” of individual millet patches is set by the maximum wild/domesticated millet patch density values (default values assume patch size = 1 ha).

I have written AgModel in pure Python with the hope of better integration to scientific Python (e.g., pandas, matplotlib) and the open-science movement. The model has a simple graphical interface, or can be run “headless.” Optionally, experiments using parameter sweeps with repetition can be set up to run in parallel on as many available processors as desired. Careful parameterization of AgModel can test scenarios where complex hunter-gatherers engaged in foraging decisions that interacted with plant evolutionary dynamics to artificially increase the prevalence of domestic type plans in the local ecosystem. When the domestic phenotype is most prevalent, we can consider the species to be “domesticated.” The temporal dynamics of the process of domestication, however, are not linear, and the timeline and longevity of the domestication event may differ under changing environmental conditions.

I will present the results of some initial experiments with AgModel into the dynamics of the forager/farmer transition, with an eye towards understanding why temporal trajectories of domestication may have varied in different times and places around the world. The experiments will show that similar foraging patterns in similar environments may lead to different outcomes (e.g., to “domestication” or not) for a variety of reasons contingent on the specific temporal patterning of any individual case.

The AgModel code is available at: https://github.com/isaacullah/AgModel

References

The model is derived/inspired by ideas and data from the following scholarly works:

Bettinger, R.L., Barton, L., Morgan, C.T., 2010. The origins of food production in North China: a different kind of agricultural revolution, Evolutionary Anthropology 19, 9-21.

Winterhalder, B., Baillargeon, W., Cappelletto, F., Daniel, J., Prescott, I.R., 1988. The population ecology of hunter-gatherers and their prey, Journal of Anthropological Archaeology 7, 289-328.

Belovsky, G.E., 1988. An optimal foraging-based model of hunter-gatherer population dynamics, Journal of Anthropological Archaeology 7, 329-372.

118. An Agent-based model of pre-Columbian land-use in the Monumental Mound Region of Amazonian Bolivia

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Joy Singarayer, University of Reading
Umberto Lombardo, Universitat Autònoma de Barcelona
Francis Mayle, University of Reading

For decades, the extent to which pre-Columbian (pre- 1492 AD) societies were able to modify and "domesticate" Amazonian environments has been heavily debated. Some of the strongest evidence for pre-Columbian landscape domestication comes from the Monumental Mound Region of the Llanos de Mojos (LM), a rainforest-savanna mosaic landscape situated in Northern Bolivia. The LM is a harsh environment in which to survive, and is vulnerable to multiple climatic hazards. This includes being susceptible to droughts during the dry season, as well as widespread flooding during the seasonal rains. In combination with poor soil quality, these hazards have restricted human land-use primarily to cattle ranching for much of the past three centuries.

However, in spite of these challenges, pre-Columbian people undertook landscape domestication in this environment to produce >150 large habitation mounds, interconnected by a complex network of causeways, canals, and lakes (Lombardo and Prümers 2010). Archaeological evidence collected from two of these habitation mounds indicates the presence of a complex agrarian society between 400 and 1400 AD (Prümers 2015). Unlike contemporary Amazonian indigenous groups, maize formed the key component within the diet of this Monumental Mound Culture (Dickau et al. 2012). This implies the society was able to perform large-scale maize cultivation within the LM.

Little is known about how the Monumental Mound Culture utilised and modified the surrounding rainforest and savanna ecosystems, as well as the population size these environments could support. Some argue that, instead of performing slash-and-burn agriculture similar to modern indigenous populations, the culture may have utilised drainage canals to enable cultivation of the open savanna (Lombardo and Prümers 2010). If true, this would constitute a form of agriculture previously unseen in pre-Columbian Amazonia. This could provide valuable lessons for improving the productivity and sustainability of contemporary cultivation practices.

Traditional palaeoecological and archaeobotanical techniques can provide an insight into the impact this society had on the surrounding rainforests and savannas. However, the records these techniques produce are inherently fragmented. A pollen record containing maize can be interpreted to reflect local cultivation, but it cannot indicate where or how much maize was grown. A modelling approach is far better suited for exploring the scale of human land-use (e.g., deforestation, arboriculture, cultivation), generating estimates of population size, and exploring the processes underlying human-environment interactions on the landscape.

In this paper we outline the development of, and preliminary experiments conducted on, an exploratory agent-based model that has been developed to generate hypotheses around the nature and extent of pre-Columbian land-use within the Monumental Mound Region. As a technique, agent-based modelling is ideal for this purpose because system characteristics (e.g., population, patterns of landscape alteration) are treated as the products of human behaviour operating at the individual level. Our model is designed to output data on the extent and spatial distribution of anthropogenically altered land patches under multiple population and land-use scenarios, such as restricting cultivation solely to areas of forested land.

To achieve this goal, our model generates a simplified representation of the Monumental Mound Culture within a virtual, gridded landscape. This landscape is spatially-explicit, informed using imported ecological, environmental, and topographical data published within peer-reviewed literature. The Monumental Mound Culture is represented as a collection of pre-Columbian household agents, which act as the main drivers of the model and represent the primary subjects under investigation. As little is known about the behaviour and cultural practices of the Monumental Mound Culture, household agent behaviour is instead based upon a series of simple rules driven by the demand for vital resources (e.g., maize). Along with agent demographics, these behavioural rules are constrained using ethnographic information sourced from modern indigenous groups living within the LM and across wider Amazonia, as well as from data collected by international organisations (e.g., WHO, FAO).

An agent-based simulation approach in this context is novel as few similar models have been developed to investigate the environmental impacts of pre-Columbian Amazonian communities. By combining data from a variety of disciplines, our model acts as a virtual laboratory to explore how changes in population size and human behaviour impact upon the extent and spatial distribution of agent-altered land on the model landscape. For example, one can observe how the spatial distribution of modified land varies when household agents are programmed to preferentially cultivate land at higher elevation, in order to avoid seasonal flooding. These model outputs can then be compared to empirical observations as they become available. This improves our understanding not only of the degree to which members of the Monumental Mound Community modified their surroundings, but also of the processes and reasons that underlie these human-environment interactions. The outputs will also act as a foundation to guide future research within the region.

Dickau, Ruth, Maria C. Bruno, José Iriarte, Heiko Prümers, Carla Jaimes Betancourt, Irene Holst, and Francis E. Mayle. 2012. "Diversity of Cultivars and Other Plant Resources Used at Habitation Sites in the Llanos de Mojos, Beni, Bolivia: Evidence from Macrobotanical Remains, Starch Grains, and Phytoliths." Journal of Archaeological Science 39 (2): 357–70. https://doi.org/10.1016/j.jas.2011.09.021.

Lombardo, Umberto, and Heiko Prümers. 2010. "Pre-Columbian Human Occupation Patterns in the Eastern Plains of the Llanos de Moxos, Bolivian Amazonia." Journal of Archaeological Science 37 (8): 1875–85. https://doi.org/10.1016/j.jas.2010.02.011.

Prümers, Heiko. 2015. Loma Mendoza. Las Excavaciones de Los Años 1999-2002. Kommission Für Archäologie Außereuropäischer Kulturen Des Deutschen Archäologischen Instituts, 2015. La Paz: Plural Editores.

http://publications.lib.chalmers.se/records/fulltext/245180/245180.pdf%0A.

31. Was there economic thought in the Roman Empire? A comparison of proxy materials and simulated idealized network theories

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The mechanisms of the Roman Imperial economy are not yet well understood although many inroads into the topic have been made for several decades. As economic theory heavily depends on quantification of values that simply cannot be known of the ancient world, proxy materials need to be taken into consideration.

With the help of amphorae and fine wares, a picture of the distributive patterns of goods with a known origin can be traced, equating an approximation of the flow of goods in the Mediterranean.

These patterns can thus be compared with ABM simulated distribution patterns based on networks theories presented by the economist Allen Wilhite that can be related with economic theories. The best fit of these above-mentioned network models with the actual proxy data will hopefully reveal some of the mechanisms of the Imperial Roman economy.

253. Modelling urban evolution - an agent-based approach to city-hinterland dynamics

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In these times of fragile and moving borders, social and political shifts, and rapid climate change, looking into the past can bring much-needed insights into large-scale long-term trends in social systems. With over 70% of the world's population predicted to live in urban areas by 2050 cities are an example of one such system. It is critical to understand the long-term evolution of urban systems if we are to identify sources, mechanisms and strategies for strengthening urban resilience and the most significant risk factors and therefore to ensure the sustainability of urban communities now and in the future. Archaeology and deep history can contribute significantly to this goal (Smith 2010).

The model

The resilience of urban systems is a fundamental factor for the stability of a larger network of social and socio-environmental relationships that may stretch over a much larger area than the city's footprint and needs a broad scope to investigate the micro- and meso- scale interactions that shape urban evolutionary trajectories. To do so, we need a generative abstract model of the city-hinterland interactions aimed at establishing the general schema for urban evolution modelling.

In this paper, we present the first exploratory model that can be used to simulate rural-urban socio-economic interactions from the longue duree perspective (Romanowska, Wren, and Crabtree 2021). It departs from the objective of modelling the processes of production and trade for some of the core goods, in particular agrarian produce, pottery and building materials. It then focuses on the decision-making processes of producers, traders and consumers: what were the socio-economic goals of these groups, what positions did they occupy, and to what extent could they adapt their economic behaviour to changing circumstances? In the end, modelling the economic interactions between the city and the hinterland allowed us to identify to what extent dependencies and inequalities arose from internal economic dynamics, or were governed by political, social and environmental developments.

The case study

The model is applied to the town and surrounding countryside of Forum Hadriani (modern Voorburg), using the economic and demographic evidence and hypotheses presented by (Buijtendorp 2010; Bruin 2017). Over the past 10 years, several research projects have focused on modelling the rural subsistence economy of the Dutch part of the Lower Germanic limes in order to answer the question of whether the local population could provide the Roman military with surplus food. For this, various modelling techniques have been used, including GIS-based carrying capacity models (Dinter et al. 2014), agent-based modelling (Joyce 2019) and cellular automata approaches (Kleijn et al. 2018). All these models have pointed to the possibility, if not the plausibility, of surplus agrarian production in the region, further supporting the hypothesis that food supplies for the Roman army were also obtained locally. In these models, the investigation of socio-economic relations between the rural population and the urban centres has not played a significant role, even when a strong economic dependency between the two can be assumed, given the widespread occurrence of imported goods in the countryside and the spatial configuration of the rural settlement patterns. The specific mechanics of economic interaction thus remain poorly understood, leading to divergent hypotheses on the reasons for economic and demographic growth and decline.

By formalising the economic interactions between the city and the hinterland we study a range of hypotheses focused on the economic aspect of urban resilience. The application of the model to a particular research question concerned with the economic interactions in the Roman Limes region shows the model's potential and its utility for archaeological applications. Finally, the baseline model is designed in a modular fashion making it easy to reuse and repurpose each of the elements.

Bruin, J. de. 2017. Rurale Gemeenschappen in de Civitas Cananefatium 50-300 Na Christus. Leiden: University of Leiden.

Buijtendorp, T. 2010. Forum Hadriani. De vergeten stad van Hadrianus: Ontwikkeling, uiterlijk en betekenis van het "Nederlands Pompeji." Amsterdam: Vrije Universiteit Amsterdam. http://dare.ubvu.vu.nl/handle/1871/16369.

Dinter, M. van, L.I. Kooistra, M.K. Dütting, P. van Rijn, and C. Cavallo. 2014. "Could the Local Population of the Lower Rhine Delta Supply the Roman Army? Part 2: Modelling the Carrying Capacity Using Archaeological, Palaeo-Ecological and Geomorphological Data." Journal of Archaeology of the Low Countries 5: 5–50.

Joyce, J. 2019. "Modelling Agricultural Strategies in the Dutch Roman Limes Zone via Agent-Based Modelling (ROMFARMS)." In Finding the Limits of the Limes. Modelling Demography, Economy and Transport on the Edge of the Roman Empire, edited by P. Verhagen, J. Joyce, and M.R. Groenhuijzen, 109–28. Simulation Studies in Archaeology. New York: Springer.

Kleijn, M. de, F. Beijaard, E. Koomen, and R. van Lanen. 2018. "Simulating Past Land Use Patterns: The Impact of the Romans on the Lower-Rhine Delta in the First Century AD." Journal of Archaeological Science: Reports 20: 244–56. https://doi.org/10.1016/j.jasrep.2018.04.006.

Romanowska, Iza, Colin D. Wren, and Stefani A. Crabtree. 2021. Agent-Based Modeling for Archaeology: Simulating the Complexity of Societies. Santa Fe: SFI Press.

Smith, Michael E. 2010. "Sprawl, Squatters and Sustainable Cities: Can Archaeological Data Shed Light on Modern Urban Issues?" Cambridge Archaeological Journal 20 (2): 229–53.

21. Model transposability: Challenges and implications of transitioning socioecological system models to new regions.

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Introduction

Despite their broad scope and reproducible methodology, socioecological system models are often developed to address specific questions in specific areas of the World characterised by distinctive subsistence and land-management strategies (Filatova et al. 2013). Complex modelling frameworks, investigating long-term human impacts on ecosystem services in one region can be quite difficult to adapt to other regions that face different threats and experienced different socio-economic and environmental processes. Spatial and temporal resolution are generally difficult to adjust, and might lead to major inferential issues (e.g. propagation of error, mismatching granularity between input and output data). Some parameters that are easy to estimate in one region can be quite complex to infer in others, and harmless assumptions about underlying spatiotemporal processes in some regions can have significant consequences in others. Most of the aforementioned limitations are widely acknowledged by the scientific community, and it is recognised that they hinder the reuse of many socioeconomical system models (Elsawah et al. 2020). This in turn has major implications on the comparability of simulation results from different regions, and in turn on the global significance of the insights provided.

In this paper we would like to assess the transposability of socioecological models by tailoring a well-established modelling framework created for prehistoric agropastoral communities in Mediterranean environments to prehistoric pastoral groups in Alpine environments. The goal of the models is to investigate how early farming communities contributed to landscape change by permanently modifying the land-cover and influencing soil-erosion dynamics.

Methods and materials

The model that we present in this paper is based on the MedLanD Modelling Laboratory or MML (Barton et al. 2012), where the subsistence of small-holder agropastoral households is simulated through Agent Based Modelling (ABM) and landscape evolution (vegetation change, soil fertility, and soil loss and accumulation) through Cellular Automata (CA) models. In the original version of MedLanD, ABM and CA are coupled using a Java software. In the version we used (MML-Lite), the coupler is embedded in the main Python codebase. A semi-adaptive version of the subsistence model vas used for the first implementation, simulating a static quota of grazing with fixed goals but enabling adaptive spatial allocation (grazing sites change from year to year). The model was run as addon in GRASS GIS environment (v. 7.8) on Linux OS.

The case study we focused on are the upland pastures of Val di Sole (Italian Alps). Human occupation of this area is documented since the early Bronze Age (BA, 3.8-3.7k BP), and is associated with environmental transformation and increasing slope instability (Angelucci et al. 2021). The ecosystems are alpine and subalpine, dominated by coniferous forest (up to 2000 m) and open grassland (up to 2700 m), and characterised by long cold winters, rainy springs and autumns, and mild summers. The extreme climatic conditions suggest that this area was primarily exploited during the summer, for hunting and livestock grazing.

The MedLanD subsistence model simulates sedentary agropastoral communities, whereas prehistoric groups in Val di Sole were semi-nomadic pastoralists. The first challenge was the adaptation of the agent properties to the new subsistence system. An interesting example is the definition of "site catchment", which imply different things in permanent villages and seasonal contexts (Ullah 2011). Alternative palaeoeconomic scenarios, based on mathematical subsistence models (Carrer et al. 2019), were produced to estimate key parameters.

The landscape evolution model of MedLanD is calibrated on the environmental characteristics of Mediterranean landscapes, which include rapid vegetation recovery, susceptibility to intense rainfall, overgrazing, etc. Alpine and subalpine landscapes are very different, and profound adjustments of land-cover, soil and precipitation parameters were required. The main challenge was the verticality of the investigated landscape, as climatic and ecological characteristics vary with elevation (Walsh and Giguet-Covex 2020).

Results & Discussion

The first results suggest that MedLanD can be transposed to the new case study in Val di Sole. Small changes in the ABM should be enough to incorporate seasonality. The landscape evolution dynamics can be revised to include spatial variability and inhomogeneous vegetation succession rates. Main challenges include streamlining the transposition process and simplifying parameters that are difficult to estimate for certain regions and/or chronologies. Future changes in the model, towards a more flexible modelling ecosystem, would encourage the reuse of MedLanD. This would enable the assessment of human-induced vegetation change and soil loss simulated in different socioecological systems (at different timescales), thus triggering new comparative discussions on long-term sustainability and landscape vulnerability.

References

Angelucci, Diego E., Francesco Carrer, Lucas Ageby, Marco Bettelli, and Elisabetta Castiglioni. 2021. 'Occupazione Pastorale Delle Alte Quote Alpine Nell'età Del Bronzo : Primi Dati Dal Sito MZ051S (Camp Da Ortisé, Val Di Sole, Trento)'. Rivista Di Scienze Preistoriche : LXXI, 2021, no. 71. https://doi.org/10.32097/1143.

Barton, C. Michael, Isaac I.T. Ullah, Sean M. Bergin, Helena Mitasova, and Hessam Sarjoughian. 2012. 'Looking for the Future in the Past: Long-Term Change in Socioecological Systems'. Ecological Modelling 241 (August): 42–53. https://doi.org/10.1016/j.ecolmodel.2012.02.010.

Carrer, Francesco, Graeme Sarson, Andrew Baggaley, Anvar Shukurov, and Diego E. Angelucci. 2019. 'Ethnoarchaeology-Based Modelling to Investigate Economic Transformations and Land-Use Change in the Alpine Uplands'. In Integrating Qualitative and Social Science Factors in Archaeological Modelling, edited by Mehdi Saqalli and Marc Vander Linden, 185–216. Computational Social Sciences. Cham: Springer International Publishing. https://doi.org/10.1007/978-3-030-12723-7_8.

Elsawah, Sondoss, Tatiana Filatova, Anthony J. Jakeman, Albert J. Kettner, Moira L. Zellner, Ioannis N. Athanasiadis, Serena H. Hamilton, et al. 2020. 'Eight Grand Challenges in Socio-Environmental Systems Modeling'. Socio-Environmental Systems Modelling 2 (January): 16226. https://doi.org/10.18174/sesmo.2020a16226.

Filatova, Tatiana, Peter H. Verburg, Dawn Cassandra Parker, and Carol Ann Stannard. 2013. 'Spatial Agent-Based Models for Socio-Ecological Systems: Challenges and Prospects'. Environmental Modelling & Software 45 (July): 1–7. https://doi.org/10.1016/j.envsoft.2013.03.017.

Ullah, Isaac I.T. 2011. 'A GIS Method for Assessing the Zone of Human-Environmental Impact around Archaeological Sites: A Test Case from the Late Neolithic of Wadi Ziqlâb, Jordan'. Journal of Archaeological Science 38 (3): 623–32. https://doi.org/10.1016/j.jas.2010.10.015.

Walsh, Kevin, and Charline Giguet-Covex. 2020. 'A History of Human Exploitation of Alpine Regions'. In Encyclopedia of the World's Biomes, 555–73. Elsevier. https://doi.org/10.1016/B978-0-12-409548-9.11908-6.

334. Simulation in the age of machine learning

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Context

Simulation is a methodological approach that aims to improve our knowledge about real-world phenomena through experimentation on mathematical models as similes. In contrast to other mathematical models, such as those used in statistics, simulation models are designed to reproduce patterns and trends in empirical data not directly but as outcomes of postulated mechanisms under controlled conditions. While other mathematical models may involve explanations, the conjecture of causality remain outside the model formulation and will be used solely to justify or interpret their formal design. Simulation models, on the other hand, are themselves formal definitions of causal relationships, sitting in-between datasets and theory. In this sense, the many varieties of simulation are often referred to as process-based or explanatory modelling, in contrast to approaches that are data-based or descriptive, among which machine learning (ML) is currently the most promising. In terms of practice, simulation modellers take on different tasks than those of data scientists, as the workflow of the former require a model to be defined with precision, and then exploring a wide range of inputs and outputs, whereas the latter demand that the input and output is given to define a model.

Main argument

The digitalisation of statistics and the increasing computational complexity in data science has pushed simulation modelling to become a rather separate and somewhat niche community of practice. In some circles and disciplines, simulation is even regarded as a lesser and weaker methodology, given its relatively freedom towards empirical data (Winsberg 2010). However, once the differences between simulation and statistical inference are well understood, together with their strengths and limits, we can go beyond the misperception of a methodological opposition.

Regarding ML, there are many opportunities for exchange and combination that hold the potential for revolutionising our approach to scientific problems (von Rueden et al. 2020). The aim of this paper is to raise awareness of the possibilities explored or still to explore, organising them according to their role in both simulation and ML workflows, and showcasing a selection of examples of applications in archaeology and beyond

Simulation for ML:

- Simulation for the creation of training datasets
- Simulation models as ML hypothesis set
- Simulation models as learning algorithms
- Simulation for validation of final ML hypothesis

ML for simulation:

- ML for model generation
- ML for model selection (e.g., Carrignon, Brughmans, and Romanowska 2020)
- ML for surrogate model generation
- ML for preprocessing or selecting input data
- ML for pattern detection in simulation output
- ML for parameter calibration and optimisation
- ML as simulation model component

Implications

These and other areas of applications are not only promising for simulation and ML studies separately but carry the possibility of inaugurating a new scientific methodology, able to treat complex problems that otherwise would have been avoided as intractable or even unsolvable. As the simulation of social and socio-ecological processes are applied to archaeology and history, such a revolution could in fact make of this approach, if not a time machine, something perhaps better: a what-if machine, informed by both consolidated human knowledge and the data of numerous generations of humans in the past.

The benefits of artificial intelligence to the achievement of the UN Global Goals remain to this day mainly instrumental, as an approach that generally makes certain analytical processes more effective and faster. That is because of the characteristic semantic void behind the mathematical formulation of ML so far. However, the further combination with simulation may be able to fill this gap in the near future, helping the more consciously exploration of the solution space lying beyond the immediate imagination of current societies.

References

Carrignon, Simon, Tom Brughmans, and Iza Romanowska. 2020. 'Tableware Trade in the Roman East: Exploring Cultural and Economic Transmission with Agent-Based Modelling and Approximate Bayesian Computation'. Edited by Sergi Lozano. PLOS ONE 15 (11): e0240414. https://doi.org/10.1371/journal.pone.0240414.

Rueden, Laura von, Sebastian Mayer, Rafet Sifa, Christian Bauckhage, and Jochen Garcke. 2020. 'Combining Machine Learning and Simulation to a Hybrid Modelling

Approach: Current and Future Directions'. In Advances in Intelligent Data Analysis XVIII, edited by Michael R. Berthold, Ad Feelders, and Georg Krempl, 12080:548–60. Lecture Notes in Computer Science. Cham: Springer International Publishing. https://doi.org/10.1007/978-3-030-44584-3_43.

Winsberg, Eric. 2010. Science in the Age of Computer Simulation. University of Chicago Press. https://doi.org/10.7208/chicago/9780226902050.001.0001.

26. For a Bright Future: Challenges and Solutions for the Long-Term Preservation of 3D and Other Complex Data in Digital Cultural Heritage

Kristin Kruse, Canton of Zurich, Department of Archaeology and Cultural Heritage
George Alexis Pantos, University of Oslo, Museum of Cultural History, Department of Collection Management
Roberta Marziani, Wessex Archaeology, Department of Geomatics
Chris Breeden, Wessex Archaeology, Department of Geomatics

Location: E107

The age of digital documentation has dawned. Fully digital methods (e.g., the use of total stations, photogrammetry, laser scans, computer modelling, etc.) are used in fieldwork as well as in analysis and communication on a regular basis. Once an exception, these complex and multidimensional data tools are increasingly the rule, and their output often exceeds both the technological capacity and the workflows of existing institutional infrastructure. Specialist repositories such as the Archaeological Data Service (ADS), the Digital Archaeology Record (tDAR) and others have pioneered approaches to long-term data storage, based around international standards and concepts such as the Open Archival Information System OAIS (CCSDS 2012). However, the volume and variety of primary data have transformed the data storage landscape. As highlighted by Moore et al. (2022), there remains a high degree of variability in archiving approaches, not only across different specialisms but also within individual communities. At the same time, innovation and the wider adoption of technology in society are set to continue. It remains to be seen whether the broader application of the London Charter (Denard 2012), the FAIR principles (Wilkinson 2016) or new standards from the widely anticipated Metaverse (Metaverse Standards Forum) will be a positive standardising force or whether the developing technologies will only exacerbate existing challenges. The OAIS archiving strategy requires the stakeholders of a shared domain to enter into dialogue with one another for the purpose of developing a meaningful preservation plan. After all, the plan will require not only the expertise and perspective of the data managers, but also of those producing and supplying the data and the downstream data consumers. This session sounds the call for further discussion. It invites papers that present strategic and theoretical approaches to the preservation and future reuse of complex digital data, as well as examples of practical workflows which achieve this aim. We are looking for participation from governmental institutions and private companies as well as individual researchers, and for papers that encourage debate. We ask that submissions include a brief introduction to the organisation represented and recommend that the papers be based on a 3D-data case study, although discussions of other types of complex digital data are also welcome. The aim of the session is to spread awareness of different approaches and outlooks, to spark an international dialogue with broad participation, and contribute to building the foundations for a bright future in digital cultural heritage.

References:

ADS Archaeology Data Service, https://archaeologydataservice.ac.uk, date accessed: 19 Aug 2022. ▪ CCSDS (2012) Reference model for an open archival information system (OAIS). https://public.ccsds.org/pubs/650x0m2.pdf, date accessed 19 Aug 2022.

Denard H. (2012) A New Introduction to the London Charter. In: Bentkowska-Kafel A., Baker D., Denard H. (eds.) Paradata and Transparency in Virtual Heritage Digital Research in the Arts and Humanities Series, 57-71. https://www.londoncharter/introduction.html, date accessed 19 Aug 2022.

Metaverse Standards Forum, http://metaverse-standards.org, date accessed 19 Aug 2022.

Moore J., Rountrey A., Scates Kettler H. (2022) 3D Data Creation to Curation: Community Standards for 3D Data Preservation, https://www.ala.org/acrl/sites/ala.org.acrl/files/content/publications/booksanddigitalresources/digital/9780838939147_3D_OA.pdf, date accessed 19 Aug 2022.

tDAR Digital Archaeological Record, https://www.tdar.org, date accessed: 19 Aug 2022.

Wilkinson M. D. et al. (2016) The FAIR Guiding Principles for scientific data management and stewardship. Scientific data, 3(1), 1–9. https://doi.org/10.1038/sdata.2016.18.

SLOT 1	
08:30 - 08:50	**Introduction**
08:50 - 09:10	254. Archiving the Third Dimension *Esther Schoenenberger (Archaeology and heritage management for the canton of Zurich)*; Raphael Annaheim (Archaeology and heritage management for the canton of Zurich)*
09:10 - 09:30	309. Experiences from the BItFROST Project: Developing a 3D repository at the Museum of Cultural History *Letizia Bonelli (Museum of Cultural History)*; Hallvard R Indgjerd (Museum of Cultural History, University of Oslo); Alexis Pantos (Museum of Cultural History); Espen Uleberg (NO)*

09:30 - 09:50	196. ᚐᚏᚉᚆᚔᚃᚓ: Reusing and Building Reusability of data into the OG(H)AM project archive *Megan N Kasten (University of Glasgow)**
09:50 - 10:10	203. Ancient Images 2.0 - Digital preservation of Gotland's Picturestones *Michael Fergusson (Viospatia AB)*; Henrik Jansson (Gotlands Museum)*
10:10 - 10:30	374. Smithsonian's Packrat: How to have your 3D cake and eat it too *Jonathan W Blundell (Smithsonian Instution)**
SLOT 2	
11:00 - 11:20	240. Building a FLOSS Multi/Metaverse for Cultural Heritage: MAPOD4D *Marco Moderato (DISPUTER - Università di Chieti)*; Roberto Taglioretti (ArcheOs Tec); Alessandra Mazzucchi (ArcheOs Tec); Vasco La Salvia (DISPUTER - Università di Chieti); Edoardo Olmo Puricelli (Osteoarc-APS); Caterina Giostra (Dipartimento di Storia, Archeologia e Storia dell'arte Università Cattolica del Sacro Cuore, Milano)*
11:20 - 11:40	**Discussion**

254. Archiving the Third Dimension

Esther Schoenenberger, Archaeology and heritage management for the canton of Zurich
Raphael Annaheim, Archaeology and heritage management for the canton of Zurich

Six years ago, our department has defined 3D photogrammetry (SfM) as new documentation standard. The 3D documentation of various sites has shown the advantages of this method, especially when documenting complex 3D structures. While generating 3D models was a well-trodden path, the storage of 3D meshes with textures needed, and still needs some exploration. For the next 4 years, we are testing an archiving solution, where access and storage are treated as two separate issues. This allows userfriendly viewing options (e.g. 3D PDF or VR application). For long term use the same models are stored seperately in a normalised geometry file (e.g. OBJ file). Since long-term standards for 3D data have yet to be established, we have decided to provide a temporary backup system by keeping the raw data (photos) together with a processing report for replication purposes. However, this is still a trial and error approach. Therefore, we would like to present our progress in this matter and discuss our approach with fellow 3D enthusiasts.

309. Experiences from the BItFROST Project: Developing a 3D repository at the Museum of Cultural History

Letizia Bonelli, Museum of Cultural History
Hallvard R Indgjerd, Museum of Cultural History, University of Oslo
Alexis Pantos, Museum of Cultural History
Espen Uleberg, NO

The Museum of Cultural History (MCH) is the largest of five Norwegian university museums. It is responsible for archaeological excavations in the Eastern and Southern counties of Norway. Every year there are 50-60 rescue excavations, and seldom any research excavations. The museum is also responsible for the curation of objects older than the reformation (1537 AD) found in this part of Norway, whether they are from excavations, surveys, metal detecting or just stray finds. MCH is partner in ARIADNE+, SEADDA and IPERION, and also leads the National cooperation UniMus:Kultur which aims to create common database solutions for the collections at the University museums with cultural historical collections; but it is also seeking interconnection between different types of information related to excavations within the ADED project. The main focus of the ADED project is to improve data accessibility through the development of a system that combines all available information related to a single excavation.

3D documentation of objects at MCH began in 2002, and the museum has been steadily building its 3D documentation capacity since, promoting and encouraging the use of 3D in research and dissemination. Today 3D capture also includes aerial, terrestrial and artefact level photogrammetry, structured light scanning as well as growing application of CT scanning. The 3D data cover a range of subjects from the museums' own excavations to documentation of artefacts held in the ethnographic collections and data acquisition for external clients.

This presentation will focus on the recent BItFROST project (https://www.khm.uio.no/english/research/projects/bitfrost/)and associated work relating to this new addition to the museum's digital infrastructure. BItFROST is a collaboration between the MCH, the Department of Archaeology, Conservation studies and History, and the Department of Media and Communication at the University of Oslo, the Visual Computing Lab at CNR-ISTI and DarkLab at the University of Lund. The central aim of the project is to develop an open and accessible portal to the 3D data being compiled at the museum and complement the existing public repositories of images, maps and excavation data. The platform interface and repository developed is targeted toward the research community and leverages the versatile 3DHop library (https://3dhop.net/) and nxz format that provides high resolution data online (Potenziani et al. 2015), while preserving full data sovereignty. However, this web portal is only one part of a much bigger picture. An additional goal within the framefork of the BItFROST project is to identify longer term preservation strategies for the variety of 3D data being acquired. The complexity of the datasets, as well as the complexity of some of the production workflows posed some major challenges while at the same time providing an opportunity to reflect on the museum's approach toward FAIR data standards (Wilkinson et al. 2016). 3D data will be interconnected with meta- and paradata, and made interoperable with existing resources and databases, in order to contextualise the data and provide improved reuse and accessibility. Through this work we have been able to better identify our principal target communities and their requirements, take stock of existing data practices across the organisation and identify weak points in available workflows and infrastructure and so work toward better solutions.

With every recording situation and documentation need being different, it is difficult to stipulate a one-size fits all approach to data management. This remains true even within a single organisation and any solution will necessarily be a tapestry of methods. In this presentation we hope to share some of the lessons learned and the practical solutions, decisions taken, resources used, and methods and scripts developed that may benefit others in a similar situation. At the same time, we will raise some of the broader questions that arise as part of this archive structuring process and contextualise our efforts within the museum's broader strategy and ongoing commitment to providing access to heritage in Norway. One of the most significant, and in some ways unexpected challenges faced inthe current project was dissemination of the affordances and limitations of 3D data in its multitudinous forms. Expectations of end users and even data producers remain very broad and the variety of communities of interest, from members of the public and museum visitors to conservators and exhibition designers, has given us cause to consider more deeply the role of these assets and see them as more than imperfect copies of originals, rather as 'extended objects' (Jeffrey et al. 2021) with their own affordances in the wider discussion that is heritage.

There is no doubt the future will throw up new archiving and workflow challenges as we continue to see the miniaturisation of technology. The growth of new AI techniques such as Neural Radiance Fields (NeRFs) are already on the horizon and documentation is set to become ever easier. However, somewhat perversely, the documentation of that documentation remains as challenging as ever.

References

Jeffrey, Stuart, Steve Love and Matthieu Poyade. 2021. "The Digital Laocoön: Replication, Narrative and Authenticity." Museum and Society 19, No 2: 166-183. https://doi.org/10.29311/mas.v19i2.3583

Potenziani, Marco, Marco Callieri, Matteo Dellepiane, Massimiliano Corsini, Federico Ponchio and Roberto Scopigno. 2015. "3DHOP: 3D Heritage Online Presenter." Computer & Graphics 52: 129-141. https://doi.org/10.1016/j.cag.2015.07.001

Wilkinson, Mark D., Michel Dumontier, IJsbrand J. Aalbersberg, Gabrielle Appleton, Myles Axton, Arie Baak, Niklas Blomberg et al. 2016. "The FAIR Guiding Principles for scientific data management and stewardship." Scientific Data 3: 1-9. https://doi.org/10.1038/sdata.2016.18

196. ᚐᚏᚄᚁᚔᚈᚓ: Reusing and Building Reusability of data into the OG(H)AM project archive

Megan N Kasten, University of Glasgow

The OG(H)AM project aims to digitally document all c.640 examples of ogham writing in all media from the 4th century AD to 1850 AD. This includes documenting each example both visually with 2D images and 3D models (or RTI where appropriate), and textually with EpiDoc/TEI XML encoding to record the ogham inscriptions and associated metadata in a machine-readable format. The quantity of inscriptions and the range of materials that have been inscribed with ogham, whether stone monument, knife handle, or manuscript, requires a consistent approach to 3D metadata from the outset to build a cohesive archive. With Linked Open Data and FAIR principles in mind, and while consulting with epigraphy.info and researchers in adjacent fields, we are developing a controlled vocabulary. This paper will explore the challenges in adapting existing standards for ogham and in developing the structure of our archive, particularly when incorporating archived 3D scans from previous projects and scanning initiatives (i.e. Ogham in 3D and Archaeoptics 3D for UCC Cork).

203. Ancient Images 2.0 - Digital preservation of Gotland's Picturestones

Michael Fergusson, Viospatia AB
Henrik Jansson, Gotlands Museum

Introduction

Based at Stockholms University and Gotland's Museum, Ancient Images 2.0 is a project funded by the Swedish Research Council and Riksbankens Jubileumsfond with four goals: 1) 3D digitization of the entire corpus of Gotlandic picturestones 2) Collection and digitization of all literature, reports, photographs and drawings, letters and other information in archives 3) Creation of an online database addressed to both public and researchers and 4) New iconographic research and interpretation based on the 3D data. Gotland's Museum is a local museum based in Visby, Sweden, and Viospatia AB is a company focused on developing automated real-time 3D inspection systems for use in manufacturing. This paper will outline our methods and present preliminary results of the project from planning, digitization, data processing, data archiving and the development of the public database. Through this paper we hope to foster discussion on how digitization projects should begin with a strong data-management plan and budget to ensure data preservation after the project ends. By presenting the lessons we learned, we hope this paper helps other projects in their planning.

Methods and materials

The project goal of preservation was key to our chosen digitization method. The requirement to capture intrinsic colour data meant that the only choice was photogrammetry. Some projects choose to rely on laser or structured light scanners because they have specifications of the highest accuracy, despite not recording true point-for-point colour data. Photogrammetry is scale invariant and allows modelling of both tiny and massive objects, but it requires accurate scale reference (Lato, Bevan and Fergusson 2012). We developed (relatively) low-cost but highly accurate scale-bars made of Invar to use in the project. We chose to use a 150 megapixel medium format digital back from PhaseOne and a custom 3D-printed metric camera body from Alpa (Rosenbauer et al. 2018). This camera was selected to reduce the amount of time spent in the field, to enable the use of high shutter speeds with strobes to allow data-capture in direct sunlight, and to reduce the number of photographs required to achieve the accuracy goal of 0.01mm at a ground pixel size of 0.04mm.

The data generated in this project is not just photographs and 3D data. Since the picturestones have been well-researched, there is a significant amount of paper-based research data including detailed texts containing all information about original find contexts and current location, object biography, chronology, inscriptions, photographs and drawings, ornamentation, interpretations, and references (Oehrl 2019). All of this data has been digitized and will be included in the public database.

From the beginning, the database was planned to be interactive, bilingual (Swedish and English), and freely available. Open source tools were a vital prerequisite as the database and 3D visualizations require tight integration. The chosen tools for achieving this were Omeka S, a web publishing platform aimed at cultural heritage institutions, and 3DHOP, a 3D visualization tool capable of handling large 3D models. Omeka S is built to be used with Linked Open Data which allows our data to be easily accessed by other systems common and free protocols. We have configured our 3DHOP viewer to allow users to toggle between RGB colours and greyscale depthmaps of the stones to better display faint carvings (figure 1).

Results

The 570 picturestones are split between 4 different locations: 1) in museum storage – primarily on pallets, 2) on display in museums or in churches, 3) built into existing buildings – primarily churches but also houses and ruins, and 4) in the wilderness – in forests, fields or on private property. Accessibility was an issue and impacted the accuracy and resolution of some photogrammetry projects. Across most projects the photogrammetric accuracy averaged 0.4px, giving us an average project accuracy of 0.06mm at a resolution of 0.075mm. The number of stones to be digitized ballooned throughout the project since many of the stones are broken in multiple fragments, and new stones were discovered during fieldwork. To cover the full scope, we captured 2x to 5x the number of photos originally anticipated per stone.

The amount of data generated by this project is in excess of 40tb, with an average of 60GB per stone; double the amount of data expected at the start of the project. The photographs are proprietary RAW format files, which required conversion to two different formats for photogrammetric processing and archiving. To cope with this amount of data several storage solutions were evaluated: cultural heritage repositories, cloud-based storage and self-hosted servers. The long-term storage was not included in the original project budget, and this lack of funding has forced us to choose self-hosting as the most cost-effective solution; allowing the project to purchase servers and transfer maintenance duties to Gotland's Museum afterwards.

Discussion

In the initial stages of the project application, making the dataset free and publicly available looked like a simple goal. Our choice of method was made to enable easy archiving of both raw data and result data, however the extreme to which we took photogrammetry in this project created several complications to achieving this core goal. Achieving metric-grade photogrammetry results is not easy, and even with the best theoretical methods there will always be difficulties achieving ideal results in the field. We hope this paper illuminates the benefits and difficulties of working with extreme high-resolution photographs for photogrammetry, and the process of developing a public database that combines 3D data with historical archaeological data.

References

Lato, Matthew & Bevan, George & Fergusson, Michael. 2012. Gigapixel Imaging and Photogrammetry: Development of a New Long Range Remote Imaging Technique. RS. 4. 3006-3021. https://doi.org/10.3390/rs4103006.

Oehrl, Sigmund. 2019. Die Bildsteine Gotlands – Probleme und neue Wege ihrer Dokumentation, Lesung und Deutung. Friedberg: Likias Verlag.

Rosenbauer, Ralph & Fontana, Filippo & Hastedt, Heidi & Luhmann, Thomas & Ochsner, David & Rieke-Zapp, Dirk & Rofallski, Robin. 2018. Advantages in Additive Manufacturing for a Medium Format Metrology Camera. 296-307. https://doi.org/10.1007/978-3-319-66866-6_28.

374. Smithsonian's Packrat: How to have your 3D cake and eat it too

Jonathan W Blundell, Smithsonian Instution

The uptake of 3D digitization as a valuable tool for investigation and documentation continues to grow across the humanities and science disciplines, a trend that is reflected around the word as well as the Smithsonian Institution. While the use of 3D digitization has proliferated, the backend systems tasked with managing the data produced by those activities usually are not designed to handel complex data and lack the necessary features for robust stewardship and publication. To address these issues, the Smithsonian's Digitization Program Office (DPO) has rolled out three tools. Cook, an automated data processing engine; Voyager, a 3D content authoring and publication platform; and Packrat, a 3D asset management and content management platform. (Smithsonian Digitization Program Office 2022) Together, they are designed to enable efficient and effective 3D capture, asset stewardship and content delivery.

For the past 5 years the Smithsonain's DPO has been developing this pipeline to support 3D digitization activities across the Smithsonian Institution (SI), which is the world's largest museum, education, and research complex, composed of 21 museums, 19 research centers, and a national zoo. Each of these units has its own unique scope of collections, data management practices, and information systems that relate to its specific domain. With 155 million objects in the SI collections spanning the last 3.5 billion years and covering every imaginable topic, from cultural heritage to the natural sciences, the institution's holdings are heterogeneous to say the least. With such a diverse set of stakeholders and possible content, the pipeline's tools have been developed to be as subject matter and system agnostic as possible. The decentralized nature of the SI also means there is less of a top down mandate to use any one system, so it is critical that the tools add value to all users in the digitization process to encourage adoption.

Centered around Packrat, the SI pipeline aims to alleviate as many of the pain points related to 3D data management, processing, and publication as possible. Packrat leverages Cook for all 3D data manipulation and inspection needs. On ingestion, any supported capture data type or 3D model type is validated, metadata is extracted, and relationships are built between capture data files and the 3D models derived from them. Also at ingest, Cook automatically generates a Voyager scene package and creates 10 models of different levels of detail and file types per model. As soon as the scene is ready, Packrat leverages Voyager to provide a quick and easy quality control review as well as an interface to enhance the 3D scene with annotations and other storytelling content. Once ingested, 3D models in Packrat are well documented and ready for preservation. Within half an hour of initial ingest, models can be ready for publication to the web along with a variety of downloads, from the original model down to a model optimized for use in real time AR. By reducing the tedious work of processing and metadata entry, we hope to encourage more users across the institution to submit their 3D work products to packrat, enabling the long term preservation of those assets and facilitating their publication and ultimate reuse.

References

Cultural Heritage Imaging. 2012. "Digital Lab Notebook." Cultural Heritage Imaging. https://culturalheritageimaging.org/Technologies/Digital_Lab_Notebook/.

IIIF Consortium. 2022. "New 3D Technical Specification Group — IIIF | International Image Interoperability Framework." IIIF. https://iiif.io/news/2022/01/11/new-3d-tsg/.

Smithsonian Digitization Program Office. 2022. "Open Source Resources | 3D Digitization." 3D Digitization. https://3d.si.edu/open-source-resources.

240. Building a FLOSS Multi/Metaverse for Cultural Heritage: MAPOD4D

Marco Moderato, DISPUTER - Università di Chieti
Roberto Taglioretti, ArcheOs Tec
Alessandra Mazzucchi, ArcheOs Tec
Vasco La Salvia, DISPUTER - Università di Chieti
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Caterina Giostra, Dipartimento di Storia, Archeologia e Storia dell'arte Università Cattolica del Sacro Cuore, Milano

One of the most recent phenomena in the digital world is the metaverse "revolution". Along with Facebook®'s announcement of its rebranding into Meta®, the word metaverse has been a hot topic of discussion in the past months. Although several commercial applications are already implemented or in the developing stage, metaverses applied to cultural heritage are still an unknown territory. The digital evolution, especially in the gaming industry has pushed the virtual environment to a new level, while showing that also videogames can convey a sense of interest and realism through historically (more or less) accurate worlds (Huggett 2020, 2).

Most digital research on cultural heritage dissemination has focused on virtual reality, with all its known issues and limits, applying mainly to architectural reconstructions (Pujol Tost 2008: 106-7, Tan and Rahaman 2009: 146-9). Often these virtual realities are also passive, meaning that the interaction (where present) is limited to the 3D environment itself.

This paper provides an overview of MAPOD4D (Multi Analysis PrObe Drone 4D) as an example of a metaverse environment applied to different fields of cultural heritage.

MAPOD4D is an innovative platform and framework for developing a multiverse of metaverses with a specific application in the field of archaeology, anthropology, history, art and cultural heritage in general.

The multiverse allows linking the different metaverses created to access real contents/data. Each metaverse can contain a virtual reality and can be linked to other metaverses. In the MAPOD4D framework, several applications interact that respond to the aims of the project and provide different datasources. These applications can be divided into five categories:

- Digital image processing
- Repository data
- Digital laboratory
- New sensors for the data acquisition
- New technological methods

The platform, the framework and the projects are developed with FLOSS software only, with the aim of maintaining cost sustainability, meaning that MAPOD4D is fully compliant to 4 laws of free libre software: the freedom to use the software for any purpose, the freedom to change the software to suit your needs, the freedom to share the software with your friends and neighbours, and the freedom to share the changes you make.

In addition to the ability to reproduce (infinite) metaverses, MAPOD4D can connect to external datasets such as databases, raster and vector data, thus providing an environment where not only 3D models can be explored, but also tables, graphs and so on can be dynamically called. This means that the interaction within MAPOD4D are not limited to the virtual reality but they embrace the datasets from which the reality was created. At this stage of development, MAPOD4D has already been tested against real datasets, with the creation of instances based on existing anthropological and archaeological examples. MAPOD4D's applications range from pure research to dissemination and span across the different branches of cultural heritage.

Hereby we provide two applications of MAPOD4D:

As an anthropological example, we propose a simulation of an osteological and interactive laboratory with the 3D digitization of grave 14 from Lovere (BG, Italy). The bones were arranged in anatomical and stand positions; the pathological elements are shown with radiological supporting analysis and we focused on elements and methods for age determination.

As for the application in archaeology, a context of the excavation of Casa Piccoli in Castelseprio (VA, Italy) was reconstructed through MAPOD4D. MAPOD was populated with data from the dig: archaeological stratigraphies were modelled as three-dimensional objects and inserted into the relevant metaverse. To these were added, at the current state of the work, measurements of magnetic anomalies and sounds.

Reference

Huggett, Jeremy. 2020. «Virtually Real or Really Virtual: Towards a Heritage Metaverse». Studies in Digital Heritage 4 (1): 1–15. https://doi.org/10.14434/sdh.v4i1.26218.

Tan, B.-K., e H. Rahaman. 2009. «Virtual heritage: Reality and criticism». In Joining Languages, Cultures and Visions, 143–56. CUMINCAD. http://papers.cumincad.org/cgi-bin/works/Show&_id=caadria2010_003/paper/cf2009_143.

Tost, Laia Pujol. 2007. «Does Virtual Archaeology Exist?» In Layers of Perception. Proceedings of the 35th International Conference on Computer Applications and Quantitative Methods in Archaeology (CAA), Berlin, Germany, April 2–6, 2007 (Kolloquien Zur Vor- Und Frühgeschichte, Vol. 10), a cura di A. Posluschny, K. Lambers, e Irmela Herzog, 101–7. Bonn.

