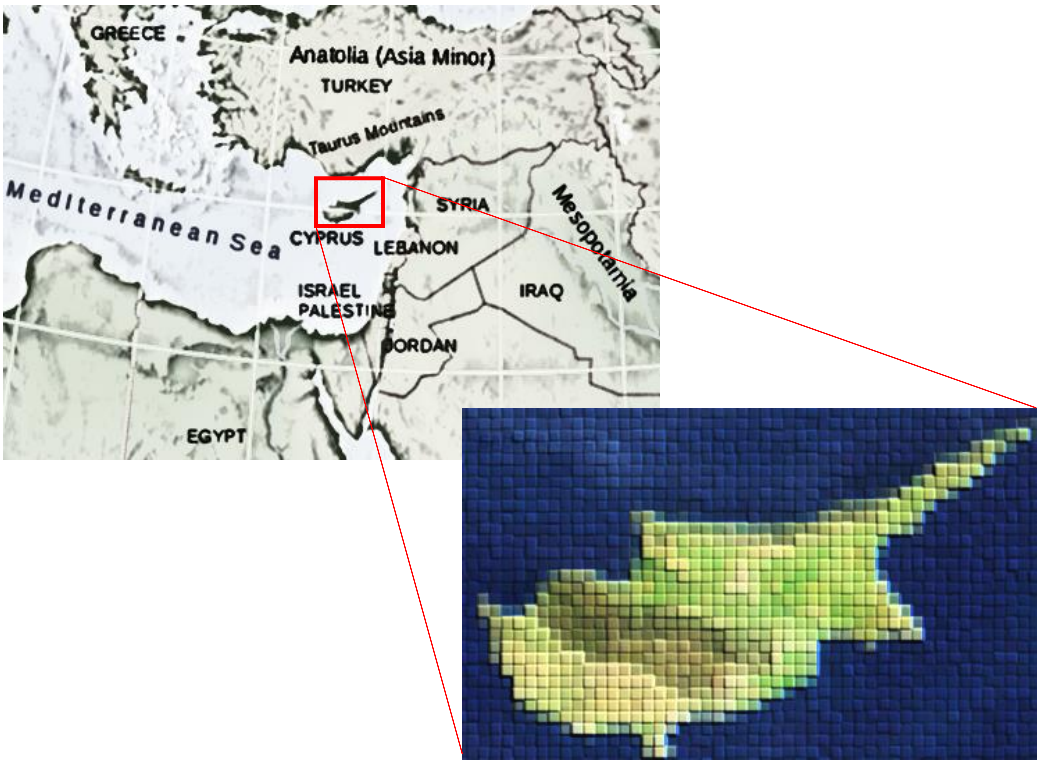
Computer Applications & Quantitative Methods in Archaeology

CAA 2021 – “DIGITAL CROSSROADS”

June, 14-18 2021
~~Limassol, Cyprus~~ Online Event

Programme and Abstracts



Cyprus University of Technology

Local Organizing Committee:

Athos Agapiou

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Phaedon Kyriakidis, *Chair of Organizing Committee*

Stelios Neophytides

Vasiliki Lysandrou

With the support of:

Welcome Note

It is my great pleasure to welcome you to CAA 2021, the 48th Conference of CAA international, the organisation for Computer Applications and Quantitative Methods in Archaeology.

The conference theme for this year is "Digital Crossroads", as the conference was originally planned to take place in Limassol Cyprus, the 3rd largest island in the Mediterranean Sea lying at the crossroads of civilisations since prehistory. The digital transformation we are all experiencing in archaeology and allied disciplines continues to highlight the role of Cyprus and the Eastern Mediterranean region as a crossroads of technologies and cultures.

The unique cultural heritage of the island of Cyprus and of the broader region acts as a positive societal and economic multiplier, but also undergoes severe pressure due to conflicts and political unrest. The need for protection, preservation and promotion of such cultural heritage, along with the strive to comprehend complex social and human-environment interactions in the region since prehistory, provide a unique context for the development and application of quantitative methods and related digital technologies as part of modern archaeological inquiry.

Although the members of the Local Organising Committee would love to have hosted you in Limassol during June 2021, the COVID-19 pandemic did not allow this plan to eventually materialise. We are still, however, delighted to have the opportunity to host this annual reference event on quantitative archaeology, and wish that your on-line experience is both scientifically fruitful and personally enjoyable. We genuinely hope to have the opportunity in the future to host you in Cyprus so that you will be able to experience yourselves the unique environment, flavours, aromas and cultures of the island we call home.

I would like to express my gratitude to the members of the Scientific Committee and to the various officers of CAA International, to the Cyprus University of Technology, and to our local supporters. Their efforts were essential in making this on-line event possible.

With warmest regards,

On behalf of the CAA 2021 Local Organising Committee

Phaedon Kyriakidis

Professor, Department of Civil Engineering and Geomatics

Cyprus University of Technology

Condensed Programme

	Monday, June 14th	Tuesday, June 15th						Wednesday, June 16th						Thursday, June 17th					
Time	Workshops	Sessions						Sessions						Sessions					
		Rooms						Rooms						Rooms					
		A	K	P	S	Ch	T	A	K	P	S	Ch	T	A	K	P	S	Ch	T
09:45-10:00		Welcome Notes																	
10:00-10:30	S31	S6	S2	S7	S25			Networking Event						Keynote					
10:30-11:00																			
11:00-11:30															S19		S22		
11:30-11:50	Coffee Break	Coffee Break						Coffee Break						Coffee Break					
11:50-12:20	S31	S6	S2	S9	S25		S12	S4	S11	S13	S17		S28	S10	S16	S24	S22	S28	S35
12:20-12:50																			
12:50-13:20																			
13:20-13:50																			
13:50-14:20																			
14:20-15:00	Lunch Break	Lunch Break						Lunch Break						Lunch Break					
15:00-15:30	Posters	S6	S2	S9	S25	S26		S5	S8		S32		S28	S15	S14	S18	S23	S32	S1
15:30-16:00	Nick Ryan Bursary																		
16:00-16:30																			
16:30-16:50		Coffee Break						Coffee Break						Coffee Break					
16:50-17:20		Keynote						CAA Annual General Assembly						S15	S5	S18	S23	S32	
17:20-17:50																			
17:50-18:20																			
18:20-18:30		Break												Closing Notes					
18:30-19:00		S21			S8	S19	S26												
19:00-19:30																			
19:30-20:00																			
20:00-20:30																			

A: Amathous, K: Kourion, P: Palaepaphos, S: Salamis, Ch: Choirokoitia, T: Tombs of the Kings

POSTER SESSION & NICK RYAN BURSARY WILL BE ACCESSIBLE TO THE PARTICIPANTS THROUGHOUT THE WHOLE CONFERENCE PERIOD

*Networking Event:

On Wednesday, June 16th (10:00-11:30 EET) we will be hosting on conference’s online platform a networking event, where participants will chat randomly with other conference attendees, get to know better and exchange ideas. Multiple chat rooms of 4 will be available during this event so one may join another room and connect with more people!

Workshop

S31. Developing R packages (Other)

Convenor(s):
Sophie C. Schmidt, German Archaeological Institute
Petr Pajdla, Masaryk University
Clemens Schmid, Max Planck Institute for the Science of Human History, CAA-SIG SSLA

Monday, June 14, Room to be announced
10:00 – 11:30, 11:50 – 14:20

A growing number of researchers use the scripting language R (R Core Team 2020) for scientific data analysis. Many organise their code in scripts and functions to perform sequences of data manipulation, statistics and visualisation. Sometimes these workflows gain in complexity and it becomes feasible to outsource core components into a dedicated R package. Packages are one of the best ways to make R code reproducible as they provide a well-established structure to share functions, data and their documentation with other R-users. The vast numbers of packages by diverse developers on the Comprehensive R Archive Network (CRAN) indicate their popularity in the scientific community and they could very well become a pillar of scientific progress in archaeology (Schmidt and Marwick 2020). Indeed more and more packages are also being developed by and for archaeologists (e.g. http://open-archaeo.info).

For CAA2021 we would like to offer a workshop to teach R-users how to develop R packages from their scripts. We believe that many archaeological R-users do not engage in package development as they lack training and the learning curve seems steep. We will try to fill this gap and offer a low-level introduction to R package development for users with basic R-skills.

This workshop is designed in tandem with the session “Tools for the Revolution: developing packages for scientific programming in archaeology” by the SIG SSLA.

Therefore:

• Do you use the scientific scripting language R for your analyses?

• Do you, too, now have a number of script files flying about and don’t know how to organise them?

Join us and learn how to create an R-package!

In this workshop we will focus on the main points in Hadley Wickham’s book on package development (Wickham 2020, https://r-pkgs.org) and create an example application together. Workshop attendees will get to know a structured workflow, which will aid them in organizing their personal scripts afterwards.

Basic topics will include: Package setup, function documentation and development cycle. As every package should come with example data, we will show how to implement these into a package, as well as more detailed function explanations within a vignette. Testing routines and licensing for publication, e.g. using git (Github, Gitlab or similar) will enable attendees to share their work safely.

Basic R knowledge is strongly recommended for the workshop. Software requirements will be announced to registered attendees later.

References

R Core Team. 2020. R: A Language and Environment for Statistical Computing. Vienna, Austria: R Foundation for Statistical Computing. https://www.R-project.org/.

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

Wickham, Hadley. 2020. R Packages. Organize, Test, Document and Share Your Code. 2nd ed. O’Reilly. https://r-pkgs.org/.

Keynotes

Barbara J. Mills

Regents Professor

School of Anthropology

University of Arizona

Tucson, AZ, USA

Title of presentation:

How Edges Become Centers: Social Network Perspectives on Regional Social Transformation

Abstract:

Regional analyses of archaeological settlement distributions have often relied on models such as World Systems Theory to characterize areas as centers vs. peripheries in which peripheries are seen as watered down versions of core areas. This flawed model still permeates archaeology but new empirical and experimental research using network analyses provide a way to revisit the role of ‘edge regions’ in the dynamic unfolding of regional settlement interaction and social change. Empirical examples from large-scale datasets from the North American Southwest illustrate the important roles of migration, social diversity, cooperation, and innovation in the transformation of social networks during the Chaco and post-Chacoan periods (AD 850-1450). These results are situated within new experimental approaches on social networks showing that social changes are more effectively carried out by individuals on the peripheries of networks who maintain wide, bridging ties. In other words, it isn’t how well-connected you are, but how you are connected. By combining empirical and experimental network analyses, we can situate our work within broader theories of social innovation and transformation.

Bio:

Barbara J. Mills (PhD, University of New Mexico) is a Regents Professor in the School of Anthropology, University of Arizona. She is an archaeological anthropologist whose research involves using material culture (especially pottery and architecture) to study migration, interaction, and social change at multiple scales from households to macro-regions. Her work employs a variety of approaches including pottery technology, social network analysis, and demography. While most of her research has been conducted in the North American Southwest, she also has archaeological experience in Guatemala, Turkey, and Kazakhstan. Following her work as director of the Silver Creek Archaeological Project in east-central Arizona, she began the collaborative Southwest Social Networks Project to synthesize data from across the region for social network and GIS analyses. Funded by the National Science Foundation, this project has now been incorporated into cyberSW, a cyberinfrastructure that makes the data from her and others’ projects available along with an analytical toolbox. Professor Mills is the recipient of the Society for American Archaeology (SAA) Award for Excellence in Archaeological Analysis – Ceramics (2015), a SAA Presidential Recognition Award (2017), the Patty Jo Watson Distinguished Lecturer for the Archaeology Division (AD) of the American Anthropological Association (AAA) (2011), and the Gordon Willey Prize (AD, AAA) for the best archaeology article in American Anthropologist (2006).She is the author or editor of 9 books and has published over 90 peer-reviewed articles and book chapters. She is the co-editor of The Oxford Handbook of Southwest Archaeology (2017) and the forthcoming Oxford Handbook of Archaeological Networks Research.

Andrew Bevan

Professor of Spatial and Comparative Archaeology

Institute of Archaeology, UCL, UK

Title of presentation:

Computational and digital archaeology after more than five decades

Abstract:

Although study of the human past via computers and digital recording is a story many decades old, it is now commonplace for archaeologists to acknowledge that they work in an increasingly altered landscape. On the one hand, a deluge of newly digital evidence is available in archaeology, with further floods coming from collaborating subject areas. Such information can be both systematic and serendipitous, is increasingly remotely-sensed and/or spatial, and offers content that is often semantically-rich and/or progressively-licensed. On the other hand, digitised archaeological 'data' is still just one corner of a more enduring ternary relationship with archaeological theory and method — and so it is also worth highlighting ways in which computational and digital archaeologies have advanced the latter two domains as well. With regard to method, for example, recent years have seen fascinating dialectics of research scale and priority, from micro-sampling to data-mining, from digitally 'thick' to 'thin' description, from sensory experience to systemic patterning, from bulk to bijou prospection or from simple to complex simulation. This paper reflects on these diluvian landscapes and complementary priorities, with a view to the exhilarating current opportunities in our field.

Bio:

Andrew Bevan is Professor of Spatial and Comparative Archaeology at the UCL Institute of Archaeology, and has had close involvement for over 15 years with a UCL MSc programme that has focused on archaeological computing, digital methods and spatial analysis. His personal research interests cluster at the intersection of traditional subjects such as archaeology, history, geography and anthropology, while these interests have often been addressed via the flexibility and formality that computing affords. His article-length publications range widely across aspects of spatial and temporal analysis, landscape archaeology, material culture studies and social theory, including research projects located in north-west Europe, central America, eastern Asia and the Mediterranean. Most of his work so far has been collaborative, including past or present research projects devoted to characterising long-term change in Mediterranean population and land use, to understanding the imperial logistics responsible for the Chinese Terracotta Army, to crowdsourcing of archaeology and heritage data online, to modelling large-scale artefact distributions or to exploring the patterns of food production and storage. He is an advocate of open science approaches to data and methods.

Sessions CAA 2021

S1. Paradata to the people! Documenting documentation and more (Roundtable)

S2. Hic sunt dracones – Improving knowledge exchange in the Semantic Web with Linked Open and FAIR data (Standard)

S4. Archaeological practices and knowledge work in the digital environment (Roundtable)

S5. From CAD to GIS. Implications of a fundamental change in documenting excavations (Standard)

S6. The archaeological perspective on the use of satellite data (Standard)

S7. Conceptualising, Processing and Visualising Vagueness in Archaeological Data (Standard)

S8. New challenges in archaeological network research (Standard)

S9. Digital fieldwork: technologies, methods and good practices (Standard)

S10. Modelling socio-ecological dynamics of past societies: recent advancements and new perspectives (Standard)

S11. Advances in Digital and Computational Archaeology in Taiwan and Neighboring Regions (Standard)

S12. Digital Infrastructures and New (and Evolving) Technologies in Archaeology (Roundtable)

S13. Our little minions, part 3: small tools with major impact (Other)

S14. Bayesian Approaches to Archaeological Questions (Standard)

S15. Archaeological Exploration of Digital Spaces (Standard)

S16. Problem and Project-based learning in Digital Archaeology Pedagogy (Standard)

S17. Tools for the Revolution: developing packages for scientific programming in archaeology (Standard)

S18. Urban Complexity in Settlements and Settlement Systems of the Mediterranean (Standard)

S19. Challenging the axiom that “absence of evidence is not evidence of absence” (Standard)

S21. Archaeology-related online community practices (Standard)

S22. From surface distributions to settlement patterns: field survey during COVID-19 (Other)

S23. 3D Scholarly Editions: Potential, Limitations, and Challenges (Standard)

S24. Ghosts in the machine: Reflections on traditions of survey practice at the eve of automation (Other)

S25. Exploring the possibilities of 3D Spatial Analysis (Standard)

S26. Moving Over Seas: Modeling Seafaring Routes to Analyze Past Connections (Standard)

S28. Computational modelling in archaeology: methods, challenges and applications (Standard)

S32. From artificial intelligence to stratigraphic reality. Dynamics of an inverse process for AI applications in archaeology (Standard)

S35. Round Table proposals for EU ERA Chair Mnemosyne (Roundtable)

S1. Paradata to the people! Documenting documentation and more (Roundtable)

Convenor(s):
Isto Huvila, Uppsala University

Thursday, June 17, Tombs of the Kings
15:00 – 16:30

A key obstacle to using and understanding archaeological legacy data is seldom the lack of general information about the data, but that there is not enough contextual knowledge of its origins and earlier use. A lack of proper understanding of how data, models, visualisations and other carriers of archaeological knowledge make it difficult or impossible to interpret them properly. The issue is accentuated in the contemporary digital contexts where documentation needs to be more explicit than ever to ensure that the traces of its making and use become and remain visible and are preserved.

The data that documents the processes relating to data and information in different forms is conventionally refered to as paradata in the literature. Even if its importance has been acknowledged already a long time and especially in field archaeology, the documentation of not only observations but the documenta-tion processes is a common practice and requirement, the systematic capturing, understanding and use of paradata is still at its infancy.

This roundtable session hosted by the CApturing Paradata for documenT- ing data creation and Use for the REsearch of the future (CAPTURE) project (www.uu.se/en/research/capture) invites short lightning talks describing evidence- based and theoretical work, positions statements and perspectives relating to archaeological paradata i.e. data about processes of, for instance, creating, using, manipulating and managing archaeological data and information in different forms (e.g. digital measurement and observation data, spatial data, visualisations, texts physical collections and features). This can include data about the making of 3D visualisations or digital or non-digital paradata about the provenance of digital or non-digital field observations. The contributions should focus on identifying theoretical and practical opportunities, challenges and gaps in how paradata is understood at the moment, how these issues should be solved and what aspects require more research.

JUNE 17th

Introduction

Isto Huvila

Integrated Data & Process Documentation through Methodology Enactment

Cesar Gonzalez-Perez

Documenting 3D cultural heritage: enabling reuse

Kate Fernie

Paradata for adding context to semantic data integration?

Douglas Tudhope

(ID: #251) Documenting the shift in meaning over long-term archaeological project

Adela Sobotkova

(ID: #98) Paradata beyond the field: creating legacy from legacy data

Ian Johnson

Discussion

S2. Hic sunt dracones – Improving knowledge exchange in the Semantic Web with Linked Open and FAIR data (Standard)

Convenor(s):
Florian Thiery, Römisch-Germanisches Zentralmuseum
Martina Trognitz, Austrian Centre for Digital Humanities at Austrian Academy of Sciences
Ethan Gruber, American Numismatic Society

Tuesday, June 15, Kourion
10:00 – 11:35, 11:50 – 14:25, 15:00 – 16:30

In historical maps, the phrase Hic sunt dracones (engl. here be dragons) is used to describe areas which were unknown to the map creator [UW19]. Today the WWW gives researchers the possibility of sharing their research (data) and enables the community to participate in the scientific discourse to create previously unknown knowledge. But much of this shared data are not findable or accessible, thus resulting in modern 'unknown data dragons'. Often these 'data dragons' lack connections to other datasets, i. e. they are not interoperable and in some cases even lack usefulness or usability. To overcome these shortcomings, a set of techniques, standards and recommendations can be used: Semantic Web and Linked Open Data, the FAIR principles and LOUD data.

Tim Berners-Lee introduced the concept of Semantic Web, where he suggested using the ideas of Open Data, semantically described resources and links, as well as usable (machine readable) interfaces and applications for creating a Giant Global Graph. In 2016 the FAIR principles were introduced [MW16]: Research data and its metadata have to be Findable, Accessible, Interoperable and Reusable. Linked Data is an essential part of the FAIR principles: "The Semantic Web isn't just about putting data on the web. It is about making links, so that a person or machine can explore the web of data. [TBL06]." Publishing research data as HTTP URIs with RDF content containing links to other resources makes data FAIR!

On top of that, these data should be open for access, re-use and universal participation [ODH19]. A five star rating system of openness [MH12] was introduced to rate Linked Data, i. e. "Linked Open Data (LOD) is Linked Data which is released under an open licence. [TBL06]. " Furthermore, LOD have to be usable for scientists and programmers to take advantage of all the LOD power. Following the LOUD principles[RS18] will make LOD even more FAIR.

Merging all these principles to create FAIR and LOUD research data results in the Sphere 7 Data Model [FT19], which enables a wide array of digital humanities and archaeological (web-)applications using LOUD and FAIR data.

The Linked Data Cloud already offers research data repositories for certain archaeological and humanities domains. Popular examples of FAIR LOUD providers are: Nomisma.org [EG18], Kerameikos.org [GS15], Pelagios [ISBS14], OpenContext [EC07], Portable Antiquities Scheme [EH18], ARIADNE [AN17] and there are more to come, e.g. NAVIS [TM18b], ARS3D [TKR19] and ARIADNEplus [AP19].

The development of more and more repositories poses challenges in handling the complex facets of data quality and completeness. This is especially valid for archaeological data, which are based on a complicated network of concepts from different knowledge domains. Moreover, it is necessary to include means of conveying knowledge about uncertainty in the data models to produce and publish transparent FAIR and LOUD data that can also describe specific stratigraphies or the (archaeological) context of objects. In order to be able to connect different data resources, exchange standards also have to be developed, published and applied.

To enable non-experts in engaging with FAIR, and especially LOUD data, small tools – minions – were created for different purposes, such as modelling a relative chronology (Alligator [DS18]), modelling and reasoning on vague edges in graph data (Academic Meta Tool [TM18]), creating annotated texts and images (Recogito [SBIS17]), and creating controlled vocabularies (Labeling System [TE16]). Furthermore, Wikidata [EGKMV14] not only offers community-driven data, but also provides a vast set of tools for using and interacting with it.

The goal of our session is to bring together experts on LOD and FAIR data, as well as anybody interested in learning about FAIR and LOUD data-driven publishing, applications and research projects based on this kind of data. We would like to discuss ideas for FAIR and LOUD data models as a basis for reproducible research and exchange in the Semantic Web.

This session is intended as a starting point for the CAA SIG on Semantics and LOUD in Archaeology. The core aim of this SIG is to use the CAA’s SIG format to raise awareness for Linked Data in archaeology by creating a friendly and open platform to discuss the role of LOUD and FAIR Data in archaeology, and to enable the CAA community to learn about LOD basics. If you wish to join the SIG, feel free to contact us to be an active part of the discussion [SIG19] and help us to navigate archaeology away from the data dragons.

The success of the sessions on data quality in Linked Data at CAA 2017 and 2018 has raised awareness of the many challenges related to FAIR and LOUD data, and encourages pursuing the debate. For this session we invite contributions that address part or all of the following issues:

- application of semantic web technologies, such as ontologies or RDF, to the archaeological domain
- modelling archaeological artefacts as FAIR and LOUD data
- modelling archaeological context, including the specificity of stratigraphy, uncertainty, and vagueness as FAIR and LOUD data
- proposals for FAIR and LOUD data exchange standards
- development of research tools producing or using FAIR and LOUD data
- identifying sources and dangers of incorrect or ambiguous LOD
- identifying duplicates across different LOD sources
- keeping track of the provenance of data as a means of solving errors and identifying their source
- setting up methodologies and tools in order to label or assess datasets based on their quality
- dealing with ambiguities resulting from multiple links in the LOD cloud

- computer vision or machine learning applications built upon controlled, semantic data

We encourage presenters to derive the problems from real-world datasets and to formulate proposals for solutions, preferably demonstrating (prototypes of) realised data-driven web applications. Since we target a broad and diverse audience because of the thematic relevance, the challenges described should also be integrated into the archaeological context (excavation, museum, archive, etc.).

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JUNE 15th

10:00 – 10:20

(ID: #233) On using the CIDOC CRM to model archaeological datasets

Marlet Olivier, Roulet Théo, Hivert Florian, Markhoff Béatrice, Rodier Xavier, Simon Gaël

10:20 – 10:40

(ID: #81) Making Practical Use of Linked Open Data

Ceri Binding, Douglas Tudhope

10:40 – 11:00

(ID: #55) Linked Open Usable Data for Archaeology Including Modeling of Interpretations

Brigit Danthine, Daniel Brandner, Gert Goldenberg, Caroline Grutsch, Gerald Hiebel, Manuel Scherer-Windisch, Markus Staudt

11:00 – 11:20

(ID: #134) Historic maps as a multifaceted LOUD resource

Junaid Abdul Jabbar, Rebecca C Roberts, Huw Jones, Marco Madella, Hector Orengo, Cameron Petrie

11:20 – 11:35

(ID: #72) Linked Open Data – Problems encountered and approaches to solving them in the numismatic domain

Karsten Tolle, David Wigg-Wolf

COFFEE BREAK

11:50 – 12:10

(ID: #198) An Open and Shut case? Towards Shared Standards for Stratigraphic Data and Heritage Linked Data or LOD

Keith May, James Taylor, Ceri Binding

12:10 – 12:30

(ID: #57) Hic sunt dracones – How to make modern data dragons LOUD and FAIR

Florian Thiery, Allard Mees

12:30 – 12:50

(ID: #243) Routes to Linked Open Data: Modelling FAIR ceramics based on CIDOC CRM and a regional data acquisition system

Sophie C. Schmidt

12:50 – 13:10

(ID: #70) The Metsemegologolo African urbanisms project: Experiences developing a database of archaeological material with a geospatial focus

Anton S Coetzee, Stefania Merlo, Justine Wintjes

13:10 – 13:30

(ID: #156) The Living Archive of Çatalhöyük: investigating the in-/transparencies of archaeological knowledge production

Dominik A Lukas

13:30 – 13:50

(ID: #135) Linked Open Data Vocabularies and Recognizing Intellectual Contributions via ORCID

Ethan Gruber, Tyler Jo Smith, Renee Gondek, Abigail Bradford

13:50 – 14:10

(ID: #145) Reflections of history: An approach to enhanced documentation of cultural heritage

Myrto Koukouli, Akrivi Katifori, Maria Boile, Dimitra Petousi, Yannis Ioannidis

14:10 – 14:25

(ID: #136) Linked Art for Archaeological Data Exchange

Ethan Gruber, Tyler Jo Smith, Renee Gondek

LUNCH BREAK

15:00 – 15:20

(ID: #258) Linking datasets in Norway

Espen Uleberg, Mieko Matsumoto, Christian-Emil Ore, Jakob Kile-Vesik

S4. Archaeological practices and knowledge work in the digital environment (Roundtable)

Convenor(s):
Isto Huvila, Uppsala University
Costis Dallas, University of Toronto
Suzie Thomas, University of Helsinki
Eleftheria Paliou, University of Cologne
Rimvydas Laužikas, Vilnius University

Wednesday, June 16, Amathous
11:50 – 14:20

At the time of rapid development of novel computer applications for archaeology, there is an increasing need to critical understanding of their implications to the practices of knowledge production in and about archaeology (cf. Lambourne et al., 2014; Selhofer & Geser, 2015; Geser & Selhofer, 2014; Geser & Niccolucci, 2016; Huvila & Huggett, 2018). In-depth insights into how digital tools and methods impact the making and use of archaeological knowledge are a key to a better understanding of how the use of digital technologies influence archaeological work and thinking and of being able to steer the use of computer applications to improve the quality of archaeological work.

There is an emerging body of work in the field ranging from the studies of field practices (e.g. Dell’Unto et al., 2017) to collections based research (e.g. Khazraee, 2019; Faniel et al., 2018), and use of digital archaeological tools and information in different branches of the society from education and public presentation to community archaeology and land development (e.g. Laužikas et al., 2018; Foka et al., 2017; Huvila, 2017) in the context of individual research projects, national initiatives, as well as EU funded projects and frameworks such as CARARE, Europeana Cloud, ARIADNEplus, ARKWORK, SEADDA and DARIAH and other multi-national efforts like in the work of the European Archaeological Council.

The session organised under the auspices of the COST Action Archaeological practices and knowledge work in the digital environment (ARKWORK) invites paper proposals on evidence-based and reflective studies of digital practices and knowledge work in archaeology relating but not limited to how material cultural heritage is being digitised, preserved and made available, how archaeological remains are documented, how the documentation and archaeological collections are used to create knowledge on archaeology and the human past, and how the knowledge the broad range of stakeholders from land development and academia to tourism and education to do their work from complementary disciplinary perspectives. The session is open for proposals and participation by archaeologists working with digital tools reflecting their use of technologies, developers of digital applications conducting user studies and evaluations and a broad range of scholars from fields including but not limited to museum studies, sociology, ethnography, information studies, science and technology studies and beyond conducting evidence-based studies of digital archaeological practices and knowledge work,

References

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JUNE 16th

Introduction

(ID: #214) Tales from Two River Banks? Is there an increasing digital divide between Development Funded archaeological practice and Research Funded archaeological practice?
Keith May

(ID: #216) Undergraduate Education Towards Digital Archaeological Practice
Nimet Pınar, Ozguner Gulhan

(ID: #106) Critical Digital Archaeology. A postphenomenological approach to AI applications in Archaeology
Gabriele Gattiglia

(ID: #54) A little knowledge is a dangerous thing: Analogue practices with digital tools
Åsa M. Larsson, Daniel Lowenborg, Maria Jonsson, Marcus Smith, Gísli Pálsson

(ID: #125) Technologies and archaeological site inscription (knowledge claim) mutation
Yashaswini Jayadevaiah, Koumudi Patil

Digital archaeology and regulatory failure: the description of the problem

Rymvidas Lauzikas

(ID: #213) Creating a Digital Data Story, Proof-of-Concept and Early Lessons
Meghan Dennis

Short Commentaries

Break

Discussion

S5. From CAD to GIS. Implications of a fundamental change in documenting excavations (Standard)

Convenor(s):
Axel G. Posluschny, Research Centre of the Keltenwelt am Glauberg
Reiner Göldner, Saxon Archaeological Heritage Office
David Bibby, Regierungspräsidium Stuttgart

Wednesday, June 16, Amathous
15:00-16:30
Thursday, June 17, Kourion
16:50-18:20

Documentation of excavations in recent years has undergone fundamental changes. After digital documentation methods have become standard with CAD tools, GIS are more and more taking over for a number of reasons:

- GIS offer database options to be combined with graphical elements
- GIS are usually used anyway to analyse excavation data
- GIS software is available as FOSS (free and open source software) in a greater variety than CAD software

However, the move from CAD to GIS has a number of implications for documenting, storing and analysing excavation data, including problems with documenting 3D structures, changing the philosophy of recording elements in the field etc. Various tools offer different approaches:

- survey2GIS (https://www.survey-tools.org/) uses recorded data from total stations and transfers these into shape files for further use.
- Tachy2GIS (https://github.com/Archaeological-Museum-Hamburg/Tachy2GIS) on the other hand uses incoming data from total stations to directly ‘draw‘ features on an attached computer. The choice for one of these approaches of course also has an impact on the documentation strategy.

GIS may also be advantageous for archiving purposes. There are highly standardized geodata formats (e.g. based on ISO 19125 Simple Features). So it would be interesting to discuss specific archaeological geodata structures with regard to preservation, archiving and re-use, preferably based on experiences from real life geodata.

We invite contributions that deal with practical aspects of the tools in use, that offer new and exciting solutions or that show case studies, where GIS has been used, solving problems or creating problems.
We would also very much welcome contributions that tackle the theoretical aspects of digital tools for documenting excavations in general and the change from CAD to GIS in special.

JUNE 16th

15:00-15:20

(ID: #232) 25 years of trends in digital data deposition at the ADS
Teagan K Zoldoske, Olivia Foster, Kieron Niven

15:20 – 15:40
(ID: #17) From CAD to GIS to BIM to where? Archaeological documentation in 3D
Markos Katsianis, Kostas Kotsakis

15:40 – 16:00

(ID: #206) A report of failure and understanding: The introduction of GIS and Open-Data as a standard for documentation and archiving in rescue excavations

Marco Schrikel, David Bibby

16:00 – 16:20

(ID: #32) TachyGIS – Support to Change from CAD to GIS
Reiner Göldner

JUNE 17th

16:50 – 17:10

(ID: #43) Steps towards database driven excavations in lakeside settlements

Niels K. Bleicher, Tim Wehrle, Claire Ries

17:10 – 17:30

(ID: #48) Open data and closed lines. Reflections on the management of CAD drawings and RDBMS from the open datasets of Massaciuccoli Romana excavations

Gabriele Gattiglia, Francesca Anichini, Filippo Sala

17:30 – 17:50

(ID: #227) New tools dealing with old issues: from graphical elements to semantic objects

Andrea D'Andrea, Alexia Pavan, Roberta Giunta

S6. The archaeological perspective on the use of satellite data (Standard)

Convenor(s):
Deodato Tapete, Italian Space Agency (ASI)
Francesca Cigna, National Research Council (CNR) – Institute of Atmospheric Sciences and Climate (ISAC), Italy
Arianna Traviglia, Italian Institute of Technology (IIT) – Centre for Cultural Heritage Technology

Tuesday, June 15, Amathous
10:00 – 11:35, 11:50 – 14:20, 15:00 – 16:35

It is undisputable that satellite data are valuable to support different types of archaeological activities such as prospection, surveying, regional mapping, condition and damage assessment. The ever-growing scientific literature provides evidence of numerous cases of successful implementation (Agapiou & Lysandrou, 2015). Online visualisation platforms such as Google Earth and Bing Maps have massively contributed to make satellite images a resource for archaeologists (Luo et al., 2018), and cloud computing facilities such as Google Earth Engine are increasingly exploited by archaeologists to analyse multi-temporal datasets (Agapiou, 2017; Orengo & Petrie, 2017).

However, the use of satellite data is not yet an established practice across the whole international community of archaeologists. Image processing expertise is mostly clustered around multi-disciplinary teams (Tapete, 2018; 2019), and some teams of field archaeologists still do not utilise satellite images in daily practice, and show limited enthusiasm in these technologies for everyday use (Ruciński et al., 2015; Rączkowski & Mickiewicz, 2019) privileging ad hoc aerial imagery.

The evidence gathered from the literature suggests that archaeologists have so far mostly exploited optical satellite images collected at high to very high spatial resolution (from 5 to less than 1 m). Less frequent is, instead, the use of other data types, such as Synthetic Aperture Radar (SAR) and multispectral imagery at lower resolution (> 5 m), e.g. Sentinel-2. Some recent studies attempted to demonstrate the value of these data (e.g., Tapete & Cigna, 2018). However, users have paid little attention to these space-borne sensors (as highlighted, e.g., in Opitz & Hermann, 2018), despite the costless accessibility, global spatial coverage, high temporal revisit and ease of data handling. Training and multi-disciplinary collaboration were proved to be effective gap-bridging actions to promote the use of new, or long-existing but yet-to-exploit, space technologies by non-experts and beginners (Tapete & Cigna, 2016). Training is also the best way to build capacity and disseminate standard methodologies (e.g., Rayne et al., 2017).

This also aligns with the efforts currently made by space agencies (e.g., the European Space Agency – ESA) to make users more acquainted with satellite data. Nevertheless, in the end it is up to the users to perceive such particular technology as useful to their scopes, and make it work in the daily practice.

To capture these divergent trends across the community, we propose to hold this standard session to understand the directions in which the use of satellite data in computer applications for archaeology is heading, based on the direct feedback from archaeologists.

The overall aim is to bring together archaeologists who already work with satellite data and scholars who can demonstrate the spectrum of archaeological challenges and unsolved problems to which satellite data can try to provide a solution.

We will select a range of papers including, but not limited to, the following topics and open questions:

- Which archaeological domains already benefit from the use of satellite data?
- Which barriers currently prevent further exploitation or make some types of data more used than others (e.g., optical vs. SAR)?
- Which requirements and expectations archaeologists have and would like to see addressed by current and future satellite data, so they can use these images as a resource for their daily practice?
- How pure observations from satellite images can be fed into archaeological interpretation and understanding of anthropogenic processes (e.g., settlement patterns or damage mapping into causal relationships between social and political organisation and environmental conditions)?
- What are the lessons learnt and best practices in the use of large amounts of satellite images for archaeological and cultural heritage recording and creation of databases?
- Which role automation can play to solve technical challenges in big data handling?

and we will welcome examples of capacity building initiatives contributing to make satellite data and standard processing routines more accessible to users.

In addition to the open call, we will solicit the submission of papers from scholars who can provide the evidence base to hold this discussion.
We expect that this session will attract a diverse audience, not limited to scholars and researchers who are highly skilled in processing satellite data, but also encompassing archaeologists, heritage practitioners and younger generations. The latter may not be already familiar or aware of these technologies, but could help to target the areas where satellite data can be better used and disseminated, and offer real use-cases with clear archaeological research questions to address. The interaction with this cross-section of the community will allow us to collect user needs and feedback in the context of the current scenario of satellite missions (e.g., EC Copernicus programme) and future developments.

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JUNE 15th

10:00 – 10:20
(ID: #52) The European Union's Copernicus Programme in Support of Cultural Heritage
Benjamin Ducke

10:20 – 10:40
(ID: #167) Copernicus Earth Observation and Big Data for Cultural Heritage Management
Athos Agapiou, Vasiliki Lysandrou

10:40 – 11:00
(ID: #22) The concept of human-trace SAR satellite initiated from past investigations of SAR in archaeology
Fulong Chen

11:00 – 11:20
(ID: #19) High-resolution or long wavelength? What is the right SAR sensor for archaeological applications
Timo Balz, Gino Caspari

11:20 – 11:35
(ID: #35) Listening to archaeologists and practitioners: analysis of the user feedback on the use of Copernicus data
Deodato Tapete, Francesca Cigna, Branka Cuca, Cristian Moise, Iulia Dana Negula

COFFEE BREAK

11:50 – 12:10
(ID: #263) Uses of Sentinel-1 and -2 imagery in heritage protection and management strategies. A case study from Ostrów Lednicki (Poland)
Lidia Zuk, Sławomir Królewicz

12:10 – 12:30
(ID: #50) Satellite remote sensing for the reconstruction and mapping of archaeological resources in alluvial environments
Nicholas L Crabb, Chris Carey, Andy Howard, Robin Jackson, Matthew Brolly, Niall Burnside

12:30 – 12:50
(ID: #62) Potential of satellite imagery analysis for archaeological heritage studies and management in the suburbs of Khartoum (Sudan)
Mariusz Drzewiecki

12:50 – 13:10

(ID: #190) Documenting and monitoring the impact of dams to cultural heritage from space. Tuning satellite data collection to meet archaeologists’ needs

Federico Zaina, Deodato Tapete

13:10 – 13:30

(ID: #152) Medieval urban sites of Iraq in the sphere of archaeological remote sensing

Lenka Starkova

13:30 – 13:50

(ID: #73) Detecting Change at Archaeological Sites in North Africa using Open-Source Satellite Imagery

Louise Rayne, Nichole Sheldrick

13:50 – 14:10

(ID: #92) Towards Big Earth Data: cloud-computing workflows for the automated detection and monitoring of endangered archaeological sites

Francesc Conesa, Hector Orengo, Agustin Lobo, Arnau Garcia-Molsosa, Adam S Green, Cameron Petrie

14:10 – 14:25

(ID: #41) How many hectares? Combining remote sensing, historical cartography, and survey data to rapidly categorize and assess the size of archaeological sites in South Asia

Adam S Green, Hector Orengo, Aftab Alam, Francesc Conesa, Arnau Garcia-Molsosa, Joanna Walker, Ravindra Nath Singh, Cameron Petrie

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LUNCH BREAK

15:00 – 15:20

(ID: #128) Prospecting archaeological archives in South Africa through hyperspectral image processing and field spectroscopy

Christian Sommer, Volker Hochschild

15:20 – 15:40

(ID: #200) Assessment of soil erosion processes on archaeological sites using the SIMWE Model and GRASS GIS: The Case Study of Amathous, Cyprus

Nikoletta Papageorgiou, Rosa Lasaponara, Athos Agapiou, Diofantos Hadjimitsis, Chris Danezis

15:40 – 16:00

(ID: #239) Challenges and Opportunities in Cultural Heritage from the development of a Digital Innovation Hub (DIH) for Earth Observation and Geospatial Information in the Eastern Mediterranean, Middle East and North Africa (EMMENA) though Eratosthenes Centre of Excellence

Georgios Leventis, Diofantos Hadjimitsis, Phaedon Kyriakidis, Kyriakos Themistocleous, Gunter Schreier, Harris Kontoes, George Komodromos, Vasiliki Lysandrou

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COFFEE BREAK

BREAK

S7. Conceptualising, Processing and Visualising Vagueness in Archaeological Data (Standard)

Convenor(s):
Cesar Gonzalez-Perez, Incipit CSIC
Patricia Martín-Rodilla, University of A Coruña
Martín Pereira-Fariña, University of Santiago de Compostela
Maria Elena Castiello, University of Bern
Leticia Tobalina, Université de Pau et des Pays de l’Adour

Tuesday, June 15, Palaepaphos
10:00 – 11:30

Background

Vagueness has always been a difficult topic in science; information that is uncertain, or entities with unclear borders, for example, are especially difficult to treat. Over the past few years, for archaeology, and for the humanities in general, vagueness has started to be considered as a rich source of knowledge when it is adequately managed. Mechanisms to record, represent and communicate vagueness have been proposed, and CAA as well as other conferences has had some very good sessions on this topic in recent years. This complements a long tradition of trying to cope with vagueness; works such as [2] and, more recently, [6], have paved the way for more recent research.

The aim of this line of research can be summaries as follows: instead of treating vagueness as an undesirable and annoying aspect of archaeological information, we should start seeing it as a valuable resource that must be recorded, processed and visualised for richer interpretations and more nuanced conclusions.

Current Research

Recently, approaches have been proposed to classify vagueness in different types (such as ontological vs. epistemic [3]), capture vague information about archaeological entities [5], or visualise vagueness in 3D archaeological reconstructions [1]. The Digital Humanities community has also paid significant attention to this, with specific projects (such as PROVIDEDH, http://www.chistera.eu/projects/providedh) and some specific workshops and tracks focusing on vagueness, such as “Complexity And Uncertainty In DH Projects: A Co-design Approach Around Data Visualization” within Digital Humanities (DH) 2019, or “Uncertainty in Digital Humanities” in the International Conference on Technological Ecosystems for Enhancing Multiculturality (TEEM) 2019. Information science and computing are also starting to work on this field, as exemplified by the ongoing special issue of Information on vagueness [4].

Most of these works, however, are extremely data-oriented, focussing on how to capture vagueness in databases or how to express it in datasets. Although this is very interesting, it only constitutes part of the necessary work; in order to treat vagueness as a valuable asset, we must **start by being aware** of its existence and impact in our data models, and include the explicit treatment of vagueness as one factor in the decision-making processes of model building in archaeology. In addition, we need tools to build and process vagueness as one dimension of the archaeological data from the field to the final report.

So far, there are no tools like these, and drawing conclusions that incorporate vague knowledge or evaluating the impact of vagueness in research outcomes is practically impossible.

Expected Contributions

In this manner, research is necessary to contribute sound philosophical arguments to the treatment of vagueness in archaeology; to provide a good conceptualisation of related ontological and epistemic issues such as precision, exactitude, accuracy, perfection, error, ambiguity, generalisation, or reliability; and to suggest notational and visual devices to convey vagueness in 3D reconstructions, maps, charts and other forms of representations. Only when a solid theoretical foundation has been set will we be able to develop computer systems that can store, process and represent vagueness as appropriate.

This is especially so in relation to space and time. Objects with fuzzy spatial boundaries (such as many archaeological sites or areas) are difficult to manage, study and preserve, and events or phases with uncertain or unclear temporal boundaries are equally hard to treat. This session aims to advance contributions to fulfil these needs.

Expected Themes

Papers are welcome in this session about the following topics, among others:

- Philosophical accounts of vagueness, including ontological and epistemic aspects.
- Relationships between linguistic, spatial, and temporal vagueness.
- Theories, ontologies and conceptual models of data vagueness in archaeology.
- Use of different computational approaches such as fuzzy logic, many-valued logics, machine learning or other quantitative approaches to the description of vagueness in archaeological data.
- Incorporating vagueness to the recording of data in the field or the lab using databases and other information systems.
- Visualisation of vagueness in final outputs of computer-aided archaeological products, including datasets, maps, timelines, sketches, 3D reconstructions and other visual representations of the archaeological record.
- Case reports of archaeological sites or areas that have been affected (positively or negatively) by the treatment of vague information.

Audience
The session will be of interest to:

• Archaeologists concerned with a richer and more nuanced representation of spatial and temporal vagueness.
• Cultural heritage managers that must make decisions on, and deal with, information that is intrinsically imprecise and uncertain.

• Developers of information systems that are aiming to capture vagueness in their data.

Session Format
This will be a standard session including an introductory invited keynote talk (20 minutes) plus a number of 20-minute papers. Time for discussion will be available.

References

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[3] C. Gonzalez-Perez, Information Modelling for Archaeology and Anthropology. Springer, 2018.
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[6] B. Smith and A. C. Varzi, “Fiat and bona fide boundaries: Towards an ontology of spatially extended objects,” in Spatial Information Theory: A Theoretical Basis for GIS, no. 1329, S. C. Hirtle and A. U. Frank, Eds. Springer, 2005, pp. 103–119.

JUNE 15th

10:00 – 10:20
(ID: #53) Dating mechanisms: possibilities and limitations of dealing with time intervals of the Roman Limes. Vagueness in the case of terra sigillata (samian) chronology
Allard Mees (RGZM), Florian Thiery

10:20 – 10:40
(ID: #202) On the Emerging Supremacy of Structured Digital Data in Archaeology
Piraye Hacıgüzeller, James Taylor, Sara Perry

10:40 – 11:00
(ID: #230) The ambiguity of the classification process in the digital environment. Typologies and quantification of shape similarity in the analysis of pottery
Agnieszka E. Kaliszewska, Rafał Bieńkowski

11:00 – 11:20
(ID: #247) A fuzzy approach to type formulation, definition and description
Danai Kafetzaki, Jeroen Poblome, Jan Aerts

11:20 – 11:40
(ID: #138) Reassessing reflexive digital archaeology - a modest proposal
Mike Kelly

S8. New challenges in archaeological network research (Standard)

Convenor(s):
Philip Verhagen, Vrije Universiteit Amsterdam
Tom Brughmans, Aarhus University
Grégoire Van Havre, Universidade Federal do Piauí
Aline Deicke, Akademie der Wissenschaften und der Literatur Mainz
Natasa Conrad, Zuse Institut Berlin
Phil Riris, Bournemouth University

Tuesday, June 15, Salamis
18:30 – 20:30

Wednesday, June 16, Kourion
15:00 – 16:30

New challenges emerge as network research becomes ever more common in archaeology: can we develop new network methods for dealing with archaeological data, and how can cross-disciplinary collaborations be leveraged to make original contributions to both archaeology and network science? In this session, we aim to explore some of the core issues in current network research that need cross-disciplinary collaboration, in particular dealing with data uncertainty in archaeology, and integrating archaeological spatial and temporal analysis in network research. This session welcomes papers on archaeological network research including but not exclusive to these new challenges.

Although a range of techniques exist in both archaeology and network science for dealing with missing data and data uncertainty, the fragmentation of the material record presents a challenge – made more explicit through the use of formal methods – that is hard to tackle. Much of the task of identifying network science equivalents of archaeological missing data techniques remains to be done, and there is a real need for identifying how archaeological approaches could lead to the development of new network mathematical and statistical techniques. But by far most pressing is the need to formally express data uncertainty and absence in our archaeological network research.

A second challenge is the inclusion of spatial and temporal archaeological analysis into network research. Archaeology as a discipline has a long tradition of spatial analysis and of exploring long-term change in datasets and past phenomena. These are two areas where archaeologists did not look towards mathematicians, physicists and sociologists for inspiration, but rather developed original network methods based on a purely archaeological tradition. As such, they are some of the most promising research topics for archaeologists to make unique contributions to network science.

The spatial phenomena archaeologists address in their network research are rather narrow and can be grouped into three broad categories: movement-, visibility- and interaction-related phenomena. The aim of network techniques in space syntax focus on exploring movement through urban space, whereas least-cost path networks tend to be used on landscape scales. Neither of these approaches have equivalents in network science (Verhagen et al. 2019). Archaeology has a strong tradition in visibility studies and is also pioneering its more diverse use in network research (Brughmans and Brandes 2017). Most visibility network analyses tend to explore theorised visual signalling networks or visual control over cultural and natural features. Most network methods used for exploring interaction potential between past communities or other cultural features belong to either absolute or relative distance approaches: such as maximum distance network, K-nearest neighbours (sometimes referred to in archaeology as proximal point analysis (PPA)), beta-skeletons, relative neighbourhood network or Gabriel graph. These, however, are derived from computational geometry and have a long tradition in network research and computer science. Moreover, this is a not a field in which archaeologists seem to push the boundaries of network science (with perhaps a few exceptions; Knappett et al. 2008).

There are a few commonalities between the archaeological applications of these movement, visibility and interaction networks. They tend to be network data representations of traditional archaeological research approaches (e.g. viewsheds, least-cost paths, urban settlement structure, community interaction), and they tend to be applied on spatially large scales with the exception of space syntax (inter-island connectivity, landscape archaeology, regional visual signalling systems). How can we diversify spatial archaeological network research? How can we go beyond making network copies of what archaeologists have done before and rather draw on the unique feature of network data (the ability to formally represent dependencies) to develop even more original spatial network techniques? This seems to us like an eminently possible task for archaeologists.

Despite being at the core of archaeological research, the use of temporal (or longitudinal) network data is common but incredibly narrow in archaeological network research. By far the most common application is to consider dating evidence for nodes or edges and to chop up the resulting networks into predefined categories that could have a typological, culture historical or chronological logic (e.g. artefact type A; Roman Republican; 400-300 BC). This process results in subnetworks sometimes referred to as snapshots, the structure of which are explored in chronological order like a filmstrip. A significantly less common approach is to represent processes of network structural change as dynamic network models (e.g. Bentley et al. 2005), or to represent dynamic processes taking place on top of network structures (e.g. Graham 2006).

This research focus of temporal archaeological network research is not at all representative of the diverse and critical ways archaeologists study temporal change. How can the archaeological research tradition inspire new temporal network approaches? How can the use of dynamic network models become more commonly applied? What temporal approaches from network science have archaeologists neglected to adopt? How can, for example, studies modeling the evolution of networks suggest explanations for the levels of complexity observed in past networks?

Recognition of these contributions outside archaeology has still to materialise due to a number of challenges. How can we ensure these archaeology-inspired approaches become known, explored and applied in other disciplines? How precisely do these spatial and temporal archaeological approaches differ from existing network methods? What existing spatial and temporal approaches in archaeology show equal potential for inspiring new network research?

Like many other aspects of archaeological network research, this challenge should be faced through cross-disciplinary collaboration with mathematicians, statisticians and physicists. Archaeological network research has a great track record of such collaborations, but not all of them have been successful and not all archaeologists find it equally easy to identify collaborators in other disciplines. How can we facilitate the communication between scholars with different disciplinary backgrounds? How can we foster archaeological network research that holds potential contributions to archaeology as well as other disciplines? What events and resources should be developed to provide a platform for cross-disciplinary contact and collaboration?