29. How do we ensure archaeological data are usable and Reusable, and for whom? Putting the R in FAIR

Sara Perry, MOLA (Museum of London Archaeology)
Holly Wright, Archaeology Data Service (ADS), University of York, UK

Location: E106

The last decade has seen extensive efforts to make digital assets more accessible and dynamic through experimentation with interoperability in cultural heritage aggregation infrastructures (e.g., the Europeana or ARIADNE portals). Such infrastructures allow static resources to be updated and cross-searched, but to do so, the metadata for these assets must be mapped in a centralised and controlled way. This can take the shape of mapping to a controlled vocabulary, thesaurus or ontology, which invariably reflects the types of terminology and relationships defined by those who are charged with curating the data (domain specialists), not those who might use the data in new and innovative ways. Digital data curation for cultural heritage has therefore reached a critical impasse. A central tension exists between the need to preserve cultural resources, and the dynamic potential for their use and reuse in democratic, just and compelling ways. At the same time, the introduction of the tetrarchy of FAIR Guiding Principles (Findable, Accessible, Interoperable, Reusable) for scientific data management and stewardship (Wilkinson et al. 2016) has set an important challenge: that each of the four principles is of equivalent importance and must therefore be engaged with equally. Within archaeology, much work has been done over the last 20 years to make data Findable, Accessible and Interoperable, but very little is understood about whether data are Reusable–and by whom (Wright and Richards 2018). The impact of this gap in knowledge is profound, as cultural heritage data are increasingly drawn into divisive debates, dangerous speech, cross-border misinformation-sharing and xenophobia, therein compromising human solidarity and social cohesion (e.g., Bonacchi and Krzyzanska 2021). Newly-funded through the Transformations: Social and cultural dynamics in the digital age programme of the Collaboration of Humanities and Social Sciences in Europe (CHANSE) Consortium, Transforming Data Re-use in Archaeology (TETRARCHs) argues that the future of digital curation depends upon reconciling this divide between collection and reuse. It aims to demonstrate that data optimised for ethical and emotive storytelling will provide the bridge between those who find or preserve heritage assets, and the diverse cross-European audiences for whom they might generate meaning. TETRARCHs builds upon international initiatives which seek to improve the accessibility of digital cultural heritage data via interfacing with those data: browsing them, searching them, and retrieving them in more 'generous' ways (e.g., (Whitelaw 2015). However, even as such experimentation grows, the assets themselves continue to be bound by relatively narrow classifications imposed by experts. Herein structure and reliability are maintained, but relevance and accessibility to the wider world remain limited (Manzo et al. 2015). The stories that can be told through the data are often narrow and pre-determined, with the vast majority devoid of affect, sensuality and agency (Krmpotich and Somerville 2016). The urgency of the predicament is heightened by growing interdisciplinary acknowledgement that this rift is directly linked to systemic bias, social inequity and racial injustice in data repositories (Sanderson and Clemens 2020). Efforts to rectify these biases include archival redescription (Pringle 2020), revised ethical metadata standards (Farnel 2018), felt-experience conceptual model extensions (Canning 2018), and alternative 'fluid ontologies' (Srinivasan 2018). The imperative for change to data infrastructures is overt. Yet recognition that such change must begin from the moment the data are conceived (as opposed to the moment they are deposited into a repository) has been slow in coming. Furthering our argument is the rapid pace of innovation with data acquisition technologies (Morgan et al. 2021), whose workflows still fail to capture important descriptive detail, emotion, human values and multiple viewpoints. Even as community-driven practices grow in popularity, fundamental redesign of our workflows and data to embed communities and justice at their core is still lacking (Dolcetti et al. 2021). Design Justice frameworks enabling such value-led, co-created redesign of digital structures are blossoming (Costanza-Chock 2020), but their systematic use in fields like archaeology is effectively nonexistent. Through an interdisciplinary team of archaeological specialists, data scientists, and museum practitioners, collaborating with three key user groups – domain experts, creative practitioners, and memory institutions – TETRARCHs will offer those who gather, curate and apply cultural heritage data with critically-aware workflows to prepare their data for enhanced re-use at every point in the data lifecycle (e.g., capture, mapping, lab-based analysis), then scenario-test such re-use through the dissemination of new narrative outputs authored by cross-European creative practitioners. The project embraces three scales of data collection in archaeology – landscape, site and artefact – exploring them via four increasingly ubiquitous technologies for data capture: airborne LiDAR, 3D scanning, digital field drawing and photography. Alongside novel workflows for field, post-excavation and archival practice, TETRARCHs will produce a controlled vocabulary for cultural heritage storytelling, assessments of data reuse effectiveness following ISO Standard 25022: Measurement of Quality in Use, and best practice recommendations for trusted digital repositories to optimise archaeological data for re-use. This session invites papers on the use and reuse of archaeological data, including case studies, examples of challenges and good practices, provocations and blue-sky thinking for the future of data re/use. Contributors may wish to engage with the themes of TETRARCHs or stretch beyond them. By hosting this session early in the life of TETRARCHs, we hope to foster discussion and collaboration with others who have comparable interests, and ensure that our outcomes are shaped in concert with such intersecting work, and are meaningful to the CAA community at large.

References:

Bonacchi, Chiara, and Marta Krzyzanska. 2021. "Heritage-Based Tribalism in Big Data Ecologies: Deploying Origin Myths for Antagonistic Othering." Big Data & Society 8 (1): 20539517211003310. Canning, Erin. 2018. "Documenting Object Experiences in the Art Museum with CIDOC CRM." In . http://www.cidoc2018.com/sites/default/files/CIDOC2018_paper_141_0.pdf.

Costanza-Chock, Sasha. 2020. Design Justice: Community-Led Practices to Build the Worlds We Need. The MIT Press.

Dolcetti, Francesca, Claire Boardman, Rachel Opitz, and Sara Perry. 2021. "Values-Led Design Cards: Building Ethically Engaged Archaeology and Heritage Experiences." Sustainability: Science Practice and Policy 13 (7): 3659.

Farnel, Sharon. 2018. "Metadata as Data: Exploring Ethical Metadata Sharing and Access for Indigenous Resources Through OCAP Principles." Proceedings of the Annual Conference of CAIS / Actes Du Congrès Annuel de l'ACSI, July. https://doi.org/10.29173/cais974.

Krmpotich, Cara, and Alexander Somerville. 2016. "Affective Presence: The Metonymical Catalogue." Museum Anthropology. https://doi.org/10.1111/muan.12123.

Manzo, Christina, Geoff Kaufman, Sukdith Punjasthitkul, and Mary Flanagan. 2015. "'By the People, For the People': Assessing the Value of Crowdsourced, User-Generated Metadata." DHQ: Digital Humanities Quarterly 9 (1).

Morgan, Colleen, Helen Petrie, Holly Wright, and James Stuart Taylor. 2021. "Drawing and Knowledge Construction in Archaeology: The Aide Mémoire Project." Journal of Field Archaeology, October, 1–15.

Pringle, E. 2020. "Provisional Semantics. AHRC: Towards a National Collection, Interim Report." AHRC. https://www.nationalcollection.org.uk/sites/default/files/2021-01/Provisional%20Semantics.pdf.

Sanderson, R., and A. Clemens. 2020. "Libraries, Archives and Museums Are Not Neutral: Working Toward Eliminating Systemic Bias and Racism in Cultural Heritage Information Systems." In . https://www.digitalmeetsculture.net/wp-content/uploads/2020/11/Euromed2020_BOOKLET-1.pdf.

Srinivasan, Ramesh. 2018. Whose Global Village?: Rethinking How Technology Shapes Our World. NYU Press.

Whitelaw, Mitchell. 2015. "Generous Interfaces for Digital Cultural Collections." https://openresearch-repository.anu.edu.au/handle/1885/153515.

Wilkinson, Mark D., Michel Dumontier, I. Jsbrand Jan Aalbersberg, Gabrielle Appleton, Myles Axton, Arie Baak, Niklas Blomberg, et al. 2016. "The FAIR Guiding Principles for Scientific Data Management and Stewardship." Scientific Data 3 (March): 160018.

Wright, Holly, and Julian D. Richards. 2018. "Reflections on Collaborative Archaeology and Large-Scale Online Research Infrastructures." Journal of Field Archaeology 43 (sup1): S60–67.

SLOT 1	
08:30 - 08:50	27. "Is this your first visit to Avebury?" - Creating, Using, and Reusing Archaeological Data in the Avebury Papers *Fran Allfrey (University of York)*; Ben Chan (University of Bournemouth); Ros Cleal (National Trust); Mark Gillings (University of Bournemouth); Colleen Morgan (GB)*
08:50 - 09:10	325. Digital Marginalia in Archaeological Archives *Sveta Matskevich (IAA)**
09:10 - 09:30	66. How Can Imagination Lead Us from Description to Interpretation in Archaeological Practice? *Tessa Poller (University of Glasgow)**
09:30 - 09:50	251. The Dynamic Collections - a 3D Web Platform of Archaeological Artefacts designed for Data Reuse and Deep Interaction. *Marco Callieri (ISTI-CNR)*; Åsa Berggren (Lund University); Nicolò NDU Dell'Unto (Department of Archaeology and Ancient History, Lund University); Paola Derudas (Lund University); Domenica Dininno (Lund University); Fredrik Ekengren (Lund University); Giuseppe Naponiello (Lund Unicersity)*
09:50 - 10:10	**Discussion**
10:10 - 10:30	38. Managing Archaeological Knowledge: A Researcher's Perspective *Meliha Handzic (International Burch University)**

	SLOT 2
11:00 - 11:20	194. From thesaurus to semantic network: make (re)usable the ANRJCJC Itineris data *Thomas Huet (University of Oxford, School of Archaeology)*; Cicolani Veronica (CNRS); Guillaume Reich (Frantiq); Sebastien Durost (Bibracte)*
11:20 - 11:40	10. True integration: moving from just finding archives to interpreting archaeological documentation utilising CRMarchaeo *Jane Jansen (Statens Historiska Museer Arkeologerna)*; Stephen Stead (GB)*
11:40 - 12:00	52. The reusability of geospatial data in archaeology using web applications: PEPAdb. *Galo Romero-García (Universidad de Sevilla)*; Daniel Sánchez Gómez (University of Seville); José Ángel Garrido-Cordero (Universidad de Sevilla); Carlos P. Odriozola (Universidad de Sevilla)*
12:00 - 12:20	348. Reuse of photogrammetric data seen from different perspectives: creators, repository providers and users *Andreas Noback (Technical University of Darmstadt)*; Claudia A. Maechler (Technical University of Darmstadt)*
12:20 - 12:40	**Discussion**
12:40 - 13:00	308. The Penfield African American Cemetery Project: Geophysics and Digital Archives for the Public *Robert Theberge (Georgia State University)*; Jeffrey B Glover (Georgia State University); Spencer Roberts (Emory University)*
	SLOT 3
14:00 - 14:20	26. Data from the past? The challenge of reusing the Finnish Heritage Agency's archaeological data *Johanna Roiha (University of Helsinki)**
14:20 - 14:40	73. High Speed 2 vs Unpath'd Waters: Which will need the most corrections? *Evelyn A Curl (Archaeology Data Service)*; Teagan K Zoldoske (Archaeology Data Service); Jamie G Geddes (Archaeology Data Service)*
14:40 - 15:00	275. How FAIR is bioarchaeological data: with a particular emphasis on making archaeological science data reusable *Alphaeus G W Lien-Talks (University of York, Historic England, Archaeology Data Service)**
15:00 - 15:20	**Discussion**
15:20 - 15:40	335. Urban Deep Mapping: The Potential for Meaning Making and Social Benefit in Urban Archive Reuse *Claire Boardman (University of York)**
15:40 - 16:00	*342. Semantic Computing Solutions for Opening Archaeological Citizen Science Data* *Eljas Oksanen (University of Helsinki)*; Frida Ehrnsten; Heikki Rantala (Aalto University); Eero Hyvonen (Aalto University and University of Helsinki)*
	SLOT 4
16:30 - 16:50	67. The understanding of re-use and barriers to re-use of archaeological data. The quality in use methodological approach *Rimvydas Lauzikas (Vilnius University Faculty of Communication)*; Kristy-Lee Seaton (University of York); Holly Wright (University of York); Keith May (Historic England); Peter McKeague (Historic Environment Scotland); Vera Moitinho de Almeida (University of Porto)*
16:50 - 17:10	293. Reuse and the Archaeology Data Service *Holly Wright (University of York)**

17:10 - 17:30	103. Friction, Stiction, and Maybe Some Fiction: Travels and Travails in Digital Data *Jeremy Huggett (University of Glasgow)**
17:30 - 17:50	**Discussion**

27. "Is this your first visit to Avebury?" - Creating, Using, and Reusing Archaeological Data in the Avebury Papers

Fran Allfrey, University of York
Ben Chan, University of Bournemouth
Ros Cleal, National Trust
Mark Gillings, University of Bournemouth
Colleen Morgan, GB

Context

The UKRI-funded Avebury Papers project is in the process of digitising the full archive of 20th century excavation and fieldwork carried out at the Avebury henge component of the

Stonehenge and Avebury World Heritage Site (WHS) in Wiltshire, England. We aim to produce a definitive research resource, and to build digital environments that encourage creative, personal, and experimental reuse of the data therein.

Notwithstanding its international importance, the only large-scale excavations (and perhaps 'large' does not do full justice to the scope and ambition of this work) that have taken place at Avebury were carried out in the first half of the 20th Century, brought to an abrupt end by the outbreak of WWII. Despite publication of two short interim reports by the excavator, and a masterful synthesis by Isobel Smith, published 26 years after Keiller's last excavation season and incorporating excavation work by Stuart Piggott in 1960, there is a strong sense here of an ambitious project that was begun but never satisfactorily finished. This was not only fieldwork on an impressive scale, but it was methodologically intrepid, fiercely experimental and generated a wealth of detailed information about Avebury's past and present.

There has been no sustained attempt to synthesise, integrate and make available the full detail encoded in the archives resulting from Keiller's work or the smaller investigations that took place after. This has led to only partial understandings of this pivotal site, a raft of orthodox explanations that have gained authority solely through repetition, circular arguments, repeated rediscoveries and a serial (wilful) forgetting of the results of previous work. This, in turn, has also allowed the site to slip free of meaningful interpretation (there is simply too much that we do not know…) and be appropriated for extreme political ends (…yet these gaps in understanding demand to be filled).

In short, the Avebury excavations are important and they have a wealth of stories to tell. Yet, at present, who is able to tell these stories or even tease out their general shape and the events, arcana and dramatis personae that animate and enchant them?

To rectify this the Avebury Papers will carry out unfinished programmes of detailed post-excavation analysis, synthesising the mass of unpublished detail that survives only in archive form.

Most critically, we are seeking to let the stories out – whether these lie within empirical measurement and scientific analysis, folklore and enchantment, or emotion and affect. As part of this, we will make the full set of data available and accessible through the design and implementation of an open access digital archive, that will provide a baseline from which all future engagements with Avebury can proceed. This will not only support future archaeological and heritage studies, but is expressly designed to stimulate, foster and nurture innovative public and creative engagement.

Main argument and discussion

This paper comes at an early and experimental stage in the Avebury Papers project, laying out our ambitions for three years' of research to come. In this paper, we will discuss our theoretical and practical strategies for developing artist-led and community-produced data creation and storytelling methods. We are developing these strategies for two interlinked reasons: firstly, to meet our ambition to open up the Avebury archive to analytic, interpretive, and creative reuse by non-specialists; and secondly, we aim to enable specialists to productively engage with the socially and culturally contingent structures which shape and are shaped by traditional archive-creation and historiography.

We will outline existing challenges in the Avebury archive, and reflect on how tensions long identified within the FAIR Guiding Principles may be productively experimented with: especially in relation to creating 'different ways in' for reuse. One particular focus will be around enabling participants to explore and reuse stories of archaeological workers. This is a key strand of work within the project, as we seek to centre the paid and unpaid working class archaeologists, women archaeologists, and artists who participated in excavations, whose fingerprints are all over the archive. Their names are rarely uttered in orthodox accounts of Avebury, and many exist merely as initials in site diaries or as incidental inclusions in site photographs.

Our aims to facilitate creative reuse of the archive align with the UK AHRC's Cultural Value Project, by developing arts-based methods for opening up original analytical pathways in order to furnish new analyses and interpretations (UKRI AHRC, 142-3). This is particularly important given world heritage is finding itself at the centre of ideological struggles; a set of contemporary debates to which Avebury's long history has much to contribute. We are galvanised by TETRARCHs' provocations which challenge archaeologists to rethink the ways in which data, finds, and documentation may be used to tell stories in more democratic and equitable ways. We will discuss existing collaborative, feminist, and anti-colonial archiving and interpretation theories and practices for opening up data (eg. D'Ignazio and Klein, 2020; James and Thornton, 2022), and reflect on how these may be put to work in the context of the Avebury archive. Finally, we will discuss our plans for measuring the efficacy and impact of our strategies for facilitating reuse.

As well as producing an archive of existing physical documentation and artefacts, the Avebury Papers will also archive itself, keeping a record of how decisions have been made, and how data has been collected and created. We are leaving fingerprints too. We will discuss our strategies for embedding within the data reminders that our data was not born digital, and that a variety of curatorial, interpretive, technological, imaginative, and institutional processes shape its creation, organisation, presentation, and use. We will therefore outline the ethical, theoretical, and practical considerations and questions that arise from our aims to produce a radically transparent and accessible archive.

References

D'Ignazio, Catherine and Lauren F. Klein. Data Feminism. 2020. MIT Press.

James, Katharine, and Amara Thornton. "On working with gender." Beyond Notability, February 24, 2022. https://beyondnotability.org/database/on-working-with-gender/

UKRI AHRC Cultural Value Project Report. March 17, 2016. https://ahrc.ukri.org/documents/publications/cultural-value-project-final-report/.

325. Digital Marginalia in Archaeological Archives

Sveta Matskevich, IAA

Our ability to predict how archaeological archives will be reused in the future is quite limited. Yet, we can learn a lot from the current and past user behavior patterns in an archive, not necessarily digital ones. Being privileged to have access to hundred years of archaeological records in a small but highly dense archaeological region opens an opportunity to observe the big picture of data reuse and provides fascinating examples of storytelling based on archived documents.

The Scientific Archive of the Israel Antiquities Authority preserves excavation files (obligatory for submission) from 1948 until today; the early ones are in the process of digitization and born-digital are from the 2010s onward. The same repository oversees the files of the Department of Antiquities of the British Mandate in Palestine (1921-1948). For these hundred years of the records of about 70% of archaeological activities in the region, we have access to a ten-year record of the user requests to both Mandatory and Israeli sections of the archive.

Among the inquiries, there is a large group of standard requests. These are coming from archaeologists who will excavate a site and wish to know its history and the history of its exploration. Whatever data acquisition workflow we create in a future digital archive platform, we need to ensure that we can accommodate a straightforward request. The other group comprises challenging and intriguing requests. These may come from the representatives of completely unexpected disciplines and archaeologists, who ask to reuse the data creatively, often by recontextualizing it.

While digitizing these collections and planning a platform for the digitized and born-digital records, we worked by the book. We created a metadata scheme based on the Dublin Core that covers the records' technical, administrative, and descriptive properties. The result, so far, is a well-structured and sufficiently described set of dry records: find lists, context cards, photographs, plans, etc. What may go missing in this data pool are "marginalia": side notes, sketches, personal messages, and personal items secondary used for data collection. All these exist in the original collection but are in danger of being sorted out and not digitized or getting lost in the digital repository because there is no way to find them. The situation is even worse with the excavations of the last two to three decades that communicate via WhatsApp messages, endless emails, and online meetings, producing much more than a standard set of records obligatory for submission to the national archive.

Part of these "lost" documents reflect the stories we tell about a site; others are important for our understanding of the history of its research, while the two stories are interwoven, and each one is essential for understanding the other. Another group of documents often dismissed already in the process of submission to an archive or digitizing are drafts that are essential for understanding the process of knowledge creation since this process is rarely reflected in publications.

In several case studies from the old and new archives, I will demonstrate the need for creating a niche for "digital marginalia": unstructured records (born-digital and digitized), correspondence, and other types of marginal notes that are essential for understanding how the official story came to existence.

66. How Can Imagination Lead Us from Description to Interpretation in Archaeological Practice?

Tessa Poller, University of Glasgow

The process that leads from description to interpretation at every scale of archaeological practice (from artefact and layer to feature and site to environment and landscape) is often not explicit or fully apparent through our standard recording systems. Traditional forms of archaeological training and practice focus first on obtaining consistent and accurate descriptions as well as gaining some level of 'experience' (which too is often poorly defined). But how are interpretations formed from observation and description? Once this question is asked, more follow… How is interpretation as a skill learned? Who does and who can form interpretation(s)? How and where are interpretations communicated? How can interpretations be reformed, changed and built upon to create new interpretation?

In this presentation I will discuss my explorations in the process of archaeological interpretation while managing field schools and directing archaeological excavations in Central Scotland over the past fifteen years (see Poller et al. 2016). Specifically, I will propose that imagination is a crucial link between description and interpretation in archaeological practice, which is largely unrecognised, undervalued, and, at times, even demonised as 'fiction'. A few studies from different perspectives have demonstrated imagination and related mechanisms such as storytelling can be used effectively as tools during the archaeological process (see van Helden & Witcher 2020; Perry 2018). More globally, however, there has been little acknowledgement in terms of how much and in which ways imagination is already employed and, significantly very little research on its potential as a skill to hone or as a tool to expand the voices and types of interpretation possible. This may in part be due to a desire to downplay subjectivity or ignorance in the self-imposed constraints embedded in our process and documentation, but this lack of appreciation may also be due to a misunderstanding of what imagination is. Philosophers of imagination such as Amy Kind (2022) have clearly recognised and defined different types of imagination. Since imagination is subject to will, it is not only transcendental or used to create impossible fantasies but can be intentionally controlled and therefore instructive. For archaeological purposes instructive imagination is significant. Kind (2020) also concludes that imagination is a skill that can be trained and enhanced through engaged and value-rich practices such as storytelling and mind-opening exercises. By embracing imagination in our systems of recording what can we imagine the future of archaeological practice to be?

Kind, Amy. 2020. "The Skill of Imagination." In The Routledge Handbook of Skill and Expertise, edited by E. Fridland and C. Pavese, 335-346. Abingdon: Routledge.

Kind, Amy. 2022. Imagination and Creative Thinking (Elements in Philosophy of Mind). Cambridge: Cambridge University Press.

Perry, Sara. 2018. "Why Are Heritage Interpreters Voiceless at the Trowel's Edge? A Plea for Rewriting the Archaeological Workflow." Advances in Archaeological Practice 6(3): 212-227.

Poller, Tessa; Watterson, Alice, Baxter, Kieran, Anderson, Jon and Keiran Duncan. 2016. "Designing Digital Engagements: The SERF Hillforts Project." http://www.seriousanimation.com/hillforts/

van Helden, Daniël and Robert Witcher (eds.) 2020. Researching the archaeological past through imagined narratives: a necessary fiction, Abingdon: Routledge.

251. The Dynamic Collections - a 3D Web Platform of Archaeological Artefacts designed for Data Reuse and Deep Interaction.

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This paper will present the latest results of the Dynamic Collections platform, a 3D web archive designed to support data reuse and deep interaction with digital archaeological artefacts. It will also discuss the possibilities offered by Web 3D access for producing knowledge, supporting research and higher education. Finally, the paper will discuss the capacity of such visualisation tools to promote FAIR principles, providing users with dynamic instruments for envisioning a broader picture of the past.

Archaeological collections are crucial for the cultural heritage sector. They are used daily for research and training cultural heritage specialists to study stylistic variation and chronological developments, and the awareness of the potential loss of archaeological materials has led curators to engage with 3D recording techniques for documenting and preserving museum collections (e.g. Arnold & Kaminski, 2014; Ekengren et al., 2021). Despite the considerable investments made in Europe for establishing data platforms for promoting large-scale research and innovation in the cultural heritage sector, it remains challenging to define the role of 3D archives in producing new knowledge.

These limits became evident during the pandemic, in which digital collections were no longer just reference sources but the only available sources for research and teaching. This situation underlined the urgent need to research strategies for the definition of digital collections as primary tools for undertaking research and for fully supporting scholars operating in the digital space.

Dynamic Collections was developed to address these issues and map new technology's impact on the constantly evolving archaeological practice.The basic idea was to go beyond using a single digital object and create an archive with functionalities for managing custom assemblages of objects (hence, dynamic collections) for studying and teaching activities.

The platform hosts a wide set of digitised artefacts, enriched by simple meta- and para-data content; the users can assemble a collection that suits their purpose from the available digital objects and then work on this custom collection by interacting/measuring/annotating the collected objects. This annotated collection can then be shared with colleagues and students to pursue a collaborative working/teaching environment. By using an efficient, streaming-friendly multiresolution data representation, and a customised navigation and visualisation interface built on top of the 3DHOP tool (https://www.3dhop.net/), the platform makes it easy to remotely access and interact with complex 3D models, and allows for the development and experimentation with new interactive tools. The project recently developed a prototype that connects 3DHOP with OMEKA-S, a web publishing platform for institutions interested in linking digital collections with other resources online (https://omeka.org/s/). This development increases the possibilities of Dynamic Collections to share digital content, publish items with linked open data, and more easily reuse the information currently stored in the system.

Dynamic Collections is an ongoing project and a collaboration between The Lund University Digital Archaeology Laboratory and the Visual Computing Laboratory, CNR-ISTI, Italy.

Several scholars currently use the system to support teaching and research, and it presently hosts more than 400 3D artefacts from different Swedish museums and research projects. More recently, it became part of the newly established Swedish National Infrastructure in Digital Archaeology SweDigArch, and it is used as a raw model by different institutions for publishing their data.

References:

Arnold, D., & Kaminski, J. (2014).3D scanning and presentation of ethnographic collections: Potentials and challenges. Journal of Museum Ethnography, 27, 78–97.

Chazan, M. (2019).The reality of artifacts: An archaeological perspective. Routledge Studies in Archaeology. New York: Routledge.

Ekengren, F., Callieri, M., Dininno, D., Berggren, Å., MacHeridis, S., & Dell'Unto, N. (2021). Dynamic Collections: A 3D Web Infrastructure for Artifact Engagement. Open Archaeology, 7(1), 337-352. https://doi.org/10.1515/opar-2020-0139

Potenziani, M., Callieri, M., Dellepiane, M., Corsini, M., Ponchio, F., & Scopigno, R. (2015). 3DHOP: 3D Heritage Online Presenter Computers & Graphics, 52, 129-141. https://doi.org/10.1016/j.cag.2015.07.001

38. Managing Archaeological Knowledge: A Researcher's Perspective

Meliha Handzic, International Burch University

So far, the majority of projects in digital archaeology have addressed archiving/curation of data and their use/reuse as separate issues. One consequence of such a divide may be a potential mismatch between available and needed data for research purposes and knowledge creation.

Most recently, there have been some notable attempts to bridge this divide and take a more holistic approach to managing archaeological knowledge (e.g. ARKWORK, SEADDA). Continuing such a trend, the purpose of this paper is to introduce an integrated model for archaeological knowledge management in digital environments and illustrate its application in the context of a specific UNESCO-listed cultural heritage (stecci).

The generic conceptual model of knowledge management (KM) presented in Figure 1 indicates different technologies and their roles in enabling and facilitating processes of development, transfer and utilisation of knowledge. The model also shows two dominant KM approaches: codification and personalisation (Hansen et al. 1999). Codification emphasises explicit knowledge stored and extracted from digital repositories, while personalisation focuses on tacit knowledge in people's minds and its sharing. It is argued here that a combination of these two approaches to managing archaeological knowledge in digital space is necessary in order to realise the full power of that knowledge.

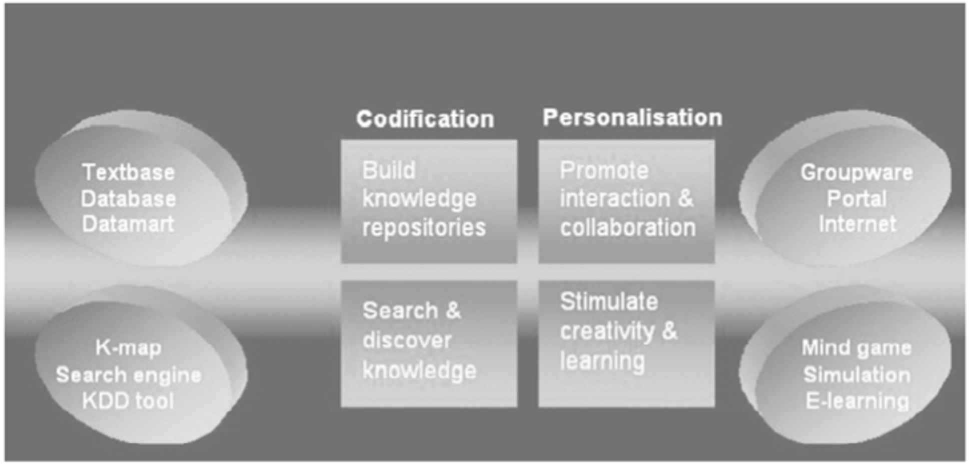

Figure 1. Types of KM Technologies and Roles (Handzic 2004)

According to Lauzikas et al. (2018), contemporary people engage with archaeological heritage objects, artefacts, information or knowledge for different reasons and in different ways. In this paper, we illustrate the application of the above conceptual model in a specific cultural heritage case (stecci) from the researcher's perspective.

With respect to knowledge repository, a systematic approach for creating digital stecci records was developed and applied including a series of templates. These were successfully tested and can serve as a reference for future knowledge capture. The model was also useful as a theoretical basis for a series of studies aimed at discovering novel spatial, temporal, and relational patterns in created digital repositories. A virtual community of practice (CoP) formed around common interests in stecci proved valuable for connecting scholars from various institutions and for maintaining active knowledge sharing. Finally, new and enriched ways of perceiving stecci through virtual artworks and games provided new interpretations and explanations of the past.

Overall, the experience gained so far suggests that the right digital space for managing archaeological knowledge needs to be dynamic (enable future additions to repositories), reliable (able to be trusted), flexible (support different research needs), interactive (allow two-way communication), and easy to use (by scholars who are not technologically savvy).

References

Handzic M. (2004), Knowledge Management: Through the Technology Glass (Series on Innovation and Knowledge Management), World Scientific Publishing, Singapore.

Hansen M.T., Nohria N. and Tierney T.J. (1999), What's your strategy for managing knowledge?, Harvard Business Review, March-April, 106-116.

Lauzikas R., Dallas C., Thomas S., Kelpslene I., Huvila I., Luengo P., Nobre H., Toumpouri M. and Vaitkevicius V. (2018), Archaeological Knowledge Production and Global Communities: Boundaries and Structure of the Field, Open Archaeology, 4, 350–364.

194. From thesaurus to semantic network: make (re)usable the ANRJCJC Itineris data

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Cicolani Veronica, CNRS
Guillaume Reich, Frantiq
Sebastien Durost, Bibracte

The ANRJC Itineris (https://anr.fr/Projet-ANR-21-CE27-0010) is a 42 months funded research project on the characterisation of Italic bronze craftsmanship in the Early Iron Age. This international project promotes an innovative and comprehensive methodological examination of the new and unpublished data acquired, combining the archaeological approach with technological, archaeometric and geostatistical analyses (Cicolani 2017, 2020). Focusing on craft techniques networks and knowledge flows modelling, this project sets out to explore the ways in which technologies, traditions and fashion behavior are transmitted over wide areas and across cultural boundaries, revealing new scenarios and social models.

In consistency with LOD and FAIR policies (Wilkinson et al. 2016), the Workpackage 3 of the ITINERIS project takes care of open-source data and tools in order to provide to the scientific community open access results, codes and data produced during the project as well as after their publication.

In this framework, the scientific collaboration with Bibracte (https://www.bibracte.fr/bibracte-numerique) will enable the development of a controlled vocabulary. Indeed, Bibracte has shown that the ISO 25964 standard for the management of thesauri is sufficiently flexible to describe the different "points of view" presiding over the elaboration of the specialised and evolving "micro-languages" of archaeologists, for the creation of terminological concepts (e.g. typo-chronologies) and for their logical modelling, as well as for structuring the data in addition to their metadata. Projected as computable graphs, the vocabulary, data and their relationships can then be used to characterise the processes of transformation and organisation of the reasoning and meaning of concepts from specialised archaeological 'micro-languages'. (Reich et al., forthcoming).

Our paper will focus in particular on how to make the ANR Itineris data (unprocessed, processed, meta, etc.) FAIR by developing structured datasets compliant with ISO standards, coding in open-source (R, Python) and using an open-source web platform (GitHub, 3DHOP) allowing users to interact with the processed data (measurements, 3D models, maps, etc.) and to download the raw data. All of this data will also be indexed using the trilingual thesaurus developed as part of the project.

Cicolani, Veronica 2017. Passeurs des Alpes. La culture de Golasecca entre Méditerranée et Europe continentale à l'âge du Fer, Paris : Éditions HERMANN , 360 p. (ISBN : 97827056 94166)

Cicolani, Veronica 2020. Interactions techno-culturelles en Italie nord-occidentale aux VIe-Ve siècles av. J.-C., Mélanges de l'École française de Rome - Antiquité [En ligne], 132-1 | 2020, mis en ligne le 07 décembre 2020, consulté le 26 janvier 2022. URL : http://journals.openedition.org/mefra/10093. doi: https://doi.org/10.4000/mefra.10093

Reich Guillaume, Durost Sebastien, Girard Jean-Pierre, Lacombe E., Rousset Miled (in press). Enjeux techniques, terminologiques et heuristiques pour la mise en réseau et l'analyse des connaissances archéologiques. Terminologie & Ontologie : Théories et Applications. Actes de la conférence TOTh 2022, Université Savoie Mont Blanc, 2-3 juin 2022. Terminologica, Chambéry : Presses Universitaires Savoie Mont Blanc.

Wilkinson, Mark D., Dumontier, Michel, Aalbersberg, Jan Aalbersberg,, Appleton, Gabrielle, Axton, Myles, Baak, Arie, Blomberg, Niklas, Boiten, Jean Willem, da Silva Santos, Luiz Bonino, Bourne, Philip E. and Bouwman Jildau et al. 2016. The FAIR Guiding Principles for scientific data management and stewardship. Scientific data, 3(1), 1–9. https://doi.org/10.1038/sdata.2016.18

10. True integration: moving from just finding archives to interpreting archaeological documentation utilising CRMarchaeo

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Stephen Stead, GB

This integration study considers how the body of archaeological excavation databases of The Archaeologists (a department within the National Historical Museums of Sweden) were prepared for integration utilising the CRMarchaeo extension of the CIDOC Conceptual Reference Model (CRM). The Archaeologists create about 250 new Intrasis-databases each year (one for each new site) and currently have 1200 active and 1100 archived databases. Traditional GIS based gazetteers allow the discovery of which archives/databases are about the correct type of site or that are in the right geographic area. However, the researcher still needs to immerse themself in the details of the individual archive to see if the research questions, excavation/recording methodology, and pragmatic responses to circumstances are compatible with the goals of the researchers' study. In comparison, with the CRMarchaeo ontology applied to the archives/databases, the work required to check if the data is fit for the study's purposes is possible at the integration layer. This means more opportunities for innovative intra- and inter-site research as the effort required to discover appropriate material is reduced.

The presentation will showcase the work undertaken by Intrasis and Paveprime to prepare this approach and the benefits that have accrued from it: in particular the improved reusability when the databases are accessible through Swedigarch and also the greater clarity in the approach to future documentation practice.

CRMarchaeo, an extension of CIDOC CRM, is a way to link a wide range of existing documentation from archaeological excavations. The CRMarchaeo extension has been created to promote a shared understanding of how to formalise the knowledge extracted from the observations made by archaeologists. It provides a set of concepts and properties that allow clear explanation (and separation) of the observations and interpretations made, both in the field and in post-excavation.

https://www.cidoc-crm.org/crmarchaeo/

SweDigArch, the Swedish National Infrastructure for Digital Archaeology, will facilitate the production of aggregated and harmonised datasets, fulfilling demands for cutting-edge integrative, interdisciplinary research on long-term socio environmental dynamics. It will enable new approaches for digital methods and reinvent archaeological research agendas.

http://swedigarch.se/

52. The reusability of geospatial data in archaeology using web applications: PEPAdb.

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Carlos P. Odriozola, Universidad de Sevilla

1. Introduction

The significant growth of digital spatial information has led archaeologists all over Europe to increasingly rely on digital data to prepare and carry out archaeological research (McKeague et al. 2019). The main interest in the publication of spatial and non-spatial indexed archaeological data is to offer users the possibility of querying, downloading, and/or accessing them in external applications. This apps are aimed to model, analyze, display, or generate new geospatial data, information, and value-added resources, both in academia and general public. Given the extremely high cost of generating spatially indexed archaeological data, the reuse of this data by users is highly expected. As the result of not complying with the FAIR EU policy, the already existing spatial indexed archaeological data are not easily accessible and therefore hard to reuse by the general public, or the academia (Sobotkova 2018). PEPAdb (Prehistoric Europe's Personal Adornment database) is a long term multidisciplinary and open research project which has materialized in a web-app for the online publication of georeferenced archaeological scientific data referring to late personal adornment in Europe's Late Prehistory. PEPAdb is maintained since 2010 through the concatenation of several R&D projects funded by the Spanish government. This initiative aims to comply with the FAIR principles encouraging the reusability of archaeological data through the use of standards by means of web spatial technologies.

2. Case study: mapping personal adornment in the Iberian Peninsula

The actual geographical coverage is restricted to the Iberian Peninsula including: a) information extracted from bibliographic resources in accordance with the standardized procedures such as: contradictions and ambiguities resolutions or cross-checking of different sources and museum pieces and b) information referring to the elemental and mineralogical composition of the analyzed museum and other institutions pieces, their provenance (when possible), a bundle of archaeometric and metric data.

3. Material and methods

3.1 Data acquisition: Fieldwork and analytical methods

The dataset resulting from this long-term project, PEPAdb, is composed by a significant amount of spatially indexed qualitative and quantitative data of very different types (table materials).

1. Molecular level analysis of geological samples and artifacts
2. Elemental composition analysis of geological samples and artifacts
3. Metrics of the indexed items

3.2 Data integration in a Relational Database Management System (RDBMS)

Spatial data integration is an essential component for personal adornment data, and it has the aim to support further analysis and produce easy understandable maps. We build up a relational data model (datamodel image) with PostgreSQL 11 tool in which the set of data items such as archaeological sites and structures, beads (and other types of personal adornment) records, mineralogy... are organized in tables.

3.3 Layer sharing and webapp customization: GIS software system for developing an archaeological application

Database systems provide the engines for GIS. In the database community, GIS are primarily associated with spatial databases. The development of ArcGIS Enterprise System provides a simple way to customize layers and deploy web-applications through ArcGIS Web AppBuilder.

3.4 Webserver configuration

In order to display a webapp to the World Wide Web (WWW) it is necessary to integrate ArcGIS Server in our institution web server: Internet Information Service (IIS). ArcGIS Web Adaptor is an application that integrates both Portal and ArcGIS Server in our webserver. During the installation, users must specify a website (https://pepadb.us.es) where content would be display.

4 Description of PEPAdb web application

PEPAdb has been designed in order to allow users to visualize and download spatial data in a HTML environment. It takes the form of a map viewer showing the frequency of the minerals used in each site or archaeological structure depending on the quality of the archaeological available, as for example, late 19th early 20th century findings in museums are labelled as belonging to a necropolis and not to a specific structure within the necropolis. Clicking on the structure / site will displays a pop-up showing the number of items recorded for that particular structure / site and the frequencies of minerals used. It has a set of widgets which allows clients to explore, upload and access data in a simple way.

5 Next steps

A further development is needed in order to create an effective tool for the scholar community. In relation to mineralogy, consideration should be given to the possibility of integrating a machine learning function to predict mineral composition based on the elemental composition. Users will upload a CSV that the algorithm will use to calculate the predictions, adding the assessment of probability for that specific prediction.

6 Concluding remarks

It is known the historical difficulty of sharing data in arts and humanities. As this is funded research, the data derived must be in Open Access, which implies a data re-use. Archaeological web applications for late Prehistory information management are completely necessary in the transfer of knowledge. Data automation is a major challenge considering that PEPAdb has thousands of records related to prehistoric materials. This is why it is necessary to establish a workflow capable of overcoming some of the limitations associated with the massive amount of data.

7 References

McKeague, Peter, Rein van't Veer, Isto Huvila, Anne Moreau, Philip Verhagen, Loup Bernard, Anwen Cooper, Chris Green, y Niels van Manen. 2019. «Mapping Our Heritage: Towards a Sustainable Future for Digital Spatial Information and Technologies in European Archaeological Heritage Management». Journal of Computer Applications in Archaeology 2 (1): 89-104. https://doi.org/10.5334/jcaa.23.

Sobotkova, Adela. 2018. «Sociotechnical Obstacles to Archaeological Data Reuse». Advances in Archaeological Practice 6 (2): 117-24. https://doi.org/10.1017/aap.2017.37.

348. Reuse of photogrammetric data seen from different perspectives: creators, repository providers and users

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While the FAIR data principles provide general guidelines for the management and stewardship of scientific data, the development of suitable solutions for its reuse requires an understanding of the life cycle of specific data. This includes knowledge about software tools, file formats and methods, but also about the stakeholders involved.

An example and a common case in the field of archaeology is the exchange of 3D data from photogrammetric acquisition and laser scanning.

In this contribution the topic of FAIR 3D data reflects experience from the ongoing development of a domain specific data repository for architecture, civil engineering and urban studies and is exemplified using the data processing within an interdisciplinary project in the field of ancient architecture and archaeology. In this project, 3D models of architectural remains serve as a basis for reconstruction models used for daylight simulation. In two case studies of Roman housing existing 3D data could be reused. For the case of Greek residential architecture, the research group conducted the building survey autoptically. Therefore, the opportunity is given to understand aspects of the repository provider perspective as well as the creator and user perspective. Contrasting those views, a best practice example for data acquisition, publication and metadata provision can be drafted.

Provider perspective

While general purpose repositories providing long-term access and preservation are well established, discipline and method related specializations of repositories, data containers and metadata standards necessary for reuse are currently under development. Repository providers alone can hardly meet the demands of heterogeneous domain specific data and metadata. Communities have to get involved to identify necessary metadata for search and interoperability, and to establish reliable exchange formats. The same is true for defining quality requirements and foster the acceptance of data publication as original scientific contribution.

Creator perspective

New 3D data was created within the use-case from a photogrammetric building survey of the Late Classical residential architecture in the ancient city of Orraon. The research questions of the project already resulted in wide-ranging preconditions for the nature and amount of 3D data needed. Nevertheless, efforts were made not only to ensure the general accessibility and reusability of the collected data, but also to meet the more specific needs of findability and interoperability. This included the development of a spatial database that allows querying any existing textual, graphical or geometric information on the dwellings from literature, archival sources or autoptic examination. To ensure the quality of the photogrammetric data, the site's appearance was documented as well as the local measurement grid, the georeferencing, the distribution of photo targets, the camera model and its lens distortion parameters et cetera as well as the accuracy of the final photogrammetric model itself. The resulting models as well as all raw data are stored together in open, long-term archivable formats as a closed dataset and are annotated by metadata, to meet the technical requirements for FAIR 3D data and standards for photogrammetric documentation work in the context of cultural heritage and building archaeology.

User perspective

Data collected for one purpose does not always fit another. Finding suitable data for the Roman case studies proved challenging, since knowledge about and access to data often enough relies on personal relations and individual contracts. In the planning phase of projects relying on 3D data already gathered, a central database or repository with the possibility to search data by location, quality, coverage, 3D preview, licence and other parameters would be beneficial. In the specific use-case of the research project high resolution 3D data of ancient residential architecture was needed for the detailed examination of architectural features relevant for lighting and the development of reconstruction models as well as additional information about the building history and accurate georeferencing.

Conclusion

Contrasting the different perspectives reveals that the handling of FAIR 3D data has to be understood as a dynamic, multi-stakeholder interaction process. Research data management needs to be understood not only as providing infrastructure but as active brokering between data providers, data creators und data users.

The privilege of access to cultural heritage, the avoidance of unnecessary damage to the site, the amount of tax money spent on labour and equipment are good arguments for FAIR data publication. But the developments toward FAIR data should be accompanied by a serious dialogue on good scientific practice and performance, and also by rethinking funding principles and practice. As all things digital, the reuse of digital data leads to a further differentiation of labour and specialisation within archaeology that may lead to an imbalance between groundwork and innovative research. Best practice has to include standards for data publication and licensing. In principle, the use of FAIR data necessitates the publication of own results as FAIR data as well.

Ducke, B., Fritsch, B., Schilling, M. (2021), Qualitätssicherung von 3D-Modellen für die Online-Publikation, in: Forum for Digital Archaeology and Infrastructure 1, 1–30 (DOI: https://doi.org/10.34780/bi19-9w1a)

Hardesty, J., Johnson, J., Wittenberg, J., Hall, N., Cook, M., Lischer-Katz, Z., Xie, Z., McDonald, R. (2020), 3D Data Repository Features, Best Practices, and Implications for Preservation Models, in: Findings from a National Forum. College & Research Libraries 81(5), 789–807

Homburg, T., Cramer, A., Raddatz, L., Mara, H. (2021), Metadata schema and ontology for capturing and processing of 3D cultural heritage objects, in: Herit Sci 9:91, 1–19 (DOI: https://doi.org/10.1186/s40494-021-00561-w)

308. The Penfield African American Cemetery Project: Geophysics and Digital Archives for the Public

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Introduction

A robust history exists for the use of geophysics within the field of archaeology, specifically within cemetery contexts (Bevan, 1991. Bigman, 2013. Conyers, 2013). As the discipline transitions to paradigms favoring engaged, public-facing components of archaeological investigations, best practices for the public dissemination of paired geophysical and geospatial data are not as well developed. Typically, complex ground penetrating radar (GPR) data are displayed as jpegs in reports or as geotiffs in GIS projects. While these approaches are adequate in many situations, it does keep the GPR analysis in a black-box and does not allow for those data to be easily linked to other historical data or to be easily accessed by future scholars.

Methods

This paper discusses a collaborative effort between archaeologists at Georgia State University's Department of Anthropology, members of the Historic Rural Churches of Georgia (HRCGA) non-profit historical society, and scholars at the Digital Initiatives Department of the Pitts Theology Library at Emory University. This interdisciplinary project seeks to incorporate archaeological field data into a digital archive infrastructure developed by Pitts Theology Library so that it can be featured alongside materials related to historic rural churches drawn from library partners to facilitate scholarly research, local history, genealogical inquiry, and more. Specifically, this case study explores the ways in which geophysical data derived from a GPR investigation within the ill-maintained African American section of an historic cemetery in Greene County, GA will interface with historical resources surrounding the associated Penfield Baptist Church in order to inform the wider narrative concerning the church's pivotal role in the growth and development of this region.

Results

This project is on-going as part of the first author's Master's Thesis research. By the time of the conference, the GPR data of Penfield cemetery will have been collected and its integration with the other datasets will be well underway.

Discussion

As part of a larger network of projects focused on the Penfield community, this work involves partnerships with the Greene County African American Museum and Mercer University's Spencer B. King, Jr. Center for Southern Studies. In seeking to preserve and disseminate geophysical and geospatial data for a public audience, this case study contributes to discussions surrounding the development and standardization of best practices for the creation of digital archives that include both historical materials and newly generated archaeological data, particularly in community-involved projects.

References

Bevan, Bruce. 1991." The search for graves." Geophysics. 56. 1310-1319. 10.1190/1.1889567.

Bigman, Daniel P. 2013. "Mapping social relationships: geophysical survey of a nineteenth-century American slave cemetery." Archaeological and Anthropological Sciences 6(1): 17–30.

Conyers, Lawrence B. 2013. "Ground-Penetrating Radar for Archaeology." 3rd ed. Altamira Press, Lanham, MD. 2014 Interpreting Ground-Penetrating Radar for Archaeology. Left Coast Press, Walnut Creek.

26. Data from the past? The challenge of reusing the Finnish Heritage Agency's archaeological data

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Introduction

The Finnish Heritage Agency is collecting and maintains data about cultural heritage in Finland. Information about archaeological heritage including archives, registers and collections is available via kulttuuriympäristön palveluikkuna -web portal. One important section is the Register of Ancient Sites (Muinaisjäännösrekisteri 2022). The register includes site coordinates, site descriptions, site classifications and links to research reports and listed finds. The spatial data is also available via WMS and WFS interfaces or as one downloadable zip file via Finnish Heritage Agency's webpage (Kulttuuriympäristön paikkatietoaineistot 2022). Datasets are published under the CC By 4.0-licence. The register is updated constantly but it also includes very old information, like linked archaeological research reports from the end of the 19th century or site descriptions that are from the early 20th century. Because some of the data is based on old research, the quality of the archaeological data available variates and missing information causes many challenges for data reuse.

This study aims to discuss the challenge of data reuse via two different case studies. In the first case study, the data was collected from a cultural perspective. The second case study is focusing the areal perspective by collecting data from one small region.

Materials and Methods

The material for both case studies is the Register of Ancient sites in Finland and all available information like research reports and listed finds that are linked to the register via Finnish Heritage Agency's web portal.

The first case study aims to find all archaeological sites that have a connection to Kiukainen culture (Soisalo and Roiha 2022). The Kiukainen culture was the end phase of the Stone Age Finland and it is known for Kiukainen pottery. The challenge in this case study was the missing information in the Register of Ancient sites. The site description or linked lists of finds don't always mention pottery type or other important details that could be used to collect the data from one cultural phase. Identifying pottery first manually from the collections was the only reliable method that could confirm the connection between the site and its cultural context.

The second case study focuses on a small region including three municipalities in East Tavastia (Itä-Häme). The area is known for many Iron-Aged sites so that period was chosen for detailed mapping of different site types in the area. The Register of Ancient sites has very structured construction where every site has the same information: main class (level of protection), municipality, period, main type, subtype, underwater (yes or no), name and identification number. This tight structure limits the search because there are no other free search options and the same problem is in the vector data because it follows the same structure as a table. Also, the data includes many mistakes in the period section, site types and subtypes. In this study, more detailed information was collected for all the sites in the area by giving every site new keywords. First, the list of all sites in that area was exported in table form from the vector data. Then new columns were added to the table for keywords and the year when the last field study at the site was done. Those keywords were collected for every site manually by reading all available information about the sites, finds and previous research. The date of the last field study was also collected at the same time while searching keywords for the sites.

Results

In the first case study all together 99 sites were found that have confirmed connection to the Kiukainen culture. However, it must be noted that only the sites that have been excavated could be confirmed with this method. The total amount of Kiukainen sites in Finland is likely much higher. The sites that have been found via survey without excavating or without finding the pottery were not included since the chosen method was identifying pottery. Another challenge was missing information and biases in the data. Many sites were excavated years ago, and the quality of the research is poor. Especially missing C14-datings were giving problems because it was impossible to evaluate which sites are simultaneous.

In the second case study, the preliminary results are promising. By classifying the sites with keywords, it is possible to find much more detailed information about the Iron-Age sites in the chosen area. Using keywords as a search option increases the data reusability remarkably, but it doesn't solve the problem of missing information, poor data quality or poor research. Mistakes in the site type or dating section are giving problems with current search options. Also, mistakes in the coordinates seem to be common and that should also be taken into account with the data reuse.

Discussion

To increase archaeological data reuse, the data should be also findable. The Finnish Heritage Agency's data is quite accessible, but not so findable. The Register of Ancient sites and other services alongside the register are missing proper search tools. The structure of the register only allows very limited search options like site type, name or dating. Another issue is missing data or poor research quality. If the fieldwork is done even today with minimum resources and without using any analyzing methods like C14 dating or other basic analyzing methods, it affects the data reusability a considerable amount. Discussions about archaeological data reuse, the quality of the archaeological field research and FAIR principles are needed in Finnish archaeology.

References

Kulttuuriympäristön paikkatietoaineistot. 2022. Accessed October 14, 2022.https://www.museovirasto.fi/en/services-and-guidelines/data-systems/kulttuuriympaeristoen-tietojaerjestelmae/kulttuuriympaeristoen-paikkatietoaineistot

Muinaisjäännösrekisteri. 2022. Accessed October 14, 2022. https://www.kyppi.fi/palveluikkuna/mjreki/read/asp/r_default.aspx

Soisalo, Janne, and Johanna Roiha. 2022. "Kiukainen Culture Site Locations—Reflections from the Coastal Lifestyle at the End of the Stone Age" Land 11, no. 9: 1606. https://doi.org/10.3390/land11091606

73. High Speed 2 vs Unpath'd Waters: keeping large projects FAIR

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The Archaeology Data Service (ADS) is an accredited digital repository for archaeological and cultural heritage data that was founded in 1996. Over the past 26 years, the ADS has accumulated over 33 TB of data from more than 4 million files. Two recent projects that the ADS has been a part of include the large rail infrastructure project High Speed 2 (HS2) and Unpath'd Waters, an AHRC funded programme, which aims to unite the UK's maritime collections under one banner. With both of these projects, the idea of reuse has been at the forefront for how we should disseminate the data generated in these projects.

The nature of the High Speed 2 project means that much of the data is being deposited with the ADS quite some time after creation, and after being passed through multiple hands. This means that the risk of corruption and general loss of knowledge about the data is high, which could have implications for its reuse value which has to be mitigated. Another concern is a lack of use and general awareness of open source software to not only create data, but to access it at the other end. For example, the software originally used to create the LIDAR 3D laser scan data from the HS2 project is not open access, so the proprietary data files being provided to the ADS risk data loss during the archiving and dissemination process.

For Unpath'd Waters, the data sets supplied can provide a great deal of valuable information about our maritime past but not all were catalogued and stored in a way that data could be easily extrapolated from it for reuse. Some of the data takes the form of PDF scans which are suboptimal for preservation and reuse of this data type. The databases across the different partners within UNPATH also contained varying terminologies for similar features or objects, for example one partner may use the specific term 'schooner' for a wreck while another partner's database may simply use 'sailing ship'. This causes problems when a person searching for the same wreck across different databases, chooses to search for 'schooner' and therefore does not find the same ship recorded under 'sailing ship' or vice versa.

This research provides two case studies of large projects amassing over 30 TB of raw data from multiple data collectors and provides examples for how things we have learned can be applied to other projects of equal size or smaller to allow for better reuse. This paper will discuss some of the challenges we have faced in aggregating data, and present some of the research opportunities it has enabled. We will demonstrate how we have been able to create new and reuse existing databases and spatial searches, such as the ARIADNE infrastructure architecture. Further, we will discuss ideas that we were unable to achieve and limitations we had due to the data itself.

Vast-Lab. "ARIADNE portal." Last modified 2022. https://portal.ariadne-infrastructure.eu/

Richards, J.D. (2002) "Digital Preservation and Access", in European Journal of Archaeology 5, 343-366. https://journals.sagepub.com/doi/abs/10.1177/146195702761692347

Richards, J.D. (2017) Twenty Years Preserving Data: A View from the United Kingdom, Advances in Archaeological Practice. Cambridge University Press, 5(3), pp. 227–237. https://doi.org/10.1017/aap.2017.11

275. How FAIR is bioarchaeological data: with a particular emphasis on making archaeological science data reusable

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Introduction

Bioarchaeology, including the study of ancient DNA, osteoarchaeology, paleopathology, palaeoproteomics, stable isotopes and zooarchaeology, is producing ever-increasing amounts of data due to advancements in molecular biology, technology and publishing techniques. These studies are often invaluable in the analysis of the lives of human ancestors.

As archaeology is a destructive process, and the data itself is generated from a finite amount of material, bioarchaeological data is of paramount importance but is currently not always easily Reusable. To ensure the long-term Reusability of this data, a possible route is to ensure that the data is FAIR. The focus of this research was to investigate this need as well as potential strategies to ensure that the data produced and curated by bioarchaeology is Accessible and Reusable to academics, researchers and the general public. Ultimately, this thesis aimed to identify the extent to which bioarchaeological data is Reusable. It is important to stress here that ethical considerations are considered throughout this process, building a foundation from the statement "as open as possible, as closed as necessary" (Landi, et al., 2020).

Methods and materials

The current practice of bioarchaeologists was analysed and compared to previous projects, data curation policies and developments in digital archaeology to establish the extent of reuse potential. To achieve this, firstly the emerging fields of bioarchaeology and digital archaeology were reviewed chronologically. These specifically were the causal effect of data publishing, data management plans, recent platforms that facilitate reuse and the advancements that make the reuse of data more important. This was epitomised by the E-RIHS D.5.3 Data Curation Policy that arose from Saving European Archaeology from the Digital Dark Age 2020 (Wright and Richards, 2020). This review made it possible to understand more about what is required for data produced in bioarchaeology to become FAIR, and thus create a better data community.

Secondly, a Needs Analysis was performed to gain more insight into the current practice of bioarchaeologists and their data. The primary methodology was the emailing of an online questionnaire to bioarchaeology specialists, principally in the UK, as well as the rest of Europe and the United States of America, as this is where most institutions are situated. The questionnaire investigated the current procedures of specialists from conception to preservation in terms of their potential for reuse, including questions on why they deposit data, in which format and data type, and where. It also included questions drawn up by the best practice guides to understand to what level current procedures meet the suggested requirements set by Wright and Richards in the E-RIHS D.5.3 (ibid). Further, it investigated various techniques to make data Reusable, such as a more uniform metadata standard, information about the primary data collection process, a single repository for bioarchaeological data, and the linking of specialist reports to the original field data. It also investigated the potential use of paradata. The data from this Needs Analysis revealed current strategies in bioarchaeology for data use and reuse. This was carried out using ethical guidance from the University of York's Archaeology Department.

As a result of these two components, this research provided a greater understanding of the extent to which data created in bioarchaeology can be reused, and identified aspects to be altered or improved in order to provide greater opportunities for reuse.

Results

Through a Needs Analysis, it was discovered that the reuse of bioarchaeological data is considered important and that there is already extensive reuse between each bioarchaeology subdiscipline. Nonetheless, currently, there is no standardised process for data creation through to deposition. As a result, this wealth of information is processed in a variety of different ways to different levels, creating a range of data types, deposited in a variety of places, with different levels of Open Access and copyright even within a specialism. These results can be broken down into the individual elements that are argued to constitute the FAIR data principles for bioarchaeology.

For Findability, the majority of specialisms used ORCiDs, with the exception of osteoarchaeology and paleopathology. As regards Persistent Identifiers, only aDNA and palaeoproteomics used them. As a result, the level of Findability is not high, and as such, more must be done to ensure that data is discoverable for reuse.

Data was relatively Accessible with almost all specialisms making their data Open Access and ensuring that the raw data is Accessible, with the exception of paleopathology. The most common place of deposition was a published report. As a result, the level of Accessibility is limited, meaning that data may not be attainable for reuse.

Interoperability is arguably the aspect which needs the most attention. Almost no specialisms believe there is an appropriate metadata schema available, with palaeoproteomics and aDNA (single specialism) being the exception. The most common data type was PDF and published fully processed. As such, it is difficult to link bioarchaeological data with other resources.

As regards Reusability, all specialisms make over 50% of their data available without copyright and this contributed to its reuse. Nonetheless, only aDNA and osteoarchaeology systematically document their data. This would suggest that, overall, data is partially Reusable.

Discussion

It is clear from these results that data is not consistent between and within individual specialisms. As such strategies must be developed to increase the Reusabilty of these datasets. The first and most important argument here is the need for a standardised data management procedure for all elements of bioarchaeology. This standardisation will require systematic changes and as such data training and communities are needed to be created within each of the specialisms to ensure that strategies are created by domain experts with an overarching body to ensure that strategies are also consistent between the different specialisms. This would help to ensure that data reuse is still encouraged and possible despite the requirements of individual needs.

Further hypothetical ideas include creation of a standardised persistent identifier and the creation of a federated search interface building upon the work of Talks (2019).

References

Alphaeus Talks, 2019. "An exploration of NLP and NER for enhanced search in osteoarchaeological and palaeopathological textual resources" (undergraduate thesis, University of York).

Landi, A, Thompson, M, Giannuzzi, V, Bonifazi, F, Labastida, I, Santos, LOB da S and Roos, M. 2020 The "A" of FAIR – As Open as Possible, as Closed as Necessary. Data Intelligence 2(1–2): 47–55. DOI: https://doi.org/10.1162/dint_a_00027.

Wright, H, and Richards, J. 2020. D.5.3 Data Curation Policy. E-RIHS PP.

335. Urban Deep Mapping: The Potential for Meaning Making and Social Benefit in Urban Archive Reuse

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In comparison with their historic cores or modern outer suburbs, the historic development of town and city planning has acted to whitewash the deep histories of inner-urban neighbourhoods; both architecturally under the dense, repetitive late 19th / early 20th century 'worker housing' and, as population churn increases, within civic memory. With no statutory protection or requirement for preservation via record at the time of building and little redevelopment since this hinterland presents as a 'sterile ring' within the historic environment record.

Without being physically or consciously visible and therefore cognitively and emotionally accessible, the active role heritage can play in the daily meaning and sense-making practices that are the connective tissue of any community is negated. Though elusive, there remain traces of deeper inner-urban pasts scattered across the city's archives, collections, memories, and myths.

This paper presents recent community-based research completed in two York, UK neighbourhoods. Using curated sets of collection/archival meta-data, engagement with each neighbourhood's Past is approached through the varying points of view of four distinct neighbourhood stakeholder groups or 'communities within communities': long term residents (including members of local heritage groups), recently arrived migrants, temporary residents (students) and frequent visitors/commuters.

Through a designed intervention, it explores the potential of institutional, community and personal archival content, participatory interpretation and place-based digital storytelling to integrate auto- and geo-biographies and return lost urban pasts to contemporary neighbourhood consciousness. In this way, it challenges existing place histories and disrupts individual and communal 'sense of place', while simultaneously creating increased opportunities for new people-place connections.

342. Semantic Computing Solutions for Opening Archaeological Citizen Science Data

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INTRODUCTION

This paper presents the interdisciplinary research project DigiNUMA that investigates challenges and solutions in data management and dissemination of pan-European Cultural Heritage, with a specific citizen science focus on opening this data to members of the public (Oksanen et al 2022). The project develops a new model for harmonising national and international archaeological datasets for Digital Humanities (DH) analysis as well as public dissemination through Linked Open Data (LOD). DigiNUMA answers current challenges and opportunities created by the digitisation of society:

1) The need for digital solutions in Cultural Heritage management stemming from the vastly increased amount of archaeological museum/collections record information generated by the public, with particular reference to the growing number of archaeological finds recovered by metal-detecting and other public finders in European countries. Finland and the UK will be discussed as case studies.

2) The pan-European need to develop an internationally operable and harmonised LOD infrastructure for using Cultural Heritage data from different countries in research.

3) Increasing the accessibility of Cultural Heritage data among different audiences, including outside the scientific community through the use of innovative LOD and semantic computing data services.

METHODS AND MATERIALS

DigiNUMA is developing the CoinSampo semantic web application that extends the FindSampo framework (Hyvönen et al 2021), Sampo model (https://seco.cs.aalto.fi/applications/sampo), and the new FindSampo system (see https://loytosampo.fi) into a transnational technical solution for Cultural Heritage data management and dissemination. The functionalities of the data services and analytical applications in development (e.g. Geographic Information Systems (GIS) analysis, statistical analyses, network analysis) are being tested using the rich and complex numismatic data from Finland (Finnish National Museum) and the UK (Portable Antiquities Scheme in England and Wales (PAS) data at the British Museum).

The project targets coin finds obtained from Finnish and English digital archives, because coins are by far the most numerous object-type reported by the members of the public the to the national finds reporting schemes, the data is often precise in terms of its dating and place of manufacture making it suitable for DH analysis, and because coins move around internationally and can be found in different collections, recording and reflecting historical exchanges that are relevant to wider European audiences.

As part of this semantic computing research DigiNUMA joins the undertaking to develop infrastructure for Cultural Heritage data management and dissemination in Finland based on ontologies extracted from the classifications and typologies used for describing Cultural Heritage artefacts. The project examines the potential offered by transnational data harmonisation strategies in developing digital heritage services. Ontological work will be complemented by user experience research on public heritage portals, in order to develop optimal solutions for structuring and disseminating heritage data.

RESULTS

In response to the challenges outline above, DigiNUMA has produced (1) ontological Finnish cultural heritage data related to coin finds; (2) new internationally relevant research on models suitable for heritage services for numismatic data, with direct relevance for all archaeological data; (3) the CoinSampo semantic cultural heritage data demonstrator, for searching, learning and analysing about numismatic materials (see https://seco.cs.aalto.fi/projects/diginuma).

DISCUSSION

This paper will investigate digital numismatic collections management challenges and potential solutions using digitised coin data from the National Museum of Finland as well as data from the PAS as a case study. Both of these datasets are largely generated by public finders, necessitating the adoption of citizen science perspectives to managing and opening Cultural Heritage data. Here, as in many European countries, archaeological citizen science (metal-detected) data is owned by museums and public heritage institutions. We will discuss digital heritage challenges that stem from combining this new data with heterogenous older catalogues and data, and in designing sustainable solutions that serve the needs of institutional collections management.

We will present the current results of the project, which aims to develop a new Finnish public data service for numismatic heritage through data harmonisation and LOD principles in concordance with the principles of pan-European undertakings such as Nomisma.org and ARIADNEplus. The possibilities that such technological platforms offer for deploying digital citizen science/crowd-sourcing data enhancement internationally, as well as their potential of assisting in museum collections management, will be discussed. The project is developing the dedicated semantic portal and data service CoinSampo for numismatic coin finds in Finland in order to allow data and the possibilities for powerful data analysis methods to be opened up to the public.

Most online Cultural Heritage data services allow objects to be examined only in the traditional catalogue format (i.e. individually record by record), meaning that larger patterns and structures in the finds data is accessible only to professional researchers in possession specialised training in complex software such as R or dedicated GIS programs. CoinSampo incorporates fast and easy analytical tools as a part of an integrated search-and-analysis feedback process of sieving through the data in the portal, opening up the possibilities for anyone without DH background - whether academics, heritage professionals or citizen scientists - to engage in creating new information and in learning about the past. Cultural heritage belongs to all, both to citizens and the researchers. This project seeks to enhance the possibilities for new knowledge discovery for a wider audience of interested participants.

REFERENCES

Oksanen, Eljas, Rantala, Heikki, Tuominen, Jouni, Lewis, Michael, Wigg-Wolf, David, Ehrnsten, Frida, and Eero Hyvönen. 2022. "Digital Humanities Solutions for Pan-European Numismatic and Archaeological Heritage Based on Linked Open Data." Proceedings of the 6th Digital Humanities in Nordic and Baltic Countries Conference (DHNB 2022): 353-61. CEUR Workshop Proceedings.

Hyvönen, Eero, Rantala, Heikki, Ikkala, Esko, Koho, Mikko, Tuominen, Jouni, Anafi, Babatunde, Thomas, Suzie, Wessman, Anna, Oksanen, Eljas, Rohiola, Ville, Kuitunen, Jutta, and Minna Ryyppö. 2021. "Citizen Science Archaeological Finds on the Semantic Web: The FindSampo Framework." Antiquity 95: 1-7. https://doi.org/10.15184/aqy.2021.87

Rantala, Heikki, Oksanen, Eljas, and Eero Hyvönen. 2022. "Harmonizing and Using Numismatic Linked Data in Digital Humanities Research and Application Development: Case DigiNUMA." The Semantic Web. ESWC 2022: 26-30. Springer.

67. The understanding of re-use and barriers to re-use of archaeological data. The quality in use methodological approach

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Over the last decade, innovation has centred on making archaeological data more interoperable, both to increase the discoverability of data through integrated cross-search, and to facilitate knowledge creation by combining data in new ways. The emerging research challenge of the next decade is optimising archaeological data for re-use and defining what constitutes good practice around re-use. For those, the important issue is the coordinate information collection to understand the current state-of-the-art regarding the use, re-use, good practices and barriers to re-use of archaeological data. The aim of the research was to understand how to optimise archives and interfaces to maximise the use and re-use of archaeological data and explore how archaeological archives can better respond to user needs. The research focus was on (i) reusing digital archaeological archives only; (ii) orientation to content usability and reusability; (iii) focus on a user-oriented approach; (iv) orientation to professional users (archaeologists). The members of the research group decided to adopt the quality in use conceptual approach for this study. Quality in use is described as "the degree to which a product or system can be used by specific users to meet their needs to achieve specific goals with effectiveness, efficiency, satisfaction, and freedom from risk in specific contexts of use" (ISO/IEC 2016). The research methodology is based on the SQuaRE (System and Software Quality Requirements and Evaluation) model, represented in the ISO/IEC 25000 standards series (ISO/IEC 2017). The quality in use metric for investigation of re-use and barriers to re-use of archaeological data were adopted from the standardized measures measurement functions and methods of ISO/IEC 25022:2016 (ISO/IEC 2016). On this background created a methodological model composed of 5 characteristics (Effectiveness, Efficiency, Satisfaction, Context coverage and Usability) with 14 measures (Task completeness, Objectives achievement, Task time, Cost-effectiveness, Overall satisfaction, Satisfaction with features, User trust in the system, data and paradata, User pleasure, Physical comfort, Context completeness, Flexible context of use and User guidance completeness). The methodology was tested with specific Contexts of use (Using cases), oriented to a specific professional archaeologist user with the specific professional goal of data re-use. There created three user cases, related to archives of 3D pottery data; radiocarbon data, and GIS data. A specific user-friendly environment was developed for this research. The main result of the testing pilot study proves that the methodology is working and could be used for full-size research. This conference paper will present the methodology of application of the quality in use approach for the measurement of the quality of archaeological digital archives, and the result of a testing pilot study on this.

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References:

1. ISO/IEC. 2016. "ISO/IEC 25022:2016(E). Systems and Software Engineering - Systems and Software Quality Requirements and Evaluation (SQuaRE) - Measurement of Quality in Use". International Organization for Standardization. https://www.iso.org/standard/35746.html.

2. ISO/IEC. 2017. "ISO/IEC 25010:10 - 10:3011. Systems and Software Engineering — Systems and software Quality Requirements and Evaluation (SQuaRE) — System and software quality models". International Organization for Standardization. https://www.iso.org/standard/35733.html.

293. Reuse and the Archaeology Data Service

Holly Wright, University of York

The Archaeology Data Service (ADS) is a national archive for archaeological data in the UK (archaeologydataservice.ac.uk. Founded in 1996, the mission of the ADS has always been to support research, learning and teaching with free, high quality and dependable digital resources, but much has changed over the last 25+ years. While our mission remains the same, how we understand the nature of the support we provide has become much more complex. This has become particularly notable due to adoption across the research data landscape of the FAIR Principles; that data must be Findable, Accessible, Interoperable and Reusable. The ADS has been working to increase compliance with the FAIR Principles, but there is still much to do.

One key aspect of making the data we hold more FAIR has been thinking holistically about our workflows. One can argue that the ADS spent 25+ years making data Findable and Accessible, and considerable progress was made over the last 10 years to understand and implement Interoperability, but we were not equally engaged with how Reusable the data was. We needed to consider the four Principles equally. So much effort was necessary to make progress with F, A and I, it is only now that we are beginning to substantively understand the importance of R, despite F, A and I being of little use without it.

This paper will discuss the challenge of engaging with Reuse by a Core Trust Seal accredited digital archive for archaeological data, when our primary remit and practical workflows are necessarily more focussed on preservation. It will explore how we are working to expand and change our understanding of Reuse through our participation in the TEtrARCHs project (tetrarchs.org), and how we are looking forward to another 10 years of progress and new challenges as we work to better put the R in FAIR for the archaeological data we hold.

103. Friction, Stiction, and Maybe Some Fiction: Travels and Travails in Digital Data

Jeremy Huggett, University of Glasgow

Digital practice is increasingly embedded in archaeological practice with access to rapidly expanding quantities of digital materials alongside the development of digital infrastructures that organise, structure, and deliver these materials. Indeed, we are told that digital technologies are now as common in archaeology as a trowel or any other tool (e.g., Antonijević 2016, 49). On the one hand, this digital environment and its associated tools can be seen as providing a convenient means of speeding up practice while leaving that practice essentially unchanged. On the other hand, practice may be radically transformed through the potential of the digital to alter space, time, memory, and how we create and communicate knowledge through introducing new ways of seeing and working with data, and new control and access points. Consequently, these may change our relationship with our means for interpreting the past and arguably with the past itself (c.f Hodder and Beckingham 2022, 1299), which should demand a critical examination of this relationship, although the effects of this access are rarely discussed (although see Hacıgüzeller et al. 2021; Huggett 2022, for example).

The digital infrastructures that archaeology is increasingly reliant upon provide access to large bodies of data through the use of metadata: it is the metadata catalogues that are searched, and the results retrieved are based on those metadata. The investigation of an archaeological research question is therefore governed by this high-level metadata summary and indeed, often stops at this point, using the derived metadata in studies using simple distribution plots according to period or type, for instance. Even in more extensive and elaborate analyses employing data mining and machine learning, there is a tendency to focus on similar high-level data (artefact categories, time periods, locations etc.) (e.g., Brandsen et al. 2022). This is not to deny the value of operating on high-level data, but it is important to recognise that such analyses operate at a considerable remove from the original, primary record, assuming it is available within the digital infrastructure at all.

To an extent, there is nothing new in this situation: it has ever been the case that much archaeological research is built upon secondary data (primary or directly observed data produced by others but capable of reuse), if not tertiary data (reworked data derived from the prior analyses of others) (e.g., Huggett 2022, 280). Rather than remaining at this secondary or tertiary (or greater) level, the challenge has always been to track back to the original data in its least processed state so as to validate the data used, but the complexities involved mean that this step may often not be feasible, whether through geographical or temporal distance, for example. In a digital environment, it might be expected that this task would be considerably simplified; however, other than the ability to review digital data from the desktop rather than travel to disparate physical archives, it is often no easier to unpack digital data than it was in the analogue days: data in digital archives are just as disconnected from their origins as data in analogue archives are. Even if the benefit of digital environments is perceived as no more than speeding up existing practice, it might be expected that digital access would make it easier to retrace how data has journeyed into its current form.

The question addressed here is whether any of this matters? It will be argued that this is important because approaches to digital data otherwise tend to simplify rather than reflect the actual complexity of the data, and in the process, underestimate its true value and real potential. The multi-layered nature and origin of archaeological data is reflected in the journeys from initial observation and recognition of key features and their selective recording, through their interpretation and re-interpretation, drafting and re-drafting into their most recent destination, be that a database, a written report, or a monograph, for example. This interleaving of data stages is a key part of the complexity of archaeological data and an understanding of how data have travelled between each of these stages is key to having confidence in the origin, extraction, and (re)use of the data in a robust and reliable way.

This paper will investigate the series of frictions that influence and limit our access to complexity. Critically, it will argue that our digital tools should make it easier to capture the data journeys so that our analyses can better reflect the reality of underlying data and avoid misunderstandings and misuse in our reuse.

References

Antonijević, Smiljana. 2015. Amongst Digital Humanists: An Ethnographic Study of Digital Knowledge Production. New York, NY: Palgrave Macmillan.

Brandsen, Alex, Suzan Verberne, Karsten Lambers, and Milco Wansleeben. 2022. 'Can BERT Dig It? Named Entity Recognition for Information Retrieval in the Archaeology Domain'. Journal on Computing and Cultural Heritage 15 (3): 1–18. https://doi.org/10.1145/3497842.

Hacıgüzeller, Piraye, James Stuart Taylor, and Sara Perry. 2021. 'On the Emerging Supremacy of Structured Digital Data in Archaeology: A Preliminary Assessment of Information, Knowledge and Wisdom Left Behind'. Open Archaeology 7 (1): 1709–30. https://doi.org/10.1515/opar-2020-0220.

Hodder, Jake, and David Beckingham. 2022. 'Digital Archives and Recombinant Historical Geographies'. Progress in Human Geography 46 (6): 1298–1310. https://doi.org/10.1177/03091325221103603.

Huggett, Jeremy. 2022. 'Data Legacies, Epistemic Anxieties, and Digital Imaginaries in Archaeology'. Digital 2 (2): 267–95. https://doi.org/10.3390/digital2020016.

37. Modelling the semantics of space – the relationship of entities creating space

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Location: E108

Over the past 50 years, digital archaeology has made enormous progress in unlocking the potential of computational approaches for the study of the human past. Particularly the application of quantitative methods on archaeological research topics has been quite extensively researched and conducted with immense success. Yet, in light of a growing awareness of the supposed objectivity of numbers and so called hard facts, ways of conceptualising, analysing and interpreting archaeological data using qualitative methods and theories have come into focus – on their own as well as in their interplay with quantitative approaches. The challenges of the fragmentary nature of the material record, the vagueness and the uncertainty implicit in data of the past, pose particular risks in archaeology and ancient history that yet also offer rich potential: Especially with increasingly interdisciplinary research tendencies, the combination and entanglement of quantitative studies with in-depth critical perspectives on the complexities of micro as well as macro patterns through the soft facts will open up this data to new and innovative avenues of research.This session aims at bringing the intangible data and approaches, techniques or applications using qualitative data into the spotlight. The extension of a quantitative focus with qualitative perspectives becomes especially evident in a field of research central to all archaeological disciplines: The study of space. Archaeology as a discipline relies primarily on three-dimensional data of spaces and objects that is very often expressed in quantitative measurements, be it length, volume or coordinates. For this reason, historically the use of analytical techniques that specifically investigate the constitution, development and shape of physical environments and/or assemblages (down to the decayed human body) are usually in the centre of attention. Apart from widely used tools – for example GIS software – and the research paradigms they embody, this focus becomes evident as early as in the data modelling stages of research processes. For example, the spatial relations as codified by the CIDOC CRM do not allow for detailed description of the interactions between actors and places nor for more complex perspectives on the spatial relations between objects that extend its – at heart – positional approach (Bekiari et al. 2022, xxii–xxiv). However, as early as the 1960s, processual archaeologists understood that the measured, physical environment was not sufficient for investigating ancient societies. As a first attempt to circumvent the problem, they extended the concept of landscape in a new way by including qualitative data, such as semantics or symbolism, into their research. At the same time, sociologists like Lefebvre (1974) redefined the concept of spatiality, which in their understanding was the outcome of social relations independent of the actor´s social class. In the 1990s, further work conceptualised organisational structures in the context of space, a movement that was shaped especially by Martina Löw's work "Raumsoziologie" (Sociology of Space; Löw 2001). This perspective, which entered cultural studies as the so-called spatial turn, enabled researchers to study (past) societies in their holistic complexity and, above all, free from hierarchical, mostly elite-oriented models of society. Nowadays, such relational models of space that are able to speak about intention and reception in the constitution of space as well as social action rather than mere construction have found wide acceptance and usage in most fields of the humanities (Werlen 1993). In the archaeological disciplines, space as a witness of social organisation can contribute to a broader and multi-faceted understanding of our cultural heritage. While, every so often, these theories and concepts have found their way into archaeological research (e.g. Gramsch/ Meier 2013, Maran 2004/05, Thaler 2044/05), their translation into specifically digital archaeology still seems to be in its infancy. This opens up a wide field for digital archaeology which has not sufficiently spread in our discipline: How can we conceptualise data models that prioritise the construction of social entanglements in their envisioning of space and spatial relations? How can we enable interoperability between such models and which aspects would this interoperability even address? How can we open up these qualitative approaches to quantitative analyses such as network research or ontology engineering, and how can we include the critical perspective necessary to interpret the results in this process? With this session, we focus on these and many other questions on computational approaches along all stages of the research process. Therefore, the session is open to all contributions concerning digital approaches to space as a social construct in archaeology and its related fields, ranging from conceptual models to analytical tools and methods to the development and applications of software, and many more. We welcome papers from any academic stage and encourage especially students and junior researchers to present their work, even if in progress. We are also very keen to receive abstracts from established scholars who may share the pitfalls and risks in integrating qualitative data into the evaluation of past societies.

References:

Bekiari, Chryssoula, George Bruseker, Martin Doerr, Ore Christian-Emil, Stead Stephen, Athanasios Velios, Erin Canning, and Philippe Michon. 2022. Volume A: Definition of the CIDOC Conceptual Reference Model. Version 7.2.1. ICOM/CIDOC Documentation Standards Group/CRM Special Interest Group. http://www.cidoc-crm.org/sites/default/files/CIDOC%20CRM_v.7.0_%2020-6-2020.pdf.

de Certeau, Michel. 1984. The Practice of Everyday Life. Berkeley: University of California Press.

Gramsch, Alexander, and Thomas Meier. 2013. "An Archaeological Outline of Ritual Dynamics and Social Space." In Counterpoint. Essays in Archaeology and Heritage Studies in Honour of Professor Kristian Kristiansen, edited by Sophie Bergerbrant and Serena Sabatini, 193–98. BAR 2508. Oxford: Archaeopress.

Lefebvre, Henri. 1974. La Production de l'espace. Paris: Éditions Anthropos.

Löw, Martina. 2001. Raumsoziologie. Frankfurt a.M.: Suhrkamp.

Maran, Joseph. 2004. "Architektur als gesellschaftlicher Raum. Zur Bedeutung sozialwissenschaftlicher Theorien für die Archäologie." Online-Publication. Heidelberg. https://www.uni-heidelberg.de/fakultaeten/philosophie/zaw/akh/akh_texte/texte0405.html.

Thaler, Ulrich. 2004. "Space-Syntax-Analyse der mykenischen Residenz von Ano Englianos." Online-Publication. Heidelberg. https://www.uni-heidelberg.de/fakultaeten/philosophie/zaw/akh/akh_texte/texte0405.html.

Werlen, Benno. 1993. Society, Action and Space: An Alternative Human Geography. London: Routledge.

	SLOT 1
08:50 - 09:10	**Introduction**
09:10 - 09:30	79. Spatial statistical analysis of shipwreck sites: a methodological proposal *José Bettencourt (CHAM, FCSH, Lisbon Nova University); Joel Santos (University of Leicester)**
09:30 - 09:50	252. Point Process Modelling of human-landscape relations in Eastern Crete *Andriana-Maria Xenaki (University of Cambridge)**
09:50 - 10:10	284. Spaces of funeral meaning. Modelling socio-spatial relations in burial contexts *Aline Deicke (University of Marburg)**
10:10 - 10:30	368. Quantifying the economy of Roman circuses - a digital approach to the study of space to evaluate the phenomena of resilience and identity of the Roman provinces. *Domenica Dininno (Lund University)**

	SLOT 2
11:00 - 11:20	260. Do we need an extended ontology for the archaeology of ancient religions? Data modelling and visualization techniques of Roman religious spaces *Asuman Lätzer-Lasar (Philipps-University Marburg, Classical Archaeology)**
11:20 - 11:40	277. Timescape of the settlement of Pancarlık : time and space of entities creating landscape *Anais Lamesa (IFEA)*; Idil Üçbaşaran (Ortahisar Belediyesi)*
11:40 - 12:00	**Discussion**

79. Spatial statistical analysis of shipwreck sites: a methodological proposal

José Bettencourt, CHAM, FCSH, Lisbon Nova University
Joel Santos, University of Leicester

Almost all underwater archaeologists admit that it is fundamental to use spatial analysis in their investigations. However, when looking at academic production, we may say that the use of GIS has become common, but as a method of representation and visualization of spatial data and as a basis for the production of maps and, nonetheless, the information obtained using this approach would allow the reconstruction of the depositional dynamics and exploration of distribution patterns through collected data related to a ship's on-board organization. This paper proposes a methodology, using a six-step framework, that will bridge the current gap in the use of spatial statistical analysis on shipwreck sites.

Inspired by spatial statistical methods that are already applied in terrestrial situations, we would like to go further, applying them to underwater contexts and developing other methods purposely for underwater challenges. This way, through the use of Geographic Information Systems (GIS) integrated with R and with the collected data, it will be possible to reconstruct deposition dynamics, its environment and explore distribution patterns, analysing a shipwreck landscape.

This methodology will be demonstrated in two distinct case studies, showing that the same structure of thought can be useful in the interpretation of different shipwrecks, as long as it regards sites with a coherent distribution during its depositional process. This methodology, using statistical tools, will strengthen context understanding, confirming, refuting, or adding new perspectives to previous interpretations. Finally, the way the framework was built, will allow its replication on other sites.

252. Point Process Modelling of human-landscape relations in Eastern Crete

Andriana-Maria Xenaki, University of Cambridge

This study explores the settlement pattern within Crete's most dominant landscape features – its rugged terrain and iconic mountains – through a case study from the Dikte massif and its environs. This region has attracted continuous and systematic archaeological research over the last 50 years, offering an unmatched context for examining the locational preferences of mountain sites in Crete. Legacy survey data from the Final Neolithic up until the Early Iron Age (ca. 4000-700/600 BCE), as well as data coming from excavations on the area, are used to examine the relationship between ancient societies and their surrounding landscape. The questions of interest include the following: have locational preferences in the mountain regions in eastern Crete changed over time? Can site location preferences be explained by environmental and/ or social factors or are there key latent variables? And finally, how do the results of the statistical analysis fit within/challenge past preconceptions about mountainous areas?

The spatial distribution of archaeological sites has been a fetish among researchers, with methods focusing on the inherent spatial dependency of sites, i.e., how the location of a given focal site is conditioned by the presence of other sites in its spatial neighbourhood. Such methods include the use of the Clarks and Evans test, Kernel Density Estimates, and more recently K and L functions and Pair Correlation Functions. Several researchers have also focused on the induced spatial dependency of archaeological sites: i.e., the relationship between sites and exogenous environmental variables that might affect site location (using, for example logistic regression, and more recently species distribution models). However, it has become clear that focusing in isolation on the induced or inherent spatial dependencies of archaeological sites is not sufficient in providing nuanced understandings of past site location.

Out of the multitude of methods that have emerged in recent years, the current study uses Point Process Models (PPM) to examine how the prehistoric inhabitants of Crete use mountainous areas. Point Process Models are used to examine the relationship between archaeological sites and environmental variables while simultaneously taking into account social variables. Even though this method is by no means new, the examples of archaeological implementations of PPM are limited (see for example Davis, DiNapoli, and Douglass 2020; Spencer and Bevan 2018). These models have been used in attempts to understand the generative processes laying behind site location, compare contrasting hypotheses as to the relationship between sites and exogenous environmental covariates, make predictions, and simulate missing settlement location data.

Here, this method was used as a heuristic tool to examine the reasons behind settlement location choices over time and to assess past assumptions about the location of sites in the mountains (Baddeley, Rubak, and Turner 2015, 299-367). The environmental variables that were put into examination include elevation, slope, distance to different geology types, visibility, etc). The spatial interaction between archaeological sites was also included in the analysis as a proxy of social interaction. Each variable was first examined on its own to delineate its relationship with archaeological sites during each chronological phase. Subsequently, a model including all the environmental and social variables was formulated for each period. In order to provide insights as to whether the models can account for the spacing of archaeological sites, the goodness of fit of the models was examined. This was done through the use of Residual K Functions in conjunction with Monte Carlo simulations (Baddeley, Rubak, and Turner 2015, 433-436). The residuals of each model were also put into examination. Finally, all of the created models were compared per chronological period. The predictive power of the models was compared through the use of an Information Criterion (AIC). This criterion was used to measure the models' quality, not in terms of the goodness of fit, but rather in terms of how well they act as approximations of the processes that generated the observed point patterns. This was done so as to be able to compare competing hypotheses regarding site location, reaching a "best model" for each chronological period-that is a model that could best predict the observed point pattern given a trade-off between the complexity of the data and the model's fit.

The aforementioned methodology allowed for the delineation of differential site location priorities across different periods and areas in Eastern Crete. It proved particularly useful in terms of narrowing down the variables that affect site location choices over time. However, just like every other method, this also comes with several challenges. In my presentation, I will also talk about some of the lurking pitfalls when using this particular method, such as sample size and the difficulties in translating model results into meaningful insights about the past.

References

Baddeley, Adrian, Ege Rubak, and Rolf Turner. 2015. Spatial point patterns: methodology and applications with R. New York: CRC Press.

Davis, Dylan S., Robert J. DiNapoli, and Kristina Douglass. 2020. "Integrating Point Process Models, Evolutionary Ecology and Traditional Knowledge Improves Landscape Archaeology—A Case from Southwest Madagascar." Geosciences 10, no. 8: 287. https://doi.org/10.3390/geosciences10080287.

Spencer, Christine, and Andrew Bevan. 2018. "Settlement location models, archaeological survey data and social change in Bronze Age Crete." Journal of Anthropological Archaeology 52: 71-86. https://doi.org/10.1016/j.jaa.2018.09.001.

284. Spaces of funeral meaning. Modelling socio-spatial relations in burial contexts

Aline Deicke, University of Marburg

Burials have long been one of the most important sources of archaeology, especially when studying past social practices and configurations. In this context, it has long been established that the way the deceased are presented in the grave is not to be understood as a mirror image, even a distorted one, of their lived realities but instead as an intentional selection of artefacts and features materializing the different identities inhabited by these persons in life and to be communicated through their burial. In the reconstruction of these identities, most research has focused on the artefacts added as grave goods, their typologies, origins, function and possible meaning, or on the features making up the burial in its entirety – from simple pits to elaborate architecture involving grave chambers and monumental tumuli. Yet, the placement of grave goods and the spatial configuration of the burial environment has received considerably less attention, even though it has to be assumed that the placement of grave goods and features as well as their spacing (Löw 2017) carries a variety of meanings which, while not always reconstructable, can still be observed.

This holds true for digital archaeology as well. Different conceptions and encodings of space answer different questions, and while some of these conceptions can be considered as well-established methods in digital archaeology, others still call for closer exploration.

For example, the wide-spread use of geographic information systems (GIS) encourages a perpective of space as measured by a geospatial coordinate system. While this is obvisouly very useful for the exact documentation of the location of an object, this attributive absolute understanding of space as topology does not lend itself readily to other, less normative conceptions of space: the location of objects in relation to the architectural features of a burial pit or chamber to answer questions regarding the standardization of burial activities, including deposition patterns; the construction of spaces within the grave as zones that give material form to different identity aspects of the deceased, and their relationship to each other; or even the role of space as an actor in the perception and negotiation of the burial process.

For the case study presented in this paper, however, the focus lies on yet another aspect: the placement of objects in relation to each other. 82 burials of the Late Urnfield period, located in a region north of the Alps that stretches from the East of France to the entrance of the Carpathian Basin, were selected to study the funeral presentation of elite identities at the dawn of the Iron Age (Deicke 2021). While the main focus was on a network analysis of the grave goods and features, a first foray into modelling and analyzing spatial relationships using a graph database was also undertaken. This initial study included consideration of different ways to encode these placements using the CIDOC-CRM as a foundational ontology. Despite the early stages of these attempts, the analysis allowed inferences about the function of objects – in this case, bronze and iron knives – that might otherwise have remained obscure and which led to insights about their very different functions and funeral meanings at the very end of the Bronze Age.

The examplary modelling presented here shows an initial attempt at conceptualizing spatial relations for one of the burials: Grave 119 of the cemetery of Franzhausen (Nußdorf ob der Traisen, Lower Austria). In this burial, a bronze knife lies across the remains of a vessel accompanied by animal bones (most likely a meat offering or remains of a funeral feast), while two iron knives were found inside of an urn, alongside the ashes of a cremated body (Lochner und Hellerschmid 2016). Similar associations of bronze knives with food offerings and iron ones with the body of the deceased can be observed in contemporaneous burials through the whole study area. While these findings might seem trivial at first glance, the different treatment of the same type of object depending on its material ties into the increasingly widespread adoption of iron at the transition from Bronze to Iron Age. The deposition of the iron knife not in a utilitarian context but as part of the personal accoutrements of the deceased hints at the important role of this new technology in elite strategies of preservation, consolidation, and attainment of power.

The model incorporates only the section of the inventory connected to the three knives and their possible functions, focusing on two types of relationships or properties: those that describe the placement of an object in relation to another, and those that provide an interpretation of this connection. Regarding the latter, type and certainty are expressed through attributes. As the model is merely a tentative first step towards a possible structure for such data, some caveats apply: for example, the plainly labelled relations of 'next to' and 'above' are in need of a more formal treatment, preferably in the form of a controlled vocabulary or even a hierarchical thesaurus. Likewise, the question of which connections should be incorporated into the model requires further clarification: should the spatial relations between all objects be codified? Or does it suffice to provide an explication of the ones deemed to be 'important'?

It can be assumed that many more insights into the function and meaning of objects, as well as the social construction of funeral space, could be inferred from the respective arrangements of grave goods. In particular, incorporating spatial relations into the data model of a corresponding knowledge graph that extends one of the models shown above could allow automatic or semi-automatic queries that would in turn point researchers to other potentially fruitful constellations. At the moment, such socio-theoretical understandings of space have not been integrated into the CIDOC CRM or compatible models such as CRMarchaeo and CRMgeo. The model shown here presents a first attempt at closing this gap and at opening up the potential for the analysis of the semantics of social space in the funeral sphere.

References:

Deicke, Aline. 2021. Zwischen Individuum und communitas. Identitätskonstruktion späturnenfelderzeitlicher Eliten im Spiegel funeraler Statusnetzwerke. Universitätsforsch. Prähist. Arch. 358. Bonn: Habelt.

Lochner, Michaela, und Irmtraud Hellerschmid. 2016. Dokumentation Franzhausen-Kokoron: Ein Gräberfeld der jüngeren Urnenfelderkultur aus Zentraleuropa. Erweiterte interaktive Datenbank mit Illustrationen und Fundbeschreibungen. Version 03/epub. Wien: Verlag der österreichischen Akademie der Wissenschaften. https://doi.org/10.1553/KatalogUFK.

Löw, Martina. 2017. Raumsoziologie. Frankfurt a.M.: Suhrkamp.

368. Quantifying the economy of Roman circuses - a digital approach to the study of space to evaluate the phenomena of resilience and identity of the Roman provinces.

Domenica Dininno, Lund University

Introduction

The spectacular circuses survive as remarkable monuments to the resources and technical sophistication of Rome; the largest being capable of seating over 250.000 spectators, making them some of the largest sporting venues of all time. Yet their large dimensions represent a potential challenge to offer a representative data set because they better reflect economic trends. They are therefore indicative of economic performance because they demonstrate a willingness of the local elites to invest, through munificentia, in the growth of cities.

This paper will present the results of a pilot project that focuses on one case study, the Circus of Maxentius in Rome, to be continued with 4 other case studies, in different parts of the Roman Empire such as Circus of Merida and Circus of Tarragona in Spain, Circus of Caesarea Marittima in Israel, and Circus of Colchester in Great Britain, included in a larger project.

The Circus of Maxentius in Rome (Italy) also known as the circus of Romulus, it was built around 311 by the emperor Maxentius in Rome, within his private building complex by the Via Appia. The remains of the cavea and part of the well-preserved carceres and traces of the spina make it the best example of a preserved Roman circus and a perfect case study to calculate the construction costs.

The aim of the paper is to identify and to analyze the phenomena of economic and civic development using circuses as indicators of the processes of foundation and consolidation of provincial structures. Finally, it will also discuss the possibilities offered by the economic data thus obtained will make it possible to compare the economic dynamics of the various provinces of the Empire and evaluate the phenomena of resilience and identity of the Roman provinces.

Methods and materials

The overall calculation of investments in architecture will be related to the macroeconomic trends of the imperial age. To this end, five case studies will be taken into consideration which allows a more accurate estimate of the investments required by measuring the five circuses on which an assessment of construction costs.

Research on ancient building history and architecture has focused in recent years on the economic aspects of the various building and work processes. For this purpose, attempts are made to quantify both the building material and the working time required to construct a building to record the magnitude and the overall economic impact. Abrams was the first that developed the principles of architectural energetics, applying it on Mayan monuments in the 80s (Abrams 1989 and 1999).

For classical archaeology, a pioneer of this type of approach was J. DeLaine in 1997, studying the Baths of Caracalla (DeLaine 1997), starting from the calculation of the elements of the construction to study the economics of large-scale building projects in imperial Rome.

The methods employed in my research are:

a. Topographical and geo-morphological analysis using updated maps and satellite data for the development of the previously webGIS platform (https://www.chnt.at/entertainment buildings-during-the-roman-empire-where-when-why). The aim is to analyse the relationship of the Maxentius circus to its surrounding structures and to understand how the urban planning of the ancient city changes.

b. Analysis of the historical and archaeological data of case study, of the sources, iconography, inscriptions to understand socio-economic aspects that led to the construction.

c. Deconstruction of buildings into measurable components and analysis and quantification of these parts with the use of Building Information Modelling (BIM). BIM relies on the definition of a semantic structure and on the use of 3D volumetric and surface models for describing the stratigraphic sequence of elements of a building by standard geometries.

d. The quantification of architectural elements of a case study will be obtained also using the image-based method (photogrammetry), which gives us the analysis of variance and the number of bricks of a portion of each circus using new tools for the classification, as machine learning applied in archaeology (Dininno 2016; Dininno 2017; Grilli et al. 2018).

e. Estimate of volumes and materials and works used in ancient buildings through architectural energetics in archaeology that generates estimates of the amount of labor and time allocated to construct these past monuments using detailed analyses of architecture (manpower, logistics, material sources, times, and costs).

Results

The research proposed in this paper is interdisciplinary ongoing project and has a multilevel approach, involving geo-morphological and socio-economic studies, architectural energy with the use of geomatics and 3D reconstruction associated with a webGIS platform.

The expected results are (i) to analyse the relationship between buildings and the surrounding area, (ii) to identify the distribution and concentration of show buildings in the regions of the Empire, (iii) to quantify investments in show architecture, (iv)to highlight presences and absences in each area, to evaluate the degree of economic and urban development, (v)to correlating regional differences considering cultural and socio-economic peculiarities.

The project is a collaboration between The Lund University Digital Archaeology Laboratory, Swedish Institute of Classical Studies in Rome and the Soprintendenza del Comune di Roma.

Discussion

How much did it cost to build a circus? Did it cost the same in all regions of the Empire? Studying the costs of large infrastructures and of their large dimensions represent a potential challenge to offer a representative data set because they better reflect economic trends.

Did the construction of the circus limit the ethnic identity according to the Roman Empire? These constructions were often subsidized by the local elite and became an opportunity to demonstrate belonging to the Roman Empire, but at the same time, they used local stones and workers who tried to simulate the “shape” of the Circus with typically local characteristics.

References

Abrams, E. M. (1989). Architecture and energy: An evolutionary perspective. Archaeological method and theory, 1 , 47-87.

DeLaine, J. (1997). The baths of Caracalla: a study in the design, construction, and economics of large-scale building projects in imperial Rome, Portsmouth 1997.

Grilli, E.; Dininno, D.; Petrucci, G.; Marsicano, L.; Remondino, F. (2018). Supervised segmentation for 3D cultural heritage, Digital Heritage 2018 archive, S. Francisco.