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JUNE 15th

18:30 – 18:50

(ID: #39) The antiquities in Phocis and Boeotia described by Gell and Dodwell

Zafeirios Avgeris

18:50 – 19:10

(ID: #84) A methodological approach for Intra - Site Analysis of Spatial Organization of Thessalian Neolithic Settlements

Maria Cristina Manzetti, Apostolos Sarris

19:10 – 19:30

(ID: #85) Fuzzy chronologies in longitudinal network studies

Daniela Greger

19:30 – 19:50

(ID: #121) Exploring visual signalling networks of Medieval strongholds in Garhwal Himalaya, India

Tom Brughmans, Nagendra Singh Rawat, Vinod Nautiyal

16th JUNE

15:00 – 15:20

(ID: #160) On the calibration of least cost path models: a large-scale simulation of boat and wagon transport in late Iron Age Gaul

Fabrice Rossi, Clara Filet

15:20 – 15:40

(ID: #182) Evaluating the Effects of Randomness on Missing Data in Archaeological Networks

Robert Bischoff, Claudine Gravel-Miguel, Cecilia Padilla

15:40 – 16:00

(ID: #199) Mathematical modeling of spreading processes on archaeological networks

Natasa Djurdjevac Conrad

16:00 – 16:20

(ID: #210) Roads and rivers. The importance of regional transportation networks for early urbanization in central Italy (1000-500 BC)

Francesca Fulminante, Luce Prignano

S9. Digital fieldwork: technologies, methods and good practices (Standard)

Convenor(s):
Łukasz Miszk, Jagiellonian University in Kraków
Wojciech Ostrowski, Warsaw University of Technology

Tuesday, June 15, Palaepaphos
11:50 – 14:20, 15:00 – 16:30

The present digital revolution and its applications in archaeology have fundamentally changed the ways in which we conduct archaeological work. We encounter these changes in many aspects of practice (Tspidis et al. 2011; Forte et al. 2012; Berggren et al. 2015. Katsianis et al. 2015):

Technological aspect: using constantly upgraded hardware and software, Spatial aspect: broad implementation of a wide range of geodetic tools, e.g. GNSS technology, enabling the global georeferencing of various spatial data, has already become almost as popular as the use of local site coordinates, Methodological aspect: the use of diverse recognized methods of archaeological science has a huge impact on the field work, including processes of data acquisition and further data processing (sampling, documenting), The 'big data' aspect: concerns archaeological data management in the context of its rapid growth, as well as diversification of data formats and electronic data carriers, Logistic aspect: connected i.a. with the necessity to possess the appropriate human resources (qualified professionals) and fitting digital solutions (information-storage capacity), as well as funding applications and planning project finances.

Among the achievements of contemporary technology, modern digital methods of 3D stratigraphic documentation, enabling the registering of excavation as it progresses, through the implementation of 3D reality modelling solutions, e.g. photogrammetry, laser scanning (Forte et al. 2012; Dell'Unto 2014; Berggren et al. 2015; Opitz 2015), seem to have the biggest impact on how we conduct the whole process of archaeological work across all aspects noted above. These methods influence the equipment used during the fieldwork, dictate the necessary software, and lead to constructing custom-tailored archaeological databases for the projects. Documenting the excavation by means of photogrammetry or with the application of GIS databases is slowly becoming a standard. That is why 3D documentation experiences have repeatedly been presented and discussed during CAA meetings. However, the majority of papers given so far on the topic have focused only on the technical aspects of this change in practice. We emphasize that the presented modern technology solutions are mainly focused on the possibilities of photogrammetry itself, and many times these seem non-complementary to the whole archaeological research process, which should be digitally enabled, as well as, including basic documentation procedures.

Therefore, for this session, we invite papers focusing on further steps of modern digital fieldwork rather than on simple data acquisition or processing. The presented papers should respond to the following questions: How does data acquisition influence fieldwork? How are 3D stratigraphic data stored and combined with other data (concerning architecture, movable finds, archaeometric analyses etc.)? How are 3D and all other data visualized, analysed and shared? What are the results of these analyses? How are these results disseminated between the research team members?

The proposed session would welcome:

Papers presenting complete photogrammetric (or other reality modelling technology) solutions which have already been practically tested during archaeological fieldwork; examples of methods application on a big scale, i.e. on vast excavation areas, for teams composed of many people etc., would be especially interesting and most welcome.

Papers presenting holistic solutions of acquiring archaeological data and data management afterwards (such as examples of various custom-tailored databases, as well as technological solutions applied within them), and also ways of data post-processing and analysing.

Papers concerning various practical aspects of human resources challenges encountered within archaeological team work, such as human work organisation during the whole project, securing of appropriately qualified staff, as well as, enabling smooth cooperation and data exchange within the team.

Presentations of specific projects with their goals, challenges and solutions applied would be most welcome.

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JUNE 15th

11:50 – 12:10

(ID: #26) AtticPOT: a borderless approach for studying Attic painted pottery in ancient Thrace

Natasa Michailidou, Despoina Tsiafaki, Kostas Stavroglou, Ioannis Mourthos, Melpomeni Karta, Markos Dimitsas

12:10 – 12:30

(ID: #45) The Aide Memoire Project: Drawing and Archaeological Knowledge Production

Colleen Morgan, James Taylor, Holly Wright, Helen Petrie

12:30 – 12:50

(ID: #109) The deep end of the FAIR principles – making legacy GIS documentation from excavations interoperable and reusable

Daniel Lowenborg, Gísli Pálsson, Åsa M Larsson, Maria Jonsson, Marcus Smith

12:50 – 13:10

(ID: #161) Developing an efficient and "sustainable" method for 3D stratigraphic documentation: issues and advantages of a digital process. The case study of the medieval site of Vetricella, Italy

Giulio Poggi, Fabrizio Falchi, Luisa Russo, Mirko Buono, Lorenzo Marasco

13:10 – 13:30

(ID: #170) LiDAR and RGB airborne orthophotos coverage and visualization and automatic recognition of archeological findings in Kephissos /Phokis

Christos Kontopoulos

13:30 – 13:50

(ID: #175) Archeometry, Science and Technology Applied to the study of rupestrian architecture. New Conclusions About The rupestrian monastery of St Pedro of Rocas in the Ribeira Sacra (Galicia, Spain)

Jorge López Quiroga, Natalia Figueiras Pimentel

13:50 – 14:10

(ID: #177) Between two worlds. Implementation of various survey methods and their impact on the research process on both sides of the Vistula river in Lesser Poland

Jan Bulas, Magdalena Okońska-Bulas, Marcin Przybyła

14:10 – 14:30

(ID: #178) Reconstructing Bell Beaker funerary practices and burial taphonomy: applying digital 3D tools in the re-analysis of old field documentation from the site of Oostwoud-

Tuithoorn, West-Frisia
Hayley L Mickleburgh, Harry Fokkens

LUNCH BREAK

15:10 – 15:30
(ID: #248) Digital photogrammetric capture of the IS looters' tunnels under the Nebi Yunus Mausoleum, Mosul: its challenges, benefits, and further potential
Juan Aguilar, Stéphane Bordas

15:30 – 15:50
(ID: #257) Digital Data Curation Model: Designing a Unified Framework for Archaeology
Tugce Karatas

15:50 – 16:10
(ID: #259) Invisible Heritage - Analysis and Technology Platform. A multi-sensors documentation of the UNESCO listed churches in Troodos (Cyprus)
Dante Abate, Kyriakos Toumbas, Marina Faka

16:10 – 16:30
(ID: #261) The Byzantine City of Mystras: The South West Gate to Hagia Sophia Monastery
Vayia V. Panagiotidis, Nikolaos Zacharias

S10. Modelling socio-ecological dynamics of past societies: recent advancements and new perspectives (Standard)

Convenor(s):
Marta Krzyzanska, University of Cambridge
Leah Brainerd, University of Cambridge

Thursday, June 17, Amathous
11:50 – 14:20

This session aims to explore the diversity of computational methods used to model the relationship between environmental factors, subsistence systems and the socio-economic organisation of past societies. Ranging from studies focused on the impact of landscape characteristics and resources availability on mobile and semi-mobile societies, to those concerned with the resilience of agricultural strategies and the rise and collapse of complex socio-political systems in the context of changing environmental conditions: human-environmental interactions and the responses and adaptations to environmental change have been major themes in archaeology across different time periods and geographic locations.

Computational modelling and statistical analysis have been commonly applied in these contexts and provide major contributions to their research. For example, agent-based modelling helps to explore the dynamics of human socioecological systems while models correlating paleoenvironmental and archaeological data provide insight into the relationship between cultural and environmental change and populations dynamics. The increasing availability and improved spatial and temporal resolution of paleoenvironmental reconstructions also enables a more widespread use of models derived from ecology, such as ecological niche models, which stimulates further methodological developments.

We are looking to bring together papers that showcase the advances in the modelling of dynamics between human societies and the environment either through specific archaeological case studies or broader methodological reflection. This may include papers that integrate archaeological and paleoenvironmental records to reveal the patterns of correlation between the two or model the availability of resources in the landscape, or papers that explicitly model the dynamics of human socioecological systems and the effects of environmental change on the organisational structure of past societies and their subsistence strategies.

We also invite studies concerned with the methodological developments, either through the critical reflection on, and the improvement of existing methods of analysis, or via new modelling approaches and the novel applications of computational methods used in the context of human-environmental interactions. We also welcome papers concerned with the quality of available environmental and archaeological data, which explore its impact on performance and the results of existing models, for example through the sensitivity analysis or by explicitly modelling uncertainty in the data.

JUNE 17th

11:50 – 12:10

(ID: #24) The application of Neyman-Scott Cluster Process in landscape archaeology

Filippo Brandolini, Stefano Costanzo, Andrea Zerboni, Habab Idriss Ahmed, Andrea Manzo

12:10 – 12:30

(ID: #181) Productive Paddies: Understanding the Spread of Rice Farming during the Yayoi Period in Japan through Modelling of Productivity and Habitat Suitability

Leah Brainerd, Enrico R Crema, Marco Madella, Akihiro Yoshida

12:30 – 12:50

(ID: #111) Using Supervised Machine Learning for Modelling Early Neolithic Survival Probability: a Bayesian Networks approach

Olga Palacios, Juan Antonio Barceló, Rosario Delgado

12:50 – 13:10

(ID: #113) IndusVillage. Modelling cropping strategies and climate change in rural settlements of the Indus Civilisation

Andreas Angourakis, Jennifer Bates, Jean-Philippe Baudouin, Alena Giesche, Joanna Walker, M. Cemre Ustunkaya, Nathan Wright, Ravindra Nath Singh, Cameron Petrie

13:10 – 13:30

(ID: #132) Modelling cooperative gathering behavior of early hominins, using comparative recent hunter-gatherer behavior

Jan-Olaf Reschke, Christine Hertler, Ericson Hoelzchen

13:30 – 13:50

(ID: #254) Nonequilibrium dynamics in models of human palaeoecology

Joe Roe

S11. Advances in Digital and Computational Archaeology in Taiwan and Neighboring Regions (Standard)

Convenor(s):
Li-Ying Wang, University of Washington
Mu-Chun Wu, National Taiwan University

Wednesday, June 16, Kourion
11:50 – 14:20

The application of digital and computational methods in Taiwan archaeology is experiencing an impressive expansion. As the potential origin of the Austronesians spreading across the Pacific Ocean, and a marine transit point from continental Asia into Japan, Taiwan archaeology is at the heart of understanding maritime trade, cultural diffusion and prototypes. Recent developments in digital archaeology and cultural heritage, as well as advances in spatial analysis and network sciences in Taiwan have all proven fruitful.

With the prospect to build bridges in order to facilitate dialogue with colleagues focusing research in and around Taiwan, this session aims to promote the advances in digital and computational archaeology in Taiwan and its neighboring regions.

This session is open to studies dealing with all periods of archaeological interest that relates to Taiwan and its neighboring regions, as well as theoretic and methodological contributions towards digital heritage, GIS, network science, ABM in this region. The presentation of in progress projects, experimental proposals, and theoretical explanations are also welcome.

JUNE 16th

11:50 – 12:10

(ID: #69) A Bayesian network modeling approach to examine social changes using burial data

Liying Wang, Ben Marwick

12:10 – 12:30

(ID: #56) Dynamic Social Structure of Old-Kucapungane: New Approach of Space Syntax with Network Analysis for Taiwan Abandoned Settlement, Kucapungane

Chung Yu Liu

12:30 – 12:50

(ID: #68) A GIS-based approach with data visualization to reconstruct a historical district: A case study of Chikan Tower in southwestern Taiwan

Ting-Yu Liu

12:50 – 13:10

(ID: #107) A southern-route model of modern human migrations to the Japanese Archipelago using GIS approaches

Atsushi Noguchi

13:10 – 13:30

(ID: #120) 3D Restores the Lost — Application of 3D Digital Restoration in Taiwan Archaeology

Chang-keng Yeh

13:30 – 13:50

(ID: #235) The problems of chronological uncertainty: Using Baysian approaches to investigate the demography and settlement patterns of the Jomon Period of Japan

Charles Simmons, Erik Gjesfjeld, Simon Kaner, Enrico R Crema

13:50 – 14:10

(ID: #47) From Ritual Landscape to Ritual Practice: Integrating Multi-Technique Recording in a Complex Landscape

Muchun Wu, Karl Smith, John Pouncett

S12. Digital Infrastructures and New (and Evolving) Technologies in Archaeology (Roundtable)

Convenor(s):
Holly Wright, University of York
Achille Felicetti, University of Florence, PIN
Ceri Binding, University of South Wales

Tuesday, June 15, Tombs of the Kings
11:50 – 14:20

Following on from the successful Digital Infrastructures for Archaeology: Past, Present and Future directions session in Krakow, the ARIADNEplus project invites participants to present and discuss the role of new technologies in digital infrastructures. Investment in new and evolving technologies within persistent digital infrastructures represents significant investment, and requires a firm understanding of the potential risks and rewards. This roundtable will consist of 10-minute presentations about the pros and cons of a technology already in use within an archaeological data infrastructure, or the introduction of a new technology that has potential for use within infrastructures.

Technologies may include, but are not limited to, Linked Data, Natural Language Processing, Image Recognition and other types of machine/deep learning. This will be followed by discussion around the challenges and potential usefulness of these technologies within archaeological data infrastructures, as we chart a course for current and future best practice.

11:50-12:00

Doug Tudhope

University of South Wales

12:00-12:10

Xavier Rodier, Olivier Marlet

University of Tours

12:10-12:20

Espen Uleberg, Mieko Matsumoto, Jakob Kile-Vesik

Museum of Cultural History, University of Oslo

Christian-Emil Ore

Department of Linguistics and Scandinavian Studies

12:20-12:30

Valentijn Gilissen

DANS: Netherlands Institute for Permanent Access to Digital Research Resources

12:30-12:40

Ethan Gruber

Ethan Gruber: American Numismatic Society

12:40-12:50

Erik Champion

Curtin University

12:50-13:00

Sara Perry

Museum of London Archaeology

S13. Our little minions, part 3: small tools with major impact (Other)

Convenor(s):
Ronald Visser, Saxion University of Applied Sciences
Moritz Mennenga, Lower Saxony Institute of Historical Coastal Research
Florian Thiery, Römisch-Germanisches Zentralmuseum

Wednesday, June 16, Palaepaphos
11:50 – 14:30

In our daily work, small self-made scripts, home-grown small applications and small hardware devices significantly help us to get work done. These little helpers -“little minions” – often reduce our workload or optimise our workflows, although they are not often presented to the outside world and the research community. 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 and – perhaps – create spontaneously “special minion interest groups”.

As we have seen in the last year’s “minion talks” there is a wide range of tools to be shared. These may be perfect examples for your own minion creation. A constantly expanding list of little minions can be found at https://github.com/caa-minions/minions.

At CAA international 2018 in Tübingen, a normal session (see S6 [LH18]) spontaneously became a “Stand-up-Minion” lightning talk with a lot of nice pieces of source code, small tools and open/free software extensions for proprietary products. In 2018 we saw a tool for photogrammetric rectification of profile images of archaeological excavations, digital tools behind Bonify, and database solutions for excavations.

In Krakow at CAA international 2019, a lot of little minions of various research domains were published to the research community (see O29 [JUK19]). Martina Trognitz gave a deeper insight into Wikidata as a LOD minion addressing a “Linked and Open Bibliography for Aegean Glyptic in the Bronze Age”. In terms of text mining, Ronald Visser showed his “little text mining minion”. Florian Thiery and Allard Mees presented two small time minions to tame relative chronology and vague information in graph modelling using “Taming Time Tools: Alligator and Academic Meta Tool”. A minion to do “serial, fast and low cost 3D pottery on site documentation” was presented by Fanet Göttlich. Furthermore, Bart Vissers presented the minion “CpyPst3D: a tool for direct exchange of 3D features with attributes between GIS, 3D-modeling environment and CAD”. Spontaneous minions were additions to profileAAR by Moritz Mennenga, the use of Heurist for collecting minions by Ian Johnson and a little minion by Gary Nobles to create a 3D volume object from point clouds of laser scans of excavation trenches.

This session invites short presentations, lightning talks – aka “minion talks” (max. 10 minutes including very short discussion) – of small coding pieces, software or hardware solutions, not only focusing on field work or excavation technology, associated evaluation or methodical approaches in data driven archaeology. Each “minion 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 (e.g. GitHub, GitLab, etc.). Proprietary products cannot be presented, but only open and freely available tools designed for them.

We invite speakers to submit a short abstract including an introduction into the tool, the link to the repository to get access to the source code and an explanation which group of researchers could benefit from the little minion and how. The tools may address the following issues, but are not limited to, data processing tools and algorithms, measuring tools, digital documentation tools, GIS-Plugins, hands-on digital inventions (for excavations) and data driven tools (e.g. Linked Data, CSV, Big Data). After previous years’ (pt.1 at CAA 2017 Tübingen and pt.2 at CAA 2018 Krakow) 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, please send an email to us (even shortly before the conference). Please come and spontaneously introduce your little minion!

The minion session is designed for technically 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, with the possibility to create spontaneously little minion special interest groups. All of us use minions in our daily work, and often tools for the same task are built multiple times. The reason for this reproduction is often that the focus in talks are on the projects and not on the technical details. This session gives these tools that are considered too unimportant to be presented in the normal talks, but take important and extensive steps in our research, a slot.

As an outcome of the session, all presented tools and links to code repositories will be available for the CAA research community. We will also collect all little minions in a “CAA little minion catalogue” (http://littleminions.link) available for the public and extended in the future on a GitHub repository at https://github.com/caa-minions/minions.

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JUNE 16th

11:50 – 12:10

(ID: #10) Democratization of Knowledge from Small Museums Online Digital Collections Reusable Human and Machine-Readable Content Models

Avgoustinos Avgousti, Georgios Papaioannou, Nikolas Bakirtzis, Sorin Hermon

12:10 – 12:30

(ID: #29) ChronochRt –make chronological charts with R

Thomas Rose, Chiara G. M. Girotto

12:30 – 12:50

(ID: #58) re3dragon – REsearch REsource REgistry for DataDragons

Florian Thiery, Allard Mees

12:50 – 13:10

(ID: #105) geoCore - A QGIS plugin to create graphical representations of drillings

Moritz Mennenga, Gerrit Bette

13:10 – 13:30

(ID: #143) APE – ArboDat Pangaea Export

Moritz Mennenga

13:30 – 13:50

(ID: #217) Grading minion to the rescue

Ronald Visser

13:50 – 14:10

(ID: #218) My little Linked Open Data Ogham Minion: visualising graph data connections using SPARQL endpoints

Florian Thiery

14:10 – 14:30

(ID: #236) Introducing a stature estimation tool for human skeletal material to the public

Mariana Koukli, Vasileios Sevetlidis, Frank Siegmund, Christina Papageorgopoulou, George P Pavlidis

S14. Bayesian Approaches to Archaeological Questions (Standard)

Convenor(s):
Martin Hinz, Institut für Archäologische Wissenschaften, Universität Bern
Caroline Heitz, Institut für Archäologische Wissenschaften, Universität Bern
Mirco Brunner, Institut für Archäologische Wissenschaften, Universität Bern
Nils Müller-Scheeßel, Institut für Ur- und Frühgeschichte, Christian-Albrechts-Universität Kiel

Thursday, June 17, Kourion
15:00 – 16:40

It is now about 30 years since Bayesian techniques triggered a revolution in 14C calibration (Buck et al. 1991), and at about the same time the first Bayesian approaches were applied beyond pure dating questions. The methodology for archaeology was then introduced to the archaeological public 25 years ago by Buck et al. (1996) in a comprehensive textbook. It may be time now, and since we have two anniversaries to celebrate, also a good opportunity to sum up the current state and new developments in this field and to discuss future developments.

Which of the high-flying expectations of the pioneering days has been confirmed, which developments have led to dead ends? What does Bayesian statistics do today in archaeology, what is its significance in relation to chronological questions, but above all, where is it otherwise applied besides this field? Where are there still development potentials, and how can Bayesian thinking fertilize archaeological discussions? What are new, exciting and innovative fields in which Bayesian approaches can prove themselves in the future?
For this session, we invite presentations that explore the limits and possibilities of Bayesian statistics in and outwith the context of chronological questions, emphasizing those that involve these procedures beyond the scope of dating archaeological objects, features or sites (e.g. analysis of satellite, bioarchaeological, demographic and spatial data, hypothesis testing, and in material culture studies). We would like to explore how the methods from this field of statistics, the influence of which in general is growing in scientific research, and the thinking associated with it can enrich the archaeological sciences in general, and where the potential for the next revolution lies.

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JUNE 17th

15:00 – 15:20
(ID: #12) nimbleCarbon: An R package for fitting and comparing demographic Bayesian growth models of radiocarbon dates
Enrico R Crema

15:20 – 15:40
(ID: #15) Reversing Bayesian Forecasting: developing a tool for prehistoric population estimates
Martin Hinz, Caroline Heitz

15:40 – 16:00
(ID: #129) Estimating the Age and Sex Composition of Zooarchaeological Assemblages with Bayesian Mixture Models
Jesse L. Wolfhagen

16:00 – 16:20
(ID: #163) Patterns of Trauma - A proof of concept using AI to distinguish interpersonal violence from accidental injury
Chiara G. M. Girotto, Henry C. W. Price, Martin Trautmann

16:20 – 16:40
(ID: #212) Bayesian models of compositional data: the case of pre-Hispanic goldwork in Colombia
Jasmine Vieri, Enrico R Crema, María Alicia Uribe-Villegas, Juanita Sáenz-Samper, Marcos Martinón-Torres

S15. Archaeological Exploration of Digital Spaces (Standard)

Convenor(s):

Lauren Herckis, Carnegie Mellon University

Thursday, June 17, Amathous

15:00 – 15:30

16:50 – 18:20

The lives people live in digital environments has been a topic of fascination for decades and a focus of analysis for nearly as long. A meaningful “place” where people interact might not always correspond to a specific physical space. Relationships are shaped, power is deployed, and culture unfolds in places that are imbued with cultural value through human activity. Anthropologists now incorporate digital ethnographies, online tracing, and other methods for understanding behavior in digital environments. In the field of social computing, the notion that meaningful places may exist without a corresponding physical space instigated a paradigm shift away from spatial models more than twenty years ago (Harrison and Dourish 1996). In these and other disciplines, new methods of understanding our lives online have rapidly proliferated. The translation of archaeological methods for use in spaceless places is a vital step for the advancement of archaeological science, and a promising new avenue of exploration.

Archaeological methods encompass the many ways that we derive meaning from the traces that people leave behind. These include the footprints, the rubbish, the spent tools and broken bits. Ours is the science of learning about people who have left the room, using any reliable means we can imagine. Anthropological archaeology is uniquely positioned to expand our understanding of ancient cultures by analyzing the residues of past behavior and explicating the relationships between sweeping social structures and an individual’s daily practice. Archaeological methods enable us to describe the cultural, biological, and technological constraints on daily lives, and to detail the myriad ways that human beings exercise their agency despite these constraints. When we want to understand how and why technologies or social organization have changed over centuries, or how these parallel processes are in fact manifestations of the same cultural developments, we turn to archaeological methods. For the past four decades, archaeology has been used to contextualize contemporary practices with regards to larger social systems and historic processes. Behavioral archaeology explains how cultural and economic forces led to the early 20th century dominance of the combustion engine. Garbagology provides a window into the relationship between consumption of perishable goods and economic stress in the United States today.

As a field, archaeology rests on a foundation of potsherds and lithic fragments. Archaeological methods derive from the analysis of physical artifacts. Their power is evident in the inferences we draw from analyzing these assemblages. Archaeological theory explores the nature of relationships between humans and the places and things that matter to us, sometimes waxing philosophical about the very thingness of things and the placeness of places (Hodder 2012). In the twenty-first century, people use immaterial objects in their daily lives. In the next hour, I might coordinate family dinner plans using a group chat, work with a colleague on another continent to collaboratively edit an academic paper, or visit an in-game “location” to see if friends are “around” so that I can “spend time with” them. These metaphorical places offer opportunities to experience meaningful encounters with people who play important roles in my life. Cultural anthropologists readily understand them to be culturally significant second and third places. Activities that take place in spaceless places include relationship building, information sharing, teaching, learning, participating in local and global economies, politics of all sorts, factionalism of many kinds, planning and other collaboration, actual construction of digital artifacts, and identity-crafting. The traces of these activities are largely intangible. Archaeology has only begun to account for some of these new ways of living. These new spaceless archaeological sites require that we translate our methods and extend our theory to understand behavior in the contemporary world. We can imagine a distinction between two different kinds of digital archaeological sites. Some digital places look like three-dimensional spaces. Many videogames, for example, require navigating apparent landscapes and encountering landmarks, participating in social encounters, and engaging with digital objects. Other digital places have no apparent landscape. Chat rooms, for example, may have a spatial metaphor without a visual component: individuals enter, interact, and leave. Meaningful interactions take place here, but there is no illusion of space.

Digital landscapes that are designed to resemble the natural world invite archaeologists to imagine virtual excavations, survey projects, and other traditional archaeological field methods, rendered in virtual archaeological sites. The place can be mapped, the activities that take place “within” the “site” can be located (eg, Reinhard 2018). But the distinction between these two kinds of digital environments is only a difference in the metaphors we can use to describe them. A long trek toward a distant in-game horizon may lead, inexorably, to the place where it began. A doorway in a virtual room may open into the room it also exits. Bodies may not decay. Objects may disappear. No digital environment is governed by the same physics, or bound by the same depositional processes, as the sites for which archaeological methods were developed. Analysis of archaeological sites has always depended on our understanding of geology and ecology, but analysis of intangible artifacts and dimensionless archaeological sites requires us to trade these sciences for a new set of rules imagined and instantiated by other contemporary people.

Cultural processes, however, do extend into spaceless places. Archaeology is uniquely positioned to make sense of human culture and to contextualize the use of these new kinds of places within larger social systems and long-term change. For example, chaîne opératoire is used to reconstruct technique, power differentials, and collaborative labor through the analysis of debitage and other physical artifacts. Chaîne opératoire can be effectively applied to collaborative writing by quantifying, classifying, and carefully analyzing editorial changes and other artifacts of labor in an Overleaf or Google document. An archaeology of spaceless places is necessary to make sense of the relationships of power and trajectories of technological change in the recent past. Archaeology of digital environments is a developing body of method and theory that will open new avenues for applied and collaborative archaeological inquiry, especially in emerging domains such as the design of virtual worlds.

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JUNE 17th

15:00 – 15:20
(ID: #9) Exploring ‘humAIn’ correspondences with digital spaces through archaeological theory and creative practice
Eloise Govier

15:20 – 15:40
(ID: #30) Digital space: archaeological reflections upon the myELeusis project
Despoina Tsiafaki, Ioannis Mourthos, Chairi Kiourt, Akrivi Katifori, Natasa Michailidou, Paraskevi Motsiou, Anestis Koutsoudis, Katerina Servi

15:40 – 16:00
(ID: #37) Videogames as what kind of artefact? Establishing effective methodologies for a solid practice of archeaogaming
Benjamin Hanussek

16:00 – 16:20
(ID: #95) Teaching Archaeology Through Digital Games: The Last Banquet in Herculaneum
Amanda Pina, Alex da Silva Martire, Maria Isabel D' Agostino Fleming

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COFFEE BREAK

16:50 – 17:10
(ID: #191) Archaeology of Spaceless Places
Lauren Herckis

17:10 – 17:30
(ID: #231) Crafting Past Places: Reimagining archaeology as usual through Minecraft
Angus Mol, Manda Forster, Aris Politopoulos, Sybille Lammes

17:30 – 17:50
(ID: #260) Geospatial archaeological information visualization and Mixed Reality: Enhancing visitors’ meaningful engagement with archaeological sites
Stella Sylaiou, Nikos Trivyzadakis, Kostas Evangelidis, Theofilos Papadopoulos

S16. Problem and Project-based learning in Digital Archaeology Pedagogy (Standard)

Convenor(s):
Costas Papadopoulos, Maastricht University
Ronald Visser, Saxion University of Applied Sciences

Thursday, June 17, Kourion
11:50 – 14:20

Teaching Digital Archaeology (DA) as a subject as well as teaching archaeology-related subjects using digital approaches has the potential to empower students with the skills and competencies required to become producers rather than passive consumers of knowledge (Cocco 2006). Despite the fact that much DA teaching utilises real-world examples, artefacts, and documentary sources, we argue that the full pedagogic potential of experiential learning (Kolb 1984; Wurdinger 2005) within a DA classroom (or a traditional archaeology classroom employing a DA ethos) can be achieved within a problem/project-based learning (PBL) environment.

PBL constructs a framework through which students engage with authentic challenges (Bell 2010; Herrington & Herrington 2007; Stein 1998) in a student-led, collaborative, engaged, and reflective environment. Teaching this way can be challenging, with student projects potentially collapsing due to a variety of managerial, technological, or interpersonal issues. As Wurdinger (2005, 69) states: ‘outcomes of the learning process are varied and often unpredictable’. Yet, despite the potential pitfalls, providing situated and experiential learning opportunities which make students responsible for their own learning (Chapman et al. 1995) has the potential for their weaknesses to become strengths hence improving their practice (Ertmer & Simons 2005).

While Digital Humanities (DH) has embraced the ethos of the Maker Culture, there is little consensus (Whitson 2015) regarding how learning by making and doing can empower students to become critical thinkers and makers (Ratto 2011) through self-reflexivity and problem solving. Creating a collaborative and experiential learning environment, on the other hand, through PBL, in which students work together to complete an end product that materialises their knowledge and understanding (Helle et al. 2006) is designed to achieve this. Finally, the process of co-creation and the management challenges (above and beyond the technical skills being imparted) that collaborative projects pose, provide students with new mechanisms to critically respond to different situations as well as with the necessary competencies for careers in academia and the private sector (Cain & Cocco 2014).

Teaching DA or DH within a PBL environment changes the role of a traditional teacher: from an instructor to a facilitator and coaching expert. This poses different challenges for the teachers, since they have to rethink their role within the classroom and adapt their teaching practices. Instead of teaching a traditional course, teachers need to (learn to) select problems/projects that are suited to the Intended Learning Outcomes of the curriculum. PBL can also better address the challenge of teaching digital natives (Visser et al. 2016); as students are at the center of the pedagogical process, they can develop a learning trajectory that suits their skills, needs, and experiences.

This session builds on the discussions carried out in CAA2019 as part of S08: Teaching Digital Archaeology in which speakers and participants reflected on issues related to traditional classes, different modalities of teaching, the evolving role of instructors as coaches and facilitators, the value of exposing students to real-world problems, successes and failures of experimental approaches to teaching, digital natives and digital immigrants, and students as owners and producers.

This session invites all teachers in DA or DH who employ or have employed problem- and project-based learning approaches in their teaching, as well as students who have experienced such teaching and learning methods. Speakers are welcome to present specific class problems and projects, however, the focus should be on the lessons learnt and the pedagogical dimension of using such approaches in undergraduate/postgraduate teaching programmes and training sessions (e.g. workshops, masterclasses, hackathons etc.). It would be an important addition if speakers would not only show successes, but also instances where PBL failed. Session organisers envision short, 10-minute reflexive presentations and an informed discussion on the potential and challenges of problem- and project-based approaches to teaching digital archaeology.

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JUNE 17th

11:50 – 12:10
(ID: #83) Digital archaeology: Where should we start from?
Emeri Farinetti, Francesca Chelazzi

12:10 – 12:30
(ID: #119) Challenging Students and Teachers with Interdisciplinary Projects
Ronald Visser

12:30 – 12:50
(ID: #237) Integrating digital and on-field activities in archaeological training
Paola Derudas

12:50 – 13:10
(ID: #131) Digital Iron Age: Data Analysis Using Mysql, QGIS, And R
Caroline von Nicolai, Stephan Luecke

13:10 – 13:30

(ID: #201) XRchaeology: The Pros and Cons of AR/VR/XR Learning Tools in Archaeology Education
Kayeleigh Sharp, Grant Miller, Bijay Raj Paudel, Upesh Nepal, Salvador Orozco Gonzalez

13:30 – 13:50

(ID: #204) Digitizing Delphi: A Case Study in Virtual Reality Pedagogy
Robert P. Stephan

S17. Tools for the Revolution: developing packages for scientific programming in archaeology (Standard)

Convenor(s):
Joe Roe, University of Copenhagen
Martin Hinz, University of Bern
Clemens Schmid, MPI-SHH

Wednesday, June 16, Salamis
11:50 – 14:20

Organised on behalf of the CAA ‘Scientific Scripting Languages in Archaeology’ special interest group (SIG-SSLA)

The increasing use of scientific programming languages (e.g. R or Python) is transforming the practice of quantitative archaeology. This “tool-driven revolution” (Schmidt and Marwick 2020) promises to greatly improve the accessibility, power, and reproducibility of computational analyses. It is a core component of the “Third Science Revolution” (Kristiansen 2014), which has major theoretical and practical implications for the discipline of archaeology as a whole.

That said, a tool-driven revolution dies without robust and versatile tools. As inveterate methodological borrowers, we can frequently rely on implementations in other fields, but the adoption of scripted analysis also reiterates the long-established need for methods designed specifically for archaeological data and archaeological problems (Kintigh 1987; Aldenderfer 1998).

Recent years have seen a proliferation in packages developed by and for archaeologists (e.g. http://open-archaeo.info/). An increasing number of computational archaeologists therefore find themselves not only in the role of analyst, but also that of a ‘research software engineer’ (Baxter et al. 2012); not just using tools, but making them.

The distinct set of skills and practices this role demands has not yet been widely discussed within the field, but establishing what constitutes ‘good’ software engineering in archaeology is vital if we are to ensure that our new tools do what they say they do, work together, can be maintained over the long term, and are accessible to the broadest possible community of archaeological practitioners.

This session, organised on behalf of the CAA-SIG “Scientific Scripting Languages in Archaeology”, will survey the state of the art in archaeological packages for R, Python, and other scientific programming languages.
We invite technical or theoretical papers on:

- critical reviews of software support for specific domains of analysis
- discussions of future priorities for package development in archaeology

- general concepts in package development as applied to archaeology (e.g. user interface design, unit testing, continuous integration, software peer review)
- new packages or significant updates to existing ones

The session is aimed at both developers, users, and prospective users of scientific programming languages in archaeology.

A companion workshop on package development for beginners is also planned.

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JUNE 16th

11:50 – 12:10

(ID: #87) Poseidon - A toolbox for archaeogenetic data management

Clemens Schmid, Ayshin Ghalichi, Wolfgang Haak, Stephan Schiffels

12:10 – 12:30

(ID: #116) outlineR: An R package to derive outline shapes from (multiple) artefacts on JPEG images

David N Matzig, Felix Riede

12:30 – 12:50

(ID: #91) CHRONOLOG: a tool for computer-assisted chronological research

Eythan Levy, Gilles Geeraerts, Frédéric Pluquet

12:50 – 13:10

(ID: #148) An open-source approach for the vulnerability assessment of archaeological deposits using GPR data in QGIS environment

Philip K Fayad, Matteo Serpetti, Stefano De Angeli

13:10 – 13:30

(ID: #150) Managing and analysing pictorial documentation with GIS and graphs

Craig Alexander, Jose Pozo, Thomas Huet

13:30 – 13:50

(ID: #108) Digital Ecosystems in Archaeological Science: A History and Taxonomy of R packages in Archaeology

Ben Marwick

13:50 – 14:10

(ID: #241) Open archaeology: a survey of collaborative software engineering in archaeological research

Zachary Batist, Joe Roe

S18. Urban Complexity in Settlements and Settlement Systems of the Mediterranean (Standard)

Convenor(s):
Katherine A. Crawford, Arizona State University
Georgios Artopoulos, The Cyprus Institute
Eleftheria Paliou, University of Cologne
Iza Romanowska, Aarhus University

Thursday, June 17, Palaepaphos
15:00 – 16:30, 16:50 – 18:20

The application of quantitative methods to the study of ancient cities and settlement networks has seen increased interest in recent years. Advances in data collection, the use of and integration of diverse big datasets, data analytics including network analysis, computation and the application of digital and quantitative methods have resulted in an increasingly diverse number of studies looking at past cities from new perspectives (e.g. Palmisano et al. 2017; Kaya and Bölen 2017; Fulminante 2019-21). This barrage of new methods, many grounded in population-level systemic thinking, but also some coming from the individual, agent-based perspective enabled researchers to investigate the structural properties and mechanisms driving complex socio-natural systems, such as past cities and towns (e.g. MISMAS; The CRANE Project; Carrignon et al. 2020). These advances have recently opened new possibilities for the study of cities and settlement systems of the Mediterranean, an area with some of the longest known records of urban occupation that could be key for studying a wide range of urban complexity topics (e.g. Lawrence et al. 2020).

This session invites papers that deal with the applications of computational and digital methodologies, including agent-based modelling, network analysis, urban scaling, gravity and spatial interaction models, space syntax, GIS, and data mining. We look for a diverse range of studies on the interactions between cities, complex meshworks of information flow, simulations of social and socio-natural activities, as well as analyses of groups of cities and their environment (the ecosystem of resources) in the Mediterranean basin. We are especially interested in papers that use agent-based modelling to adopt a comparative and diachronic perspective to studying transformations and transitions of urban and settlement systems and works that focus on the area of Eastern Mediterranean, in particular.

Potential topics of consideration include but are not limited to:

- Settlement persistence,
- Multi-scale spatial patterns within urban complexes and across settlements,
- Inter and/or intra urban settlement dynamics & interactions,
- Transitions and diachronic transformations of urban/settlement patterns,
- Urban network interactions and modelling,
- Urban-environmental processes; the impact of climate disturbances on cities and their resources,
- Formal analysis of cities development of time,

- Processes involved in urban centres formation and abandonment.

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MISAMS (Modelling Inhabited Spaces of the Ancient Mediterranean Sea), https://cordis.europa.eu/project/rcn/108224/en

The CRANE Project (Computational Research on the Ancient Near East) https://www.crane.utoronto.ca/

JUNE 17th

15:00 – 15:20
(ID: #64) PolisABM: Modelling polis formation, urban systems and social complexity in the eastern Mediterranean from Iron Age to Hellenistic times
Dries Daems

15:20 – 15:40
(ID: #115) GIS-based landform classification of settlements in the Pantelis Valley (Sitia, Crete) to assess water management, from the Classical to the Venetian periods
Nadia Coutsinas, Athanasios Argyriou, Marianna Katifori

15:40 – 16:00
(ID: #151) Towards discovering the similarities of regular Mediterranean cities using network analysis
Anna Fijałkowska, Paulina Konarzewska, Anna Kubicka, Wojciech Ostrowski, Artur Nowicki, Łukasz Miszk, Ewdoksia Papuci-Władyka

16:00 – 16:20
(ID: #142) SNA and ANT in the study of local identities: central Italian centres and their cemeteries
Ulla M. Rajala

16:20 – 16:40
(ID: #252) Reshaping a Roman city with GIS analyses and rescue archaeology. Palma (Mallorca, Balearic Islands)
Bartomeu Vallori-Márquez

COFFEE BREAK

17:10 – 17:30
(ID: #44) Comparing Time and Energy in Urban Spatial Networks: A Least-Cost Analysis of Water Fetching in Pompeii
Matthew Notarian

S19. Challenging the axiom that “absence of evidence is not evidence of absence” (Standard)

Convenor(s):
Stephen Stead, Paveprime Ltd – University of the Arts London (UAL)
George Bruseker, Getty
Athanasios Velios, University of the Arts London (UAL)

Tuesday, June 15, Choirokitia
18:30 – 20:30

Cultural Heritage documentation generally only shows things that have been identified in the field or secondary documents. However, this means that absences are rarely explicitly documented and thus there is a generally held believe that the lack of documentation of presence fails to prove the absence of something. This is a solid assumption where it is likely that our knowledge is incomplete (Romans in Tywi Forest in Wales) but becomes more of an issue where it is either very unlikely (Romans in Venezuela) or where comprehensive research shows no evidence (Blind-tooled decoration on a book with well-preserved covers). How then do we record the cases where we have good reason to believe that there actually is an absence?

This session is intended to provide an opportunity for practitioners grappling with documenting absence to talk about their approaches. Papers are invited to discuss:

a) how researchers establish complete knowledge in specific areas of their domain to argue with certainty that there is absence of a feature,

b) how researchers evaluate conclusions in their domain while being uncertain whether lack of documentation means absence of a feature,

c) how researchers come up with criteria to help them choose which features to document as absent,

d) what is the kind of automatic reasoning that researchers can compute based on knowledge of absence of a feature.

So, if you are wrestling with recording sterile deposits or areas that show no remains after intensive field survey or missing features during finds conservation we want to hear from you!

The session will include invited papers about initiatives from the CIDOC Conceptual Reference Model Special Interest Group (CIDOC CRM-SIG) to help make data about documented absence interoperable and reusable.

JUNE 15th

18:30 – 18:50
(ID: #99) Negative placeholders: Knowing when nothing is more significant than something
Jennifer A. Loughmiller-Cardinal

18:50 – 19:10
(ID: #240) Settlement dynamics and blank areas: the case study of the Ager Pisanus
Antonio Campus

19:10 – 19:30
(ID: #112) No Dragons Here: recording the absence of archaeological remains during field survey
Martijn van Leusen

19:30 – 19:50
(ID: #139) Documenting types and absence of types using the CIDOC CRM
Athanasios Velios

19:50 – 20:10
(ID: #93) The Linked Conservation Data semantic test data set
Stephen Stead

20:10 – 20:30
(ID: #94) The application of CRMinf to documenting negative conclusions
Stephen Stead

S21. Archaeology-related online community practices (Standard)

Convenor(s):
Rimvydas Laužikas, Vilnius University
Costis Dallas, University of Toronto
Ingrida Kelpšienė, Vilnius University
Suzie Thomas, University of Helsinki

Tuesday, June 15, Amathous
18:30 – 20:30

The increasing recognition of the need for openness in archaeological research, communication and resource management, as well as the broader availability and uptake of Web 2.0 / Web 3.0 technologies and approaches across the whole spectrum of archaeological work is contributing to the rising use of online social media platforms by academic archaeologists, archaeological heritage management and communication professionals, amateurs and members of communities engaged with archaeology.

In this context archaeological heritage and archaeological scholarly knowledge has often enjoyed a particular status as a form of sharing heritage/sharing knowledge that, capturing the public imagination, has become the locus for the new different archaeology-related digital community practices. The session brings together researchers and research projects studying archaeology-related practices in social media platforms. It aims to present and highlight the ongoing work on the topic, including theoretical and empirical research on archaeological work, knowledge production and use by professional archaeologists and non-professional archaeology-engaged communities, operating across different social media platforms.

JUNE 15th

18:30 – 18:50

(ID: #11) Digital technologies applied to Antarctic Archaeology

Alex da Silva Martire, Andrés Zarankin, Fernanda Codevilla

18:50 – 19:10

(ID: #27) Impact of the Digital Archaeology Practices on the Regulatory Framework Design and eCommunities

Vladislav V. Fomin, Rimvydas Lauzikas, Tadas Ziziunas

19:10 – 19:30

(ID: #140) Using Spatial Storytelling Platforms for Public Archaeology, Open Data, and Scholarly Publishing

Matthew Howland, Brady Liss, Mohammad Najjar, Thomas Levy

19:30 – 19:50

(ID: #166) CAA-GR online community practices during the pandemic: Outcomes of the first series of online roundtable sessions

Athos Agapiou, Markos Katsianis, George Pavlidis, Dorina Moullou, Tuna Kalayci, Stella Sylaiou

S22. From surface distributions to settlement patterns: field survey during COVID-19 (Other)

Convenor(s):
Buławka Nazarij, University of Warsaw, Faculty of Archaeology, Department of Near Eastern Archaeology
Chyla Julia Maria, University of Warsaw, Antiquity of Southern Europe Research Centre, Faculty of Archaeology
Cirigliano Giuseppe Prospero, University of Siena, Department of History and Cultural Heritage
Sobotkova Adéla, Aarhus University, School of Culture and Society

Thursday, June 17, Salamis
11:00 – 11:40, 11:50 – 14:20

Archaeological field surveys, even the most intensive and systematic ones, cannot be considered flawless methods of acquiring data. Archaeological landscapes' state of preservation, surface collection methods and agenda, visibility and personal preferences can affect the final results. It is not simply just the registration of observations, but a process of continuous interpretation starting from where to survey, what to collect, and how.

Research conducted in the 1990s and early 2000s found increasing precision in mapping and in the resolution of surveys to be a solution to the most pressing problems in settlement pattern studies and landscape archaeology. Today, mapping precision does not seem to be a problem thanks to widely available portable GNSS equipment and specialized software dedicated to field data acquisition (Mobile GIS). Or is it? Reflection is needed on the technological advances of the past decades. What have archaeological studies gained thanks to these technological achievements, and what are the implications of new, higher resolution data for crucial topics in scientific debate, such as complex societies?

Currently, it is difficult to conduct field research because of the COVID-19 pandemic, but it is possible to step back and reflect on its theoretical and technical aspects of this methodology. The aim of this session is to continue the discussion of the changes that are happening in archaeological field prospection today, which we have been pursuing since CAA 2017 in Atlanta, through the Mobile GIS sessions.

This session invites papers discussing broad interpretive and methodological aspects of landscape archaeology, settlement pattern studies, field survey (micro and macro scale) and Mobile GIS, theoretical or technical papers, and case studies from around the world. When submitting please specify if you want to present a long (15 minutes) or short (10 minutes) paper.

This session will conclude with a roundtable discussion.

JUNE 17th

11:00 – 11:20
(ID: #38) Mobile GIS survey in Mustis
Tomasz Waliszewski, Monika Rekowska, Krzysztof Misiewicz, Jamal Hajji, Chokri Touihri, Julia M. Chyla, Jerzy Oleksiak

11:20 – 11:40
(ID: #79) Model-led survey with mobile GIS: the prediction and survey of karstic caves and rockshelters in Kazakhstan
Patrick Cuthbertson, Tobias Ullmann, Christian Büdel, Aristeidis Varis, Abay Namen, Reimar Seltmann, Denné Reed, Zhaken Taimagambetov, Radu Iovita

COFFEE BREAK

11:50 – 12:10
(ID: #164) Evaluating an Ancient Landscape Using Remote Sensing: The Kotroni Archaeological Survey Project (KASP)
Anastasia Dakouri-Hild, Athos Agapiou, Stephen Davis, Will Rourk

12:10 – 12:30
(ID: #253) Integrating legacy data for archaeological and remote survey at the 7th-15th century site of Unguja Ukuu, Zanzibar
Tom Fitton, Stephanie Wynne-Jones

12:30 – 12:50

(ID: #158) Good digital tools do not make or break field survey - but they sure help!
Adela Sobotkova, Petra Hermankova

12:50 – 13:10

(ID: #168) ArchaeoCosmos. Historical Geography of the Mediterranean and the Near East from the Prehistory to Late Antiquity

Konstantinos Kopanias

13:10 – 13:30

(ID: #184) Treasured hunters? The application of amateur archaeological datasets from North-Western Europe in spatial analysis

Linda Bjerketvedt

13:30 – 13:5-

(ID: #63) Southern Latium (Italy) in Roman Republican and Imperial Times – Considerations on Legacy Data and Site Location Modelling

Michael Teichmann

13:50 – 14:10

(ID: #144) But why here? Deciphering the past choices with the use of GIS methods. The Orońsko flint mining area case study

Nazarij Bulawka, Katarzyna Kerneder-Gubała

S23. 3D Scholarly Editions: Potential, Limitations, and Challenges (Standard)

Convenor(s):
Costas Papadopoulos, Maastricht University
Susan Schreibman, Maastricht University

Thursday, June 17, Palaepaphos
15:00 – 16:30
16:50 – 18:20

Three-dimensional models and reconstructions have been used in the last thirty years across many fields in the humanities and social sciences to bridge time and space; to become immersed in the past through virtual worlds; to explore physical artefacts from multiple angles; to allow interactive close-ups and see features not visible with the naked eye; and to analyse sociocultural phenomena and simulate the experience and perception of objects and spaces. Despite this plethora of research, 3D digitisation initiatives by cultural institutions, and a growing number of higher education institutions teaching 3D skills, methods, and theories, 3D scholarship is still faced with scepticism and hesitation. This is not only because of the constant technological shifts and exigencies and the fragile ecosystem within which 3D projects are being developed, but also due to their non-conventional nature that does not adhere to established academic practices. In addition, no stable infrastructure exists to support this form of knowledge production and therefore, bespoke solutions only serve the needs of individuals projects and do not provide long-term and sustainable solutions.

As a result, 3D scholarship exists in a fragmented information space: the knowledge generated from the models is published in articles, while the models themselves rarely become part of scholarly record. When interactive 3D artefacts are included in online publications they function as illustrative figures without making visible the scholarship that has gone into their creation (e.g. sources, decision-making, and methodologies). The reproducibility of such models remains rather limited; decisions, sources, and variables stay with the team which means that their validity cannot be checked and the whole process of creation (including both the decisions of the researcher but also the technology itself) remains blackboxed and thus inaccessible to other audiences. Without a concerted undertaking, 3D – along with other ephemeral born-digital data is at the most risk of disappearing from the scholarly record.

This session explores a new conceptual model/framework for 3D scholarship; that of a 3D scholarly Edition that can function as a knowledge site that provides a framework for 3D scholarship and the communication of the results of that scholarship within a single spatio-temporal environment that is immersive and multisensorial (Papadopoulos & Schreibman 2019; Schreibman and Papadopoulos 2019). 3D Scholarly Editions can operate as a forum for scholarly argument and/or critical debate, for scholars to test out and critique the intent and meaning of those who formed/used/acted within those historic objects or environments. This framework differs from that of a digital monograph (e.g. Stanford University Press' digital monographs; Michigan University Press' Gabii Project) that largely uses narrative with 3D models having an illustrative function. The model of the 3DSE is annotative, utilising the model itself to embed contextual information.

This session welcomes researchers who have been thinking about their 3D work along the lines of 3D Scholarly Editions and who find that available publication models are insufficient for communicating the value and meaning of 3D as well as the decision-making and argumentation that goes into and/or is developed from 3D scholarship. Session speakers are encouraged to submit paper proposals that a) discuss conceptual and methodological frameworks to capture and make available the process of knowledge production in 3D projects; and, b) problematise the conceptual and technical limitations of 3D scholarship, especially in relation to peer-review, archiving and 3D FAIR Data, annotation, and 3D infrastructures. Representatives from cultural heritage institutions embarking on 3D digitisation or from those which are already 3D digitising their collections (works of art, archaeological objects, etc.) and are using proprietary or bespoke solutions to contextualise them are also encouraged to share their views and experiences. Case studies as well as theoretical, conceptual, and methodological problematisations are equally welcome.

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JUNE 17th

15:00 – 15:20
(ID: #211) Making Meaningful Models as a Digital Novice: Modelling Bronze Age Food Vessels from Archeological Illustrations in Maya and Mudbox
Rosemary M Hanson

15:20 – 15:40
(ID: #244) Standardized output or standardized workflow? Discussion approaches to 3D mini- and micro photogrammetry of archaeological artefacts and their scientific usability
Łukasz A. Czyżewski

15:40 – 16:00
(ID: #127) What‘s in store? Normalized Artifact Databases from 3D-Acquisition Campaigns
Hubert Mara, Bartosz Bogacz

16:00 – 16:20
(ID: #14) ART3mis: Ray-based textual annotation on 3D cultural objects
Vasileios Arampatzakis, Vasileios Sevetlidis, Fotis Arnaoutoglou, Athanasios Kalogeras, Christos Koulamas, Aris Lalos, Chairi Kiourt, George Ioannakis, Anestis Koutsoudis, George P. Pavlidis

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COFFEE BREAK

16:50 – 17:10
(ID: #101) The presentation of XRF assay data on 3D objects
Joshua Emmitt, Jeremy Armstrong

17:10 – 17:30
(ID: #104) Publication of a PhD in 3D: An interactive VR library of Dutch merchant ships
John McCarthy

17:30 – 17:50
(ID: #154) Integrating 3D modelling and publication for archaeological and historical research: a 3D modelling archaeologist’s perspective
Tijm Lanjouw

17:50 – 18:10
(ID: #234) Defining a new paradigm for knowledge production and management within digital archaeology
Paola Derudas

S24. Ghosts in the machine: Reflections on traditions of survey practice at the eve of automation (Other)

Convenor(s):
Lucy Killoran, University of Glasgow & Historic Environment Scotland
George Geddes, Historic Environment Scotland

Thursday, June 17, Palaepaphos
11:50 – 14:20

This session aims to capture discussion at the interface of traditional archaeological survey practices and emerging computational approaches to survey, specifically the application of Artificial Intelligence (AI) and Computer Vision (CV) based processes of analysis to remote sensing data sets. These approaches require decisions to be made on survey methodology which are then built into the automated system. However, the essential questions of classification (‘what is it’) and detection (‘where is it’) have been addressed in many different ways over the development of survey practice. A key takeaway of this session is to encourage the critical consideration of manual survey practices as an important stage in the ethical design of automated survey systems.

The development of survey practice has been both interdisciplinary—for instance, the interconnection of archaeological, geographical and anthropological methodologies in the context of the twentieth-century evolution of mapping and field survey (Wickstead, 2019)—and intradisciplinary—for comparison: observational on-the-ground field survey; eye-in-the-sky remote sensing; human-ecological or environmental analyses; psychogeographical contemporary-archaeological dérives. It is also widely recognised that contemporary survey practices, and their stated or implicit objectives, vary substantially between individual practitioners, different regional and geographic traditions, between ascribed intradisciplinary labels, and across distinct disciplinary shifts over time (Fleming, 2007; Johnson, 2007, 2012; David and Thomas, 2008; Halliday, 2013; Cowley, 2015).

For instance, in the UK, after more than three centuries of use and development, field-based earthwork survey is identified as an indispensable archaeological craft with the capacity to teach foundational skills in seeing and understanding (Historic England, 2017, 2018; Poller, 2018); encompassing an entanglement of observation, interpretation, depiction and classification. Aerial photography and remote sensing may give the impression of distance from the object of observation, but this in itself does not equal objectivity (Wickstead and Barber, 2012; Palmer, 2013). In such a framework, vision and interpretation occurs inside the human ‘black box’ and is still being untangled from conceptions of vision dating back to the nineteenth century (Wickstead and Barber, 2012).

Accordingly, this multiplicity of inflections upon the essential inquiries of ‘what’ and ‘where’ shows that archaeological survey practices cannot be easily articulated under one set of rules. Furthermore, both ground-level and aerial survey practices have been augmented by digital processes providing varying levels of input by machine or automation since the 1970s (Wheatley and Gillings, 2002), affecting both survey practices and their products. The revolutionary impact of technologies such as Airborne Laser Scanning on archaeological practice since the late 1990s has seen data sets for archaeological survey proliferate rapidly, alongside an extending suite of data collection, analysis and management practices (Hesse, 2013; Kokalj, Zakšek and Oštir, 2013; Opitz, 2013, 2016; Banaszek, Cowley and Middleton, 2018; Opitz and Herrmann, 2018).

Discourse around ‘automation’, as the term is understood today, has a definable focus on the potential existential ramifications of this emerging technology (Frey, 2019; Moradi and Levy, 2020; Ponce, 2020; Spaulding, 2020). It is not new to posit that these proliferating data sets present a vital opportunity for large-scale heritage management (Challis et al., 2008; Cowley et al., 2020), or, to this end, to advocate for a critically-examined integration of AI with long-standing traditions of practice (Cowley, 2012; Bennett, Cowley and De Laet, 2014; Ball, Anderson and Chan, 2017; Trier, Cowley and Waldeland, 2019), but many issues raised by the latest generation of technological changes remain unresolved.

Ethical approaches to the design of automated systems require a rigorous consideration of and accountability for exactly how the system reaches its results, as well as a proactive approach to understanding and mitigating the human biases which can be uncritically included within the system (Samek et al., 2019; The Royal Society, 2019; Centre for Data Ethics and Innovation, 2020; Kroll, 2020; Vilone and Longo, 2020). In the context of archaeological survey practice, these biases are complex (Cowley, 2016)—so long as they remain implicit, unwritten, or otherwise un-interrogated. Scholarship within the computing sphere of archaeology refers to the missing element as paradata, or data about how the data were collected (the sister of metadata, the data about data) (Huggett, 2020; Huvila 2021).

In more philosophical areas of the discipline this may be referred to as capturing the experiential or phenomenological element to landscape practices (Millican, 2012). So, how are we to assess this missing paradata, this experiential aspect of survey—an interconnected web of complex, subjective, idiosyncratic, expert, but mostly unwritten approaches to visual observation and perception—when designing vitally-needed automated approaches to landscape survey? AI and CV are fundamentally new tools in archaeology and represent a compelling nexus between observer-led and remote sensing survey practices. This session invites papers that reflect upon the miscellany of approaches that influence contemporary archaeological topographic and aerial survey practices, at this particular moment in the early stages of survey automation by AI. The format of the session will be a mix of 10-minute papers and roundtable discussion, with an expected outcome of presenting a wide range of intradisciplinary traditions and exploring how survey practitioners think about their own practice. Contributions should reflect upon the development of different practices and traditions, identify how they have fully, partially or not-quite intersected with one another, and locate them in the collective trajectory of survey practice, both past and future.

This session will be of interest to researchers and practitioners working across the broad sphere of survey, from observer-led and remote sensing to those working on AI and CV approaches, but participation is also encouraged from those concerned with other approaches to landscape and landscape analysis, heritage management, digital archaeology, disciplinary theory, methods and history, interpretive practices or other related fields. Contributions to this session will inform the PhD ‘Automation in the practice of archaeological survey – integrating Machine Learning, Computer Vision, People, and Practice’, a Collaborative Doctoral Award supervised between the University of Glasgow and Historic Environment Scotland.

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JUNE 17th

11:50 – 12:10
(ID: #66) Find 'em all: Large-scale automation to detect complex archaeological sites with Deep Learning – A case study on English hillforts
Jürgen Landauer, Wouter B. Verschoof-van der Vaart

12:10 – 12:30
(ID: #110) Applying automated object detection in archaeological practice: a case study from the southern Netherlands
Wouter B. Verschoof-van der Vaart, Karsten Lambers

12:30 – 12:50
(ID: #155) Surveying with non-humans: challenges and opportunities
Dimitrij Mlekuz Vrhovnik

12:50 – 13:10
(ID: #22) iSEGMound – a Reproducible Workflow for Mound Detection in LiDAR-derived DTMs
Agnes Schneider

S25. Exploring the possibilities of 3D Spatial Analysis (Standard)

Convenor(s):
Alexander C.Q. Jansen, Department of Archaeology, Durham University
Gary Nobles, Oxford Archaeology
James Taylor, Department of Archaeology, University of York
Marina Gavryushkina, Faculty of Archaeology, Leiden University

Tuesday, June 15, Salamis
10:00 – 10:35, 11:50 – 14:25, 15:00 – 16:30

With the steadily increasing use of 3D spatial analysis as a methodology in the broad field of archaeology, the CAA Special Interest Group 3D Spatial Analysis welcomes papers which are oriented towards the analysis of 3D space.

Innovation in 3D spatial analysis is the next ‘big thing’. As archaeologists, what does 3D afford us that 2D and 2.5D approaches do not? What added complexities does working in 3D bring and how do we resolve or theorise around those complexities? As archaeologists first and foremost, aside from the restrictions of technological limitations, why do we want to apply 3D spatial analysis, how would we apply it and what questions would it help answer? Papers are invited which cover any form of 3D spatial data: recorded geospatial data (GIS/CAD), interpretive 3D modelled data (procedural modelling/Archaeological BIM/Heritage BIM (ABIM/HBIM)), semantic analysis, and even imagined spaces and their physical manifestations (e.g., 3D printing). Crucially papers should go beyond the presentation of purely 3D recording/modelling methods and processes. What insights can we achieve which are not possible from visual inspection alone? While we would like presentations, which push the boundaries (theoretically/technologically), we also welcome position papers. Presenters may want to consider how their research fits within archaeological workflows (established or burgeoning) and broader Spatial Data Infrastructures; what does the integration of associated data bring and what analytical capabilities does or could this create? How do we use these 3D digital objects, datasets and results once they are created? What purpose do they serve, what will their legacy be? Presenters are urged to discuss how the results of 3D spatial analysis are communicated. What are the merits of staying in 3D space against reducing or simplifying it to 2.5D and 2D presentation formats and vice versa?

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 for 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 can be presented as a 10-minute lightning talk, while those with a more traditional structure may be better suited for a 20-minute standard format. The author 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 principal themes which emerge from the presented papers. Facilitated through the 3D Spatial Analysis CAA SIG, we endeavour to keep these discussions continuing beyond the meetings at CAA International. The session will begin with 20-minute case study presentations, followed by 10-minute position papers/lightning talks, and ending with the discussion.

JUNE 15th

10:00 – 10:20
(ID: #245) Evaluating Two Methods of 3D Spatial Analysis (UAV-based Photogrammetry and Ground-Based LiDAR) for Quantifying Erosion
Kelsey A. Pennanen

10:20 – 10:40
(ID: #162) 3D shape of past human activities: the paradigmatic example of mining landscape
Alexander Maass, Angela Celauro, Maria Marsella

10:40 – 11:00
(ID: #141) Using VR to analyse GeoPhysics data - a case study
Paul Harwood, Mark Harwood

11:00 – 11:20
(ID: #13) FundUS – an Interactive 3D Visualization Software for Palaeolithic Excavation Data
Selina Andrews, Stefan Rudolf Radicke

11:20 – 11:35
(ID: #80) Position, Privilege and Potential - 10-minute lightning talk
Meagan Mangum

COFFEE BREAK

11:50 – 12:10
(ID: #242) From 2D documentation to parametric reconstruction of archaeological structures and procedural modelling of an ancient town
Anna Kubicka, Łukasz Miszk, Artur Nowicki, Wojciech Ostrowski, Anna Fijałkowska, Paulina Konarzewska, Ewdoksia Papuci-Władyka

12:10 – 12:30
(ID: #137) Pompeii within Ancient Virtual Skies: From Urban Orientations to 3-D Visualisation
Ilaria Cristofaro, Michele Silani, Georg Zotti

12:30 – 12:50

(ID: #194) Multiscalar Approaches to Digital Documentation of Archaeological Sites. The case studies of Flavian Amphitheater, Temple of the Divine Claudius and the Theater of Marcellus in Rome

Martina Attenni, Marika Griffo, Carlo Bianchini, Carlo Inglese, Alfonso Ippolito

12:50 – 13:10

(ID: #146) Towards a workflow for documenting, processing and archiving large excavation contexts on-the-fly. Challenges and lessons learnt at The Palace of Nestor Project, Pylos

Cristiano Putzolu, Michael Loy, John Wallrodt, Sharon Stocker, Jack Davis

13:10 – 13:30

(ID: #78) From the material culture to the lived space. A virtual reconstruction of a Minoan workshop

Bastien Rueff, Alexandre Pinto, Katerina Messini, Haris Procopiou

13:30 – 13:50

(ID: #188) Experimental archaeology in immersive Virtual Reality: a 3D reconstruction of a mortuary structure of Tomb 21, a Bronze Age mortuary structure from Ayios Vasileios, Greece

Yannick de Raaff, Gary R. Nobles

13:50 – 14:10

(ID: #130) Intersite analysis based on intrasite contexts in the museum database

Espen Uleberg, Mieko Matsumoto, Steinar Kristensen, Judyta Zawalska

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LUNCH BREAK

15:00 – 15:20

3D G[EYE]S: Integrating Eye Tracking and 3D Geographical Information Systems

Danilo Marco Campanaro, Giacomo Landeschi

15:20 – 15:40

(ID: #86) Reviewing 3D GIS in Archaeological Research, does it really exist?

Gary R. Nobles

15:40 – 16:00

(ID: #193) Exploring the possibilities of 3D Spatial Analysis: Discussion

Gary R. Nobles, Alexander Jansen, Marina Gavryushkina, James Taylor

S26. Moving Over Seas: Modeling Seafaring Routes to Analyze Past Connections (Standard)

Convenor(s):
Emma Slayton, Carnegie Mellon University
Karl Smith, University of Oxford

Tuesday, June 15, Choirokitia
15:00 – 16:30

Tombs of the Kings
18:30 – 20:50

Understanding human mobility is a key factor in being able to read the past, as many past communities were oriented around their place in the world, their relationships with their neighbors, and the resources around them. In many cases the archaeological record supports the existence of sea travel without capturing evidence of the corridors or specifics of this movement. Computer-based analysis can be used to fill in these gaps. With the increasing availability of large datasets, more detailed and accurate weather records, and forecasted models of past conditions, as well as advances in GIS applications and simulations, our understanding of seascapes, coastal landscapes, and navigation is expanding. As digital archaeology is crucial to the investigation of these spaces, this session will focus on individual or groups who have used modeling or computation to analyze the key question of seafaring sharing their processes and expertise.

Over the past 30-odd years there has been increasing interest in understanding the difficulties faced by seafarers in moving across the waves, resulting more recently in a push to develop models that address this practice in greater detail. More researchers are evaluating both the use of the water’s surface and the interaction between seascapes and adjoining land-based sites, which is essential for understanding the use and meaning of maritime spaces in the past. Over the past several years, the community focused on this area has grown, due in part to sessions like this at large international conferences (ex. Slayton and Safadi 2017, Slayton 2019), as well as numerous research projects and papers shared by individual archaeologists or labs (for lists of efforts to model water-based movement in the field of archaeology see Davies and Bickler 2015: Table 1 and Slayton 2018: Table 1).

Though the community is coming together, and indeed edited volumes (ex. Ducruet 2017) are being produced, there are still conversations on data, methods, and theories needed to showcase these efforts and broaden the general knowledge for our community of practice. Despite the presence of these sessions, presentations, and published works, 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. These include researchers focused on broader themes facing computational archaeology as a whole, such as using big data to answer questions around seafaring modeling (Ducruet 2017; Napolitano et a;. 2019), the impacts on research of findings from experimental archaeology (Dixon 2018; Pomey and Poveda 2018), or the influence computer gaming / XR experiences may have on our interpretation of the past (Blakely 2018; Poullis et al. 2019). This session will also seek to encourage active discussion between participants as a way to foster new ideas, collaborations, and building blocks on which future modeling can be run.

This virtual conference session is an opportunity to further develop this community, encouraging wider participation from our colleagues working in this area, and focusing on various aspects of modeling movement across water including (but not limited) to:

● Computational case studies exploring seafaring and voyaging

● Computational case studies exploring coastal landscapes, and interaction in the context of movement between sea and land

● Discussion of maritime cultural landscapes

● Discussion of experimental archaeological studies of seafaring

● Discussion of various methodologies used to evaluate sea-based movement

● Issues facing the field of water movement modeling

● Use of water modeling as outreach (e.g. computer games, VR experiences)

● Use of big data (emerging climate data sets) as a base for modeling seafaring

Through this session we aim to explore and highlight different approaches to analyzing maritime spaces, within the context of a broader sub discipline of computational archaeology, and bring together researchers who participate in maritime digital archaeology.

In tandem with this session, the authors plan to propose a new CAA International interest group to continue to foster the water-based movement modeling community. If you have any questions or would like to join the special interest group, contact eslayton@andrew.cmu.edu.

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JUNE 15th

15:00 – 15:18

(ID: #262) Four Ways to Paddle a Canoe: Comparing the successes and failures of four different seafaring computational models to capture pre-Columbian movement in the Caribbean

Emma Slayton

15:18 – 15:36

(ID: #82) Between land and sea: modelling terrestrial mobility and maritime interaction on Crete during the Late Bronze Age

Paula Gheorghiade, Henry C. W. Price, Ray Rivers, Tim Evans

15:36 – 15:54

(ID: #196) A Web-service for dynamic least-cost-maritime-path analysis and visualization within the context of seafaring in the Eastern Mediterranean during the Classical period

Georgios Leventis, Elias Frentzos, Phaedon Kyriakidis, Dimitrios Skarlatos, Dimitra Perissiou, Stella Demesticha, Glafkos Cariolou

15:54 – 16:12

(ID: #250) A null model of drift-induced maritime connectivity between Cyprus and its surrounding coastal areas at the onset of the Holocene

Phaedon Kyriakidis, Andreas Nikolaidis, Constantinos Panayiotou, Georgios Leventis, Evangelos Akylas, Constantine Michaelides, Dora Moutsiou, Carole McCartney, Lina Bitsakaki, Stella Demesticha, Vassiliki Kassianidou, Daniela Bar-Yosef Mayer, Yizhaq Makovsky

16:12 – 16:30

(ID: #75) Digital Navigator on the Seas of the Selden Map of China: Sequential Least-Cost Path Analysis Using Dynamic Wind Data in the Early 17th Century South China Sea

Wesa Perttola

COFFEE BREAK

BREAK

18:30 – 18:50

(ID: #97) Navigating Seaways, Datasets, and Methods: Integrating Environmental and Archaeological Data into an Agent-Based Navigation Model for the Iron Age English Channel

Karl J. Smith

18:50 – 19:10

(ID: #224) Insular Interconnectivity in the Viking Age: A View from Norse Jarlshof, Shetland Islands, UK

Trent M. Carney

19:10 – 19:30

(ID: #118) Maritime mobility across the Neolithic seaways of North West Europe

Crystal Safadi, Fraser Sturt

19:30 – 19:50

(ID: #40) Cretan ports and harbors from Late Antiquity to the Byzantine Early Middle Ages (4th – early 9th c. AD)

Konstantinos Roussos

19:50 – 20:10

(ID: #205) Technologies of Resilience, Climate Disaster, and Maritime Networks: A Case Study of Cycladic Small Worlds

Katherine Jarriel

20:10 – 20:30

(ID: #169) Virtual Vaka: A Computational Tool for Thinking About Seafaring

Ben Davies, Simon Bickler

S28. Computational modelling in archaeology: methods, challenges and applications (Standard)

Convenor(s):
Iza Romanowska, Aarhus University
Colin D. Wren, University of Colorado
Stefani A. Crabtree, Utah State University
Sebastian Fajardo, Department of Materials Science and Engineering, Delft University of Technology

Wednesday, June 16, Tombs of the Kings
11:50 – 14:20
15:00 – 16:40
Thursday, June 17, Choirokoitia
11:50 – 14:20

The steady stream of publications involving archaeological computational models is a clear sign of the discipline’s dedication to the epistemological turn towards formal theory building and testing. Where hypotheses used to be generated verbally in natural language as possible explanations, they are now increasingly often expressed as GIS, agent-based modelling (ABM) or statistical models and meticulously tested against data. The session will showcase the breadth of applications, the ingenuity of researchers deploying new or adapted methods and the depth of insight gained thanks to computational modelling.

With increasing numbers of archaeologists becoming proficient in computer programming it seems that some of the technical and training-related hurdles are being overcome. In general, while some methods in archaeological computational modelling are well established and widely deployed, others (e.g., ABM) are still an emerging subfield with many exciting and fresh applications.
We will structure the session upon the three major questions:

- **The current landscape of computational modelling**: what are the strong versus the weak areas? Are certain topics, time periods, types of questions more often modelled than others? If so, why is that?
- **Potential areas for growth**: what are the obvious methodological and archaeological directions for computational modelling? Are technical skills still an impediment for a wider adoption?
- **Disciplinary best practice**: the need for open science is well recognised among computational archaeologists, but are there other ways in which we can make it easier for members of other branches of archaeology to engage with the computational modelling?

We invite archaeological modellers to present their current case studies, discuss new methods and issues they have encountered as well as their thoughts on the role of computational modelling in general archaeological practice. Computational modelling is meant broadly here as any digital technologies that enable the researcher to represent a real-world system to test hypotheses regarding past human behaviour.

JUNE 16th

11:50 – 12:10
(ID: #46) A multiscalar approach to landscape connectivity using circuit theory

Xavier Rubio-Campillo

12:10 – 12:30
(ID: #159) Stable results from spatial interaction models: was this settlement really popular?
Fabrice Rossi, Clara Filet

12:30 – 12:50
(ID: #195) Multiproxies modeling to support new insights in landscape archaeology: the case studies of Pecora and Cornia valleys in Southern Tuscany, Central Italy
Giulio Poggi, Luisa Dallai, Vanessa Volpi, Steven Arthur Loiselle, Giuseppe Rino Stricchi

12:50 – 13:10
(ID: #149) future developments of historic landscape character: challenges and pitfalls

Francesco Carrer, Nurdan Erdogan, Sam Turner

13:10 – 13:30

(ID: #23) The Toyah Phase Paradox

Bonnie L. Etter

13:30 – 13:50
(ID: #157) Ontological behavior modeling and reasoning to capture tool use among primates and hominins

Pierre R Mercuriali, Geeske Langejans, Carlos Hernández Corbato

13:50 – 14:10
(ID: #28) Using difference-modelling and computational fluid dynamics to investigate site formation processes at shipwreck sites

Jan Majcher, Rory Quinn, Ruth Plets, Chris McGonigle, Thomas Smyth, Fabio Sacchetti

LUNCH BREAK

15:00 – 15:20

(ID: #71) Agent-based modelling to assess hominin role in creating and maintaining vegetation openness during the Last Interglacial and the Early – Middle Holocene in Europe: overview of a planned simulation

Anastasia Nikulina, Fulco Scherjon, Katharine MacDonald, Anhelina Zapolska, Frank Artur, Maria Antonia Serge, Elena Pearce, Marco Davoli, Jan Kolen, Wil Roebroeks

15:20 – 15:40

(ID: #34) Computational modelling of Neolithic spread: archaeology and genetics

Joaquim Fort, Joaquim Pérez-Losada

15:40 – 16:00

(ID: #249) Strategy, tactics, supply and logistics of a Roman military intervention as a dynamic system: Middle Danube region during the Marcomannic wars

Marek Vlach, Balázs Komoróczy

16:00 – 16:20

(ID: #102) Replication of Results from Village, an Agent-Based Model of Socio-Ecological Dynamics in the North American Southwest

James R. Allison

16:20 – 16:40

(ID: #153) Teaching archaeological agent-based modelling through replication

Colin Wren, Stefani Crabtree, Iza Romanowska

JUNE 17th

11:50 – 12:10

(ID: #220) Petri nets for modeling non-linear dynamics of ancient adhesive technology systems

Sebastian Fajardo, Paul Kozowyk, Geeske Langejans

12:10 – 12:30

(ID: #179) Virtual Knapping with Neural Networks: A Proof of Concept

Jordy D Orellana Figueroa, Jonathan Reeves, Shannon McPherron, Claudio Tennie

12:30 – 12:50

(ID: #228) Modeling the material performance of ceramic vessels in view of their function and utilization

Anno Hein, Vassilis Kilikoglou

12:50 – 13:10

(ID: #209) Computer Vision Understanding of Narrative Strategies on Greek Vases

Torsten S. Bendschus, Prathmesh Madhu, Ronak Kosti, Corinna Reinhardt

13:10 – 13:30

(ID: #133) Automated Segmentation of Hieratic on Papyri

Bartosz Bogacz, Tobias Konrad, Svenja A. Gülden, Hubert Mara

13:30 – 13:50

(ID: #76) Was Asclepius more popular in times of the Antonine plague? Answers from temporal modeling of epigraphic and numismatic evidence

Tomas Glomb

13:50 – 14:10

(ID: #33) Estimating Sex from Calcaneus Measurements in a 19th Century Dutch Population: A Machine Learning Approach

Anne C. Dijkstra

S32. From artificial intelligence to stratigraphic reality. Dynamics of an inverse process for AI applications in archaeology (Standard)

Convenor(s):
Luigi Magnini, University of Sassari
Cinzia Bettineschi, University of Padova

Wednesday, June 16, Salamis
15:00 – 16:30
Thursday, June 17, Choirokoitia
15:00 – 16:30
16:50 – 18:20

Recently, artificial intelligence (AI) has become increasingly important in many archaeological fields, as testified by the growing number of publications, dedicated workshops, and sessions at international conferences (Schneider et alii 2015; Sevara et alii 2016; Ortengo, Garcia-Molsosa 2019; Davis 2019; Caspari, Crespo 2019; Dolejš et alii 2019; Fiorucci et alii 2020). Object-Pattern-Scenery Recognition, Machine Learning, Convolutional Neural Networks and ArchaeOBIA constitute some of the most widespread methods. These approaches are driving renewed innovation and experimentation in archaeological image analysis at the multi-scale level, further encouraging the shift from qualitative classification and interpretation to a truly quantitative and reproducible approach (Bennet, Cowley, De Laet 2014).

The initial burst of blind enthusiasm for AI derived from its numerous accomplishments is now being followed by a more reasoned reflection on the limits imposed by the very nature of archaeological sites and materials. In fact, the intrinsic incompleteness of the available data, especially the problems of equifinality and multifinality, rarely allow for a comprehensive and univocal classification of the archaeological objects even within the same or very similar case studies (Magnini, Bettineschi 2019; Casana 2020).

This session welcomes theoretical reflections, but also successful and not-so-successful case studies which highlight the synergy between artificial intelligence and the study of formation/ transformation/ postdepositional processes. The focus is multi-scalar, encompassing landscape-level, but also object-level and microscopic-level applications and their peculiar issues (e.g. partial obliteration, fragmentation, alteration, weathering and so on). This session is particularly interested in contributions focused on pecial assessment methods, from remote cross-validation to classic fieldwork, to statistical and mathematical approaches.

Our aim is to stimulate a profitable discussion on the limits, potential, and the future directions of automated image analysis in archaeology, stressing possible new directions for overcoming the uniqueness and incompleteness of the archaeological record. Ideally, the session aims to bridge the gap between the shovelless computer-archaeologists working from their couches and the ‘old trowels’, who claim the primacy of fieldwork and look with suspicion at new practices involving a fully digital, analytical protocol.

We particularly encourage authors to submit papers related to the following research questions:

- What are the strengths and weaknesses the different AI methods (OPSR/CNN/ML/OBIA) in coping with the incompleteness of the archaeological record?
- What can we learn from a theoretical reflection on stratigraphy, formation processes and objects biographies in order to improve (semi)automated classifications?
- How can we integrate the diachronic evolution of materials and landscapes into automated classification protocols?
- What can we learn from modeling and comparing the efficiency of digital and field-based assessment strategies?
- Is a real integration of field archaeology and automated detection possible? And if so, which is the expected impact of this interaction?

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JUNE 16th

15:00 – 15:20
Session introduction
Cinzia Bettineschi, Luigi Magnini

15:20 – 15:40
(ID: #96) Objectives and Information: Mutual information, composite probabilities, and partitioning of archaeological sets
James S. Cardinal

15:40 – 16:00
(ID: #49) Ceramic Fabric Classification of Petrographic Thin Sections Using Convolution Neural Networks
Mike Lyons

16:00 – 16:20
(ID: #103) Application of machine learning to stone artefact identification
Rebecca Phillipps, Joshua Emmitt, Sina Masoud-Ansari, Stacey Middleton, Simon Holdaway

JUNE 17th

15:00 – 15:20
(ID: #183) From field drawings to artifact data extraction using an object-oriented methodology
Floriane Peudon, Eric Masson, Agnès Lamotte

15:20 – 15:40
(ID: #256) Convolutional Neural Networks for Ground-Penetrating Radar
Katie M Simon, Christopher Angel, William Johnston

15:40 – 16:00
(ID: #100) Autonomous Archaeological Survey in the Southern Peruvian Andes
James Zimmer-Dauphinee, Steven Wernke

16:00 – 16:20
(ID: #203) Dealing with an unbalanced dataset in Archaeology: a case study in the rock art archaeological sites of the Pajéu Watershed, Pernambuco/Brazil
Lucas B. Souza, Demétrio Mutzenberg, Eduardo Krempser

COFFEE BREAK

16:50 – 17:10
(ID: #226) Mapping World War I heritage from historical aerial photography using Convolutional Neural Network approaches
Giovanni Azzalin

17:10 – 17:30
(ID: #16) Using machine intelligence to locate ephemeral archaeological landscape modifications: A case from Madagascar
Dylan Davis

17:30 – 17:50
(ID: #219) Clearing the clearance cairns: an object/pattern/scenery recognition case-study from the Highland of Asiago (Eastern Pre-Alpine area-Italy)
Armando De Guio

S35. Round Table proposals for EU ERA Chair Mnemosyne (Roundtable)

Convenor(s):
Francesco Ripanti, Cyprus University of Technology

Harriet Cliffen, Cyprus University of Technology

Nenad Joncic, Cyprus University of Technology

Marina Toumpouri, Cyprus University of Technology

Giulia Osti, Cyprus University of Technology

Douglas Pritchard, Cyprus University of Technology

Eleanna Avouri, Cyprus University of Technology

Kyriakos Efstathiou, Cyprus University of Technology

Marinos Ioannides, Cyprus University of Technology

Thursday, June 17, Tombs of the Kings
11:50 – 14:20

The contemporary fast-paced evolution of tools and technologies that can be applied to facilitate Digital Cultural Heritage (DCH), from storytelling within museum exhibitions to e-archives, has enabled brand new scenarios in terms of human-machine interaction. The diversification of mobile devices and the ease of access to digital resources can now allow Cultural Heritage (CH) stakeholders – or better prosumers – to customise their interactions with the past and the present, even in real time. As the group of CH stakeholders is growing larger and more diverese, the conventional categorisations that included mostly traditional CH professionals are out-of-date and too limited: therefore, current and potential end users of DCH remain largely unidentified.

The development of methodologies and tools in order to address and understand their needs, motivations, degree of CH knowledge and technical expertise, has emerged as a critically important step in efforts towards the creation and implementation of guidelines on User Centred Design (UCD) for DCH. Therefore, this pioneering roundtable offers the opportunity to experts and/or practitioners from any field of DCH, to exchange and provide insights from the perspective of their sector about UCD. The participants can contribute as DCH users, as well as representatives of their institutions, which make CH digital assets available for use and re-use. Existing personalisation practices and tools will be discussed, along with specific methodological gaps in the area and proposals that will enrich current knowledge concerning use and reuse of DCH assets. The roundtable also considers the impact of the current pandemic on the needs of the users, and on how DCH is accessed, preserved and shared.

This session is organised by the European Research Area (ERA) Chair Mnemosyne on Digital Cultural Heritage (DCH), a research programme centred on the holistic documentation of the DCH lifecycle in support of existing and potential user needs. Contributions are not limited to researchers related to the project but are open for the wider DCH community. Participants are called to submit position papers that must not exceed 8 pages in total (references included), based on which they will be required to prepare a presentation with the duration of 10 or 15 minutes. We believe that a multidisciplinary approach is necessary in order to tackle UCD in DCH; contributions from any sector addressing global and post-pandemic UCD challenges are welcome, especially those covering topics such as:

Personas, stakeholder analysis and other approaches to user categorisation in DCH,

UI for specialised audiences in Knowledge Management in DCH (the story, memory and identity to be used by the audience, beyond concerns around 3D objects and environments),

Crowdsourcing and user needs in long term digital preservation, e-archiving and DCH repositories,

Interoperability, compatibility and standards in DCH Knowledge Management systems, for long-term preservation and e-archiving,

UX design in relation to Virtual Archaeology, -Museums, immersive technologies and serious games.

JUNE 17th

11:50 – 12:10
The ERA Chair project “MNEMOSYNE”
Kyriakos Efstathiou

12:10 – 12:30
(ID: #255) User experience design of Full-Immersive Serious Games for improvement of Cultural Heritage Communication and Understanding
Leyteris Anastasovitis, Christina Tsita, Maya Satratzemi, Manos Roumeliotis

12:30 – 12:50
(ID: #172) Reflecting on the use of facilitated dialogue to support user centered design in digital cultural heritage
Dimitra Petousi, Akrivi Katifori

12:50 – 13:10
(ID: #229) What can human-centred design achieve? Openness and inclusivity for enabling participatory digital heritage
Angeliki Tzouganatou

13:10 – 13:30
(ID: #180) From archaeological to digital data: a holistic reflection on the design of a serious game for users’ engagement
Samanta Mariotti

13:30 – 13:50
(ID: #207) User-centered design for digital applications on Underwater Cultural Heritage
Alexandros Tourtas, Anastasia Chourmouziadi

Posters

The Use of Sequential Spectral Filtering in Digital Multispectral Imaging for Identifying Pigments on Ancient Sculpture
Orestis Kourakis, Dimitrios Karolidis, Elissavet Dotsika, Angeliki Koukouvou, Dimitrios Tzetzis

Near Presence Analysis: A New Technique for Analyzing the Spatial Distribution of Material in Irregularly Distributed Surface Survey Data
Eli Weaverdyck

The French National 3D Data Repository for Humanities: Features, Feedback and Open Questions

Sarah Tournon-Valiente, Vincent Baillet, Chayani mehdi, Xavier Granier, Bruno Dutailly, Valentin Grimaud

3D visualisation - a form of exploring, studying and experiencing the past. Reconstructions of the Early Iron Age settlements discovered at the sites of Stary Śleszów 17 and Milejowice 19
Małgorzata Markiewicz

Pedestrian surface survey nowadays with Covid-19: an example of QField application
Alessia Mandorlo

Three Approaches to the Sharing and Re-use of Survey Data
Martijn van Leusen, Tymon de Haas, Niels Wouda

Integrating legacy archaeological data into an ontology based on Human Ecodynamics: the case of the NABO archaeological reports in the DataARC Project
Pablo Barruezo Vaquero

Data augmentation of iberian pottery collections for DeepLearning based classification
José M. Fuertes, Manuel Lucena, Celia Cintas, Pablo Navarro

The study of the Christian origins of the Ribeira Sacra (Galicia, Spain) through New Technologies. Geophysical Prospecting and Photogrammetric Survey
Natalia Figueiras Pimentel, Jorge López Quiroga

An exploration of NLP and NER for enhanced search in osteoarchaeological and palaeopathological textual resources

Alphaeus G. W. Talks

Politia II: a Virtual Tour Management System

Vasileios Sevetlidis, Cristina Manzetti, Gianluca Cantoro, Nikolaos Papadopoulos, Ilias Fiotakis, George P Pavlidis, Apostolos Sarris

Do water soil erosion phenomena threat cultural heritage sites? The case study of Chania, Crete, Greece

Christos Polykretis, Dimitrios D Alexakis, Manolis Grillakis, Athos Agapiou, Branka Cuca, Nikos Papadopoulos, Apostolos Sarris

Digitally Re-creating the Assembly Church: Using 3D Modeling to Enhance Archaeological Research

Cynthia Deuell, Lisa E. Fischer

Protection, and Valorization of Eastern Mediterranean Cultural Heritage: A role for the ERATOSTHENES Centre of Excellence

Georgios Leventis, Diofantos Hadjimitsis, Phaedon Kyriakidis, Kyriakos Themistocleous, Athos Agapiou, Gunter Schreier, Harris Kontoes, George Komodromos, Despina Makri, Vasiliki Lysandrou

How to review research software in archaeology?

Timo Homburg, Anne Klammt, Hubert Mara, Clemens Schmid, Sophie C. Schmidt, Florian Thiery, Martina Trognitz

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ID number: 9

Exploring ‘humAIn’ correspondences with digital spaces through archaeological theory and creative practice

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Abstract:

Interweaving archaeological theory and method, creative practice, and ethnographic research, in this paper I explore the surface of digital spaces. Specifically, I attend to fingertip gestures on digital screens. Within archaeological research, Bennison-Chapman and Hager (2018) have examined fingerprints and handprints found on clay artefacts at the Neolithic site Boncuklu Höyük, Turkey (2018, 112). Using Reflectance Transformation Imaging (RTI), they examined the ‘friction ridge density’ to identify sex and age of the makers, and found that the small, geometric clay objects were predominantly made by adult females (2018, 122). Inspired by their work, in this paper I discuss tactile engagement with the digital surface of a smartphone. In many respects, the smartphone now operationalises many facets of human engagement with the world. As a portal to digital contact – to digital spaces – the smartphone entity articulates the parameters of the user experience (see Verhoeff 2009). Thinking through the movement of fingers across the Neolithic clay objects, and the sensorial and cognitive theory that is often used to understand this type of engagement within archaeology, in this research I attempt to make visible – actual even – the ephemeral movements of fingertips across the surface of a digital screen using traditional art-making materials (ink or charcoal ‘drawings’).

The fingertip on the screen makes meanings; every tap, swipe, and pause (gestures) creates data, and by corresponding with digital screens humans effectively code their intentions via their behaviour with the device. In addition to motherboards, hard drives, and fiber optics – those physical entities that appear to make haptic engagement quite literal – are the im/material dimensions of algorithms and cloud software (on digital materiality see van den Boomen et al. 2009). The efficacy of the digital gesture is demonstrated through the continuous data it produces. My ‘drawings’ (Figure 1), as ‘gestures’, are made to assess the tangible qualities of fingertip movements across the screen, and to explore how the parameters of engagement constrain (even forfeit) human sensory experience.

By creatively engaging with the digital surface to highlight the ephemeral qualities of human-computer correspondence, I focus on the mode of contact: the place where human and computer ‘systems’ meet (the interface). Archaeology – as a method of interpretation and mode of engagement – affords a sensitivity that responds to the intelligibility of the material coagulations that cartograph the lived-in world. By using archaeological theory and methods to query tangible engagement with such devices, I emphasise how the mode of engagement with the digital space is integral to the phenomena, and argue the case for embracing a Baradian (2007) approach to the 'material-discursive practices' that challenges a distinct cut between the virtual and the actual in the exploration of digital spaces in archaeology.

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ID number: 10

DEMOCRATIZATION OF KNOWLEDGE FROM SMALL MUSEUMS ONLINE DIGITAL COLLECTIONS Reusable Human and Machine-Readable Content Models

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Abstract:

Cultural heritage digitization and online accessibility offer an unprecedented opportunity to democratize knowledge. Since the Web launching in the 1990s, museums have begun sharing their materials online as an alternative source of democratized information to diverse audiences. Online digital collections are more than just an adaptation to keep up. They represent the culture of the world as they form an increasing trend towards a world in which knowledge is digitally preserved, stored, and disseminated instantaneously through a global and concatenate digital network.

However, the majority of small museums do not enjoy the fruits of this digital revolution. Many small museums do not publish their physical collections online (publishing for humans). The ones that manage to publish online, do not apply technologies designed for wider interoperability on the Web (publishing for machines). This creates difficulties in discovering, sharing, and reusing the resources (Freire et al. 2018). Moreover, uploading a digital file online is not enough. Metadata creation and aggregation are necessary, so major search providers (e.g. Google, Yandex, and Bing) or centralized projects such as Europeana can gather associated metadata to make resources more discoverable and usable. Therefore, it is clear that small museums need to take immediate action and publish their data in both human-readable and machine-readable formats. Such intervention would encourage the democratization of knowledge to future generations.

This paper addresses the above problems by approaching small museums in Cyprus. We will present the characteristics of a work-in-progress solution called Reusable Human and Machine Readable Content Models (RhMrCm) on top of the state-of-the-art open-source Content Management Framework Drupal. Drupal, one of the top open-source Content Management Systems / Frameworks, is the most popular in the cultural heritage domain. Drupal is scalable and comes with the support of Semantic Web technologies, especially RDFa. Drupal uses the Schema.org vocabulary which is very useful for cultural and arts data (Watson 2013). The Schema.org vocabulary has been designed for broader interoperability on the Web and is readable by major search providers and metadata aggregators such as Europeana. It can be extended to be used by specialized communities (Riley 2017), and it is suitable for describing cultural heritage objects (Freire et al., 2018). It is worth noting that the RhMrCm approach differs from traditional cultural heritage platforms such as the Omeka Content Management System. Compared to large and robust ecosystems available for other significant Content Management Systems such as WordPress and Drupal, Dombrowski (2016) argues that Omeka can be described as a reasonably moderate CMS with minor community support, plugins, developers, and users.

Our RhMrCm work-in-progress prototype operates on existing tools familiar to scholars and prevalent among cultural institutions. It includes installation packages that can extend the functionality of the Drupal core system towards cultural heritage objects. Each installation package represents a single object such as a Book, Painting, Sculpture. Users can use one or more packages to create online digital collections. Installation packages can be created, reused, and linked across various online collections. Moreover, the RhMrCm can easily be installed via a user interface without prior technical knowledge. When installed, it automatically generates the content model and all necessary data fields (title, creator, date, material) to represent specific objects and collections. Models are pre-mapped into the Schema.org vocabulary. The data populated is machine-readable and understandable by web crawlers, metadata aggregators, and other machines.

In this paper, we present and evaluate the first two RhMrCm models in order to demonstrate the benefits of the solution for small museums in Cyprus.

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ID number: 11

Digital technologies applied to Antarctic Archaeology

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Abstract:

Since 2009, the Laboratory of Antarctic Studies in Human Sciences - LEACH (based at the Federal University of Minas Gerais – UFMG, Brazil) has been working in the research and mediation of Antarctic archeology from the perspective of Public Archeology. The international project "White landscapes: archeology, anthropology, history and conservation of human occupations in the South Shetland Islands, Antarctica", under development by the LEACH-UFMG team, aims to understand the human occupation strategies of the last continent over time. The project, which is the foundation of LEACH, is an interdisciplinary research carried out by archeologists, historians, anthropologists and conservatives from different institutions and nationalities (Brazilians, Argentines, Chileans, Americans and Australians), and has about 20 years of research on alternative stories on the colonization of Antarctica.

In this sense, it is important to point out that, according to official history, the first human groups to reach the southern continent were discoverers, explorers and / or scientists, who had a spirit of leadership and adventure (Maddison, 2014). According to this perspective, the "discovery" of Antarctica was a one-off event, the result of a casual action, according to which Captain William Smith, of English nationality, when deflecting strong winds during the commercial trip he made between Buenos Aires (Argentina) and Valparaíso (Chile), would have seen, for the first time, the South Shetland Islands (Busch, 1985). In general, it is a colonized, factual narrative that exalts great "men" and events.

In opposition to this perspective, archaeological research has been highlighting ordinary people who were agents of this process of incorporating Antarctica into the modern world (Zarankin, Salerno and Senatori, 2011). The main sources of information for the development of the research are the material traces and the written documents (such as, for example, the notebooks of log, logbooks and travel journals) written by the sealers and whalers, of different nations, who went to Antarctica for the purpose of hunting marine mammals to use fur and fat as raw material for the expanding clothing industry; as fuel, for public lighting; and as a lubricant for machinery. From the confrontation between this information, it is possible to access the daily lives of these subordinate groups, understanding how the historical process of capital globalization was experienced by those who were exploited and left rare written testimonies about their lives.

However, in addition to researching alternative stories about the human occupation of Antarctica, the LEACH base project seeks to build them in an alternative way, suggesting plural perspectives on the Antarctic past and challenging the authoritarianism of archaeologists in traditional archaeological investigations. Starting from a digital approach to Public Archeology, new technologies are used - such as, for example, video games, three-dimensional scans of the sites, 3D prints of artifacts, videos, visual drone records, digital database and the LEACH website - as potential dialogue tools with the non-archaeological

public, in a perspective clearly based on the Digital Humanities. The products that the mentioned technologies provide - different from technical drawings and scientific texts, for example - do not need a previous knowledge of the subject, nor an understanding of scientific conventions to be "read"; therefore, they present themselves as non-linear possibilities to rewrite the history of the Antarctic continent.

In this perspective, the main objective of this work is to present the digital approaches of LEACH-UFMG in three concomitant aspects: 1) applied to the archaeological field in Antarctica during excavations undertaken on the site (3D laser scanning of remains and landscapes, image captures by drones, and data logging on tablets); 2) applied to artifacts and collections analyzed in the laboratory (3D printing, 3D laser scanning and photogrammetry); 3) applied to mediation with the archaeological and non-archaeological public (itinerant sensory exhibition that simulates the Antarctic environment, Virtual and Augmented Reality, and digital video game about the daily life of the sealers and whalers, as well as the current archaeological expeditions in territories of the Antarctica). Thus, with this work, we seek to demonstrate how we narrow the communication channels between archaeologists and non-archaeologists, encouraging the construction of multivocal narratives about the human occupation of Antarctica.

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ID number: 12

nimbleCarbon: an R package for fitting and comparing demographic Bayesian growth models of radiocarbon dates

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Abstract:

Large collections of radiocarbon dates are increasingly employed to infer past population dynamics, often by constructing summed probability distributions of calibrated radiocarbon dates (SPD). While SPDs can offer quick visual summaries of the data, their direct inferential power is limit as they do not provide means visually discern patterns arising from sampling error or calibration effects from genuine fluctuations in radiocarbon density. Several methods have been proposed in the last few years to address these issues; most focused on null hypothesis significance tests (via random permutations or Monte Carlo simulations) or non-parametric approaches designed to visually reconstruct the underlying shape of the distribution (e.g. Gaussian Mixtures and Bayesian KDE). However, these solutions do not cover the need for obtaining parameter estimates of growth rates, carrying capacities, and change points, nor provide the right statistical framework for formal model comparison. As a result, several scholars have been directly using SPDs for correlative analyses, regression fitting, and AIC-based model comparison without taking into account that such applications do not take into account sample sizes or the impact of calibration-effect measurement errors. At best, the direct use of SPDs for statistical inference would provide incorrect measures of uncertainty; at worst, they can lead to erroneous conclusions.

This paper introduces a new Bayesian solution that adapts and extends the basic concepts of phase modelling of radiocarbon dates (as implemented in common software packages such as OxCal) to models depicting population dynamics. The core idea consists of treating radiocarbon dates as random draws from discrete probability distributions that are conceptualised as bounded growth models. These growth models can be derived from difference equation models of population dynamics, and their parameters can be made directly interpretable as growth rates, change-points, or proportion of carrying capacity and estimated via MCMC. The paper will introduce the core theoretical framework behind the proposed approach and nimbleCarbon, a dedicated R package that provides a library of growth models and utility functions for calibration, MCMC processing, and posterior predictive checks. The method will be illustrated through its application on simulated datasets as well as two archaeological case studies: one focusing on the putative relationship between cooling events and demographic decline in the Middle Jeulmun pottery period in South Korea, and the other on the demographic impact of the introduction of rice and millet farming in Japan during the 1st millennium BCE.

ID number: 13

FundUS – an Interactive 3D Visualization Software for Palaeolithic Excavation Data

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Abstract:

In this abstract, we propose a software which allows for the interactive 3D visualization and spatial analysis of excavation data from palaeolithic archaeology, called FundUS.

Palaeolithic archaeology collects a high amount of data during excavations, which is often recorded digitally. This includes 3D measurements of individual finds, groups of finds, and topographical data, but also classifications of finds.

To work with the data after the excavation, it is helpful to visualize the 3D measurements of finds and topographical data for interpreting the connections between finds and features. Currently, this is either achieved through a labor-intensive manual process with graphics software or using an assistive software solution.

Currently available software solutions for data visualization in palaeolithic archaeology are often not optimized for the specific needs of the field in terms of what is needed for evaluation purposes. Twelve software solutions have been analyzed with regard to the amount of work needed for them to display the collected data. Only one was able to use the data with little preparation, while most other solutions required the data to manually be transferred into a different format first. Of the twelve solutions, only two were able to display all categories of data (finds, groups of small finds and topographical data).

Additionally, many of the software solutions examined were unavailable as source code, thus not allowing for further development to be based on their previous work. Of the twelve solutions, only four were available for use with testing data or available as source code.

Only one of the examined solutions, ArcGIS Online, was available for use with new data and able to display all data. This solution was one of the GIS applications currently widely in use with archaeologists, but had the downside of requiring the data to be reformatted manually upfront. (1)

Evaluation of data collected in the field would be easier with a dedicated software able to reconstruct the structure of the excavation. This software must be able to work well with the data as recorded, minimizing the amount of data manipulation needed for the visualization to be displayed, thus eliminating potential errors. The software should also accurately recreate the excavation and allow for interactive exploration to help identify the context and relevant combinations of findings. The software would ideally be open source so it can be adapted to different needs.

FundUS is an excavation analysis system developed in cooperation with Prof. Floss and his team at the University of Tübingen. Its main purpose is to give an abstract yet accurate overview of the excavation data in 3D space and allow for interactive filtering of the data displayed. The tool is also designed to fit into the current workflow by using the recorded data without requiring it to be reformatted. FundUS is not mainly intended to be used at the

excavation site, but rather as an evaluation tool after the data has been collected. It is published open source, so it can be developed further by the community.

The analysis system is based on Unreal Engine 4 for its real-time visualization and runs a local Java Spring server as an intermediary between the underlying Microsoft Access database and the visualization. Due to its layered architecture, it is possible to adapt FundUS to other database formats by adjusting or replacing the server while keeping the visualization as-is. The complete software suite runs offline on a stand-alone PC.

The software takes in the data gathered at the excavation in the form of an Access database. The excavation recording system used to create this database is EDMwin (2), with the 3D measurements being taken using a total station. From the 3D coordinates it displays the location of finds and geological layers. By visualizing the data in 3D none of the information is lost to dimensionality reduction, although 2D views like top-down perspective are still possible.

FundUS is reconstructing geological layers from a group of measurement points using the Delaunay triangulation as a form of procedural modelling. (3) It is applied to the x and y coordinates of measurement points to create a plane of triangles. The z coordinate is added after the triangulation to reshape the plane into the geological layer. Every group of measurements is reconstructed individually, with all groups of the same geological layer colored the same way in the visualization.

The software displays both single and group finds with symbols according to the category the find belongs to (compare Figure 1). Every find is part of a layer as specified in the database, allowing for a layer-by-layer exploration of the excavation.

The software allows for interactive filtering, both by geological layer and by different categories of finds. It also includes free movement, zooming and rotation in the 3D representation. It is possible to switch between perspective and orthographic mode and select individual finds to show additional data from the database in a text box. Additionally, the user can restrict the area displayed on all three axes, thus allowing for cross sections of the excavation to be visualized. The interactive visualization happens in real-time with no noticeable input lag or process delays.

FundUS has been tested by archaeologists from Tübingen using excavation data from Germolles “En Roche” (Prof. Floss, 2018), who deemed it a helpful tool for evaluation purposes. Out of 5 survey participants, all of them found FundUS to make parts of the evaluation process easier. On average, the participants reported 65.07 % time savings in comparison to conventional methods when creating a visualization for evaluation purposes. Creating a visualization took, on average, only four steps as opposed to six steps in the current process.

In its current state, FundUS is able to partially fulfill the demand for a specialized evaluation software in palaeolithic archaeology. Due to the positive reception, the software is being further developed to include additional tools for analyzing the data to support the evaluation of an excavation. Future versions are to include options to export generated views for publication.

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ID number: 14

ART3mis: Ray-based textual annotation on 3D cultural objects

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Abstract:

As 3D objects are progressively becoming pervasive in archaeology and cultural heritage applications, enhanced functionalities surpassing the simplistic 3D visualisation are required all the more. Among the first and most fundamental such requirements is the attachment of metadata on top of the 3D representation of the cultural objects and the capability of a multi-layered representation. To be able to provide such rich environments for visualisation and study, those systems need to be complemented or coupled with what is called annotation functionalities.

3D object annotation is the process of selecting a region over a 3D surface and linking that region to a high-level representation either in structured or in free form. Annotation on 3D objects is typically considered in two forms, either as an automated feature or semantics-based region segmentation (Nousias et al. 2020) or as a manually (or in some cases computer assisted) selected region characterization (Arnaoutoglou et al. 2003). While the former form relates to automated semantics extraction for various computer vision and graphics applications, the latter is most suited to cultural heritage applications, like conservation. In this scenario, 3D objects are presented to experts, which are called to annotate either the various degradation effects on a reconstructed object’s surface, or any restoration processes that took place (Ponchio et al. 2020).

Since there has been no standardization in this field, each project and research team typically comes up with a new idea, method and approach to implement an annotation tool that is usually domain or even problem-specific. There is also no standardization to how the annotations are stored, that is, how the metadata are to be recorded, thus having today a multitude of approaches and solutions. Among the most challenging issues in implementing a 3D annotation system are (a) the GUI design, (b) the input conversion and association, (c) the management of high-res data, (d) the representation schemes, (e) the annotation format and data handling, and (f) the annotation as a web application (Ponchio et al. 2020).