260. Do we need an extended ontology for the archaeology of ancient religions? Data modelling and visualization techniques of Roman religious spaces

Asuman Lätzer-Lasar, Philipps-University Marburg, Classical Archaeology

The aim of the paper is to present different digital approaches to the archaeological record, such as data modelling and knowledge networks, as well as visualization techniques, such as viewsheds, to focus on and analyze the qualitative aspects of the find contexts. Based on the final evaluation, it will be discussed whether the CIDOC CRM ontology, which serves as basic vocabulary for the semantic knowledge network, should be specifically extended for the study of ancient religions.

Especially when it comes to religious spaces, not solely quantitative results are significant when investigating ancient societies and their religious activities. Rather intellectual entities, such as self-world relations, atmospheres, or emotions play as well an important role, although they are not easy to detect nor quantify. The last decades, with the emergence of diverse approaches from sociology, cultural studies or anthropology, the study of the materiality and practices of ancient religions have enormously changed. First of all, the sociological conceptualization of “space” in the 1960s to 1990s has led to an understanding of spaces firstly, as the result of social interaction (Lefebvre; Hofmann/ Lätzer-Lasar) and secondly, as shared space with its own locally produced place identity (Hayden/Walker 2013). In the first case, the so-called social space is constituted by human interactions as well as social practices, thus dissolving the container perspective on the concept of space. Social practices, however are intangible cultural remains that in many cases can be reconstructed from the remaining materiality, in other cases they can be derived indirectly from the material. In religious spaces, for instance funerary contexts, libations can be assumed in case a terracotta tube is found at the burial place, at other tombs, with no installations for a liquid ritual, commemoration practices are only deducible through the shaping of the objects and the environment. The interpretation of an environment inside a building or outside in the public/nature can be modeled through digital tools, such as viewshed analyses or the modeling of human behavior in it or other parameters, such as sunlight, aura etc.

The second, place identities, change, for instance, depending on the different social groups that are/were present in the place (co-spatiality) and their social actions (Werlen 1993), or the temporal circumstances (chronology-related) impacting on the assemblage, or the narrative (e.g., social imaginaire) about that place. Thereby an amount of highly fragmented and unquantifiable data is generated that is usable for archaeological questions. Digitization offers the possibility to visualize and thus structure the data. The latter is important for a comparative approach. Furthermore, digital modelling enables to reconstruct the missing data, in the case of viewsheds, for instance, experience-based data relating to vision can be generated.

At the moment, it still seems to be a desideratum of the digital humanities to develop a more visible way to integrate the resulting qualitative data into existing digital infrastructures where they are correlated with quantitative data.

Based on the case study of intra-urban Republican burial places in the city Rome, I present firstly the diverse digital tools that are used to generate qualitative data and secondly, bring these heterogenous and fragmented data into a data model with the intention to make it comparable among the different archaeological find contexts.

Place identity plays a significant role, as burials in the city were forbidden by law since the 5th century BCE. However, with the growth of the city, tombs that had previously been on the outskirts suddenly found themselves in the midst of a heterogeneous and lively urban fabric. Place identities, or one could speak of a place biography, changed. But how do we illustrate the chronological development in semantic web models? And which intellectual entities are then assigned to place with its materiality, and space with its practices? Are data model based on the CIDOC CRM vocabulary sufficient enough for the creation of knowledge networks? Or do we need an extension for the religious sphere? Finally, how do we combine the digital tools in a meaningful, but also reliable way?

Literature:

David J. Bodenhamer et al. (eds.) 2015. Deep Maps and Spatial Narratives, Bloomington, IN: Indiana University Press.

Hayden, Robert M.; Walker, Timothy D. 2013. ‘Intersecting Religioscapes: A Comparative Approach to Trajectories of Change, Scale, and Competitive Sharing of Religious Spaces’, Journal of the American Academy of Religion 81. 399–426.

Hofmann, Kerstin P.; Lätzer-Lasar, Asuman 2022. ‘Archaeology and Sacred Space: On ancient and contemporary practices of (de-)sacralization of the Palatine in Rome’, in: Bachmann-Medick, Doris; Kugele, Jens; Stornig, Katharina (eds.), Conceptualizing Sacred Space(s). Perspectives from the Study of Culture Special Issue, Saeculum, 2021/2. Jahrbuch für Universalgeschichte.

Lefebvre, Henri 1974. The Production of Space. Blackwell Publishing.

Werlen, Benno 1993. Society, Action and Space. An Alternative Human Geography. London: Routledge.

277. Timescape of the settlement of Pancarlık : time and space of entities creating landscape

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Idil Üçbaşaran, Ortahisar Belediyesi

The region of Cappadocia is located in the middle of central Anatolian region, Turkey. We can have insights on its long history by retracing the meaning given through time to the designation “Cappadocia”. Indeed, the association between the name and the geographical area has moving boundaries.

During the Roman time, Cappadocia was used to name a province (administrative region). Afterwards, during the Byzantine period, the toponym “Cappadocia” bore several definitions. It was used to designate three eparchies (religious province of the Byzantine Church) and two themes (military regions). Today, the geographical area associated to the name Cappadocia is built out of four administrative provinces of the Turkish Republic: Aksaray, Niğde, Kayseri and Nevşehir. The word keeps being used even if it does not have any administrative base, its meaning has moving boundaries according to the circumstances (historical context, religious context, geographical context, touristic context, etc.) (Lamesa A. 2016).

Therefore, there is no Cappadocia per se, but the works brought by the early travellers, geographers and historians was deeply anchored in the interpretation of the landscape. Indeed, Cappadocia has a very peculiar geomorphology which helps to well define the area in space. Given so, it was tempting to stick this continuous whole on its history, reinforced by the fact that Byzantine testimonies located in the area, are crafted into the rock. Furthermore, in the line of this theoretical vision, Cappadocia is seen as a Byzantine area, keeping into the dark the long durée space life of the churches. This rhetorical vision restrains our understanding of the communities who lived nearby, which used and transformed the church and its surroundings for their own needs along the time. Our paper aims to challenge the still well anchored vision of Cappadocia, using the example of a rock-cut church as case study.

Located in the territory of Ürgüp, not far from the valley of Ortahisar, the site of Pancarlık is known in the literature most exclusively by its eponym church. The rock-cut church is one of the oldest rock-cut worship places with large, sculpted decoration. However, until recently with the analysis of R. Ousterhout (Ousterhout 2017, 44-45), the Pancarlık church was only ascribed to the Byzantine period, as well as its vicinity.

Three scales will be used to deconstruct the currently theoretical framework: we will start with the church itself. As widely noticed by R. Ousterhout, several occupation phases can be noticed by simply carefully looking at the design and changes made in the nave. Then the second scale will include the church in its closest surroundings. Close to the church indeed, several structures – for worship or agriculture activities – can be found, forming a complex site. By extending our first hypothesis from the analysis of the church and applying it to the whole site, we think that it would reveal the evolution of the settlement. At last, we will consider the site itself in its territory and landscape. As mentioned above, the site of Pancarlık is located on the vicinity of two towns (Ürgüp and Ortahisar) as well as a large valley where some rock-cut tombs attest the occupation of the area in ancient times.

To do so, we will use GIS and analytic geospatial tools crossing with written sources and chrono-typology and therefore, we will propose a new reading of the settlement and reintroduce, thanks to these different spatial scales, the temporality of the place

or – to use the word of B. Adam (Adam 1998)– its timescape.

44. Roads to Complexity: Technological and Quantitative Approaches to Human and Objects Connectivity

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Lorenzo Zamboni, Università degli Studi di Milano
Daniele Bursich, Università degli Studi di Salerno

Location: E105

Connectivity is how people and things relate with each other through space and time, and roads are a primal and widespread human strategy to achieve this crucial goal in evolutionary and historical terms. A road is a hinge between individuals and cultures, along the road events happen, stories intertwine, goods are exchanged and cultural processes spread leading to the nourishing of communities and territories. Both as trails or engineering works, roads usually depart from given 'centers' to reach remote territories, creating new paths for interaction and cultural contamination. The analysis of connectivity and its material signs is a common research topic in the current archaeological agenda, with several case studies showing the degree of human-things entanglement. However, understanding past movements requires a shift from traditional archaeological ontologies, grounded in fieldwork and descriptive studies, towards more analytical-based studies. Moreover, the landscape along a road is constantly changing, in synergy (or in contrast) with other natural and human features and leading to endless potential variations over time. There are therefore many types of roads embedded in urban, rural or even deserted landscapes, connecting territories through several modes and tempos of mobility.

The street is the privileged place for the movement of human society that moves through the cities. But also from city to city, from settlement to settlement. Within the public and private spaces intended for movement and mobility, human relationships flourish. These are the places where knowledge is born: here are new practices such as barter which then turns into commerce, the traffic and movement of goods, as well as the spread of art, which is contaminated through social relations (Greek potters for example).

There are also peoples based on movement, such as the caravan cities, which trade goods from the Far East, becoming the privileged places for markets and street vendors who move from one continent to another. As well as trade motivated by religion, which is a very strong reason for cultural influence, both in settled populations and in nomadic ones by vocation.

The road / path / trail is also the privileged place for the pilgrim who moves from one religious place to another. The streets have also constituted international commercial networks since the Bronze Age, the privileged dimension for the breeding of cattle through mountain paths, the standardization and the new invention of Roman roads, which constitute one of the success factors of the Roman empire, up to intangible paths such as the aboriginal "ways of songs".

This session welcomes papers dealing with human connectivity and objects mobility through the application of new technologies and state-of-the-art methods. Any type of connectivity and any category of infrastructures could be explored, including: physical and immaterial pathways, road construction techniques and maintenance, the archaeology of roads and streets in urban and landscape context. More specifically, we want to explore how road architecture could have influenced common and transit spaces, which agency do roads have in cultural and socio-economic terms. These investigations are increasingly characterised by digital technologies (network analysis, big data, surveys, space syntax, and so on), which allows us to promote reconstructions, hypotheses and simulations, adding greater descriptiveness and coherence to the research synthesis process.

We also encourage the submission of papers dealing with geospatial and statistical analysis, network analysis, and of course reconstruction of sections of routes with innovative and immersive technologies. Acquiring, viewing and disseminating data through dynamic databases therefore produces a shift from traditional methods of recording information, promoting new ways of using knowledge.

	SLOT 2
11:00 - 11:20	40. Mobility and the reuse of Roman Roads for the deposition of Viking Age silver hoards in northwest England *Wyatt Wilcox (University of Oxford)**
11:20 - 11:40	63. Algorithms and Exponential Random Graph Models – How to make the most of incomplete archaeological data *Deborah Priß (Durham University)*; John Wainwright (Durham University); Dan Lawrence (Durham University); Laura Turnbull-Lloyd (Durham University); Christina Prell (Faculty of Spatial Sciences, University of Groningen); Christodoulos Karittevlis (AAISCS); Andreas Ioannides (AAISCS)*
11:40 - 12:00	177. Streets and Neighbourhoods: A case study from modern day İstanbul *Tuna Kalaycı (Leiden University, Faculty of Archaeology)*; Scott Branting (COS); Dominique Langis-Barsetti (University of Toronto); Jessica Robkin (UCF)*
12:00 - 12:20	372. Find Stories: Bioanthropology and Material Culture Synergies to evaluate the impact of short term mobilities *Konstantinos P Trimmis (University of Bristol)*; Christianne L Fernee (University of Bristol)*

12:20 - 12:40	Discussion

40. Mobility and the reuse of Roman Roads for the deposition of Viking Age silver hoards in northwest England

Wyatt Wilcox, University of Oxford

Introduction

There are 16 known Viking Age silver hoards that were buried in northwest England. The silver buried in the northwest represents great wealth and range of contact in the hands of the Vikings at this time – silver pieces buried as part of the hoards originate from as far away as the Middle East. There is a particular temporal concentration of hoarding in the early tenth century, during the height of Viking control in the kingdoms of York and Dublin. It is generally understood that the hoards in the northwest are of a Danelaw character, were intended for retrieval, and were buried where they were as the northwest exists on an essentially straight line between York and Dublin. Furthermore, recent research and excavation has illustrated that the Roman road network was probably re-used and maintained by interested parties travelling between early medieval period destinations in the northwest. However, the specific routes of early medieval period pathways are not known other than fragmentary courses of Roman road. This paper seeks to use computational least cost path modelling to examine the situation of the silver hoards in the context of the road network in the northwest. Can the silver hoards be seen as related to the re-used Roman road network linking York and Dublin via the trans-Pennine mountain crossings to Lancashire, Cheshire, and Cumbria? Are the hoards consistently buried near to pathways, but far enough away to be concealed from general foot travel? To address these questions, a probability-based network suite of optimal pathways was built that takes into account recently rediscovered fragments of Roman road that have come to light in the northwest in the past half-decade (Ratledge, 2021), multiple cost of vertical movement functions to simulate the agency of different walkers in the landscape, and uncertainty due to errors inherent in the DEM creation process.

Figure 1. The Silverdale Hoard. Boughton, D (2011) "LANCUM-65C1B4: A EARLY MEDIEVAL HOARD". Portable Antiquities Scheme, 2022.

Methods

This paper's methodology comprises two segments:

1. The generation of optimal pathways between all potential early medieval destinations in the northwest of England, utilising multiple cost functions for vertical movement, a Monte Carlo simulation to address uncertainty inherent in DEM creation, newly-discovered courses of Roman roads, and wetlands.

2. The generation of optimal paths from possible points of departure from main routeways to the depositional points of the silver hoards using the methodology established in step one.

A family of optimal pathways was generated for each of the possible early medieval destinations using the Distance Accumulation and Optimal Path as Line tools in ArcGIS Pro, prioritising non-wetland routes along known segments of Roman road. A probability-based network of optimal paths was created using a Monte Carlo simulation to model uncertainty due to errors in the digital elevation model (c.f. Fisher 1993). To robustly estimate the agency of different walkers, three equations for estimating walking speed along paths (listed in Herzog, 2020) were implemented for each DEM created in the Monte Carlo simulation process. A cost raster for horizontal movement was created to prioritise travel along known segments of Roman roads and to avoid travel through early medieval period wetlands. Wetlands were modelled in ArcHydro's Wetland Identification Model, with supplementary data taken from the RAMSAR internationally recognised wetlands convention. Costs of movement were calculated using a surface approximation based on the Eikonal Equation (Sethian 1999). The counts of overlapping features from the simulated

optimal pathways for each cost function were displayed, reflecting the probability that line segments were used in the optimal pathway.

A new network was generated from potential points of departure from the optimal path network to the hoard depositional locations. Optimal paths were generated at defined intervals along the previously-simulated optimal pathways simulating potential points of departure near the hoards. These new optimal paths were created using the same probability-based modelling process as described above.

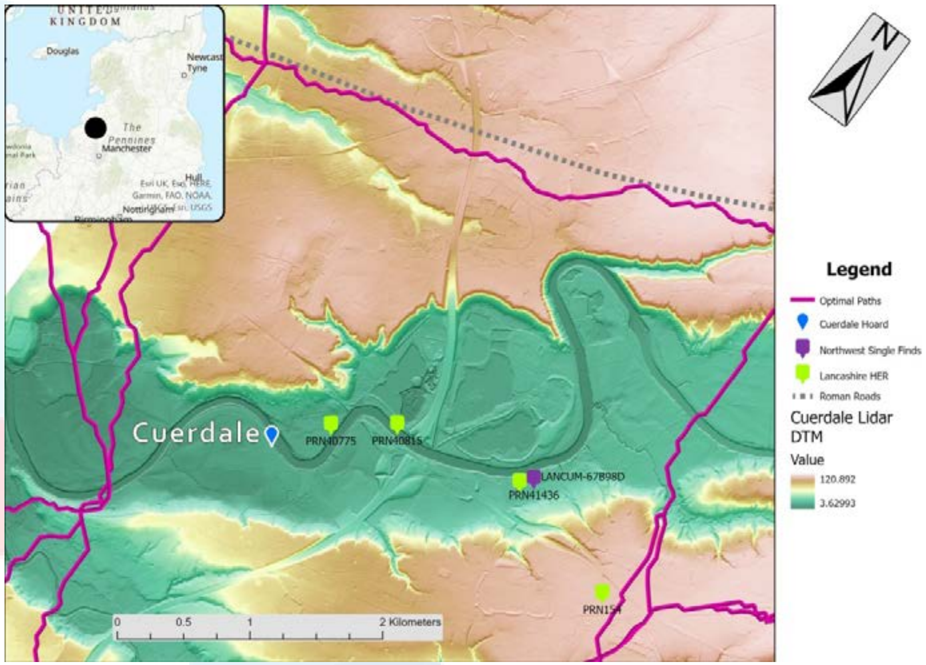

Figure 2. Optimal paths near the Cuerdale hoard, illustrating its associated River Ribble crossing points near Walton-le-Dale and Samlesbury

Results and Discussion

The specific courses of early medieval period routes were not previously known in northwest England, apart from fragmentary Roman road evidence. The optimal pathways illustrated in this analysis have linked the known destinations using a robust methodology. Two possible interpretations of the hoards' relationship to routeways can be discussed based on the results of the analysis. Firstly, the hoards can be seen as related to the early medieval re-use of Roman roads linking York and Dublin. It has been suggested previously that the material composition of the silver in the hoards suggests that the hoards are related to transportation from York to Dublin. The results of this paper's optimal pathways modelling indicate that the silver hoards may have been located within a close walking range of 15-30 minutes from early medieval period routeways shared between several destinations in the network linking York to Dublin. Secondly, the distance between the hoards and their nearest optimal pathways indicates that the hoards may have been intended to be concealed from the main routeways and possibly later retrieved. Several of the hoards in the northwest have previously been classified as deposits intended for retrieval due to the presence of lead containers. The 15-30 minute walking time from optimal pathways to the hoards can lead to tentative suggestions that the depositors intended to return and retrieve the hoards. Their method of facilitating a return may have been selecting easy-to-reach locations away from commonly-frequented routes.

References

Fisher, Peter F. "Algorithm and Implementation Uncertainty in Viewshed Analysis." International Journal of Geographical Information Systems 7, no. 4 (1993): 331-47.

Herzog, Irmela. 2020. "Spatial Analysis Based On Cost Functions." Archaeological Spatial Analysis, 333.

Ratledge, David, and the Roman Roads Research Association, dir. 2021. How LiDAR Is Transforming Our Understanding of the Roman Road Network in NW Eng by David Ratledge. https://www.youtube.com/watch?v=MCefNA0o2b8.

63. Algorithms and Exponential Random Graph Models – How to make the most of incomplete archaeological data

Deborah Priß, Durham University
John Wainwright, Durham University
Dan Lawrence, Durham University
Laura Turnbull-Lloyd, Durham University
Christina Prell, Faculty of Spatial Sciences, University of Groningen
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Introduction

Network analysis has been increasingly used in archaeology during the last two decades and is a promising approach to understanding past human societies (Brughmans and Peeples 2017). However, doing network analysis adds another layer of difficulty because not only the data's sparseness often presents a problem for several network metrics and models but also defining the network itself can be challenging.

Mesopotamian hollow ways are physical remains of past people's movements and can tell us about the connectivity of the societies that produced them. They are structures that, in theory, lend themselves well for network analysis: physical edges that connect sites, i.e. nodes, with each other. However, these data are partial, with gaps in the routes, and the settlement record is – as far as we know – far from complete.

In this paper, we present computational methods to enhance fragmented archaeological data. Two algorithms were developed to overcome the issue of missing data for a) the network of Bronze-Age hollow ways in Mesopotamia and b) the settlement system for the same period and region. The improved data sets will be used as the input of an exponential random graph model (ERGM) and we will show how sensitive the outcomes of the ERGM are to dataset completeness.

Materials and methods

Data for the hollow ways (6543 lines) was downloaded from The Harvard WorldMap Project

(https://worldmap.maps.arcgis.com/home/item.html?id=c04e5bca73ec447ca1979c3b1d5ec8cd); data for the settlements was provided by the Fragile Crescent Project (FCP, not public; 489 points), Tuna Kalaycı (https://zenodo.org/record/7048407#.YzwkvEyZOHs; 910 points) and drawn from the AWOL website (http://ancientworldonline.blogspot.com/2011/07/ane-placemarks-for-googleearth.html; 359 points).

Algorithms

We developed an algorithm to fill the gaps in the hollow ways so that they form a network close to the one people in the past would have encountered. The fragments are connected based on the following assumptions:

- Distance is important: only hollow ways within a certain distance of each other are connected.
- Angle is important: only hollow ways that run in the same direction are connected.
- Location is important: only non-parallel lines are connected.

Based on the most significant characteristic of the hollow ways – their radiating from settlements – another algorithm was developed to find areas where several hollow ways intersect, potentially indicating a site. From the end points of every hollow way, a pre-defined area is created in which to look for potential settlements. Every cell in this area is assigned a value based on the distance from the end point, with the value decreasing with increasing distance according to a decay function. If grid cells are in overlapping areas of two or more hollow ways, their values are summed.

Exponential Random Graph Models

ERGMs are discrete, time-based models that are used to stochastically analyse cross-sectional networks by comparing an observed network to randomly generated ones (Lusher, Koskinen, and Robins 2013). They are used to assess how and why ties are formed within a social network as the outcome of local dynamic processes, in our case, to estimate the social processes behind the formation of the hollow-way system.

Several hypotheses are tested by translating them into local network statistics, often referred to as ERGM effects or terms. They take the form of network configurations, particular patterns of connections among a subset of nodes, such as a closed triad among three nodes. Those configurations are specified to test hypothesised social processes pertaining to tie formation or tie presence (e.g. the likelihood of observing ties embedded in closed triads). Their significance is estimated via MCMC algorithms that handle the interdependencies inherent in network data.

ERGM results have been known to be affected by as little as 10% missing data (Green et al. 2019) and hence, archaeological data make estimations a severe challenge. Finding valid ways for imputing missing network data therefore remains a continual struggle.

Results

For the initial runs of the first algorithm, only a subset of the hollow-way data was used to reduce computational time. For this subset, the parameter values that returned the best trade-off between too few new hollow-way segments and too many artefacts generated 1836 new lines between 1915 original lines. The two sets of lines were merged to allow more runs with increasing parameter values to fill more gaps without generating too many artefacts.

The result of the second algorithm can be represented as a heatmap with higher values indicating a higher probability of a site. Those locations were cross-checked to validate them with CORONA satellite images and the site data sets. The resulting data set comprised 19 new sites (i.e. not recorded in any of the available data sets but visible on satellite images), and 12.5% to 64.2% of the known sites were picked up. 39 of 176 sites predicted by the algorithm could not be correlated with the documented sites or confirmed with the satellite images. The two algorithms provide more complete data from which a network of nodes (sites) and edges (hollow ways) can be extracted.

The ERGM will be run on the improved data set as well as different subsets of the original data to compare the results and assess the usefulness of a) the algorithms to create more complete and reliable data sets and b) the ERGM itself for the investigation of tie formation processes in archaeological research. The final results will be presented at the conference.

Discussion

Incomplete data are – and always will be – a huge issue in archaeological research. With developments in IT and increasing computational power, we can now address this issue more effectively, efficiently, reproducible and (probably) less biased. The approaches presented in this paper contribute to the efforts of computationally handling missing data.

One of the major limitations of the presented methods is that the parameter values of the algorithms and the ERGM terms still need to be determined by the researcher. Here, bias cannot be avoided as the choice relies on their expertise and experiences. Although these methods will never return "perfect" results, they can be utilised and adjusted for any archaeological research question that uses similar data and are not restricted to a specific region or period.

References

Brughmans, Tom, and Matthew A. Peeples. 2017. 'Trends in Archaeological Network Research: A Bibliometric Analysis'. Journal of Historical Network Research 1 (2017): 1–24.

Green, Harold D., Stanley Wasserman, Kayla de la Haye, Joshua D. EmBree, Matthew Hoover, and Marc PunKay. 2019. 'Systematic Investigation of the Effects of Missing Data on Statistical Models for Networks'. RAND Corporation https://www.rand.org/pubs/working_papers/WR1314.html.

Lusher, Dean, Johan Koskinen, and Garry Robins, eds. 2013. Exponential Random Graph Models for Social Networks: Theory, Methods, and Applications. Structural Analysis in the Social Sciences 32. Cambridge: Cambridge University Press.

177. Streets and Neighbourhoods: A case study from modern day İstanbul

Tuna Kalaycı, Leiden University, Faculty of Archaeology
Scott Branting, COS
Dominique Langis-Barsetti, University of Toronto
Jessica Robkin, UCF

Introduction

The scholarship of modern cities is afforded the advantage of evaluating the impact of civic planning on the formation of neighbourhoods (Filion and Hammond, 2003). The possibility of reaching out to neighbourhood residents and collecting empirical data is a unique opportunity for modern urban studies. Historical and archaeological studies lack this access to living residents but they in turn offer access to a much wider range of neighbourhoods and cities that evolved in the past within different social and environmental contexts (Pacifico and Truex, 2019). Urbanists looking at neighbourhoods in the present can employ methods, especially those involving interactive surveys or participant observation, but do not have direct applicability in historic or archaeological contexts. Instead, proxies for these forms of collected data or alternative methodologies must be developed and employed. We suggest streets can be a proxy. It is possible to evaluate streets diachronically and synchronically as they can be persistent urban elements and "resist" to change.

Site Selection

The area of Istanbul has seen millennia of habitation. The core of the built environment hearkens back to the reconceptualization of the city as an imperial capital by the Roman Emperor Constantine in the early 4th century CE. It grew into a mega-city of its time and of all subsequent periods, with the various rebuilt city walls, monuments, buildings, and even some of the neighbourhoods remaining within the built environment, reused and re-envisioned by succeeding generations of inhabitants. Istanbul was selected for this study as it bridges time from the end of the classical periods into the modern world. This allows a wider variety of historic and modern methods to be brought to bear to understand neighbourhoods within the city. Indeed, well defined historic neighbourhoods are found within Istanbul and form the test bed of the space syntax methods for defining neighbourhoods from the urban street plan.

Methodology

Space syntax is a set of methods designed to answer questions related to connectivity within an urban built environment by looking at how structures and built elements are related through a transportation network. Created by Bill Hillier in the 1970s, space syntax was originally conceived to address urban planning inadequacies from previous decades of urban development. It offers a set of promising techniques for studying neighbourhoods. It can identify differences within the spatial configuration of the urban form, which could better direct assumptions on neighbourhood demarcation (Zhu, 2012).

Urban Data Acquisition

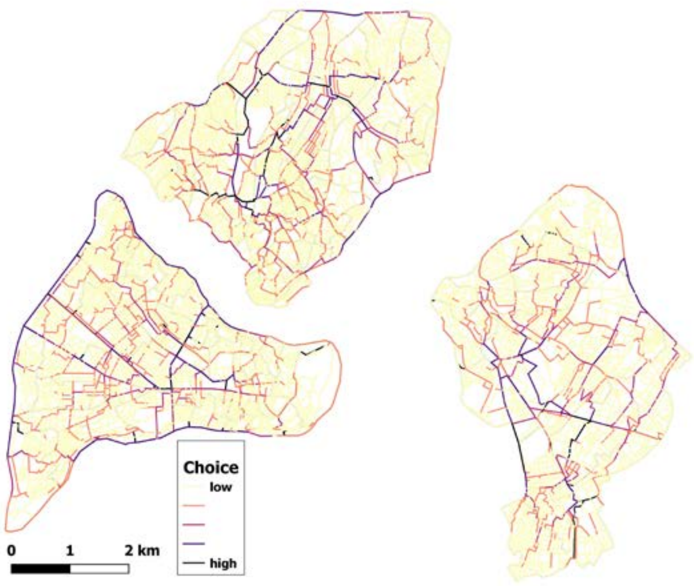
We acquired transportation and municipality data from two data warehouses built on the collaborative OpenStreetMap (OSM) project. We downloaded the street network of Istanbul from 'Geofabrik' servers. The data package is GIS-ready, so it is prepared for further spatial manipulation. The 'OSM-Boundaries' initiative distributes administrative datasets and we acquired three datasets based on the OSM hierarchy level 6 and 8.

Space Syntax

Following the pre-processing, we exported data in depthmapX, the open-source spatial analysis software for spatial networks. We then deployed the axial and segment analysis capability of the software and produced 27 space syntax variables. In particular, we choose 200, 400, 800, 1600, and 3200 for metric radii and explored different segment step depths under the expectation that different step values indicate different scales in the road network. Finally, we retrieved the results back in QGIS and explored them for potential patterns and matches with the existing neighbourhood boundaries.

Results

Visual investigation suggested we could group space syntax variables in four broad categories for the case of Istanbul. In the first group, there existed variables (e.g., Connectivity) that appeared to be distributed randomly and exhibited little-to-no patterning. The variables originating from segment analysis produced more promising results. The Choice emerges as a potential variable for neighbourhood analysis (Figure). The variable is akin to Betweenness Centrality in Graph Theory and can indicate if the road can be considered as a route for through traffic. Incidentally, streets with high Choice values coincided clearly with some of the neighbourhood boundaries in the study area. The step depth (n) appears to be an important.



Time-Depth

In our study, we also briefly trace the history of the street network of İstanbul. Our data mainly originates from the digitization of historical maps and models. We explore the street networks of Byzantine Constantinople, Ottoman Constantinople, early 20th century, alongside modern-day İstanbul. Visual interpretation of the street network evolution reveals some streets are indeed persistent to urban change. Using these results, we further explore the imprints of these "permanent streets", mainly in the context of urban neighborhoods and as their potential boundary markers, also in the early days of this once the mighty capital of empires.

Conclusion

The use of space syntax for exploring the networks that underlie the built environment of neighbourhoods offers promise for analysis of ancient, historic, and modern cities. In our own work, the development and initial testing of these tools within historic Istanbul affords us the opportunity to use them to better explore ancient cities. The identification of potential neighbourhoods will provide us with an intermediary scale of analysis that can complement our ongoing research into both households and the entire city. Historic Istanbul has allowed us to identify potential variables that can be applied in the more distant past. Specific variables identified in this study include Choice, Integration, and Total Depth. Our analysis shows the Choice variable is the most beneficial to explore potential neighbourhood boundaries. Integration and Total Depth may be used to highlight neighbourhood cores. Generation of these variables for different depths provide scalability.

Exploring tools such as space syntax, which are as applicable to analysis of the past as they are to the present and future because of their direct linkages to the built environment, can enable a much longer-term vision of cities, their components, and their ultimate resilience across generations of inhabitants. While there are limitations in the forms of data and analysis available to archaeologists and historians, finding ways to engage these scholars opens multiple spatio-temporal scales of analysis and provides an enormous wealth of real-world examples for building more resilient and livable cities.

References

Filion, P., and K. Hammond. 2003. 'Neighbourhood Land Use and Performance: The Evolution of Neighbourhood Morphology over the 20th Century'. Environment and Planning B 30 (2): 271–96.

Pacifico, David, and Lise A. Truex. 2019. '1 Why Neighborhoods? The Neighborhood in Archaeological Theory and Practice'. Archeological Papers of the American Anthropological Association 30 (1): 5–19.

Zhu, J. 2012. Chinese Spatial Strategies: Imperial Beijing, 1420-1911. Taylor & Francis

372. Find Stories: Bioanthropology and Material Culture Synergies to evaluate the impact of short term mobilities

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Christianne L Fernee, University of Bristol

Introduction

Finds stories promote synergies between proxies to address the impact of short term mobilities on individuals, their material culture, and their environments. Finds Stories focus on the transhumance groups in North Western Greece, that are moving annually from lowlands to uplands with their flocks, following the same routes, roads, at least since the 16^{th} century CE. However, the methods developed as part of Finds Stories, can equally be applied to similar groups elsewhere. Finds Stories, promotes a multiproxy approach where material culture studies, bioanthropology, and landscape archaeology work in synergy.

Materials and Methods

As materials for Finds Stories case study the pastoral route from the Thessaly lowlands in central Greece to the Pindus Mountains in Western Greek Macedonia has been selected. The route, which pastorals are calling 'Diava', was mapped and sampling for environmental isotopes along the route have been conducted. Historic skeletal remains from 25 individuals, dated between 1860 and 1950, that used to be moving along this route have been analysed. Equally 84 objects directly related to the annual journey have been recorded.

For mapping the 'Diava' aerial and terrestrial survey was utilised. Equally geoarchaeological coring at campsite locations across the routes took place to determine their stratigraphy, duration of human activity in each locality, and to sample for environmental isotopes. For the skeletal remains analysis osteoarchaeological analysis was conducted, while stable isotope analysis for diet (δ 13C and δ 15N) and mobility (87Sr/86Sr and δ18O) on these individuals have been analysed. Long bones (humeri, femora and tibiae) from the same assemblage have been CT scanned and Cross-Sectional Properties (CSP), Geometric Morphometric (GM) analysis and Finite Element Analysis have been undertaken to record differences in long bone biomechanics. Finally cementum analysis have been performed to explore the different life history patterns, particularly reproductive events, of these individuals.

For the material culture proxy an object biography approach has been followed. The artefacts analysed for the purpose of the project are selected with the intention to encompass a broad spectrum of biographical parameters. Starting points in their exploration are their formal and technological attributes, as they relate to the evolution of styles, the chaîne opératoire, or the duration and nature of usage. These parameters, however, provide only a partial understanding of the life of the artefacts. The reconstruction of their biographical narratives further takes into consideration the objects' diverse entanglements, from the social contexts of their production and use, and the meanings ascribed to them throughout their many metaphorical lives and deaths, as they enter and leave people's lives, down to the point of their incorporation in museum collections or in archaeological research. Computational statistics, and special analyses have been conducted to achieve data synergy between the different proxies.

Results

Finds Stories multiproxy approach showed that circular, transhumance, mobility impacts all aspects of life from the everyday household items to the human body, and the natural environment whiten mobility takes place. Body morphological variations that are both aspect of the mobility patterns and the use of certain objects could be observed, while equally material culture have been created to follow certain body and landscape traits.

Discussion

Finds Stories perceives transhumance not solely as a socio-economic system but as a symbiotic assemblage of people, landscapes, animals, and material culture, within which one is depending on another. Finds Stories analysis shows transhumance as an assemblage of different agencies, that can be studied following assemblage theory principles that highlights the interdependencies between agents. Studying in Synergy the people that moving, their landscape, and their material culture, and analysing both spatial and statically the datasets, Finds Stories records the interdependencies between these agencies. How one depends on the other in order to exist, and how one changes as the other changes. For example, the bodies – material culture symbiotic relationship is recorded and analysed, showing a significant impact on skeletal variation based on the analysis of the tools an individual was using. Then ultimately all these interdependencies are plotted along the route, the long road that is the conduit of people, ideals, and maps the impact of the movement. The central road of the route then is highlighted, because all, material culture and bodies are actually being shaped by the natural agency of the 'diava'

16. Archiving information on archaeological practices and knowledge work in the digital environment: workflows, paradata and beyond

Isto Huvila, Uppsala University
Jessica Kaiser, Uppsala University

Location: E103

Knowledge of archaeological work – from fieldwork and post-excavation and laboratory analyses to visualisation and beyond – is crucial for understanding and using its different outputs independently if they are digital or non-digital data, reports, or monographs, digital visualisations, or models. There is a growing corpus of empirical and theoretical research and accounts of practical work on documenting, capturing and keeping information pertaining to archaeological, scientific and scholarly practices. These studies range from the documentation of traces (e.g. Morgan & Eve, 2012), paradata (e.g. Gant & Reilly, 2017; Denard, 2012; Huvila et al. 2021) and, for example, provenance metadata (e.g. Huggett, 2014) and how information can be preserved as a part of the archaeological record. This session invites presentations of evidence-based, theoretical and reflective work relating to archiving of information that describes and documents digital archaeological practices. The session is open to quantitative and qualitative evidence-based studies of archiving and re-use of archived information on archaeological practices and knowledge work, as well as theoretical work shedding light on different, for example, epistemological aspects of the topic. Further, the session welcomes reflections and descriptions of how such information has been archived or is planned to be archived in practice. Relevant contexts for presentations discussing archiving and the implications of different types of information archived on archaeological practices and knowledge work in the digital environment range from archiving and preserving fieldwork, to the documentation of data creation (for example, database design and management), working on legacy documentation, metadata and paradata, automatic and manual archiving and beyond. Proposals are welcome from the entire CAA community including archaeologists, social and computer scientists, heritage, museum and information studies researchers and practitioners. The format of the session (Standard session) consists of paper presentations and discussion, including a concluding open forum for sharing and collecting ideas for future research on and in relation to traces of digital archaeological practices. The session is affiliated with the CAASIG ARKWORK on archaeological practises and knowledge work in the digital environment.

References:

Denard, H. (2012). A new introduction to the London Charter. In A. Bentkowska-Kafel, H. Denard, & D. Baker, A. Bentkowska-Kafel, H. Denard, & D. Baker (Eds.), Paradata and transparency in virtual heritage (pp. 57–71). Farnham: Ashgate.

Gant, S., & Reilly, P. (2017). Different expressions of the same mode: a recent dialogue between archaeological and contemporary drawing practices. Journal of Visual Art Practice , 17 (1), 100–120. https://doi.org/10.1080/14702029.2017.1384974

Huggett, J. (2014). Promise and Paradox: Accessing Open Data in Archaeology. In C. Mills, M. Pidd, & E. Ward, C. Mills, M. Pidd, & E. Ward (Eds.), Proceedings of the Digital Humanities Congress 2012. Studies in the Digital Humanities. Sheffield: HRI Online Publications.

Huvila, I., Sköld, O., & Börjesson, L. (2021). Documenting information making in archaeological field reports. Journal of Documentation, 77(5), 1107–1127. https://doi.org/10.1108/JD-11-2020-0188

Morgan, C., & Eve, S. (2012). DIY and digital archaeology: what are you doing to participate? World Archaeology , 44 (4), 521–537. https://doi.org/10.1080/00438243.2012.741810

SLOT 3	
14:00 - 14:20	**Introduction**
14:20 - 14:40	96. Successful archiving and management of paradata depends on your paradata-in-hand *Isto Huvila (SE)*; Zanna C Friberg (Uppsala university)*
14:40 - 15:00	221. Research workflows, paradata, information visualisation: feedback on an exploratory integration of issues and practices *Iwona Dudek (CNRS)*; Jean-Yves BLAISE (CNRS)*
15:00 - 15:20	72. 25 years of archiving: Exploring what people see as deposit worthy *Teagan K Zoldoske (Archaeology Data Service)*; Becky Hirst (Archaeology Data Service)*
15:20 - 15:40	126. HORAI: An integrated management platform for historical information *Pablo del Fresno Bernal (Sistemes de Gestió del Patrimoni SCCL); Sonia Medina Gordo (Universitat de Barcelona, Institut d'Arqueologia)*; Esther Travé Allepuz (Universitat de Barcelona, Institut d'Arqueologia)*
15:40 - 16:00	**Discussion**

SLOT 4	
16:30 - 16:50	140. A focus on the future of our tiny piece of the past: Digital Archiving of a long-term and multi-participant regional project *Scott Madry (University of North Carolina at Chapel Hill)*; Gregory Jansen (U. Maryland College Park); Seth Murray (North Carolina State University); Elizabeth Jones (UNC-Chapel Hill); Lia Willcoxon (North Carolina State University)*
16:50 - 17:10	347. Reconstructing Acquarossa - Reconstructing in 3D as a methodology for organizing and interpreting legacy data *Maarten H. Sepers (University of Amsterdam)**
17:10 - 17:30	30. Transforming the CIDOC-CRM model into a megalithic monument property graph *Ariele Câmara (ISCTE)*; Ana de Almeida (Iscte Instituto Universitário de Lisboa); João Oliveira (Iscte Instituto Universitário de Lisboa)*
17:30 - 17:50	245. Text Parsing Archaeological Legacy Data: A Software Methodology to Generate Maps from Handwritten Excavation Documentation *Emily Fletcher (Purdue University)**
17:50 - 18:10	**Discussion**

96. Successful archiving and management of paradata depends on your paradata-in-hand

Isto Huvila, SE
Zanna C Friberg, Uppsala university

Introduction

Earlier studies have pointed to the diversity of information that can be informative of the making, processing and use of archaeological data (Huvila, Sköld, and Börjesson 2021). Simultaneously, a comprehensive understanding of the making and processing of data has been highlighted as a key to their future usability (Huggett 2012). The heterogeneity and multiplicity of such information—often referred to in archaeological literature as paradata—poses a challenge to its consistent management and archiving. To overcome these challenges requires both empirical and theoretical understanding the nature of paradata, including, what is paradata and when a particular piece of information qualifies as such, what needs and requirements data creators and users have for paradata, how paradata is interacted with, and what is required to cater for such needs in the long run. In parallel, what is needed is to contextualise paradata and paradata-related needs and interactions in the framework of data management and archiving.

The aim of this presentation is to provide insights into the premises of successful management and archiving of paradata. The presentation draws from an on-going study of mixed-methods study of archaeological paradata, paradata-related needs and practices in the context of the ERC-funded research project CAPTURE on paradata and process documentation for facilitating data reuse. The findings from the analysis of the empirical material are discussed in relation to a conceptual apparatus derived from archival theory to situate and explicate the nature and function of paradata and its relation to the data it describes.

Material and methods

The presentation draws from a series of studies in the context of the CAPTURE project to draw insights into what needs to be taken into account when planning for, ingesting, managing and preserving archaeology-related paradata. The studies have identified paradata needs and behaviours and paradata types through interviews (N=33) and a survey (N=92) with European and Northamerican archaeologists with experience of creating, managing and reusing data, and document analysis of a corpus of archaeological grey literature.

Results and discussion

The findings so far from the studies of existing paradata, paradata needs and behaviours alike point to a need to develop comprehensive and diverse means for managing and archiving the heterogeneous body of paradata. A key premise of this is to base the management approach on the specific instances of paradata available on a given dataset, the dataset itself and other related data-on-data including formal and informal, structured and unstructured metadata. Rather than necessarily aiming at a scheme of archiving and managing paradata as a separate body of data-on-data, a more pertinent approach might be to consider a networked approach that aligns with the archival principle of respect des fonds (Duchein 1983). Keeping individual pieces of information capable of functioning as paradata in their 'original' contexts, but provide a meta-level map of where they can be found as a finding aid. This could be expected to also resolve some of the issues of not knowing what will be needed/ used as paradata in the future, since the meta-level map could be a flexible enough tool to allow for new directions to be added without disturbing the original ones. Further, such a map does not need to be specific to individual institutions but could also function as an inter-institutional directory to paradata across management contexts (i.e. data repositories, traditional archives, museums etc).

References

Duchein, Michel. 1983. 'Theoretical Principles and Practical Problems of Respect Des Fonds in Archival Science'. Archivaria 16 (1): 64–82.

Huggett, Jeremy. 2012. 'Promise and Paradox: Accessing Open Data in Archaeology'. In Proceedings of the Digital Humanities Congress 2012, Sheffield, 6–8th September 2012, edited by Clare Mills, Michael Pidd, and Esther Ward. Sheffield: Humanities Research Institute.

Huvila, Isto, Olle Sköld, and Lisa Börjesson. 2021. 'Documenting Information Making in Archaeological Field Reports'. Journal of Documentation 77 (5): 1107–27. https://doi.org/10.1108/JD-11-2020-0188.

221. Research workflows, paradata, information visualisation: feedback on an exploratory integration of issues and practices

Iwona Dudek, CNRS
Jean-Yves BLAISE, CNRS

Documentarists, archaeologists, cultural historians, computer scientists and ICT practitioners – more and more frequently stress the necessity/lack of reliable tools, in documenting all aspects of research processes (i.e. its intellectual/cognitive, methodological, technological, tacit elements). The research initiative that we propose to discuss bases on the idea that, beyond metadata describing outputs themselves, the scientific community concerned is awaiting for 'paradata' that would include means to ensure verifiability, reproducibility and comparability of research workflows.

Its core objective can be summed up as follows:

- renewing the way we can keep track of heterogeneous research activities' results (ranging from scientific outputs per se to dissemination products),
- associating each result with a formal description of the research pipeline (series of activities) that lead to its creation,
- representing research pipelines / processes as workflows that act as a mean to organise and structure paradata,
- building on the InfoVis (information visualisation) scientific field's legacy to promote non-verbal reasoning, and context + focus analyses of workflows,
- ultimately, promoting (through visual means) reflexive analyses of our research practices (e.g., types of activities, relations between processes, stop points and bottlenecks) and of how they change over time.

An experimental web information system was developed as a reaction to the above practical and epistemological questions, in the context of a scientific unit studying the architectural heritage (from both the historical sciences perspective, and an engineering science standpoint). The article presents the methodological and analytical potential of this web-based information system for the description, analysis and information sharing of archaeological research workflows.

The main purpose of the system is to identify the various results obtained through scientific studies, and to describe formally the processes that led to this or that result, listing the most important elements necessary for a proper understanding of the described result. Elements taken into account include: structure of the process, methods and approach used in the investigation (group of activities, activity descriptors), tools and instruments (including hardware and software), actors and their roles within the process (organisations and individuals), scientific context of the process (e.g., organisational framework, objectives), information sources, inputs (e.g., outputs produced previously and described by a specific process), dates …

The described processes can be of different natures. The basic type of process is the 'documentation process' - describing and documenting sequences of activities in a specific real case (e.g., documentation describing the course of an architectural inventory of a specific object).

Planned operations ('project process') may also be recorded in the format of a process (i.e. sequences of activities that shall be mobilised in order to produce a particular type of output, preceding processes ...).

The ultimate goal, however, is an epistemological and methodological analysis of the practices described using the possibilities offered by Information Visualisation.

The methodological specificity of our approach is therefore based on (a) outputs identification, (b) structuration and description of the individual processes that lead to their creation using 'predefined' work activities, (c) combination of individual processes into more complex systems via relationships/ by the use of relations (e.g., previous process, part of the project) and (d) the fundamental role of methods from the field of Information Visualisation (e.g., the use non-verbal thinking, stepping beyond the linear nature of text structure not always well suited to the description of scientific processes, etc.)

The contribution will first detail how the notion of paradata unfolds in practical terms in the abovementioned web IS. It will therefore define the key concepts behind our approach – outputs, activities, activity descriptors, patterns of iteration and repetition in activities, hierarchical structuring of activities, processes as chains of activities, relations between processes, etc.

A brief description of the state of the art will first help positioning the above concepts with regards to the scientific literature on processes, workflows and paradata, in and outside of the heritage studies field. Regarding workflows descriptions it will underline differences in objectives, methods and techniques of description as well as the practices of employing them – typically differences between business and scientific workflows (e.g., Wassermann et al. 2007), uses in keeping track of a research path (including failures and trials) or in previewing a research path (e.g., Mauri, et al. 2020). Finally we will discuss the methodological intersection of information visualisation and workflow analyses investigated for instance in (McLachlan et Webley, 2021).

Particular attention will be paid to the knowledge and practice elicitation stage, which is crucial if the information system is to be extended to other scientific fields. Such a step was recently taken in cooperation with a group of archaeologists and the system was extended to explore its potential in archaeology - more precisely in the field data acquisition phase.

Tacit knowledge is known to be arduous to pass on. The contribution will discuss a research line that we are opening in relation with this issue: introducing the concept of 'theoretical process' that will potentially help passing on know-how and expertise of an individual or a research team.

Theoretical aspects will be illustrated with practical examples. The current methodological and practical limitations of the system will be discussed in the end of the paper.

Our aim is not to convince anyone to abandon existing documentation practices and to replace them with the methods proposed by the information system under discussion, but rather to encourage reflection on the use, in one/some way or another, of theoretical principles or practical solutions proposed by the system.

References:

Wassermann, B., Emmerich, W., Butchart, B., Cameron, N., Chen, L., Patel, J. (2007). Sedna: A BPEL-Based Environment for Visual Scientific Workflow Modeling. In: Taylor, I.J., Deelman, E., Gannon, D.B., Shields, M. (eds) Workflows for e-Science. Springer, London. https://doi.org/10.1007/978-1-84628-757-2_26

Mauri, M., Briones, Á., Gobbo, B., Colombo, G. (2020), Research protocol diagrams as didactic tools to act critically in dataset design processes. Proceedings of INTED2020 Conference (14th International Technology, Education and Development Conference), Valencia, Spain, pp 9034-9043

McLachlan, S., Webley, L.C. (2021), "Visualisation of law and legal Process: An opportunity missed", Information Visualization 2021, Vol. 20(2-3) pp. 192-204. ISSN 1473-8716

72. 25 years of archiving: Exploring what people see as deposit worthy

Teagan K Zoldoske, Archaeology Data Service
Becky Hirst, Archaeology Data Service

The Archaeology Data Service (ADS) is an accredited digital repository for archaeological and cultural heritage data that was founded in 1996. Over the past 26 years, the ADS has accumulated over 33 TB of data from more than 4 million files. Working with colleagues within both the academic and commercial sectors, the ADS has worked to actively promote best practice and improve standards whilst providing archiving services that ensure the ongoing preservation and dissemination of datasets. To this end, the ADS has helped create and maintain a series of Guides to Good Practice to actively promote and explain best practice for both born-digital and digitised material.