Methodologically, annotations can be attached either to single points, lines, voxels, or regions on a 3D object’s surface. In addition, annotation regions can be defined (a) on the surface of the objects, as collections of polygons, (b) on the texture of the objects, in UV-space, apparently leading to a 2D annotation approach and (c) on a hybrid space, fusing annotation on 2D images with reprojection techniques to transfer the annotations in 3D space.

This paper presents ART3mis, a user-friendly interactive textual annotation tool for 3D cultural objects, which is primarily focusing on heritage conservators. The idea originated in the EU

project WARMEST where an annotation tool was needed for the conservators to annotate the degradation on the 3D models of the columns in the Patio de los Leones in the UNESCO World Heritage Site of Alhambra, Granada, Spain. As the tool was required for scientific use by experts with no technical skills in 3D imaging and graphics, the tool had to follow the intuitive WYSIWYG design and be able to handle the various 3D models available from the 3D digitization that was applied in real time. Image-based digitization was employed, and highly detailed 3D replicas had been created, thus models of high polygon counts need to be handled in real time.

ART3mis is using the direct-on-surface annotation approach, by providing various ways of selecting a region of interest on an object’s 3D model surface. It should be noted that ART3mis works on the textured 3D model, which is a method that has been largely discussed in the relevant literature as the most appropriate, as in many cases the texture assists in a more accurate identification of defects or degradations on materials for conservation applications. In addition, ART3mis supports not only the one-time annotation but also the processing of previous annotations, consisting a complete annotation management tool. The annotation storage strategy selected in this case was that of a json structured text file, which is a technique that becomes pervasive in today’s Web-connected systems.

ART3mis includes a typical 3D model viewing interface that supports multiple region selections on a single 3D object. Selection can be done by either (a) using a typical lasso technique (as in many 2D imaging software), which enables the selection of any region of interest on top of an object’s surface, or (b) using a brush technique (user-defined brush size), which enables the ‘painting’ of a region of interest. Multiple regions can be selected in this way, color-coded and connected with textual annotations, all stored in json format for future use.

Currently, ART3mis supports OBJ (with accompanying MTL, JPG, etc.) files for textured 3D models and saves the annotations in JSON format. It is limited to the Windows platform and is not yet converted to a cross-platform Web-based application.

ID number: 15

Reversing Bayesian Forecasting: developing a tool for prehistoric population estimates

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Abstract:

Introduction

Bayesian methods and techniques have been used very successfully in recent decades in archaeology to resolve chronological issues. On the other hand, there has been an increased interest in demographic analysis for at least a decade now. This was triggered by the current shift towards re-focusing on broader aspects of the human past. Also, there is an increased interest in human-environment relationships, which further increases the relevance of population estimates. To understand human-environment relationships in the past and the dynamics of socio-ecological systems, it is essential to have a robust estimate of population sizes. Size and density of population are crucial factors for the reconstruction of group sizes, the character and range of political institutions for social organization, the constraints and possibilities of economic practice, the number of people available for collective activities, for economic and social exchange systems, and the creation and maintenance of collective identities. Most estimates of population sizes currently work on limited spatial scales or use proxies that hardly allow for absolute numbers (e.g. sum calibration). The figures that form the basis for estimating the population density of prehistoric societies are currently mostly from vague data or unsuitable ethnographic records and are often decades old.

The SNSF project QuantHum aims at developing the first quantitative index of human-impact intensity for paleoecological records. The working area hereby is Switzerland and Italy. Population data collected from independent archaeological sources serve as a qualifier to validate estimates derived from pollen data. For this task, which is already transdisciplinary by design, a method must be used which, based on the broadest possible basis of the partly little informative, heterogeneous and sometimes biased data of archaeological research, nevertheless obtains the most reliable absolute estimation of population numbers possible.

Methods and Materials

In demography in general, the last decade has triggered an upswing in the application of Bayesian methods, so that a Bayesian demography has been announced. Bayesian demography is currently at the forefront of methodological developments in this area but has reached such maturity that the United Nations has been using it since 2015 for population forecasts and projections. The Bayesian approach offers the possibility of combining heterogeneous data and at the same time qualifying them in terms of uncertainty and credibility. This is precisely where it becomes very interesting for archaeological data since they are mostly inaccurate, biased, sparse, simplified and often based on simplistic assumptions.

We used a Monte Carlo Markov Chain approach, to combine multiple data sources and theoretical assumptions on the population density in the working area. This includes general

proxies like a general growth factor, dendro data, 14C sum calibration, and overarching expert knowledge. This is combined with site-based estimations of settlement sizes and densities, anthropological data, and more local expert opinions, which are all probably bad estimators, but can support or disprove each other . The data were weighted and qualified according to their plausibility and coverage within the bayesian hierarchical model that serves as an estimator for absolute population numbers. One risk of this approach is, that if all available data are included in the model there is no 'ground truth' left to compare the predictions of the model against these. But in this approach this likelyhood check is part of the modeling approach itself, so that this model framework is not delivering the model as such, but an estimation of its adequacy and uncertainity at the same time. Other approaches or proxy data can also be incorporated as submodels, like e.g. settlement scaling.

Results

In a pilot study, presented at the EAA 2019, it was possible to show how such an approach can integrate very different sources of information. Using this methodology it is not only possible to use the whole range of archaeological information at hand, but also the uncertainty of the estimation can be quantified. Building on a non-informative prior, with every layer of information the resulting population estimate becomes more reliable. In this presentation, we would like to illustrate our approach and give some first results of the ongoing evaluation of the demographic estimations of the time between Mesolithic and Iron Age in Switzerland and Italy.

Discussion

We believe that the use of Bayesian demography in archaeology has the potential to revolutionize demographic research. Most studies to date have focused on one proxy alone, which at best is correlated with several others for validation purposes. However, since no proxy is error-free and unbiased, only the combination of all possible information can provide an average, and thus probably more accurate, estimate of past population trends. This method succeeds in integrating the currently widespread use of 14C data as an overarching demographic indicator and taking advantage of methodological developments in this field, without, however, naively and blindly following only this highest controversial analytical path. Thus Bayesian demography, applied to archaeological questions, currently has a similar potential as Bayesian calibration for 14C data itself had.

ID number: 16

Using machine intelligence to locate ephemeral archaeological landscape modifications: A case from Madagascar

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Abstract:

Introduction

Archaeological deposits in southwest Madagascar – which have been occupied by foraging populations for millennia – generally bear ephemeral traces of past human activity and lack the intensive kinds of landscape modification that remote sensing archaeologists typically look for as evidence of human environmental impacts (e.g., agricultural modifications, monumental architecture, etc.). While machine learning and AI approaches have made considerable progress in detecting archaeological features (i.e., mounds, agricultural fields, etc.), the use of these methods for locating subtle traces of human activity are still in their infancy. In this paper I address this shortcoming by using high-resolution satellite imagery and machine learning to identify a legacy of human-landscape co-evolution in the Velondriake region of Southwest Madagascar. Results show promise for harnessing machine learning to investigate ancient foraging societies, which are often understudied due to the ephemeral nature of their archaeological materials.

Methods & Materials

This project consists of two major phases: Phase 1 uses medium resolution (10m) Sentinel-2 imagery to create predictive models of archaeological settlement patterns (see Davis et al. 2020). Here my colleagues and I incorporate SVM classifiers, spatial statistics, ethnographic records, and models from human behavioral ecology to identify likely zones of human activity in the study area based on environmental resource distribution. In phase 2, the primary focus of this paper, I use the ground-verified results of Phase 1 (consisting of 100 confirmed archaeological and 80 non-archaeological deposits) combined with other pre-recorded archaeological site locations (n=230) to train a random-forest probability (RFp) classifier in Google Earth Engine (GEE) using 3 years of seasonally averaged PlanetScope imagery (3m). These results are used to locate ephemeral foraging sites from the Late Holocene (ca. 1000 BP – 4000 BP). A total of 290 confirmed archaeological deposits and 63 non-archaeological deposits located from ground testing during Phase 1 are used as training data while 40 archaeological and 17 non-archaeological deposits are withheld as training data (12% sample). Validated results from the RFp analysis are converted into shapefiles and the amount of land-area consisting of anthropogenic components is quantified using GIS to understand the extent of human impacts on this landscape.

Results

Phase 1 identified archaeological sites with an accuracy of approximately 85%, resulting in the detection of over 100 new archaeological deposits in the study region. These ground-validated archaeological deposits were then incorporated into training datasets for the implementation of the RFp model in Phase 2. Results of Phase 2 show that accounting for

differences in seasonality allows for the identification of subtle soil and vegetative changes in Madagascar related to anthropogenic disturbances. The RFp model achieved high accuracy based on validation data (F1 = 0.93) and reveals a broad landscape of human activity covering hundreds-to-thousands of years of occupation history. According to the subsequent GIS analysis of the RFp results, approximately 17% of the study area has been significantly modified by human activity associated with a mix of foraging, pastoralist, and agricultural activities.

Discussion

Coastal foragers in southwest Madagascar left a discernable trace on the modern landscape. The results indicate that archaeological landscapes can be distinguished from surrounding environments using multitemporal composites of multispectral imagery and machine learning. As such, this work suggests that the development of machine-learning and cloud-based computational processing is unlocking the capabilities of detecting even the faintest traces of human presence on landscapes. Thus, we can conclude that geophysical properties of the landscape are impacted by a legacy of repeated human landscape use over hundreds-to-thousands of years.

While the abilities of multispectral and hyperspectral imagery have long been established for archaeology, the detection of scant artifact scatters is not the norm (c.f., Orengo and Garcia-Molsosa 2019). Rather, most research has focused on the detection of dominant landscape features or modifications, like architecture and agricultural development. As a result, our knowledge of the extent of human occupancy and its connection to ecological conditions remains poor in many regions around the world (Stephens et al. 2019). By refocusing attention to a landscape perspective – rather than a feature or site-based focus) we can better understand the full impact that ancient populations had on local ecological conditions.

The results of this analysis demonstrate that automated methods of remote sensing can be successful in the detection of subtle anthropogenic landscape modifications associated with foraging societies using medium- and high-resolution satellite imagery. However, an iterative investigative process is crucial for success. Part of this iterative effort requires a synergy between field-based investigations and digital/remote investigations. The results presented here show that while these kinds of projects are sometimes difficult to achieve, they result in extremely beneficial collaborations between local and academic communities that help to quickly document the archaeological record.

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ID number: 17

From CAD to GIS to BIM to where? Archaeological documentation in 3D

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Abstract:

Since the 1980s archaeological projects at the University of Thessaloniki, Greece, adopted digital technologies for the recording and the graphic display of excavation features and deposits. Even before the use of CAD, attempts were made towards the 2D wireframe representation of excavation contexts to facilitate visual inspection and correlation with actual stratigraphic sections. The early adoption of CAD initially targeted the possibility to integrate 2D excavation plans in a single platform, but quickly demonstrated its potential contribution to interpretation through the three-dimensional graphic display of recorded excavation features (Kotsakis et al. 1995). The wider adoption of GIS technology in combination with 3D display environments enabled the reconceptualization of the excavation recording methodology into a 3D excavation data workflow that would link attribute and spatial information towards facilitating the post-excavation exploration of archaeological data (Katsianis et al. 2008).

In the last 30 years the technological focus for documenting intra-site research has gradually shifted from CAD to GIS and recent attempts to HBIM and/or ABIM. However, as technology evolved in each sector, breakthroughs in one sector were adopted or incorporated in the other, each informing and transforming the available technologies. In this presentation we are trying to situate our experience in using some of these platforms and discuss some of their evolving traits and parameters.

Within this framework several issues are investigated:

a) Raster/Voxel vs Vector representation in 3D: The implementation of photogrammetric and laser-scanning 3D documentation procedures has downplayed the need of raster models to represent 2.5D excavation surfaces, while B-reps, solid geometries or 3D symbols can provide alternatives to voxel-based models.

b) Graphic simplification vs photorealism in 3D visualization: Graphic displays facilitate understanding through patterning, while realism can be informative of the original look and feel. Since an absolute or precise replication or reality is impossible or even undesired due to its operational restrictions, a balance should be sought that takes the best of both worlds to provide a richer analytical 3D environment.

c) Analytical potential of current excavation data configurations: Although CAD representations are based on solid geometric modelling foundations, analytical capacities beyond query, measurement and topology are currently limited in both 3D CAD and BIM environments. 3D GIS visualization environments can provide tools for 3D data exploration and basic spatial statistics, but are still some way from manifesting their true analytical potential in 3D, due to limitations in handling 3D topological information.

d) Semantic modelling of the excavation universe: Conceptual abstraction of the main elements and aims of excavation fieldwork are a necessary first step towards integrative and operational data models in 3D that allow effective management, facilitate data exploration and generate new information.

Relevant examples are taken from work in the context of the Paliambela Kolindros and Thessaloniki Toumba excavation projects as well as the Acropolis Restoration Service database visualization platform. These are discussed in their historical context and in conjunction with relevant examples from research generated at the international level (e.g. Polig 2017). In this respect, the combined consideration of different methodologies, tools and available software solutions in CAD, GIS and BIM approaches has the potential:

a) to detect the limitations and potentials in each application category,

b) to provide a more inclusive understanding of the graphical requirements for representing and handling excavation features in 3D,

c) to inform current attempts towards 3D intra-site research and 3D spatial analysis.

The gradual shift from CAD based documentation to GIS and recently also to BIM approaches manifests the need and the desire to effectively model the excavation documentation process. Although the use of each technology results to target-specific documentation approaches and distinct geometric data types, our review recognizes their complementary usage in different stages of the spatial modelling procedure (e.g. data capture, digitization, semantic tagging, topology). In this respect, CAD tools remain relevant to geometric modeling, GIS continue to play an integral role in combining and analyzing cross-scale graphical, thematic and temporal information, while HBIM maintains its usability in the proper structural division of standing architecture, conservation assessment and 3D reconstruction.

ID number: 19

High-resolution or long wavelength? What is the right SAR sensor for archaeological applications

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Abstract:

The usage of Synthetic Aperture Radar (SAR) in archaeology is becoming more widespread since the commercial availability of high-resolution SAR data from the TerraSAR-X and COSMO SkyMed missions. Examples of applications in landscape archaeology (Rosendings), looting detection and cultural heritage protection (Tapete), and the mapping of burial mounds (Caspari) are just a fraction of the possibilities with SAR.

SAR has a several advantages that makes it a unique remote sensing tool. The electromagnetic waves in the centimeter wavelengths used in SAR penetrate most clouds and allow for continuous almost weather independent monitoring. The capability of Radar to measure distance differences in high precision allow for precise generation of digital surface models and the measurement of millimetric surface motions.

Another interesting feature of SAR, especially for archaeology, is the ability to penetrate coverage, including dry soil, and achieve sub-surface measurements. This ability depends on the wavelength though, with longer wavelengths allowing deeper penetration. On the other hand, archaeology is typically interested in relatively small objects, requiring the highest available resolution in remote sensing applications.

In SAR there is a tradeoff between high-resolution and long wavelengths though. The implications of this tradeoff on archaeological applications is seldom discussed though.

In the paper we are investigating the advantages and trade-offs between high-resolution and long wavelength data in more detail.

ID number: 22

The concept of human-trace SAR satellite initiated from past investigations of SAR in archaeology

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Abstract:

Different from optical approaches, e.g. recording the multi-spectral reflectivity, Synthetic Aperture Radar (SAR) receives complex format echoes including backscattering amplitudes and phase variations. As a complementary remote sensing tool, SAR is characterized by the all-weather and all-day operation capability using active microwave signals to observe scenarios, and consequently this technology is suitable for the subsurface and/or under-canopy imaging. Aforementioned merits hastened an innovative research field, so-called SAR in archaeology whose development can be mainly divided into two eras: Firstly, from 1980s to the beginning of this century, the established framework of SAR in archaeology laid a solid foundation by analysing abundant SAR data provided by NASA/JPL, such as SIR-A/B, SIR-C/L, AIRSAR and SRTM. Second, from 2006 to now, SAR for archaeology entered into a golden application era taking advantage of the emergence of new multi-mode, high-resolution and multi-polarization space-borne SAR platforms, represented by ALOS PALSAR 1/2, Radarsat-2, TerraSAR/TanDEX-X, COSMO-SkyMed and Sentinel-1 A/B, as well as the relevant methodology developed in archaeological feature detection and object recognition, in particular on the rise of Big Earth Data.

However, the extension of SAR in archaeological applications has been hampered by the lack of application-oriented satellites (e.g. P-band SAR), resulting in a suspended pilot-testing research stage along with seldom new archaeological discoveries based on qualitative interpretations. Based on our past experiences (e.g. the proposed crop, shadow, soil and damp archaeological marks on SAR images/products), in this study, the concept of the human-trace SAR satellite is proposed along with the key technology development for subsurface archaeology. Three scientific issues will be exploited, including i) the backscatter mechanism and the signal attenuation of L/P SAR, ii) the discrimination and isolation of SAR echoes from surface and subsurface, and iii) the TomoSAR imaging of dielectric layers for geoarchaeology. The feasibility assessment of the human-trace SAR satellite promotes the sub-disciplinary progress of quantitative SAR in archaeology. It also facilitates the sustainable conservation of cultural properties along Belt and Road (BAR) by providing relevant methodologies and models through pilot studies.

ID number: 23

The Toyah Phase Paradox

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Abstract:

The Toyah Phase has been the center of debate about Texas prehistory, since J. Charles Kelly first defined it in 1947. Known widely as the Toyah Phase Paradox, research has struggled to reconcile the homogenous expression of this protohistoric to historic archaeological record in central Texas and the high levels of ethnic diversity witnessed by French and Spanish explorers at the turn of the 18th-century. Recent studies have related geographic and temporal variation in artifact styles to “communities of practice” using standard 2D measurement techniques, with varying degrees of success. We build on this research by using a geometric morphometric approach to collect shape data from previously published (1983-2013) photographs of Perdiz projectile points (134 points) from sites across the state, a hallmark of Toyah assemblages. The primary goal of the study is to explore how 2D imaging and geometric morphometric analyses can identify localized variants of Perdiz points based on shape. This work, in turn, may be used to infer patterns of interaction between village clusters through network analyses at the regional scale. Implications for how cultural plurality in central Texas may have influenced Spanish missionization are discussed.

ID number: 24

The application of Neyman-Scott Cluster Process in landscape archaeology

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Abstract:

Here we present the first application to archaeology of a spatial statistics tool that was developed for cosmology: the Neyman-Scott cluster (NSC) process. Cluster processes are modifications of the Poisson process to incorporate additional random influences (doubly stochastic Poisson process) and are often chosen when the point pattern is likely to be influenced by unobserved covariates. The NSC model can be seen as the result of a two-stage random mechanism: it first generates unobservable parent points that are located according to a Homogeneous Poisson Process (HPP); then each of the parent points generates a random number of offspring points scattered around its location. The offsprings are the actually observed points and their locations depend on their parents’ locations.

In this research, the NSC process has been employed to explore the spatial distribution of Islamic tombs in Eastern Sudan. Our study highlights the existence of a built funerary landscape with galaxy-like aggregations of monuments driven by multiple layers of societal behaviour. We suggest that the distribution of cairns was controlled by a synthesis of opportunistic geological constraints and cultural superstructure conditioned by tribal kinship, still embedded in the social memory of the local Beja people.

ID number: 26

AtticPOT: a borderless approach for studying Attic painted pottery in ancient Thrace

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Abstract:

Introduction

AtticPOT (http://atticpot.ipet.gr/) is a digital archaeology project focused on the diffusion of Attic painted pottery in ancient Thrace from the 6th to the 4th century BCE. This dominant type of Greek figured pottery bears various artistic, technological, ideological, economic and sociopolitical perspectives of antiquity, thus is a very important part of an archaeological analysis. When studying ancient Thrace, interactions between Thracians and Greeks are depicted through the imported pottery, with the Attic workshops holding an important place (Avramidou and Tsiafaki 2015). With the aim to collaboratively study the distribution and the role of this ware, the AtticPOT [Attic PO(ttery in) T(hrace] digital repository was created, along with several other digital tools.

Among the relevant efforts to actively involve the Information and Communication Technologies in the recording, management, study and presentation of ancient Greek pottery, the Beazley Archive, a printed collection of 25,000 Attic vases and fragments, was among the first to be digitized and available online (Beazley Archive Pottery Database, https://www.beazley.ox.ac.uk). To this should be added the Corpus Vasorum Antiquorum series started back in the 1919), with over 350 printed volumes until today, electronically available through the web (http://www.cvaonline.org). Another more recent, innovative, open access repository is the Levantine Ceramics Project (https://www.levantineceramics.org/), which is making data on ceramic wares (Attic among others, too), shapes, and laboratory analyses available for scholars online.

Methods and materials

Within this framework and given the importance of Attic painted pottery for Classical Archaeology, along with the current international academic interest in ancient Thrace, the AtticPOT project aims to contribute to the expansion of knowledge on this part of the ancient world, promote a deeper understanding of the diffusion and production of Attic pottery and enrich the notion of interconnection between Athens and Thrace, employing digital techniques and methods.

The project focuses on recording Attic painted vases (intact or fragmentary) discovered in sites of ancient Thrace, in various contexts (settlements, burial, sanctuaries) and now kept in various collections, sites and countries, thus located within different research and practical contexts. The developed repository aggregates published vases coming from a variety of publications (printed or digital books, conference proceedings, journal articles, reports, theses

etc.), and from all the four different modern countries (Greece, Turkey, Bulgaria and Romania) ancient Thrace was dispersed. Therefore, among the main challenges of the project was to overcome the language barrier, since a significant number of the recorded pottery comes from sites of those countries and it is published in Greek, Turkish, Bulgarian and Romanian.

The gathered data on the vast number of vases could not be handled efficiently and meaningfully without the help of the digital tools. These tools contribute immensely to the visualisation, understanding and interpretation of the gathered data and to the spatial, chronological and statistical study and synthesis. Namely, the digital tools tear down the borders and make the data and all the information available to the research community (McManamon 2018).

Discussion

Although pottery repositories are gradually becoming a rather common technology, only few offer the possibility for a quantitative approach, usually correlating two different search terms with each other (i.e. in the ‘Statistical analysis tool’ on the Beazley Archive Pottery Database, https://www.beazley.ox.ac.uk/news%20archive/statistical.htm and the ‘Quantitative Analysis’ on the Kerameikos.org project, http://kerameikos.org/research/distribution, although not available for a full review). AtticPOT enhances further the statistical tools and additionally it enables the scholar to compose specific collections of ‘favorite’ vases, using multiple criteria, to search the full or ‘favorites’ collection according to two variables and create graphs based on these parameters.

Thus, the AtticPOT project undertakes a quantitative study of vases, shapes and iconographic themes, an investigation of potters, painters and workshops discovered in ancient Thrace, and a contextual analysis of the vases, focusing on chronology and provenance. The research will help answer archaeological questions still open, fill certain gaps and further promote scientific research. Additionally, it will tackle statistical analysis, which is a rather complex issue for pottery specialists, since the collected material is usually a non-random selection and since pottery collections based on published material have several limitations, that stem mainly from the intensity of field research and the extent of publications.

Results

The AtticPOT project employs digital technologies aiming to investigate shapes, iconography and uses of Attic vases in ancient Thrace, as well as to explore the commercial roads through which this pottery was disseminated and assess the local preferences. Ultimately, AtticPOT wishes to examine the influence of Attic vases on local societies (i.e. burial, cultural and other customs), the Thracian view of these imported vases, and the multicultural interconnection (or not) of every area.

Though a project in progress, the already large numbers of recorded pottery allow us to formulate some preliminary quantitative results, to trace useful patterns concerning the use and presence of Attic pottery in Thrace and to exhibit the capabilities of the search and statistical analysis engines. As a result, the AtticPOT repository has become an evolving tool for researchers who wish to study imported Attic pottery in the territory of ancient Thrace without having to consider the limitations imposed by the modern national borders. The employed crowdsourcing techniques will also contribute to the expansion of the knowledge on Attic pottery in the examined area, with ancient Thrace and Attic vases serving as a case study for the use of multiple ICT tools within and for a network of digital archaeological research.

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ID number: 27

Impact of the Digital Archaeology Practices on the Regulatory Framework Design and eCommunities

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Abstract:

The discourses of the 'impact on archaeology research' and 'impact on community archaeology' are dominated by discussion on the importance of digital archaeology (Huvila and Hugget, 2018). However, digital archaeology practices are important in other discourses, too. In this paper, we aim to discuss two of them: the technology-focused impact of digital archaeology practices on the regulatory system (Gozman et al., 2022) and the associated e-society practices (Magoulas et al., 2007). Two specific questions are 1) how digital archaeology practices are changing the regulatory framework?, and 2) what effect does this have on society?

Regulatory frameworks provide the statutory basis for defining specific institutional and societal roles in a particular domain. Developed in the pre-computer age, today the regulatory frameworks often are incapable to accommodate practices partially or completely supported by technology. In the context of e-society development, regulatory frameworks must cater for transparency of and trust in government services, their effectiveness, also by broadening the degree of inclusion of e-communities in various public discourses. At the same time, government employees often lack digital competencies required for the adoption of advanced technologies into government services, while regulatory frameworks preclude societal participation in the provision of services, even when such participation would be beneficial to the state.

This paper reports on the Vilnius university-led initiative of development of an automated solution for 3D spatial scanning and AI-based heritage monitoring practices (Žižiūnas and Amilevičius, 2020). We use Trifecta model of organizational regulation (de Vaujany et al., 2018) as a synthesizing device to analyse the interaction of technology with the regulatory system and practices. Our analysis helps understand and demonstrate how technology-focused development is affected by existing and shapes the future regulatory system and practices of heritage preservation.

Results of the analysis suggest that the solution under development bears promise to become a ‘fix’ to the regulatory failure and disruptor to the existing practice, but its implementation demands re-defining the scope and nature of the monitoring process and development of new statutory rules on digitized services. Our work has also brought forth a critical understanding of the breadth of effects of government service digitization initiative. Starting from (the expected need for) redefinition of heritage monitoring, we can see effects on processes for data collection and the very understanding of what constitutes the data (types of technology used to create imagery, image formats, perspectives, resolution, etc.) for heritage monitoring.

Our work also illuminated possibilities for broader e-society development and the higher level of societal inclusion into heritage monitoring process, in its shift from conceptualization of the

heritage site as a physical complex of objects to that of virtual sets of imagery, making the heritage object accessible at any time, identifiable, traceable, explorable, crowdsoursable and participatory from different spatial and time perspective at the same time.

This paper was prepared as part of the project "Automated monitoring of urban heritage implementing 3D technologies". The project has received funding from the European Regional Development Fund (project No 01.2.2-LMT-K-718-01-0043) under a grant agreement with the Research Council of Lithuania (LMTLT).

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ID number: 28

Using difference-modelling and computational fluid dynamics to investigate site formation processes at shipwreck sites

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Abstract:

Introduction

Many historic, metal-hulled shipwrecks are designated as war graves, often lost in tragic circumstances due to naval warfare. These sites also act as time capsules, providing insights into technological solutions of their time and life on board. Shipwrecks are not only recognized as heritage and archaeological assets, but also function as aggregators for biodiversity, popular with sport divers and fishers. From an environmental perspective, metal hulled wrecks may act as pollution sources as fuel tanks and ordnance decay over time, releasing toxins into the marine environment. Although shipwrecks are often treated as obstacles to seabed engineering in the offshore renewables industry, they can also act as good analogues for the deterioration of manmade structures on the seabed over time. Despite these diverse, and sometimes conflicting interests, metal wrecks remain under-researched in terms of their long-term stability on the seabed.

Similar to terrestrial archaeological sites, submerged shipwrecks undergo complex site formation processes. Natural processes affecting the preservation state of shipwrecks are influenced by changes in sediment budgets, controlled by coupled sediment- and hydro-dynamic processes (Ward, Larcombe, and Veth 1999). Sediment erosion and deposition due to tidal currents and storms at shipwreck sites may have detrimental effects on the stability of their fragile structures (Quinn 2006), often compunded by corrosion. The integrity of wreck sites may be further compromised by anthropogenic impacts, for example commercial fishing, dumping at sea and offshore engineering. To understand which shipwrecks are prone to accelerated deterioration, the influence of natural and anthropogenic factors must be understood at a variety of spatial and temporal scales.

Our research combines geophysical and oceanographic data with computational fluid dynamic (CFD) simulations to understand these processes at three historic shipwreck sites. This novel integration of data and computational modelling allows for the construction of detailed site formation models, aiding management and providing insight into in-situ preservation issues of historic shipwrecks.

Methods

This paper discusses the contrasting site formation processes at three wreck sites off Dublin in the Irish Sea: FV St. Michan, SS WM Barkley and HMS Vanguard. FV St. Michan, resting in 72 m of water in polymodal sediments, was a British trawler captured and sunk in 1918 by German U-96, with no loss of life. SS WM Barkley, the first steamship of the Guinness stout

company, was sunk in 1917 by German UC-75 with five casualties. The wreck currently rests in 56 m of water, in sandy sediments. Finally, the Audacious-class ironclad battleship HMS Vanguard sank in fog in 1875 due to a collision with her sister ship HMS Iron Duke, with no casualties. She rests in 40 m of water, on a sandy seabed.

Time-lapse bathymetric surveys were designed to provide high-resolution multibeam echosounder (MBES) coverage of the shipwreck sites in 2010, 2015, 2016, and 2019. The data were gathered using the Marine Institute’s (Ireland) RV Celtic Voyager with Kongsberg EM3002 and EM2040 MBES. Shallow-seismic data were collected with an SES probe 5000 sub-bottom profiler and sediment samples were acquired using a Shipek grab. Tidal current data were obtained for the wreck sites from a shelf-scale computational model run by the Marine Institute of Ireland.

The data were integrated in GIS using ArcMap v. 10.6.1 to provide site characterization and construct difference models of geomorphic change over a 10-year period. Point clouds were visualized using CloudCompare v.2.12, which also served for meshing DEM data to the stereolithographic (.stl) format. The meshed shipwreck geometries were used as inputs for CFD simulations, which were performed using an open-source CFD package OpenFOAM v.6 to investigate patterns of flow and turbulence.

Results

The wreck sites are influenced by different environmental and anthropogenic factors and therefore are characterized by varying seabed dynamics. Results indicate that some of the sites are highly dynamic, while others remain nearly static, despite all being located in the same shelf sea, at moderate water depths (26 to 84 m). Results of the difference modelling indicate that FV St. Michan, resting in polymodal sediments, is characterized by very little variation in the adjacent seabed. However, it has been clearly influenced by commercial fishing activities. Although SS WM Barkley and HMS Vanguard are both located on sand banks and surrounded by pervasive sand dunes, the former is characterized by very significant and rapid shifts in the seabed, while the latter remains nearly static. Additionally, SS WM Barkley experienced significant structural damage, recorded in the high-resolution point clouds. CFD simulations indicate that continuous tidal forcing might have caused the damage to the hull of WM Barkley and allow us to investigate which forces are responsible for the geomorphic change at the site.

Discussion

We argue that the strong variability in dynamism between the sites results in different rates of site formation. Wrecks resting on static seabeds are less influenced by combined hydro- and sediment- dynamic action, and more by chemical (corrosion) and biological (biofouling) processes. Conversely, dynamic sites are dominated by the physical processes, with corrosion and biological action having a secondary influence.

These insights would have been impossible without combining difference modelling and CFD simulations, which have delivered data about dominant physical forces affecting the site formation (Fig. 1). As the integrated approach allows us to construct data-informed site formation models, it provides important information for underwater cultural heritage management.

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ID number: 29

ChronochRt –make chronological charts with R

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Abstract:

Plotting of chronological charts (i.e. a graphical representation of chronological units) and especially modification of them has always been a tedious task. Regardless if they are made with a spreadsheet or a vector graphics programme, different obstacles arise. Tools exist but none of them seem to be focusing on the needs of archaeologists and complex chronologies. Based on the tidyverse, the R package ChronochRt will allow to automatically draw chronological charts based on input via the command line as well as spreadsheets with a pre-defined layout. It can handle text and image labels as well as unclear start and end dates of a chronological unit. Furthermore, it is able to display two chronological systems simultaneously, e.g. either within one region or competing long and short chronologies. Time units ranging from BCE and CE are effortlessly integrated in one diagram. Further manipulation by the user and export of the chart into various file formats is provided within the ggplot2 environment.

The aimed group of users is all researchers dealing with chronological data and needing to display them. Yet untested, it might be possible to adapt the package for other contexts, e.g. plotting a conference programme with parallel sessions.

The source code of the package is available from: gitlab.com/roset/chronochrt

ID number: 30

Digital space: archaeological reflections upon the myELeusis project

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Abstract:

Introduction

Space, objects and time are the pillars of archaeological discourse. Although, whenever dealing with space, Classical Archaeology confined itself to topography, during the last three decades classical archaeologists have enriched their analytical toolbox with the terms “space” and “landscape” (Plantzos 2014, 247-248) and negotiations of these notions through the employment of digital technologies.

The project myELeusis (https://myeleusis.com/) aims to initiate into ancient Eleusis and its Mysteries the visitors of the site before, during, and after their visit, through enhanced interactive personalized experiences. myELeusis employs modern interactive methods to enrich the visitors’ experience at the sanctuary of Demeter and the archaeological museum of Eleusis. Within this framework, it develops a series of applications that offer a holistic experience of the Eleusinian Sanctuary of Demeter and Kore, a major site of sanctity for the Greco-Roman world, numbered among the most prominent and world-renowned classical sites in Greece and recognized worldwide for its Mysteries (Papangeli 2002). The two applications of the project chosen to be presented here, myELeusis.PS (Personalized Storytelling) and myELeusis.SG (Serious Game), deal with a major challenge of our digitized world: the formation of digital space in the service of interpreting antiquity. The main challenge this paper attempts to deal with, is how our understanding of space and landscape, in relation to modern needs and interpretations of the past, can influence the way we perceive digital space in applications created to serve people, usually referred to either with the more discriptive term “public” or the more complex term “society” , both in archaeological sites and museums.

Methods and materials

The chosen two applications will be the major tools for the accomplishment of the aforementioned goal. On the one hand, myELeusis.PS is an application, which adopts a story-centered approach of the archaeological site through personalized interactive digital storytelling experiences (Katifori, et al. 2018). The interactive digital narrative will allow its users to explore while visiting the archaeological site of Eleusis through the eyes of different fictional characters, involved in a common mystery story plot. The visitors-users interact with important monuments in the context of a whodunit, that piques their interest and their emotional connection to the site and its history. Each visitor-user is assigned a character, through the perspective of which they may experience the story, through a brief, playful quiz.

On the other hand, myELeusis.SG is a gamified educational approach based on serious games technologies (Kiourt, et al. 2020). The latter will speed up the comprehension of the cultural reserve in an interactive, entertaining and instructive manner, within a virtual environment reproducing the museum of modern Eleusis and composed of multi-level personalized content. Its scenario attempts to enhance knowledge of cultural heritage by spreading a mystery in the ancient world of Eleusis. The player follows the story of Persephone’s abduction, the founding myth of Eleusinian Mysteries, and is able to choose among three different characters (Persephone, Demeter and Hades), who, although narrate the same story, they present it in different versions. The main purpose of SG is to enrich the user΄s experience by allowing an intuitive interaction with the museum artifacts and to offer knowledge with the most pleasant ways to everyone. The proposed multi-dimensional form of myELeusis.SG (Figure 1) is considered to be one of the primary factors for successful user engagement, playing, at the same time, the role of the driving force that promotes concentration in the activity process and user encouragement for further self-improvement.

Discussion

Promoting “outdoors” and “indoors” activities, myELeusisPS and myEleusisSG share similar theoretical framework with applications such as The CHESS project, Skriduklaustur Augmented Reality Treasure Hunt & Quiz Game, or Emotive and goes beyond them as concerns the archaeological perspective. The combination of these two applications, introduces us to the main issue discussed in this paper: creating digital space shares many features, as well as identical problems, with organizing and promoting conventional archaeological sites. Major archaeological sites of classical antiquity (e.g., Athenian Acropolis) are more or less the result of modern cleansing, with this ruling mentality still being present. This strategy has been proved quite useful for nation-states, since modern societies are practically unable to remember experientially, without the aid of archives, anniversaries, or commemorative discourse. Under the influence of memory studies, classical archaeology can now chart the complex relations of memory and space, based on clear distinctions between “lieux de mémoire”, which is used quite often by archaeologists, though sometimes erroneously, “milieux de mémoire” and “landscape” (Plantzos 2014, 250-266). MyELeusis.PS and myELeusis.SG are used as case studies for this discussion.

Results

Our contribution to this discussion passes through the two state of the art presented applications. MyELeusis.PS and myELeusis.SG allow us to reflect on the creation of digital space, the resemblances and differences between digital and physical space, in terms of the time frame, materiality, edutainment etc., as well as the role of the small group of connoisseurs that create cultural landscapes, whether in natural or digital world. Behind all these, lies another question: is digital space created in service of archaeological purposes more of a “lieu de mémoire” or of a landscape? A definite answer is neither an easy task, nor a requisite.

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ID number: 31

THE USE OF SEQUENTIAL SPECTRAL FILTERING IN DIGITAL MULTISPECTRAL IMAGING FOR IDENTIFYING PIGMENTS ON ANCIENT SCULPTURE

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Abstract:

The use of pigments and colorants for decorating ancient Greek and Roman sculpture with bright colors has been the subject of an ongoing debate among art and archaeology scholars since the beginning of the nineteenth century. Recent discoveries and advancements in analytic and documentation technologies established the practice of polychromy in the Greco-Roman period by detecting the remains of paint on ancient statues in a solid manner. Our work follows this stream of research for identifying the remains of color on the surface of ancient sculpture. More specifically, we investigate the use and application of multispectral digital imaging as a cost-effective and noninvasive technique for detecting and documenting pigments on ancient sculpture. In our research, we use the term multispectral digital imaging to describe a set of images taken at different parts of the electromagnetic spectrum that range from ultraviolet to visible, and infrared radiation [1]. For our research, we are using sequential spectral filtering to acquire multiple digital images of an object at selected visible and non-visible spectral bands. First, we place various bandpass interference filters on the light source and/or on the lens of a DSLR (Digital single-lens reflex) camera that is manually modified to be able to record IR radiation. These filters spectrally separate the light that is reflected from the object under investigation. Next, we acquire several images of the object at specific wavelength regions of the electromagnetic spectrum. Then, we process the images using specialized imaging software [2]. Following this, we perform a band to band comparison analysis of the images. Finally, we digitally re-colorize the images that appear to have the greatest tonal contrast by mapping each tone of grey with the reference color target. The resulting image, as shown in Figure 1, offers a vivid depiction of the areas of the object that appear to bear traces of color. For selecting which bandpass interference filters to use for identifying the pigments, we employ data for ancient pigments' spectra from both the Fiber Optics Reflectance Spectra (FORS) of Pictorial Materials (run by the Restoration Laboratory of the Opificio delle Pietre Dure and the Applied Spectroscopy Laboratory of the Institute of Applied Physics "Nello Carrara" of the Italian National Research Council) and the Cultural Heritage Science Open Source (CHSOS) databases [3]. In the case study presented here, we sought to examine a Roman marble plaque that was found in the premises of the Galerius palace complex in Thessaloniki, Greece, for identifying traces of a red pigment that was used for highlighting the inscription. Our results indicate that there is great potential in using digital multispectral imaging for investigating pigment traces on ancient sculpture. Our work contributes to current research on ancient polychromy by extending the use of multispectral imaging from paintings and manuscripts to stone sculpture. Finally, our research further advances the field with the creation of a cost-effective comprehensive database of reference images of pigments under different wavelength regions of the electromagnetic spectrum.

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ID number: 32

TachyGIS – Support to Change from CAD to GIS

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Abstract:

The presentation will address aims of excavation survey and 3D documentation with total station and GIS. It will inform about an ongoing FOSS development of a tool that directly connects total station and GIS with a focus on effective excavation workflow. So it may be primarily interesting for excavators as well as for documentalists. It may also be interesting for scientists with their demands to the analysis of 3D excavation documentation. Furthermore the developing team is highly interested in constructive feedback and in active contributions, both leading to synergy effects within the FOSS project.

TachyGIS is an idea to survey archaeological excavations with total station and GIS. Former CAD based approach (with field book and 3D visualization) are transferred to GIS. It was presented and discussed during the workshop “Digitale Grabungsdokumentation – objektiv und nachhaltig” (Göldner 2018, Räther and Schubert 2018). A working group of the association of state archaeologists in Germany is also concerned with TachyGIS (Kommission Archäologie und Informationssysteme 2018). The TachyGIS idea meets current challenges of total station survey like increased license costs, deficient attribute integration and insufficient sustainability.

The presented project idea “TachyGIS” is to transfer features of existing CAD based approach (especially coordinate transfer from total station and 3D visualization) into GIS and meet the above mentioned challenges. Therefore cost reduction is possible with cooperative FOSS (Free and Open Source Software) development, attribution is realized by GIS respectively geodata and sustainability can be achieved by using geodatabases with standard data formats.

FOSS has high potential to limit costs, not only by (cost) free use of existing software, but also by free development of user specific software components. There are only costs for new, additional software components. This positive effect can be multiplied by controlled cooperation! Using modularity and standardization lead to successful IT processes because they ensure flexibility and sustainability. Interacting with suitable cooperation, they build a “Triangle of Success in FOSS”, which is able to permanently reduce costs (Göldner 2015).

The presented basic concept contains a system overview, a functional model and a data model. A TachyGIS system contains of total station and field book / notebook with data connection. TachyGIS software modules import 3D surveying coordinates via total station interface and interact with appropriate GIS components to record and visualize them. Surveying data is recorded in a geodatabase in standardized and sustainable geodata format, so it is easily accessible from GIS and can be analyzed using GIS methods.

TachyGIS consists of three necessary functional components: total station interface, recording/attribution and visualization. Total station interface directly imports measurement data from total station to TachyGIS modules. Recording/attribution performs editing of geo objects (points, lines, polygons) from measured coordinates and assigns attributes like object

ID or object type from controlled vocabulary. 3D visualization supports survey and recording. Besides that, many more functions to support daily excavation life are desired and an appropriate user interface is needed. But there are already many useful functions available in GIS that can be instantly used.

Geodata model considers 3D recording of points, lines and polygons (areas). OGC standard “Simple Features Access” with WKT characteristic is recommended. Important attributes are: activity (excavation) code, basic object type, object ID (e.g. find no.), kind of object, annotation and remark. Further attributes and relationships are usually recorded in a specific excavation database and they may be linked by the object ID.

Realization of TachyGIS is on the way. There is a suitable prototype available that supports all basic functions of TachyGIS including 3D view and editing now. There are also further development activities, provided and coordinated by at least two institutions and foremost targeting excavation specific user interface and a more sophisticated interaction with the total station. And there is an expanding group of interested people in discussion about more detailed requirements.

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ID number: 33

Estimating Sex from Calcaneus Measurements in a 19th Century Dutch Population: A Machine Learning Approach

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Abstract:

The estimation of sex is considered to be one of the fundamental steps in the identification of human skeletal remains in archaeological, forensic, and disaster victim identification (DVI) settings and typically involves scoring various features of the pelvis and the cranium. Though this method has proven to be highly accurate, in practice it fails to take into account aspects such as fragmentation due to post-depositional processes and taphonomy. It is therefore essential to consider a variety of methods for sex estimation that take into account factors such as these. The calcaneus, or heel bone, is the largest bone in the foot and is often recovered fairly intact. This is mainly due to it being a weight bearing bone with a dense and compact structure, as well as it being protected from taphonomic changes with the use of footwear. The potential of the calcaneus in metric skeletal sex estimation methods has been established in previous studies using a variety of skeletal collections from different parts of the globe, and its validity has been recognized to be population specific. So far, no research has been conducted using a Dutch population, making this study the first to do so. In addition to being the first using a population from the Netherlands, this research is also unique in its use of this specific set of measurements, the presence of archival records with known sex, and the statistical methods employed. The present study extends the current research in metric sex estimation methods in human skeletal remains by establishing sexual dimorphism in the calcaneus and deriving population specific equations using the known 19th century Middenbeemster collection from the Netherlands.

The sample used in the present study consisted of 96 adult individuals (44 males, 52 females) from the known osteoarchaeological Middenbeemster collection from the Netherlands. Without prior knowledge of the sex of these individuals, measurements were obtained from both the left and the right calcaneus whenever possible with a standard digital vernier sliding caliper measured to the nearest 0.01 mm, and in the case of circumference measurements with a retractable tape measure. In total, seven measurements were taken from both left and right calcaneus whenever possible, namely maximum length (MAXL), maximum height (MAXH), middle breadth (MIDB), minimal breadth (MINB), load arm length (LAL), load arm width (LAW), and posterior circumference (PCF). For each measurement, left and right side were treated as seperate variables, reflected by placing L2_ or R2_ before a variable and thus resulting in a variable name such as L2_MAXL or R2_LAL.

Machine learning algorithms for supervised learning using binomial logistic regression were developed using R Studio, with the sample split into a train (n=77) and test (n=19) set (80:20 ratio) in order to validate the computed models. Three different multiple variable models were developed, one consisting of left side variables, one of right side variables, and one consisting of variables from both sides. Furthermore, models based on each of the variables seperately were computed as well.

The presence of sexual dimorphism in calcanei from the Middenbeemster collection was established with an independent 2-group t-test, conducted for each variable individually. Statistically significant differences were found between males and females with p-values ranging between and , with one outlier ( ) in L2_PCF. Three multiple variable models were computed and cross-validated, with one including both left and right variables (Model I), one including left variables only (Model II), and one including right variables only (Model III). Most optimal model Model I (R2_MAXL, R2_MAXH, R2_LAL, R2_LAW, R2_PCF, L2_MAXL, L2_LAW, and L2_PCF) yielded an accuracy of 83.33%, Model II (L2_MAXL, L2_MIDB, L2_MINB, L2_LAL, and L2_LAW) an accuracy of 80.95%, and Model III (R2_MAXL, R2_MAXH, R2_MIDB, R2_LAL, R2_LAW, and R2_PCF) an accuracy of 82.35%. Accuracies for the single variable models computed and cross-validated in this study were for nine out of fourteen variables 70%, with four of these nine variables scoring 75%. The highest accuracy was found for L2_MIDB (79.82%), followed by R2_LAW (77.88%).

Though the potential of the calcaneus in skeletal sex estimation has been established in several studies thus far, the fact that no comparable study on skeletal elements exists using similar statistical methods is something that should be addressed. Regrettably, it appears to be the case that in the previously conducted research both the selection and execution of an appropriate statistical methodology poses some challenges. Most studies relating to calcaneus-based sex estimation methods share the same statistical approach of Discriminant Function Analysis (DFA), often regardless of the research questions posed or the sample size used in the study, and generally solely based on the fact that it was also used in previous research. Additionally, in several instances the application of classification appears to have been incorrectly understood as that of cross-validation. These methodological concerns in previously conducted research naturally makes it somewhat challenging to compare those results with the results of this, or other contemporary research. However, considering the novelty of the present research, ample directions for further research could be envisioned, such as but not limited to the application of other machine learning methods or workflows.

Though this study is the first to develop a calcaneus-based metric method for estimating sex in human skeletal remains in a Dutch population using a machine learning approach, the results of this research are extremely promising. Introducing such a valid adjunctive method for sex estimation in Dutch individuals could be vastly beneficial in the analysis of human skeletal remains in archaeological, forensic, and disaster victim identification (DVI) settings.

ID number: 34

Computational modelling of Neolithic spread: archaeology and genetics

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Abstract:

We report a computational modelling approach of Neolithic spread and compare it to archaeological and genetic data. This approach uses integer numbers for the population sizes, so it is more realistic than a previous one (Isern, Fort and de Rioja, Sci. Rep. 2017). However, implementing this is not straightforward and we will explain the difficulties and solutions that we have implemented. Our new approach correctly reproduces the arrival times of the Neolithic at several regions of the Near East and Europe, as well as the cline of mitochondrial haplogroup K that has been detected using ancient DNA data. We discuss the implications of our model on the dispersal and interbreeding behaviour of farmers and hunter-gatherers. We also discuss differences along the two main routes of Neolithic spread, namely an inland route along the Balkans and central Europe and a coastal route along the Northern Mediterranean coast.

ID number: 35

Listening to archaeologists and practitioners: analysis of the user feedback on the use of Copernicus data

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Abstract:

It is probably unfeasible to quantify the whole entirety of the body of literature, initiatives and projects focused on archaeology and/or cultural heritage wherein satellite data have been exploited so far by archaeologists and practitioners, from the very basic usage (e.g. as a basemap to locate the study area) to more complex processing, geospatial analysis and multi-data integration. On the other side, there is abundant literature, mostly led by remote sensing experts, that demonstrates what new or well-established satellite technologies can do for archaeological and cultural heritage applications.

However, is the above evidence sufficient to prove that satellite data and methods have already become part of the common background across the community of archaeologists and practitioners?

Do innovation and increased accessibility (e.g. through open data policy, open source software, online tutorials and Massive Open Online Courses) necessarily translate into "intellectual accessibility"?

Without appropriate skills and knowledge, users will not be able to fully interpret and use the "vast amounts of datasets thrown at them" (Cuca & Hadjimitsis, 2017). High professional skills are required even to process intuitive datasets (e.g. optical images), so education and training are key to bridge the gap. Similar conclusions apply to more complex Synthetic Aperture Radar (SAR) data (Tapete & Cigna, 2017).

The European Commission's "Copernicus" programme aims to provide important strategic, social and economic benefits, through the deployment of an effective user engagement strategy to stimulate the uptake of Copernicus data, services and information (European Commission et al., 2016). Towards this objective, dialogue with users is crucial.

Following this rationale, we organised and chaired the session "Sentinels and Copernicus Contributing Missions for Cultural & Natural Heritage" at the European Space Agency's 2019 Living Planet Symposium, organised with the support of the Italian Space Agency, and held on 13-17 May 2019 in Milan (Italy). After the open call for abstracts and a peer-review process involving experts in the field, 12 presentations and 19 posters were included in the final programme. An assorted cross-section of the user community was brought together, with a good representation of the remote sensing science core regarding Earth observation applications on cultural heritage, experts from academia and research institutes, companies working with public authorities as well as space archaeologists engaging with stakeholders in Middle East, North Africa and Asia.

The following elements were common to all the presentations:

i. Clear identification of user category

ii. Type of question(s) to address (e.g. archaeological research, condition assessment, operational service)

iii. Satellite data type and methods used

iv. Lessons learnt, including things that did not work well or could have been improved

v. Engagement of further users and stakeholders, and their degree of involvement

vi. Suggestions for improvements or specific requirements

In this paper, we present the results of our analysis of the above elements, and the key messages that came out during the lively discussion with the presenters, in the hope to stimulate feedback from the CAA2020 delegates to explore this topic further.

Sentinel-1 and Sentinel-2 of the Copernicus fleet were the main satellite constellations used. Sentinel-1 SAR data were mostly exploited for ground stability and condition assessment studies based on interferometric methods, by very expert users capable to process these data themselves. Thanks to project partnerships, end-users (e.g. public authorities and conservators) were directly involved to define user requirements and set up the portals and workflows to exchange the extracted information, so to inform the decision making process. Sentinel-2 multispectral data were, instead, most preferred by archaeologists for desk-based studies aiming to gather evidence base to verify later in the field.

Processing platforms (e.g. Google Earth Engine) are increasingly exploited by the space archaeology community to process Sentinel time series, thus making the data handling task more sustainable, without the need to host and manage in-house expensive hardware and software infrastructure.

While no specific needs were expressed to access more or new satellite data, or for new science/operational satellites, more can be done to make the user community aware of the value of Copernicus Contributing Missions, either optical and SAR, to complement the Sentinel data.

Same comment can be made with regard to the existing downstream services tailored to the specific needs of Copernicus users, such as the Climate Change service that was not yet considered to investigate the spatial and temporal changes of meteorological conditions and vegetation cover contributing to environmental threats at archaeological sites. Corine and higher resolution land cover products released at European scale by the Copernicus Land Monitoring Service, are definitely more used. However, some issues were found for the implementation at local scale in certain geographic contexts, due to the characteristics of the crops (e.g. in Poland).

To assess the user uptake of satellite data we need to account for the diversity of the archaeological and cultural heritage community. The archaeological community encompasses academic, heritage preservation and commercial archaeology, and skills greatly vary and could be limited to mere observational level and intuitive understanding of satellite images, up to lack of interest in satellite data. In this context, a clear need was expressed for more investment in training and education initiatives and to facilitate the accessibility to existing satellite data, analysis ready products and processing routines, so to increase the capability of users to work on satellite images (particularly SAR data) and generate value-added products.

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ID number: 37

Videogames as what kind of artefact? Establishing effective methodologies for a solid practice of archeaogaming

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Abstract:

It is a statistical fact that nowadays more people spend more of their time in digital worlds (i.e., the internet, social media, videogames). The global COVID-19 pandemic in 2020/2021 has pushed the boundaries of these circumstances even further. While the global economy seemed crippled by the Corona-Crisis, the videogame industry managed to increase its sales and, most importantly, its traffic of players. While this trend continues, the scientific world is urged to deal even more excessively with digital technologies to create, optimise, and understand these better. One of these technologies are videogames. They offer digital spaces ripe with great potential to experience stories, discover new perspectives and to find recreation within the virtual habitus they offer.

Archaeology has been ever since an academic field that looked at artefacts, once habituated spaces and technologies that humans left behind. Moreover, the method of archaeogaming has proven in the last years that archaeological research is still relevant and progressive within a society that is endorsed and driven by digital technologies. Andrew Reinhard has defined archaeogaming as a practice that deals with the archaeology in and of videogames (Reinhard 2018). A practice that has found an increased interest among a new generation of archaeologists has been eagerly publishing numerous articles in that regard. Besides that a growing body of research has emerged by established scholars in and close to the field that enable the study of virtual worlds (Champion 2019). Yet, while the ambitions of this movement are respectable, a far reaching methodology that effectively addresses the internal ludic nature but also external technocapitalistic entanglements of videogames lags behind. If archaeogaming claims to study video games as artefacts, what kind of artefacts are they? More appropriate research may be enabled to address concrete issues about and within videogames from an archaeological perspective in answering this question. This can be only done if archaeogaming moves closer to the field of game studies.

Game studies, a subfield of cultural studies, has been relentless in the last two decades to create progressive and practical methodologies for the research and analysis of videogames and their social, economic, technological and cultural context. One of these methods is Sotamaa's functional division of videogame artefacts. To apply proper research on videogames, one needs to be clear on what aspect of the game one refers to. Videogames are by virtue composite media and can be therefore studied as (1) material artefacts, (2) software artefacts or (3) cultural artefacts (Sotamaa 2016). (1) Videogames may be consumed virtually, yet they left and still leave their material footprint on our planet behind. From consoles to cartridges and from collectibles to server farms. Videogames have considerable materiality that can be studied on its own. (2) Videogames unfold through their procedurality. “In other words, digital games are always intimately tied to the ways in which computers operate” (Sotamaa 2016: 5). Videogames are grounded in software and can be studied entirely as software. (3) Videogames may be hard- or software, but they are also tied to time and space.

They reflect the period and the culture in which they were produced. These aspects can be traced down in the visual design or story and language of the game. Yet, social aspects can also be portrayed in games that represent the culture in which they were created (i.e., racism, sexism, class identities). Hence, videogames can be treated as containers of cultural codes, symbols and ideas of their designers and audience.

Methods such as Sotamaa's are very known in the field of game studies. As a digital archaeologist or archaeogamer who still has to tap by her/himself on a vast range of publications that emerge monthly in the field of game studies, it is challenging to come across such methodologies as one primarily relies on the publications or references of other archaeologists that research videogames. The most efficient way to accelerate the establishment of solid methodologies for archaeogaming would be to collaborate with game studies institutions directly and eventually work on seminars or classes for students. Or in short, for a progressive practice of archaeogaming, archaeologists must move closer to game studies and not draw game studies closer to them.

To ground my assessment and suggestion, I intend to present the methodological issues of studying games on the basis of Sotama's functional division of videogame artefacts. I will illustrate how virtual worlds, in consideration of the three types of artefacts, should be studied to produce a solid practice archaeogaming. For that, I have chosen to present the game Death Stranding — a game in which players need to transport cargo from one place to another. During the transportation, the player encounters challenging geography for which s/he can use ladders, ropes or other tools to traverse the terrain. These tools can be left by the player to be used by other online players. Properly placed tools can receive likes or different emotive responses by players to communicate their regards to the host of a well-placed tool (see fig.1). This case serves well for an attempt in archaeogaming but shows already intricacies in studying this aspect of the game. Is this game feature part of the videogame artefact's material, software or cultural attribute? This case shall be discussed from all three perspectives to present the complexity and carefulness required in studying videogames.

Once the case is presented, I will conclude and suggest essential steps towards a progressive archaeogaming practice that should entail the collaboration between archaeologists and game studies researchers in creating a joint syllabus, class or seminar for students. The archaeological viewpoint offers valuable theoretical toolkits for the assessment of virtual worlds. Yet, a better convergence with other fields such game studies or digital humanities is required to foster the competencies of the archaeologist of tomorrow.

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ID number: 38

Mobile GIS survey in Mustis

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Abstract:

The goal of the Mustis Summer School “Unearth, Describe, Understand: Archaeology of a Roman Town” was to introduce students to interdisciplinary methods of archaeological documentation, including field prospection with the use of mobile GIS.

The archaeological site of Mustis is located around 15 km from one of best preserved Roman city in Northen Africa – Dugga, Tunesia. The history of Mustis, its plan, even its extension, and its closest surroundings, is unknown.

During the Summer School, we had the opportunity to conduct archaeological field work with the use of Surevy 123, mobile GIS application on smartphones. Twenty two Polish and Tunisian students participated in Crowd Data Collection of archaeological artifacts located on the surface of the site. It allowed students to learn about new technologies used in archaeology, as well as about Roman artifacts. At the same time, it allowed us to supplement the results of geophysical prospection of the Roman town of Mustis, and help in the better recognition of its borders.

In the presentation, we would like to discuss results of the field prospection in the context of the used methodology, precision of measurements, postprocessing, and the final integration of the collected information with the geophysical prospection. Another interesting aspect of our work was the quality control of the dataset collected independently by our group of students. We would like to present the process of survey creation, specially crafted for the need of field research in Mustis, as well as the logistics in conducting the field survey and its results. Additionally, we would like to propose a “good practice” of publication not only for the results of surveys, but also for the code of the questionnaire created within the application.

ID number: 40

Cretan ports and harbors from Late Antiquity to the Byzantine Early Middle Ages (4th – early 9th c. AD)

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Abstract:

Modern archaeology approaches ports and harbors as integral parts of maritime cultural landscapes and, by consequence, of past societies’ everyday life. Recent port and harbor studies have been increasingly benefited from the advantages offered by computer-based analysis to explore the multiple roles played by these maritime infrastructures in particular historical periods and geographic regions. This paper focuses on Crete, a diachronically inhabited large island within the Aegean and the eastern Mediterranean, seeking to investigate meticulously a wide range of key topics related to Cretan ports and harbors between the 4th and early 9th centuries AD.

In Late antiquity (4th – 7th centuries AD) Crete benefited from its localized environmental advantages, the island’s strategic location and the favorable historical circumstances achieving considerable prosperity. Archaeological investigations have shown that a dense network of various maritime sites with harbor facilities developed along the complex coastline of the island. Despite the abundance of archaeological remains, however, important aspects of this situation have not been studied in detail. The multiple roles played by the Cretan ports and harbors, as well as the challenges faced by mariners in moving around the island have not been fully understood.

From the late 7th century AD onwards Crete appeared to enter a period of crisis and insecurity. Until recently, many scholars supported the view that cities and coastal settlements in Crete had already been abandoned as a result of Arab hostility. As such, the complex sequence of changes that occurred in Crete during these centuries has been poorly understood. Modern approaches have shown that the situation appeared to have been more complicated and cannot be fully described by a such simplistic assessment. Although, it is widely accepted that major changes did happen in coastal settled landscapes in the transition from Late Antiquity to the Early Medieval centuries, the picture is rather diverse and needs to be seen from a more constructive point of view.

This inquiry emphasizes on: a) the interaction between seascapes, coastal landscapes (adjoining coastal sites, i.e. ports, harbors and maritime settlements), and navigation, b) the interaction between the local environmental factors in all their complexity and the human activity that would have taken place at land and sea, c) the meaning of maritime spaces in the past; d) the sailing conditions faced by seafarers in moving around Crete; and e) the development of micro- and macro-scale commercial and military networks. This approach looks beyond the examination of sites or infrastructures in isolation taking into account the topographical features of Crete and the local environmental parameters of the island’s sites.

Due to the complexity of the topic, the research sets an interdisciplinary framework, which includes historical and archaeological approaches, combined with spatial analytical tools

offered by Digital Humanities. These tools strongly contribute to the study, analysis, visualization and interpretation of the coastal landscapes.

This presentation will focus on the period of Late Antiquity. So far, 84 port and harbor sites, which have functioned between the 4th and the 7th century AD, have been recorded along the coasts of Crete and the numerous offshore islands. A wide range of published archaeological and historical evidence as well as data related to the environmental context of these sites have been collected. Concurrently, the necessary cartographic data were collected and digitized in GIS environment. Wind data from functioning weather stations in the vicinity of the coastline of Crete, provided by the Hellenic National Meteorological Service, were analyzed for the needs of the research. The distribution of these stations along the coastline gives us an overall picture of the sailing conditions offshore of Crete. Average winds and extreme winds histograms as well as rode diagrams have been generated. The archaeological, historical, environmental, and cartographic data have been incorporated into a GIS environment. Interpolation maps showing the winds conditions around Crete for each month of the year have been created. Several spatial analyses, such as viewshed analysis, least cost path analysis and sail-powered navigation least-cost paths, have been performed.

Interesting results of the research, which will be discussed in the context of the conference, concern the sailing conditions around Crete and the human-environmental interaction. For example, on the south coast, the environmental conditions for navigation during summer when northerly winds blow are not favorable in every section of this route. Although the south coastline possessed an important number of closely spaced anchorages, it is not particularly hospitable, due to the fact that most of them are vulnerable to intense winds coming from the south in winter and the strong northerly squalls year-round. Wind forces are on the side of a passing ship, given the fact that air masses send violent winds down the lee side of the mountains to the southern coast, and spawns squalls and gales. In such conditions the winds can dash the ship against shallows or completely disorientated it, since it would be difficult to approach the coast and find a safe shelter.

Additionally, the results of the research regarding the development of local networks of primary ports and secondary harbors on the Cretan coasts as well as the multiple roles they played by offshore islands will also be discussed. The analysis of the diverse collected data suggests that ancient maritime communities, in order to overcome obstacles created by the vulnerability of primary ports in particular weather conditions and support their functionality, developed a local network of secondary small harbors and anchorages where the natural topography created sheltered conditions for the prevailing winds. Furthermore, the numerous satellite islands, islets and rocks played significant role in human-environmental interaction, the selection of harbor sites, the construction of harbor infrastructures and the maritime traffic around the island.

This research is co-financed by Greece and the European Union (European Social Fund - ESF) through the Operational Programme «Human Resources Development, Education and Lifelong Learning» in the context of the project “Reinforcement of Postdoctoral Researchers - 2nd Cycle” (MIS-5033021).

ID number: 41

How many hectares? Combining remote sensing, historical cartography, and survey data to rapidly categorize and assess the size of archaeological sites in South Asia

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Abstract:

Introduction

Settlement size is one of the most important metrics in the discipline of archaeology, providing the basis for a wide range of archaeological and heritage programmes, including spatial analysis, landscape interpretation, and preservation initiatives. Indeed, hectare measurements of archaeological sites are almost always listed in remote sensing and field survey analysis of ancient landscapes in parts of the world that saw the early origin of complex societies (e.g. Wilkinson 2003). Many of these regions, such as South Asia, are also undergoing considerable present-day urbanization and intensive agricultural development, which is putting pressure on heritage landscapes and threatening the preservation of many archaeological sites (e.g. Conesa et al. 2015; Green et al. 2019; Orengo et al. 2020). Site size provides a starting point for estimating everything from past population size to hierarchy in past settlement systems. And yet, site size is subject to an enormous range of past and present-day impacts, and as such, measuring the extent of archaeological sites is one of archaeology’s most fraught areas of quantification.

Methods:

This paper considers the size of a sample of at least four sites in different parts of South Asia, a region that has been home to many different complex societies, polities, and empires for more than four millennia. In this talk, we evaluate the potential of remote sensing, historical cartography, and survey data to improve assessments of site extent in South Asia. We draw upon analyses undertaken as part of the Land, Water and Settlement, TwoRains and TIGR2ESS projects, each of which is concerned with the past management of South Asian landscapes. We will offer a functional definition for ‘archaeological site’ in South Asia, restricting our focus to the parts of ancient settlements elevated above the surrounding alluvium – acknowledging that this removes certain kinds of past settlements from our analysis. We will then experiment with different methods for measuring the extent of each kind of past settlement. The techniques we use include Multi-Spectral Multi-Temporal Analysis Techniques, analysis of TanDEM-X data, measuring the apparent extent of archaeological sites in a range of historical maps, such as those produced by the Survey of India in the early twentieth Century, and aerial photography combined with field surveys to assess and measure sites in the field.

Expectations:

We anticipate finding that, alone, each method will yield a different result for sites belonging to different periods in South Asia’s past. Not every method of measuring site extent will be

available for every site under study. Remote sensing analyses will the most feasible for wide application, and will provide the most detailed model of the extent and shape of each of the sites that are well-preserved, but it struggles to differentiate between ancient and modern materials and to identify sites with low relief. Historical cartography will reveal the possible extent of sites in the past, but will be relatively coarse-grained with respect to the shape and is unavailable for a range of sites from different periods. Ground surveys will make it possible to clearly differentiate between ancient and modern cultural materials, but will provide high resolution information across restricted transects.

Discussion:

Given the different strengths and weaknesses of each approach for measuring archaeological sites, we suggest that a combined approach makes up for the shortfalls of each particular method. We also suggest that in instances where it provides the largest value, historical cartography may provide the strongest starting point for site measurement, as it controls for later destruction events. Comparing historical cartography values to those ascertained from the analysis of remote sensing data may provide initial support for the presence of a possible archaeological site and help us determine the extent to which a site has been damaged or destroyed. Remote sensing data may also yield insights into the sub-surface characteristics of archaeological sites, revealing areas that early land surveyors may have omitted from their surveys. Field surveys are required to ground truth the results predicted by the other size assessment techniques, and may also provide a method for confirming the sub-surface morphology of archaeological sites. In instances where historical cartography suggests the presence of a site that is not found on remote sensing imagery, field survey may be the sole method for confirming the possibility of a past site location. We offer a combined protocol for generating a strong metrics for past site size, which will enable subsequent analysis of past landscapes and enable the preservation of cultural heritage.

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ID number: 42

Near Presence Analysis: A New Technique for Analyzing the Spatial Distribution of Material in Irregularly Distributed Surface Survey Data

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Abstract:

This paper describes a statistical method for detecting clustering of datable material in irregularly distributed survey units using only presence/absence data, which was developed for the Molyvoti, Thrace Archaeology Project (MTAP). The method is implemented primarily in R, but uses a near table generated by ArcGIS Pro. It is not intended to identify ‘sites,’ per se, but to be an aid to interpretation used in conjunction with other types of qualitative data to identify and characterize activity areas.

Defining sites in pedestrian surface survey is an old problem (e.g., Gallant 1986). Most projects use some form of measurement of the density of ceramics, but this is problematic in regions with a long history of occupation where ancient activity areas overlapped one another. Analyzing the density of material from a specific period is only valid if the collected sample accurately and consistently represents the quantity of material from every time period in each unit. The chronotype collection strategy used at MTAP was designed to collect a sample that reflected the range of material present on the surface, but not its quantity (Given, Knapp, and Coleman 2003). Therefore, the chronologically specific data available are best regarded as presence/absence rather than continuous data and therefore unsuitable for density measures. Standard methods for identifying spatial autocorrelation in binary data, like the join count statistic or methods of point pattern analysis, are not well-suited to survey data that contain large gaps of unsurveyed area between blocks of units (Cliff and Ord 1973).

Therefore, a new method was developed based on a “Near Presence” (NP) statistic. Calculations are performed using an R script that will be made available on github. It requires a shapefile of survey units, a table of chronological data with columns for each period populated by the values 1 indicating presence and 0 indicating absence, and a near table generated by ArcGIS Pro with the fields storing the IDs of input features, neighbors, and distances. This near table defines the spatial model used for analysis. I use 8 nearest neighbors, but depending on the geographic distribution of units, others could choose a different number of neighbors or define proximity using a maximum distance. For any given period, each unit’s NP statistic is the average of the values of its neighbors weighted by distance. The significance of the statistic is determined through a permutation test, in which 1’s and 0’s are shuffled between all units and a new NP statistic calculated. This is done 1000 times, creating a distribution of random NP statistics that is unique to each unit. Comparison with this distribution determines whether the observed NP statistic is high or low according to a user-defined cutoff value. Units that both contain material from the period in question and have a high NP statistic form part of the core of a cluster. The script outputs a table with the NP ranks of every unit in every period and a shapefile with a textual description of the results indicating for each unit whether material is present or absent and whether the NP score was high, low, or moderate. Using these descriptions as categories for symbology allows one to visually identify clusters and suppress scattered, isolated occurrences of material. The

results are most useful when used in combination with other types of data. Combination with density data helps one tease apart the palimpsest of surface material, and qualitative data about the types of artifacts found in these clusters supports the identification of activity areas.

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ID number: 43

Steps towards database driven excavations in lakeside settlements

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Abstract:

Prehistoric circumalpine lakeside settlements are well known for their waterlogged deposits and consequently the numerous interdisciplinary analyses and results. However, only in rare cases, deposits and structures have been analysed quantitatively which is partly due to problems related to traditional excavation methods and the resulting data.

In Immensee-Dorfplatz (SZ), we conducted a rescue excavation in 2020, employing a new, database-driven documentation system that breaks down the stratigraphy into thousands of individual stacked cuboids with semiquantitative descriptions. Information on the finds are stored in the same way. The stratigraphic representation in 3D is done generically. Profile soil photographs are mounted into the same 3D-model in order to verify and validate the database content.

While profile photography-mosaicking and volumetric representations of the stratigraphy can also be done with CAD, the use of GIS allows for a dynamic link to the database and to interdisciplinary data from other sources (government, scientific community. Etc.) without the need to rebuild everything in CAD. In an earlier excavation, PhoToPlan had been used for the profile photographs, but the analyses of find distributions, building structures and of the layers was done in GIS. This meant that several expensive software packages had to be used. In the new system, the different data categories are brought together in just one software that holds a number of spatial statistics tools readily at hand. Still, for open source purposes, analyses like e.g. linear models of find distributions can be done in R, based on exports from the database.

We argue that the 3D-representations are useful for the communication to the public (especially combined with other ArcGis based 3D software like CityEngine). For scientific purposes, however, we see the greatest potential in the breakdown of drawings, text and subjective verbal descriptions into well-defined terms and (semi-)quantitative documentation since these open the way for reproducible spatial analyses and consequently for much more explicit debates on methods and underlying assumptions. We will demonstrate this using an example from the study of layer genesis and taphonomy.

We present the mode and logics of the excavation and the methods of the following data-handling. We also demonstrate our approach to use ESRI ArcScene for the stratigraphic visualizations and analyses. For the 3D-positioning of soil-profile photographs, we experimented with different software packages and methods. For all aspects of the project, we discuss strengths and weaknesses of our approach and the different software solutions.

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ID number: 44

Comparing Time and Energy in Urban Spatial Networks: A Least-Cost Analysis of Water Fetching in Pompeii

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Abstract:

Context:

Least-cost analysis, although only rarely applied to urban environments, is a valuable heuristic tool for investigating movement and dynamic activity across ancient cities. Methodologically, its application within urban road networks must be accomplished using different workflows than traditional landscape scale, raster-based accumulated cost surfaces. By confining cost paths to a vector line network, it bears structural similarities to network analysis, and can be used to model connections between spatially linked nodes. Moreover, by calculating the direction-dependent effects of slope on both walking speed and energy, it represents a truly three-dimensional network approach to urban movement. Recent studies (e.g. Wernke, Kohut, and Traslaviña 2017) offer practical applications based on ArcGIS’ Closest Facility function, although none have yet been applied to Pompeii’s well-preserved urban street network. As part of an ongoing project exploring water fetching in Pompeii, I have developed an anisotropic spatial network model that links all 2000+ doorways in the city to its 43 public fountains.

The transport of water from street fountains to living and working spaces in Pompeii has never been systematically studied, despite superb preservation that allows for street-by-street, unit-level detail. Fetching water was routine but arduous labor likely done by enslaved and female populations. As often noted, fountains were nodes of social interaction that defined natural neighborhoods. This study refines previous qualitative hypotheses by generating more nuanced overlapping districts that are quantified by unit count, size, function, time and energy, and aggregate pedestrian traffic. The results reconstruct the scale of labor of marginalized sectors of Roman society, and could offer quantifiable points of comparison to other Roman cities and contemporary worldwide water provision.

Main Argument:

In this paper, I compare the sensitivity and suitability of various cost functions based on time and calories as applied to an intra-urban spatial network model of water fetching from public fountains in Pompeii. By adjusting variables for household population, daily water requirements, walking speed, and the size and weight of collection vessels, each method offers quantified measures of labor and water accessibility across the city. Using these variables, one can estimate, for example, the number of trips required by each household per day, and subsequently, the total time spent fetching water per household. Calculations of energy expenditure, however, could shed additional light on the tradeoff between the frequency of trips and the heaviness of loads that those tasked with daily water collection certainly faced. It may also help to quantify the real costs of obtaining water for upper floor dwellers in comparison to ground floor units. The well-known Pandolf equation, combined

with the correction for negative slopes derived by Santee et al. (2003), calculates differential energy costs based on the weight of the load carried, as well as walking speed and slope. The volume (and hence weight) of collection vessels is negatively correlated with the number of trips, but positively correlated with expended energy since carrying heavier loads is more efficient yet more laborious. However, the distance of individual units from the nearest fountain, as well as the need to climb stairs, must also be accounted for since both correlate positively with respect to time and expended energy. Different strategies, therefore, may have been employed by individuals depending upon their distance and elevation from a fountain.

Pompeii's aqueduct fed water system has been the subject of countless studies, but none have yet comprehensively examined the transport of water from street fountains into private dwellings. Although as many as 10% of households had private water connections, disruptions to the water infrastructure in the final decades of the city's existence interrupted an unknown proportion of these. There is also debate whether these lines served a utilitarian function or were strictly for display. Nonetheless, the vast majority of Pompeii's inhabitants relied upon public fountains, and this labor inevitably fell to marginalized populations, such as women and slaves, as scant literary evidence and cross-cultural comparison make clear. Previous research, moreover, has noted the importance of the public fountains as nodes of social interaction given their daily use, perhaps even forming the centers of natural neighborhoods. A unit-by-unit network analysis offers the opportunity to refine and quantify several aspects of these previous studies, such as the exact area and boundaries of these districts, the number and size of units served by each fountain, the aggregate street traffic generated by fountain activity, and the likely crowding around specific fountains that were overutilized in comparison to their basin volumes.

Methods and Applications:

The GIS workflow utilized in this study can be applied to many other urban archaeological sites for which sufficient elevation data is available, and to different ends. Nodes in the network are represented by a point feature class while the edges (streets) are rendered in a polyline. Here, nodes represent doorways and fountains, but the same method could be used to analyze movement between any locations of interest within an urban plan. To calculate least-cost paths through an urban network, elevation points from an underlying DEM are imported to the polyline vector street network. This is subdivided into segments roughly corresponding to the resolution of the raster data, in this case 3 meters. The elevation of the start and end points of each segment can then be used to calculate slope (in both directions) and 3D length, which are input as variables into various cost equations for speed and metabolic rate. This study compares, for speed, Tobler's hiking function and alternatives proposed by Márquez-Pérez, Vallejo-Villalta, and Álvarez-Francoso, and Irmsicher and Clarke, and, for energy, the Pandolf-Santee formula. Outputs in walking speed are converted to the time cost (in minutes) for traversing each 3-meter segment. Metabolic costs in watts are converted to more familiar kcals per minute, and then energy costs per segment by multiplying by the time costs. The energy equation requires an individual's body weight, but for this a constant of 65 kg is used, while various load weights are compared ranging from 2 to 25 kg, representing empty and full vessels of varying sizes. These steps were automated by customizing a 3D Network Python Toolbox for ArcGIS created by Higgins (2019). The resulting values are then used as impedances in the Closest Facility function of ArcGIS' Network Analysis extension. Since the impedance values are direction-dependent, the result is a true anisotropic least-cost path. The analysis is run in both directions (unit to fountain, and fountain to unit) and corresponding pairs are tallied (using empty and full vessel weights, respectively) to calculate round-trip costs in minutes and calories. These totals are then multiplied by daily requirements for water per household population to derive daily cost values.

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ID number: 45

The Aide Memoire Project: Drawing and Archaeological Knowledge Production

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Abstract:

Drawing is a key method within many aspects of archaeology including field recording, artefact illustration, and post-excavation dissemination. Yet relatively little is known about the contributions of drawing to archaeological knowledge construction. At the same time, digital recording methods are increasingly displacing traditional by-hand drawing in archaeological recording. The Aide Memoire Project conducted a survey and a series of experiments in field recording and artefact illustration to better understand 1) the perception of digital and by-hand drawing in archaeology 2) how drawing contributes to the creation of mental models that allow archaeologists to understand and interpret archaeological remains and artefacts and 3) what impact digital drawing has on the creation of these mental models. Our experimental toolkit includes the NASA Task Load Index to assess and compare the mental load while drawing digitally or by hand. We conclude that there are significant pedagogical, academic and professional implications to consider when removing or replacing by-hand drawing with digital recording in archaeological methodology. Furthermore, the Aide Memoire Project’s research on drawing in archaeology has enabled us to propose a model of how archaeologists interpret archaeological remains and artefacts, and begin to understand the implications for the long-term preservation and re-use of by-hand vs. digital drawing in archaeology.

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A multiscalar approach to landscape connectivity using circuit theory

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Abstract:

Least-Cost Path analysis (LCP) is the most widely used tool to explore connectivity of archaeological regions (Güimil-Fariña and Parcero-Oubiña, 2015; Herzog, 2014). The concept is based on the creation of a surface map defining the cost of passing through each cell of a raster map covering the entire area under study; LCP identifies the optimal route that connects any two given points within this raster map by computing the path with the minimal accumulated cost.

One of the challenges of LCP analysis is that the search for the single optimal pathway is not well suited to explore connectivity for the entire region. The basic algorithm can only identify one single path between two points; some variations introduce stochastic processes to explore multiple paths, but the fact remains that LCP was not designed to analyse regional connectivity. A possible solution is the analysis of natural corridors: a set of random points are defined at the perimeter of the archaeological region and then LCP is computed for each possible set of pairs. The final step is to quantify the density of optimal pathways at each cell of the map, thus generating a connectivity map for the region (Murrieta-Flores, 2012; Yubero-Gómez et al., 2015). This approach allows the archaeologists to identify the most important pathways independently of the archaeological data, but it still is limited by the optimality of the paths.

Circuit theory (CT) is an alternative approach to connectivity analysis that is widely used in ecological research (McRae et al., 2008). CT is based on the idea of quantifying the chances that an individual moving between two areas will visit any location within a delimited region. The algorithm does not generate a single path like LCP does, and for this reason it is better suited to identify key mobility landmarks, bottlenecks, crossroads and secondary routes. This approach to connectivity makes CT an interesting choice for archaeological studies in regional mobility because it seems able to capture mobility dynamics for the entire area under study instead of its main pathways.

While not as popular as LCP, CT has been previously used in archaeological contexts on a number of case studies (Howey, 2011; Thayn et al., 2016). These works show how the use of circuit theory-based connectivity can strengthen traditional LCP-based mobility analysis for archaeological case studies. The benefits were mostly focused on the identification of multiple possible paths between multiple origins and destinations.

We present here the application of CT for a conflict archaeology case study: the siege and destruction of Puig Ciutat (Spain) that occurred around 49 BC in the context of Julius Caesar's Civil War. This site is located at a hill surrounded by cliffs except for two areas where a defensive system was found by archaeological fieldworks. Excavations also identified evidence of widespread fires suggesting that the settlement was destroyed by a deliberate violent event which is supported by the presence of a large amount of untouched artefacts found inside the

different rooms such as amphorae, tableware or game pieces (Ble Gimeno, 2016 : 107-109). Existing evidence suggests that Puig Ciutat was a settlement occupied by a Roman military unit during mid 1st century BC; the garrison was assaulted by a Roman enemy after what seems like a a brief period of time (Padrós Gómez et al., 2019). The written sources that cover the civil war do not mention any battle that could be linked to the evidence found at Puig Ciutat, but the site is close to Ilerda where an earlier engagement between Caesarian and Pompeian troops took place in 49BC. The finding of a violent event with no supporting written evidence is a common issue in conflict archaeology and generates several interpretative challenges on the causes of these events as well as the identity of the archaeological conflict sites. We focus here on developing a novel computational method combining CT, viewshed analysis and hypothesis testing to explore the role played by Puig Ciutat at two scales: strategic and regional.

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From Ritual Landscape to Ritual Practice: Integrating Multi-Technique Recording in a Complex Landscape

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Abstract:

This paper presents an overview of the variety of spatial technologies applied and their implications by UAISK (Udruga za arheološka istraživanja spačvanskog krajolika). This archaeological research project is an international cooperation between National Taiwan University, University of Southampton, University of Oxford and Heidelberg University. The project is dedicated to the exploration, research and analysis of the Bronze Age ritual landscape in the region of the Spačva Basin in eastern Croatia. Over the past decade, we have been investigating this previously unknown landscape through numerous burial and settlement sites. While focusing on the burial site of Purić-Ljubanj and the tell site of Tezga, we are able to establish an understanding of their ritual practice and their perception of as well as interaction with the region.

This project utilizes spatial analyses techniques, especially GIS, social network analysis and visibility analysis, to investigate the identity creation and social relations through the visibility of ritual performances. The role and effects of visibility is hardwired in the study of landscape researches. On the other hand, ritual itself is a performance behavior (Turner 1969). Ritual is not simply a practice full of symbolic meanings. The performance has its audience and social messages. Therefore, studying the visual effects of ritual performance enables archaeologists to understand the social and political meanings encoded in the ritual behavior. Perception has always been a major topic in landscape studies where visibility stands in a crucial role in structuring and interpreting the surrounding environment. The visual and concealment of ritual behavior is the representation of an agent’s power dominance. The control over things to be seen or hidden from certain people implies the division between us and the others (Thomas 1993). This research utilizes the site Purić-Ljubanj as a case study to investigate the cremation ritual performance of Late Bronze Age tumulus landscape in Croatia. Whereas the building of burial mounds on a flat plain and the cremation ritual themselves are a prominent visual display, the orientation of ritual location on the mounds creates bind spots in certain angles where the ritual is hidden from view. The coexistence of visible and concealed performance suggests the division between us and the others in social communities. Through topographic and geophysical survey, local topography and ritual location can be identified and visibility analysis can be conducted. And, by combining the spatial distribution of tumulus and visibility analysis, this research investigates the visual effect of ritual behavior and the creation of identity and social relations in Purić-Ljubanj.

In order to grasp the archaeological understanding of this landscape, we adapted various techniques such as LiDAR, photogrammetry, and geophysical survey to record and present its complexity at different scales. With the help of local knowledge and hand-held GPS, we are able to pinpoint over 20 burial sites involving a little more than 1000 burial mounds spread across a 200 km2 area. Topographic survey using total station and terrestrial LiDAR illustrated the variety of mound morphology and their distributional patterns. Excavation and analysis

on the material remains suggests that individual burial mounds are multiple burials reused repeatedly and possibly owned by the same family. While the reason behind different morphology of these mounds are still unknown, it is evident that the larger mounds are earlier than the small mounds through C14 dating. With that in mind, it is possible that the size and distribution of these mounds reflect certain social organization. Recent geophysical survey using magnetometer on Purić-Ljubanj have successfully detected the location of the cremation ritual that took place on these tumuli. By identifying the location, slope and direction of this cremation ritual on the burial mound, we are now capable of analyzing its visual direction in relation to its social-spatial setting. Furthermore, this allows us to start the discussion on social boundary, community identity and individual agency.

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Open data and closed lines. Reflections on the management of CAD drawings and RDBMS from the open datasets of Massaciuccoli Romana excavations.

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Abstract:

Introduction

Italian archaeology makes huge use of CAD for describing archaeological excavations. GIS system was widely used from the 1990s in landscape archaeology, being more useful (and of more practical use) for describing and analysing archaeological data on a large scale than on a small one. The reasons for this attitude are many and, in some cases, controversial. One of these is related to the straightforward transposition of handmade drawings to digital support, i.e. a basic way for graphically managing, print and sometimes publish the archaeological records. Another is related to the necessity of delivering the site documentation to the Italian Superintendency where GIS platforms were (and in some cases, still are) unknown. Finally, GIS was considered more devoted to ICT-skilled archaeologists, and more expensive (especially when open-source alternatives were not available). GIS power of analysis was not taken into consideration, except for a few innovative cases (Valenti and Nardini 2004, 341-358). Even if now many excavations are managed with GIS software, the problem remains with the reuse of data initially produced on CAD. This is the focus of our paper. Tha MAPPA lab of the University of Pisa is addressing a High Definition Archaeology project on the Roman site of Massaciuccoli in the north-western coast of Tuscany. The site, a Roman villa, was excavated from the 18th century but in 2010-12, a new area was extensively investigated permitting the discovering of part of a rural complex, which has been musealised in situ. Starting from the data of the 2010-12 campaigns (Anichini 2012) fully disseminated as open data on the portal http://www.massaciuccoliromana.org, the project created a GIS where all the data were systematised and reused to realise spatial analysis on the pottery findings for better understanding the function of the different spaces and their chronology, and new information, such as those coming from non-invasive techniques (XRF, etc.), can be added.

Methods and materials

The open dataset was composed of a CAD file containing 1659 layers (lines for describing the extent of contexts, lines for the characterisation of the components, points for the elevation), an RDBMS containing the context sheet and the quantification of the findings. Given our purpose of realising spatial analysis, we needed to export the CAD file into GIS files. In the beginning, it was necessary to correct some of the main mistakes/differences from CAD to GIS working in CAD environment:

- geolocation of the file initially created on local coordinates;
- creation of closed polylines for all the stratigraphic units for allowing the line to polygon operation;
- completion of the extent of the context when missing (section, missing edges, etc.);

- managing uncomplete context plans (i.e. contexts partially drawn due to multi-context plans);
- managing the missing stratigraphic units (i.e. cuts and fillings).

When imported in GIS environment, we created:

- a polygon shapefile for describing the extent of the contexts,
- a line shapefile for the characterisation merging the feature on the base of each stratigraphic unit.

The complete workflow took 4 person/month and was carried out using Autocad® 2019 and qGIS 3.4 Madeira software.

Results

The results were:

(i) the creation of an excavation GIS where:

(a) all the stratigraphic units (deposits and cuts) are described in the same shapefile as polygons;

(b) each stratigraphic unit has been linked to the RDBMS allowing spatial search and spatial analysis on pottery quantifications;

(c) the characterisations are described as lines and used only for visualisation and print purposes.

(ii) the creation of guidelines for helping archaeologists to realise context plan documentation in a way that could easily allow the exportation to GIS (i.e. the need for single context plans instead of multi-context plans);

(iii) the highlight some of the most common methodological mistakes in the use of CAD for archaeological excavation instead of GIS;

(iv) dissemination of a new GIS dataset containing the cleaned data produced during the excavation.

Discussion

This research highlights that (i) archaeological documentation is not a mere description of the existing stratigraphy, but also a starting point for the in-depth analysis; (ii) until the development of more performing 3D GIS, excavation plans should be preferably realised in a GIS environment; (iii) the reuse of data is often complicated by the technical choices made by archaeologists, and the work needed to export the archaeological documentation from CAD to GIS is often underestimated in terms of personnel effort, as well as the value of GIS for time and costs optimisation in data management and data analysis.

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Ceramic Fabric Classification of Petrographic Thin Sections Using Convolution Neural Networks

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Abstract:

Introduction

Classification of ceramic fabrics has long held a significant role in archaeological pursuits. It helps answer research questions related to ceramic technology, provenance, and exchange and provides an overall more profound understanding of the ceramic material at hand. One of the most effective means of classification is through petrographic thin section analysis. However, ceramic petrography is a difficult and often tedious task that requires direct observation and manual sorting by domain experts. Over the last several years, machine learning applications using convolutional neural networks (CNNs) have offered new opportunities and perspectives of how we can study archaeological materials and features, as they often prove an effective means of recognition and classification. Applications vary greatly, ranging from macro-scale pottery type classification to numerous examples of feature identification in LiDAR or satellite data. Geirhos et al. (2018) have shown CNNs to have a strong bias towards recognizing textures rather than shapes. This has direct implications for the recognition of fabrics, which are highly textural. The research here explores a new approach to the automated recognition and classification of ceramic fabrics with a deep learning CNN model, which can act as a supporting tool for experts in the field by presorting ceramics into their corresponding fabrics.

Methods and materials

The work here is based on pottery from the Cocal-period (AD 1000–1525) archaeological site of Guadalupe on the northeast coast of Honduras, a region that has experienced relatively little archaeological investigation. The site consists of a mound feature situated on a natural terrace with a dense concentration of ceramic material resting above an occupational horizon and several burials. The ceramic style comprises vessel types ranging from deep storage jars to shallow bowls that often exhibit tripod appliquéd supports. As for decoration, they are adorned with a wide range of incisions and appliqués that broadly conform to several specific motif types (see Fecher et al. 2020). Pottery samples were collected from Guadalupe from 2018 to 2020 to acquire a representative sample of ceramic fabrics.

Thin sections of collected samples were made and then analyzed under a polarized light microscope to identify each ceramic fabric and group them. The sample selection was then limited to fabrics with at least three example sherds each, which were photographed under cross-polarized light. The 1069 resulting images pertain to 24 sherds classified into one of five fabric groups and serve as the data with which to build the model.

Building the models employed a standard transfer learning process whereby the bottom layers of two CNNs are pre-trained on the ImageNet data set and frozen, while a single pooling layer and three dense layers were added to `tune' each model to the thin section data set.

Specifically, the VGG19 and ResNet50 were compared against each other using two approaches to partitioning training, validation, and testing data. In the first approach (Approach A), a standard 80:10:10 split of the partitions was used, while the second approach (Approach B) excludes all photos of a random sherd of each fabric type from the training and validation data and reserves it for the testing data. The second approach ensures that the model can classify 'unfamiliar' sherds that were not included in the training or validation partitions.

Results

In each of four tests, the model can classify each thin section image into one of five fabric groups with over 93% classification accuracy. Tests employing Approach A perform better with a minimum accuracy of 99.1% (VGG19) and a maximum of 100% (ResNet50). Approach B performs slightly worse with a minimum accuracy of 93.6% (ResNet50) and a maximum of 96.3% (VGG19). Misclassifications occur most often between the two most texturally similar fabrics. In all cases, however, the majority of images of each sherd is classified correctly.

Discussion

Several other projects have engaged in similar pursuits using CNNs but have geared their research towards macro-scale analyses. For example, Chetouani et al. (2018) achieved 95+% accuracy in the automatic classification of engraved patterns in pottery. The ArchAIDE project (Wright and Gattiglia 2018) has seen similar success in the shape-based classification of Roman amphorae and Terra Sigillata and decoration-based classification of Majolica of Montelupo.

The method presented here focuses on fabrics, i. e., on the microscale. It relies on building a model from images of already-classified ceramic fabrics. Therefore, it is not a means of creating a new classification scheme. Instead, it allows the expertise of those who have defined a classification to be embedded in and accessed via a deep learning model.

Furthermore, the case presented here depends on a very limited data set regarding the number of images, sherds, and fabrics. In virtually all deep learning tasks, a large sample size is paramount. Increasing the sample size and breadth of fabrics included would greatly improve the significance of findings and increase applicability to the broader region.

Despite these issues, the current results serve as a proof of concept that deep learning with CNNs is an accessible and effective method for classifying ceramic fabrics based on images of petrographic thin sections. A next step would be to scale the application of this technique to a better researched and more extensive ceramic assemblage or expand on the data set from Guadalupe. With further experimentation, it is also conceivable that a similar technique can be used to generate a novel fabric classification using k-mean clustering or autoencoding.

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Satellite remote sensing for the reconstruction and mapping of archaeological resources in alluvial environments.

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Abstract:

Introduction

The deposition of fine-grained alluvial sediments within river floodplains can bury, conceal, and preserve archaeological sites and features. These sediments are often thick (>1m), preventing the detection of archaeological remains using common prospection techniques, such as shallow geophysical survey and aerial photography. Despite this, it is possible to determine zones of archaeological/paleoenvironmental potential in alluvial environments through deposit modelling; the recording of sub-surface sediments and stratigraphy, to identify geomorphological variation (Carey et al. 2018). This is normally achieved through intrusive investigations, such as boreholes/coring or trial trenching. However, the analysis of alluvial landform assemblages from remotely sensed data has significant potential to aid the investigation of these environments (Challis and Howard 2003). Moreover, with several recent technological advancements and reductions in cost, remotely sensed datasets are increasingly accessible for geoarchaeological research. As such, this paper provides an assessment of the capability of contemporary remote sensing techniques to model geomorphological components of river valleys and identify their archaeological potential. It reviews previous applications and provides a case study where such datasets have been deployed and compared with ground-based sediment sampling.

Materials and Methods

Airborne LiDAR, Satellite multispectral and Synthetic Aperture Radar (SAR)data have been collected for the Lower Lugg Valley, UK. Previous archaeological investigations in the area have shown that the alluvial sediment sequence is interspersed with significant and complex archaeological remains, and organic-rich sediments deposited within paleochannels. Significantly the higher, drier areas were shown to provide the foci for archaeological activity, particularly during prehistory, whereas the lowland flood-prone areas were likely unattractive locations for human settlement (Jackson and Miller 2011). As such, it is possible to model the distribution of archaeological remains in relation to this subsurface topography. The basis for this model is the application of multiple remote sensing methods, which are used to sub-divide the valley floor into different landform units, such as paleochannels and areas of higher, drier floodplain. These interpretations were subsequently ground-truthed through archaeological cores/boreholes (Figure 1a-d).

Results

For this study, Open Government Licence LiDAR data was downloaded as a 1 m DTM composite. The data are displayed in a tightly constrained colour-scale to enhance any subtle, low-relief variations (Figure 1a). This highlights the central, vertically accreting portion, of the alluvial corridor and a series of more discrete landforms. One of the most clearly defined is a meandering former river channel, located directly east of the present river course (L1). To the west of the river, there is also a high-point, which may relate to a gravel ridge or island (L2). However, any deeply buried landforms, or those that do not display any surface expression, may be very difficult to visualise. It is, therefore, necessary to compare this against other remotely sensed datasets.

The nature and depth of alluvial deposition and presence of geomorphological landforms can affect vegetation health. For example, slightly higher areas with thinner minerogenic alluvium and a greater depth of sand and gravel deposits are likely to be more freely draining. Conversely, specific landforms such as paleochannels or areas of organic-rich deposits, increase soil moisture, allowing for increased vegetation health during dry periods. The analysis of this using multispectral sensors can, therefore, be used to relate surface conditions to sub-surface sediments.

Multispectral data were obtained from the WorldView-2 system for a notably dry period during May 2020. This includes eight spectral bands at 2 m resolution and a single panchromatic band at 0.5 m resolution, allowing for the pan-sharpening of the coarser bands. A single composite multispectral image is reproduced here (Figure 1b), but 45 spectral ratios/indices, were calculated to increase contrast. Separability measures were then employed to provide a quantification of the effectiveness of these for the characterisation of geomorphological components and archaeological features. Within the image presented, it is possible to identify the former channel to the east of the River Lugg (M1). The response is more complex than the LiDAR data, owing to variation in the composition of the channel deposits, with more coarse material probably being located at the channel edges. This is less clear to the north of the area, as the fields were recently ploughed, reducing vegetation cover, although it is still visible as soil marks. To the west of the River Lugg, a gravel island has been interpreted that corresponds with a high point in the LiDAR data. This is characterised by an area of healthier vegetation surrounded by more sparse vegetation/bare soil (M2).

A radar time series was acquired via the COSMO-SkyMed (CSK) mission. This comprised 74 images distributed between 2014 and 2020 that were collected in ‘StripMap’ mode, providing a spatial resolution of approximately 3 m. This can be used to measure dielectric properties and moisture content and the time series also enabled the study of consistently wetter/drier areas in relation to modern flooding episodes. Three SAR images from the winter of 2019/2020 are presented in a composite image in Figure 1c. The flooding is characterized by a specular response from a smooth water surface, resulting in no signal being scattered back to the sensor, hence flooded areas appear dark. Consistently flooding areas correspond with areas of lower surface topography. This is significant as these areas are likely to have been unfavourable for archaeological activity, but their consistently wet nature contributes to the preservation of important paleoenvironmental remains. Moreover, several morphological aspects of the floodplain, including the former channel (S1) and gravel island (S2) are also very well defined.

Discussion

The analysis of these remote sensing datasets has identified landforms that can be interpreted in terms of their archaeological and paleoenvironmental potential. However, a more meaningful interpretation has been achieved through the combination of multiple data sources, each measuring different surface properties that can be used as a proxy indicator of subsurface sediment architectures. The results demonstrate that these technologies can provide significant insights into the geomorphological complexity and variability of alluvial environments and subsequently facilitate a geoarchaeological assessment of their potential. The results will, therefore, be of interest to archaeologists and heritage managers working within these environments, as they can offer a more cost-effective and holistic analysis of archaeological resources in alluviated landscapes.

ID number: 52

The European Union's Copernicus Programme in Support of Cultural Heritage

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Abstract:

This contribution will provide an update on the current state of Copernicus support for cultural heritage. It intents to raise awareness of the importance of Copernicus for our discipline and suggests starting points for designing archaeological applications around Copernicus products and services.

Context and background:

Copernicus is the European Union’s ambitious space technology programme that already provides many essential services in support of environmental protection, land management, oceanography, weather and climate research, etc. More recently, the European Commission (EC; through DG GROW) has been investigating the feasibility of extending the official scope of Copernicus into the Cultural Heritage (CH) domain.

To provide a baseline, a PwC study, published in late 2018[1], conducted an EU-wide user poll on the topic of remote sensing data for CH. The study compiled detailed data on user activities and needs, based on the responses of 89 individuals that represented six different user communities. It found that up to two thirds of CH user needs could, in theory, be covered by existing Copernicus technologies (depending on the level of support granted by the EC). This was expressed as three options for future implementation:

1. No additional budget for developing new CH products within Copernicus (i.e. basic support).

2. Investment into a new online platform fully dedicated to Copernicus CH products, and into tailoring existing products for CH needs.

3. Creation of a dedicated Copernicus Service for Cultural Heritage, on the same level as existing services (Land Monitoring, Marine Monitoring, etc.).

In 2019, the Copernicus Cultural Heritage Task Force (CHTF) was created to include representatives of CH institutions from all EU member states. The objectives of the CHTF were to update and enhance the PwC study’s data base, analyse the member states’ own capacities to contribute to Copernicus CH coverage and report its conclusions and recommendations to the EC. The task force's report was published in 2020[2].

Applications:

The fact that “native” Copernicus technology does not include high-resolution imagery in the visible spectrum might reduce its attractiveness at first glance. However, several aspects should be kept in mind:

* Copernicus is constantly evolving, with a long-term view. This makes it all the more important that stakeholders from archaeology and related domains express their user needs continuously.

* High-resolution imagery (and other products) are provided through associated Copernicus partners to selected Copernicus Services. Whether these will also be made available to CH institutions (and to what extent) will depend, among other things, on how well the “security and safeguarding character” of site monitoring and emergency interventions can be developed by CH institutions.

* Most importantly: Copernicus (and related) technologies have great potential for large-area CH management and protection[3]. New and innovative approaches must be developed to harness this potential.

As far as the future of effective, large-area management and protection of CH is concerned, perhaps the biggest Copernicus potential lies in fully integrative approaches that combine data, methods and policies from the domains of natural and archaeological heritage. Indeed, in the aforementioned PwC study, “Cultural Heritage” is defined as both “Tangible Heritage” and “Natural Heritage”, making it very clear that the EC views such integrative approaches as essential to the successful application of Copernicus technology in the CH sector.

Perspectives:

Remote sensing technology is capable of addressing the challenges of global CH management and protection in a cost-effective and comprehensive way. In the near future, institutional support by Copernicus for CH will open up potentials for much-needed innovation.

But to realise this enormous potential, our discipline must learn to think beyond the traditional paradigm of “the more visible detail, the better” and unlock the potential of large-area sensors and multi/hyperspectral data from the environmental domain. Given the current challenges (of climate change, mass tourism, land degradation etc.), effective management and protection of sites and monuments, parks and historic areas must make use of such synergies.

The degree to which archaeology and cultural heritage will actually benefit from Copernicus is directly related to the commitment of all relevant stakeholders: The EC has recognised the importance and benefits of technological support for CH. It is now up to all EU citizens with an interest in remote sensing for the CH domain to get involved, innovate and ensure that this support will be as extensive as possible.

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ID number: 53

Dating mechanisms: possibilities and limitations of dealing with time intervals of the Roman Limes. Vagueness in the case of terra sigillata (samian) chronology.

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Abstract:

Introduction

The development of the Roman Limes has always been thought to have been a corner-stone in establishing chronologies of various finds-groups in archaeology. The consecutive construction of Limes sections, each time deeper into enemy territory, should theoretically provide a solid framework for dating artefacts found at the individual military camps in each segment, but the precise chronological time intervals of the occupation phases has remained until now very sketchy. Thus finds from Limes sections have been widely used to date the same sort of finds found elsewhere which do not have dated contexts. However, since there are only very few historical dates attached to the Limes sections, many military camps on the Limes have only been dated by comparing material from the few dated military Limes camps, which causes a circular reasoning. The time intervals of Limes sections such as those of \`Hadrian’s Wall\` or the German Wetterau-Limes are thus suffering from temporal vagueness within the underlying dating mechanisms and a lack of absolute dates. In order to generate knowledge about the underlying processes of dealing with vagueness in these time intervals, visualisation of the underlying reasoning process is required in order to outline the dimension of the temporal vagueness involved. The increasing usage of semantics and graph technologies in the digital humanities offers methodologies to tackle these complicated archaeological issues. Low-threshold online available tools dealing with semantic based methods and algorithms could help the scientific community to explore the possibilities of these emerging techniques.

Methods and Materials

In order to handle the problem of solving and visualising vagueness within the sequences of relative dating intervals, we use the following methods: first we start with a 3D distance calculation of given Correspondence Analysis (CA) results, in which the quantitative relations between finds and proposed time intervals are set out. Following the \`horseshoe paradigm\`, the calculated distances of the presumed time intervals provide us with a measure of overlap between the intervals. After that, our \`Alligator Algorithm\` will be applied. This method calculates and fixes datable and non-datable (floating) periods, by finding the next 3D CA neighbours. The intermediate result of fixed and floating time intervals are then stored as \`virtual fuzzy years\`. This enables us to establish a relative chronology based on Allen’s interval algebra. Any \`virtual fuzzy year\` resulting from that is then transformed into relative \`Allen time intervals\` (‘later then’, ‘overlaps with’ etc.) and stored in Resource Description Format (RDF) structures to visualise the results.

A second method is applied by using the Academic Meta Tool (AMT). This tool allows for deployment of temporal reasoning including statements about the vagueness. In this case, we

use the `Allen time interval` results and calculate the degree of connection between the periods (vagueness). From there, an AMT ontology is developed which consists of the implemented reasoning methods to establish the chronological vagueness within and between the periods involved. The reasoning results are stored in graph structures like RDF to visualise the results.