Given its history, the ADS can work as a time capsule that shows what methods of documentation were being used and preserved during excavations over the past 25 years. This paper will discuss the holdings of the ADS and explore what people have chosen to archive, both the data and the metadata relating to it, and what we find is notably absent.

Richards, J.D. (2002) "Digital Preservation and Access", in European Journal of Archaeology 5, 343-366. https://journals.sagepub.com/doi/abs/10.1177/146195702761692347

Richards, J.D. (2017) Twenty Years Preserving Data: A View from the United Kingdom, Advances in Archaeological Practice. Cambridge University Press, 5(3), pp. 227–237. https://doi.org/10.1017/aap.2017.11

126. HORAI: An integrated management platform for historical information

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Sonia Medina Gordo, Universitat de Barcelona, Institut d'Arqueologia
Esther Travé Allepuz, Universitat de Barcelona, Institut d'Arqueologia

The study of a site may consist of several phases that can range from a preliminary study of the place to a proposal for restoration and conservation when needed. All these activities entail the assemblage of a dataset including information retrieved from different sources and by applying dissimilar techniques. Probably, one of the most delicate is the archaeological excavation itself, when implying the removal of vestiges, because of the unrepeatable quality of the data record, since it is precisely the destruction of this document what allows us to acquire knowledge. As a result, archiving has become a key piece in the archaeological practice.

The almost destructive nature of archaeological research suggests reconsidering the way we engage with the archaeological record within present-day digital contexts, either for digitised or born-digital data. The current debate places emphasis on how the information we generate should be used but, until recently, it has paid little attention to the archiving process itself (Opgenhaffen 2022). Conversely, there is a lack of knowledge integration arising not only from the use of different data formats, but from the provenience of information as well, being the difficult dialogue between Archaeology and History a good example of this issue. The former relates to the so-called curation crisis, and the latter hinders a comprehensive, interchangeable capture and use of archaeological information, as conceptualisations for retrieving data are diverse.

Therefore, we believe that information management and archiving practices in archaeological research should improve both record life-cycle and the synergies between disciplines working on the past. Accordingly, HORAI platform (www.horai.es) has been created. It is an integrated management platform for scholars and heritage managers to have an efficient conceptual framework, and it supplies the necessary tools for record management and information preservation. As such, HORAI can be used for different purposes: heritage recording, historical research or transdisciplinary management, and it does so without conceptual or information management boundaries.

This methodological and technical solution makes use of three main categories: Unit of Topography (UT), Unit of Stratigraphy (US) and Actor (Ac). Together, they are the underpinning concepts that enables us to extent its use from archaeological to non-archaeological vestiges, as it has been already discussed together with their definitions elsewhere (Travé, del Fresno, and Mauri 2020). This approach is a significant step forward within archaeological practices, as it allows for agreement and better data manipulation dealing with interoperability problems and silos of information from a non-technological viewpoint. Accordingly, the archiving or reusability of the archaeological record, graphic and cartographic documentation together with other kind of data follow the same ontological criteria.

Besides, HORAI provides a proposal for standardised document management and information curation according to standards and methods of Archival Science. Therefore, four operational phases are displayed corresponding to (1) administrative management; (2) data capture and raw data management; (3) digitalisation, interpretation and exploitation of the captured information, and (4) automated administrative or academic communication of the project/archaeological survey. Indeed, it is also worth mentioning that those raw data that we capture during the archaeological work as Units of Stratigraphy, can be synthesized and grouped in the form of Units of Topography, thus generating new data (or capta) that can be integrated or reused together with other sources.

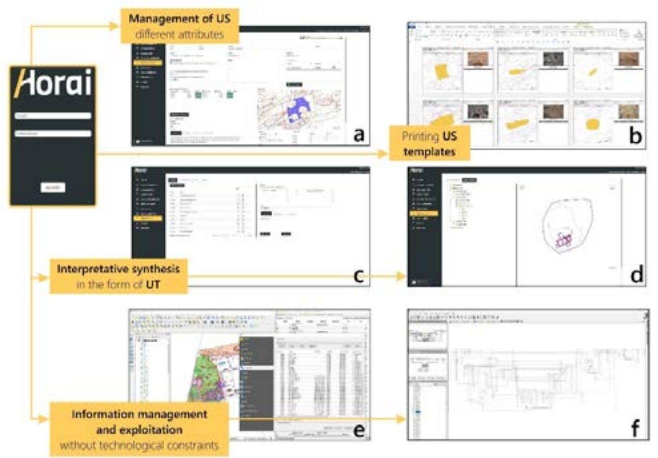

Figure 1. HORAI interface and some platform's functionalities. Amongst these, there are those dedicated to US description themselves (a) along with their automated printing templates (b); the US clustering captured as UT (c, d, f); and examples for management and exploitation on other interconnected software (e, f).

The platform (Figure 1) includes some tables devoted to the management of US descriptive, graphic, cartographic and temporal dimension, and a few others from which we can handle the interpretative synthesis of these very units in the form of UT. Moreover, it does not depend on any specific database application nor on any GIS-based software. Each working group can implement HORAI to those tools they are familiar with for their projects. This means that each person or group can manage independently, but interconnected, the same heritage element, historical period or a specific theme without technological constraints as long as they adjust their models to the previously mentioned semantic data model (Travé, del Fresno, and Mauri 2020).

Given the complex nature of historical information management, we consider essential to have a precise conceptualisation to ensure that different information systems can be integrated, and information within can be exchanged. Such information integration proposals already have well-known semantic reference models, as is the case of CIDOC CRM for cultural heritage documentation. On the other hand, the manner in which records are recognised, generated and preserved in digital environments is a key issue. In that respect, one of the big challenges lies in critically recognising what information needs to be kept for future research. From this perspective, the integrated management platform HORAI not only goes beyond on the archaeological archiving practices by extending its suitability to other research fields, but it also recognises that it is worth investing time in how information will be stored, while taking advantage of the transformative capacity of data for reuse and recycling in other contexts (Huggett 2022).

References

Huggett, Jeremy. 2022. "Data Legacies, Epistemic Anxieties and Digital Imaginaries in Archaeology". Digital 2, no. 2: 267–295. https://doi.org/10.3390/digital2020016.

Opgenhaffen, Loes. 2022. "Archives in action. The impact of digital technology on archaeological recording strategies and ensuing open research archives". Digital Applications in Archaeology and Cultural Heritage 27, e00231. https://doi.org/10.1016/j.daach.2022.e00231.

Travé Allepuz, Esther, Pablo del Fresno Bernal and Alfred Mauri Martí. 2020. "Ontology-mediated Historical Data Modelling: Theoretical and Practical Tools for an Integrated Construction of the Past". Information 11, no. 4: 182. https://doi.org/10.3390/info11040182.

140. A focus on the future of our tiny piece of the past: Digital Archiving of a long-term and multi-participant regional project

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Elizabeth Jones, UNC-Chapel Hill
Lia Willcoxon, North Carolina State University

Introduction

This paper will consider the practical realities that have been encountered while seeking to create a useable Digital Archiving system of a long-term and multi-participant research project. The lead author has been involved in archaeological and landscape research in the Burgundy region of France for the past 40+ years. This long-lived project has continued across several generations, institutions, continents, and disciplines, and began in the mid 1970's before many of our commonly used digital data types and capabilities even existed. Over the decades, many individual researchers, students, and local community members have participated in our broadly defined research activities, conducting field and laboratory research, and they have, cumulatively, woven a tapestry of knowledge regarding some 2,000 years of the interaction between peoples and their landscapes in our study area. Many project participants have moved on to other interests and some have passed away. Homes and personal archives have sadly burned, and offices and labs have been flooded. All while an analogue method of work has transitioned to a digital paradigm that is completely unrecognizable from how we began our journey. As this project slowly winds down, the issues of both analog and digital data preservation and means of providing continued access to other researchers who may be interested in accessing our vast repositories and datasets has become one of great interest to our group. How can we address the proper archiving and metadata of thousands of individual analog and digital records and datasets located in multiple institutions and attics? How can we even accurately know what we all have? How can these be properly archived and preserved? And most importantly, how can other researchers gain access to these for future use after we are no longer here to share them? This is the topic of our paper.

Methods and materials

Digital archiving has become an established field of study, primarily within schools of library and information science. It integrates traditional library and archives methods and theory, computer science, databases, the internet, and the various disciplinary traditions of those seeking to properly archive their data. It began as more of an end-of-career records repository, but has evolved to be a tool provided to new hires to be used throughout ones career. This has also been a subject of important discussion within the archaeology community and CAA (Huvila 2008, Wright and Richards 2018, Richards et al. 2021). In our discovery process, we have evaluated several currently available digital archiving environments, and have worked with experts in the field to better understand the capabilities, processes, strengths, and limitations of these various capabilities. Tools investigated include DSpace, from MIT, and UNC's Dataverse, among others.

Results

We have begun an initial analysis of our needs and goals, along with an initial investigation into what digital archiving is and what it, in its current state of evolution, can (and cannot) provide to our particular situation. As a practical first step, we have begun to amass the first order listing of extant data, in both analog and digital formats, from various current and former project participants. These include general data type, amounts, condition, location, sensitivity, ownership, etc. A simple Excel spreadsheet on a Google Docs folder has been created to catalogue what and how much of each type of record has been located for use in this project. Much of our existing analog data is in the process of being scanned, including large numbers of 35 mm slides (remember those?), field and aerial photographs, historical documents and manuscripts, paper maps, and other field and lab documents and archival records. Most of these still do not have any metadata, provenance, or keywords at this point. Our digital data include large amounts of scanned maps, documents, and photos, and also an extensive project GIS and remote sensing archive, databases, websites, posters, and more. Our next step will be to evaluate our various options in terms of digital archiving software and institutional support available to our project members, and then we intend to map out a realistic work program to populate our archives. We envision multiple archives as we are affiliated with several institutions who can assist us. We will then begin the actual process of creating, annotating, and managing our project digital archives.

Discussion

This is an ongoing process and we do not yet have final results. But our situation is likely mirrored throughout the archaeological community. Large landscape projects, including archaeological, historical ecology, and related activities, often consist of multiple researchers from many different disciplines, institutions, and academic perspectives. Each participant brings with them large amounts of disparate raw, intermediate, and finished data in both analog and digital formats. Such projects can be very long-lived, continuing for several decades, with both people, technologies, data formats, and media coming and going over time. Such projects can generate massive amounts of data, both digital and analog, which should be properly conserved and archived, and these should also be made available as a matter of course to the largest possible number of researchers, both within the project as well as beyond, after initial publication of results. Proper care must be taken for human subjects and sensitive archaeological site data, even after the specific project is ended. Digital archiving and related tools now exist that can be incorporated into new projects directly as they begin, so that they become another tool for the use of the researchers, but this requires specific knowledge and expertise outside our fields, which is not always available to archaeological projects. Our project has struggled to keep track of the data held by various participants over the years, and significant data has also been lost. Data retained by former participants is rarely scanned or catalogued, nor does it contain metadata or is it accessible using keywords or geotags. We hope that our experiences in seeking, well after the fact, to incorporate this important new capability into our work will be useful not only for our project and researchers in our ongoing work, but also for those who may come after us. We also hope that our experiences will be helpful to the larger community, to assist others to incorporate these tools into their future work as a matter of course.

References

Huvila, I. "Participatory archive: towards decentralised curation, radical user orientation, and broader contextualisation of records management". Arch Sci 8, 15–36 (2008). https://doi.org/10.1007/s10502-008-9071-0

Richards, J.D., Jakobsson, U., Novák, D., Štular, B. and Wright, H. 2021 "Digital Archiving in Archaeology: The State of the Art". Internet Archaeology 58. https://doi.org/10.11141/ia.58.23

Wright, H. and Richards, J.D. 2018 "Reflections on collaborative archaeology and large-scale online research infrastructures", Journal of Field Archaeology 43, supp1., S60-S67 https://doi.org/10.1080/00934690.2018.1511960

347. Reconstructing Acquarossa - Reconstructing in 3D as a methodology for organizing and interpreting legacy data

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For archaeologists, the primary data sources for studying people in the past are the physical remains they have left in the archaeological record. Excavations provide access to the archaeological record by collecting, documenting, and interpreting these remains. What data become available depends, apart from the presence and conservation of the physical remains themselves, to a great extent, on the choices made by the excavating archaeologists. Excavated remains get a new meaning in an ex situ context, from which archaeologists aim to track, reconstruct and understand their original context and meaning. (Lucas 2012, 258-259) The data available to archaeologists depends, among others, on what archaeological observations were made, documented, interpreted and made available. These factors are largely determined by notions of how archaeological research should be done and will differ through time, influenced by developments in archaeological thinking and the available methods and techniques. (Lucas 2017, 261-263 & 267) In other words, 'old' archaeological data may not meet the criteria that contemporary research would demand and may therefore not be as applicable in contemporary research with new or different research questions.

This paper addresses the question of how these archaeological legacy data can be used meaningfully in present-day archaeological research. The term legacy data is intended to signify the differences between 'old' and present-day archaeological data. (Aspöck 2020, 11) As a case study the data from the archaeological excavations at Acquarossa zone B, an early Etruscan settlement site near Viterbo Italy, conducted between 1966-1971 are examined to recognize and understand possible discrepancies in how and what data were used by the original excavating archaeologists and how and what data were used or desired by subsequent scholars. It provides insight into what data are available, how these data were created, what questions had to be answered, and how these data are available and accessible today. The rationale for selecting Acquarossa as a case study is due to the importance of this site for studying and understanding the significant changes in, among others, architecture and the organization of society that occurred during the late Orientalizing and Archaic periods in Etruria. Though not all excavation data are fully processed yet, much data are published only partially, preliminarily, or in a fragmented fashion. If the archaeological excavations at Acquarossa were conducted today, they would have been carried out differently, with different ideas, questions, methods, and (digital) techniques. These circumstances permit the use of the term legacy data to describe them.

It is necessary, however, to emphasize the importance of these legacy data. Ex situ preserved excavation data are unique and irreplaceable due to the irreversible nature of excavation. Despite the significance of the data and research potential, the available data do not always seem to be sufficient for use by other scholars and for new research. This leads to contradictory situations in which the data cannot be disregarded completely but can only be used to a limited extent with the risk of erroneous use or exclusion of data from consideration. This paper seeks to resolve this contradictory state by proposing a methodology using 3D reconstruction for digitally and spatially collecting, organizing, analyzing, testing and providing access to legacy data to be used meaningfully in present-day archaeological research.

References

Aspöck, Edeltraud. 2020. "Old excavation data: what can we do?" In Old Excavation Data.What Can We Do? Edited by Edeltraud Aspöck, Seta Štuhec, Karin Kopetzky & Matthias Kucera, OREA 16, pp. 11-23. Austrian Academy of Sciences Press, Vienna. https://doi.org/10.1553/0x003bca0e.

Lucas, Gavin. 2012. Understanding the archaeological record. Cambridge. Cambridge University Press.

Lucas, Gavin. 2017. "The paradigm concept in archaeology." World Archaeology, 49 (2): 260-270. https://doi.org/10.1080/00438243.2016.1252688.

30. Transforming the CIDOC-CRM model into a megalithic monument property graph

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This paper presents a method to implement a megalithic monument knowledge graph (KG) to store information about building components as graph nodes. As a study of case we use the dolmens of the region of Pavia (Portugal). To build the KG, information has been extracted from unstructured data to populate a schema model based on the International Committee for Documentation - Conceptual Reference Model (CIDOC-CRM). This model was then implemented in a native graph NoSQL database. The CRM is an ISO standard formal ontology that works as a guide for good practices in conceptual modeling in order to structure and link cultural heritage information (Bekiari et al., 2021). Projects such as EPISA and ARIADNE Plus are using the CRM models to standardize the current unstructured data information that was dispersed throughout different repositories. However, most of the found models focus on the use of non-native graph databases to represent archaeological construction techniques and materials, with only a few examples using this representation for the building components.

Non-native graph databases use columnar databases, relational databases, or other general purpose data storages, resulting in performance and scalability issues since these models are not optimized for storing and processing graph data. Graph storage, on the other hand, is specifically designed for storing and retrieving highly interconnected data, which makes it the most efficient method when dealing with graph data. A KG model represents class properties and relationships. While metadata-based approaches focus on the semantic representation of the domain knowledge (schema), instance-based approaches allow representing the instances (individuals) in each class, as well as their properties and how they relate between them. Empirical data usability is significantly affected by this technical difference due to its relevant practical implications. According to Vogt "The consequences affect findability, accessibility, and explorability of empirical data as well as their comparability, expandability, universal usability and reusability, and overall machine-actionability." (Vogt 2021, 1).

Our goal is that a megalithic monument KG can represent information about the architectural building components of dolmens in a granular level. This goal can be achieved using the CRM principles in a native graph database, enabling information retrieval and the understanding of the similarities and differences between monuments. An initial challenge was implementing CIDOC-CRM, an event-based model for representing archaeological information, where relevant events are often implicit in records, and monuments can be explored and described from different perspectives. In order to handle representation and information versioning events, the KG was defined with an event-driven version model (Camara et al 2022).

This paper focuses on the transformation of the CIDOC-CRM ontology into a property-graph, as well as the extraction of information about dolmens and their constituents that was used to populate the KG. The information has required elements such as designation(s); time span (constructions, uses, changes and researches about the structure); localization; components parts (e.g. chamber, corridor, burial mounds, capstone and orthostat); dimension of each component and conservation state.

The information to populate the KG was manually collected from natural language texts found in an archaeological letter and a specialized database (Endovélico) that aggregates the information about archaeological monuments of the region under analysis. Controlled vocabularies about cultural heritage (ROSSIO thesauri) together with domain knowledge and some terminology were used to define the terms needed to label the information to be extracted. The archaeological monument's information was transformed into a semi-structured data (CSV file) using the previously defined labels in order to prepare the information for bulk load.

While the CSV was used to populate the classes with their respectives properties and instances, the KG labels were defined using some of the entities and relations defined by the CIDOC-CRM. Before associating nodes with properties, we defined the schema mappings between the existing data and the CRM model and specified the rules for generating unique identifiers for each new monument. The model was built using Neo4J, a property-graph database. Generally, the property graph model consists of nodes (entities), relationships (edges), and properties (attributes), and both entities and relationships can have attributes, while property values can only have data types. Neo4J is a native graph database and the most popular non-SPARQL graph database that also supports a mature query language (Cypher). Native graph database architecture tends to perform queries faster, run more efficiently and enables scaling while retaining the hallmark query speed as the dataset grows when compared with non-native graphs in both storage and processing. Neo4j scales better for larger datasets allowing a better manipulation of multidimensional data and for data aggregation.

Through modeling of a property graph based on predefined labels as a KG, we were able to transform semantic data from text into instances and properties, based on CIDOC CRM schema, as illustrated by Figure 1. This knowledge-driven model was built to represent the dolmens in a formal and structured manner. That is, it manages the representation at granular levels of all the structural level information of dolmens.

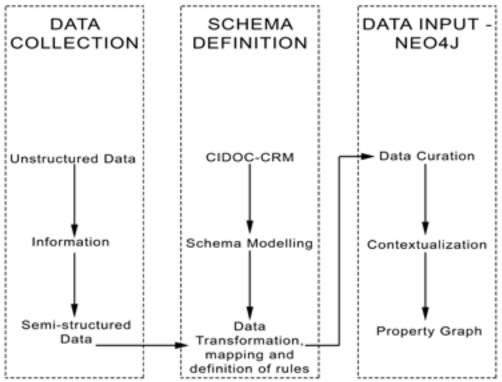

Figure 1: Data collection, schema definition, and data input are the main tasks for building this property graph. According to the text, implementing this property graph involved extracting relevant information from unstructured data, transforming it into semistructured data (CSV file), mapping existing data to CIDOC-CRM, and setting up linking rules. The CSV file served as our entry point for transforming the information into properties and instances to populate the KG. Ultimately, the data was curated and contextualized.

In conclusion, in archaeology, the use of a KG in a native graph database can improve the data storage and processing, making it interoperable between humans, between humans and machines and machine-to-machine. Finally, the next phase of this research aims to use this KG to assist automatized approaches based on machine learning to recognize dolmens in remote sensing imagery. The possibility of providing high level knowledge to computer vision object recognition makes machines capable of contextualizing the objects represented in images more accurately and resolving uncertainty in the classification.

Reference:

Bekiari, Chryssoula., Bruseker, George., Doerr, Martin., Ore, Christian-Emil, Stead, Stephen, and Velios, Athanasios. (2021). Volume A: Definition of the CIDOC Conceptual Reference Model.

Câmara Ariele., Almeida., Ana Maria de, and Oliveira., João Pedro (2022). Versioning: Representing Cultural Heritage Evidences on CIDOC-CRM via a case study. 16th International Conference on Information Technology and Applications (ICITA 2022). Lisbon, Portugal (20 - 22 October).

Vogt, L. (2021). FAIR data representation in times of eScience: a comparison of instance-based and class-based semantic representations of empirical data using phenotype descriptions as example. Journal of Biomedical Semantics, 12(1), 1-25.

245. Text Parsing Archaeological Legacy Data: A Software Methodology to Generate Maps from Handwritten Excavation Documentation

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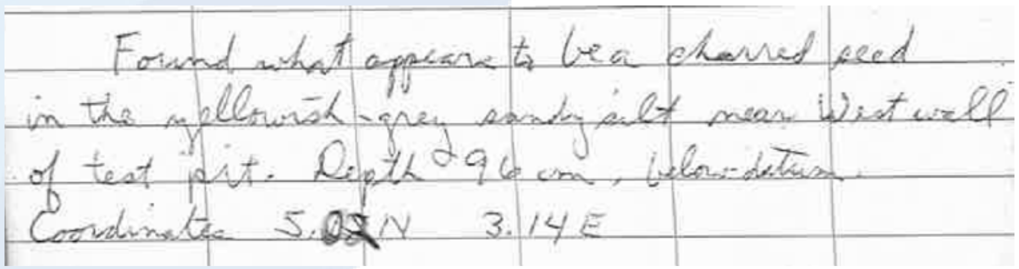
Introduction

Legacy data (documents and datasets from past research, e.g., archived data) represent a valuable corpus of information to archaeology and related disciplines, but these datasets are notoriously difficult to work with. This is particularly troublesome for analog (i.e., physical, or not digitized) datasets—in fact, Heath et al. suggest that broad, multi-site analyses are biased towards digital datasets and tend to exclude physical data as they are more difficult to use (2019, 91-114). In this paper, I explore if custom software may reduce this obstacle. Specifically, can custom software reduce the time required to digitize archaeological legacy data into machine-readable texts and maps, without compromising accuracy?

Methods and Materials

The focus of this paper is a body of field notebooks that document the 1975 excavation of the Gulkana Site, located in south-central Alaska and inhabited roughly a millennium ago. This excavation was designed to retrieve information from the site prior to its partial destruction through gravel mining. The excavation was primarily documented through an unpublished report (Workman 1977, 1-174) and roughly 50 field notebooks handwritten by excavators (see Figure 1). For this pilot study, I focused on a subset of these notebooks that describe the excavation of a semi-subterranean structure referred to as Feature 40.


Found what appears to be a charred seed
in the yellowish-grey sandy silt near West wall
of test pit. Depth 96 cm, below datum.
Coordinates 5.02 N 3.14 E

To address my research question, I compared the time required to digitize these field notebooks manually versus automating this process with custom software. Prior to this research, field notebooks had already been scanned into PDFs, but were not machine-readable. For this project, digitizing involved not only making the texts of the notebooks machine-readable, but also extracting spatial data from these texts and using this data to map the excavation using ArcGIS Pro. Texts were transcribed and typed into a .txt file. Next, I extracted each instance of spatial data, and the appropriate label, into a table. Spatial data in this corpus takes the form of relative locations (i.e., N24W6), so mapping entailed using guidelines in ArcGIS Pro to estimate distance and then drawing the appropriate shape (point, polygon, line) and entering the label into the attribute table. I next explored using software to do this work. First, I trained an Optical Character Recognition model to digitize the handwritten text in the notebooks. I then created an algorithm (ArchLocateR) to parse these texts for spatial data and accompanying labels. Finally, I created an algorithm (ArchShape) to convert this spatial data into a Shapefile map.

Results

I found it time consuming and difficult to train the OCR model to identify the handwritten characters in the field notebooks. Even after training, the model had low accuracy (just 0.7% of characters were identified correctly). However, ArchLocateR and ArchShape were much more successful. ArchLocateR extracted 68 of 76 locations (89%) from the corpus and extracted at least part of the correct label for 68% of labeled locations. ArchLocateR completed this text parsing in significantly less time than the researcher, requiring just 17 seconds per document compared to my average of 32 minutes. The maps generated with ArchShape are remarkably similar to those created manually by the researcher, and also required significantly less time—64 seconds as opposed to the 98 minutes I spent on this task.

Discussion

As future work expands on this pilot study, it may be possible to improve the software's accuracy. ArchLocateR may be improved by using a machine learning approach such as Named Entity Recognition to identify the labels for locations. The costs of training an OCR model may be minimized through outsourcing to student researchers or using a cleaner dataset (such as the National Institute of Standards and Technology's databases).

The Gulkana Site is an apt example of the continuing value of archaeological legacy data. More native copper artifacts have been recovered from Gulkana than from any other site in the Alaska-Yukon region; in fact, Gulkana accounts for roughly one third of the regional total (Cooper 2012, 565-590). Therefore, the Gulkana Site has the potential to improve academic understanding of metalworking innovation in hunter-gatherers. In spite of this potential, however, the Gulkana Site has never been comprehensively published—in part because its documentation is spread across two legacy datasets (one analog, and one digital, but out of date). This pilot study represents a first step at synthesizing these legacy datasets to facilitate new analysis of a valuable site.

The Gulkana Site is also valued by the Ahtna people as a heritage site. Ahtna leaders are interested in the study of the Gulkana Site and in making information about the site more accessible to Ahtna people. For this reason, the legacy data of the Gulkana Site is also relevant to burgeoning discussions of FAIR and CARE in archaeological data management.

Revitalizing archaeological legacy data is particularly pertinent in the current moment. In recent years, the pandemic demonstrated the value of legacy data when many archaeologists turned to it as a safety net to continue conducting research when in-person fieldwork became impossible. I hope that this paper can capitalize on this momentum to bring more attention to legacy datasets and how they can be incorporated in ongoing analysis.

Citations

Cooper, H. Kory. 2012. "Innovation and Prestige Among Northern Hunter-Gatherers: Late Prehistoric Native Copper Use in Alaska and Yukon." American Antiquity 77 (3): 565–90. https://doi.org/10.7183/0002-7316.77.3.565.

Heath, Barbara J., Mark A. Freeman, and Eric G. Schweickart. 2019. "Integration and Accessibility: A Case Study of the Curles Neck (44HE388) Legacy Data." In New Life for Archaeological Collections, edited by Rebecca Allen and Ben Ford, 91–114. Lincoln, Nebraska: University of Nebraska Press and the Society for Historical Archaeology. http://ebookcentral.proquest.com/lib/purdue/detail.action?docID=5719708.

Workman, W. B. 1977. "Archaeological Investigations at GUL-077, a Prehistoric Site near Gulkana, Alaska." Unpublished Report. Anchorage: Alaska Methodist University.

28. Digital Humanities, Digital Archaeology

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Maria Elena Castiello, University of Bern (Switzerland)
Christophe Tufféry, Inrap, Paris (France)

Location: E108

Roundtable

At CAA 2022 in Oxford, the roundtable "Archaeology and Digital Humanities: The Road Already Travelled and the Road Ahead" produced a fruitful discussion on the commonalities and differences between Digital Humanities and Digital Archaeology, two fields that have seemingly evolved in parallel over the last two decades without much interchange. There is a chapter on "Computing for archaeologists" in (Schreibman et al., 2004), where the authors describe a barrier to the inclusion of archaeology as part of the Digital Humanities in these terms: "The discipline at large has not fully absorbed the need to preserve access to digital data for future scholars. It has not yet found an effective and relatively standard way to present digital data as part of a final publication. Its educational institutions have not accepted the need to prepare all archaeologists in the use of those computer technologies necessary in the field and the laboratory. In part, these problems reflect the nature of the discipline, a uniquely fragmented one consisting of practitioners who may have begun as historians, art historians, students of ancient languages, or anthropologists – but not as scientists dependent upon a tradition of prompt and full data sharing. The problems also reflect the unique independence of archaeologists, who must have a strong entrepreneurial spirit in order to fund and operate complex projects." Of course, many of these barriers have been eased since then. A subsequent edition of the same work, (Schreibman et al., 2016), however, focuses on the methodologies and technologies used by the Digital Humanities rather than the epistemological or theoretical grounds of these fields, somewhat diluting their relationship. In addition, (Huggett, 2012) also points out that the relationships between digital archaeology and the Digital Humanities are difficult to determine, given the vagueness with which Digital Humanities have been described. This issue compounds the problem of tracing and studying the relationships between the two disciplines. In any case, the fact that both fields have been coexisting for decades and generating academic, professional, and disciplinary knowledge separately but bringing together very similar works in methodologies, approaches, and technologies merits a profound reflection on the implications and consequences of seeing archaeological computing as a branch of the Digital Humanities. The recent and ongoing evolution of digital practices in archaeology is reflected in the growing importance of contributions (articles, tools, events) from professionals who are not archaeologists. For some of them, mainly in archaeometry and archaeosciences, their training profile is often that of engineers from the sciences of the earth and the universe, with specialized skills in mathematics, statistics, model designing, computer and data science, programming languages. How can archaeologists cross points of view, compare conceptual models, make coexisting different criteria for the administration of proof? The round table will generate an open debate in which three guest speakers will offer position papers for and against placing archaeological computing work within the sphere of Digital Humanities, motivating the advantages and disadvantages of doing so, and delving into the possible weaknesses and strengths of doing so, showing real examples and/or collaborations. The main objective is to continue shedding light on this disciplinary relationship. The guest speakers will be invited considering their contributions to these fields, and ensuring that a diverse and comprehensive set of viewpoints are presented. Guest speakers (and hopefully attendees) will address these topics:

- What is Digital Humanities? What is Digital Archaeology?
- What are the commonalities and differences between the two fields in terms of theory, methods, techniques, and results?
- How are multi-, inter- and trans-disciplinarity issues handled by each field?
- Which of these differences are accidental, and which essential?
- Can or should Digital Archaeology be considered part of the Digital Humanities?
- How can Digital Archaeology benefit from the advance in Digital Humanities and vice versa?
- What converging strategies are possible and adequate between the two fields

The discussants present at this roundtable will be:

Dr. Colleen Morgan from the University of York

Dr. Agiatis Bernadou from Digital Curation Unit Athena Research and Innovation Centre and DARIAH director

Dr. Sebastian Hageneuer from the University of Cologne

References:

Huggett, J. (2012). Core or Periphery? Digital Humanities from an Archaeological Perspective. Historical Social Research / Historische Sozialforschung, 37(3 (141)), 86–105. http://www.jstor.org/stable/41636599 Schreibman, S., Siemens, R., & Unsworth, J. (Eds.). (2004). A Companion to Digital Humanities. Blackwell. http://www.digitalhumanities.org/companion/ Schreibman, S., Siemens, R., & Unsworth, J.

(Eds.). (2016). A New Companion to Digital Humanities (second edition). Blackwell.

34. Computational Approaches and Remote Sensing Applications in Desertic Areas

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Location: E104

Past natural and human activities have left marks on the landscape of every type of environment on the surface of our planet. These can be recognized even after millennia; they can be ephemeral or clearly apparent. Their visibility is dependent on the time passed and the natural or human activities that took place over time, but many of them can be detected via remote sensing techniques. Arid environments often experience strong dusty winds and a continuous movement of dunes or soil particles. These conditions can quickly and entirely cover (or preserve) historical and paleo-environmental remains, creating an obstacle to ground surveys, and a hindrance to some remote sensing techniques. Remote sensing methods focusing on far distance optical, radar and multispectral scanning, allow researchers to overcome these obstacles, providing valuable information about modern and ancient geomorphological, hydrographical, environmental, and archaeological evidence. In the past few decades, many arid areas of our planet have been scanned via various remote sensing methods, and many of the images are in open access repositories, meaning that there is a wealth of information freely available. Archaeological studies initially focused on the analysis of space photos coming from declassified spy satellites (Corona and Hexagon) and optical imagery from Landsat, SPOT, and ASTER missions. This was followed by work on Very High Resolution (VHR) imagery from Ikonos-2, QuickBird-2, GeoEye-1, WorldView-1/2/3/4, Pléiades-1A/1B and Pléiades Neo missions. These images offered unparalleled resources to the manual detection and analysis of the archaeological sites. Recently, UAV photography, 3D modelling, and free commercial optical satellite and aerial imagery provided by web map service such as Google Earth and Bing Maps has opened up new avenues of research. Satellite radar imagery (as opposed to photographs) coming from SIR-A/B/C, AIRSAR and SRTM SAR or 2nd generation multi-bands SAR systems such as ALOS PALSAR, TerraSAR-X/TanDEM-X, COSMO-SkyMed and Radarsat-2 or aerial/UAV LiDAR scans that penetrate the superficial covering layers and reach the historical traces have been invaluable. Archaeologists have now also started to exploit the resources coming from multi-spectral (and soon hyper-spectral) satellite missions like Sentinel 2 to detect or monitor historical features via their spectral signatures. All this information was (and usually is still), processed through a variety of manual techniques, enhancing archaeological marks and proxy indicators, and post-processed via various human operators analyses and protocols. Recently, many new automatic supervised and unsupervised computational approaches (Filters, Machine and Deep Learning algorithms, AI, etc.) have added powerful new tools and workflows to the thematic interpretation of images with considerable savings in the processing time. The results of all these studies have already enabled archaeologists to detect many new archaeological sites and paleo-environmental features. This facilitates the monitoring and measurement of conservation risks of endangered historical sites, and the unveiling of ancient pathways, hydrological features, and settlements. All of this contributes to the planning of effective conservation strategies and study and re-use of hidden resources, in collaboration with local and international authorities. The session we are proposing will focus discussion on the results coming from studies relating to the usage of aerial/UAV/satellite remote sensing resources; manual and automatic computational workflows of image analysis; and the limitations and opportunities of these techniques applied in desertic and arid contexts for the aforementioned purposes. We therefore encourage the submission of papers that highlight innovative remote-based archaeological applications in desertic areas, following or proposing similar topics:

- Use of multi-petabyte repositories of geospatial datasets in arid environment
- Remote sensing analysis of large areas or landscape analyses over time-series in arid environments
- Application of complex computing, cloud-based computing, or multiplatform workflows to overcome archaeological remote sensing problems in desertic areas
- Geospatial data processing and post-processing via manual procedures (Analysts training, Analyses Protocols, Database, etc.) and automatic/semi-automatic approaches (Filters, Machine Learning and Deep Learning algorithms, AI, etc.) in arid environments
- Joint or integrated use of optical, multispectral and radar satellite imagery
- Derivative works coming from remote sensing and computational analyses to study, monitor and preserve historical contexts or plan future activities in desertic region in agreement with local, international, public or research institutions

References:

Amani M., Ghorbanian A., Ahmadi S.A., Kakooei M., Moghimi A., Mirmazloumi S.M., Moghaddam S.H.A., Mahdavi S., Ghahremanloo M., Parsian S., Wu Q., Brisco B. 2020. Google Earth Engine Cloud Computing Platform for Remote Sensing Big Data Applications: A Comprehensive Review, in IEEE Journal of Selected Topics in Applied Earth Observation and Remote Sensing, 13

Casana J., 2014. Regional scale archaeological remote sensing in the age of big data. Automated site discovery vs. brute force methods in Advance in Archaeological Practice, 2(3), 222233. https://doi.org/10.7183/23263768.2.3.222

Costanzo S., Brandolini F., Idriss Ahmed H., Zerboni A., Manzo A. 2021. Creating the funerary landscape of Eastern Sudan, in PLoSONE, July 7 2021, 16(7):e0253511, doi: https://doi.org/10.1371/journal.pone.0253511

Di Giacomo G., Scardozzi G. 2012. Multitemporal High-Resolution Satellite Images for the Study and Monitoring of an Ancient Mesopotamian City and its Surrounding Landscape: The Case of Ur, in International Journal of Geophysics, 2012, ID 716296, https://doi.org/10.1155/2012/716296

Fabiani U., Lucarini G. 2010. Spatial research and geomatic resources applied to the archaeology of the Farafra Oasis (Western Desert, Egypt), in Rivista di scienze preistoriche, LX, 2010, pp. 331-347

Gauthier Y., Gauthier C. 2008. Monuments en trou de serrure, monuments à alignement, monuments en "V" et croissants: contribution à l'étude des populations sahariennes, in Cahiers de l'AARS, 12, 2008, pp. 1-20

Gauthier Y., Gauthier C. 2017. Monuments funéraires sahariens et aires culturelles, in Les Cahiers de l'AARS, 11, 2007

Harrower M.J., Schuetter J., Mccorriston J., Goel P.K., Senn M.J. 2013. Survey, Automated Detection, and Spatial Distribution Analysis of Cairn Tombs in Ancient Southern Arabia. In Mapping Archaeological Landscapes from Space, in Mapping Archaeological Landscapes from Space 2013, 259268, https://doi.org/10.1007/9781461460749_22

Kvamme K., 2020. Automated Archaeological Feature Detection Using Deep Learning on Optical UAV Imagery: Preliminary Results; Bevan, in Computational Approaches to Archaeological Spaces, 2020, pp. 53-68

Lasaponara R., Masini N. 2013. Satellite Synthetic Aperture Radar in Archaeology and Cultural Landscape: An Overview, in Archaeological Prospection, 20:71-78, 2013, https://doi.org/10.1002/arp.1452

Lasaponara R., Masini N. 2018. Space-Based Identification of Archaeological Illegal Excavations and a New Automatic Method for Looting Feature Extraction in Desert Areas, in Surveys in Geophysics, 39, 2018, pp. 1323–1346

Lasaponara R., Masini N. 2019. Active Satellite Sensors in Cultural Heritage Research. The Use of SAR for Archaeological Prospection, in Remote Sensing for Archaeology and Cultural Landscapes, Best Practices and Perspectives Across Europe and the Middle East, 2019, DOI: https://doi.org/10.1007/978-3-030-10979-0_7

Masini N., Lasaponara R. 2019. Recent and Past Archaeological Looting by Satellite Remote Sensing: Approach and Application in Syria, in Remote Sensing for Archaeology and Cultural Landscapes, 2019, doi: https://doi.org/10.1007/978-3-030-10979-0_8

Menze, B.H. & Ur, J.A. 2012. Mapping patterns of long-term settlement in Northern Mesopotamia at a large scale. Proceedings of the National Academy of Sciences, 109(14): E778-E787

Orengo H.A., Conesa F.C., Garcia-Molsosa A., Lobo A., Green A.S., Madella M., Petrie C.A. 2020. Automated detection of archaeological mounds using machine-learning classification of multisensor and multitemporal satellite data, in Proceedings of the National Academy of Science of the United States of America, PNAS 2020, 117, 31, 2020, pp. 18240-18250

Rayne L., Gatto M.C., Abdulaati L., Al-Haddad M., Sterry M., Sheldrick N., Mattingly D. 2020. Detecting Change at Archaeological Sites in North Africa Using Open-Source Satellite Imagery, in Remote Sensing, 12, 22, 2694

Rayne, L., Bradbury, J., Mattingly, D., Philip, G., Bewley, R. and Wilson, A. 2017. From Above and on the Ground: Geospatial Methods for Recording Endangered Archaeology in the Middle East and North Africa. Geosciences 7: 100

Scardozzi G. 2010. Multitemporal satellite high resolution images for the knowledge and the monitoring of the Iraqi archaeological sites: the case of Seleucia on the Tigris, in Photo Interpretation. European Journal of Applied Remote Sensing, 4, 2010, pp. 143-160

Scardozzi G. 2011. Multitemporal Satellite Images for Knowledge of the Assyrian Capital Cities and for Monitoring Landscape Transformations in the Upper Course of Tigris River, in International Journal of Geophysics, 2011, ID 917306, https://doi.org/10.1155/2011/917306

Tapete D., Cigna F., Donoghue D.N.M. 2016. Looting marks' in space borne SAR imagery: Measuring rates of archaeological looting in Apamea (Syria) with TerraSARX Staring Spotlight, in Remote Sensing of Environment, 178, 42581

	SLOT 3
14:00 - 14:20	336. Study and enhancement of the heritage value of a fortified settlement along the Limes Arabicus. Umm ar-Rasas (Amman, Jordan) between remote sensing and photogrammetry. *Francesca Di Palma (University of Bari Aldo Moro)*; Giuseppe Scardozzi (CNR-ISPC (Institute for Heritage Science)); Roberto Gabrielli (Institute of Heritage Science of the Italian National Research Council (CNR-ISPC)); Pasquale P Merola (CNR/Institute of Heritage Science); Ilaria Miccoli (Institute of Heritage Science of the Italian National Research Council (CNR-ISPC))*
14:20 - 14:40	358. Integrated remote sensing approaches and near-surface geophysical survey for large-scale assessment of cultural heritage: A case study from central Arizona *Tamas Polanyi (Sandbox Archaeology)*; Shelby Manney (Arizona Army National Guard)*
14:40 - 15:00	321. Assessing detection rates of Holocene archaeological structures from various satellite imagery sources, along the southern edge of the Nefud Desert. *Amy G Hatton (Max Planck Institute for Geoanthropology)**
15:00 - 15:20	383. Remote sensing based approaches for the automatic extraction and characterization of archaeological looting features: the coastal desert of Peru *Nicola Masini (CNR-ISPC); Alessia Brucato (UNIBA - CNR ISPC)*; Rosa Lasaponara (CNR-IMAA)*
15:20 - 15:40	318. VHR satellite imagery-based detection of archaeological sites looting in desertic regions via Deep Learning approaches. *Arianna Traviglia (Istituto Italiano di Tecnologia (IIT))*; Maria Cristina Salvi (Istituto Italiano di Tecnologia); Marco Fiorucci (Istituto Italiano di Tecnologia); Gregory Sech (Istituto Italiano di Tecnologia); Ayesha Anwar (Università Ca' Foscari Venezia); Riccardo Giovanelli (Istituto Italiano di Tecnologia); Michela De Bernardin (Istituto Italiano di Tecnologia)*
15:40 - 16:00	115. Near East irrigation studies beyond SRTM and CORONA. Preliminary results of the UnderTheSands project *Nazarij Bulawka (Landscape Archaeology Research Group, Catalan Institute of Classical Archaeology)*; Hector A. Orengo (Landscape Archaeology Research Group, Catalan Institute of Classical Archaeology)*
	SLOT 4
16:30 - 16:50	61. Detecting change with Google Earth Engine in the desert regions of North Africa *Nichole Sheldrick (University of Leicester)*; Ahmed Mahmoud (University of Leicester); Louise Rayne (Newcastle University)*
16:50 - 17:10	**Discussion**

336. Study and enhancement of the heritage value of a fortified settlement along the Limes Arabicus. Umm ar-Rasas (Amman, Jordan) between remote sensing and photogrammetry.

Francesca Di Palma, University of Bari Aldo Moro
Giuseppe Scardozzi, CNR-ISPC, Institute for Heritage Science
Roberto Gabrielli, Institute of Heritage Science of the Italian National Research Council, CNR-ISPC
Pasquale P Merola, CNR/Institute of Heritage Science
Ilaria Miccoli, Institute of Heritage Science of the Italian National Research Council, CNR-ISPC

Limes Arabicus is an excellent laboratory for experimenting with the enormous potential of historical remote sensing data for the identification and documentation of fortified centres located along this sector of the eastern frontier of the Roman Empire, first, and then the Byzantine Empire. Remote sensing in association with the modern survey techniques and tools, such as photogrammetry and laser scanner, now make it possible to identify, document and study the ancient settlements in this area, as well as to develop programs for the valorisation of the sites, designing real and virtual routes for a better use of the archaeological areas. Here we present a preliminary contribution relating to the site of Umm ar-Rasas (Amman, Jordan), a fortified centre along the Via Traiana Nova. Since the early 1800s, some explorers documented this site, characterized by the presence of a tetrarchic castrum and, to the north, of a Byzantine settlement. Starting from the second half of the 1980s, it has been the subject of archaeological investigations. The excavations, conducted by the missions of the Studium Biblicum Franciscanum of Jerusalem (Piccirillo and Alliata 1994) and of the Swiss Max van Berchem Foundation (Bujard 2008), involved a portion of the castrum and, mainly, the settlement north of this fortified site, bringing back to light precious mosaic floors, which have made the site of Umm ar-Rasas famous. From 2013 to 2019, the Institute of Heritage Science of the Italian National Research Council (CNR-ISPC), in collaboration with the Jordanian Department of Antiquities (DOA) and co-financed by the Italian Ministry of Foreign Affairs and International Cooperation (MAECI), conducted topographic and 3D surveys of the Saint Stephen, Bishop Sergius and Saint Paul Churches, in the inhabited area north of the castrum, in order both to document the state of conservation of the mosaic floors and to plan a better access of the area for tourists (Gabrielli, Portarena and Franceschinis 2017). Starting from 2021, the CNR-ISPC investigations focused on the castrum and the territory to the north and east of the Byzantine settlement. Topographical and architectural surveys were conducted to verify on the ground the crop marks found by the analysis of historical and recent remote sensing images and to document the building phases of the fortification.

The field surveys were preceded by an analysis of a multitemporal remote sensing documentation, acquired from aerial and satellite platforms. First of all, historical aerial photos taken by Sir Marc Aurel Stein in 1939 and space photos acquired by Corona KH-4B and Hexagon KH-9 satellites between the 1960s and 1970s were georeferenced, analysed and interpreted. The study of the aerial photos, taken from a height varying between 600 and 1200 feet, and of the space photos, with a spatial resolution between 1.8 and 0.60 m, allowed documenting the preserved structures and identifying archaeological crop, dump and shadow marks linked to buried ancient features. This research activity made it possible to design ground checks for the study and reconstruction of the ancient topography of the site and of the historical landscape. Furthermore, the panchromatic and multispectral data of two very high-resolution satellite images, a Pléiades 1B from 2020 (max. spatial resolution 0.5 m) and a Pléiades Neo from 2022 (max. spatial resolution 0.3 m), were processed in order to identify other marks linked to buried ancient remains and to produce orthorectified images used as base maps during field surveys. Lastly, the archaeological features acquired from the multitemporal documentation improved the archaeological map of the site, in integration to the detailed plans of the castrum and the excavated sectors of the inhabited area produced during recent topographic surveys or previous investigations. The recent topographic survey and 3D architectural survey of the castrum walls took place by means of: differential GPS Leica 530 s; terrestrial photogrammetry test, performed with Canon 5D mark II (24 MPixel); aerial photogrammetry performed with two Pole 1,70 m (for high detail) and 5m for the archaeological structure; two laser scanner Faro 120 and Faro 330 x. A system was ad hoc developed with the aim to complete the high-resolution documentation of the masonry; in particular, photogrammetry techniques were used with many shots in order to obtain a better chromatic definition of the surfaces and a better photographic detail. A correct description of the deformations walls was instead obtained through laser scanner acquisition, with 200 scans for each wall face and 2000 photos for each mosaic (Twin Churches), which highlighted significant anomalies.

In two years, many relevant and reliable data have been collected and archived relating to the building phases and subsequent transformations of the walls of the castrum, as well as to its state of conservation. An initial mapping was carried out of the places of extraction of stone materials, water reserves, canalization systems and organization of the cultivated land around the settlement. The data are merging into an archaeological map, integrated into a GIS platform, aimed at documenting the ancient topography of Umm ar-Rasas and which will constitute a knowledge base for the site's valorisation activities.

At the current state of the site, with the collapses that cover much of the interior of the castrum, it is not possible to recognize a construction phase of the Severian age, hypothesized because of the materials found in old excavations. However, it is hoped to be able to carry out geophysical prospecting during future missions that will allow to acquire elements on the topography of the area inside the walls of the tetrarch fortification and highlight any pre-existences, in view and with the intention of creating a more updated plan of the castrum.

Bujard, Jacques. 2008. "Kastron Mefaa, un bourg à l'époque byzantine: Travaux de la Mission archéologique de la Fondation Max van Berchem à Umm al-Rasas, Jordanie (1988-1997)", PhD diss., University of Fribourg 2008.

Piccirillo, Michele and Alliata, Eugenio. 1994. "Umm al-Rasas Mayfa'ah. Vol. I. Gli scavi del Complesso di Santo Stefano (SBF maior 28)", Jerusalem: Edizioni Custodia di Terra Santa.