This study uses the online available database `Samian Research`, based on the `Names on Terra Sigillata` project of Leeds and Reading Universities funded by the AHRC and the RGZM at Mainz (RGZM 2021). The database comprises a quarter of a million potters’ stamps on Terra Sigillata, recorded from dated and non-dated sites from all over the Roman Empire. Since the same South Gaulish potters’ stamps may occur on different sections of the Limes in different parts of Europe, this material allows a) for comparison and b) for temporal reasoning between the Limes sections of the 1st and 2nd century AD.

Results

The `Alligator Algorithm` and `AMT Algorithm` employ online software solutions based on Linked Data and semantic technologies, JavaScript, JAVA and a RDF4J triplestore. As a result, the little minions `Alligator` (Thiery and Mees 2019) and `Academic Meta Tool` (Unold and Thiery 2017) have been implemented on an operational level. In combination as a `linked pipe`, they are able to make the mechanisms of Limes-dating based on specific material find-categories more comprehensible. `Alligator` was developed by the department of Scientific IT at the RGZM, AMT is a joint project between i3mainz and RGZM within the mainzed network.

As an example, with the help of this new tool `Alligator`, it is possible to analyse and visualise the dependencies within the dating arguments of individual Limes sections when using Terra Sigillata data. `Virtual timelines` may show the position of the `Main-Limes` and the `Odenwald-Limes` in `virtual absolute years` as a fundament for a relative Limes chronology.

With the help of AMT, temporal reasoning with vague connections is possible. The output formatted as RDF, Linked (Open) Data and other graph formats, enables interoperability and reusability to establish reproducible research as a basis for Open Science.

The tools presented are enabling archaeological statements about the chronological sequences of different Limes sections. Some German Limes sections are apparently to be dated considerably later than thought hitherto, whereas others seem to be less reliably dated. This research also pushes forward the question whether the supply of the identical group of find-material was identical in all parts of the Limes sections involved.

Discussion

The implication of this methodological breakthrough for dating time intervals of Limes sections with Terra Sigillata using Allen’s reasoning algorithm is clear: Terra Sigillata is in archaeology apparently highly overestimated in its absolute dating capability. Whereas the establishing of relative chronologies can - due to the huge amount of material involved in the analysis - be considered as solid and stable, establishing exact starting and / or end dates of Limes parts is clearly beyond the dating capacities of this find category. This new method of dealing with uncertain time intervals opens possibilities for comparisons with other timeline oriented methods used to date Limes sites such as with coin dates. It also offers opportunities to handle stylistically defined ceramic periods in prehistory with similar vague timelines in combination with C14 dates.

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ID number: 54

A little knowledge is a dangerous thing: Analogue practices with digital tools.

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Abstract:

Archaeologists have been quick to adopt digital tools and services, perhaps too quick. While there is a high level of technical skill among many archaeologists working professionally and with research, this skill can obscure a lack of deeper understanding of digital knowledge production. This becomes evident when looking at the primary data created during fieldwork, where unawareness about the importance of digital interoperability and preservation prevents reuse. The authors are currently working with a Swedish research infrastructure project aimed at preserving digital archaeological documentation and making it accessible and reusable. The process is bringing to light many of the issues surrounding archaeological practices in digital environments and the products thereof. The datasets lack necessary information, standardised vocabularies and quality controls and have not been prepared for archiving purposes. Practices which may be less than optimal in an analogue setting become near catastrophic in a digital one. We welcome the opportunity to discuss these issues with the session participants.

ID number: 55

Linked Open Usable Data for Archaeology Including Modeling of Interpretations

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Abstract:

Introduction

In accordance with the goals of the session we want to present an approach that is able to provide LOUD data for prehistoric mining archaeology applying the FAIR principles and making use of the CIDOC CRM ontology (Le Boeuf et al. 2019) and its extensions as conceptual model to make the data Interoperable and Reusable. The approach will be illustrated with a use case from several projects related to prehistoric mining activities in the eastern Alps of Austria. The data were collected during various scientific research campaigns and as the data are of archaeological nature, the methodologies and guidelines of ARIADNE (Advanced Research Infrastructure for Archaeological Data Networking in Europe) were used to process the data making them FAIR (FORCE11 2019). Modelling the documentation of archaeological resources using the CIDOC CRM has been undertaken by various projects and initiatives although the use of the CRMarchaeo and CRMscience extensions which have been developed within ARIADNE has been rather rare. We want to make use of these extensions and take the next step to model interpretations with the CRMinf extension. On the example of a published paper based on the results from the archaeological research we show how to represent the interpretations in RDF and how to link them to the resources and facts they were based on. The work on FAIR data and data modelling is integrated into the COST Action SEADDA.

Methods and Materials

To make the data Findable and Accessible they were deposited at the Zenodo repository located at the CERN Data Center which has experience in long-term archiving and assigns DOIs (Digital Object Identifier).

While each project has its own way of documenting their research, all metadata were encoded with shared vocabularies and ontologies. Most importantly the relation between (1) the research objects like stratigraphical units or different findings, (2) the activities like excavating or analyzing a find and (3) the actors like archaeologist or a labor were semantically modelled and separated from any interpretation. Because of such detailed modelled provenances, it is possible to explicitly specify the different research activities with their specific methodologies and lining them to the investigating person or institution.

As stated above, the research data derives from different projects at the research center HIMAT (History of Mining Activities in Tyrol and adjacent areas) of the Archaeological Department of the University of Innsbruck. The documentations were merely done according to the guidelines of the Federal Monuments Office (BDA – Bundesdenkmalamt).

To ensure long-term preservation all documentation files were converted to file formats specified by the guidelines of the ADS (Archaeology Data Service, York) before uploading them to Zenodo and receiving a citable DOI. For the conversion a python-program was written within the research-project “FAIR Data for Prehistoric Mining Archaeology” (Hiebel et al. 2019). Because Zenodo gives one single DOI to a whole dataset the python-program also writes a metadata-file where each folder and file receives a unique identifier consisting of the Zenodo-DOI and an ongoing number. While this “step”, although important, is pretty simple and not really innovative, it is the combination of the different data and documents from the individual projects which make the data truly Interoperable and Reusable. It needs to fulfill basically two requirements. First the model behind all resources needs to be general enough that all projects can be included, but compact enough to allow the research on specific questions. And secondly a shared vocabulary/thesaurus and ontology which is usable but extended enough to fulfill all needs.

For the creation of the metadata for all generated and deposited files and research documents the CIDOC CRM ontology with its extension was used. CIDOC CRM is an ISO standard for Cultural Heritage Information, which was adopted as the conceptual background by ARIADNE. CIDOC CRM was extended in the course of ARIADNE with CRMarchaeo to model archaeological excavations and which was build based on the official documentation requirements of different countries including the Austrian Federal Monuments Office. CRMsci was used to model scientific observations. To model digital provenance, the extension CRMdig was used, for geographic information the extension CRMgeo. A particular focus will be laid on CRMinf to represent argumentations leading to interpretations that are information objects which may have belief values attached. Concepts specific to mining archaeology research are organized with the DARIAH Back Bone Thesaurus, a model for sustainable interoperable thesauri maintenance, developed in the European Union Digital Research Infrastructure for the Arts and Humanities (DARIAH). SKOS (Simple Knowledge Organization System) was used to organize our vocabularies, another semantic web standard for sharing and linking knowledge organization systems such as thesauri, taxonomies, classification schemes and subject heading systems.

Results and Discussion

We will present an approach how to integrative model different research projects with different output data with a shared ontology and thesaurus to make them not only Findable and Accessible but moreover also Interoperable and Reusable based on the FAIR-principles. The methodology is based on semantic web standards like SKOS or the DARIAH Backbone Thesaurus and on CIDOC CRM and its extensions CRMarcheo, CRMsci, CRMdig, CRMgeo and CRMinf, the preferred metadata schema of ARIADNE EU-Infrastructure for Archaeological Resources. Therefore the metadata standard employed here is adequate for documentation at hand and in addition a consensus on a European level. Moreover the use of CIDOC CRM as an event centric ontology enables the recording of detailed provenance which can be attached to the events of observation, measurement, interpretation and creation or modification of the documentation.

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ID number: 56

Dynamic Social Structure of Old-Kucapungane: New Approach of Space Syntax with Network Analysis for Taiwan Abandoned Settlement, Kucapungane

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Abstract:

Introduction

This research combines quantitative analysis, in the form of spatial analysis, and qualitative analysis, as in ethnographic data, to scrutinize the socio-spatial paradigm. Using the site Old-Kucapungane as a case example, this approach successfully identifies different local communities as suggested through ethnographic researches.

Access analysis, one of the space syntax analytical methods, has been widely applied to archaeological material with physical boundaries of space (such as ancient cities, settlements, buildings) and provides insights into the nature of social structure understudy. However, this technique has been criticized for failing to discuss social relations from agent-based approaches due to its assumption of space as a de-populated and independent unit. As a result, not only human behavior and the decision-making process completely restricted by the physical spatial layout, but also the contextual meaning between people and space are removed from its social context.

Nowadays, many archaeologists start to adapt multi-approaches to compare the dialectical interplay between different data and attempt to understand the mutually constituted relation between society and space. One of the alternative approaches reworks the basic algorithm of space syntax and combines the measurement of network analysis as a methodological improvement. My article aims to combine space syntax and social network analysis to study the social organization of Old-Kucapungane, an abandoned settlement in Taiwan. Through combining proximal point analysis used in social network analysis, space syntax can measure the step-depth value of each household and identify household groups with strong ties from a local interaction perspective.

This approach combines spatial analysis and ethnographic interviews that confirm the presence of household-based localized communities, which is the first attempt in Taiwan archaeology. Moreover, these localized communities and their dynamic social boundaries can be further observed through ritual practice and reflect the integration of kinship, social hierarchy, and historical meanings of space.

Methods and materials

Old-Kucapungane is a well-preserved abandoned slate house settlement in Taiwan. The Kucapungane people lived in the settlement for the past 600-700 years, but were forced to move out 50 years ago due to government policies. Nonetheless, since they abandoned Old-Kucapungane relatively recently, some of them still have retained the memories of life experiences in this settlement. This makes Old-Kucapungane a perfect example for a comparative study between archaeology and ethnography. The settlement layout and

ethnographic data, such as household genealogy, nuptiality data, and traditional exchange behavior of Old-Kucapungane, will be my main research materials to reveal the social organization structure of Kucapungane.

Space syntax posits that there is a lawful relation between spatial configuration, human movement, and co-presence interaction behavior (Hillier 2014, 27-29). For example, highly integrated spaces encourage contiguous activities, while highly segregated spaces limit the interaction of agents to different sub-communities. Since space syntax assumes that space is neutral and independent, we need to link these de-population spaces to agent activities within their social interaction contexts.

I develop a method for this study that includes four steps. First, I translate the settlement layout of Old-Kucapungane (such as roads, platforms, houses) into a series of convexes as large as possible for mutual visibility to cover the entire settlement. Then I connect each convex to illustrate a justified access graph (The convex map is drawn by space syntax software Depthmap).

Second, I use proximal point analysis (PPA) to identify local communities with stronger ties. The tie-dependence assumption of PPA in an archaeological context is that if node i contacts with node j and node j contacts with h, then it is more likely that i would contact with h as well, known as transitivity relation (Amati et al. 2020, 193-194). Following this assumption, I specify that each house node is connected to all house nodes and account for each step-depth value of the edge using space syntax software Jass. Then I separate community division through social network analysis software Pajek by predicting the specific step-depth value of community boundary. In which case, this specific step-depth value marks the boundary where certain households are more strongly interconnected that forms a local community.

Third, I use the two formulae to measure the integration of each community area and simulate the potentially available social interaction of each community area ： (1) Convex articulation = Number of convex spaces / Number of room blocks (Stone 2000, 201-205). The lower the value of the convex articulation, the greater the amount of open space that is available for supra-family interaction; (2) Convex ringness = number of islands/2*(number of convex spaces)-5. The lower the value, the greater the fragmentation of space and the greater the control of interaction in that space. The higher the value, the less fragmentation present, which means the lower the control of interaction in any single space.

Fourth, I compare the results of archaeological spatial analysis with ethnographic research. This approach not only cross-validates space syntax which combines measures in social network analysis but also gives insight into how settlement layout can be used to identify social organization structures, especially for interaction behavioral patterns in a community.

Results

By combining the proximal point analysis and space syntax, the results show that there are two communities in Old-Kucapungane: western and eastern. In terms of spatial layout, the western community is relatively fragmented, and the interaction behavior of each house shows a greater degree of control than the eastern side (convex ringiness of western is lower than eastern). This suggests the behavioral pattern of heterogeneous and people on the western side tend to restrict their interactions. In contrast, the spatial distribution of the eastern community is more integrated with a lower degree of control. It demonstrates the behavioral pattern of homogeneity, and interaction behaviors within the area are less controlled.

Meanwhile, the ethnographic data concurs with a similar pattern of this result. Since the western side of Old-Kucapungane is developed earlier, it consists of big chiefs and most high-rank nobles, and is also the center for feasting rituals. Therefore, other low-rank nobles and commoners, who separated from the households in the western area, live in the eastern area. The western people often emphasize they accumulate social prestige through obeying traditional exchange behavior between noble and commoner throughout their history. When Millet Harvest Festival is held by Old-Kucapunagne people, the people living in the eastern area need to go back to the western area to join the feasting rituals of the big chief.

Generally, the western area people are more hierarchical, whereas the eastern area people are more egalitarian. And through the ethnographical data, such as ritual practice, we can reveal the dynamic process of how the social relation boundary is formed and changed.

Conclusion

In conclusion, the results of comparing spatial analysis and ethnographic data highlight that the new approach, space syntax combined with network science, can predict the differences of social interaction and the community division effectively for Old-Kucapungane through a local interaction perspective. Furthermore, this method could be useful and suitable for settlement studies to provide insight into social relations through the interaction between people and space.

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ID number: 57

Hic sunt dracones – How to make modern data dragons LOUD and FAIR

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Abstract:

Today, many archaeological data is usually stored in relational databases. One of the advantages of these storage technologies is e.g. referential integrity, allowing for well structured datasets. However, in order to reach web based interoperability and FAIR data, additional technologies such as machine readable interfaces and Linked Open Usable Data (LOUD) are compulsory. We call such data without a LOUD publication “modern data dragons”. Whereas SQL technology may cover just as well the F, A and R capabilities of the FAIR principles on local systems, web based interoperability (I) and Open Access (A) is clearly the advantage of the RDF-LOD technology. Enhancing SQL databases by applying LOD technologies enables the application of the RDF standard (I), semantic modelling (R), interlinking of data, and Open Access by offering a SPARQL endpoint.To support the development and publication of LOUD resources, the CAA Special Interest Group (SIG) on Semantics and LOUD in Archaeology (SIG-DataDragon) was established in 2020.

Archaeological data is often characterised by hidden assumptions as well as vague and uncertain statements, which have to be made visible by using e.g. semantic modelling. The transformation process from relational structures into LOD has to be simple and applicable to other databases and modelling structures. As a consequence, the resulting data should be published as well as being made findable and accessible in catalogues of archaeological resources. This paper demonstrates methods and workflows to achieve LOUD and FAIR data with the example of the Samian Research database and the re3dragon – REsearch REsource REgistry for DataDragons – catalogue and API.

In this study we are using the online database Samian Research, which is based on the Names on Terra Sigillata project, driven by Leeds and Reading Universities funded by the AHRC, the Corpus Vasorum Arretinorum and the RGZM at Mainz (RGZM 2021). The database comprises a quarter of a million potters’ stamps on Terra Sigillata, recorded from dated and non-dated sites from all over the Roman Empire. Since the same potter may have worked in different kiln sites, there is a vagueness in the possible attribution of potters to kiln sites. Vagueness and uncertainties also occur in the context of the determination of partial vessel fragments (e. g. when only a base fragment of a vessel is preserved) which may be attributable to different possible types of pot forms.

The Samian database is structured in a relational database and accessible by online query masks, which were developed from the late 1990s onwards. The scientific data are ongoing curated by an active international research community. Although the series of interfaces comprise a RESTful API and WFS, Research Software Engineers (RSEs) would expect also LOUD machine readable interfaces. This implies that we have to establish and implement methods to reach two major keystones: (#keystone1) create FAIR LOD which is directly connected to the origin database and is interlinked to external repositories, (#keystone2) create research

tools – c. f. Little Minions – to make this data usable and findable, by enabling third party software using this resource for further analysis.

By implementing #keystone1 and in order to provide the Samian Research Database resource as FAIR LOD, we created a semi-automatic transformation process as well as a CIDOC-CRM and SKOS based ontology, starting from a PostgreSQL database, creating transformation processes to generate CSV and Turtle files using ColdFusion and Python, resulting in a SPARQL endpoint based on a RDF4J triplestore and published with GeoPubby (Thiery, Mees, and Gottwald 2020). In this workflow we also modelled vagueness and uncertainty for relations between e. g. potters and kiln sites using the Academic Meta Tool (AMT).

Creating and implementing research software for #keystone2 can be shown using re3dragon (Thiery 2021). The re3dragon tool envisages two aims: (1) publication of an open extendable archaeology related LOD resource catalogue, including authority data, thesauri, controlled vocabularies, gazetteers (e. g. GeoNames, Pleiades), time gazetteers (e. g. ChronOntology, PeriodO), as well as typologies and domain specific resources (e. g. nomisma, Roman Open Data); (2) offering an API for requesting distributed LOD resources providing the resources in a standardised JSON format based on JSKOS.

(Figure 1: Distribution map of Dressel 6b amphoras and Terra Sigillata from Pisa, generated by combined SPARQL querying of distributed resources) https://my.hidrive.com/lnk/9tzCv3o8

Using the former mentioned methods and workflows we created and published 7.869.468 triples and 306.615 instances under a DPPL License (status: 4/12/2020) as well as the underlying ontology as Linked Open Samian Ware to reach #keystone1. On top of that, the relations between historically grown different Samian typologies are semantically modelled in an ontology, and interlinked with Linked Open Samian / Red Slip Ware data. The Ceramic Typologies Ontology Viewer is able to visualise this typology graph displaying semantic connections, e. g. tradition, publisher, generic form, same form, service member, or identical potform properties. The core of the re3dragon API is published on GitHub. This enables the Linked Open Samian Ware data to become reusable and to reach #keystone2. Therefore, this new FAIR and LOUD resource allows also for e. g. geospatial analysis using QGIS and the SPARQLing Unicorn QGIS Plugin, where two distributed LOD resources (e. g. Linked Open Samian Ware and Roman Open Data) can be sparqled and e.g. combined in one distribution map (figure 1).

Making modern data dragons LOUD and FAIR has huge implications for archaeological research: combining distributed online resources of completely different find groups (e. g. amphoras and Terra Sigillata) offer entirely new research perspectives. In this case, clear differential markets for contemporaneous goods such as Dressel 6b amphoras (black dots) and Terra Sigillata from Pisa (red dots) are discernable. This opens research questions related to market strategies in the Augustean period.

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re3dragon – REsearch REsource REgistry for DataDragons

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Abstract:

Cartographers in historical maps used the phrase `Hic sunt dracones` (historically translated as here be dragons) to describe areas which were unknown to the map creator. Today, the digital data universe is full of unknown data, which are not FAIR (Findable, Accessible, Interoperable and Reusable). The World Wide Web offers researchers the possibility to share research data and enables the community to participate in the scientific discourse to create previously unknown knowledge. However, much of this data is not findable or accessible, thus resulting in modern unknown data dragons. These data dragons lack connections to other datasets, which leads to non-interoperability and in some cases unusability. To overcome these shortcomings, a set of techniques, standards and recommendations can be used: Semantic Web and Linked Open Data (LOD) and as a consequence Linked Open Usable Data (LOUD) (Thiery et al. 2019). To tame and unveil the modern data dragons, the CAA Special Interest Group (SIG) on Semantics and LOUD in Archaeology (SIG-DataDragon) was established in 2020.

Data dragons require a safe home base, a digital lair, where they can group together, be found and be accessible. This data dragon LOD lair home and machine readable access is combined in the re3dragon - the REsearch REsource REgistry for DataDragons. The Little Minion re3dragon tool envisages two aims: (1) publication of an open extendable archaeology related LOD resource catalogue (Dragon Lair) including authority data (e. g. Integrated Authority File - GND), thesauri (e. g. Getty AAT, Heritage Data Vocabularies), controlled vocabularies, gazetteers (e. g. GeoNames, Pleiades), (space-) time gazetteers (e. g. ChronOntology, PeriodO), as well as typologies and domain specific resources (e. g. Roman Open Data, Nomisma, Linked Open Samian Ware), and (2) offering an API for requesting distributed LOD resources (Dragon Items) providing resources in a standardised JSON format based on JSKOS (Voß 2021). The re3dragon API is coded in JAVA using e. g. Maven and Apache Jena and is published Open Source on GitHub (Thiery 2021).

This minion talk focuses on the semantic modelling structure, the API and the possibility of participation. The modern data dragons need your help! Code with us to create new accessible archaeological dragon lairs.

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The French National 3D Data Repository for Humanities: Features, Feedback and Open Questions

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Abstract:

We introduce the French National 3D Data Repository for Humanities designed for the conservation and the publication of 3D research data in the field of Humanities and Social Sciences. We present the choices made for the data organization, metadata, standards and infrastructure towards a FAIR service. With 419 references at the time of the writing, we have feedback on some challenges to develop such a service and to make it widely used. This leads to open questions and future developments.

Context

Research in the field of Humanities and Social Sciences (HSS) are integrating the use of 3D data in their scientific practice. With the democratization of 3D technologies, the increasing number of 3D models raises several questions [3] around a major one: how to ensure data transmission for future research? The resulting questions concern the archiving, conservation or publication processes, and thus the data format, the standard metadata and the infrastructure.

Archiving digital data is an issue for research and Cultural Heritage institutes [1]. In 2014, with the support of French national digital infrastructure for HSS (Huma-num), a consortium "3D for Humanities" has been created as a scientific network of 3D models producers and users in the field of archaeology and Cultural Heritage. It led to the deployment in 2018 of the National 3D Data Repository (CND3D) for the conservation and publication of 3D data, with all related documents and well-defined metadata scheme, within the goal of a FAIR service.

Features

The CND3D is organized around the two notions [2] of

1.Virtual object: a 3D digital instance of a coherent entity, from a Cultural Heritage point of view: that has been digitized and/or restituted. Each virtual object includes not only the final model, but also to all the documents (from digital scans, images, ... to texts) that have been used.

2.Deposit: a collection of coherent virtual objects.

All the documents, the virtual object, and the deposit are associated with corresponding metadata.

Findable and Accessible: Publishing data means making them available to the scientific community. It is therefore necessary to ensure that documentation and metadata complies with interoperable standards. We use Dublin Core with an ongoing alignment with the CIDOC-CRM to integrate the European ARIADNE portal. While keeping the possibility of defining its own referential, the CND3D is aligned with PeriodO, Geonames and the PACTOLS thesauri.

The metadata can be filled on-line, or off-line with a specific open source software named aLTAG3D (a Long Term Archive Generator for 3D). This software allows us to construct the package, object-by-object by attaching the sources to it and by filling in, at all levels the requested metadata. It was designed to simplify the tedious task of metadata filling for such complex data.

Interoperable and Reusability: A DOI is assigned at deposit and virtual object levels. This DOI allows publications in the open archive HAL to point the referenced 3D. Reciprocally, the related publications in HAL are referenced by their unique identifier.

The ultimate goal of FAIR is to optimize the reuse of data. Standard 3D formats (PLY and DAE) and non-standard formats are allowed (later ones without archiving possibility). By using standards formats, data and metadata can be pushed to a long term archiving facility (CINES - National Computer Center for Higher Education).

Storage: We use a national networked distributed, long-term and secured storage facilities provided by Huma-Num. To preserve the accessing right on sensitive data, authentication and right management are included.

Feedback

Creating new deposits and references to virtual objects requires the same amount of work than adding a classical publication on an open archive, despite a few more dedicated metadata for HSS referencement.

However, the time spent to actually deposit each object can be quite large, according to the data complexity since it contains not only 3D files, but also all the related documents. The quantity, as well as the variety of metadata is increasing with the different files, which can considerably increase the time required for a data record. Despite that aLTAG3D simplifies the process and is a real asset thanks to its easy handling and architecture, we have to develop more tools which ease data deposit, including plug-ins to automatically retrieve already existing metadata.

Open Questions

Our tools will be evolving according to technology, but also to the needs of users, such as the integration of a 3D viewer. Among existing technologies [1], we are experimenting 3DHOP for meshes and Potree.org for point clouds. But the main challenge is the creation of a perennial services while minimizing the required to be increased storage cost that has an economical and ecological impact that we can not neglect for such data sizes.

Other questions concern the possibility to define a standard and perennial use of the 3D model as a support of external references in the spirit of annotations or SIG. This comes together with the always increasing possible interconnections with other repositories by the use or newly defined or new metadata standards and will increase the visibility of the indexed objects.

The main challenge for the wide acceptance remains to ease the filling process of metadata for such complex data. It illustrates even more that any digitization project needs to integrate data management, and define the just amount of pertinent data to create, with a reduced but well documented number of files.

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ID number: 62

Potential of satellite imagery analysis for archaeological heritage studies and management in the suburbs of Khartoum (Sudan)

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Abstract:

The main aim of this presentation is to discuss the application of advanced Earth observation techniques in the studies and management of archaeological heritage in the most populated regions of Sub-Saharan Africa. The subject will be presented in a case study from Sudan.

Khartoum, the modern capital of Sudan, started as a small fishing community close to the confluence of the White Nile and the Blue Nile. Its transformation into the regional centre began in the 19th century. However, it has been the last 30 years that witnessed the most rapid and uncontrolled urban as well as rural expansion of the agglomeration. Today, the region has a population reaching 5 million and it is the most developed part of the country.

The archaeological heritage of the area is understudied. Efforts of the few researchers working in the region point to the conclusion that in the early Holocene (approx. 10,000–3000 BC) and again in the Medieval period (approx. 6th–15th century AD) the region housed the largest communities. Numerous, diverse and unique material remains from the periods are pointing to a focal role of these lands and societies in the context of entire Sub-Saharan Africa. Scientific expeditions working to study the early Holocene remains uncovered large burial grounds with a wide variety of grave goods as well as settlements where unique Mesolithic (approx. 10,000–5000 BC) and Neolithic (5000–3000 BC) stratified deposits are often preserved.

In the Medieval period, the confluence of the White Nile and the Blue Nile was the centre of the kingdom of Alwa. Its capital developed for almost a millennium at Soba on the right bank of the Blue Nile. According to the 10th-century traveller and emissary Ibn Selim al-Aswani, the city had fine houses and large monasteries, churches with rich furnishing, a district inhabited by Muslims and beautiful gardens (Vantini 1975, 613). The remains of Soba cover approx. 2.75km² making it one of the biggest archaeological sites in Sudan. However, the state of research on the kingdom heartland is extremely unbalanced. Soba has been at the centre of systematic research while its hinterlands are almost unknown.

Medieval travellers (Al-Aswani and Ibn Hawqal) wrote that Alwa was the most powerful kingdom in Nubia with vast resources at their disposal and close ties to nomadic herders. Central Alwa was suitable for agriculture, pasture and permanent settlement in rivers valleys and beyond. The great potential of the region is extensively used today since one of the largest irrigation systems in the world covers Gezira, the land between the Blue Nile and the White Nile.

Up to date, medieval archaeological features have been documented mainly as a context to the early Holocene remains by expeditions focused on prehistory. Besides, architectural remnants, artificial rainwater pools (Arab. hafir) and salt mines have been reported in the region, however, detailed information as to their location and chronology are often lacking.

Sudanese authorities responsible for archaeological heritage as well as archaeologists have been using high-resolution optical imagery in their work (mainly Google Earth and Bing Maps images). There are only a few examples in the regional studies where older satellite imagery, including the Corona satellite photographs, have been utilised. The Corona imagery is of great value since it shows the region before the rapid urban and rural development (Fig. 1). However, the low spatial resolution can be an obstacle in site-focused studies which are a common type of archaeological research conducted in the region.

Optical satellite imagery with various temporal resolution might be useful for research aiming at identifying and understanding the settlement palimpsests in the region and monitoring archaeological heritage in cooperation with local authorities.

Satellite imagery analysis might be a solution to the uprising heritage protection challenge in Sudan as well as other Sub-Saharan countries (Davis and Douglass 2020). With large territories of mainly desert to savannah vegetation coverage (Sudan is the third biggest country in Africa) as well as ongoing intensive urban development and farming, Sudanese researchers and heritage authorities are lively interested in finding viable solutions to the challenges of archaeological heritage identification, understanding, and monitoring.

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ID number: 63

Southern Latium (Italy) in Roman Republican and Imperial Times – Considerations on Legacy Data and Site Location Modelling

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Abstract:

Introduction

The present paper focuses on GIS-based quantitative approaches to Roman settlement patterns in southern Latium (Central Italy) (Teichmann 2017; Teichmann 2020). The research area reaches from the Tiber Valley in the north to the westward-facing slopes of the Alban Hills, the Lepini and the Ausoni Mountains and to Terracina in the southeast. The study area is of particular historical importance as it was closely connected to Rome. The chronological focus is on the time-frame of late 4th century BC to early 4th century AD.

Methods and materials

Data for more than 5000 archaeological sites was collected in a Geographical Information System by digitizing them from archaeological maps, which were published during almost a century (from the 1920s onwards). Therefore, questions concerning the changing landscape perception as well as landscape transformation processes affecting it in the 20th century have to be considered. Most survey maps were created in the tradition of the Italian School of Ancient Topography.

Descriptive site location analysis is conducted for sites of various types (villae, villae rusticae and hamlets) in different landscapes (such as alluvial plain, coastline, volcanic hill or limestone mountain) to assess the role of various environmental and cultural variables for the choice of settlement sites, and to assess the impact of cultural and ecological factors for the choice of locations (Teichman 2017; Teichmann 2020). The kernel-density-estimation method is used to identify hotspots of activity in Republican and Imperial Times. A similar approach is chosen to map the distribution of luxury indicators (such as mosaic tesserae, marble pieces, wall painting fragments) to identify areas of accumulated wealth in rural areas (Teichmann 2019).

Results

The role of various cultural and environmental variables could be successfully assessed by applying quantitative methods as a number of statistically significant patterns were identified.

Some patterns were observed in several micro-research areas (for example that numerous settlement sites are found at higher elevations, on slightly inclined slopes and with an orientation to the east, sometimes also to the south). These spots were meant to guarantee good air circulation, avoiding particularly damp locations. Otherwise, the overall picture for various site types and even adjacent areas is quite heterogeneous pointing to a high local variablity. The kernel-density estimation is suitable to assess questions of continuity and change regarding the establishment of new sites in Republican and Imperial times in several micro-areas, as well as the identification of rural areas where wealth was accumulated. The

surroundings of the ancient town of Velitrae (today´s Velletri) will be discussed as a case study for the latter approaches.

Discussion

The paper presents a case study of working with archaeological legacy data in complex, intensely used ancient landscapes, which were of major importance due to their vicinity to Rome. Various aspects such as methodological issues of working with data of varying spatial and chrological accuray are discussed alongside the results of analyses concerning settlement patterns and issues of social archaeology.

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PolisABM: Modelling polis formation, urban systems and social complexity in the eastern Mediterranean from Iron Age to Hellenistic times

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Abstract:

Urbanism has traditionally been one of the most extensively studied topics in Mediterranean archaeology, resulting in an abundance of both empirical observations and theories on the origins and development of ancient cities. Unfortunately, such theoretical models have rarely been expressed formally, nor have they often been directly validated against the available empirical data. One project where a first degree of integration between data and theory has been initiated can be found in the works of John Bintliff and the Boeotia Project. Years of intensive survey activities in Boeotia have resulted in a mass of empirical data on local settlements and regional settlement systems (Bintliff 2019). This data was also used to propose an extensive theoretical model of urban development, polis formation and associated trajectories of social complexity from Archaic to Medieval times in mainland Greece (Bintliff et al. 2007). While these provide valuable first steps, the full integration of theory, model and data is yet to be accomplished as the model was never formally defined nor independently validated against other datasets.

The aims of this paper are twofold: (1) to replicate Bintliff’s theoretical model of polis formation by implementing it as part of an agent-based model (PolisABM), and (2) validating this model against available empirical data in two case studies of settlement systems from Iron Age to Hellenistic times (900-100 BCE). In the first case study, I will test the original model against the relevant datasets obtained from the published results of the Boeotia Project itself. Next, I will explore the limits of the model as an explanatory framework for polis formation outside of the Greek mainland by integrating it in a recently developed theoretical framework of social complexity (Daems 2021). I will then test this model against external datasets collected from southwest Anatolia, covering the regions of Lycia and Pisidia. Through this work, I aim to contribute to the further integration of theory building, computational modelling and data analysis in the study of Mediterranean urbanism. I purposefully propose to use existing theories and legacy data, as well as new theories and original data, to illustrate the wealth of untapped potential in this field and point towards future avenues of exploration.

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ID number: 66

Find 'em all: Large-scale automation to detect complex archaeological sites with Deep Learning – A case study on English hillforts

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Abstract:

Introduction

Nowadays many different approaches, based on "Artificial Intelligence" (AI), are being developed for landscape archaeology, for instance to map charcoal kilns or barrows in remotely-sensed data (e.g., Verschoof-van der Vaart et al. 2020). These research projects have shown that Deep Learning Convolutional Neural Networks (CNNs) are able to detect these types of objects which generally have a relatively simple, recurring geometrical shape. Only recently researchers have explored the ability of CNNs to detect more complex archaeological objects, such as hollow roads (Verschoof-van der Vaart and Landauer 2021). The question remains whether these methods are able to detect objects of an even higher degree of complexity, such as Roman Villae Rusticae or Medieval motte and bailey castles, which lack a uniform shape and/or groundplan. Therefore, in this research we test the ability of a CNN to detect one of these complex object types: prehistoric hillforts.

Finding English hillforts

For Britain and Ireland, Lock and Ralston (2017) published an excellent online database, including descriptions, preservation information, and GPS coordinates of more than 4,000 Bronze- and Iron Age hillforts. To construct a training dataset the central coordinates of known hillforts in this database were used to automatically download 500 by 500 m patches of LiDAR data, which is freely available for most of England with a 1 m resolution (https://environment.data.gov.uk/). Negative examples, i.e., images without hillforts, were created by downloading patches of LiDAR data with a random central coordinate. We are confident of the validity of this approach as hillforts cover only a tiny fraction of the land, which makes it extremely unlikely that a patch containing a hillfort is selected by chance.

Subsequently, the downloaded LiDAR data was pre-processed, for example by normalizing the LiDAR data and by removing hillforts from the dataset that had disappeared due to urban development and were no longer discernible, as the latter have a negative impact on the performance of the CNN.

Preliminary results

After pre-processing, the developed dataset was used to train a "ResNet-34" CNN (see Verschoof-van der Vaart and Landauer 2021). During training the CNN reached a classification accuracy of 94.2%. To test the CNN, it was used on a dataset containing 30 hillforts from a control group not used for training. A total of 25 (83%) were classified as hillforts with a confidence level of 50% or above.

However, research has shown that when these automated approaches are used beyond an ideal experimental setting the performance decreases and studies ‘in the wild’ are needed to

investigate the true potential of the approach (Verschoof-van der Vaart et al. 2020). Therefore, we selected five areas (approx. 100 km2 each) with different geological characteristics, such as "coastal" or "mountainous", throughout England. The LiDAR data of these areas was cut into patches and presented to the trained CNN. The evaluation is still ongoing, but already a few possible hillforts were found, although we deem it necessary to investigate each of these further, ideally with prospection on the ground. Moreover, we found that the detection quality is somewhat better in mountainous areas for reasons currently unknown, possibly leading to less detections of hillforts in other geological settings.

Discussion

The results demonstrate that CNNs are able to map complex archaeological objects in both an experimental setting as well as ‘in the wild’, i.e. on a landscape level with various terrain. While the results are promising, these need to be validated in the field by experienced field archaeologists to fully assess the capability of the approach. Unfortunately, this has been not possible due to the current COVID-19 situation.

Initial results show that the aptness to find unknown sites is highly dependent on the examples in the training dataset. For instance, the model can only find sites with a similar degree of preservation to the training examples. Therefore, extra attention should be given to the development of the training dataset. It might be necessary to prune the dataset in favor of less well-defined examples, in order to improve the overall performance of the model. Therefore, future research will focus on expanding the dataset with more examples, e.g. hillforts from other countries such as Scotland, with various levels of preservation.

While these automated approaches show great potential for archaeological mapping, the general availability of data and the relative apparent implementation of CNNs could introduce a somewhat urgent area of concern for cultural heritage authorities in the near future, as the risk of looting of previously unknown sites could increase.

This research served as a proof of concept. In the future we aim at using the same approach to detect different complex archaeological objects, such as Villae Rusticae across the Roman Empire.

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ID number: 67

3D visualisation - a form of exploring, studying and experiencing the past. Reconstructions of the Early Iron Age settlements discovered at the sites of Stary Ślesków 17 and Milejowice 19 (poster)

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Abstract:

The will to protect cultural heritage has become an impulse to construct three-dimensional visualisations, which can be regarded as a form of discovering, studying and experiencing the past. Thanks to a computer program and properly manipulated 3D models, scientists can test out their research hypotheses, basing on mutual relations between the models.

During archaeological excavations conducted in 2000 by the Institute of Archaeology and Ethnology of the Polish Academy of Sciences in Wrocław due to the modernisation of a motorway, two settlements from the Early Iron Age, Stary Śleszów 17 and Milejowice 19, were discovered and explored. The sites were located about 4 km from each other. The settlements were outstanding in terms of spatial development. In the area of the settlement in Stary Śleszów a circular structure surrounded with a fence was discovered. Within the structure there were buildings in post construction. It was an inhabited, visibly separated part of the settlement. Similarly separated part yet considerably larger, was discovered at the site in Milejowice. The settlements were probably inhabited by people of high social or economic status. The situation is consistent with tendencies observed in the whole Hallstatt culture, where significant changes in social structure took place.

Preparing 3D visualisations of the settlements discovered at the sites of Stary Śleszów 17 and Milejowice 19 were part of the project „Spatial and functional structures of settlements in the Early Iron Age in Silesia in a social aspect”. The project was funded by the National Science Center (2015/17/B/HS3/01314). The aim of the project was to prepare models of social structure of the settlements basing on an analysis of spatial and functional organisation (GIS analyses) and their 3D reconstruction (Buchner, Markiewicz 2019, Markiewicz 2019).

The visual presentation in the form of a 3D reconstruction of the Hallstatt settlement from Milejowice and Stary Śleszów are a computer created images based on analysis of the sources obtained during excavation work. The purpose of 3D imaging of the features discovered on sites was to provide a spatial representation of the settlement’s buildings, divided into individual phases. The visual presentation of settlement complexes is a valuable source of information on early Iron Age construction. The visualisation verified the collected data, and 3D modelling facilitated the interpretation of the research results. With the help of three-dimensional modelling, it was possible to analyze the spatial organization of settlement complexes and to separate the individual phases of development of the designated zones. It should be noted, however, that digital reconstructions of settlement complexes from Milejowice and Stary Śleszów remain the hypothesis of researchers, based on their analysis of documentation and theoretical assumptions.

For spatial reconstruction, one of many possible suggestions for interpreting the buildings of this settlement was selected. Individual stages of development of settlement complexes were determined based on the stratigraphic relations of features, absolute dating (dendrochronological and 14C analyses), and artefactual dating (mainly fragments of pottery and special artefacts). In the event of difficulties in distinguishing the relics of buildings as being older or younger, J. Kopiasz applied the theoretical spatialmetric analysis of the settlement development, citing the findings of T. Gralak regarding length measurements used in the construction and layout of settlements from the Early Iron Age in Lower Silesia.

In the article by E. Bugaj and J. Kopiasz (2006, 178), the authors, discussing the spatial organization of buildings in Milejowice 19, noticed that ‘based on the existing premises, including mainly the pottery material at our disposal, we cannot define subsequent stages of development’. A few years later, thanks to the use of Computer Aided Design (CAD) and 3D modelling, it was possible to carry out an analysis of spatial organization of settlement complexes from Milejowice and to determine individual phases of development of designated zones. Thanks to spatial imaging one can now see more. The possibility of working in a program for creating 3D images, viewing models from any angle and distance introduced a new quality to research work.

Reconstruction of the settlements was prepared on the basis of an analysis and interpretation of source material, according to the directions given in the London Charter. The document contains methods providing the highest quality of 3D reconstructions and verification measures that allow to check historical reliability of 3D models.

The visualisations were made using Autodesk 3ds Max 3D design software with V-ray rendering engine. These images were prepared as 2D illustrations for articles presenting the research results of the implemented project. Their potential has not been fully realized. The presentation in the 2D form excludes the transfer of full knowledge about the sources and the process of creating visualisations. The recipient does not know the decisions made by the research team. Therefore, it is extremely important to discuss the use of settlement models within the knowledge site of 3D Scholarly Editions.

ID number: 68

A GIS-based approach with data visualization to reconstruct a historical district: A case study of Chikan Tower in southwestern Taiwan

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Abstract:

Introduction

Fort Provintia, current-day Chikan Tower, was an important Dutch East India Company (VOC) outpost in the 17th century in Chikan area, southwestern Taiwan. The Dutch recruited people from Southeast China to cultivate the land in Chikan area, that introduced foreign materials in to Taiwan, such as porcelains and stonewares, signifying the beginning of the historical period of Taiwan. Based on historical records, Fort Provintia was an administrative and commercial center of VOC during 1624-1662 and later taken over and continuously used by the Chinese Kingdom of Tungning in 1662-1683.During the Qing Dynasty(1683-1895), Fort Provincia was demolished by the rebellion in 1721. In the late 19th century, a series of temples and schools were built on the ruin of Fort Provincia, becoming the current-day Chikan Tower. Also, in the early days of Japanese rule (1895-1945), Chikan Tower was used as military hospital until 1917.

Since 2018, we have conducted several archaeological excavations at Chikan Tower, the former Fort Provintia. The site was occupied from the Late Neolithic to the historical period, corresponding to descriptions in historical records. In 2019, we excavated 25 pits on the east side of Chikan Tower, revealing about 1800 pieces of Neolithic pottery sherds and 1300 pieces of porcelain dated from the late 17th century to the early 20th century, according to their styles. In addition to artifacts, we found archaeological features, such as historical walls, floors, and street pavements, indicative of house structures. However, some Neolithic pottery sherds was found in the strata of the historical period that suggests some level of disturbance across the site, preventing accurate determination of chronological contexts in a finer resolution.

In this study, we introduce a workflow using multiple methods, including GIS approaches, historical maps, and stratigraphic data visualization, to effectively identify house layouts and post-deposit processes of those archaeological remains for a site with multi-components. Fort Provincia was built in 1653 and used for about 400 years with different purposes since then. We ask: Did house layout in the surrounding area of Chikan Tower change though different colonial periods, from the Dutch, Kingdom of Tungning, Qing dynasty, to Japanese colonization? Also, can we detect the extent of Neolithic disturbance across the site to understand the post-deposit processes caused by human activities? Answering those questions will help us to understand the history of land use and landscape in this area.

Methods and materials

In this research we analyzed two types of materials, structural remains and stratigraphic layers that contain artifacts from the Neolithic period to the historical period.

Structural remains

Structural remains include a series of pavements. According to the evidence of trampling and the degree of erosion, we identified indoor and outdoor floor, where indoor floor is generally preserved well that may also indicate the presence of roof.

Since traditional houses in Taiwan normally include indoor and outdoor spaces in a single building, we used QGIS to overlay the aerial photo of structural remains and historical maps from the years of 1875, 1913, and 1933 to distinguish between street pavements and outdoor spaces of houses. These maps were made by the Qing and Japanese government respectively.

We used a drone to take a series of aerial photos, then used QGIS to georeference them. After overlaying the current Cadastral map and historical maps, we compared the relationship between structural remains and the buildings on the map of 1913 to identify specific houses and streets in our research area.

Stratigraphic layers

We used pandas Python library to append all stratigraphic sections into a single dataframe, then joined the coordinates of excavated pits to order the data by their locations and orientations. We then visualized the locations of artifacts in stratigraphic layers using the seaborn Python library to find their distribution patterns.

Results

The results of our overlay analysis of historical maps of the Qing Dynasty and Japanese colonization period reveals that some house structures were present on the map of 1875. This indicates a continuous use by the Japanese colonial government. The historical map from 1913 demonstrates that most of the household structures close to Chikan tower existed since then. By comparing aerial photos with historical maps, we can see the streets in this area did not change substantially since the urban plan in 1933 by the Japanese until they were destroyed in WWII.

For the distribution of artifacts, the results of our stratigraphic visualizations demonstrate post-depositional processes of human activities from the historical period and confirm the extent of the Neolithic component (Figure 1). The visualization below shows that the Neolithic pottery sherds are clustered in the strata ranging from 1 to 1.2 meters below the surface (EL 6.8 to 7 meters), while the porcelain pieces recognized produced between the 17th to the 20th century are scattered from 0.8 to 2.5 meters below the surface (EL 5.5 to 7.7 meters). The overlapping of the Neolithic context and the historical context indicates human activities in the historical period had great impacts on the conservation of Neolithic context of this area.

Discussion

As an administrative and commercial center in the Dutch colonization period, the Neolithic remains at Chikan area were heavily disturbed by human activities since 1624. This is challenging for archaeologists to identify chronology due to mixing contexts of artifacts. The seaborn library provides a efficient way for us to identify the extent of disturbance by visualizing the distribution of artifacts in stratigraphic sections. QGIS offers another method for us to compare different types of spatial data to identify the function of structural remains and confirm the layout of houses and streets.

Using those techniques, we demonstrate a workflow for an early stage of post-excavation analysis to reconstruct house arrangements and street layouts of the historical period and detect the extent of disturbance for a single site. This research highlights a practical approach that can be applied to other multi-component historical sites to better identify chronology and spatial arrangement of structural remains.

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ID number: 69

A Bayesian network modeling approach to examine social changes using burial data

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Abstract:

Introduction:

Network analysis has increasingly applied by archaeologists to explore interactions and relationships in past societies to study questions related to exchange, migration, or social transformation (Brughmans 2013). Based on network science and graph theory, an archaeological phenomenon can be constructed as a network where formal network methods usually focus on describing static structure and associated statistics presented by that network. Recently, complex network modeling provides many new tools for hypothesis testing on the formation of networks to understand the interrelations between entities in a dynamic way. In those network modeling methods, exponential random graph models (ERGMs) are an important family of stochastic models that allows direct modeling for the formation of edges, or ties, between nodes (Robins et al. 2007). Despite ERGMs' promising ability to evaluate dynamic social processes behind observed archaeological networks, computational difficulties and the sensitivity to uncertainties to some extent limits the practical applications of ERGMs to archaeology, where results could be challenging for interpretation (Caimo et al. 2017).

In this paper, we employ a Bayesian approach to ERGMs that can incorporate prior information and empirical data to provide an efficient computational process and effective quantification of uncertainty. We applied this Bayesian network modeling to test a hypothesis of social change associated with the European colonial activities by studying burial data from Kiwulan, a late Iron Age site (1350-1850 AD) in northeastern Taiwan. Using the theoretical framework of horizontal hierarchy, we test a hypothesis of changes from a corporate mode (a structure showing more subgroups with less wealth differentiation) to a network mode (a centralized structure with more wealth differentiation) in the burial network after European arrival. We ask: (1) did European colonial activities result in increased social inequality in Indigenous society in ways that can be detected by analysis of burial networks? (2) if so, what are the major variables affecting or forming unequal social positions that might hint at social heterogeneity?

Methods and Materials:

We analyzed burial data collected from the excavation reports, and the original fieldwork notes for the upper component of Kiwulan (Chen, 2007). To compare burial networks, we assigned burials to the pre-European period (n = 29), European and post-European period (n = 49) according to an established fine-grained chronology. Based on the assumption that social status and associated relations can be represented by sharing similar prestige goods, we built networks where burials (nodes in the network) that are linked when they have the same foreign prestige goods in common. The prestige goods we identified include gold-foil beads,

carnelian beads, glass beads, Chinese porcelains, stonewares, gold foils, and fish-shaped ornaments that their use as prestige indicators were also mentioned in historical records.

Based on our hypothesis, we model a network with increased social inequality to be represented by endogenous network effects: low transitivity and high centralization. We include nodal covariates, such as age, sex, ritual activity, and wealth level, to explore the importance of these variables in tie forming. We also include the physical distance between burials as an indicator of kinship-based relations since the deceased from the same family were buried nearby. To evaluate our anthropological model of changes in power strategies, we incorporated different prior information for the network variables that are meaningful for social inequality, especially for transitivity and centralization. We applied Markov chain Monte Carlo (MCMC) simulation in a Bayesian framework using the approximate exchange algorithm to simulate 1000 network graphs from the estimated posterior distribution in ERGMs. After simulation, we examined our results by summarized posterior statistics to see any significant patterns. Then we applied Bayesian goodness of fit diagnostics to check how well our observations fit the estimated posterior parameter distribution.

Results:

For nodal covariates in the pre-European model, the ritual activities represented by pots (ritual feasting) have a significant effect on the formation of relations between burials. On the other hand, the wealth rank, represented by burial values (wealth level), has a negative effect and is not significant. This demonstrates that burials with ritual pottery tend to form relations. For the endogenous network effects, transitivity presents a significant positive effect, while centralization demonstrates a negative effect. The high positive value for transitivity suggests a tendency of burials with similar burial goods to be clustered as connected communities, indicative of the presence of multiple corporate groups sharing burial goods in common. In contrast, the strong negative centralization shows there is a tendency toward decentralization that reflects most burials having a similar number of ties. This might imply that individuals have equal access to the flow of trade goods.

After the arrival of Europeans, the nodal covariates of wealth rank show significant positive effects. This indicates burials in the same wealth level tend to be more connected with each other. Similar to the pre-European network, transitivity demonstrates a significant positive effect, but much weaker than in the pre-European network. In contrast, centralization has a significantly higher positive effect than the pre-European network. This means there is a tendency toward centralization that reflects a limited number of burials having many more ties than others. This implies more access to trade goods, and increased wealth accumulation and display behaviors in burial events. For both networks, age, sex, and physical variables are not significant.

Discussion:

In general, the post-European network model has a smaller transitivity effect and a positive centralization effect with significant wealth differences compared to the pre-European network model. This may suggest a reduced tendency toward clustering but high tendency toward centralization after the European presence that supports our social change model that Kiwulan shifted from a more corporate-based to a more networked-based society, as indicated in the grave goods and burial attributes. Our case study demonstrates the methodological benefits of Bayesian inference on ERGMs to inform and enhance studies of relational data in archaeology. In addition, Bayesian network modeling can be applied to a wide range of archaeological data to examine the formation of relationships using robust probabilistic inference to give insights into the dynamic processes of socio-cultural phenomena.

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ID number: 70

The Metsemegologolo African urbanisms project: Experiences developing a database of archaeological material with a geospatial focus.

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Abstract:

This project originated as the result of a call for proposals to develop ’African-oriented’ archival digitisation initiatives, with our focus being on the significant holdings of archaeological and historic material related to pre-colonial Tswana settlements in Southern Africa (Botswana and South Africa). This material takes a wide range of forms, including personal notebooks of missionaries and early colonists, historic and modern maps, and varied archaeological and ethnographic material including three-dimensional objects. Additional research material includes environmental datasets, for example historic climatic and land cover information for the region. Collectively these sources are spread across numerous institutions, including the University of the Witwatersrand, University of Botswana, Botswana National Museum, KwaZulu-Natal Museum, and others. At the time of inception, some already existed in digital form, but most have to be digitised using book scanners, photography or 3D-photogrammetry.

As we are not Archivists, and are approaching the requirements and problems of this archive as domain specialists, the philosophical and critical approach to the internals of an archive are of less interest to us than the idea of a highly usable repository of information; reflecting Rick Prelinger’s realisation "that an archive’s highest calling is to be consumed by its users" (Prelinger 2019, 18). We reflect on experiences in negotiating the structure of this archive, technical decisions and implementation, and use-cases. This is an attempt to not just provide a usable, searchable archive of archaeological material for researchers within the domain, but to also explore the potential for emergent datasets or Berry’s "hidden archives" (Blom et al. 2016) by reconvening formerly atomised datasets and collections in a new, generative data space.

As a departure from more ’traditional’ organisational models, the primary schema for organisation of this archive is spatial; that is, instead of the archive’s organisational model being ’fonds’ oriented, it is ’place’ oriented. Given that a particular ’place’, e.g. a town or an archaeological site, may have many collections associated with it at any given time, the approach of using a fonds as primary entry point is somewhat limiting in this case. Many items within the collections already have location meta- data indirectly available, obtained through direct measurement on site or extracted from excavation documentation. Additionally, some sites already have geospatial datasets available in the form of ESRI shapefiles. With the emphasis on location, a data model informed by CIDOC-CRM seemed a suitable choice, albeit with an emphasis on ’place’ (both temporal and spatial) rather than on ’event’, as is usual with CIDOC implementations. Other primary concepts used are that of ’actors’ (people, institutions, or equipment) and physical things – all of these having both spatial and temporal characteristics – with the possibility to inscribe a range of precision on both, e.g. exact date or

time span, and exact location (to DGPS precision) or approximate location (map reference or narrative description of area). Additionally, we make provision for links to academic works related to specific objects or sites (and in some cases a digital copy of the original – this being dependent, obviously, on distribution rights).

The user interaction model is conceptualised (with reference to Arches,2 CLAROS (Kurtz et al. 2009) and similar projects) with the ability to have both a web-map based interface, and traditional (text- based) search features, ultimately offering (hopefully, with the help of manual transcription and possibly tools such as Transkribus3) full-text access to the aforementioned textual material. The web mapping feature offers the ability to spatially visualise the relationships between sites, and objects within sites, and the option of performing spatial queries on the database, for example 'distance', 'contains', 'overlap', 'area' and so on.

The original brief strongly recommended that our (and other projects funded under the same programme) leverage existing archival and online collection-oriented platforms such as AtoM4 or Omeka.5 These constraints were specified primarily to ensure 'future-proofing' of the archives through both continuity of support and development of these platforms, and deployment of standard metadata formats and tools. However, a functional implementation of a platform as envisioned within this project requires a spatial database as part of the backend. Given that AtoM is incompatible with these requirements (without major modification), we are currently experimenting with a system consisting of custom developed software incorporating a spatial database (SpatiaLite and PostGIS) and existing web-based mapping technologies (Mapserver and OpenLayers). We are considering a parallel instantiation of AtoM as an alternative interface and a comparative experimental 'control' – given that we have also implemented data interchange APIs such as 'OAI-PMH' and the ability to export and import various XML formats, such as EAD-XML, allowing interchange and aggregation with these current (and future) platforms, and export of data into 'neutral' flat-file formats to ensure data longevity.

In the long term, a desirable goal would be to publish access to our data and vocabularies using Linked Open Data (LOD) standards (Geser, 2016). Obviously the core of the system needs to be built with this in mind now, not later, and so we are currently investigating standards and potential other data providers which may inform our own practice in this matter.

Despite the relatively rich mapping interface, an internal requirement for this project is also the possibility to deploy in a relatively low-resource environment, both on the server and client side; allowing for use in limited bandwidth situations. Additionally, care is being taken to comply with recommendations for FAIR data principles.

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Agent-based modelling to assess hominin role in creating and maintaining vegetation openness during the Last Interglacial and the Early – Middle Holocene in Europe: overview of a planned simulation

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Abstract:

The starting point of significant anthropogenic environmental changes and the role of hunter-gatherers in past landscape transformations are debated (e.g. Smith and Zeder 2013). There is no research protocol to define which proxies and methods should be included when studying landscape change. There is also no common alternative approach when specific evidence is absent. European regions have not been studied in equal detail, and do not provide a unified set of proxies reflecting hunter-gatherer impact on landscapes. Relationships between evidence for vegetation changes and hunter-gatherer subsistence activities are often ambiguous. Even where a strong correlation between hominin presence and landscape change can be established, this does not imply causation, because landscape changes are often complex. Hence, the need for new approaches. Agent-based models (ABM) are commonly used to assess complex systems. Emergent patterns occur via interaction between individuals and between them and their environment (Romanowska et al. 2019). Therefore, ABM will be applied in the current study to answer the following research question: “What was the role of hunter-gatherer activities in creating and maintaining vegetation openness during the Last Interglacial and the Early-Middle Holocene in Europe?”.

Firstly, the environment will be created using a digital elevation model, available spatial data on the distribution of rivers and large lakes, shoreline information and maps of initial vegetation cover created via climatic variables. Climate simulations will be achieved using a high resolution dynamical downscaling technique within the iLOVECLIM climate model, which is a global earth system model of intermediate complexity and consists of components describing the dynamics of coupled Atmosphere-Ocean-Ice-Vegetation systems. A sophisticated dynamic vegetation model (CARAIB) is coupled to the iLOVECLIM which simulates the vegetation evolution from the local vegetation to the global scales. It simulates the major processes of plant development such as growth and their Plant Functional Types in response to climatic changes. Secondly, the ABM will be implemented in the NetLogo modelling environment. The vegetation openness of the (initial) environment will be modified by three types of agents: hominins, large herbivores and lightning.

The first type represents Neanderthals and Mesolithic populations which can transform vegetation directly via consumption of plants and burning, and indirectly via hunting herbivores that forage on grasslands. Population demography (initial size, birth and mortality rates) will be defined via sliders. These variables will allow one to define population

growth/decline, and, consequently, increase/decrease intensity of hominin pressure on landscapes. Individual hominins move for burning, foraging or hunting within a limited area around their camp sites. The extent of the areas will depend on the group's mobility type.

The second type of agents modifying landscapes are herbivores, which are hunted by hunter-gatherers. They consume grasslands, halt forest and shrublands growth, reproduce and die, and move around landscapes searching for grasslands. Lightning is the third type of agent impacting landscapes, and it can reduce areas covered by vegetation via burning. Climatic variables will be used to define probability of ignition and further fire behaviour. After any type of impact (burning or consumption), vegetation regenerates. The speed of regeneration and the duration of the whole process will be defined based on climatic variables.

The expected results include maps of modified landscapes. However, a number of other types of data are critical for interpretation. To define roles for each type of agent in landscape modifications, several comparisons will be made during the third research step. Recent developments in quantitative reconstructions of pollen-based plant cover make it possible to provide more realistic reconstructions of past landscape openness using a modelling approach, the Landscape Reconstruction Algorithm (LRA). The results obtained through the first model of LRA, REVEALS (Regional Estimates of VEgetation Abundance from Large Sites), will be compared with maps of climate-based vegetation cover. The latter maps are based solely on modelled climatic variables, and show vegetation composition created only by climate. Therefore, this comparison will allow one to distinguish the role of climatic conditions in pollen-based vegetation reconstruction from other types of impact (large herbivores and hominins).

Afterwards, palynological reconstructions will be compared with maps of functional diversity newly obtained for herbivores (i.e. as a proxy for megafaunal impact on landscapes because such maps show intensity of herbivore impact). This comparison will reveal the impact of large herbivores on actual vegetation cover. As a result, the joint climatic and herbivore impact will be identified within pollen reconstructions, and the hominin role will be established by a process of elimination.

Similarly, ABM results will be compared with maps of functional diversity for herbivores and maps of climate-based vegetation cover. This comparison will distinguish climatic and herbivore roles in simulated vegetation transformations, and hominin presence in ABM maps will be obtained. Finally, the results of two stages of data comparison (hominin presence in pollen data and ABM maps) will be used to clarify the hominin role in creating and maintaining vegetation openness in Europe.

The results of the current research will allow us to identify the impact of two groups of hunter-gatherers (Neanderthals and Mesolithic populations) on past European landscapes. Multiple types of data newly obtained within the Terranova project will be used in this research. Wider implications of the current study include contributing data to the ongoing debate about the starting point of significant vegetation changes by humans and the speed of vegetation transformation due to natural ignition (e.g. lightning), anthropogenic and megafaunal ecological impact through time.

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Linked Open Data – Problems encountered and approaches to solving them in the numismatic domain

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Abstract:

As the session announcement points out, we face a range of challenges in the world of Linked Open Data (LOD). These include: data quality, incomplete data, how to handle uncertain data, identifying duplicates across different datasets, and the need to have different levels of granularity. Based on our experience working on the datasets Antike Fundmünzen in Europa (AFE) and Corpus Nummorum Thracorum (CNT), as well as on Nomisma.org, we will discuss various problems that we have encountered even within just the domain of numismatics, but which need to be solved in order to facilitate trans-domain linking of LOUD and FAIR data.

In this abstract, we present only first brief remarks on the challenges we have faced in the form of use cases and our current approaches to tackling them:

- data quality and incomplete data – as we presented at CAA 2017 [1] and 2018, automated analysis of the data regarding its inconsistency necessarily also depends on the existing data. Without redundant data inconsistencies are difficult to discover. Currently, we are using rules implemented as SPARQL queries on RDF representations of the data using the vocabulary and ontology of Nomisma.org. This modelling approach ensures that our rules and their implementation can be applied unchanged to other datasets.

- how to handle uncertain data – this is an important issue, especially for the domain of archaeology where uncertainties are omnipresent. There are different approaches to modelling uncertainty [2]. However, there is still a lack of clear guidance and blue prints as to how to deal with it. Communities like Nomisma.org (and so we too) have the task of defining them. Unfortunately, this is a relatively complex, and time and energy consuming process, and so most projects instead concentrate on issues that are more prestigious and apparent.

- identifying duplicates across datasets – identifying duplicates within one dataset can already be challenging. But when we export different datasets to other resources, we face new and more complex problems. For example, in the uploads of the datasets from KENOM and AFE to Online Coins of the Roman Empire (OCRE) we have encountered difficulties caused by the fact that both systems use different approaches to mask the exact coordinates of sensitive or confidential findspots of coins (either by simply removing the last digits of exact coordinates, or instead using the centre point of the parish the findspot is located in). Such differences need to be taken into account when searching for duplicates.

- the need to have different levels of granularity – within our work in Nomisma.org, on several occasions we have encountered the problem that people used different granularity levels when talking about concepts. For example, what is Rome, what do we mean by it? The city, or a mint? And if a mint, which one: Roman, medieval, the Vatican? In a natural language, the context determines the final meaning of a word, but in LOD concepts are clearly defined. Some context information is given in these definitions, but since context is an endless beast,

it can never be complete. And even if that were the case, it would make it nearly impossible for the concepts to be reused! The process of defining the concepts also often forces domain experts to discuss their different usages in the first place. For example, the term imitation can used by experts to refer to very different phenomena, from a fraudulent counterfeit to a cheap souvenir for tourists. How granular can we be when there is no consensus on the usage of the concept?

Of course, there are many more challenges than those mentioned here. However, they need to be tackled in order to further the acceptance of LOD and increase trust in existing LOD datasets. We believe that solutions for those challenges must be accepted and implemented by the community of users and data providers. Reaching agreement on possible solutions is a challenge in itself and we do not expect to arrive at one solution that everybody can accept and use. However, it is important that the general direction is similar in order to facilitate the exchange of FAIR and LOUD data.

We do not have solutions to all these problems, but hope that by presenting examples and use cases drawn from the numismatic domain we can contribute to a productive discussion.

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ID number: 73

Detecting Change at Archaeological Sites in North Africa using Open-Source Satellite Imagery

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Abstract:

Introduction

Our paper presents a remote sensing workflow for identifying modern activities that threaten archaeological sites, developed as part of the work of the Endangered Archaeology of the Middle East and North Africa (EAMENA) project, based at the Universities of Leicester, Durham and Oxford. Since 2015, the EAMENA project has been funded by Arcadia to use Earth observation to document archaeological sites across the MENA region and the threats posed to them in an online database. An additional grant from the Cultural Protection Fund facilitated training of staff at partner institutions across the region in EAMENA’s methodology from 2017-2021.

Methods

High-resolution imagery and a standardised image interpretation workflow is first used for digitising archaeology. Information about archaeological sites is recorded in EAMENA’s Arches 5 database. EAMENA then applies open-source data to automate monitoring of changes to and around sites across large regions using Google Earth Engine. First, open-source Sentinel-2 image collections are filtered into two collections, representing an earlier and a later date range, ideally corresponding as closely as possible to periods in which fieldwork has been undertaken. A cloud mask is applied and a median composite generated from the image collections. A per-pixel change magnitude image is then computed to measure the difference between the two composites. A threshold is then applied to retain areas of more significant change and can be appended to a layer of site points. The methods and data are easy to apply and modify for heritage professionals. This has the potential to speed up the detection and prevention of damage to archaeological sites and makes use of Google’s high performance computing power and access to catalogues of open-source satellite imagery with regular revisits.

We applied our workflow and performed field validation during 2019-2020 at two case studies, the Aswan and Kom-Ombo area in Egypt (collaborating with the AKAP project), and the Jufra oases in Libya. AKAP has worked north of modern Aswan recording a variety of sites dating from the Palaeolithic to the pre-modern era, and consisting of findspots, scatters, towns, temples, cemeteries, quarries, and rock art. Archaeological sites in the region are at risk from land reclamation, quarrying, and urban development, including the construction of a new city (New Aswan) on the west bank. In Jufra, sites include ancient water management, settlements and cairn cemeteries. Jufra has some of the earliest evidence for agriculture in the Central Sahara but modern agriculture is fast expanding and threatening the remains. Validation comprised running the change-detection scripts then visiting a sample of the sites in 2019-2020 using GPS to identify whether the algorithm was correct to either indicate

change or no change at these sites. These sites had previously been visited and recorded in earlier field seasons so comparison in the field was possible.

A next phase of this work is currently being undertaken to develop methods of classifying the type of change being identified by the current workflow by applying and refining land classification training algorithms and combining these with the automatic change detection methods described above.

Results and Training

Our current change detection workflow has an overall accuracy of the results ranging from 85–91%. Human activities, such as construction, agriculture, rubbish dumping, burning and natural processes were successfully detected at archaeological sites by the algorithm. This allowed these sites to be prioritised for validation and recording. Some instances of change too small to be detected by Sentinel-2 were missed, and false positives were caused by registration errors and shadows.

This paper shows that the expansion of agricultural and urban areas particularly threatens the survival of archaeological sites, but our extensive online database of archaeological sites and programme of training courses places us in a unique position to make our methods widely available. The EAMENA database now has over 40 active users in Tunisia, Libya, and Egypt who are also trained in remote sensing and GIS. Since 2017, we have provided training to North African colleagues focussing on the use of freely available satellite imagery for archaeological site identification and monitoring and on-the-ground location of sites using GPS. Participants were trained in Geographical Information Systems and remote sensing to analyse patterns of damage and threat, focusing on open source software, especially QGIS and Google Earth Engine, including, in the later phases of the training, using our change-detection methodology.

ID number: 75

Digital Navigator on the Seas of the Selden Map of China: Sequential Least-Cost Path Analysis Using Dynamic Wind Data in the Early 17th Century South China Sea

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Abstract:

The historical importance of the Selden map of China to the maritime trade networks of East and Southeast Asia was recognized in 2008 when trade routes crisscrossing its seas were noticed (Batchelor 2013, 37–63). It dates to c. 1619 CE and has several striking features that differentiate it from other Chinese maps of the era. Among these is the scale bar, whose units are not explained on the map, but according to the popular view are a measure of time and not of distance. Therefore, it is possible to calculate sailing durations for each route.

In my forthcoming article I propose a novel method of simulating directed sailing voyages, which is compared against some of the routes on the Selden Map. The model is inspired by the works of Leidwanger (2013, 3302–8) and Alberti (2018, 510–28), but instead of yearly or monthly mean winds, the least-cost path analysis is done in 6-hourly segments with the wind conditions changing accordingly. The process is automated with Python macros utilizing ArcGIS Pro 2.5/2.7’s tools. As a semi-enclosed sea where currents and wave direction generally follow the winds, the South China Sea offers a suitable setting for this type of modelling. In addition, the monsoon reverses the dominant wind direction twice per year giving the trade routes a natural rhythm as well.

The wind data is derived from the Climate Forecast System Reanalysis (CFSR) dataset. CFSR and its successor CFSv2 offer hourly data (forecasted from 6-hourly measurements) at 0,5° resolution (c. 56 km at the equator) from January 1979 to near present. Recent global warming has decreased the winds speeds in the area, hence wind data from 1979–1980 is used to be more in line with the circumstances of early 17th century. General Bathymetric Chart of the Oceans’ GEBCO_2020 dataset is used for identifying the coastline and assigning extra costs to shallows and the proximity to island groups implied on the Selden map to be avoided. GEBCO_2020’s resolution is 15 arc seconds (c. 460 m at the equator), which is resampled into 500 m grid. The abovementioned wind data is interpolated to this resolution using natural neighbour interpolation.

In general, the fastest simulated voyages somewhat underestimate the sailing durations measured from the Selden map. There are multiple possible reasons for this: e.g. the digital navigator is free to choose the course and is not confined to the exact route on the Selden map, the route is highly optimized or the Selden map values reflect more of an average voyage in favourable conditions. Nevertheless, the model shows that a ship with simplified general properties for the era is capable of reaching the speeds of the Selden map; though further validation of the method is needed in the future.

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ID number: 76

Was Asclepius more popular in times of the Antonine plague? Answers from temporal modeling of epigraphic and numismatic evidence

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Abstract:

The paper focuses on testing the hypothesis produced by the academic debate that the cult of Asclepius, a Greco-Roman god of medicine, was more popular in times of the Antonine plague (Ploeg 2018). The rationale behind the hypothesis is that the goal of having good health became a more pressing issue during the epidemic. It cannot be said that a consensus with respect to the supposed rise in popularity of Asclepius in times of the Antonine plague has been reached in the academic debate. While the proponents of the hypothesis argue that the increase in the amount of epigraphic evidence of the worship of Asclepius can be potentially related to the plague, opponents claim that there are no indicators of such phenomenon (for discussion see e.g. Ambasciano 2016).

The paper presents a quantitative exploration of the hypothesis to bring further arguments and clarity to a topic that has been, so far, studied mainly by the established methods of historiography. The paper evaluates the potential increase in popularity of Asclepius in two groups of the society: 1) general population, and 2) Roman emperors.

With respect to 1) general population, epigraphic evidence for the worship of Asclepius collected from the Epigraphic Database Heidelberg (EDH) is selected as a suitable quantifiable proxy for measuring the degree of popularity of the cult among the population. The main task with this proxy was to evaluate if there was indeed an increase in the number of inscriptions dedicated to Asclepius in the period of the Antonine plague and how is the potential change in the number of these inscriptions comparable to the dedications to other deities and to the whole habit of making Latin inscriptions. This evaluation, however, faces the problem that the ranges for the dates of origins of a significant amount of EDH inscriptions are at least 50 years wide, thus introducing temporal uncertainty to the analysis. For this reason, a Monte Carlo approach was selected as an appropriate tool to tackle this problem. First, a Monte Carlo algorithm was used to estimate 1000 possible dates of origins for each inscription (between their terminus post and ante quem). Second, a python script simulated 1000 possible temporal distributions of the inscriptions based on the estimates from the previous step. The result then represents an estimation of probable amounts of inscriptions belonging to specific periods of time. This estimation can be subsequently checked whether it supports the hypothesis from the debate that Asclepius was more popular in times of the Antonine plague or not.

With respect to 2) Roman emperors, the Roman coins digitized by the Online Coins of the Roman Empire (OCRE) and the Roman Provincial Coinage (RPC) are conceptualized as a proxy for exploring sentiments and ideological inclinations of Roman emperors. That Roman elites used coinage for such purposes can be illustrated in the following examples. Carausius, who was a military commander and proclaimed himself the emperor in Britain ruling over Imperium Britanniarum, issued a number of coin types depicting Britannia. Similarly,

Vespasian’s strong ties with Egypt can be observed also on coins bearing the image of the god Serapis that the emperor issued. To explore the potential increase in popularity of Asclepius among Roman emperors ruling in times of the Antonine (or later Cyprian) plague, the coin types depicting Asclepius (and other deities related to health) were counted, categorized, and attributed to individual emperors.

The results of the Monte Carlo approach to the EDH inscriptions revealed a potential increase in the number of inscriptions in the second half of the 2nd century CE, which could have been, at first glance, correlated with the Antonine plague raging between ca 165-180 CE. However, if we compare the temporal distribution and rates of change between the data for Asclepius and dedications to other deities and with the entire EDH dataset, we can see very similar trends in the data; i.e., a result that does not support the hypothesis from the debate that Asclepius’s increased popularity in times of the Antonine plague can be documented by the number of inscriptions. Rather, it shows that the potential increase of the number of inscriptions dedicated to Asclepius is part of the general habit of making inscriptions which was more intensive in that period of time. Considering the popularity of the cult among the Roman emperors, the number of coins types depicting Asclepius is higher under the emperors ruling just after the probable peak of the Antonine plague and under those ruling in the time of the Cyprian plague (active in ca 249-262 CE). The paper demonstrates the potential of quantitative approaches to validate hypotheses already existing in the debate. However, at the same time, the paper argues that it is important to conceptualize and use such an approach as a supplementary methodology in synthesis with the established methods of historiography and to keep in mind the limits related to the uncertainties in the data.

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ID number: 78

From the material culture to the lived space. A virtual reconstruction of a Minoan workshop

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Abstract:

The Potter’s Workshop of Quartier Mu at Malia (Crete, Middle Bronze Age, c. 1800-1700 B.C.) was a polyvalent building sheltering pottery and stone vessels manufacturing as well as domestic activities. Our presentation will focus on the sensory ambiances in which such activities were performed. By doing so, we will propose a new methodology for reconstructing the lived space in ancient households, beyond solely architectural aspects. As enhanced by anthropologists and cognitive psychologists, reconstructing sensory ambiances may shed light on the role of senses in the manufacturing processes.

We carried out experiments that helped identifying the manufacturing and function of lithic tools found in the Potter’s Workshop of Quartier Mu at Malia. We recorded the sounds provided by the identified activities, namely grinding, polishing, crushing, sharpening, knapping, picketing. The sounds have been extracted and treated by a noise reduction tool in Audacity. Additionnaly, we conducted experiments on the flames produced by lamps found in the same building. We recorded the light obtained with a large range of animal and vegetal fuels thanks to a photometric cell. The recorded data have been incorporated in a three-dimensional model of the building, using Autodesk 3dsMax, Corona Renderer and Adobe Premiere. We thus obtained a realistic depiction of the lived space, taking into account the materials’ physical properties.

We observed a large variety of sound and light atmospheres depending on the moment of the day and of the dusk as well as the performed activities. The materials also play a significant role on the distribution of light and sounds. For example the colour of floors, walls and ceiling intensify or reduce illumination while their texture acts on the acoustic performance characteristics. Finally, we obtained preliminary results on the domestic comfort perception. We showed that some activities could not be performed below a certain amount of illumination.

ID number: 79

Model-led survey with mobile GIS: the prediction and survey of karstic caves and rockshelters in Kazakhstan

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Abstract:

The foothill and piedmont zones of Central Asia (A.K.A. the ‘Inner Asian Mountain Corridor’, or IAMC) have been identified as a potential series of refugia that may have facilitated hominin occupation and dispersal within the region during the Pleistocene. Although a number of cave sites and open-air sites have already been identified by scholars working in the region, the limited Pleistocene record has hampered the assessment of the IAMC as a zone of hominin occupation and dispersal. Our project targeted karstic caves and rockshelters in particular to address the dearth of chronological and environmental evidence. These features are more likely to preserve sediments appropriate for dating, as well as unique preservation conditions for fossils and even DNA. We present on our approach and results from integrated model-building and model-led survey in the IAMC in Kazakhstan, facilitated by mobile GIS and GNSS. The technology was central to our iterative process of ‘continuous interpretation’, from model-building phases to data collection phases. This allowed us to ground-truth our models, successfully locate karstic caves and rockshelters, and subsequently to identify salient geomorphic features underlying karstic cave and rockshelter location in the region.

We built two models using landform classification and drawing on the concept of Topographic Position Index (TPI), one model to lead survey in 2018, and a subsequent revised model to lead survey in 2019. The 2018 model was an unsupervised landform classification model, the results of which were classified into three categories of predictive value (high, medium, low), and then masked to the extent of limestones and undifferentiated carbonates in the study region. The 2019 model used cave and rockshelter locations from the results of the 2018 survey in a supervised minimum-distance classification aimed at further reducing the potential survey area. The results of this second model were also classified into three similar categories of high, medium, and low predictive value, and masked with the same lithological data. Both models were succeeded by field seasons during which they were ground-truthed, and results could be reincorporated into subsequent reassessment of the modelling. The use of a mobile GIS platform (GIS Pro, iOS) in our surveys provided our solution for data collection of karstic features in the field, and also meant that our models were easily accessible and could be queried in the field during logistical discussions and during real-time navigation. Use of a GNSS surveyor permitted precise real-time location for this navigation in relation to the model, but also for appreciating landscape position and topographic features during survey.

Through our approach of model-led survey, we located and recorded 95 caves and rockshelters in the area of the IAMC in Kazakhstan during our time in the field. Around a third

of these contained some form of accumulated sediment. Our models were successful in helping us to target these features, and then further in identifying the geomorphic factors that underlie the location of these features in the landscape. Our approach embraces the concept of field survey as a process of continuous interpretation, and this was enabled by our use of mobile GIS and the use of survey data for further modelling. The technology allowed us to be highly mobile and cover a lot of ground during survey while still maintaining focus. In particular, real-time overlays with geological and military topographic maps proved informative and useful, both scientifically as well as logistically. Having the models available for investigation in the field allowed us to adapt quickly while keeping our scientific goals paramount. Ultimately, the combination of the models and mobile GIS enabled a targeted and adaptive approach that allowed us to reduce the survey area substantially, and feed the results of our surveys into further modelling.

ID number: 80

Position, Privilege and Potential - 10-minute lightning talk

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Abstract:

Current dialogs about power and privilege are (rightly) focused on action and moving from discussion to action. For researchers interested Classical Archaeology these debates, though not entirely new, are particularly important. Hamilakis argued that ‘Greece’s richly diverse, multi-ethnic and multi-cultural material past needs to be highlighted and promoted as such’ (2008, 9). Significant work has gone into looking beyond privileged materials and interpretations that excluded local, indigenous components, often constructing a ‘Greekness’ rooted in modern colonialism. Scholars such as Tiverios, Archibald, and Greaves have explored the origins of Greek ‘colonisation’ from the Thermaic Gulf to Anatolia, shining light on the local populaces once elided by ancient and modern sources and illuminating the ‘Dark Age’. From the Thermaic Gulf to the Troad researchers such as Papadopoulos, Mueller, Aslan and others have dramatically altered our view of Early Iron Age (EIA)/Geometric era inhabitants, demonstrating new depths to Thracian social organisation, technological skills and networks in which they actively participated. Despite decades of self-critique, the discipline still faces serious challenges that can be boiled down to questions of privilege. What is studied? Who studies it?

This paper argues that digitization, and especially the dissemination of 3D spatial analysis data, has the potential to democratise research; bring new perspectives to bear on sites, material culture and interpretations. First, the ‘tyranny’ of the metropoleis (city-states) in archaeological research is examined. Using Archaic Oisyme as a case study the paper demonstrate not only the necessity of studying smaller settlements or ‘village-states’, but importance of doing so using geographic information system (GIS) and 3D special analysis data.

Tyranny of the Metropoleis

‘Greek colonization produced about 230 colonies and settlements … fewer than half have been studied archaeologically’ (Tsetskhladze 2008, lxiii).

The situation is more dire than this statement conveys. First, we must understand the parameters of what is meant by archaeological study. The typical settlement in Archaic and Classical eras were small, more aptly called ‘village-states’ (Bintliff 2014, 264), rather than the common moniker city-state. Frequently, research into these is limited to surface survey, small scale excavations and field reports. They may be briefly mentioned in compendiums or in relation to larger settlements, and articles tend to focus on distinctive assemblages such as Attic and Corinthian pottery. There is little to no examination of the context. This can be particularly problematic when initial reports are preliminary, incomplete, or in some worst-case scenarios, nearly a century old. Sites that are subject to intensive investigation are usually those that loom large in the physical and/or literary landscape. Thus, the tyranny of the metropoleis has created yet another narrative of privilege.

As we move towards an increasingly digitised research environment it is imperative that village-states are brought into the discussion. If they are not, then we are excluding the very settlements that are most representative of average lifeways (Bintliff 2014, 264). This is not just a problem of data loss; it risks obscuring important factors for assessing the larger settlements which are under investigation. Using the case study of the North West Aegean, or Strymonic Gulf, we will see 3D spatial analysis could assist in the 'what is studied' dilemma.

In the Strymonic Gulf, metropoleis such as Thasos, Amphipolis, Stageira, Argilos are the primary targets of research. As these sites prospered, many established spheres of influence and/or 'sub-colonies; of their own. Recent research is calling into question the nature of the relationship between Greeks and Thracians in these ventures, suggesting the indigenous populace were active partners, rather than passive recipients of Greek goods and culture. It is precisely in this area that investigations of village-states may be particularly important. A diachronic study of one such village-state, the Thasian sub-colony of Oisyme, indicates a peculiar amalgamation of 'local' and 'foreign' elements. A key part of this analysis was building a rather simple 3D (re)construction of the documented architectural elements, the acropolis temple and fortifications of the settlement. The result was an entirely new interpretation of the organisation and function of the temple and its architectural phases wherein pre-classical structures were preserved throughout the life of the Oisyme. Using various forms of 3D spatial analyses regionally would allow for network models showing links between sites over time.

Ideally, a permanent platform with broad popular appeal could host the data generated. Something along the lines of Google Earth Engine that supports complex GIS analyses, but with a peer review panel comprised of volunteer specialists to review submissions. This sort of modular approach could allow for independent and small-scale research to add data for each site and expanded to other regions. Details of imagery, architecture and environment could be studied from a semiotics framework to reveal various levels of messaging and audience. I envision this a sort of Mobile Museum, or perhaps more accurately a Museum of Mobility, as it actively encourages users to see links between peoples and places. Similar collaborative projects are already underway, such as: https://gis.periegesis.org/; https://recogito.pelagios.org; https://pelagios.org/.

Access

How does this affect the second area of privilege, or the 'who' question, and why 3D over 2D or 2.5D? The answer comes in various forms of bottlenecks in education, access, and specialisation. Classical archaeology is still too often restricted to students with access to Greek and Latin courses, and funding for literature and travel. This is particularly discouraging for students from underserved communities. While internet access is far from equal across populations and classes, it is arguably more available than traditional mediums. Translation programmes and the nature of visual data may also lessen the gap caused by linguistic differences. 2D plan views and 2.5D are useful but can be difficult for students and non-specialists to work with and understand, as is the particular language (jargon) used for classical studies. 3D (re)creations and spatial analyses open the door for interested 'laity', young scholars, and non-classical specialists to engage with the data, bringing new ideas, models, and parallels for research, thus democratising access to the ancient world.

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ID number: 81

Making Practical Use of Linked Open Data

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Abstract:

This presentation reports on the use of cultural heritage Linked Open Data (LOD) within the context of an ongoing international archaeological data integration project. It describes techniques to improve interoperability and reusability by use of data enrichment and mapping to external LOD resources.

Cultural Heritage data is routinely aggregated and archived on a national basis in many European countries – the UK Archaeology Data Service (ADS), Data Archiving and Networked Services (DANS) in the Netherlands and the Swedish National Data Service (SND) are examples of such national data aggregation services. With increasing emphasis on collaborative, cross-domain working and the potential for reuse of resources both in research/academia and in industry there is a move towards larger-scale (international) integration of metadata e.g. Europeana (Museums), EAGLE (Epigraphy) and ARIADNE/ARIADNEplus (Archaeology).

With this, plus initiatives such as FAIR (Findable, Accessible, Interoperable and Reusable) comes an expectation of integration, interoperability and reusability of the data. However, aggregation does not automatically mean integration, and integration does not automatically lead to interoperability. Data integration can be achieved through use of common data schema; interoperability is achieved through use of common data types, and by reference to common vocabularies – providing shared understanding and expectation of the context, scope and meaning of the data.

ARIADNEplus is an ongoing 4-year project funded by the European Commission under the Horizon 2020 programme, involving 41 partners from 23 European countries, plus 4 international partners. The project builds on the initial ARIADNE project which previously successfully integrated approximately 2 million metadata records describing archaeological datasets, also producing a portal for cross searching the integrated metadata according to three main facets: Where (space) / When (time) / What (subject). The project is utilizing LOD to enrich the incoming datasets.

The “where” and “when” facets can be described and communicated using common data types and measurable and comparable values (e.g. spatial coordinates relative to a known location on the earth, date ranges relative to a known epoch). However, the “what” (subject) aspect is more difficult to define in an unambiguous and commonly understood form. An effective way to improve interoperability and reusability of subject data is to reference externally defined knowledge organization systems. Structured knowledge organization systems such as controlled vocabularies (thesauri, gazetteers, glossaries etc.) comprise conceptual reference resources for the purposes of subject indexing. A controlled vocabulary is inherently reusable as it describes persistent terms and concepts relating to a particular domain, but is not necessarily restricted in scope to any particular dataset.

Subject indexing of local data records is sometimes undertaken with little/less/no regard to achieving wider interoperability with other (external) datasets, or to the problems of multilingual access. This results in isolated ‘data islands’ – maybe internally consistent and coherent but with no connection to the wider world. The ARIADNEplus project aggregates multilingual subject metadata originating from 23 different countries, and so a multinational and multilingual approach to subject indexing and retrieval is required. Linking everything to everything would result in a very tangled web of data, so we take the approach of establishing common points of reference as a mediating hub between multilingual datasets. Concepts in local vocabularies are mapped to the concept identifiers of a central ‘spine’ vocabulary - the Getty Vocabulary Program Art & Architecture Thesaurus (AAT), which provides useful authoritative multilingual reference resources describing cultural heritage concepts.

Data provider domain experts produce mappings using a prototype application – the Vocabulary Matching Tool (VMT). This is a browser-based application with no user installation or configuration requirements, having a multilingual user interface. At the time of writing, the current UI languages supported are German, English, Spanish, French, Italian & Dutch. Instructions and general guidance on mappings were also produced to assist with the process.

It was important not to expose users unnecessarily to details of the wider integration strategy and associated technology stack e.g. ontologies, thesauri, RDF, SKOS. The VMT makes practical use of LOD under the covers by accessing the Getty Vocabulary Program SPARQL endpoint to obtain and present relevant AAT information. Users can search and browse the AAT, viewing the hierarchical context and scope of concepts to make a better-informed match. SKOS mapping properties are used to express the mappings (Miles and Bechofer 2009).

In addition to local concept mappings, we have extracted 917,000+ multilingual terms from Wikidata knowledge base, by identifying concepts already pre-mapped to AAT concepts and extracting all multilingual terms associated with them. These terms will further expand the ARIADNEplus entry vocabulary for the development of enhanced multilingual search facilities.

LOD is also being utilized to enrich data records where named periods (e.g. “Medieval”) are present in the metadata. Named periods are in fact complex concepts, encompassing timespans, spatial extents and sometimes cultural forms (Niccolucci and Hermon 2015). Perio.do is a multilingual gazetteer of period definitions for describing historical and archaeological named periods according to geographical region. It comprises a series of 'collections' (named period lists) where each individual period definition is associated with a geographical area and a start date and end date. Periods and collections have 'permalink' identifiers for clear, unambiguously referencing - e.g. the identifier http://n2t.net/ark:/99152/p0rrjd9gjx9 defines period "Moyen Âge" (Middle Ages) in collection http://n2t.net/ark:/99152/p0rrjd9 "INRAP: Chronologie Generale. 2007". Named periods in ARIADNEplus will be defined with reference to Perio.do, the purpose of Perio.do in ARIADNEplus is however different to the use of AAT. Rather than aligning data to common identifiers, Perio.do will enrich records already indexed with period names - providing start/end dates making these records comparable and searchable in the same way as other date information.

Much effort in recent years has been devoted to the production of LOD; to date there has been less emphasis on subsequent practical usage of these resources. Existing LOD knowledge organization systems such as AAT, Perio.do and Wikidata act as effective hubs in the wider distributed web of data. The ARIADNEplus project is making practical use of these LOD resources to improve interoperability and reusability of integrated datasets, and to enhance search capabilities. The approach also exposes potential new links between previously disparate multilingual resources.

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ID number: 82

Between land and sea: modelling terrestrial mobility and maritime interaction on Crete during the Late Bronze Age

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Abstract:

Our paper is centred around the larger question of how we can understand interaction on and between island communities. With a focus on several sites on the island of Crete – the largest and southernmost island in the Mediterranean – we consider both terrestrial and maritime mobility between these settlements for the Late Bronze Age (LBA). For communities on Crete, distance and landscape likely played an important role in the frequency, range and type of contact, whether this contact was for social or economic reasons. For example, coastal communities like Kommos and Chania were actively engaged in both regional island and maritime interaction, taking advantage of the opportunities afforded by their proximity to the sea. Communities to the north could theoretically engage in such off-island contact more frequently and more easily once the requisite technological needs were met, due to the proximity of the northern Cycladic islands approximately 100-115 kilometres shore to shore.

Our paper combines GIS, terrestrial, and maritime modelling to demonstrate the importance of multi-method approaches for a richer understanding of land to sea mobility. We are especially interested in understanding how and why certain coastal nodes (sites) grow and become central in these larger maritime networks, while others, despite similar geographical positioning, fail to follow a similar trajectory. Our results are compared with excavated archaeological data from a 13,700 ceramic dataset collected by one of us (PG) for the LBA. Our goal is to advocate for more inclusive, multi-method approaches to studying mobility and interaction in the LBA Aegean.

ID number: 83

Digital archaeology: Where should we start from?

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Abstract:

Among the challenges that this 2020-2021 pandemic bestows upon us, one concerns the global ‘digital turn’, in the job market, in scholarship and in social relations. This is particularly significant in the entire field of education as e-learning is frequently the only possible way of teaching/learning across the world. This simple point has profoundly stimulated our reflexive approach to education as digital archaeologists, making us wonder: Is this a point of no return? Is training in archaeology going digital? And if so, might this be the prelude to what Huggett defined as ‘the third wave’ of digital archaeology when our understanding of the digital transformation of archaeological knowledge will go beyond the programming and will extensively and reflexively ‘consider the intermediation of digital technologies at every stage of the production of archaeological knowledge’ (Huggett 2015: 88)?

In our opinion, there is still a certain ambiguity when speaking about digital archaeology, and it is pivoted around the gap between doing digitally and thinking digitally. Specific curricula in digital archaeology are still rare in EU academia (especially in the Mediterranean region), and the use of digital techniques is a fluid discourse that is fragmented across a broad branch of disciplines and classes. Frequently, it is confined to the postgraduate level of education, delegated to field experience or postponed to the final essays. We are led to believe that the first step towards digital thinking should lie in the undergraduate level of education. In this perspective, we suggest that data-sharing may be the linchpin of the entire story as it is one of the core components of digital culture in research (Stuart et al. 2018). Can we promote this shift towards digital thinking by involving our students in research projects based on data-sharing since the first academic education level?

Data engagement, in our opinion, is the supporting actor of this movie: commonly, we train our students to deal with data that we have produced as field archaeologists or – at the most – we let them play with data that they have produced for our field projects. Why don’t we subvert this rationale by teaching and practising data collection as a collaborative practice targeted towards somebody else? This calls us to open our and our students’ mind to both the ‘culture’ of data sharing and the fragility of our archaeological data, to be able to take care of it from a scientific perspective.

In this context, we experimented with creating an open GIS-based web infrastructure (based on a PostgreSQL/PostGIS DB) where students are asked to perform their entire piece of research. They operate as independent producers of their own data and archaeological knowledge but are aware that they share every piece of work, be it a point-line-polygon feature or an analytical tool. Triple sharing is envisaged: with their professors, the other students and the broader archaeological community. Whilst letting the professors access their content production might be frightening, the horizontal sharing among students is a powerful strategy to introduce them to data aggregation and comparison actively and to address data quality and consistency personally. A from-student-to-student perspective is perceived as a

comfort zone and, at the same time, it can successfully let our students be the protagonists of this process and directly deliver their own ‘product’ to the open community.

As it has been argued, imagining that our data is being reused by someone else might make us approach the creation and design of our data in a different way (Archaeology Data Service 2014). In order to better understand how students engage with the entire workflow within the infrastructure, we monitor the relationship of every student with the entire data cycle, from data production to data cleansing, sharing and reuse. The aim is to estimate the degree of awareness and confidence during the different stages of the research, from the very beginning to the end. By involving the students in this collective reflexive process, we push them to reflect upon their personal engagement with archaeological data, boosting the broader discourse about the new protagonists of 21st-century archaeology and the ongoing ‘digital turn’.

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ID number: 84

A methodological approach for Intra - Site Analysis of Spatial Organization of Thessalian Neolithic Settlements

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Abstract:

During the IGEAN (Innovative Geophysical Approaches for the Study of Early Agricultural Villages of Neolithic) project, more than 20 Neolithic-EBA settlements in the area of Thessaly, Central Greece, were investigated through various geophysical approaches. The project identified many features (rectangular structures, burnt or unburnt foundations, surrounding walls, multiple ditches and other minor anomalies), which illustrate the evolution of these villages during different occupation periods (Kalayci, Simon, and Sarris 2017).

Four such tells (Almyros2, Perdika1, Rizomilos2 and Almyriotiki) were selected to be studied in-depth about their intra-site spatial organisation. The settlements were selected based on the different layout characteristics, as it was perceived from the interpretation of the geophysical results. The study aimed to examine if these settlements were conceived following a determined spatial organisation and to identify possible hotspots that might have been used by the inhabitants during particular occasions and activities. Moreover, this research wants also to increase and to incite the use of combined technologies (in this case, geophysics space syntax and 3D visibility analysis) to answer the same question, in order to reach stronger and more valuable interpretations, above all in contexts not widely documented.

There are previous applications of space syntax to study the spatial organization of prehistoric villages and other historical contexts, mainly in order to understand the social attitude and economical aspect of such populations as it is explained by Chapman (1990) and Van Nes (2014). The article of Cutting (2003) is particularly remarkable since she stressed what it should be the real utility of space syntax analysis in archaeological contexts, that means “a tool to think with”, suggesting a reasonable adaptation of such technology that was created mainly for architectural and urban studies (Cutting 2003). Despite the idea of space syntax was developed more than forty years ago and that it can be a powerful tool to add data and enhance archaeological interpretation, this method did not have a wide application yet, probably because it was not implemented with the right attitude. The combination of space syntax, geophysics and 3D visibility analysis may lead to new valuable methodological approaches, above all for such historical contexts unable to reveal many information. 3D visibility analysis in archaeology is a quite new tool but it already showed its value and utility as demonstrated by Manzetti in an architectural context such as in Roman theatres (2015) and by Landeschi and his colleagues in a urban environment such as Pompeii (2016) (Landeschi et al. 2016).

The analyses were conducted by considering the different layout of the settlements in different periods. The instruments employed in this research were consisting of space syntax analysis and 3D visibility analysis, starting from geophysical anomalies. The space syntax analysis (consisting of axial map and convex map) reveals the areas of the settlements that

were more and less integrated and connected with other spaces. The 3D visibility analysis indicates the frequency of visibility within the settlements suggesting which areas were the most visible and which ones were the most hidden to the sight of agents from within or from outside the settlements.

The analyses of the axial maps show that there was probably some intentionality and some planning in the spatial distribution of built and unbuilt spaces, to have integration and connection within the same settlement. The analyses of the convex maps along with the 3D visibility analysis unveiled interesting connections between integrated/segregated spaces and visible/invisible spaces. The results from the axial map analyses, together with the one from the convex map analyses and the frequency of visibility maps suggest a particular spatial organization that can bring to new interpretations about the culture of the Thessalian Neolithic populations.

The promising results obtained from the combination of such technologies hopefully will encourage specialists to adopt, compare and develop more integrated methodologies. In the future, the results and the interpretations will be also enriched through the virtual acoustics analysis, which can add meaningful information about which areas of the sites were used for public gatherings or ceremonies, according to their acoustics characteristics, still considering their visibility and spatial properties.

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ID number: 85

Fuzzy chronologies in longitudinal network studies

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Abstract:

The relationship between archaeological data and chronology is notoriously complicated. Material finds gain significance through their spatial and chronological context, and yet it remains especially difficult to date archaeological objects. Scholars have therefore reverted to fuzzy time concepts that avoid precise dates, such as vaguely defined timespans, stylistic groups, or even relative chronologies. These approximate dates allow to reconstruct a progressive order of finds without demanding a commitment to a fixed moment in time.

While this intentional vagueness reflects the characteristic inaccuracy of archaeological data, its integration into long-term computational studies remains a challenge. Longitudinal networks represent the development of relationships over a longer timeframe and are most frequently conceived as a series of sequential snapshots, each representing the state of the network at a certain point in time. They require data that can be properly sequenced and attributed to suitable time windows, which should be defined as a representative unit to highlight changes in the relationships. An ideal longitudinal network would be built on chronologically crisp data corresponding to the chosen time window, which archaeology cannot provide. It is therefore necessary to devise strategies to adapt network studies to the fuzzy nature of archaeological data.

Certain tools have been developed to overcome the chronological fuzziness in longitudinal networks for well-dated pottery productions of more recent periods. S. Carrignon et al. (Carrignon, Brughmans, and Romanowska 2020) have worked with cumulative probabilities to determine the likelihood of a pottery type having been produced in particular time window. This method, originally developed by E. Fentress and P. Perkins, (Fentress and Perkins 1988, 207–8), is based on the assumption of a uniform probability distribution of a vessel’s production within the timespan it has been dated to. The statistical value of a data record within different time windows can consequently be apportioned according to the probability degree of its affiliation, which allows to control and minimize statistical errors.

The limits of this technique become apparent when chronologies get fuzzier. Especially in pre- and protohistoric times, interval timestamps are rare. Fixed chronological points are few due to the absence of a written record, and the dating methods reflect these shortcomings. Whereas some vase types from well-studied productions can be interval dated, most other productions are only roughly dated or attributed to regional stylistic groups. These concepts are often loosely anchored in absolute chronology and were intentionally developed to avoid precise intervals.

Dates like “at the end of the 7th century B.C.” or “early Middle Geometric” are commonplace, as they allow us to refine rough dates without demanding too much commitment. Translating them into concrete chronological intervals is however difficult. When does the end of a century start? Does this term describe the last five years, the last quarter or the last third of

the century? The limits of these chronological periods are not only fuzzy, but depend also on their interpretation by each individual researcher. They bear a degree of subjectivity that biases a direct comparison to crisper timestamps.

Without scientific methods to define fuzzy timestamps more precisely, arbitrary choices need to be made to specify their limits and exploit them mathematically. This process distorts reality, however. The reliability of a timestamp depends on the degree of certainty to which its limits can be designated and is therefore not necessarily the same over the entire period. Timespans such as “at the end of the century” have a relatively clear ending, yet their beginning is uncertain. Eliminating this uncertainty by fixing a starting date introduces statistical errors, as the probability of an object being produced in the early phases of this interval is smaller.

We suggest the use of fuzzy logic to minimize such errors in longitudinal network studies. Fuzzy logic allows to render partial affiliations in systems that are not built on Boolean data, such as time windows in archaeological research, through membership functions. Membership values are deliberately chosen according to the researcher’s evaluation of the bias of his data. Linguistic nuances and uncertainties can thereby be translated into numeral values without needing a firm mathematical basis. Although fuzzy logic has been employed to normalize sample defaults in archaeological studies, particularly in spatial analyses (e.g. Fábrega-Alvarez und Parcero-Oubiña 2019), its potential to resolve the chronological issues of longitudinal network approaches has not yet been exploited.

Membership values can be used to ascribe different levels of certitude to subintervals of timestamps. This procedure allows to counterbalance the statistical deficiencies of a data record with a fuzzy timestamp in a longitudinal network and reduces chronological simplifications. The weighted interval timestamps offer a basis to calculate cumulative probabilities that reflect the different levels of uncertainty of the data and allow for a better proportioned attribution of values to time windows. The ensuing longitudinal network can consequently incorporate chronologically ambiguous data and still aim at a representative depiction of the material record, as will be demonstrated on an ego-network based on fine pottery imports discovered in the necropolis of Amathus.

The use of fuzzy logic is of particular interest to studies with inconsistent and imprecise chronological data. Large-scale distribution studies in particular struggle with heterogeneous dates, as they often comprise objects from different production centres that are dated according to local chronologies. Finds from excavations by different institutions may also be dated according to various dating traditions. The normalization of these fuzzy time concepts is essential to modelling realistic longitudinal networks and to understanding long-term dynamics in mobility, trade or cultural interaction.

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ID number: 86

3D G[EYE]S: INTEGRATING EYE TRACKING AND 3D GEOGRAPHICAL INFORMATION SYSTEMS

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Abstract:

A joint collaboration between the Laboratoriet för Digital Arkeologi (DARKlab, https://www.darklab.lu.se/) and the Humanities laboratory (https://www.humlab.lu.se/) within Lund University, Sweden, allowed researchers to develop an innovative work pipeline to collect, visualize and analyze data from Virtual Reality-based Eye-tracking in a GIS environment, by combining software and hardware solutions, including the HTC TOBII Vive, Unity, Cognitive 3D, and ArcGIS PRO. The aim was to test the possibility of integrating in a three-dimensional GIS, data related to human visual attention (series of cognitive operations that allow the selection of relevant information from a visual scene), in order to measure which parts of a 3D model (in this case a historically based reconstruction of a Pompeian house) drew the attention of the user while moving in the virtual space. This study draws upon the longstanding tradition of visibility studies in archaeology (Madry and Crumley 1990; Gaffney and Stancic 1991; Wheatley 1995; Llobera 1996; van Leusen 1999), which in the last fifteen years has started to encompass different methodological approaches based on the combination of techniques such as GIS, 3D modelling, VR (Earl 2007; Paliou 2013; Papadopoulos and Earl 2014; Landeschi et al. 2016; Opitz 2017; Richards-Rissetto 2017) . VR-based Eye-Tracking is still an emerging technology and so far, there are no available examples in the literature about the possibility of integrating the output data generated by an eye-tracker embedded in a VR headset into GIS software. Addressing this is essential because for archaeologists and cultural heritage specialists in general, it is crucial to geolocate the visual behavior of a user in order to evaluate historical hypotheses, inspect endangered monuments, or assess museum visitors’ experience. This paper presents our work toward such an integration.

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ID number: 87

Poseidon - A toolbox for archaeogenetic data management

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Abstract:

The recent increase in openly available ancient human DNA samples demands for new software solutions to store, distribute and analyse both genomic as well as archaeological context data. In this paper we present Poseidon, a computational framework including an open data format, software, and a public online repository to enable convenient, reliable, and FAIR access to genotype data from all around the world.

Archaeogenetics has become a fast accelerating field, with new data coming out faster than people can co-analyse (Orlando et al. 2021). If one considers samples currently being processed in the world's largest laboratories, we are now quickly approaching genome-wide data for 10,000 ancient human individuals. In addition, emergent fields such as ancient metagenomics and paleo-proteomics are adding complexity to a data landscape that already hosts traditional archaeological data with contributions from long-established non-genetic technologies like radiocarbon dating and stable isotope analyses.

Data from genetic analyses in academic papers is usually shared by releasing raw sequencing output into public repositories like the European Nucleotide Archive (ENA). Archaeological context information for individual samples is documented in supplementary tables attached to the publications. So while most data in the field is technically accessible, it does not satisfy the FAIR principles of open data: Findability, Accessibility, Interoperability, and Reproducibility (Wilkinson et al. 2016)

Beyond ethical concerns, this raises a number of concrete practical issues:

- Intermediate data such as genotypes or metagenomic profiles are often not released at all, making it hard to reproduce specific results.

- The connection between individuals, contextual information and genetic data is challenging to maintain across very different repositories and sources.

- Meta-analyses spanning datasets require enormous amounts of work on data collection and curation.

- Incrementally produced data, for example by adding new data to previously published individuals, cannot be easily connected to the same individuals.