Gabrielli, Roberto, Portarena, Damiano and Franceschinis, Mauro. 2017. "Tecniche di documentazione dei tappeti musivi del sito archeologico di Umm al-Rasas Kastron Mefaa (Giordania)." Archeologia e calcolatori, n. 28.1: 201-218 https://doi.org/10.19282/AC.28.1.2017.12

358. Integrated remote sensing approaches and near-surface geophysical survey for large-scale assessment of cultural heritage: A case study from central Arizona

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Shelby Manney, Arizona Army National Guard

Archaeological surveys and cultural resources management in the American Southwest rely mostly on conventional surface survey to establish the presence, distribution, and preservation level of cultural resources. Large swaths of the subcontinent have been covered by pedestrian surveyors since the early boom in cultural resources management in the 1980s. In the subtropical deserts of central and southern Arizona, characterized by scarce vegetation and good surface visibility, archaeologists and cultural heritage managers have been operating under the impression that surface manifestations of past human practices offer sufficient and reliable evidence guiding preservation efforts. Providing a more nuanced approach, there is an increasing effort to establish large-scale archaeological predicative models based on environmental, geomorphological, and hydrological data supplementing direct archaeological evidence. However, the systematic application of instrumental survey technologies and their integration into resources management standards has received less or no attention. With a long-term project initiated in 2016, we seek to remedy this omission and establish best practices resulting in more reliable predictions and more effective preservation. This effort involves the standardization and integration of the use of transect recording unit or TRU-based surface surveys, UAV photography, LiDAR mapping, 3D modelling, multiscalar geophysical prospection, hydrological and vegetation surveys. Following the development of an aerial-survey-based predictive model for the distribution of sub-surface archeological assemblages in an area of dense Hohokam occupation, we conducted a systematic geophysical sampling survey as a mode of non-intrusive digital groundtruthing. In this paper, we discuss the results of our current efforts at this critical stage of the project. We offer a refined predictive model for potentially well-preserved cultural resources, and—using archaeological assemblages as proxy—we provide an approach to assess soil erosion and geomorphology.

References

Casana J., 2014. Regional scale archaeological remote sensing in the age of big data. Automated site discovery vs. brute force methods in Advance in Archaeological Practice, 2(3), 222233. https://doi.org/10.7183/23263768.2.3.222

Heilen, M. 2020. The Role of Modeling and Synthesis in Creative Mitigation. Advances in Archaeological Practice 8(3), 2020, pp. 263–274. https://doi.org/10.1017/aap.2020.23

Kvamme K., 2020. Automated Archaeological Feature Detection Using Deep Learning on Optical UAV Imagery: Preliminary Results; Bevan, in Computational Approaches to Archaeological Spaces, 2020, pp. 53-68

Lasaponara R., Masini N. 2019. Active Satellite Sensors in Cultural Heritage Research. The Use of SAR for Archaeological Prospection, in Remote Sensing for Archaeology and Cultural Landscapes, Best Practices and Perspectives Across Europe and the Middle East, 2019, DOI: https://doi.org/10.1007/978-3-030-10979-0-7

321. Assessing detection rates of Holocene archaeological structures from various satellite imagery sources, along the southern edge of the Nefud Desert.

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The archaeological record of the Arabian Peninsula is rich, stretching back to the Late Middle Pleistocene. One of the most visible features of this archaeological record are the numerous stone structures that were built during the Holocene. These were first identified on a large scale through the use of remote sensing. RAF pilots in the 1920's were astonished by the large number of stone structures that were visible in Harrat ash-Sham, a lava field that spans across southern Syria, Jordan and northern Saudi Arabia. In recent years the use of remote sensing in Saudi Arabia has received renewed interest due to the availability of high resolution imagery from free platforms such as Bing Aerial and Google Satellite imagery (Kennedy 2011). Detection of archaeological sites through remote sensing is particularly useful in desert settings where archaeological remains are more clearly visible due to the lack of vegetation. On the Arabian Peninsula these stone structures are known collectively as the 'works of old men' and range in size from small 1-2 meter wide cairns to monumental structures such as kites that can be kilometers long. There are likely hundreds of thousands of structures across the entire landmass of the Arabian Peninsula. While remotely sensed imagery has been used to identify archaeological remains in Arabia (Harrower et al. 2013), there has been little work to compare the visibility of archaeological features in imagery from different sources. I have conducted a manual systematic survey of Google Satellite and Bing Aerial imagery to identify stone structures across five study areas located along the southern margins of the Nefud desert, in north western Saudi Arabia. All visible stone structures have been recorded and assigned a structure type where possible. In total 716 structures were identified across 2496 km2 of the five study areas. Walking surveys and UAV flights were conducted in three areas of high stone structure density within the study areas to ground truth structures identified in satellite imagery. Additionally this was aimed at helping to identify any small structures that are not visible in satellite imagery. I aim to compare various types of imagery to assess how detection rates of stone structures differ. I will compare Very High Resolution (VHR) imagery from Worldview 2 and Worldview 3 (both 50cm) to Bing Aerial, Google Satellite and KH-9 (Hexagon) declassified imagery. These comparisons will allow for an understanding of how great of an effect different resolutions have on detection of stone structures (with resolutions ranging from 50cm to ~4m). Additionally, KH-9 imagery from the late 1970's will be compared to Worldview 2 and 3 imagery from 2017 and 2021 respectively, to determine how visibility of structures has been impacted over time. The study areas have been chosen to include a range of topography such as dune fields of the Nefud Desert, large sandstone outcrops (Jebels) and basin playa. This was done due to noticeable differences in structure visibility across these different land forms. Remote sensing is an invaluable methodology that has allowed for the documentation of thousands of stone structures across the Arabian Peninsula, especially through large scale projects such as EAMENA (Bewley et al. 2016). This would have been extremely difficult and time consuming to document on the ground. While remote sensing allows for rapid and efficient documentation of structures, there is still a prohibitive cost to buying VHR satellite imagery. I aim to quantify the gain in detection rates that VHR imagery offers when compared to freely available satellite imagery. While the resolution of freely available satellite imagery may vary, it can come close to that of VHR imagery in some areas. Additionally, by documenting different structure types I hope to understand how structure size and form affects their visibility in satellite imagery, where smaller objects are likely to be more difficult to identify. Stone structures are one of the most striking features of the Holocene archaeological record in the Arabian Peninsula. They offer a record of human demography and landscape use over the past 10,000 years. By better understanding detection rates of stone structures in different satellite imagery sources we can conduct more well informed remote sensing studies. Allowing us to learn more about how humans were using the landscape, and how this has changed over time.

318. VHR satellite imagery-based detection of archaeological sites looting in desertic regions via Deep Learning approaches.

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Satellite remote sensing nowadays represents an invaluable resource not only for visual and automatic detection of marks on the landscape related to anthropogenic activities, but also for identifying and monitoring archaeological sites impacted by looting (Tapete and Cigna 2019), i.e., the destruction and ransacking of archaeological sites to unearth artifacts for sale on the illicit market for antiquities. In some specific cases, these two remarkably different types of detections go hand in hand and the discovery of new marks related to past anthropogenic activities goes along with the sighting of the signs of more recent illegal human activities, this phenomenon being particularly evident in isolated or inaccessible regions of the world. The spreading of criminal plundering activities occurs particularly, as a matter of fact, in isolated areas, where surveillance and access are complicated, and intensifies during times of dramatic events such as conflicts and political instabilities, as seen in the past decades with particular intensity in the MENA region. In all these situations, remote sensing has enabled (and keep ensuring) not only the continuation in remote fashion of academic research focused on the 'archaeology of the landscape' in times when on the ground work is complex or unsafe, but also provides for monitoring and keeping record of the evolution of the plundering and despoliation phenomena.

The use of teledetection for uncovering looting occurrences is a relatively recent addition to the archaeological remote sensing scholarship. Attempts to pinpoint illegal activities of looters have relied mainly on optical on-screen identification of illegal pits and trenches' excavations, with only a handful of studies applying semi-automatic or automatic recognition (e.g., Lauricella et al. 2017, Lasaponara and Masini 2018). The scale and severity of the problem, however, calls for the swift development of automation approaches enabling the continuous monitoring of wide swaths of landscapes in a systematic way over extended periods. Thus, this paper focuses on novel approaches of automated detection that are currently being developed within the framework of the ESA-funded ALCEO project (Automatic Looting Classification from Earth Observation Activity) to identify and analyse ransacked sites in order to collect intelligence about ongoing and past criminal activities that can be used by international and local Law Enforcement Agencies (LEA). For a serendipity effect, the identification of looted sites carries with it, in given circumstances, the recognition of archaeological features (proxies for buried archaeological contexts) associated with plundering traces. The trend here is obvious: unidentified archaeological sites are the most appealing to looters as material culture removed from unknown archaeological contexts is the hardest to be identified when emerging in the (shady) antiquities market. As far as the geographic locations considered in this ongoing project, the association of the two types of detections has been particularly recurrent in the desertic areas: visual identification of pillaged sites carries often with it the identification of soil marks in spatial connection with them. In general, the identification of looted sites in arid environments is simpler than in other areas, due to a combination of vegetation and buildings' absence (which could hinder or limit the detection), virtual homogeneity of landscape, and the quite regular and recursive shape and physical characteristics of the excavated traces. These characteristics make desertic environments affected by looting highly suitable for rapidly building a training dataset to train machine learning algorithms or models. Based on this assumption, three geographic areas in arid zones of the MENA region, known for being affected by looting activities, have been selected as case studies to create a representative training dataset: Aswan in Egypt, Ebla and Dura Europos in Syria.

The multitemporal training dataset is formed by image pairs: one non-labelled image at an initial time, and a second image acquired at a later stage in time, labelled with (bounding boxes) polygons in correspondence of looting pits. Ransacking pits and trenches have been then visually detected and digitised, labelling each of them based on their shape and frequency, and adding also a value representing the level of confidence in the identification. Overall disturbance areas, on which pits and trenches insist, have been also recorded and annotated as well as the density of the recognised pits/trenches. A supervised change detection Deep Neural Network has subsequently been developed, using annotated image pairs to identify the changes related to looting. The dataset includes multitemporal Very High-Resolution multispectral images (Quickbird, Worldview2, Pléiades), which have been acquired in pre-defined time windows to minimise environmental and meteorological disturbances and maximise the possibilities of visually detecting the searched object. To additionally increase the spatial resolution of images, image fusion techniques have been employed when co-registered panchromatic data were available; radiometric and spectral enhancements have been also applied to obtain images more suitable for visual inspections.

Initial results are showing the ability of Deep Learning to identify looting activities in desertic environments, which will be further magnified in the future by the improvement in the quality of the training data that will include the tagging of looting occurrences located on other environments. Developed algorithms will be tested for detection and tracking of looting activities on additional ecosystems to increase their effectiveness and their ability to track down unlawful excavations.

References

Tapete, Deodato, and Francesca Cigna. 2019. "Detection of Archaeological Looting from Space: Methods, Achievements and Challenges" Remote Sensing 11, no. 20: 2389. https://doi.org/10.3390/rs11202389

Lauricella, Anthony, Joshua Cannon, Scott Branting, and Emily Hammer. 2017. "Semi-automated detection of looting in Afghanistan using multispectral imagery and principal component analysis". Antiquity 91, no 359: 1344-1355. https://doi.org/10.15184/aqy.2017.90/

Lasaponara, Rosa, and Nicola Masini. 2018. "Space-Based Identification of Archaeological Illegal Excavations and a New Automatic Method for Looting Feature Extraction in Desert Areas". Surveys in Geophysics 39, no 4: 1323–1346. http://doi.org/10.1007/s10712-018-9480-4.

115. Near East irrigation studies beyond SRTM and CORONA. Preliminary results of the UnderTheSands project

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Hector A. Orengo, Landscape Archaeology Research Group, Catalan Institute of Classical Archaeology

Wittfogel's hydraulic hypothesis (1957) motivated much of the early archaeological discourse in the Near East to seek a connection between large-scale irrigation and the centralized power in early states; provoking researchers to challenge his views. The current research shows a more complicated picture2. Various agencies controlled the irrigation works, but water management was indeed the backbone of ancient Near Eastern society.

Advances in irrigation research have used multiple methods, from historical analyses to the use of GIS. In terms of remote sensing, LANDSAT (Adams 1981), CORONA and SRTM satellite imagery paved the way for large-scale landscape studies in the Near East (Ur 2002; Philip et al. 2002; Wilkinson 2003). Unfortunately, because of the political situation, most of the research on irrigation has almost stopped in recent years or moved elsewhere. The importance of irrigation studies has not diminished but its magnitude has rather increased due to current environmental and political issues.

The paper will present the UnderTheSands project, aiming to locate and reconstruct the irrigation network of the areas under study in the Near East and explore their chronological dynamics. Four areas have been selected for the project. These are located in Iraq, Iran and Turkmenistan. The chosen regions in UnderTheSands have diversified characteristics, which will allow to development of a novel workflow for the large-scale analysis of irrigation networks that later can be applied to any other areas presenting similar features. By studying the irrigation networks in these selected areas, we will understand the long-term socio-economic and historical circumstances that produced and maintained these irrigation networks.

The proposed methodology will include remote sensing, terrain analysis, hybrid Machine / Deep Learning methods, archaeomorphology, spatial correlation indices, and historical studies) and various spatial data sources (including multispectral imaging, synthetic aperture radar, and TanDEM-X). The application of Google Earth Engine (GEE) will create a possibility to work with an enormous amount of data incorporating the workflow developed by UnderTheSands. The project will be based at the Landscape Archaeology Research Group (GIAP) at the Catalan Institute of Classical Archaeology (ICAC) in Tarragona.

The paper will present the research objectives, methods and initial results of the "UnderTheSands: Ancient irrigation detection and analysis using advanced remote sensing methods" project (HORIZON-MSCA-2021-PF-01-101062705), funded by The European Union.

Adams, Robert McCormick. 1981. Heartland of Cities. Surveys of Ancient Settlement and Land Use on the Central Floodplain of the Euphrates. Chicago / London: University of Chicago Press.

Philip, G, D Donoghue, A Beck, and N Galiatsatos. 2002. "CORONA Satellite Photography: An Archaeological Application from the Middle East." Antiquity 76 (291): 109–18.

Ur, Jason A. 2002. "Surface Collection and Offsite Studies at Tell Hamoukar, 1999." Iraq 64: 15–43. https://doi.org/10.2307/4200517.

Wilkinson, Tony James. 2003. Archaeological Landscapes of the Near East. Tucson: University of Arizona Press.

Wittfogel, Karl August. 1957. Oriental Despotism; a Comparative Study of Total Power. New Haven: Yale University Press.

61. Detecting change with Google Earth Engine in the desert regions of North Africa

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Louise Rayne, Newcastle University

Introduction

This paper will present recent developments in a remote sensing workflow being developed by the Endangered Archaeology in the Middle East and North Africa (EAMENA) project for automating the detection of threats and damage to archaeological sites in the desert regions of North Africa. Based at the Universities of Leicester, Durham, and Oxford, and funded by the Arcadia Fund, the EAMENA project was established in 2015 with the primary purpose of using earth observation to document archaeological sites across the MENA region and record damage and threats to those sites in an online database (https://database.eamena.org/).

Background and Methods

The EAMENA project has developed an Automatic Change Detection (ACD) methodology for the purposes of rapidly analysing landscapes to detect potential damage and threats to archaeological sites. The existing workflow uses free satellite imagery and high-performance computing power available via Google Earth Engine. The bespoke script compares composite Sentinel-2 satellite images to highlight areas of change and identify where these changes have occurred within proximity of known archaeological sites. This version was previously published in *Remote Sensing* (Rayne *et al*. 2020) and illustrated with two case studies in Libya and Egypt where field validation was undertaken and with an overall accuracy between 8591 %.

While the established ACD workflow successfully identifies change between satellite imagery composites of different dates, it provides only a binary classification indicating change or no change per pixel. Users must consult other high-resolution imagery or conduct field visits to validate the results and identify the type of change that has actually occurred. In order to further refine our results we have therefore begun to develop a methodology which will use land classification to automatically categorise the type of change which has occurred. This methodology uses machine learning classifiers (i.e. Random Forest) to carry out a supervised classification of land cover in the study area and analyses time series of satellite images to identify changes over time, adapted from methods used in Mahmoud 2022. Five different land feature types have been identified in the study area: sand dunes, vegetation, bare soil, mountains, and buildings. Training sample have been collected from archived high-resolution images in Google Earth for each land class in order to train the Random Forest classifier and validate its results.

Case Studies

This paper will investigate two case studies to test our methodology in desert regions. The first case study will investigate an area in the south of Morocco, along the edge of the Sahara. Here, a series of abandoned medieval oasis settlements and prehistoric cairn cemeteries are increasingly threatened by natural processes which have been exacerbated by climate change in recent years such as shifting sand dunes and flash floods, as well as issues of looting and other human intervention. Fieldwork in this area in November 2022 will enable us to conduct validation of the results.

The second case study covers the town of Beni Ulid and its surrounding area in Libya, a region which has been occupied continuously since antiquity. The remains of farms, villages, and agricultural landscapes dating from the Roman period onwards are interspersed throughout the modern town. As is the case in many parts of Libya, the rapid expansion of the modern town and agriculture, aided by modern irrigation techniques, has already destroyed many of these sites and threatens others (Rayne, Sheldrick, and Nikolaus 2017). For both case studies, by analysing and comparing sequential classified images, we can identify where archaeological sites are within proximity to significant land cover changes and therefore at risk of being damaged or affected by these changes.

Discussion

Our initial testing has identified a number of challenges specific to desertic regions. One is that we see significant overlap between the land cover features. For instance, urban areas are built-up on bare land soil, which can result in misclassifying urban areas as bare soil and vice versa. In addition, in the area of our Morocco case study, many buildings are constructed of earthen materials such as mudbrick or rammed earth, which blend in with their surroundings and can result in additional misclassification. Another misclassification we have encountered occurs between urban and mountain areas as the urban areas tend to have rocky soil or sand between buildings and settlements. We are currently testing ways to overcome these issues by increasing the number of training samples and determining the optimal number of classes.

Another issue is the medium spatial resolution of the satellite sensor (i.e. Sentinel-2 with 10 m) which limits the identification of land features where two land types might be found within the same pixel. For this issue we are investigating the use of spectral unmixing methods to distinguish the variation between the different classes within the same pixel, which will have a significant impact on accurately identifying the type of change in land cover. We are also investigating how we can adapt our scripts to use higher resolution imagery, e.g. PlanetScope (3 m) and RapidEye (5 m) imagery.

By continuing to develop our ACD methodology and refining its ability to classify changes in land use, we hope to establish a workflow which will improve the speed and ease of monitoring archaeological sites and rapidly identify which sites are most at risk, helping heritage professionals to quickly and efficiently target resources where they are needed most. Since 2017 the EAMENA project has provided training to North African colleagues in our remote sensing methodologies, including our ACD workflows, funded by the British Council's Cultural Protection Fund, and hope to conduct further training in 2023. We also aim to create user-friendly online change detection applications which will be optimised for use in different environments in order to improve accessibility and uptake of these tools.

References

Mahmoud, Ahmed Mutasim Abdalla. 2022. "Monitoring Sand Dune Movement using Remote Sensing." PhD thesis, University of Nottingham.

Rayne, Louise, Maria Carmela Gatto, Lamin Abdulaati, Muftah Al-Haddad, Martin Sterry, Nichole Sheldrick, and David Mattingly. 2020. "Detecting change at archaeological sites in North Africa using open-source satellite imagery." *Remote Sensing* 12, no. 22: 3694. https://doi.org/10.3390/rs12223694

Rayne, Louise, Nichole Sheldrick, and Julia Nikolaus. 2017. "Endangered Archaeology in Libya: Recording Damage and Destruction." *Libyan Studies* 48 (2017): 23–49.

https://doi.org/10.1017/lis.2017.7.

35. Indigenous Knowledge and Digital Archaeology: potential, problems and prospects

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Patricia Murrieta Flores, Lancaster University

Location: E105

To date, several research projects have sought to establish collaborations between indigenous communities and archaeologists. Such works have drawn attention to the benefits but also the challenges of combining archaeological theory and methods, including digital and computational methods, with indigenous worldviews. On one hand, the use of digital technologies in archaeological projects engaging indigenous communities has offered new possibilities for the preservation, management and interpretation of archaeological heritage and valuable insights into critical and widely debated themes in archaeological and anthropological research (Raichlen et al. 2014; Wood et al. 2021). At the same time, interactions between local communities and digital archaeology experts have opened up new opportunities for reciprocal knowledge transfer, and, in some cases, the economic sustainability of indigenous groups. Nonetheless, the use of digital methods in indigenous archaeology and heritage has also raised a number of issues with respect to the imposition of colonial practices and frameworks, ethical conduct in scientific practice, and equitable participation in data governance (management, ownership, accessibility) and knowledge production (Gupta et al. 2020; Sanger and Barnett 2022). This session invites papers that discuss the potential and challenges of using digital tools and methods in collaborative research between archaeologists and indigenous communities. We especially encourage contributions that focus upon (1) the experiences and benefits of interacting with indigenous communities to advance digital archaeological research and computational modelling, (2) the integration of indigenous knowledge systems into data capture, digitisation, dissemination, and analysis and (3) the ways in which digital archaeology can support the economic sustainability of indigenous groups and empower indigenous communities to investigate and communicate their past.

We are also interested more broadly in papers exploring synergies between indigenous knowledge and digital archaeology, and contributions that discuss ethical considerations related to the participation of indigenous communities in digital archaeological research.

References

Neha Gupta, Sue Blair & Ramona Nicholas (2020) What We See, What We Don’t See: Data Governance, Archaeological Spatial Databases and the Rights of Indigenous Peoples in an Age of Big Data, Journal of Field Archaeology, 45:sup1, S39-S50, https://doi.org/10.1080/00934690.2020.1713969

Raichlen, David A., et al. (2014) “Evidence of Lévy walk foraging patterns in human hunter–gatherers.”Proceedings of the National Academy of Sciences 111.2: 728-733.

Sanger,M., & Barnett, K. (2021). Remote Sensing and Indigenous Communities: Challenges and Opportunities. Advances in Archaeological Practice, 9(3), 194-201. https://doi.org/10.1017/aap.2021.19

Wood, B., Harris, J., Raichlen, D., Pontzer, H., Sayre, K., Sancilio, A., Berbesque, C., Crittenden, A., Mabulla, A., McElreath, R., Cashdan, E., and Jones, J.H. (2021) “Gendered movement ecology and landscape use in Hadza hunter-gatherers” Nature Human Behaviour 5 (4), 436-446.

	SLOT 3
14:00 - 14:20	81. Our Tuesday Meetings: Discussing Collaboration for Digital Heritage Research at the former Old Sun Indian Residential School, Alberta Canada *Madisen Hvidberg (University of Calgary)*; Angeline Ayoungman (Old Sun Community College); Gwendora Bear Chief (Old Sun Community College); Peter Dawson (University of Calgary)*
14:20 - 14:40	23. Indigenous Data Sovereignty: Indigenizing Anthropological Data Collection and Management Practices *Lindsay M Montgomery (University of Toronto)**
14:40 - 15:00	130. Community-Oriented Approaches for Digital Documentation of Indigenous Hunting Ice Patch Landscapes *Kelsey A Pennanen (University of Calgary)**
15:00 - 15:20	267. Stories from St Augustine’s College: Negotiating global memorialisation in digital archaeology *Catriona E Cooper (Canterbury Christ Church University)*; Abi Kingsnorth (Canterbury Chirst Church University); Ralph Norman (Canterbury Christ Church University); David van Krieken Vannerley (Canterbury Christ Church University)*
15:20 - 15:40	1. Understanding the national, regional and local sea level rise risk to coastal archaeology: a case study from Aotearoa / New Zealand. *Ben D Jones (University of Auckland)**

15:40 - 16:00	**Discussion**
SLOT 4	
16:30 - 16:50	356. Tapping into Indigenous Knowledge to advance computational models of hunter-gatherer societies *Eleftheria Paliou (University of Cologne)*; Oliver Vogels (University of Cologne); Lucía Cobo-Sánchez (University of Cologne); Tilman Lenssen-Erz (University of Cologne)*
16:50 - 17:10	172. Simulating pastoral landscapes: ethnoarchaeology and computer modelling in the Aspromonte Massif (Southern Italy) *Guillem Domingo-Ribas (Newcastle University)*; Francesco Carrer (Newcastle University)*
17:10 - 17:30	24. Gaming for submerged ancient landscapes in Australia *John McCarthy (Flinders University)*; Michael O'Leary (University of Western Australia); Ulysse Lebrec (University of Western Australia)*
17:30 - 17:50	227. Towards Collaborative Archaeogame Design and Development: Iteration, Innovation and the Southern Jê *Priscilla Ulguim (Vrije Universiteit Brussel)*; Juan Hiriart (University of Salford); Florencio Fernandes (Terra Indígena Rio das Cobras); Claudia Parellada (Museu Paranaense); Juliana Salles Machado (Universidade Federal de Santa Catarina); Silvia Copé (Universidade Federal do Rio Grande do Sul); Fabíola SIlva (Museu de Arqueologia e Etnologia da Universidade de São Paulo)*
17:50 - 18:10	**Discussion**

81. Our Tuesday Meetings: Discussing Collaboration for Digital Heritage Research at the former Old Sun Indian Residential School, Alberta Canada

Madisen Hvidberg, University of Calgary
Angeline Ayoungman, Old Sun Community College
Gwendora Bear Chief, Old Sun Community College
Peter Dawson, University of Calgary

Working closely with Indigenous partners from the Siksika Nation this project combines Indigenous knowledge with digital documentation and archiving practices to address the history and legacy of the Indian Residential School System (IRS) in Canada.

IRS were government-sponsored religious institutions that were established with the direct aim of assimilating Indigenous children into the accepted Euro-Canadian culture (Hanson 2019; Miller 2012). As a federal initiative, over 130 residential schools were opened and operated across Canada between 1831 and 1996, and more than 150,000 children attended (Miller 2012). Attendance for the children brought to these schools was mandatory and they were frequently taken from their families by force, often sent to schools far from their home with the intent of further severing connections to their Indigenous roots. To avoid rigorous legal issues many survivors have dealt with the trauma alone or turned to destructive means of coping such as substance abuse. The impacts of intergenerational trauma are becoming more and more evident, and there is a nation-wide issue of disconnect between future generations and cultural traditions.

The use of digital technologies for preserving heritage sites with dark histories has been suggested in other places of the world, such as for war sites in Europe (Kidd 2016; Miles 2002) but have yet to be used for difficult heritage documentation in Canada. A digital approach is valuable for use at sites of trauma because technologies can be used to create virtual replicas that allow for a degree of separation whereby the user interacts with something associated with a traumatic place instead of the actual place itself. Digital methods can also often be used to offset the costs of physical preservation, be used for making and aiding in management decisions of sites, as well as allow for far reaching dissemination and engagement through web-based applications (Colley 2015:15; Hvidberg and Dawson 2018:126).

However, data is still predominantly used for visualization aspects of engagement as well as for academic research analyses (Champion 2021:5; Richardson 2022:201). Digital heritage is rarely included in conversations of social justice, and the ethics of a digital practice are generally under explored, especially in an Indigenous-led research directive (Richardson 2022:201). Yet due to the adaptability of a digital approach, these methods are being used in a way that uniquely addresses social issues today as they relate to specific Indigenous communities whose histories are intertwined with residential school sites.

In 2020 this project digitally documented the former Old Sun Indian Residential School building, now Old Sun Community College, located on the Siksika Nation in Treaty 7 territory of Alberta, Canada. This structure was documented with a combination of terrestrial laser scanning and UAV photogrammetry using a Z+F 5010X IMAGER, Z+F 5016 IMAGER, Leica BLK 360, and eBee SenseFly drone. In the two years since, we have worked closely with an advisory committee of Old Sun IRS survivors to develop a community-driven research framework to explore the integration of Indigenous knowledges with digital practices for documentation, production, and mobilization of research. Ultimately, we seek to empower Siksika to investigate and reclaim their own history surrounding Old Sun and the Indian residential school system.

To accomplish this, the authors of this paper, including representatives from the University of Calgary and the IRS survivor advisory committee have been meeting on Tuesdays for the last year. These meetings have proven to be the central space for bringing together Western and Indigenous knowledge systems in the context of the overarching Old Sun IRS research project. Exciting and varied research ventures, such as the mapping of elder memories with GIS, combining oral history and archival research to recreate landscapes, and the use of physicalized models for mnemonic devices and virtual reconstruction have occurred in these meetings.

What cannot be forgotten though is that every component of this research project deals with and is inseparable from a deeply emotional history. Whether from direct or intergenerational experiences, the trauma of the IRS system is something that every Indigenous person in Canada lives with today. The history captured by our digital technology is a history that Siksika must content with daily. Weekly meetings have provided a space to consistently engage with the living and emotional components of this project. We have open and honest discussions about the difficulties of working with such a traumatic history, but also about how we can derive strength from the process. Our Tuesday meetings are where spirituality, healing, and relationship building remain an active part of an on-going research project and in this presentation we would like to share the story of them with you.

References

Champion, E.Virtual Heritage: A Guide. Ubiquity Press, 2021.

Colley, S. Ethics and Digital Heritage. In The Ethics of Cultural Heritage, edited by T. Ireland, pp. 13-32. Springer, 2015.

Hanson, E. 2019. The Residential School System. First Nations and Indigenous Studies, The University of British Columbia. Electronic document. accessed August 3, 2022.

https://indigenousfoundations.arts.ubc.ca/the_residential_school_system

Hvidberg, M., and P. Dawson. Digital Methods for Mediating Impacts of Heritage Relocation and their Implications for the Perrenoud Homestead. Archaeological Survey of Alberta Occasional Paper No. 38 (2018):120-129.

Kidd, J. With New Eyes I See: Embodiment, Empathy and Silence in Digital Heritage Interpretation. International Journal of Heritage Studies 21 (2016):54-66.

Miller, J. 2012. Residential Schools in Canada | The Canadian Encyclopedia. Electronic document,: accessed: 20 February 2021. https://www.thecanadianencyclopedia.ca/en/article/residential-schools.

Richardson, L.J. The Dark Side of Digital Heritage: Ethics and Sustainability in Practice. In Critical Archaeology in the Digital Age: Proceedings of the 12th IEMA Visiting Scholar Conference, pp. 201-210. Cotsen Institute of Archaeology Press, 2022.

23. Indigenous Data Sovereignty: Indigenizing Anthropological Data Collection and Management Practices

Lindsay M Montgomery, University of Toronto

Since 2011, there has been a steady growth in the application of the concept of sovereignty within the digital sphere, which encompasses the technologies, infrastructures, data, and content produced through electronic computing techniques (Couture and Toupin 2019). One iteration of this larger trend is the concept of Indigenous digital sovereignty, which has been used by Indigenous peoples and Indigenous-led social movements as a discursive tool for claiming control over multiple facets of the digital sphere. The discourse of Indigenous digital sovereignty is part of long-standing anti-establishment and anti-imperialist activism among Indigenous peoples working to reclaim control over their lands, bodies, knowledge, and information. As part of a radical decolonizing and Indigenizing paradigm, Indigenous data sovereignty seeks to restructure existing power dynamics around digital data and to develop alternative representations of Indigenous peoples based on this data by using methodologies that are not rooted in colonialism (Walter 2016).

In this paper, I will present two case studies that engage with the framework of Indigenous data sovereignty in order to demonstrate how this concept challenges traditional anthropological practices of data collection, curation, analysis, and dissemination. The first example presents the results of a content analysis of over 1600 unique posts referencing the Missing and Murdered Indigenous Women and Girls Movement on Twitter. This study demonstrates the important role that social media plays in the creation of a digital counter public (Graham and Smith 2016) that supports Indigenous-led cyber activism against epistemic gendered violence. In discussing the results of this study, I will highlight ethical questions that arose during the study around informed consent and user anonymity when conducting research on Indigenous-produced textual data within the public domain. The second case study is based on a new collaborative multi-institutional archaeological research project I am engaged in with Picuris Pueblo in northern New Mexico. In this example, I will highlight the potential of advanced technologies like LiDAR to document archaeological landscapes and the challenges that Indigenous collaboration poses to traditional research dissemination and publication practices. In drawing a comparison between cases that use methods from within sociocultural anthropology and archaeology, this talk will draw attention to how distinct types of data present different challenges and opportunities for enacting Indigenous digital sovereignty.

References

Couture, Stephane and Sophie Toupin, "What does the notion of "sovereignty" mean when referring to the digital?," New media & society 21, no. 10 (2019): 2305-2322.

Graham, Roderick and Shawn Smith, "The Content of Our #Characters: Black Twitter as Counter public," Sociology of Race and Ethnicity 2, no. 4 (2016): 433-449.

Walter, Maggie. "Data politics and Indigenous representation in Australian statistics." In Indigenous Data Sovereignty: Toward an Agenda (CAEPR), edited by Tahu Kukutai and John Taylor, 79-98. Canberra, Australia: ANU Press, 2016.

130. Community-Oriented Approaches for Digital Documentation of Indigenous Hunting Ice Patch Landscapes

Kelsey A Pennanen, University of Calgary

Ice patch landscapes help to reveal the tenacity and longevity of Indigenous history through the abundance of millennia-old objects uncovered every year, as well as hunting blind complexes built at high altitudes. This project uses digital archaeology and community-oriented Indigenous approaches to knowledge to document these significant landscapes. Using a multifaceted approach, including aerial photogrammetry, immersive panoramic imagery, and digital storytelling methods, this project documents First Nations Citizens, Youth, Elders, and hunters' experiences on the landscape to gain a holistic understanding of the deep history and immense transformation in the face of anthropogenic climate change. This project and its priorities were identified by committees from local self-governing First Nations from Carcross/Tagish First Nation, Champagne and Aishihik First Nations, and Kwanlin Dün First Nation in Yukon Territory, Northern Canada. Through this, numerous field seasons of cooperative learning experiences and interactions on the mountainous high-alpine landscape have allowed us to digitally capture acres of significantly modified cultural landscapes to cm-scale resolution. In addition to collecting hunter and Elder experiences on the land, researchers train and work alongside youth to build capacity in communities for local land management practices. Together, we have captured imagery of the vast mountainous landscapes to preserve an immersive record as this ecosystem exists with permanent snowpack including footage of the curious caribou and cautious sheep that seek the refuge of the ice. This presentation will focus on a summary of the past three years of collaborative research, preliminary outcomes, learning opportunities, and knowledge produced through these experiences. The outcomes of this project are producing a public-facing platform for use by the community for education, outreach, and for use as tourism alternatives.

The recovery of cryogenically frozen hunting artifacts from melting ice patches in Canada's Yukon Territory has contributed to an understanding of the exceptional Indigenous hunting tradition in the region (Greer & Strand 2012; Hare et al. 2004). Ice patches in southern Yukon have undergone extreme melt since the 1990s, but in the past three years experienced the heaviest snowfall accumulations witnessed in recent decades. First Nations Heritage managers identified the priority to better understand these places as Indigenous hunting landscapes, and this slight reprieve from the catastrophic melt provided the opportunity to research how hunting has historically taken place on the mountain by looking beyond the ice patches. This led to the development of a project focused on digital documentation strategies incorporating traditional Indigenous knowledge to research alpine hunting blind complexes. The past three summers have been eventful field seasons of collaborative learning experiences and interactions in high-alpine landscape. This has allowed us to digitally capture over eleven acres of significantly modified cultural features in cm-scale accuracies at three mountain heritage complexes.

This research project involves the use of numerous digital recording techniques to document information on hunting blind complexes, archaeological recoveries, ecological activity, and Indigenous traditional knowledge associated with built hunting features in the Southern Lakes region of Yukon territory. Intensive 3-dimensional mapping was conducted using over 40 transecting overlapping grids flown with a DJI Mavic 2 Professional and processed using Pix4DMapper software. In creating these detailed and interactive three-dimensional visualizations of alpine hunting landscapes, new insights have been forged. These datasets have revealed significant modifications—while mapping the game trails, drive lanes, and hunting blinds on the mountain block where the Alligator and Friday Creek ice patches are situated, close to 70 hunting blind structures have been recognized in addition to miles of trails and countless archaeological features. The ice patch cultural data is playing a key role in land management planning by Carcross/Tagish and Kwanlin Dün First Nations (Carcross/Tagish First Nation et al. 2020). Ecological models of caribou and sheep distribution are derived from collaring data provided by the Government of Yukon (2021) and are mapped in relation to archaeological features. Along with these datasets, digital storytelling methods are employed using a DJI Pocket, DJI Mavic Mini 2, and Sony camera to create 360degree panoramic imagery to capture Elders' and hunters' experiences on the land. These various lines of inquiry will be combined to create both a visually captivating public-facing digital heritage outreach platform, and a GIS-based interactive stacked-knowledge database that is owned, accessible, and controlled by First Nations community members. These visualizations will be employed in future interpretive products and used as research aids when interviewing individuals that have experience hunting in these settings.

Heritage is under threat from climate change, with impacts disproportionately effecting Indigenous communities (Nicholas and Smith 2020). However, research using digitization strategies developed through collaborative partnerships with Indigenous communities aims at addressing some of the losses being experienced through digitally archiving and sharing knowledge on threatened heritage sites. As archaeologists, it is our ethical duty to protect heritage, and this research allows for heritage to be presented and connected in new and innovative ways. Given the increasingly warming climate, continued threats face northern heritage, therefore it is of great significance to document these locations as they currently exist. This urgency makes the preservation of all materials and structures relating to caribou/sheep hunting within the ice patch sites of considerable value for the rare analytic information about the past that can be provided. This project uses 3D technology to help organize and relate the ecological, biological, and cultural components of a mountainscape with the objective of visualizing incongruent material records through a more genuine sense of place and tradition as informed by First Nations perspectives. Archaeology is inherently a colonial discipline, but by acknowledging our positionality and reframing our research agendas, we can begin to reorient the discipline as one that utilizes skills and technology to provide valuable services to support and empower Indigenous communities. With our experiences in cutting-edge digital technologies and 3-dimensional spatial mapping, we can begin to bridge epistemologies of Indigenous ways of knowing and Western-colonial understandings. With a community-centered approach to work, and a priority of outcomes identified by local First Nations communities together we work to understand, preserve, relate, and appreciate these spaces connected through time and space by engaging in new ways.

References Cited:

Carcross/Tagish First Nation, Kwanlin Dün First Nation, & Ta'an Kwäch'än Council. (2020). How We Walk With the Land and Water. Https://www.Howwewalk.Org/.

Government of Yukon. (2021, July 5). Southern Lakes Caribou: Monitoring a recovering woodland caribou herd in Yukon. https://Storymaps.Arcgis.Com/Collections/9849a0b2f05a47a2a190d49d74b56f9f.

Greer, S., & Strand, D. (2012). Cultural landscapes, past and present, and the South Yukon ice patches. Arctic. https://doi.org/10.14430/arctic4189

Hare, P. G., Greer, S., Gotthardt, R., Farnell, R., Bowyer, V., Schweger, C., & Strand, D. (2004). Ethnographic and archaeological investigations of alpine ice patches in southwest Yukon, Canada. Arctic. https://doi.org/10.14430/arctic503

Nicholas, G., & Smith, C. (2020). Considering the denigration and destruction of Indigenous heritage as violence. Critical Global Perspectives on Cultural Memory and Heritage. Construction, Transformation and Destruction, 131-154.

1. Understanding the national, regional and local sea level rise risk to coastal archaeology: a case study from Aotearoa / New Zealand.

Ben D Jones, University of Auckland

Coastal hazards threaten properties, infrastructure and cultural sites globally, and sea-level rise (SLR) will escalate this problem (Dawson et al 2020). Aotearoa / New Zealand faces a similar problem as the coastal zone contains a high number (n = 9054) of archaeological sites which are vulnerable to the effects of coastal erosion and inundation (Figure 1). Sea-level rise (SLR) and changing wave patterns will reshape Aotearoa's coast over the next century and beyond and will likely be accompanied by more frequent storm surges, especially in shallow harbors, river mouths and estuaries (Bell et al 2017). Thus, it is widely expected that rates of coastal erosion and inundation will accelerate under SLR, although there will be considerable local-scale variability due to complicating factors, such as the effects of local sediment supply to shorelines. This indicates the need for a multi-scalar approach to better understand the impacts of SLR on coastal archaeology in Aotearoa

Coastal archaeological risk is a function of the susceptibility of coastal areas to inundation and erosion processes, and the capacity of those areas to adapt to new climatic conditions, and as a consequence the impact of SLR. Dawson et al (2020) state that archaeological site vulnerability "is determined by its exposure (the scale of the potential impact of a climatic event) and its sensitivity (or degree to which it could be affected by that exposure)" (p8281). They suggest a four-step process to address the archaeological impacts related to SLR: 1) prepare an inventory of existing archaeological site data (location, type, date); 2) update the inventory by surveying the coastal margin to identify new sites, and checking the state of existing sites; 3) determine archaeological site vulnerability based on the data from 1 and 2; and 4) provide strategies and recommendations to minimize risk. Work of this form is still needed in Aotearoa.

In this paper we describe national, regional, and local analysis of coastal archaeological sites (midden, earthworks and burials) in Aotearoa and their risk to coastal erosion. The national scale analysis uses GIS methods to merge and query environmental and archaeological datasets to provide a first pass assessment of sites in danger to future SLR impacts of erosion and inundation. The regional analysis focuses on Te Tai Tokerau (Northland) and explores coastal archaeological sites in the context of newly updated historical shoreline change rates, revealing that many of Te Tai Tokerau's archaeological sites are located on eroding coastlines. The calculation relied on digitizing historical aerial imagery, mapping historical shorelines, and calculating future coastal erosion hazard zones (CEHZ). The CEHZ zone calculation was dependent on the historical shoreline change dataset and combining hindcast wave data, future SLR projections, dune stability to short term erosion, and shoreline response equations based on bathymetric and LiDAR datasets. We also discuss a local Te Tai Tokerau case study, detailing ongoing work to sample, characterise and radiocarbon date eroding archaeological sites before they are lost.

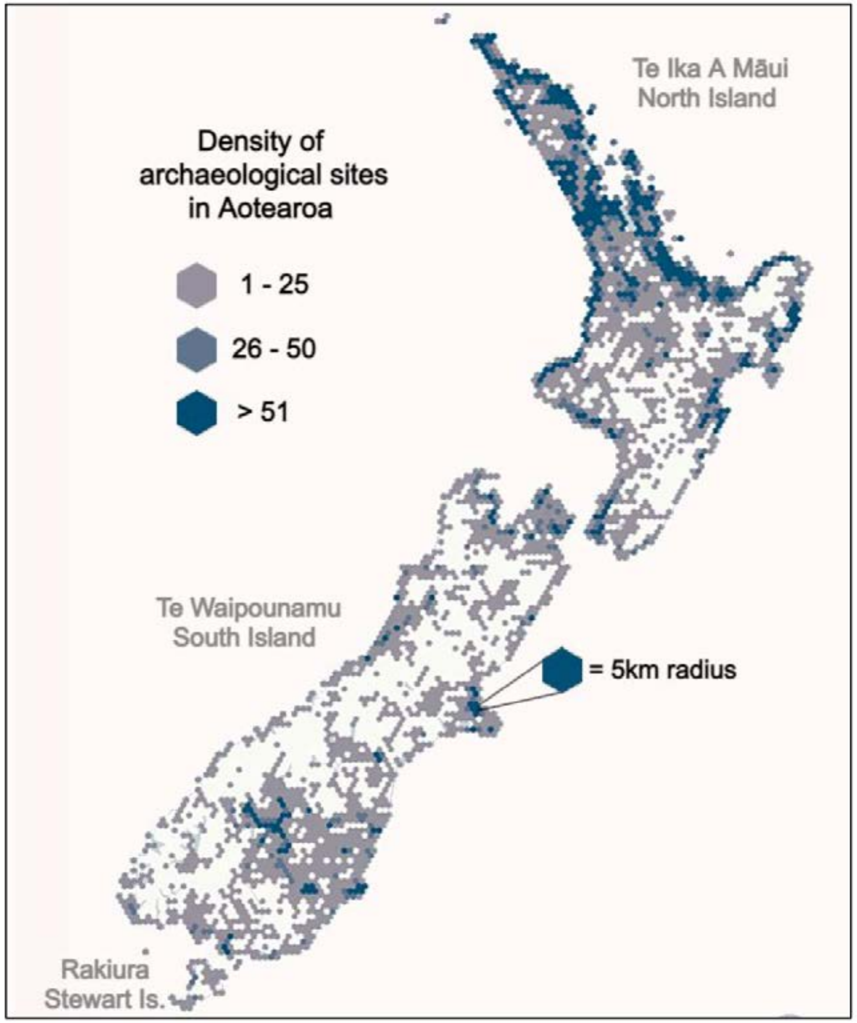

Figure 1: Density of known archaeological sites in Aotearoa as of May 2020 – approximately 73400 sites. Note the concentration of locations along coastal margins.

The findings of the national, regional and local case studies suggest 1) landform sensitivity provides a key proxy for understanding the archaeological risk to SLR, 2) more refined archaeological site location information is needed at a national scale, and 3) coastal erosion is of greater concern in Aotearoa compared to inundation when considering archaeological risk. This might also be the case for coastal island systems similar to Aotearoa.

Overall, the method and results presented in this paper will be of interest to archaeologists, heritage and environmental managers, and indigenous groups tasked with conservation of coastal heritage under the threat of SLR. The work presented in the talk is of particular importance to Māori (the indigenous people of Aotearoa) due to the scale of at-risk archaeological heritage, for which there are a range of possible actions spanning complete preservation through to letting nature take its course. Like any large grouping of people, there are a range of opinions as to what is preferable – there is not one universal Māori view (Awatere et al 2021). The key for Māori is how connected they feel to the sites at risk, and in general burial sites are of greater importance than midden sites (Awatere et al 2021). However, a sense of nostalgia is felt for all sites that have been lost as well as those at risk. The talk will draw attention to the scale of coastal archaeology in Aotearoa that is in need of adequate documentation, preservation and protection in the face of SLR. Robust coastal erosion and inundation datasets are needed to more deeply understand potential SLR-driven impacts on coastal archaeology and provide a scientific foundation for considering adaptation options. These insights are useful globally as other countries are facing similar problems.

References

Awatere, S., King, D. N., Reid, J., Williams, L., Masters-Awatere, B., Harris, P., & Pirkar, J. (2021). He huringa āhuarangi, he huringa ao: A changing climate, a changing world. Te Arotahi Pap. Ser, 7, 1-11.

Bell, R. J. S. P., Lawrence, J., Allan, S., Blackett, P., Stephens, S., Hannah, J., & Davies, K. (2017). Coastal hazards and climate change: guidance for local government. Ministry for the Environment.

Dawson T, Hambly J, and Kelley A. (2020). Coastal heritage, global climate change, public engagement, and citizen science. PNAS, 117(15), 8280–8286. https://doi.org/10.1073/pnas.1912246117/-/DCSupplemental

267. Stories from St Augustine's College: Negotiating global memorialisation in digital archaeology

Catriona E Cooper, Canterbury Christ Church University
Abi Kingsnorth, Canterbury Chirst Church University
Ralph Norman, Canterbury Christ Church University
David van Krieken Vannerley, Canterbury Christ Church University

St Augustine's College (1848-1947) was founded to train missionary clergy for the growing number overseas Bishoprics established at that time. The college attracted students from around the globe, and the alumni charted paths to and from Asia, Africa, and the America's. This historical international exchange presents a unique moment in the history of Canterbury and the Church of England, and has relevance for our contemporary understanding of empire, identity, and religion. Despite the important role that the college played in the global Anglican community, the history is little-known.

The Stories from St Augustine's College project is starting to explore the history of the College. The college archives held by Canterbury Cathedral include extensive student records and precious photographs of the student cohorts. The global reach of the students is also captured in the carved panels in the College's Lower Memorial Chapel where walls list the origins and destinations of its deceased students. These records shout out for further study and initial project scoping highlights potential for network analysis to explore relationships of Missionaries across the globe, GIS to present the global reach of the network and digital building recording to enrichen "the List" and public understanding of the building in Canterbury.

The toppling of Edward Colston's statue in Bristol in the summer of 2020 launched a widescale review across the UK of the subjects of memorials. The removal of statues, while popular with the public, is often complex as a result of scheduling. Historic English instead recommend additional interpretation recontextualising memorials or statutory, as appropriate. The St Augustine's Memorial Chapel offers an interesting case study here: a series of memorials which capture elements of colonial practices such as religious missions. However, an additional layer to the ethical complexity of this dataset is that while the UK reviews the "appropriateness" of memorials of this type, a memorial for one of the students (Archdeacon Thomas Lightfoot) found in the St Augustine's College archive's memorial in South Africa is being renovated and restored.

As we start to form an advisory board for our project we are thinking about who is connected to this unique collection and what associated communities might want from this research. In this paper we will be asking questions about:

- How we can involve relevant communities spread across the globe?
- How we might use digital archaeological approaches to provide access to this

material (not currently available online or open to the public)?

- How we can best represent the interests of indigenous groups who have been impacted by the work of these missions?

This material is not available online, and the chapel is not open to the public, currently rendering the history inaccessible. We will discuss our initial project scoping including digitising and visualising a complex digital dataset, think about whether initial digital outreach is enough to capture the views and interests of such a disparate group of stakeholders, and whether our initial efforts to record these stories and relationships are enough to shed-light on a complex colonial past.

356. Bringing indigenous knowledge into computational models of hunter-gatherer mobility and behaviour

Eleftheria Paliou, University of Cologne
Oliver Vogels, University of Cologne
Lucía Cobo-Sánchez, University of Cologne
Tilman Lenssen-Erz, University of Cologne

Introduction

Computational models of hunter-gatherer mobility and behaviour have long been used in archaeology to offer insights into the choice of site location, the subsistence strategies, survival resilience and social development of early human societies. Central to these models are foraging practices that would have shaped prehistoric human behaviour, human-animal and human-environment interactions. To date, ethnographic research has been instrumental in helping archaeologists theorise foraging behaviour, nonetheless several aspects of traditional hunting practices (i.e. hunting on foot, with a bow and arrow as opposed to firearms, and without orientation instruments) have yet to be systematically explored and are still little understood. This paper will discuss research results obtained in the framework of an interdisciplinary and collaborative project that aims to bridge this gap by bringing together archaeologists and indigenous hunting experts. The project offers a rare opportunity to capture using geospatial technologies the movements of Ju/'hoansi and Hai//kom San game tracking experts during hunting bouts in arid landscapes in Namibia. During four field seasons, which took place between 2019 and 2022, a variety of georeferenced quantitative data (including movement trajectories, heart rate, caloric expenditure, and wind data), as well as qualitative information on decision-making during hunting were collected. These datasets allow the investigation of different aspects of human mobility and behaviour during traditional hunting practices. In our work we explore in particular how the collected data can offer insights into (1) the decision-making process during hunting (following animal tracks, approaching game, aborting hunting etc); (2) the adoption of optimizing search strategies (e.g. Lévy walks; Raichlen et al. 2014) and movement patterns (energy or time minimising); (3) wayfinding in familiar and unfamiliar landscapes; (4) the energetic costs of movement during hunting; and (5) environmental factors (topography, precipitation and vegetation) affecting hunting success in arid environments. This paper will discuss how data collected during fieldwork can be used to inform and develop further computational models of past hunter-gatherer mobility and behaviour, and in particular GIS-based and agent-based models. More specifically, the focus will be upon qualitative observations and quantitative data analyses that offer new insights into wayfinding behaviour, human-animal and human-environment interactions in arid and semi-arid landscapes. In the end this paper will also discuss the benefits of collaboration and reciprocal knowledge transfer between archaeologists and indigenous experts.

Methods and materials

Data collection in our project took place in two study areas in Namibia (Doro!nawas mountains/western central Namibia and Nyae Nyae Conservancy/north eastern Namibia) that differ with respect to the amount, distribution and type of vegetation, as well as the degree of the indigenous experts' familiarity with the environment. We recorded the movements of tracking experts in the course of dozens of hunting bouts in these two regions using geospatial technologies. The hunting bouts involve following animal tracks, approaching animals and "shooting" animals with a camera from a distance up to 50m (i.e. the distance from which presumably the San hunters would have successfully shot an animal with a bow and poisonous arrow). In the course of the hunting bouts, GPS smart watches were used to collect data on trajectories of movement, heart rate, speed, calories and elevation. The Cybertracker App, a software originally developed to support research for nature conservation purposes, was customised to our project needs and was used to take GPS measurements related to animal tracking (spoor and animal sightings), environmental data (terrain and vegetation observations) and decision-making while hunting (tracking animal footprints, approaching animals, etc). Furthermore, our project collected a large number of image data captured with GoPro cameras and audio recordings on decision making during hunting. Finally, mobile ultrasonic wind measurement devices were used to collect data on wind-speed and wind direction, as qualitative observations during fieldwork suggested that the trackers often choose to move against the wind so that the animals cannot sense their presence by smell.

Collected datasets were examined with respect to their fit to existing cost functions that have been discussed in the context of GIS-based least cost path analysis (Herzog 2014), as well as power law functions related to Lévy walk patterns (Raichlen et al. 2014). Furthermore, environmental information (historic data derived from the USGS FEWS NET Data Portal) on the locations in which the indigenous trackers approached or successfully "shot" animals during fieldwork was analysed quantitatively using logistic regression and multivariate logistic regression. This approach allowed us to formally identify which environmental variables or combination of variables (for example, elevation, distance to water sources, distance to vegetated areas, rainfall data etc) are associated with those locations that offer greater potential for successful hunts. Finally, qualitative data on decision making during hunting were also collected via formal and informal interviews that took place during and after the hunting bouts.

Some preliminary results and Discussion

Results can be used to inform and develop further computational models of past hunter-gatherer mobility and behaviour, and in particular GIS-based and agent-based models. The preliminary analysis of movement trajectories from our first study area suggests that human movement during hunting has similarities to Lévy walk patterns, especially while attempting to approach animals that have been sighted. On the contrary, such patterns are not observed while returning back to the camp, namely when the hunters have stopped engaging with hunting. Furthermore, the "back-to-camp" trajectories in many occasions seem to follow closely GIS-based least-cost path calculations.

When it comes to modelling the movements of hunter-gatherer groups, the above results suggest that GIS-based least-cost path calculations have limited potential in identifying areas of human activity in the landscape. Least-cost path calculations are still relevant when moving between an origin and a destination (back-to-camp route), but they are not well-suited for predicting forager mobility in the context of hunting, where movement is determined by human-animal interactions and wind direction. On the other hand, GIS-based models aiming at identifying wider areas in the landscape that offer good environmental conditions for successful hunts (e.g. proximity to water, vegetation etc) seem better suited for indicating possible activity areas of hunter-gatherer groups. The results of the multivariate logistic regression analysis described above can be used to inform GIS-based models of this type, as well as support the conceptualisation of human-environment interactions in agent-based simulations of hunter-gatherer mobility and behaviour. Our ongoing work in developing agent-based models has also benefitted from a multitude of qualitative data on decision making during hunting as well as other relevant aspects of indigenous knowledge that we had not originally foreseen (e.g. controlled small-scale fire practices that aim to encourage vegetation growth and attract wildlife among other things). To conclude, the collaboration with indigenous tracking experts has offered valuable new insights into foraging and hunting practices in arid environments and has greatly supported our model building efforts.

References

Herzog, Irmela. "Least-Cost Paths—Some Methodological Issues." Internet Archaeology 36 (2014). https://doi.org/10.11141/ia.36.5

Raichlen, David A., Brian M. Wood, Adam D. Gordon, Audax Z. P. Mabulla, Frank W. Marlowe, and Herman Pontzer. "Evidence of Lévy Walk Foraging Patterns in Human Hunter–gatherers." Proceedings of the National Academy of Sciences 111, no. 2 (2014): 728–33. https://doi.org/10.1073/pnas.1318616111.

172. Simulating pastoral landscapes: ethnoarchaeology and computer modelling in the Aspromonte Massif (Southern Italy)

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Pastoralism, landscape, and archaeology: a short overview

Managed grazing occupies a quarter of the global land surface, extending over 33 million square kilometres. Managed grazing systems, or pastoralism, are considered by some scholars the most extensive form of land use on Earth, and FAO estimates that more than 200 million people rely on these practices for a living. Thus, animal husbandry is viewed as one of the main triggers of landscape change in many places, particularly in areas where crops are less likely to grow. Simultaneously, livestock mobility has a critical function for the conservation of fragile ecosystems, and it provides a unique character in many rural areas after centuries of pastoral practices.

Upland Mediterranean landscapes are an outstanding example of this phenomenon. Despite the radical changes that socioeconomic systems have undergone over the last centuries, pastoralism is the main human activity in most of the mountainous areas in the northern Mediterranean, both in the present and in the past. However, the study of past and present pastoral practices used to be a neglected topic in archaeological research due to the assumed "archaeological invisibility" of the sites where shepherds lived and worked, particularly those corresponding to mobile pastoral strategies.

This view has been challenged thanks to ethnoarchaeological research, which has enabled archaeologists to detect, record and understand mobile pastoral practices and sites, overcoming methodological issues that arose from the rugged nature of mountainous areas and the absence of a rich pastoral artefactual and architectural material culture. In short, ethnoarchaeology has paved the way for more detailed data on pastoral mobility patterns, production strategies, occupation of the landscape that, in turn, enabled a more nuanced understanding of mobile systems of livestock husbandry (Biagetti, 2014).

Ethnoarchaeology in the Aspromonte Massif, computational modelling and simulation

Our paper introduces the ethnoarchaeological work carried out in a village at the Aspromonte Massif (Calabria, Italy), Africo Vecchio, as well as the new opportunities that it has opened for computer modelling and simulation as a means of studying mobile pastoral practices in landscape archaeology. At the same time, starting from our experience during the last two years, our presentation also wants to stress the potential of ethnoarchaeological projects for working with local communities towards the preservation, interpretation and dissemination of knowledge of pastoral landscapes of the recent past.

Located in the mountainous south-western end of the Italian peninsula and abandoned in 1954, Africo Vecchio was a village whose economic activities were centred around pastoralism. As in many other villages of Aspromonte, local population lived under conditions of severe poverty, due to socioeconomic issues, famine, diseases, natural disasters, lack of integration into larger economic networks, as well as the absence of public investment; these issues over time led to the depopulation of the mountains in the mid-20th Century. On the other hand, very few examples of historical archaeology in Southern Calabria can be found, while research interest on the Aspromonte has been rare and has generally neglected the pastoral past (and present) of these mountains (Robb et al., 2020).

With the final objective of addressing how landscape characteristics have shaped pastoral practices, the transhumant pastoral system of Africo Vecchio has been documented and studied through an interdisciplinary suit of approaches, among which meetings and interviews with shepherds have played a key role. Various ethnoarchaeological fieldwork campaigns have generated a body of knowledge that has informed the development of agent-based models (ABM) simulating livestock mobility and grazing strategies, whose results will be compared against the recorded characteristics of the historic landscape and environments (Cegielski & Rogers, 2016).

Besides providing critical information about land management, local communities have been engaged in participatory events to identify and discuss the key issues associated with the survival of traditional pastoralism. These priorities have in turn informed the development of ABM. Knowledge exchange was facilitated by the use digital tools for the production of cognitive maps.

Benefits and challenges: work in Africo Vecchio

Our paper revolves around the new horizons that close collaboration with local communities can open for digital archaeological research, and how the latter can be of benefit for local communities. First, we will introduce how this type of projects can become a proper way to ensure that the existing knowledge about recent human activities is no longer under the threat of being lost, and the ways in which it can inform policymakers. Second, we will discuss how regular meetings, visits to the study area, round tables including stakeholders, talks, or participatory GIS with members of the local community can foster a fluid exchange of information in both directions, while ensuring transparency in scientific practice and, most importantly, how it can awaken the interest of wider sectors of the local community in its own pastoral past. Altogether, we will present the assets, challenges and, above all, the potential that engaging members of the local community in a project of this type has meant for the development of computer simulations on pastoral landscapes and, especially, how the created synergies can favour the preservation and understanding of past pastoral landscapes.

References

Biagetti, S. (2014). Ethnoarchaeology of the Kel Tadrart Tuareg. Pastoralism and resilience in Central Sahara. Springer.

Cegielski, W. H., & Rogers, J. D. (2016). Rethinking the role of Agent-Based Modeling in archaeology. Journal of Anthropological Archaeology, 41, 283–298. https://doi.org/10.1016/J.JAA.2016.01.009

Robb, J., Chesson, M. S., Forbes, H., Foxhall, L., Foxhall-Forbes, H., Lazrus, P. K., Michelaki, K., Chiodo, A. P., & Yoon, D. (2020). The Twentieth Century Invention of Ancient Mountains: The Archaeology of Highland Aspromonte. International Journal of Historical Archaeology. https://doi.org/10.1007/s10761-020-00543-x

24. Gaming for submerged ancient landscapes in Australia

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Ulysse Lebrec, University of Western Australia

Archaeological surveys in recent decades have increasingly confirmed longstanding scientific expectations and traditional knowledge in many parts of the world that the physical remains of ancient cultural heritage sites from submerged landscapes survive below current sea-levels, in some cases far offshore and at depths down to 130m. Submerged geological units represent the lowlands of past terrestrial archaeological landscapes of Pleistocene and early to mid-Holocene date.

In Australia, it is now known that there has been human occupation of the continent for 50-65,000 years, with a relative absence of glaciation through that period and minimal effects of isostasy (McCarthy et al. 2022, 5). This suggests that the total area of past human occupation lost to sea-level change was approximately one third the current size of Australia, extending offshore for several hundred kilometres in some areas. At times of lowest sea level, the landmasses of Australia, Tasmania and New Guinea were merged into a single continent of Sahul and all of this area was inhabited by the ancestors of Indigenous Australians, Torres Strait Islanders and New Guineans.

In 2019 we were part of the team that discovered the first direct archaeological evidence of submerged ancient underwater sites in Australia (Benjamin et al. 2019). These discoveries demonstrated that Indigenous archaeological sites do survive underwater, with major implications for offshore development and the long-term sustainable management of Australia's seabed.

Research in this area in Australia has been galvanised by these discoveries but despite a rapidly rising profile for this research within the scientific and heritage specialist community, the wider Australian public remains largely unaware of the existence of submerged archaeological landscapes. Working in partnership with Traditional Owners, we have pursued several initiatives aimed at raising the profile of this heritage including documentaries, animations, regional studies and contributions to museum displays. We are also working towards diver training for young Indigenous researchers to participate in future fieldwork. Here we describe a virtual reconstruction of a section of Australian submerged landscape, based on real high-resolution bathymetry and geological analysis (Lebrec et al. 2021). This reconstruction is at an early stage of development but shows a 20km2 section of the Australian seabed as it may have appeared when sea-level was far lower. This will be disseminated through a playable free computer game, and will engage both the wider Australian public with the concept of ancient submerged landscapes, as well as providing a tool for Traditional Owners to co-design with the 3D specialists to produce an useful visualisation tool and to experience part of the lost landscape of their ancestors.

Benjamin, Jonathan, Michael O'Leary, Jo McDonald, Chelsea Wiseman, John McCarthy, Emma Beckett, Patrick Morrison et al. "Aboriginal artefacts on the continental shelf reveal ancient drowned cultural landscapes in northwest Australia." PloS one 15, no. 7 (2020): e0233912.

Lebrec, Ulysse, Victorien Paumard, Michael J. O'Leary, and Simon C. Lang. "Towards a regional high-resolution bathymetry of the North West Shelf of Australia based on Sentinel-2 satellite images, 3D seismic surveys, and historical datasets." Earth System Science Data 13, no. 11 (2021): 5191-5212.

McCarthy, John, Chelsea Wiseman, Katherine Woo, David Steinberg, Michael O'Leary, Daryl Wesley, Liam M. Brady, Sean Ulm, and Jonathan Benjamin. "Beneath the Top End: A regional assessment of submerged archaeological potential in the Northern Territory, Australia." Australian Archaeology 88, no. 1 (2022): 65-83.

227. Towards Collaborative Archaeogame Design and Development: Iteration, Innovation and the Southern Jê

Priscilla Ulguim, Vrije Universiteit Brussel
Juan Hiriart, University of Salford
Florencio Fernandes, Terra Indígena Rio das Cobras
Claudia Parellada, Museu Paranaense
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Fabíola SIlva, Museu de Arqueologia e Etnologia da Universidade de São Paulo

Games and digital technologies are increasingly part of archaeological investigation and interpretation. As built environments, games provide the means to immerse players in synthetic worlds constructed with a painstaking level of detail. As a form of narrative engagement, games affectively connect audiences with diverse pasts. In this light, archaeogaming attempts to combine archaeological data in order to create versions of the past to engage the player and communicate research through non-traditional methods.

However, relevant communities, designers, and archaeologists face challenges in balancing nuanced worldviews with different strands of research and game design. Among the challenges which designers face are how to ethically engage with communities to co-create narratives, interpret gaps in the archaeological record, and balance meaningful educational elements. In addition, attempts to simply apply information from academic works risk overlooking the interactive nature of the medium. Instead, games may be augmented with drawings, video, audio, AR, VR, and supporting materials to provide information via multiple methods and platforms.

In this paper, we propose that designers should work with stakeholders using participatory methods and prototyping techniques, fomenting the development of skills and knowledge to allow groups to independently iterate and innovate indigenous gaming experiences.

Our project combines archaeological and ethnographic data associated with the lifeways of Southern Jê groups over the past millennium in a collaborative archaeogaming approach that intends to communicate past lifeways and create practical ethical frameworks for future game development while building on synergies between indigenous and non-indigenous knowledge.

We highlight challenges in designing an experience that critically evaluates academic research, supporting education while being mindful and ethical towards traditional cultures and multiple levels of their representation within games.

Keywords: Collaborative Archaeogaming; Southern Jê; Brazilian Archaeology; Digital Ethics; Indigenous Knowledge.

38. Computational Modeling Water-Based Movement

Emma Slayton, Carnegie Mellon University

Location: E107

This session invites members of the Computational Modeling Water-Based Movement Special Interest Group, and those with similar interests and research foci, to present updates on their work. As this computational archaeological focus is still developing (excitingly with an increasing number of papers at CAA every year), many researchers still have their own singular methods, applications, and algorithms to discuss past mobility practices. Despite the presence of several publications on these themes (see bibliography), there are still those just starting in this work who are unaware of our developing community, or researchers who are deeply involved in this type of modeling who are not connected with other corners of the community due to a difference in the focus of region or time period. Scholars researching similar questions are often unaware of one another's work and theoretical underpinnings, which in turn can lead to the re-invention of the wheel, duplicated projects, and individuals needlessly struggling to overcome challenges that have been tackled and solved by other researchers. Having researchers learn about what else is happening in the field can only serve to broaden the capabilities of our work as a whole. For example, where different approaches have been applied to address similar topics we can learn from each other's successes and failures. Many researchers have explored Agent Based Modeling approaches in similar areas to where deterministic pathway analysis has been used, with different climate data as the base (e.x. Smith 2020 and Litvine 2022), helping to point out the benefits of each approach. On the flip side, we have several researchers using the same approach in the same region (e.x. Blakley 2018 and Poullis et al 2019), but with different results that can help researchers judge the fidelity of different projects. Recent efforts to combat the siloing of researchers include the creation of the CAA Special interest group sharing the name of this session, as well as several other sessions and roundtables at past conferences (e.g. Kyriakidis et al. 2022; Slayton et al. 2022). In addition, this session seeks to build off outcomes of the CAST conference held at Stanford in 2022. In the spirit of these past sessions, and newly concentrated interest modeling water-based mobility in the past using computational means, this session seeks to further develop this community. We hope to bring together researchers from multiple corners of this discussion, including but not limited to computational archeology, anthropology, oceanography, atmospheric sciences, geography, and computer science. We encourage our colleagues working in this area to submit paper on various aspects of modeling movement across water including (but not limited) to: Case studies exploring seafaring and voyaging using computational methods Case studies exploring coastal environments using computational methods Use of water modeling as outreach (e.g. computer games, VR experiences) Evaluation of theory employed to add context to computationally modeling water based mobility Issues facing the field of water movement modeling Finding, using, and maintaining climate data sets for use in modeling .Through this session we hope presenters will explore and showcase various approaches to analyzing and researching maritime spaces. We also hope this session brings together researchers who participate in maritime digital archeology, so as to further develop participation and interest in the Computational Modeling Water-Based Movement Special Interest Group. If you have any questions or would like to join the special interest group, contact eslayton@andrew.cmu.edu.

References:

Litvine, A, Lewis, J., and Starzec, A. (2022) CAA Oxford. Session 27. Modelling prehistoric maritime mobility. Paper 98. Where did the ships sail? Simulating European shipping routes before the age of steam.

Blakely, S. (2018). Sailing with the Gods: serious games in an ancient sea. thersites. Journal for Transcultural Presences & Diachronic Identities from Antiquity to Date, 7.

Borreggine, M., Powell, E., Pico, T., Mitrovica, J. X., Meadow, R., & Tryon, C. (2022). Not a bathtub: A consideration of sea-level physics for archaeological models of human migration. Journal of Archaeological Science, 137, 105507.

Davies, B., Bickler, S. H., & Traviglia, A. (2015). Sailing the simulated seas: A new simulation for evaluating prehistoric seafaring. Across Space and Time: Papers from the 41st Conference on Computer Applications and Quantitative Methods in Archaeology, Perth, 25–28 March 2013, 215–223. Amsterdam: Amsterdam University Press.

Gosden, C., & Pavlides, C. (1994). Are islands insular? Landscape vs. Seascape in the case of the Arawe Islands, Papua New Guinea. Archaeology in Oceania, 29(3), 162–171.

Kyriakidis, P., Gravanis, E., Demesticha, S., Reepmeyer, C. Moutsiou, T., Bar-Yosef, B., Chliaoutakis, A., Zervakis, H., Theodorou, K., Xoplaki, E., and Montello, D. (2022) CAA Oxford. Session 27. Modelling prehistoric maritime mobility Jarriel, K. (2018). Across the Surface of the Sea: Maritime Interaction in the Cycladic Early Bronze Age. Journal of Mediterranean Archaeology, 31(1).

Laituri, M. (2011). Indigenous peoples' issues and indigenous uses of GIS. The SAGE Handbook of GIS and Society, 1996, 202–221.

Leidwanger, J., & Knappett, C. (2018). Maritime networks, connectivity, and mobility in the ancient Mediterranean. Maritime networks in the ancient Mediterranean world, 1-21.

Lewis, D. (1994). We, the navigators: The ancient art of landfinding in the Pacific. University of Hawaii Press.

Lock, G., & Pouncett, J. (2017). Spatial thinking in archaeology: Is GIS the answer? Journal of Archaeological Science, 84, 129–135.

Poullis, C., Kersten-Oertel, M., Benjamin, J. P., Philbin-Briscoe, O., Simon, B., Perissiou, D., ... & Rizvic, S. (2019). Evaluation of "The Seafarers": A serious game on seaborne trade in the Mediterranean Sea during the Classical period. Digital Applications in Archaeology and Cultural Heritage, 12, e00090.

El Safadi, C. (2018). The maritime world of the early Bronze Age Levant through space and time (Doctoral dissertation, University of Southampton).

Smith, K. (2020). Modelling Seafaring in Iron Age Atlantic Europe. PhD Dissertation, University of Oxford: Oxford.

Slayton, E., & Smith, K. (2021, July). Moving Over Seas: Modeling Seafaring Routes to Analyze Past Connections. Presented at the Computer Applications and Quantitative Methods in Archaeology, Cyprus.

Slayton, E, Borreggine, J. Farr, R. H., Jarriel, K., Leidwanger, J., El Safadi, C., Davies, B., and Smith, K. (2022) CAA Oxford. Session 23. Computational archaeology and seafaring theory.

SLOT 3	
14:00 - 14:20	312. A Framework for Modeling/Simulating Controls, Patterns and Consequences of Maritime Human Mobility Potential in Early Prehistory *Phaedon Kyriakidis (CUT)*; Elias Gravanis (Cyprus University of Technology)*
14:20 - 14:40	178. Any Port in a Storm? Investigating Voyage-Planning with an Agent-Based Navigation Model *Karl J Smith (University of Oxford)**
14:40 - 15:00	169. Agency in Flow. River Oriented Land Use Decisions During the Late Upper Palaeolithic and Late Palaeolithic in the Middle Rhine Valley *Tjaark Siemssen (University of Oxford)*; Andreas Maier (Universität zu Köln)*
15:00 - 15:20	326. Seaing the Value of Communities of Practice: Connecting computational archeology research to community engagement and seafaring practitioner expertise *Emma Slayton (US)*; Marisa Borreggine (Harvard University); Helen Farr (University of Southampton); Katherine Jarriel (Purdue University); Justin Leidwanger (Standford University)*
15:20 - 15:40	349. The State of the Field of Seafaring Modeling: Conversations from the CAST Workshop *Katherine Jarriel (Purdue University)*; Marisa Borreggine (Harvard University); Helen Farr (University of Southampton); Justin Leidwanger (Stanford University); Emma Slayton (US)*
15:40 - 16:00	**Discussion**

312. A Framework for Modeling/Simulating Controls, Patterns and Consequences of Maritime Human Mobility Potential in Early Prehistory

Phaedon Kyriakidis, CUT
Elias Gravanis, Cyprus University of Technology

Context

Unaided (without navigation instruments) seaborne movement underpins frontier research inquiry into prehistoric human-environment interactions within a maritime context, such as water-crossings during human dispersals, seafaring, island colonisation, as well as resource transport and cultural transmission. Seaborne movement is controlled by a multitude of factors, including geographical context defining origin/destination locations and coastal morphology, weather and ocean conditions, demographics, resources availability, trip motivation, risk attitude, navigation capabilities, social and cultural traits, as well as marine, e.g., vessel, technology. Some of these factors/controls are unique to the maritime environment, rendering methods and algorithms for modeling/simulating maritime mobility distinct from similar methods in a terrestrial context. Simulation-based computational models of seaborne movement, in particular, have been long ago used to test archaeological hypotheses related to colonisation, migration, and cultural contact; classical examples are simulation models for the colonization of Oceania and the Pacific. Kyriakidis et al. (2022) presents a recent example of sea-drifting simulation in the eastern Mediterranean context of the island of Cyprus. Key mobility-related research questions, however, remain open: these pertain to the feasibility for seaborne movement within a few days or within a season, to the spatiotemporal intensity of maritime mobility (number of seaborne trips) across a few generations, to the long-term effects of maritime mobility on population spatiotemporal dynamics, including colonisation and abandonment.

Main arguments

This work sketches the development of a theoretical framework for modeling/simulating unaided seaborne movement potential, encompassing key facets of maritime human mobility. These range from factors affecting/controlling seaborne movement, to patterns of mobility those factors might generate both at the individual and population level, to consequences of those patterns on both short-term (over a few generations) and long-term (over thousands of years) population dynamics. More precisely, the proposed framework capitalises on the ecological concept of (maritime) connectivity as a proxy for (seaborne human) mobility. Adopting a landscape ecology terminology, potential connectivity refers to the possibility for movement between locations, as opposed to realized mobility pertaining to corroborated or actual mobility; in archaeology, connectivity is often used in lieu of potential mobility which is reserved for realized mobility (Knappett, 2018).

The proposed framework considers links between patterns of maritime potential connectivity as controlled by seascape characteristics such as islands, coastal areas, and distances between (what is termed in ecology structural connectivity), in conjunction with weather and ocean characteristics, human traits facilitating movement such as spatial cognition and postulated type of vessel used (functional connectivity), as well as population and opportunities (or lack thereof) controlling the number of people engaged in mobility (population or demographic connectivity). As demographic connectivity underpins the transmission of knowledge, goods, diseases, and impacts population growth and decline, the proposed framework also encompasses effects of demographic connectivity on human population dynamics. A key component is also the explicit attention placed to geographical knowledge (dynamical seascape, resources) acquired and transmitted during mobility on the resulting patterns of functional and demographic connectivity. Interactions among factors controlling both functional and demographic connectivity, as well as the resulting patterns of connectivity, are modelled as varying both in space and in time; the same holds true for the links between demographic maritime connectivity and population dynamics. The above concepts have direct analogues in the fields of demography, migration, and transportation; relevant human geography applications, however, are almost exclusively found in present-day terrestrial mobility contexts.

The operationalization of the proposed framework invokes methods from spatial analysis and modeling grounded in geography and allied spatial sciences. More specifically, agent-based modeling (ABM), see for example Romanowska et al. (2021), is employed to characterize seaborne movement feasibility between arbitrary origin and destination locations, focusing on environmental, cognitive, and technological controls on movement, irrespective of origin/destination attractiveness, under the constraint of returning to the origin location, akin to central place foraging. The scope of the ABM is expanded to account for destination choices, employing spatial interaction models to estimate the intensity (number of trips) of movement between origin and destination locations over longer time periods spanning a few generations. The spatial as well as temporal patterns in the resulting/emerging feasibility and intensity networks, respectively, is elucidated via spatial network analysis. Metapopulation dynamics models encompassing population growth models at multiple regions, such archipelagos, linked by in- and out-migration flows, are last employed to characterise: (a) short-term (over few generations) population dynamics facilitating the transmission of geographical knowledge and/or cultural traits, and (b) long-term (over thousands of years) population dynamics underpinning survival/extinction probabilities for the entire metapopulation, source-sink dynamics, as well as colonisation and abandonment processes.

Implications

Although the elucidation of patterns, controls on, and implications of connectivity is a central research theme in movement ecology, landscape ecology, and marine ecology, there exists no analogous line of research within the context of unaided seaborne movement underpinning early prehistoric maritime mobility. The framework set forth in this work integrates relevant research efforts in geographic information science, as per recent calls towards a closer integration between human movement research and animal movement ecology; the proposed framework also echoes recent calls from the side of ecology towards transferring ecological concepts and models of connectivity to socio-environmental systems. It is anticipated that the framework set forth in this work will facilitate theory building, hypothesis testing, and model limitations exploration across multiple disciplines, including prehistoric archaeology, geography, and landscape ecology.

References

Knappett, C. (2018): From network connectivity to human mobility: Models for Minoanization. Journal of Archaeological Method and Theory 25, 974-995.

Kyriakidis, P., Moutsiou, T., Nikolaidis, A. et al. (2022): Virtual sea-drifting experiments between the island of Cyprus and the surrounding mainland in the early prehistoric Eastern Mediterranean. Heritage 5(4), 3081–3099.

Romanowska, I., Wren, C.D., and Crabtree, S.A. (2021): Agent-based Modeling for Archaeology: Simulating the Complexity of Societies. The Santa Fe Institute Press.

178. Any Port in a Storm? Investigating Voyage-Planning with an Agent-Based Navigation Model

Karl J Smith, University of Oxford

This paper demonstrates how an agent-based approach to modelling maritime movement can be adapted to answer questions about the location of coastal sites and their significance in regional maritime networks. Specifically, this paper re-examines the results of a case study in the author's doctoral thesis by developing an agent-based model (ABM) to allow simulated navigators to change their intended destination based on pre-set criteria. This in turn allows for the identification and comparison of 'convenient' landing places within the wider seascape of south-central Britain, and can help contextualise sites along the coast westward from Hengistbury Head (in Dorset, UK) in the Late Iron Age.

The computational modelling of movement over seas is complicated by the complex interactions of physical forces (winds, currents, weather, etc.), and by the fact that the process of navigation can rely on processes that are difficult to parameterise. In the first place, conditions at sea can change rapidly and unpredictably. This makes sailing difficult to model with terrestrial route-finding algorithms, which generally consider environmental variables to be static. In the second place, sailors navigating out of sight of land without instruments such as compasses, hydrometers, chronometers, or GPS generally rely on methods that can be very imprecise. For example, one of the most common non-instrumental navigational techniques is known as dead reckoning, whereby navigators use an estimate of their ship's speed to determine how far along a straight course they have sailed in a set amount of time. This can be difficult to model with statistical approaches like least-cost path analysis, which assume that the analyser (i.e. the entity in search of a path) has perfect knowledge of all the costs involved in traversing an area. The challenges involved in modelling directed movement over waterways have led archaeologists to explore many different methodologies, including least-cost path analysis, the isochrone method, agent-based modelling, and coordinated approaches that use one or more of these. A thread that runs through many of these approaches is that they test pre-defined routes, and usually characterise these routes in turns of 'successful' and 'unsuccessful' voyages. Although it seems safe to assume that prehistoric wayfarers would have preferred to reach their intended destinations, it is much less clear whether they would have considered making landfall in another location a disastrous – or unexpected – outcome.

This paper develops an agent-based seafaring model which was produced during author's doctoral research. This model simulated sailed routes across the western English Channel in the Late Iron Age. This paper focusses on a particular case study that examined voyages along a single route – from Le Yaudet (in Brittany, France) to Hengistbury Head – both coastal sites where excavation has produced evidence for the movement of goods across the Channel. Hengistbury Head has long been considered an important entrepot for the south coast of Britain, and Le Yaudet has been suggested as its continental 'counterpart'. When summarising the results of simulated voyages for this case study it was found that although southbound crossings were fairly direct, many northbound ships were pulled far to the west of Hengistbury Head by currents and tides. Most of these simulated navigators made landfall on the east side of Start Point (in Devon, UK), and from there attempted to tack westward along the coast to reach Hengistbury. In this analysis voyages were only identified as 'successful' if the simulated ship reached its pre-set destination – therefore most of these Le Yaudet/Lizard Head/Hengistbury Head voyages were counted as failures despite the fact that many of them passed close to good harbours and landing places.

One of the advantages of agent-based models is that the process by which simulated agents interact with their environment can be easily modified. The analysis described in this paper uses the same agent-based navigation model that underpinned the aforesaid case study, but with a few important modifications. Firstly, simulated navigators now attempt to estimate how long their voyage will last at each timestep, based on their progress up until that point, updating this estimate as the simulation progresses. The simulation also makes an estimate of how long it would take to land in each nearby harbour. Where landmarks are clearly visible the script assumes that simulated voyagers are aware of their position, but when no landmarks are visible then they use dead reckoning in order estimate their ship's location. The script then compares these estimates – of the simulated ship's position, the expected time to its original destination, and the expected travel times to alternative harbours – in order to decide whether the destination point should be changed. In the simulations described in this paper different criteria for making this decision are used. In some, simulated navigators may change their destinations at will in order to make as quick a crossing as possible. In others, modelled sailors will only change destinations when all expectation of reaching their intended port has been lost.

These simulations accomplish three important objectives. First of all, they address a potential problem with the results of the author's previous research and are used to evaluate that work. Secondly, they enrich our understanding of Late Iron Age contacts across the west-central English Channel by identifying ports that may have been visited by northbound ships on the way to Hengistbury Head. By looking at the places where simulated navigators change their plans under different conditions, they can be used to argue for 'inflection points' along the coast, where Iron Age navigators may have made important decisions about their journeys. Finally, they advance the development of archaeological seafaring models in general – and agent-based seafaring models in particular.

Cunliffe, Barry W., and Philip De. Jersey. Armorica and Britain : Cross-Channel Relationships in the Late First Millenium BC. Studies in Celtic Coinage ; No. 3. Oxford: Oxford University Committee for Archaeology, 1997.

Slayton, E.R. 2018. “Seascape Corridors. Modeling Routes to Connect Communities Across the Caribbean Sea.” Ph.D. thesis, Leiden University.

Smith, K.J. 2020. “Modelling Seafaring in Iron Age Atlantic Europe.” Ph.D. thesis, University of Oxford.

169. Agency in Flow. River Oriented Land Use Decisions During the Late Upper Palaeolithic and Late Palaeolithic in the Middle Rhine Valley

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Introduction

Rivers are often seen to have played an important role for Palaeolithic hunter-gatherers both as landmarks and as a resource location. While the former view regards rivers as passive guidelines or obstacles, the latter reduces them to their economic value. Both views, therefore, look at generic properties, and may assume equal validity towards all rivers and their sections. By taking such an approach there is risk of overlooking the interactions between humans and specific rivers within the landscape and their phenomenological significance.

With this research, we aim to contribute to the discussion by considering an historically contingent and specific case of interaction between humans and a particular section of an individual river: the Rhine in the Neuwied Basin. Using an agent based model, we identify differences in the fluvial-oriented land use decisions between the Late Upper Palaeolithic and the succeeding Late Palaeolithic occupations within the region.

Material and Methods

Our approach is partly based on the model presented by Hölzchen et al. (2021), concerned with the crossing of the Strait of Gibraltar by early Upper Palaeolithic hunter-gatherers. First, a hydrological analysis is conducted using the r.terraflow function in QGIS on a digital elevation model (DEM) of the Rhine Basin. Accumulated flow is classified into three distinct classes allowing for a comparison of different water levels. The DEM, the flow classes, and flow directions are imported into a GIS-integrated NetLogo model. Agents are spawned on site locations in the Neuwied Basin and beyond and roam the landscape following three primary rules associated with the standard deviation of a correlated random walk.

If the Rhine river is within a given range, agents move towards it by probability a. Moreover, the closer an agent is to the Rhine river, the higher is the standard deviation of the correlated random walk, amplified or lowered by probability b. Finally, if the agent is approaching any water body, probability c defines the probability of an attempt to cross it.

An experiment is set up in NetLogo comparing significances in density of agent distribution after 100 ticks. Tested are significances following a change of initial location of sites, a change of water level class, and individual changes of the three agent parameters corresponding to probabilities a, b and c.

Results

The model necessitates the application of distinct behavioural differences in order for agents to sustain the density and extent of either Late Upper Palaeolithic or Late Palaeolithic sites. Statistical tests show no significant difference when initial site locations are changed or the water level is adjusted to a higher or lower class. However, a change in agent parameters associated with the standard deviation of random walks (probabilities a, b and c) do significantly change initial density and extent of the model. In order to sustain the Late Upper Palaeolithic pattern, probabilities to move water-directed (a) need to be more than twice as high compared to the Late Palaeolithic pattern.

Discussion

Several ecological and social explanations may aid understanding of a change of spatial behaviour in regards to water bodies in the Neuwied Basin. Within a framework emphasising subsistence-settlement systems, a concentration of resources with a potential focus on sedentary salmonids during the Late Upper Palaeolithic points towards a differentiated land use practice due to variation in the distribution of resources.

Further, a familiarity with the given landscape could be a potential reason for the high site use redundancy during the Late Upper Palaeolithic. A lower familiarity is indicated by seasonal proxies on sites in the area as well as larger raw material procurements and exotic material during the Late Upper Palaeolithic (Kretschmer 2015).

The concept of Entanglement may further help explain otherwise vague relations between humans and landscape (Hussain and Floss 2016). With an emphasis on the complex and intertwined relations between the natural and the social, such narratives allow for a less ecologically strict perspective and emphasise the continuous negotiation of humans with their surroundings.

Lastly, rivers may act as vectors for knowledge transmission. With humans travelling along rivers, rivers become not only functional causeways for the transport of physical objects, but also become vectors of constantly changing and negotiated knowledge, conjoining natural and social space.

Conclusion

We observe a clear shift from a dominant focal role of the Rhine during the Late Upper Palaeolithic to a less important spatial entity during the Late Palaeolithic. These differences are likely as much an expression of a changed perception of the Rhine as they are a result of environmental change, and the transition from a pioneering to a stationary settlement phase. Each of these aspects are inextricably intertwined, and further investigation within this framework is essential to understand the changing relationship between humans and riverine landscapes.

References

Hölzchen, Ericson, Christine Hertler, Ana Mateos, Jesús Rodríguez, Jan Ole Berndt, and Ingo Timm. 2021. 'Discovering the Opposite Shore: How Did Hominins Cross Sea Straits?' PLoS ONE 16 (June).

Hussain, Shumon T., and Harald Floss. 2016. 'Streams as Entanglement of Nature and Culture: European Upper Paleolithic River Systems and Their Role as Features of Spatial Organization'. Journal of Archaeological Method and Theory 23 (4): 1162–1218.

Kretschmer, Inga. 2015. Demographische Untersuchungen zu Bevölkerungsdichten, Mobilität und Landnutzungsmustern im späten Jungpaläolithikum. Kölner Studien zur prähistorischen Archäologie. Rahden/Westf: Dissertation, Universität zu Köln, 2014.

326. Seaing the Value of Communities of Practice: Connecting computational archeology research to community engagement and seafaring practitioner expertise

Emma Slayton, US
Marisa Borreggine, Harvard University
Helen Farr, University of Southampton
Katherine Jarriel, Purdue University
Justin Leidwanger, Standford University

Past CAA papers have focused on community engagement with digital computational methods, prominently in regards to interacting with 3D models or creating interactive databases for the broader public. These efforts further our communities' understanding of the past, and possible pasts, that broaden both the publics and our academic understanding of our research. The organizing team behind the Computational Archaeology and Seafaring Theory (CAST) workshop hope to build off of this tradition. We do this by discussing how we, as computational archaeology and anthropology theorists who study seafaring, can better collaborate with those who practice experimental seafaring of the past, traditional practitioners, and local communities who engage with the history of these efforts as a part of their cultural heritage. These efforts can include working directly with those who have firsthand experience using traditional seafaring methods and toolkits. This effort broadens the knowledge base of archaeologists who study those practices and guide them to more practical and constructive computational methods.

The CAST workshop aims to bring together an interdisciplinary group of archaeologists, ocean scientists, and anthropologists with a shared interest in deeply social modeling ancient seafaring: from material culture to intangible heritage, routes, technology, skills, and knowledges that can better inform our understanding of human relationships with maritime space and the marine environment. Over four days at Stanford University, the CAST meeting will provide an opportunity for new and cross-disciplinary discussion, methodological and theoretical masterclasses, and mini-workshops to share knowledge and approaches, to drive the future of research discourse and practice. Roughly 20 members of the computational seafaring modeling community, traditional practitioners, and experimental archaeologists will meet to discuss these issues, including community and academy relationships. This paper will bring together findings from this workshop session and expand upon the experience and expertise of those present - conducting an overview of the benefits of and past examples of working with community partners as computational archaeologists.

A part of the workshop will focus on Design, Collaboration, and Dissemination. These sessions will involve intense discussion, reference past work done by participants, and inspire new areas for collaboration which can foster discussion in this CAA Session on Computational Modeling Water-Based Movement.

Design:

Assessing how we can work with communities of practice to determine their need for understanding past seafaring, and how to determine what our work might be able to offer to them. What is the line between community need driving research and how our research can meet those community needs?

Collaboration:

Engagement between archaeologists and seafaring experts can lead to practitioners having input into the process of developing holistic models of past seafaring practices. As individuals with experience in using or constructing traditional sailing or paddle vessels, these practitioners should be able to suggest new ways of considering modelatiy seafaring techniques, technologies, and toolkits in various water based contexts.

Dissemination:

We also intend to explore how members of the workshop directly communicate with communities of practice about our results, but also to engage broader publics in our research. This includes a discussion of the several popular models for analyzing seafaring practices in an historical or archaeological context (ORBIS), as well as efforts to explore game creation around past seafaring travel that can draw everyday gamers into the past (e.g., The Seafarers and Sailing with the Gods).

Our goal is not only to communicate results from the CAST workshop, but also to gather feedback from those who are actively engaged in seafaring modeling research, regularly use their computational archeology skills to engage with the public, or learn from communities of practice. The authors intend to provide a standalone resource on the outcomes of the workshop. This paper will serve as a resource for others in the field, allowing for the sharing of ideas around research and engagement more broadly, which we feel will benefit the development of more community inspired or collaborative projects.

Bibliography

Aswani, S., & Lauer, M. (2006). Incorporating fishermen's local knowledge and behavior into geographical information systems (GIS) for designing marine protected areas in Oceania. Human Organization, 65(1), 81–102.

Bérard, B., Billard, J. Y., l'Etang, T., Lalubie, G., Nicolizas, C., Ramstein, B., & Slayton, E. (2016). Technologie du fait maritime chez les Kalinago des Petites Antilles aux XVIe et XVIIe siècles. Journal de la société des américanistes, 102(102-1), 129-158.

Blakely, Sandra. "Sailing with the Gods: serious games in an ancient sea." thersites. Journal for Transcultural Presences & Diachronic Identities from Antiquity to Date 7 (2018).

Cherry, J. F., & Leppard, T. P. (2015). Experimental archaeology and the earliest seagoing: the limitations of inference. World Archaeology, 47(5), 740-755.

Laituri, M. (2011). Indigenous peoples' issues and indigenous uses of GIS. The SAGE Handbook of GIS and Society, 1996, 202–221.

Meeks, Elijah. "The design and implementation of ORBIS: The Stanford geospatial network model of the Roman world." Bulletin of the Association for Information Science and Technology 41, no. 2 (2015): 17-21.

Poullis, Charalambos, Marta Kersten-Oertel, J. Praveen Benjamin, Oliver Philbin-Briscoe, Bart Simon, Dimitra Perissiou, Stella Demesticha et al. "Evaluation of "The Seafarers": A serious game on seaborne trade in the Mediterranean sea during the Classical period." Digital Applications in Archaeology and Cultural Heritage 12 (2019): e00090.

349. The State of the Field of Seafaring Modeling: Conversations from the CAST Workshop

Katherine Jarriel, Purdue University
Marisa Borreggine, Harvard University
Helen Farr, University of Southampton
Justin Leidwanger, Stanford University
Emma Slayton, US

The Computational Archaeology and Seafaring Theory (CAST) workshop, scheduled to be held at Stanford University in December 2022, aims to bring together an international, interdisciplinary group of archaeologists, ocean scientists, and anthropologists with a shared interest in the computational modeling of ancient seafaring. Many researchers have built their own individual systems for modeling past seafaring, resulting in widely varying approaches. This yields diverse views, but often in silos, such that scholars researching similar questions are often unaware of one another's work and theoretical underpinnings. This workshop presents an opportunity to connect these researchers and promote collaborative and synthetic approaches.

One of the major objectives of this workshop is to facilitate a discussion of the state of the field in seafaring modeling and to identify future goals, challenges, and avenues of collaboration. In this presentation, the organizers of the CAST workshop will synthesize critical takeaways from the workshop's discussions. In the aim of bridging research silos, we also hope to foster continued discussion with the wider audience at CAA 2023. While the focus of this presentation is computational models of seafaring, the discussion of bridging analytical methods and theoretical approaches that center dynamism and agency will be of wide relevance to archaeological research. The conversation is a timely one, both in terms of exploring the possibilities of computational analysis and in addressing its challenges.

While the role of human-ocean interaction has long been the subject of archaeological research, recent developments in modeling maritime movement provides unique insight into questions of past seafaring and the marine environments. These approaches have informed broader scholarly discussion on a range of topics, including early hominin migrations, technology, skill and knowledge, social organization, and globalization. These narratives also contribute to discussions of maritime cultural heritage and fall within the scope of the United Nations Decade of Ocean Science for Sustainable Development (2021-2030), which aims to "change humanity's relationship with the ocean."

One of the major challenges of a computational approach to seafaring has been the need to understand the sea as a social space within formal models of past seascapes. Traditionally, computational modeling has struggled to move beyond environmental determinism and least-cost pathways to consider the social spaces of seaborne activities and interaction. However, human relationships structure life with and on the sea and are deeply embedded in the affordances of this environment. Geospatial tools typically treat the sea as a blank canvas or quantifiable resource. One of the goals of the CAST workshop is to understand maritime spaces as places of interaction by incorporating tools that reflect uncertainty, affordance, and agency of humans, objects, and the ever-changing environment. These theoretical and social processes of seafaring serve as a foundation for workshop discussion of formal modeling and qualitative practice. Workshop attendees will explore the relationship between computational modeling and archaeological theory in order to consider the ways in which researchers can integrate agency and computational models.

Some specific topics of discussion will include: how to expand the traditional structures and approaches to computational models, like agent-based modeling and path distance tools in GIS; how to design climate models, palaeo-circulation and tidal models, and how these virtual decisions affect and intersect with experience; how to define routes or corridors of movement; how to deal with uncertainty and stochastic elements; and how to consider theories of agency and behavior, social networks, as well as materiality of seacraft and water and their entanglement with humans).

Overall, this discussion of modeling aims to move beyond resource-driven algorithms to reflect varied experience, knowledge, and decision making in dynamic marine environments.

14. Robotics and Archaeology - on the state of the art and beyond

Daniel Carvalho, UNIARQ; FCT; LAQU

Location: E107

Robots are an integral part of contemporary society. From healthcare to manufacture, agriculture and industrial contexts, robots play fundamental roles, indispensable to maintaining and sustaining numerous systems. Archaeology, as well as various areas, utilizes robots in its endeavors: on the field, in laboratories, in presentations to the public. From automatic typologies to UAVs that reach the depths that humans can not fathom to venture, robots aid archaeologists in concluding their tasks, in an efficient and reliable way. Is it possible to go even further and elevate the role of robots within Archaeology? Are robots to be used as extensions and tools or can we conjoin them with Artificial Intelligence, and build an Artificial Archaeologist? In this session, we intend to discuss the present state of robotics in Archaeology and dwell on the possibilities that lie in the near future. Proposals, although not exclusive, would be very welcome on these lines of thought, both concerning eventual case studies and theoretical reflections: How do archaeologists use robots, in which circumstances and what are their benefits and drawbacks; Robots and the act of the excavation – should robots do fieldwork for us? How archaeologists can use robots for building knowledge and how would it affect the discipline; What should be the ethical concerns that surround the use of robots in Archaeology?

We encourage papers from students and ECR in different phases of their research, to provide a space for showing their ongoing work and progress.

SLOT 4	
16:30 - 16:50	332. Envisioning the forthcoming era of robotics and automation in archaeology: a position paper *Arianna Traviglia (Istituto Italiano di Tecnologia (IIT))*; Ferdinando Cannella (Istituto Italiano di Tecnologia)*
16:50 - 17:10	111. The contribution of robotic archaeology and automated controlled experimentation in use-wear analysis. *Joao MF Marreiros (TraCEr. MONREPOS-RGZM. ICArEHB, UAlg)*; Ivan Calandra (TraCEr. MONREPOS-RGZM); Geoff Carver (TraCEr. MONREPOS-RGZM); Walter Gneisinger (TraCEr. MONREPOS-RGZM); David Nora (Hebrew University of Jerusalem); Eduardo Paixao (TraCEr. MONREPOS-RGZM); Hannah Rausch (TraCEr. MONREPOS-RGZM); Jerome Robitaille (TraCEr. MONREPOS-RGZM); Lisa Schunk (University of Wroclaw)*
17:10 - 17:30	106. Marine robotic technologies and vision-based approaches within the underwater archaeological research *Eleni Diamanti (NTNU)*; Mauhing Yip (NTNU); Oyvind Odegard (NO); Annette Stahl (Norwegian University of Science and Technology)*
17:30 - 17:50	89. Exploiting RFID Technology and Robotics in the Museum *Antonis Dimitriou (Aristotle University of Thessaloniki); Stella Papadopoulou (Archaeological Museum of Thessaloniki); Maria Dermenoudi (Archaeological Museum of Thessaloniki); Vasiliki Drakaki (Archaeological Museum of Thessaloniki); Andreana Malama (Aristotle University of Thessaloniki); Alexandros Filotheou (Aristotle University of Thessaloniki); Aristidis Raptopoulos Chatzistefanou (Aristotle University of Thessaloniki); Anastasios Tzitzis (Aristotle University of Thessaloniki); Spyros Megalou (Aristotle University of Thessaloniki); Stavroula Siachalou (Aristotle University of Thessaloniki); Aggelos Bletsas (School of ECE & TSI, Technical Univ. of Crete); Traianos Yioultsis (Aristotle University of Thessaloniki); Anna Maria Velentza (University of Macedonia); Sofia Pliasa (University of Macedonia); Nikolaos Fachantidis (University of Macedonia); Angela Moneda (Archaeological Museum of Thessaloniki)*; Evangelia Tsangaraki (Archaeological Museum of Thessaloniki); Dimitrios Karolidis (Archaeological Museum of Thessaloniki); Charalampos Tsoungaris (Archaeological Museum of Thessaloniki); Panagiota Balafa (Archaeological Museum of Thessaloniki); Angeliki Koukouvou (Archaeological Museum of Thessaloniki)*
17:50 - 18:10	384. Automated high-resolution ground-penetrating radar prospection with an uncrewed ground vehicle at an archaeological site *Lieven Verdonck (Archéologie et Philologie d'Orient et d'Occident, École normale supérieure, Paris)*; Michel Dabas (Archéologie et Philologie d'Orient et d'Occident, Ecole normale supérieure, Paris)*

89. Exploiting RFID Technology and Robotics in the Museum

Antonis Dimitriou, Aristotle University of Thessaloniki
Stella Papadopoulou, Archaeological Museum of Thessaloniki
Maria Dermenoudi, Archaeological Museum of Thessaloniki
Vasiliki Drakaki, Archaeological Museum of Thessaloniki
Andreana Malama, Aristotle University of Thessaloniki
Alexandros Filotheou, Aristotle University of Thessaloniki
Aristidis Raptopoulos Chatzistefanou, Aristotle University of Thessaloniki
Anastasios Tzitzis, Aristotle University of Thessaloniki
Spyros Megalou, Aristotle University of Thessaloniki
Stavroula Siachalou, Aristotle University of Thessaloniki
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Angela Moneda, Archaeological Museum of Thessaloniki
Evangelia Tsangaraki, Archaeological Museum of Thessaloniki
Dimitrios Karolidis, Archaeological Museum of Thessaloniki
Charalampos Tsoungaris, Archaeological Museum of Thessaloniki
Panagiota Balafa, Archaeological Museum of Thessaloniki
Angeliki Koukouvou, Archaeological Museum of Thessaloniki

Introduction

This work summarizes the outcome of project “CultureID”, co-funded by the European Union and Greek national funds. The project aims to implement technologies like the Internet of Things, Robotics, Big Data analysis, and Artificial Intelligence in the field of cultural heritage. In this context, the group exploits RFID technology to i) develop a complete solution for the collection management of the Archaeological Museum of Thessaloniki, ii) provide location-based guided tours to the visitors, iii) track the visitors’ interests with respect to the museum’s artifacts and iv) present new forms of interactions by introducing a prototype RFID-enabled social robot. Partners in the project are the “Archaeological Museum of Thessaloniki”, the “School of Electrical and Computer Engineering” of the “Aristotle University of Thessaloniki”, the “Department of Educational & Social Policy” from the “University of Macedonia”, and two companies, “Trinity” and “Kenotom”. The interdisciplinarity of the project demands expertise in Archaeology, Restoration, Electrical Engineering, Robotics in Education etc. The group includes experts from the above fields.

Section I. RFID technology

The basic units of an RFID system are the RFID-reader and the RFID-tag. An RFID-tag is typically passive (battery-less), low cost (~0.01€) and comprises a chip and an antenna. The tag gets powered-up by the reader and back-scatters its unique id, stored in its internal memory. The group has attached at least one tag to each artifact of the museum. As soon as the reader “reads” a tag, it queries the database to retrieve the association with the specific artifact and then access all stored information related to the artifact. This information includes more than 120 fields, and lists everything related to the artifact. The reader may scan up to 900 RFID tags per second from a distance as far-away as 14m.

Section II. Exploitation of RFID technology

We have developed a web-based application for the entire management of the Museum. The app gives access to different content, depending on authentication-level of the museum’s personnel. The app collects (and stores) information from the database. The database includes all information related to the following applications.

A. Continuous tracing of the artifacts

Our first aim was continuous monitoring and automated registration (tracing) of the artifacts’ relocation within the museum as well as their participation in temporary exhibitions. To address that, we developed methods to attach RFID tags to each artifact, depending on its material, size and position (in the exhibition or in storage) (Dermenoudi 2021). Furthermore, personnel are also associated with unique RFID-cards. RFID readers have been installed in several locations inside the museum to control the flow of tags and personnel. When a moving tag is identified along with the associated personnel, a “flag” is initialized in the app, forcing the identified employee to store in the database the reason for the relocation of the artifact. This information is linked to the artifact and is added to its “history”. This method ensures the digital preservation of each artifact’s history.

B. Location dependent guided-tours

Secondly, RFID tags were attached to each visitor’s ticket. As a result, it has become possible to identify the position of each visitor. We have developed a web-based guide. The visitor may use his/her own smartphones to enjoy the content of the guide, which is automatically updated based on their identified position inside the museum.

C. Statistics of Interest

We have developed prototype methods to accurately trace the movement of people inside the museum (Tzitzis 2022), (Megalou 2022). By using RFID technology, instead of cameras, we avoid any possibility of identification of a living individual, which would violate GDPR laws. More specifically, each visitor is and remains an unidentified (with respect to one’s actual ID) RFID-tag. Hence, monitoring is not mapped to a specific individual, but is only used for statistics; i.e. total-time spent at each artifact, heat maps inside the museum, etc.

D. Development of a Prototype Social Robot and a Portable RFID reader

Finally, we have designed and constructed a prototype Social robot and a portable RFID reader. The robot is equipped with several sensors, actuators and algorithms, in order to support:

- Motion
- Map creation
- Localization of its own pose (position and direction) in the (museum's) map
- Automatic Speech Recognition
- Text-to-Speech
- Artificial Intelligence
- Verbal, Visual, Touch and RFID Interaction with visitors and/or artifacts

The robot has been designed to interact with younger and adult visitors. Younger visitors learn by playing games with robot, during their visit. (Pliasa 2021) In this context, the robot presents stories, related to the exhibits, while showing videos on its screen as well as on the ground through a projector. Then, it poses questions. The answer for each question is related to the museum's artifacts in the surrounding area. Visitors are invited to use the portable reader, which is able to "guide" them to the appropriate location, where the answer is "hidden", again exploiting the RFID tags attached to the artifacts. Once they retrieve the answer, they return to the robot to continue with the next "riddle" in this "hidden-treasure-game".

Interaction with adult visitors includes guided-tours and "discussions" with respect to specific exhibits. The robot attracts visitors and shares its knowledge. We have trained the robot by embedding machine learning algorithms, related to the most significant artifacts of the museum.

References

Dermenoudi, Maria, Dimitris Karolidis, Aggeliki Moneda, Vasiliki Drakaki, and Antonis Dimitriou. 2021. "The Use of RFID Technology for the Collection Management in the Archaeological Museum of Thessaloniki." In 2021 6th International Conference on Smart and Sustainable Technologies (SpliTech), 01–06. Bol and Split, Croatia: IEEE. https://doi.org/10.23919/SpliTech52315.2021.9566423.

Megalou, Spyros, Aristidis Raptopoulos Chatzistefanou, Anastasios Tzitzis, Traianos V. Yioultsis, and Antonis G. Dimitriou. 2022. "Passive UHF-RFID Hyperbolic Positioning of Moving Tags by Exploiting Neural Networks." IEEE Journal of Radio Frequency Identification 6: 402–12. https://doi.org/10.1109/JRFID.2022.3158730.

Pliasa, Sofia, Anna Maria Velentza, Antonis G. Dimitriou, and Nikos Fachantidis. 2021. "Interaction of a Social Robot with Visitors inside a Museum through RFID Technology." In 2021 6th International Conference on Smart and Sustainable Technologies (SpliTech), 01–06. Bol and Split, Croatia: IEEE. https://doi.org/10.23919/SpliTech52315.2021.9566435.

Tzitzis, Anastasios, Aristidis Raptopoulos Chatzistefanou, Spyros Megalou, Stavroula Siachalou, Traianos Yioultsis, and Antonis G. Dimitriou. 2022. "Device-Free Human Tracking Exploiting Phase Disturbances and Particle Filters." In 2022 IEEE International Conference on RFID (RFID), 126–31. Las Vegas, NV, USA: IEEE. https://doi.org/10.1109/RFID54732.2022.9795987.

111. The contribution of robotic archaeology and automated controlled experimentation in use-wear analysis.

Joao MF Marreiros, TraCEr. MONREPOS-RGZM. ICArEHB, UAlg
Ivan Calandra, TraCEr. MONREPOS-RGZM
Geoff Carver, TraCEr. MONREPOS-RGZM
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Hannah Rausch, TraCEr. MONREPOS-RGZM
Jerome Robitaille, TraCEr. MONREPOS-RGZM
Lisa Schunk, University of Wroclaw

The artifact variability visible in the archaeological record shows that in the past human populations frequently change, adjust, and innovate technologies. Such adjustments are known to likely represent human adaptative behaviours to dynamic ecological, social, and cultural processes. Untangling the character and demands for such changes is therefore crucial for identifying, reconstructing and fully understanding the origins of key human behavioural traits over time. Major behavioural traits are known to be rooted in our early human evolutionary journey through the Palaeolithic, and are commonly associated with the emergence of new technological solutions (i.e. artifacts).

However, the Palaeolithic archaeological record is marked by a significant variability of artifacts and raw materials, which are not always easy to assess and interpret. To tackle such variability, as in other areas of the archaeological research, archaeologists rely on experimental replications. Archaeological experiments allow us to not only evaluate and replicate technologies, but also generate reference libraries against which artifacts can be compared. While replicating artifacts modes of production, design, and use, these libraries are also crucial for discriminating diagnostic features and attributes.

In use-wear studies, such libraries are crucial in use-wear studies and artifact functional analysis. In fact, the reconstruction of tool use heavily relies on reference collections of macro and micro traces of use (Marreiros et al. 2020). Based on actualistic experiments, while traces of use are known to correlate with worked materials, it is also known that these vary according to variables such as duration and/or intensity of use, force, motion, etc. Yet actualistic experiments are limited to controlling and measuring such variables, and therefore the formation processes of the different traces of use cannot be fully understood. Opportunely, robotic apparatus can be used to tackle such limitations (Calandra et al. 2020).

Based on different case studies (e.g. Paixão et al. 2021, Schunk et al. In press), our talk aims at discussing the contribution of robotic archaeology in the field of artifact functional analysis, including studies on tool design, performance, and qualitative and quantitative use-wear analysis.

Calandra, Ivan, Gneisinger, Walter and Marreiros, Joao. 2020. 'A Versatile Mechanized Setup for Controlled Experiments in Archeology A Versatile Mechanized Setup for Controlled Experiments in Archeology'. STAR: Science & Technology of Archaeological Research 00 (0): 1–11. https://doi.org/10.1080/20548923.2020.1757899.

Marreiros, João, Calandra, Ivan, Gneisinger, Walter, Paixão, Eduardo, Pedergnana, Antonella and Schunk. Lisa. 2020. 'Rethinking Use-Wear Analysis and Experimentation as Applied to the Study of Past Hominin Tool Use'. Journal of Paleolithic Archaeology, May. https://doi.org/10.1007/s41982-020-00058-1.

Paixão, Eduardo, Pedergnana, Antonella, Marreiros, Joao, Dubreuil, Laure, Prévost, Marión, Zaidner, Yossi, Carver, Carve and Gneisinger, Walter. 2021. 'Using Mechanical Experiments to Study Ground Stone Tool Use: Exploring Of, Formation of Percussive and Grinding Wear Traces on Limestone Tools.' Journal of Archaeological Science: Reports 37 (April). https://doi.org/10.1016/j.jasrep.2021.102971.

Schunk, Lisa, Calandra, Ivan, Bob, Konstantin, Gneisinger, Walter and Marreiros, Joao. The role of artificial contact material in experimental use-wear studies: a controlled proxy to understand use-wear formation and fracture mechanics. Journal of Archaeological Science: Reports. [In press]

106. Marine robotic technologies and vision-based approaches within the underwater archaeological research

Eleni Diamanti, NTNU
Mauhing Yip, NTNU
Oyvind Odegard, NO
Annette Stahl, Norwegian University of Science and Technology

By definition, Underwater Cultural Heritage (UCH) is inaccessible to archaeologists and the public without the application of technological help of some kind. In shallow waters, diving gear can allow human presence on the seabed for a limited time and was an enabling technology for the development of marine archaeology as a sub-discipline. In areas that are too deep, or otherwise prohibiting diving, the use of robots is often the only realistic option available for detecting, investigating and experiencing underwater cultural heritage.

Although robots do not have the physiological limitations that humans do for being under water for long durations, in practice time is still an important factor in terms of energy consumption (batteries) or operational costs (expensive surface vessels). Effectiveness is still an important benchmark for methodological choices. The constantly increasing capabilities of payload sensors for a variety of platform options, from remote operated vehicles (ROVs) to fully autonomous ones (ASVs, AUVs), smooth the path for the maritime archaeologist to pick the right tools for the right venture [1, 2]. For the surveying, mapping and investigation of UCH sites, acoustic means can provide large-scale results underwater, but lag behind optical sensors in resolution and photorealistic capabilities, two keystones when it comes to the archaeological interpretation of a site. Multiple underwater imaging systems adjusted on underwater vehicles as well as robust computer vision approaches offer significant potentials in high-resolution data acquisition and processing respectively, in notable autonomy levels [Figure 1, see attached abstract].

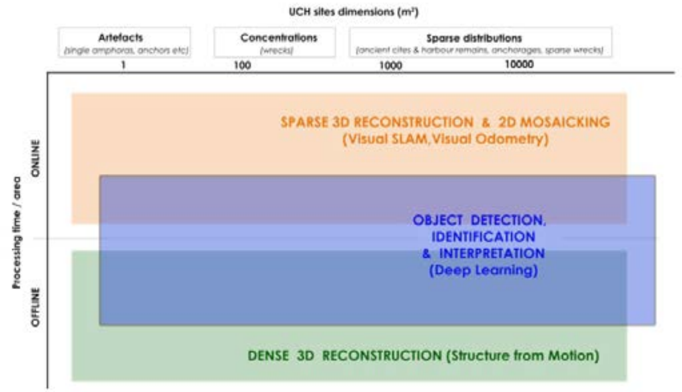

Figure 1: Surveying, mapping and interpretation of underwater archaeological sites of different structural complexities in various autonomy levels (processing time). The research deals solely with vision-based approaches on data acquired through marine robotic means.

The current work discusses such potentials through the prism of their usage in marine archaeological research. Mission planning, detection and identification of objects of interest, 2D/3D mapping and interpretation of UCH sites are based solely on visual perception and are investigated through various scales of autonomy (mission-time and offline). A comprehensive overview of the state-of-the-art marine technologies and algorithmic solutions is reported, while the authors present samples of their ongoing research, in both simulation and real-world operations.

Since vision-based mapping is range-dependent, inevitably poses the dominant challenges of the underwater medium, like light attenuation, color absorption, turbidity, dynamics and refraction. Those challenges are escalating dramatically when no a priori knowledge is available and the area, where the robot navigates, is completely unknown. Recent literature presents promising steps towards intelligent path planning approaches for optimal collection and online assessment of visual data, collision avoidance and operational cost-effectiveness.

Sensor data must provide a situational awareness that is sufficient for both archaeological and operational decision making. Maneuvering and operation of a robotic platform must be sufficient precise and tactile to perform visual scanning in sites of delicate and fragile objects or in sites of high structural complexity.

In scenarios of existing basic a priori knowledge of a site's environment, mapping and documentation projects are first launched within simulation environments. Developing and working with synthetic datasets exceeds the cost-effectiveness of real world missions, as (nearly) all salient parameters of the site's geometry and prevailing conditions can be parameterized and controllable [3]. The vehicle's trajectories, the sensor's distances-viewpoints (sensors poses) or the desired spatial resolution are pre-estimated in a considerable level of accuracy.

The goals of a non-intrusive mission to document an identified wreck site can be defined in three tasks: a) simulate the environment mapping using a priori knowledge, to optimize sensor and parameter setup along with the motion planning, b) survey (initial data acquisition) of the entire site of interest and c) adaptive planning and perception to advance the initial data with respect to missing information and interest of detail with the underlying main aim to produce a dataset of high resolution and quality for interpretation and classification post mission. To be able to perform these three tasks in a roughly known environment, a robot must have certain capabilities. It must be able to autonomously navigate within the site while keeping track of its own position in relation to the spatial extent of the site (Visual SLAM or planning based on acoustic image/bathy), and it must be able to assess the quality of the optical images regarding turbidity, occlusions and light fields. In case the quality or coverage does not satisfy the mission goals, it must be able to adaptively re-plan tasks to remedy the situation.

Surveying extended geographic areas for the potential detection and classification of sites of UCH interest via autonomous robotic missions requires a lot of input data from the maritime archaeologist during the initialization phase. Once the mission is launched, a great challenge that arises is to make the underwater vehicle's perception able to re-evaluate the overall assessment process and classification libraries based on new, growing data in mission-time. Decisions on the survey's boundaries as well as relevance and levels of importance of detected targets will be potentially made exclusively by robots, pushing notably autonomy limits. The up-to-today fiction idea of surveying, detecting and documenting an UCH site in the same dive is now highly considered.

References

[1] Ludvigsen, M. and Sørensen, A.J., 2016. Towards integrated autonomous underwater operations for ocean mapping and monitoring. Annual Reviews in Control, 42, pp.145-157.

[2] Ødegård, Ø., Nornes, S.M., Ludvigsen, M., Maarleveld, T.J. and Sørensen, A.J., 2016, March. Autonomy in marine archaeology. In 43rd Annual Conference on Computer Applications and Quantitative Methods in Archaeology: Keep the Revolution Going (pp. 857-865). Archaeopress.

[3] Zwilgmeyer, P.G.O., Yip, M., Teigen, A.L., Mester, R. and Stahl, A., 2021. The VAROS synthetic underwater data set: Towards realistic multi-sensor underwater data with ground truth. In Proceedings of the IEEE/CVF international conference on computer vision (pp. 3722-3730).

384. Automated high-resolution ground-penetrating radar prospection with an uncrewed ground vehicle at an archaeological site

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Although large progress has been made in geophysical data acquisition, the survey of large areas together with a high spatial resolution remains time-consuming even when using multiple sensors in parallel. In order to overcome this problem, one possibility is the use of uncrewed aerial vehicles. Tests with drone-borne electromagnetic induction instruments and magnetometers have been conducted.

Air-launched ground-penetrating radar (GPR) surveys were also tested, but result in decreasing reflection amplitudes (and therefore reduced penetration depth) and lower spatial resolution (Diamanti and Annan 2017, 1694). Therefore ground-based methods should also be explored.

A small, four-wheeled Clearpath Robotics Husky uncrewed ground vehicle (UGV), with a maximum speed of ~1 m/s and a payload of up to 75 kg, was tested to investigate its suitability for automated GPR prospection (Verdonck 2021, 220). It is equipped with wheel encoders, an inertial measurement unit (IMU), and a GNSS receiving corrections from permanent reference stations via mobile internet. Additional position measurements were obtained by tracking a prism placed on top of the Husky using a robotic total station. These allow the UGV to estimate its position, orientation and velocity, through data fusion by means of an extended Kalman filter, which is part of the Robot Operating System (ROS), an open source framework structured as a large number of small programs or 'nodes' (Quigley, Gerkey and Smart 2016).

In July 2021, the Husky was tested at the Roman town Falerii Novi (Italy), which was surveyed previously with a GPR array towed by an all-terrain vehicle. The UGV pulled two 500 MHz GPR antennae, covering an area of 1600 m2. The objectives of the survey were to investigate (1) how accurately the robot can follow predefined survey lines; (2) if the robot can independently reach a series of predefined goals; (3) how well the UGV can avoid obstacles; (4) which sensors are essential for localization and navigation; and (5) possible interference between UGV and GPR.

The accuracy of the UGV when following predefined lines was tested at speeds of 0.3–0.9 m/s. Although there were cross-line errors of up to 0.2 m, for all speeds the errors were relatively consistent within and between traverses. As a consequence, the survey area was evenly covered, and sample density approximated theoretical requirements for 500 MHz GPR antennae. This resulted in time slices of the same quality as the ones collected with the human-driven GPR platform. Three manual interventions were necessary, when the UGV could not reach a waypoint, mainly because of wheel slippage in the shifting sand covering parts of the test site.

The UGV's ability to avoid obstacles was tested in two ways. A Velodyne VLP-16 LiDAR mounted in the front of the Husky allowed it to successfully avoid an obstacle of ~0.5 m x 0.3 m x 1 m. At the same time, long vegetation caused the LiDAR to identify a number of false positives, which made the Husky deviate from its path. This occurred more often when plants had thick stems, and less in the case of grass. Also, after having avoided the obstacle, the robot often did not return to the predefined transect line, but followed a parallel path to reach the next waypoint. This is because the ROS planner finds a path with minimal cost. This cost is only based on the distance from the target and from obstacles, not on the proximity from the original predefined line. Alternatively, the position and dimensions of the obstacles can be measured with a GNSS before the start of the survey, and additional waypoints can be given to the UGV so that it can avoid the obstacles without using a LiDAR. This is more time consuming but led to good results at Falerii Novi.

Another question is which sensors are vital for the UGV to navigate. In order to obtain a precise position estimate, the wheel encoders (whether in combination with the IMU or not) were not sufficient, but RTK GNSS or the tracking total station were essential. To investigate which sensors are necessary to reliably calculate the robot's orientation, several sensor combinations were tried: GNSS–wheel encoders, GNSS–wheel encoders–IMU, and GNSS-wheel encoders–tracking total station. It was found that the UGV performed equally well using only GNSS–wheel encoders, and that the use of extra sensors such as IMU or tracking total station was not essential. At the moment, it is being investigated how accurately this single GNSS instrument can predict also the coordinates of the GPR antennae pulled behind the robot.

When measuring interference between the sensors mounted onto the UGV and the GPR antennae, the most important source of noise was the 900 MHz transmitter of the wireless emergency stop. It had to be kept at a distance of at least a few metres not to interfere with the GPR receiver.

After each transect, raw GPR data are automatically transferred from the notebook on the UGV to a base station computer for quality control in the field. A simple data processing flow was developed, including dewow, time zero correction, gain, background removal, conversion of GNSS coordinates to a projected coordinate system, calculation of individual antenna coordinates, and the creation of horizontal slices. Currently, the use of semi-automated interpretation algorithms based on convolutional neural networks is being investigated, both for rapid visualisation of the results as they are transferred by the UGV, and as an aid in the final delineation and interpretation.

References

Diamanti, Nectaria, and Peter Annan. 2017. "Air-launched and ground-coupled GPR data." In 11th European Conference on Antennas and Propagation (EUCAP), Paris, 19-24 March 2017, 1694-1698. New York: IEEE.

Quigley, Morgan, Brian Gerkey, and William D. Smart. 2016. Programming robots with ROS. A practical introduction to the Robot Operating System. Sebastopol, CA: O'Reilly Media Inc.

Verdonck, Lieven. 2021. "ArchGeoRobot: Automated archaeo-geophysical data acquisition using an unmanned ground vehicle." ArcheoSciences 45 (1): 219-221.

332. Envisioning the forthcoming era of robotics and automation in archaeology: a position paper

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In the decade characterised by the dominant emerging of robotics, ubiquitous to all domains, archaeology –and humanities at large– seem to be only tangentially affected by this revolution. This might appear quite curious as archaeology in the past has been always fast to appropriate new technological developments generated for application in other disciplines. It is even more surprising as archaeology, which is under many respects a very 'physical' discipline (no doubt the most physical discipline of the humanities, with fieldwork being at its very core), could highly benefit from technologies that reduce the physical labour of operators and spare them from repetitive actions. It comes as a surprise, therefore, that we have so far assisted only to scanty attempts to use robotics to support archaeological research mainly by undertaking surveys (on ground, underground, underwater, from air) in conditions where it would have been hard or dangerous for a human operator to perform any activity. R&D have not gone that far since a few pioneering works: products have been developed to discover and monitor underwater cultural heritage at high depth through Autonomous Underwater Robotic and sensing systems (AUVs) or explore and map inaccessible or unsafe areas of archaeological sites (Dell'Erba et al. 2011); Unmanned aerial vehicles (UAV), aka drones, have been modified to adapt them to archaeological survey needs (Ceccarelli et al. 2018); basic robotic systems have been customised for digitisation of archaeological venues; telepresence robots have been designed to increase museum visitors engagement and enable them to explore in a new way the collections (Lupetti 2015); cobot systems assisted conservators in handling heritage artefacts and care for them. UAVs deserve probably a separate discussion here as, while being largely used in supporting archaeological research on the field by now, they enjoy continuous performance improvement that is almost exclusively driven by their use in other domains, the archaeological one being a real niche not worthy of much customised development. Drones aside, however, most of these robotic platforms have had short life and after initial enthusiasm, drawn by the novelty, and/or after being used for a specific occurrence, ended up in oblivion. The reasons for this are several (economic, mainly), but it all comes down to the limited understanding of archaeological work practices (often fantasised by non-operators) and real needs in archaeological routines by robotic platform designers and to the lack of contacts between domains that lead to the absence of an R&D ecosystem that can nest such collaboration and drive advances at the interplay of the two disciplines.

With this in mind, the CCHT (the Venetian centre of the Italian Institute of Technology –IIT– focused on the development of technologies for cultural heritage) has undertaken in collaboration with other Research Lines and facilities of the Institute a number of experimental projects focused on the development of robotic and cobotic platforms that can assist and collaborate with archaeologist and are designed based on the specific needs of the archaeological discipline and practise. Through the presentation of four of the most advanced projects available at IIT, this position paper will focus on the theories behind those applications, delving into the design phase and the elements considered when conceiving these platforms. It will explore how the discussions among a variety of researchers have led to build infrastructures that combine previously fragmented technologies into single unified platforms that enable smarter robotics, able to achieve more capable machines using a combination of technologies including machine vision, AI, cloud computing, 5G, and industry 4.0 hardware.

The four projects relate to a variety of applications in the archaeological practice, from the analysis of material culture to its storage and its reconstruction when shattered, as far as to the monitoring of archaeological sites.

3D scanning of archaeological objects is at the basis of digital conservation of archaeological heritage, but it is still a time-consuming activity, notwithstanding the improvement of sensors, able by now to automatically scan objects in a fast and accurate way. If we consider the 4th dimension of time (i.e., the necessity of repeating the scanning at given intervals of time) and the huge quantity of heritage objects globally available it is clear that the overall procedure should be automated as much as possible. This concept is at the core of the development of technologies to automatically scan archaeological items by activating sensors based on requirements of accuracy of reconstruction, coverage of object to scan, and safety when moving arms.

Large frescoes in shattered conditions, reduced into thousands of fragments, rarely find their way back to a reconstructed object. This is the goal of the EC funded REPAIR project (an acronym for Reconstructing the Past: Artificial Intelligence and Robotics meet cultural heritage) which aims to develop an intelligent robotic system that will autonomously process, match and physically assemble large fractured frescoes at a fraction of the time it takes humans to do so through the integration of novel technologies in the fields of robotics, computer vision and artificial intelligence.

Ground robots coupled with drones are being developed to monitor archaeological areas based on the principles of autonomy, efficiency, repeatability, and reliability. The autonomous robot system operates throughout archaeological sites in order to monitor the conservation state of structures and to identify potential structural damages that might threaten the stability of the built environments, without requiring any human supervision.

Finally, the advancements in industrial robotics of the IIT InBot (Industrial Robotics Facility) underpin the development of an autonomous archaeological items storage system able to stock up, keep track, and deliver on request objects kept in museum storages.

The paper will critically engage in the discussion about the collaborative aspects of working with robots, trying to eliminate misconceptions, and reflecting on the advantages of removing time-consuming tasks away from human operators, while objectively considering the current limits of machines and future scenarios.

References

Dell'Erba, R., Moriconi, C., Bonanno, G., Cavallini, F., Cupertino, G. HARNESS: a robotic swarm to explore and protect underwater cultural heritage. Science and Technology for the Safeguard of Cultural Heritage in the Mediterranean Basin, Nov 2011, Instabul.

Ceccarelli, M., Cafolla, D., Russo M., Carbone, 2018. HeritageBot platform for service in Cultural Heritage frames. International Journal of Advanced Robotic Systems. 2018;15(4).

Lupetti, Maria, Germak, Claudio, Giuliano, Luca, 2015. Robots and Cultural Heritage: New Museum Experiences. 10.14236/ewic/eva2015.36.

27. Exploring new ways of visualizing archaeological data

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Location: E108

Data visualisations are becoming common research tools in humanistic inquiry. Besides outputs of modelling efforts and communication tools, data visualisations help bring new perspective to otherwise familiar data (Lev Manovich, 2015). However, while visualisations for encouraging such rich and varied exploration are being developed in neighbouring fields of literature and cultural studies, archaeology seems to have few such explorative examples outside the use of GIS (Gupta and Devillers, 2017). Explorative interfaces created for humanistic research are made generous in their browsing (Whitelaw, 2015), speculative and playful in their interaction features (Hinrichs, Forlini, & Moynihan, 2016), semantically rich in their layouts (Gortana, von Tenspolde, Guhlmann, & Dörk, 2018) and critical in their points-of-view (Drucker, 2015). GIS allows for more efficient management and analysis of the collected spatial data and provides an easy way to map spatial archaeological data. However, traditional GIS mapping does not easily support temporal data, which can lead to a reduction of the complexity of archaeological phenomena (Andrienko et al. 2010). In this session we want to explore new ways of visualizations to better handle the different dimensions of (spatial) archaeological datasets to reveal new patterns and create new knowledge. Among others we are hoping to explore questions such as: How to visually unpack multidimensional datasets from long-running archaeological projects? What novel visualization techniques can highlight so far undervalued perspectives of spatial data? How can the inevitable uncertainties underlying the data be communicated in visualizations? While we welcome all types of visualization, the session hopes to attract papers with customized geovisualizations and non-traditional GIS mapping of archaeological data. The session aims to provide a stimulating discussion to identify problems and opportunities. We invite authors to provide a good insight into their methods.

References:

Andrienko, G., N. Andrienko, U. Demsar, D. Dransch, J. Dykes, S.I. abrikant, M. Jern , M.J. Kraak , H. Schumann and C. Tominsk (2010). Space, time and visual analytics. International Journal of Geographical Information Science, 24(10), 1577–1600.

Drucker, J. (2015). Graphical Approaches to the Digital Humanities. In A New Companion to Digital Humanities. https://doi.org/10.1002/9781118680605.ch17
Gortana, F., von Tenspolde, F., Guhlmann, D., & Dörk, M. (2018). Off the Grid: Visualizing a Numismatic Collection as Dynamic Piles and Streams. Open Library of Humanities, 4(2), 1–25. https://doi.org/10.16995/olh.280

Gupta, N. and R. Devillers (2017) Geographic visualization in archaeology, Journal of Archaeological Method and Theory, 24 (3):852-885.

Hinrichs, U., Forlini, S., & Moynihan, B. (2016). Speculative Practices: Utilizing InfoVis to Explore Untapped Literary Collections. IEEE Transactions on Visualization and Computer Graphics, 22(1), 429–438. https://doi.org/10.1109/TVCG.2015.2467452

Lev Manovich. (2015). Data Science and Digital Art History. International Journal for Digital Art History, (1). https://doi.org/https://doi.org/10.11588/dah.2015.1.21631

Whitelaw, M. (2015). Generous Interfaces for Digital Cultural Collections. DHQ: Digital Humanities Quarterly, 9(1). Retrieved from http://www.digitalhumanities.org/dhq/vol/001/2/index.html

SLOT 4	
16:30 - 16:50	226. Visual encoding of a 3D virtual reconstruction’s scientific justification: feedback from a proof-of-concept research *Jean-Yves BLAISE (CNRS)*; Iwona Dudek (CNRS); Simon Gaël (CITERES - LAT, University of Tours); Laurent Bergerot (CNRS)*
16:50 - 17:10	235. Querying the Past—using Artificial Intelligence to Identify Architecture *Aaron Pattee (ALudwig-Maximilians-University in Munich)*; Cindy Kroeber (Friedrich-Schiller-University in Jena); Jonas Bruschke (Julius-Maximilian-University in Würzburg); Ronja Utescher (University of Bielefeld); Ferdinand Maiwald (Friedrich-Schiller-University in Jena); Sina Zarriess (Friedrich Schiller University Jena); Stephan Hoppe (Ludwig-Maximilians-University in Munich); Florian Niebling (Julius-Maximilian-University in Würzburg); Sander Münster (Friedrich-Schiller-University in Jena)*
17:10 - 17:30	143. Another pair of eyes. Approaching the Sagalassos settlement data through a customized “SiteVis” visualization *Ralf Vandam (VUB)*; Georgia Panagiotidou (UCL); Andrew Vande Moere (KU Leuven); Jeroen Poblome (KU Leuven)*

17:30 - 17:50	185. Playing 'Fun Games with Time and Space': Digital Assemblages of the O.G.S. Crawford Archive *Beth Hodgett (Birkbeck)*; Karl Smith (University of Oxford); Katie Campbell (Cambridge); Adam Dawson (University of Oxford)*

226. Visual encoding of a 3D virtual reconstruction's scientific justification: feedback from a proof-of-concept research

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A 3D virtual reconstruction is the result of experts' analyses aiming to propose a plausible spatial arrangement for a building that has changed over time. It is before all the result of an interpretation of available data and information underpinned by 'knowledge' (explicit, tacit, …). Each 3D reconstruction - obtained by means of a synchronic or diachronic study - is a hypothesis.

But a 3D virtual reconstruction is also a technical work, through which assertive geometrical forms have to be chosen in order to represent that spatial arrangement, even if uncertainties were spotted during the interpretation step. On the other hand, from the knowledge and information visualisation standpoint, a 3D virtual reconstruction confronts researchers with the challenge of finding a compromise between interpretation and assertions, even within the graphical encoding of a 3D model (if the model aims to serve analytical purposes).

This research is based on a methodological proposal: introducing justification matrices that allow to associate to the components of a 3D virtual reconstruction, "indicators" that formalise in a synthetic way an assessment of plausibility. In other words, these matrices deliver information on the scientific justification of a given spatial arrangement.

The experiment led to the creation of a proof-of-concept prototype allowing a user to interact in real time with the graphic appearance of each object, represented in a 3D reconstruction, according to the values of its justification matrix. The approach is applied to four phases of the evolution of Marmoutier abbey's hostelry (corresponding to four synchronous states - 12^{th}, 13^{th}, 15^{th} and 18^{th} centuries), and re-uses 3D virtual reconstructions produced a few years ago by the team of archaeologists involved in this experiment.

Several system querying modalities have been experimented in order to better circumscribe the services such a prototype can offer - those will be detailed in the final contribution. The prototype is based on a combination of classical and open technologies for the web (RDBMS, JS/CSS/HTML interface, 3D JavaScript library Three.js). It is already operational and available online with free access. The experiment intersects three families of research issues, briefly commented on below.

The knowledge representation issue.

How to account for the uncertainties associated with a 3D virtual reconstruction in a formal and shareable way, conducive to a comparison within a study case, or between case studies? And what exactly are these uncertainties about? Architectural forms? Their spatial arrangement? Their very existence? Can this notion of uncertainty be formalized in any way other than by an accompanying discourse? On this question, the scientific literature proposes numerous methodological reference points, often discipline-centered, leading to a formalization of uncertainty factors (e.g., Skeels et al. 2010, Zuk et al. 2007, Thomson et al. 2005). In addition, from an archaeological standpoint, how can we exploit the notion of argumentation, present for example in J.C Gardin's logicism (Dallas, 2015), to make the choices made by an analyst more readable within 3D models?

In response, we have designed the above-mentioned justification matrix formalism and experimented with it. The formalism allows to assign individual 3D objects or to groups of objects a quantitative evaluation of their plausibility by crossing 4 criteria: shape, dimensions, existence, and position. This formalism materialises the vision of one analyst, and could potentially allow the materialisation of differences between analyses. It does not constitute an argumentation as such, but it reveals the result of an argumentation. The argumentation itself can naturally be associated with the object as paradata – but this is another discussion, falling outside of the scope of our contribution.

The graphic semiology issue.

A 3D virtual reconstruction is in essence a visual product, in which graphic components are combined. What graphic vocabulary should be proposed, what interaction modalities in the 3D model should be implemented so that the subjective choices behind a restitution hypothesis are legible? How can comparisons between the different components of a 3D model (from the point of view of their relative plausibility) be facilitated? J. Bertin's graphic semiology (Bertin, J. 2010.) has spread well beyond its original discipline, geography, and particularly in the field of information visualization. However, it is hard to say there is an equivalent methodological reference point in the field of 3D heritage-related modelling. In that area of concern, after decades of research, practices still tend to privilege realism over semantic encoding, and representations often primarily serve visual communication objectives. At the end of the day, 3D virtual reconstructions often do not really provide services (in terms of scientific added value) commensurate with the effort made.

In the proof-of-concept prototype we present a set of simple graphical variables map the values of the above-mentioned justification matrices, for each object or group of objects.

The 3D content repurposability issue

How can we re-use 3D content for other purposes, in our case 3D virtual reconstructions created primarily for scientific mediation and in a technological context that is sometimes obsolete today?

This issue can be seen primarily as a purely practical matter concerning technology.

But it can also be seen as part of a broad societal movement towards more sustainability and economy of means, a movement that does affect the field of scientific research. This is not a new issue, however, and the emergence of many XML-based formats where the information is detached from the application contexts is proof of this. But developing today such good practices does not necessarily provide practical solutions concerning the reuse of existing content.

The interface that we present has been developed to work online thanks to the open source Three.js library, and exploits a systematic repurposing of the original 3D models.

The contribution will further discuss the above research context, provide details concerning the proof-of-concept protoype's implementation and usage scenarios, and draw upcoming lines of research.

Skeels, M., Lee, B., Smith, G. Robertson, G. (2010). Revealing uncertainty for information visualization. Information Visualization, Vol. 9, 1, pp.70– 81. Macmillan Publishers Ltd.

Zuk, T., Carpendale, Sheelagh. (2007). Visualization of Uncertainty and Reasoning, In Proc SG 2007, edited by A. Butz et al., pp. 164–177. LNCS 4569. Berlin Heidelberg: Springer-Verlag.

Thomson, J.R., Hetzler, E., MacEachren, A., Gahegan, M., Pavel, M. (2005). A typology for Visualizing Uncertainty. Proceedings of the SPIE-VDA 2005: SPIE Proceedings, Vol. 5669 https://doi.org/10.1117/12.587254

Dallas, C. (2015). Jean-Claude Gardin on Archaeological Data, Representation and Knowledge: Implications for Digital Archaeology. Journal of Archaeological Method and Theory. Vol. 23, No. 1, pp. 305-330, Springer

Bertin, J. (2010). Semiology of Graphics: Diagrams, Networks, Maps. ESRI Press (orig. edition in French 1967)

235. Querying the Past—using Artificial Intelligence to Identify Architecture

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The study of architectural art history has greatly benefitted from innovative, computer-aided approaches in recent years. From high resolution 2D photos of building edifices, to 3D models of entire structures, these emerging techniques are laying the foundation for new methodologies in researching architecture. Provided the three dimensional nature of buildings, research projects have appropriately focused upon techniques that produce digital replicas of their forms, such as Structure from Motion (SfM) Photogrammetry and Terrestrial Laser Scanning (TLS). However, one critical aspect in the study of architecture has largely been dormant since the emergence of these technologies, namely, the computer-aided description of architectural elements. Although Artificial Intelligence (AI)-based methodologies have been tremendously developed in recent years within the field of Computer Vision, it has served a more marginal role with regard to image searches in repositories and retrieval systems. Current processes within Computer Vision extract purely visual features within images of related sources, which are then classified based upon these characteristics alone. Unfortunately, key contextual data in the form of text or metadata are not linked to the images. This project seeks to establish an AI-based approach towards modelling image sources and their multimodal contexts as a new technique for researchers in the Humanities. Using a city model of Dresden, Germany, as our main case study, we will demonstrate how we are using AI to identify architectural elements directly from 3D models rather than rely upon text descriptors.

143. Another pair of eyes. Approaching the Sagalassos settlement data through a customized "SiteVis" visualization

Ralf Vandam, VUB
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Since the beginning of regional archaeological research, distribution maps have most often been presented fairly straightforward through the so-called dots on a map approach. These maps are generally simplistic, with dots representing sites of a certain period, and can become more complex if site classifications or more rarely multiple periods are incorporated. The introduction of intensive surveys in the late 1970s gradually led to the visualizations of more continuous archaeological landscapes, with off- and on-site patterns which was facilitated by the emergence of GIS in archaeology during the late 1980s. GIS allows for more efficient management and analysis of the collected spatial data and provides an easy way to map spatial archaeological data. However, as argued, GIS does not easily support temporal data, which can lead to a reduction of the complexity of archaeological phenomena. Furthermore, there is the perception in our discipline that visualization is only useful for representing something already known from the data, but visualizations may instead be the means by which to reveal new patterns and create new knowledge, especially when the dataset becomes overly complex. After 27 years of archaeological survey initiatives, we as the Sagalassos Archaeological Research Project are currently grappling with these challenges as our dataset has evolved into a rich resource containing multiple dimensions worthy of exploration.

Through an iterative design approach including data visualization specialists, we documented several ways to visualize this data, combining the dimensions of time, location, function and incorporating the aspect of survey methodology. After assessing them for their potential, we propose a custom interactive visualization that we call a SiteVis to address the aforementioned issues. In this paper we will introduce our visualization, but will mainly focus on the patterns that we were able to pick up through this new approach and attempt to explain them. We believe that this paper will be of interest for other archaeological projects working with regional archaeological data wanting to gain insights beyond the means of traditional visualizations.

185. Playing 'Fun Games with Time and Space': Digital Assemblages of the O.G.S. Crawford Archive

Beth Hodgett, Birkbeck
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The archaeologist and photographer O.G.S. Crawford (1886-1957) arrived at Sutton Hoo on the evening of 24th July 1939. The excavation of the now-famous ship-burial had begun several months previously, and with the threat of war hanging over Europe, was frantically racing to a crescendo. The historical circumstances of the dig need little introduction; the story of local archaeologist Basil Brown's discovery of the ship burial and his subsequent side-lining from the excavation has been the subject of numerous publications and even a recent Netflix film adaptation. These accounts have centred around the events of the key seventeen days during which a small team of excavators extracted a total of 263 finds from the burial chamber. Crawford was present for five of these days, taking a total of 136 photographs in his semi-official capacity as excavation photographer. In the present these photographs are housed in the archives of the Institute of Archaeology, Oxford. Though a few key images from the archive have been reproduced in prominent publications, Crawford's photographs have never previously been studied as a coherent collection. In this paper we explore the potential of turning to this rich yet under-referenced collection and make the case that a return to the archives can cast new light on the human stories underlying the excavation. Moreover, we make the case that the application of GIS modelling and photogrammetric techniques can call into question fundamental assumptions about the nature of historic archaeological recording practices, and provide new avenues for reinterpreting and visualising heritage data.

The destruction of excavation led to disciplinary anxiety surrounding the production of archaeological archives resulting in the "philosophical dogma…that the archive should be a complete and objective record of an excavation that must be then kept forever" as a proxy for the archaeological record (Swain 2012:252-253). Between the inter-war period and the post-processual turn archaeologists in Britain were trained to think of data collection in the field as an objective process of assembling 'facts' entirely separate from the "subjectivity and speculation" that took place in post-excavation interpretation (Hodder 1997:692-694). The combination of this emphasis on assembling a total record, the highly regimented visual conventions of archaeological photography and the long-standing association between the indexical trace of the camera and the production of mechanical objectivity has led to the characterisation of archaeological photography as a clinically detached practice in which "the photographer's human presence, and artists' tendency to subjectivity held in check by his mechanical apparatus" (Bohrer 2011:7).

At present archaeologists are increasingly turning to historic archives; leaning on the potential of archival records to provide 'access' to sites that have been destroyed, damaged or are located in politically unstable regions, or seeking to extract new information from 'old' data. Yet many of these approaches are still premised on the assumption that archaeological archives are neutral and complete repositories of 'facts'. In our paper we decry this assumption, noting numerous instances where the recording practices at Sutton Hoo are instead demonstrative of subjectivity and uncertainty, and speak to the interests and concerns of individual excavators present at the site. Carver (2011) and Bruce-Mitford (1975) have previously highlighted specific gaps in the Sutton Hoo documentation, with crucial plans being lost during the war, finds being recorded with a variety of different designations throughout the course of the excavation, and areas of the burial chamber being inconsistently assigned numerical or alphabetic designations. Similarly, Hodgett (2019) has demonstrated that Crawford's photography of the excavation was highly selective, focusing almost exclusively on only twenty key finds. To compound these issues, the site itself was damaged during the course of the war, limiting the ability to address these gaps through excavation.

Instead, we turn to the potential of producing new digital assemblages of Crawford's photographs as a strategy to highlight and visualise the uncertainties and subjectivities outlined above, and to reveal the human presence of Crawford as a photographer. Specifically, we use Crawford's photographs to generate photogrammetric models of the excavation at Sutton Hoo during Crawford's five days on site. We use these models to (1) track and examine Crawford's photographic process at Sutton Hoo by mapping his movements on a temporospatial GIS plan of the site, (2) highlight elements of the excavation that were (or were not) selected for recording by the excavators, (3) contextualise drawn plans of the site and attempt to supplement plans that have been lost, and (4) by visualising the 2D photographs in three dimensions in order to enhance our understanding of the micro-topography and nature of the archaeological deposits. By doing so we aim to expose the fallacy of the 'total record' while also demonstrating how digital methods can be used to enrich what some might consider 'incomplete' or 'imprecise' archival material. In applying these methods, we argue that not only can a return to archival photographs provide an alternative path forward where re-excavation is not possible, it can also illuminate the very human stories of pivotal moments in the discipline's history. By tracing the temporal and spatial relationships between Crawford's photographs in the GIS model, it is possible to recognise a palpable excitement in his movements, dashing from find to find armed with his camera. In a similar sense, gaps in the models produced by photogrammetry also speak to Crawford's personal experience of the excavation, mapping the intensity of his occupation of different areas of the site. Our models also visually flag absences in the archival source documents. Similarly, the faint shadow effects produced by photogrammetric software accounting for the presence of excavators in source images works to acknowledge the human labour behind the excavation.

REFERENCES

Bohrer, F.N. 2011. Photography and Archaeology. London. Reaktion Books.

Bruce-Mitford, R. 1975. The Sutton Hoo Ship Burial, Volume I. London: British Museum Publications Group.

Carver, M. 2011. Sutton Hoo an Archaeography. In: Schofield, J. ed., 2011. Great Excavations: Shaping the Archaeological Profession. Oxford: Oxbow Books, pp.25-43.

Hodder, I. 1997. Always Momentary, Fluid and Flexible: Towards a Reflexive Excavation Methodology, Antiquity, 71(273), pp.691-700.

Hodgett, B. 2019. 'Rear Elevation' and Other Stories: Re-Excavating Presence in O.G.S. Crawford's Photographs of the 1939 Sutton Hoo Excavation, Antiquity, 93(370), pp.1-5.

Swain, H. 2012. Archive Archaeology. In: McDavid, R. and Carman, J. eds., 2012. The Oxford Handbook of Public Archaeology. Oxford: Oxford University Press.