To mitigate some of these problems, we propose a package data format which bundles the big genotype data in industry-standard formats (EIGENSTRAT, PLINK) with a flat context data file: The .janno file. For each sample, this human- and machine-readable .tsv file format stores metadata (e.g. publication, keywords) together with information about spatiotemporal origin (e.g. coordinates, radiocarbon dates) and genetic data preparation context (e.g. shotgun sequencing vs. target enrichment) as well as quality markers (e.g. number of autosomal SNPs

on the 1240k array). Genotype data and .janno file are supplemented with a BibTeX file for the relevant citations plus optional metadata files (README, CHANGELOG) to make the package complete.

The main workhorse for operations on these Poseidon packages is the command-line software trident. It is written in the functional programming language Haskell, builds on strong type-safety and clean interfaces, and provides modules for package creation, inspection, validation and analysis. trident handles both context data as well as the large genotype data files -- the latter via stream processing. Sample entities are internally represented with specific data types, which ensures strict parsing constraints to maintain structural correctness and machine readability for all data in Poseidon. trident also serves as a command line client to download already available packages from a central online repository we host and maintain. We implemented the respective webserver relying on the same Haskell infrastructure as trident.

For integration of Poseidon packages with an R data analysis pipeline, we provide the poseidonR package to load .janno files into a tidyverse-compatible, tibble-derived S3 object. poseidonR also provides functions for bulk radiocarbon date calibration and age sampling on these janno objects.

In the spirit of the session, our presentation will highlight multiple aspects of our learning experience when developing Poseidon. This includes...

- the value we saw in a clear file format definition for the .janno file

- the advantages of a strictly typed programming language like Haskell for parsing operations

- the challenges of command line interfaces as the true lingua franca of scientific computing (Prasad et al. 2020)

- the necessity for code review, unit tests and manual alpha testing

Poseidon is a community project. Code and data are open. All documentation for the data format as well as the software tools are available online. Both for software development and for (context) data keeping we rely on version control with Git/Github.

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ID number: 88

ARISE – Interactive Archaeology and Electronic Simulations: a Brazilian research group for Digital Archaeology

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Abstract:

The objective of this presentation is to promote the main projects developed by the research group ARISE - Interactive Archaeology and Electronic Simulations (www.arise.mae.usp.br), based at the Museum of Archaeology and Ethnology at the University of São Paulo, Brazil, one of the first academic research groups in the country to develop projects on Digital Archaeology and videogames.

Based on the scientific debate about the concept of Digital Humanities (Schreibman, Siemens, Unsworth, 2016), the research group ARISE was founded in March 2017 with the purpose of inserting Brazilian academic production in Archaeology into discussions about the potential of the digital world and its applicability in archaeological studies. Since its foundation, ARISE has sought to foster academic analysis of interactive electronic media (electronic games, serious games, digital simulations) and to produce interactive projects for museums and educational institutions, in order to promote the results of research in Archaeology and History for the whole society.

Although recently founded, the group has in its history a vast list of scientific productions, such as the promotion of events and academic courses focused on the several topics of Digital Archaeology accessible to students and the general public, as for instance the first national symposium exclusively dedicated to Digital Archaeology; interviews with specialists in the various areas of Digital Archaeology; the production of videos and papers analyzing the representation of Archaeology and material culture in digital games; archaeological excavations, based on the methods and methodologies presented by Archaeogaming (Reinhard, 2018), in digital games with the participation of the community through livestreaming platforms; etc.

Also based on the use of electronic devices for the analysis and extroversion of results from archaeological research in interactive three-dimensional environments, one of the fundamental concepts of Cyber-Archaeology (Forte, 2010), ARISE was responsible for the development of the game “Sambaquis: a history before Brazil”, in partnership with the Research Group on Heritage Education and Archaeology-GRUPEP, from the University of the South of Santa Catarina (Unisul-Brazil), which aims to present the daily life of the inhabitants of coastal Brazilian sambaquis (shell mounds) to the player; in addition to having also several interactive projects under development, through partnerships with other departments and laboratories at the University of São Paulo and other Brazilian universities, such as the board game “The Triumphs of Turlough”, developed in partnership with the Laboratory of Medieval

Studies-LEME of the History Department at University of São Paulo, whose scenario is set in the southwest Ireland in the 13th and 14th centuries; the digital game “Engenho dos Erasmos”, developed in partnership with Cátedra Jaime Cortesão at the Faculty of Philosophy, Languages and Human Sciences at University of São Paulo, based on the first years of operation of Erasmos sugar mill, located in the city of Santos-Brazil; and the “Antarctic Archaeology Project”, developed in partnership with the Laboratory of Antarctic Studies in Human Sciences - LEACH (Federal University of Minas Gerais - UFMG, Brazil), whose main theme is the 19th century Antarctic expeditions.

ID number: 90

Pedestrian surface survey nowadays with Covid-19: an example of QField application

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Abstract:

Working in the field at the time of Covid-19 in the archaeological field means downsizing the research activity and limiting the staff employed. Therefore, you must expand the working time and the costs, however it is not always possible to support them. If the sustainability of the distance between people and the absence of contact during excavation investigations could be zero, otherwise it appears to be for the surveys, which are well combined with the needs related to the pandemic: distance and open air. In this sense, for the survey, the use of MobileGIS in the field, which allows you to acquire, store, manipulate, analyse and view geospatial data directly in the field, enable also to work wide and regular distances (Campana 2018, 79-86). Furthermore, the MobileGIS allows you to manage all its functions directly on your device, without people necessarily coming into direct contact with each other, using a unique project for everyone. An example of what has already been said was the activity performed in October 2020 - in full pandemic emergency - by a small group of students from the University of Siena, on occasion of the master’s thesis research project. The group was composed of only three people and this led to an increase in times and a decrease in the number of recognized hectares, but there was no lack of commitment and the will to work. All this was possible thanks to the collaboration between the Archaeological Superintendence, Fine Arts and Landscape of Umbria and the Laboratory of Landscape Archaeology and Remote Sensing (LAP&T) of the University of Siena. The investigation has as its object of study the ancient landscape of the Tevere’s Valley in the territory of Perugia (Umbria, Italy): the main objective of the research is to understand the dynamics and man-environment interaction that have affected this territory in ancient times and in its historical development. First, the survey was planned on a computer in QGIS, collecting all the information and data obtained from previous investigations and studies. For the survey, the QField mobile application was tested, which proved to be useful to best meet the needs that arise from time to time during work (Guarino and Montagnetti 2019). In this sense it is possible to identify the most significant advantages: thanks to the possibility of adding, modifying and manipulating the data directly in the field, using only the information necessary at the moment, it allows you to move on the ground following a grid or path, loaded before field operations and guided by the GPS. A second advantage is that it is very intuitive and easy to use, precisely because it uses the same settings as QGIS and just like it, with MobileGIS it is possible to turn on and off the layers to be used and add the information collected. Finally, the combination of the two programs, QGIS and QField allows to optimize the working times of both the survey and the post-processing of the collected data.

ID number: 91

CHRONOLOG: a tool for computer-assisted chronological research

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Abstract:

Introduction

Archaeological research often involves complex debates regarding the chronology of archaeological strata, pottery types and royal figures. Yet, outside the field of radiocarbon calibration, computers are rarely used as a decision-making tool in these debates. We present a new tool called CHRONOLOG, which enables users to encode a wide set of chronological constraints, automatically checks their consistency and computes chronological estimates of dates and durations of chronological periods. The tool is based on algorithmic techniques from the field of temporal logics (Shostak 1981, Dill 1989) which, until recently, have never been applied to the field of archaeological chronology (see Geeraerts, Levy, and Pluquet 2017).

Data model

The CHRONOLOG data model features three types of objects:

- • **Periods**: a Period is a continuous interval of time, without gaps. It is characterized by a *start date*, an *end date*, and a *duration*. It can represent a reign, an archaeological stratum, or a historical period, among others.
- • **Sequences**: a Sequence is an ordered set of Periods where each Period starts exactly when the preceding one ends.
- • **Synchronisms**: a Synchronism is a chronological constraint involving two Periods. The CHRONOLOG data model features several types of synchronisms, the most common one being *contemporaneity*, a constraint that imposes that the two Periods have at least one unit of time in common.

Additional constraints can be added on the start date, end date and duration of a Period:

- • *Lower bound*: e.g. a date not earlier than 1984 CE or a duration of at least 5 years.
- • *Upper bound*: e.g. a date not later than 1984 CE or a duration of at most 5 years.
- • *Range*: e.g. a date between 1984 and 1990 CE or a duration between 5 and 10 years. This is equivalent to having both a lower and an upper bound.
- • *Exact value:* e.g. the date 1984 CE or a duration of 5 years. This is equivalent to identical lower and upper bounds.

Main operations

CHRONOLOG automates two basic operations on chronological networks:

- • **Consistency check**: this operation consists in checking whether all the encoded constraints are coherent, or whether they feature a contradiction.
- • **Tightening**: this operation consists in computing the tightest possible ranges for each start date, end date and duration.

These operations enable two important applications:

- **Checking the impact of local changes**: every time a local change is made to the network, CHRONOLOG immediately launches a consistency check. If the model is found to be consistent, the tightening operation is applied, showing the impact of the local change on the overall model.
- • **Testing chronological hypotheses:** one can want to check if a certain chronological hypothesis is true. For example: can two given kings have been contemporaries?

Example

In the kingdom of ChronoLand, king Albert and king Baldwin have reigned successively. Albert's reign starts no earlier than 1200 CE and lasts at most 10 years. Baldwin's reign ends no later than 1300 CE and lasts at least 35 years. The capital city of ChronoLand was excavated and revealed two strata. The earliest one (Stratum 2) was built during the reign of Albert, and the latest one (Stratum 1) was destroyed during the reign of Baldwin. We further assume that each stratum lasted for at least 20 years.

The ChronoLand example can also illustrate the two practical applications mentioned above. For example, what would be the impact of adding a 70 years upper bound to the duration of Baldwin's reign? This would limit the duration of each stratum to at most 60 years. This bound is due to the fact the time-span of our strata is bounded by the total duration of the dynasty, which is at most 80 years (10+70). Since each stratum has at least 20 years, the other one can have at most 60 years (80-20).

Another example is to check the following chronological hypothesis: is it possible that king Albert built Stratum 1? The answer is no, because, having already built Stratum 2, which lasts at least 20 years, and having reigned at most 10 years, his reign necessarily ended before the end of Stratum 2. The answers to these two questions are hard to obtain manually, yet can be obtained within a second with the use of CHRONOLOG.

Conclusion

The CHRONOLOG software enables users to build chronological model according to the data model described above. It implements fast algorithms in order to check consistency and to compute the tightened ranges of all dates and durations in real-time, even on models featuring hundreds of constraints. This allows users involved in chronological debates to test their models interactively and to check the global chronological impact of local chronological changes to the model. The objective of our software is to put chronological debates in archaeology on a more scientific and rigorous footing.

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ID number: 92

Towards Big Earth Data: cloud-computing workflows for the automated detection and monitoring of endangered archaeological sites

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Abstract:

1. Research background

The remote assessment and analysis of disturbances and damage affecting the preservation of cultural heritage have become particularly important over the past decade, certainly as a result of improvements in the availability and acquisition of global geospatial data and innovations in software and image processing techniques (see Tapete and Cigna 2019). The recent consolidation of cloud-based platforms for the scientific analysis and visualisation of open-source satellite imagery offers a game-changing scenario in archaeological landscape investigations. Platforms such as Google Earth Engine (GEE) and the Copernicus’ Data and Information Access Services (DIAS) enormously facilitate the handling of Big Earth Data. The latest is a concept that embraces -but is not limited to- the use of massive, complex, heterogeneous and multi-temporal Earth Observation datasets. Nowadays, remote sensing archaeologists have access to planetary-scale satellite constellations and derived products (see Agapiou et al. 2019, Orengo et al. 2020), thus expanding our capabilities to operate with multi-sensor and multi-temporal data at larger spatial and temporal scales, in particular in remote areas with little or almost no background information. Simultaneously, new and more efficient algorithms, coupled with reproducible processing chains and available code, can dramatically reduce the computational costs invested in data acquisition and processing, thus leaving more time and resources for data interpretation and compared studies.

2. Methods and implementation

This paper will present a novel approach that combines into a single, reproducible and exportable workflow 1) the multi-temporal monitoring of agricultural expansion using big data imagery datasets; and 2) the automatic detection of potentially endangered cultural heritage ad archeological sites by recent encroaching with new irrigation developments. Our approach primarily benefits from the optimal temporal and spatial resolution of the free and open-source Sentinel satellite missions, and the performance reliability of multi-spectral indexes for the remote assessment of vegetation phenology and seasonality. We move forward from standard change detection approaches by analysing multi-temporal and cumulative yearly vegetation changes. We use GEE as a cloud-computing platform for rapid access to the latest image data catalogue and effective image processing, but also for importing and integrating external vector files, such as archaeological and heritage data gazeteers and inventories. This has significant implications for the conversion of this approach into a global tool that can be implemented, modified -and improved by both scholars and heritage practitioners.

3. Results and discussion

The algorithm is tested in the fragile archaeological landscape of the Cholistan Desert in Pakistan. The area was core for the development of the Indus Civilisation (c. 3500-1600 BC), and it is home to hundreds of well-preserved mounds. As many other drylands elsewhere, recent developments on irrigation schemes put at severe risk the preservation and visibility of many archaeological locations. The results of the analysis are evaluated and discussed with distinct historical and present-day geospatial datasets that are available for the study area such as the new PlanetScope high-resolution satellite imagery. We finally discuss the opportunities and limitations for the global implementation of the algorithm in the context of new appraisals for data sharing and method reproducibility in remote-based archaeological investigations.

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ID number: 93

The Linked Conservation Data semantic test data set

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Abstract:

A proposed new extension of the CIDOC-CRM allows the creation of statements that specific identifiable instances of a class do not have any instances of another class associated with them, providing the opportunity to record negative evidence. For example, it can be used to record that a particular defensive tower had no windows, or a specific archaeological deposit had no pottery in it. In normal databases these absences would appear as a lack of records linking window-like features to the Tower or no pottery records associated with the deposit. The interpretation of this lack of records is then in the hands of the user: if they subscribe to an Open-World view the absence is just an artifact of incomplete knowledge or if they are less "Open" minded it can be taken as anything from lack of knowledge through to an absence of windows or pottery. The ability of the original practitioner to say, with some degree of certainty, that there were no windows or pottery is lost. In addition, the integration of different data sources from, potentially different schools of recording practice, might generate contradictions or new insights.

The challenge is then how to provide tools that can explore the resulting composite data sets, that vary in granularity, complexity and completeness and seek out the extra insights or contradictions. These tools do not exist and are difficult to develop without data sets to trial them on. However, such data sets are resource intensive to compile and typically consist of a few hand-crafted records and there is a lack of impetuous to create them as there are no tools to exploit them: a chicken and egg problem. This data set provides a large body of rich data that such tools can work on with documented examples of contradictions and extra insights.

ID number: 94

The application of CRMinf to documenting negative conclusions

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Abstract:

The role of the CRMinf argumentation extension of the CIDOC CRM in documenting the inference chains supporting justifiable conclusions is well documented and understood. However, there is less experience with using CRMinf to document the lack of conviction in a conclusion or indeed in refuting a conclusion.

CRMinf allows the documentation of the adoption of beliefs from others on the basis of trust or the assessment of the underlying inference chains (see for example the excavation at Rigny (Buard et al 2018)). It also allows a practitioner to explicitly state that they do not believe in the conclusions made in previous work as well as laying out clearly on what basis such rejection is founded. This ability to refute previous conclusions, whether from others or yourself, also provides a mechanism to demonstrate the range of materials, theories and secondary evidence that have been considered alongside the primary evidence consulted.

The mechanics of implementing such documentation are explained together with examples that show its application to a variety of archaeological situations.

ID number: 95

TEACHING ARCHAEOLOGY TROUGHT DIGITAL GAMES: THE LAST BANQUET IN HERCULANEUM

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Abstract:

"The Last Banquet in Herculaneum" was the first electronic game developed by the Laboratory for Roman Provincial Archaeology (LARP), a thematic laboratory located in the Museum of Archaeology and Ethnology of University of Sao Paulo (MAE/USP) and aims to research the Roman presence in its areas of domination inside and outside the Mediterranean sphere. The processes of cultural transformation in material culture are investigated through analyzes that assess the changes that have occurred in their multiple aspects, in view of the variability of the contexts of societies subjected to imperial power.

The main objective of this presentation is to introduce the game "The Last Banquet in Herculaneum", the methodology applied in your development and the steps that a specialized team of archaeologists followed to get the game done and how this game can be used for playful and unconventional learning.

The methodology applied in this analysis is centered in cyber-achaeology theories, combining Archaeology with a post-human era, in the sense that it is possible to disseminate the results of archaeological studies as didactic-educational resources (Martire, 2017). It also has methods and techniques focused on analysis and virtual excavations of archaeological sites, with the term better known as "Archaeogaming" (Reinhard, 2018).

The game depicts the last day in Herculaneum before the Vesuvius volcano eruption in 79 AD, it delivers diverse elements of material culture present in Roman world and has interactive environments represented on an immersive three-dimensional platform. The player is encouraged to enter and experience diverse common scenarios in Rome, such as: Domus, the Market, the Pottery Workshops, the Warehouse and the Sacred Area. The main objective of the game is spread knowledge about the history of Rome through the playfulness and interactivity presented in the game, engaging users to know Roman coins, their gods, the types of goods that were exchanged, the counting system, among other unique characteristics showed in the game (Fleming, Maria Isabel & Martire, Alex, 2019).

One characteristic is particularly important to highlight: all its development was thought by archaeologists from different areas present in Archaeology. The production and the puzzles that will be solved in each step was thought and developed to provide adequate information about the archaeological context presented in the game, precisely in Herculaneum, 79 AD, at eruption of Vesuvius.

The game is part of an adventure genre, based on point-and-click and produced by Unity engine with a plug-in named "Adventure Creator" to create a 3D world experienced by the player in the game. It was released on October 10, 2018 and featured the mobile version (for iOS and Android), however, the Windows version was also presented and made available for

download. There is no age rating, but your target audience is students of the last years of Elementary School, with age 10 to 14 years old.

Along with the game "The Last Banquet in Herculaneum", a Didactic Guide was released, designed to assist professors in the classroom to use the game as a didact non-convectional way of learning, bringing the educator closer to his students, with the aim of teaching History through different and non-traditional forms (Gregori & Pina, 2018). The guide is divided in six sections, such as: 1. Introduction; 2. The city of Herculaneum: Teaching the history of Rome; 3. Suggested activities from the game scenario's; 4. Lessons plans; 5. Book and website suggestions and 6. Bibliography. It is worth mentioning that the guide is available only in Portuguese.

In 2020 we had the joy to receive a proposal to place "The Last Banquet in Herculaneum" on the school curriculum of the entire municipality of Sao Paulo, which totalize approximately 12 million of people living. The formalities were made and now the students enrolled in last years of Elementary School in the municipality network received the game as suggestion of didactic content.

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ID number: 96

Objectives and Information: Mutual information, composite probabilities, and partitioning of archaeological sets

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Abstract:

The process of partitioning archaeological sets (i.e., inferring unidentified spatial, temporal, or categorical subdivisions) is essentially one of identifying a unique suite of features that will characterize a coherent unit of information. Computational methods for partitioning inherently rely on some form of quantization of those features, but also on the optimization of a previously defined objective function to evaluate the relative coherence (i.e., similarity or dissimilarity) between those features. The choice of methods determines the relationship between the nature of that objective function, derivation of the values to be assessed, and various threshold or tuning parameters. Underpinning all these computational methods is a conceptualization and calculation of the underlying conditional probabilities between concurrent events and the correlated information content of that concurrence.

Partitioning of archaeological data is subject to the further considerations and complications arising from numerous sources of obfuscation. Firstly, the indigenous or emic categories are unknown and quite often themselves the objectives of analysis. That means that the target probability spaces of those partitions are undefined. Secondly, the source or training data are subject to numerous difficulties arising from site formation, post-deposition, and archaeological method transformations. This leads to a degradation of the observable features on which to contextualize and bound that probability space analytically.

We can, however, consider feature sets in terms of coherent nodes of mutual information. An information-theoretic approach proposed by Justeson in 1973 suggested a method for inferring the total information probability space of an undifferentiated assemblage based on calculating an assemblage’s information entropy. That approach demonstrated that archaeological assemblages exhibited well-known power law characteristics when considered from that perspective. Furthermore, we may consider the various data transformations in terms of unknown signal-mitigating effects, such as those described by Bunge in 1963, on the transmission of information. If we consider the archaeological case of site formation processes through the lens of signal degradation, it may be feasible to mitigate the information loss by similar methods.

The fundamental premise of Shannon’s information theory is that the transmission and inherent structure of information can be addressed independently from its meaningful content. In the archaeological case that meaningful content is typically unknown, ill-defined, or obscured. By adapting methods to explore that inherent structure through sets of mutual information, though, we may be able to delineate those meaningful domains by utilizing appropriate proxy measures.

This methodological paper discusses the conceptual interdependence of information, conditional probabilities, and their relationship to objective and distance functions commonly

used in quantitative archaeological analyses. The reliance on common objective functions such as ordinary least squares (OLS) or maximum likelihood estimation (MLE), and the pervasive use of the Euclidean distance function, may or may not be appropriate choices. Instead, we need to take a deeper consideration of the processes that we are trying to model, and the mathematics behind the scenes, before we attempt to adopt more complex and opaque approaches of machine learning.

ID number: 97

Navigating Seaways, Datasets, and Methods: Integrating Environmental and Archaeological Data into an Agent-Based Navigation Model for the Iron Age English Channel.

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Abstract:

This paper reflects on the development of an agent-based model designed to examine Iron Age sailed voyages in the Western English Channel. In particular, this paper describes how an agent-based approach can be designed to integrate high-resolution meteorological, hydrographic, and terrestrial data in order to evaluate interpretations of coastal sites in the late Iron Age. In this context, archaeological interpretation of coastal sites has been heavily influenced by our conceptions of the ocean and its relationship to prehistoric seafarers. Just as theories that consider seaways as dangerous or unpredictable tend to characterise coastal sites as ‘forts’ or ‘refuges’, theories that emphasize seaways’ potential to move people and goods quickly over long distances are more likely to see the same sites as ‘trading posts’ or ‘entrepots’. One of the central questions here – ‘how easy or difficult were these voyages?’ – is difficult to answer by reference to the few documentary sources and excavation reports that mention these coastal sites. Answers to this question cannot be found by consulting only environmental data sources, since voyages can be made easier by – for example – using different types of boat, having different types of knowledge or experience, or by placing seamarks in prominent places along the shore. Equally any attempt to answer the question using purely archaeological data ignores the fact that environmental conditions like strong winds or foul currents can have strong (and sometimes overwhelming) effects on ships caught up in them.

Archaeologists have been creating computational models to describe prehistoric seafaring since before the widespread adoption of GIS-based movement modelling (for example: McGrail 1983). But whereas terrestrial movement models have become common archaeological tools, relatively few movement models have been built to describe seafaring (for a survey of these models, see Slayton 2018). One of the main reasons for this is that seafaring is a complicated process in which highly dynamic environmental factors (such as wind, tide, and swell) combine with cultural factors (ship type and performance, sea knowledge, and navigational skill). To engage with these environmental factors archaeologists have had to find creative ways to incorporate disparate data sources into their models, including: meteorological data from buoys and weather stations, sailing manuals and gazetteers, atmospheric weather models, and hydrographic forecasts. The model described here incorporates environmental and archaeological datasets in a Python script that executes ESRI ArcGIS geoprocessing tools. On the environmental side, this analysis uses European weather forecasts and sea-state forecasts published by the Service Hydrographique et Océanographique de la Marine as multidimensional arrays in addition to digital elevation models from the Shuttle Radar Topography Mission and the General Bathymetric Chart of the Oceans. Archaeological datasets used by the model consist of sets of site / seamark extents based on online databases such as the Atlas of Hillforts of Britain and Ireland, documentary

research, and governmental records. Sea trials from reconstructed ships were consulted in order to develop a set of speed diagrams for Iron Age watercraft, and archaeological surveys were used to select sets of potential landing places along the northern and southern coasts of the Western Channel. Local relief analysis was also used in order to identify a set of ‘prominent places’ that may have been used as seamarks, in order to provide a comparison with a set of archaeologically attested potential seamarks. This model iterates through time-increments to simulate the course of a sailed voyage. At each timestep, the model is designed to estimate (1) local conditions such as current and wind direction/speed, (2) whether any seamarks are visible, and (3) the vessel’s location relative to its intended destination based on the results of the visibility analysis. Based on these estimated results, the model selects the heading that moves the vessel closest to its destination, and then simulates a course along the selected heading using ‘real’ environmental values.

This paper discusses the process of integrating archaeological and environmental data into this model, and presents results from the programme of simulations in support of the author’s D.Phil. research. In order to investigate the placement of coastal sites within the Channel simulations have been performed under different sets of variables in order to determine which most affect the success of voyages. These variables are: starting / ending place, date within study period, type of ship, topographic / archaeological seamarks, and the ability to ‘estimate’ local conditions within the simulation. By simulating these voyages across a wide range of dates and under different variables, I attempt to determine the degree to which these variables affect the success of voyages along particular routes. By designing the model to collect data on seamarks from the visibility analysis, the model can also be used to assess their suitability as seamarks. This project advances the creation of agent-based navigation models by demonstrating how they can be deployed to answer relevant archaeological questions. In the context of the Iron Age English Channel, these questions include: Are coastal sites situated in places that would make them convenient seamarks? Did the Channel Islands serve as a stopping place for ships making the crossing? Is there a landing place on the French coast ‘linked’ to the British entrepot at Hengistbury Head? These are questions that are difficult to address computationally without a model that describes the process of navigation by reference to cultural information and detailed, fully 3D environmental datasets. Agent-based modelling makes it possible to access these datasets (which can be difficult to work into a desktop-GIS workflow) and to treat them as inputs to a navigational process by which a simulated navigator ‘decides’ which course to set.

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ID number: 98

Title

Paradata beyond the field: creating legacy from legacy data

*Ian Johnson (AU)**

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Abstract:

Two specific characteristics of spreadsheets and databases have contributed to a 'dark age' of data modelling and database creation stretching back several decades. 1. the ease of creating a column/field with no documentation other than a cryptic name (encouraged by the legacy of 8 character naming limits and a desire for 'conciseness'); 2. the technical demands for creating rich data structures, resulting in corner-cutting solutions (for example, omission of essential relationships, concatenation of coded values and notes in poorly documented text fields, and multiple data stores with weak cross-referencing).

Reversing such entropic degradation to re-contextualise the database resource, revalue the effort that went into its creation, and build a useful integrated legacy database requires access to paradata which is rarely recorded and/or forensic comparison between the original material (if preserved) and the data.

In this brief paper I will illustrate some of the steps taken in converting legacy data to Heurist on a number of projects, ranging from my PhD field notes to an Access database containing contexts and finds from 100 excavations over a quarter century. Key takeaways are the importance of developing and documenting an understanding of how the data were generated while key personnel are still available to decrypt the process, the need to better document the process of data modelling and data extraction when creating databases, and the need to integrate ALL available information in a single integrated data structure if the resource is to remain useful over the long term.

ID number: 99

Title

Negative placeholders: Knowing when nothing is more significant than something

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Abstract:

Archaeologically, we infer from a lack of information as frequently as we do from materials found and observable measurements of a site. The presence/absence dichotomy is a fundamental premise in archaeological approaches. For instance, the boundaries of a site, the features and qualities of material goods, and context all call for a certain excising of information quickly assessed with a binary yes/no or zero/one that may or (more likely) may not be described.

When and how, though, do we recognize that the lack of “X” is significant? As importantly, how do we recognize the need to keep that information active in the process of analyses? All too often we fail to keep track of the absence of an expected, anticipated, or potential feature of a site or artifact. As a placeholder within our inquiry, the noted element’s lack of presence or expression should ensure that our continued process of interpretation accounts for both what we see and what we do not.

Historically, the invention of zero (as the description of the lack of something) indicates a need for a placeholder, necessitated by some further processual step requiring that place is described. For example, the notation indicating lack of any digit in the 1’s, 10’s, 100’s place et cetera allows mathematical calculations of any further interest. This critical dependence on the recording something of “nothing” is, however, very often overlooked.

Methodologically, we are seeking to explain archaeological phenomena that should, in the end, describe as closely as possible the original use, function, and purpose intended and maintained by the producers. To do so, we need to specify where something is not found as thoroughly as where it is… to indicate and explain why some artifact, some symbol, or some feature appears in one context but not another. To ensure, and to check our methods against, the always-present potential biases necessitating the maintenance of the “place-holding” negatives that should be thoroughly considered (Hales 2005).

In this paper, I present a narrative from my own work (Loughmiller-Cardinal 2018) on archaeological residues relating how finding a pattern of nothing proved to be far more significant than single finds of somethings. In that case, the lack of finding of chemical indicators of chocolate was inconsistent with current interpretations of Classic Mayan cylinders bearing text seemingly stating that the vessel was used to consume chocolate beverages. The finding of no evidence indicated a pattern that triangulated use, purpose, and function of a well-known class of artifacts, leading to a new interpretative framework, and suggested an empirical approach towards behavioral materiality. That “non-find” up-ended longstanding interpretations and decipherments that otherwise would likely have gone unchallenged.

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ID number: 100

Autonomous Archaeological Survey in the Southern Peruvian Andes

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Abstract:

Introduction

Interest in the automated survey of remotely sensed data for archaeological features is rapidly growing. However, before they can be broadly applied to answer archaeological problems, such automation techniques must be proven reliable. The practice of withholding a randomly selected partition of the data for the purposes of model evaluation is standard practice in machine learning workflows, however this practice must be further examined with remotely sensed geographic data. Adjacent image tiles cannot, as would be typical for images in many other machine learning applications, be treated as independent data points. Rather it should be expected that adjacent tiles are spatially autocorrelated, resulting in overconfidence in the model if adjacent or spatially proximate tiles are placed in both the training set and the data sets reserved for model evaluation. This research compares the results of a convolutional neural network model to a random and independent manually coded data set to examine the model's recall and precision. Furthermore, it compares results to existing pedestrian surveys conducted to examine the differences in survey outcomes between automated satellite and field-based survey methods.

In so doing, this research begins to address global disparities in the application of machine learning in archaeology. A 2020 survey of the literature revealed limited archeological applications of machine intelligence in South America and none whatsoever in Peru (Davis 2020). This is especially unfortunate as the large-scale study of settlement patterns in the rugged and high-altitude environment of the Andes is difficult to accomplish through more traditional archaeological means. Previous efforts at harnessing satellite imagery for this purpose have relied entirely on the manual coding of site locations and attributes through the use of citizen scientists or trained teams of professionals (Parcak 2019; Wernke, VanValkenburgh, and Saito 2020). Such efforts require hundreds or thousands of participant/hours to cover substantial areas. Automation of site location and identification would reduce these burdens and allow for fully regional and supraregional studies of settlement pattern and variation.

Methods and materials

Satellite imagery from Digital Globe's WorldView I and WorldView 2 satellite constellations, covering approximately 4000 square kilometers between the cities of Arequipa and Cuzco, was used to conduct a survey for archaeological structures utilizing transfer learning on a CNN with a ResNet-50 backbone. The imagery was split into 76.8x76.8m tiles (256 pixels at 0.3m resolution) and 5,000 tiles were randomly selected to be manually coded for the presence or absence of archaeological structures, (defined as round or rectangular structures, no more than 30m in dimension that appear abandoned and/or appear to lack modern roofing and maintenance). Of the 5,000 tiles, approximately 1% (n=47) yielded examples of archaeological

structures. This data was then augmented with an additional 308 tiles containing archaeological structures to provide the model with sufficient examples of structure presence for training and testing. Initial modelling efforts revealed that modern structures were often confused with archaeological structures, and so an additional 1,183 tiles containing modern structures tagged as negative were further added to the dataset. Removing tiles which fell on the edge of the image and so did not form a complete tile, resulted in a total of 6,428 tagged tiles for model training and testing.

The data were then split into training, validation and testing sets. To avoid spatially proximate tiles being split between the training, validation and testing sets, any tiles within 400m of each other were designated as being a part of the same "locus." The resulting loci were split with 80% of loci put in the training set, 10% in the validation set and 10% in the testing set. All tiles from each site were placed in the same data set. Data augmentation techniques including vertical and horizontal flips, random rotations, and transformation to black/white images were used to increase the size of the data available for training and reduce overfitting.

Results

Initial results of the model are promising, especially when considering the severe class imbalance between tiles containing archaeological structures and tiles without. When compared with the validation set, the model achieved approximately an 88% recall of the features with 82% precision (Selected results shown in figure). Given the nature of archaeological research, false positives are less concerning than false negatives as false positives can be eliminated though more traditional methods in following analysis steps, while false negatives represent missing data. Therefore, the higher recall rate and slightly suppressed precision strikes a reasonable balance.

Nevertheless, further work is necessary. A review of the data suggests that the model frequently confused modern architecture with archaeological structures. This will substantially skew any attempts at using the data for archaeological analyses. Furthermore, the model currently is merely locating the structures, not providing any further information about them. Future steps must include classification of structures into meaningful archaeological components.

Discussion

Initial results demonstrate that convolutional neural networks and satellite imagery are promising tools for archaeological survey in the Andes. High recall rates suggest that most visible archaeological structures in the imagery are being captured by the model, and high precision rates suggest that broad patterning in site location is not the result of false positives. The distribution of these sites is already capable of providing insight into long-term settlement patterns in the region. However, this research presents an initial model. Further modelling efforts such as locus classification, as opposed to merely locus location, will be crucial to examine more important questions such as the relationship between pastoral and agricultural settlements. Furthermore, the expansion of the model to identify other types of archaeological features, such as the Andes’ extensive agricultural terracing, will help to present a more holistic understanding of the region’s economic and social activity. Finally, it must be acknowledged that satellite surveys are only capable of identifying sites with persistent standing architecture. Further comparison to pedestrian survey samples is therefore vital to evaluate and account for the bias that is introduced into our understanding of the archaeological record through remote sensing.

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ID number: 101

The presentation of XRF assay data on 3D objects

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Abstract:

Introduction

The presentation of x-ray fluorescence data (XRF) assays has been restricted to tables or graphical representations, which may be in a 3D format but do not incorporate the actual objects they are from. While in many cases only single assays are taken from an object and so this is not an issue, in objects with variable composition it can hinder interpretations. The presentation of multiple XRF assays on the object they are taken from in 3D enables a new way of presenting the variable compositions of composite objects which aids in their interpretation.

We present a method to display and interpolate assay data on 3D models. However, this method is still hindered by the traditional issues with publishing 3D data. There are many challenges in publishing 3D data which includes first and foremost the inability to translate 3D image into traditional 2D print mediums. Even when 3D file formats are able to be published they are either published as supplemental data, on an external platform, or in a reduced way which limits what is able to be shown. We present the methodology for the creation of interpolated 3D model textures, and discuss the challenges when publishing such data.

Methods, materials, and results

We use the pyvista python package to interpolate assay values where they were recorded on an object. This creates a false color texture of the object that is used to display the differing elemental compositions across the object, and provides a more accessible way to display XRF results. Data can be published either as part of Jupyter notebook with the models and associated XRF assay data, or can be translated into models for other publication mediums such as Sketchfab or 3D PDFs. Displaying all the relevant information such as labels can be difficult in these mediums, and while not desirable, often a hybrid model of 2D and 3D is required where the 3D results are shown as static images. In addition, while we exemplify this method with pXRF data, it could be used to plot and interpolate any numerical data on a 3D model.

We exemplify this method on a Roman bust, supposedly of Publia Fulvia Plautilla (wife of the emperor Caracala, who reigned from 188-217 CE), from a private collection. The results of the portable XRF analysis on the object are presented and show variation in composition across the bust. Visual examination casts some doubt as well and corraborates the pXRF analysis. Given the 3D nature of the object these results are better represented in the 3D medium than it would be otherwise.

ID number: 102

Replication of Results from Village, an Agent-Based Model of Socio-Ecological Dynamics in the North American Southwest

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Abstract:

Recently, archaeologists have developed increasingly realistic agent-based models to explore the dynamics of human socioecological systems. One of the best-known of these is Village, developed as part of the Village Ecodynamics Project and described in a number of publications (e.g., Crabtree et al. 2017; Kohler and Varien 2012). Village uses paleoclimatic and soil data to create a spatially explicit model of maize and wild resource productivity for a portion of the North American Southwest, and it populates the landscape with agents conceived as Ancestral Pueblo households, who farm, hunt, gather wood, and interact on the virtual landscape. Recent iterations of the model (Crabtree et al. 2017) examine warfare, the formation, fusion, and fissioning of territorial groups, and development complex socio-political systems among those groups.

The fine-grained, spatially explicit modeling of productivity is a great strength of Village, but the complexity of the model and the number of agents means that it takes a long time to run. Village also creates voluminous output that is challenging to analyze. This limits the number of parameter combinations and/or the number of iterations of each parameter combination that are practical. Crabtree et al. (2017), for instance, reports results for 36 combinations of parameters, but only 15 runs for each combination. The results are interesting and provocative, and there is no reason to doubt them in general, but some questions remain. Specifically, 1) given the stochastic nature of parts of the model, is 15 runs really enough to characterize the variability in output from a given parameter combination?; and 2) what effect would expanding the range of tested parameters have?

In this paper, I take advantage of the fact that the model code is freely available (at https://github.com/crowcanyon/vep_sim_beyondhooperville) to do additional analysis of model results. My analysis partially replicates and expands on the analyses presented in Crabtree et al. (2017). I explore the effects of smaller and larger values for the maximum size simple groups can have prior to fissioning, and I also replicate some of the specific parameter combinations used by Crabtree et al. These replications include 100 iterations for each parameter combination, to more securely document the range of model outcomes for each parameter setting than is possible with smaller numbers of iterations. This exploration of the Village model enables critical reflection on its strengths and weaknesses, as well as those of similarly complex agent-based models of the socio-ecological dynamics of past societies.

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ID number: 103

Application of machine learning to stone artefact identification

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Abstract:

Introduction

Stone artefacts are a ubiquitous in archaeological contexts world-wide. Their use in making inferences about the human past is wide-ranging from early arguments regarding the antiquity of the people on earth through to contemporary interpretations about the formation of the archaeological record. In a heritage setting, stone artefacts indicate the presence of archaeological remains therefore rapid identification of stone artefacts in comparison to natural lithic clasts is desirable. Conventionally this relies on the ability of observers to identify landmark features, such as flake scars however consistency requires skill, and even if basic knowledge is acquired identification may be difficult due to raw material type or fragmentation of the object. Machine learning offers one solution. Current applications seek to classify artefacts or landscape features. Here we apply machine learning in the context of flaked stone artefact identification seeking first to differentiate natural lithic clasts from flaked stone artefacts and second to differentiate flakes, cores, and tools. We discuss critical issues related to error rate and confidence in identifications.

Methods and materials

We use the NVIDIA Deep Learning GPU Training System (DIGITS) to conduct image classification of stone artefacts. We test this method on three different stone artefact assemblages from the Fayum, Egypt; Ahuahu Great Mercury Island, New Zealand; and Western New South Wales, Australia.

Results

Initial results from the study suggest that a high degree of confidence can be achieved in identifying an artefact versus a natural lithic clast, as well as identifying basic categories of flake, core, and tool. This pilot study also reveals issues related to the generation of samples for machine learning. Stone artefact assemblages routinely contain high numbers of flakes in comparison to tools and cores and this is problematic for training.

Discussion

Potential applications of this technology include a variety of heritage contexts where specialist knowledge of stone artefacts is limited, as are funds for such projects. In addition, this project highlights problems with classification both from an ontological and methodological perspective. Classification of stone artefacts has a long history in archaeology and is often applied uncritically to analyses. Given the weight of human behavioural inference drawn from lithic classification, we suggest these issues warrant more detailed consideration, especially in locations like New Zealand where stone artefact studies are extremely limited.

ID number: 104

Publication of a PhD in 3D: An interactive VR library of Dutch merchant ships

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Abstract:

This presentation describes a 3D presentation of a recently completed a PhD study, wherein key elements of a PhD undertaken in a traditional format have been reworked into a Virtual Reality format, aimed principally at a specialist audience but accessible to all.

The original study explored how technological advances might shift the gaze of maritime archaeologists beyond a long emphasis on individual ships, towards broader trends in vessel use, design and modification over long periods, and made heavy use of 3D scanning, modelling and data analysis. The key inspiration for this study was the rise in 3D photogrammetry for archaeological survey of shipwreck sites over the last decade (McCarthy and Benjamin 2014; McCarthy et al 2020).

As part of this, a substantial data gathering programme captured historic vessel data in a wide variety of formats, from historical manuscripts, diver scans of shipwrecks, and iconographic evidence, all of which were converted into digital spatial assets which could be more easily compared. This process was underpinned by a detailed study of scale and dimensions as practised by contemporary shipwrights. The study focused on seventeenth- and eighteenth-century ocean-going Dutch merchant ships and developed a substantial digital library through diving and scanning fieldwork.

One part of this study involved the creation of a Virtual Reality dive experience, focussing on the experience of diving on a single reconstructed 17th century shipwreck in Iceland (McCarthy and Martin 2020). That experience was non-interactive and was specifically designed to give members of the public a sense of this inaccessible historic shipwreck. This presentation will focus on a second Virtual Reality experience, but one that is interactive and is designed to allow a more specialist user group to examine and experience the PhD data in detail and at their own pace.

At the core of the study is a corpus of scanned contemporary ship models, held in museums across the Netherlands, Belgium, Norway, the UK and the USA. This presentation will describe a Unity-based interactive Virtual Reality experience which allows users to explore the data from the PhD in a virtual environment, exploring the contextual historical data gathered for each digital asset and to experience them at a variety of scales. These outputs complement the traditional form of publication presented in the PhD itself. Issues around content generation, dissemination, archiving and access will be discussed.

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ID number: 105

geoCore - A QGIS plugin to create graphical representations of drillings

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Abstract:

One of the main problems with displaying core data is the individual layout and definition not only through different disciplines but also between institutions or even single researchers. To solve this problem the Lower Saxony Institute for historical Coastal Research and the T-Systems on site services gmbh developed a QGIS-Plugin to provide a very flexible open source tool. The geoCore plugin offers the possibility to display and export drilling data from different sources and different disciplines highly flexible in its spatial context. In order to be able to draw the data, only the spatial data of the boreholes and the data of the individual strata are required. These are given according to a fixed definition. In order to do justice to the use of different signatures, the specific description of the layers can be defined in a yml file and thus adapted. The cores can be displayed individually or as transects with layer grouping. geoCore thus represents a significant improvement in the evaluation and processing options for coring in multidisciplinary projects in QGIS.

https://plugins.qgis.org/plugins/geoCore/

ID number: 106

Critical Digital Archaeology. A postphenomenological approach to AI applications in Archaeology.

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Abstract:

Digital technologies have certainly changed the way we do archaeology. They are not neutral tools but tools that mediate our knowledge of material evidence. In the last years, CAA Conferences have hosted discussions about digital archaeology theory or critical digital archaeology. In the same timeframe, Artificial Intelligence (AI) techniques have been applied in various archaeology fields. This contribution stems from the reflections arising on the sidelines of the ArchAIDE project (www.archaide.eu), which developed AI tools to recognise ceramics. The time has come to discuss the use of AI in archaeology critically, trying to answer questions, among the others, on how technological mediation takes place in archaeology, particularly through AI, and if its effects are disruptive concerning epistemology and hermeneutics. In doing this, postphenomenology and material hermeneutics, as a way for describing the relationship between archaeology and technology, will be taken into consideration, focusing on the relationship between archaeology and digital and, in particular, between archaeology and AI.

Postphenomenology conceptualises the relationship between human being and technology in terms of technological mediation and embodiment. In embodiment relations technology becomes part of our experience of the world. As long as it enters into our body, technology becomes a means of experience, not an object of experience in use. Embodiment is characterised by the paradox between total transparency and omnipotence. A paradox that can also be found in the digital sphere, between the transparency of the infrastructure that allows the use and transformation of information, i.e. the virtuality, and the hardware that needs to be continuously updated as it is never considered adequate, never fast enough. Technologies also have hermeneutical aspects. Postphenomenology defines hermeneutic relations as those through which we extract information and interpret the world through technologies. Since extraction and interpretation mean reading, hermeneutic relations include embodiment. Besides, technologies not only give voice to things, but they also produce new meanings and direct users to specific meanings. In archaeology, hermeneutic relations can be easily shown using technologies related to representing a particular view. For example, the view of a monument as represented by a digital camera can supply different interpretative perspective from the view of the same monument depicted by a hyperspectral camera. These different perspectives reveal an essential aspect of hermeneutic relations: technology is never neutral. Even a simple picture has a specific point of view, underlying assumptions and potential biases. These are intrinsic in any hermeneutic relation.

Scholars like Peter-Paul Verbeek suggest that technologies have intentionality that directs to specific ways of operating or thinking, and more widely, to a particular interpretation, distinguishing it into hybrid intentionality and composite intentionality. Te former refers to human/technology merging rather than interacting, whereas the latter refers to the addition of human and technological artefacts intentionalities. In this second case, intentionality is directed to construct reality and show a novel way of seeing the world instead of representing

a phenomenon. For example, hyperspectral imaging produces a visible image of an archaeological artefact showing molecular bonds that are not visible to the human eye. In composite intentionality, the outcome and the instrument, e.g. the hyperspectral image and the hyperspectral camera, form all together the technology element.

Materiality can be intertwined into hermeneutic relations by splitting the technology element. For example, Heather Wiltse separates it into substrate and trace. The former refers to materiality, the latter the information handled by the former. It is the same separation that exists between hardware and software. Similarly, Liberati, analysing augmented reality technology and its relations with users, distinguishes between technology, i.e. the technological artefact, and object, i.e. the information.

In the digital world, technology supports information to talk. If we consider a big data approach, where algorithms find correlations between data, the focus moves on technologies’ role in generating an interpretation; in other words, on the mediating role of algorithms in perceiving the world. Such digital material hermeneutics emphasises the necessity to comprehend digital technologies’ role in mediating archaeology to assess the view of the past they provide. In today’s archaeology, a new platform or application (as in ArchAIDE) determines new informational structures and may even lead to changes in the content itself. Let us observe this aspect from the digitisation/datafication perspective. Digitisation is the migration of something in digital support. A digitised document (i.e. an archaeological report or an excavation plan) is an heir of the analogue age. Datafication is the transformation of an object or a phenomenon into tabular data that can be analysed through algorithms. This is the same distinction that Lev Manovich envisages between a document (digitisation) and a performance (datafication). The former represents a fixed visual representation that can be accessed identically and repeatedly. The second represents a changing and unstable representation. In the performance, algorithms deliver information and define how it is submitted to the users. Therefore, datafication can perform hermeneutic tasks. By extracting meaning from data, the algorithms perform hermeneutics. Furthermore, the virtual cognitive process is embodied in computational media. In the case of ArchAIDE, it has a digital material hermeneutics coupled with the mobile device’s materiality. AI technology actively mediates the world and possesses technological intentionality; therefore, hermeneutic relations in AI reflect the algorithms’ technological intentionality. Because algorithms distinguish between the algorithm and the data, the technology element should be divided into two also in the case of AI. The algorithm achieves the interpretation and directs the user what to read.

Consequently, AI algorithms have autonomy and intentionality; they require a certain amount of cognition and create a trace in the world. This is a non-anthropocentric shift that embodies the more and more crucial role of AI algorithms. In the AI age, Archaeology’s challenge is to recognise technology as an actor (or maybe as an agent) on whom we depend on extracting meaning and, at the same time, as something that partially reflects our hermeneutics.

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ID number: 107

A southern-route model of modern human migrations to the Japanese Archipelago using GIS approaches

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Abstract:

Introduction

Despite of continuous debates on the earliest human occupation in the Japanese Archipelago prior to 40ka or not, it is remarkable that the number of Upper Palaeolithic sites is substantially rising and rapidly increasing after 40ka. This indicates the immediate expansion in the exploitation of new niche space by Homo sapiens.

Due to the geographical setting of archipelago, Homo sapiens must cross straits in the north- the Sakhalin-Krill-Hokkaido (SKH) Is. to the Palaeo-Honshu (mainland) Is. via Tsugaru Strait, the west- the Korean Peninsula to Palaeo-Honshu Is. via Tsushima Strait or the south- along the Nansei Islands to Palaeo-Honshu. All those islands were never connected as land bridges even during the maximum sea regression period in glacial stages. Therefore, exploring the origin of Upper Paleolithic culture and population in the Japanese Archipelago is critical to understand the modern human dispersal in East Asia.

Traditionally there are three models for migration routes based on lithic technology and tool types. The northern-route model focuses on the typical microblade technology (i.e. Northern Microblade Industry: NMI, Yue et al. 2021). The distribution of NMI covers from the southern Siberia to the Japanese Archipelago. The western-route model focuses on another typical lithic tool type, Tanged Point (TA), which is distributed both in the Korean Peninsula and the western part of Japanese Archipelago (Chang 2013). On the contrary, the southern-route model has long been neglected due to lack of referable lithic type. However, the recent genetic studies suggest the relationship between Southeast Asia and the Japanese Archipelago. Here we use Pebble tool- Axe Complex (PAC) in the Early Upper Palaeolithic (EUP: ca.38~34ka) as the indicator of southern connection.

Conventional studies on human migration into the Japanese Archipelago usually focuses on the comparison of lithic types and their technology found in the Asian continent and the Japanese Archipelago. With the development of digital repository hosting the nationwide archaeological data in Japan, we are able to examine paleolithic sites incorporating spatial data to understand human migration in a comprehensive way. We ask the question: whether we can detect a migration route from the spatial distribution of palaeolithic sites with three different lithic technologies. To answer this question, we employ GIS-based approaches to reevaluate the migration models by analyzing the distribution of paleolithic sites across Japan Archipelago.

Methods and materials

We used data of paleolithic site collected from two online repositries, a) the Japanese Paleolithic site database (JPRA-DB); and b) the Comprehensive Database of Archaeological Site

Report in Japan (SORAN). As of February 2021, there are about 14500 site-wise entries in JPRA-DB and 6137 publication-wise entries in SORAN covering entire Japan. JPRA-DB provides site locations with geocoordinates and summaries of findings, such as lithic tool type, archaeological features, and original references, while SORAN provides publication data and full text of 1583 reports. We also used an additional dataset of C14 dating is obtained from another database managed by the National Museum of Japanese History that includes about 1300 entries of Palaeolithic sites.

We first extracted sites containing focal lithic tool types from attribution-based the JPRA-DB to obtain spatial data and create a distribution map. We combined the spatial data with text-based data from the SORAN to gather more details about sites. We then examined tempo-spatial distribution pattern of focal lithic types, density estimation, and trend-surface analysis on Q-GIS and R. For late Pleistocene (Upper Palaeolithic) conditions, we combined digital terrain elevation model and bathymetry model to reconstruct palaeo-landmass which is partially submerged beneath the sea after the terminal Pleistocene.

Results

The results demonstrate that the distributions of two distinctive focal types, NMI and TA, have similar spatial patterns. NMI shows a strong connection to the northeastern Asia through the Palaeo-SKH Is. and surrounding areas of the Japan Sea corridor. However, the timing of the emergence and dispersal of NMI in the northeastern Asia is 28ka. There is a gap of 1000 years between the earliest migration to the Japanese Archipelago. Thus, NMI could no longer be the indicator of migration route and timing. The distribution of TA within the Japanese Archipelago is particularly distributed in the western rim of the Palaeo-Honshu Is. The recent research at Suyangae site in the Republic of Korea reveals that the emergence of TA is dated back to 42ka, which could be initial dispersal into the Japanese Archipelago. However, current studies suggest that the appearance of TA in the Japanese Archipelago is around 30ka or later. There is still a gap of 1000 years between the first appearance of TA in the Korean Peninsula and the secured date of dispersal into the Japanese Archipelago.

For the EUP-PAC technology, the density estimation shows a concentrated distribution in the central Palaeo-Honshu Is., where is far from any entry points into the archipelago. However, if we consider the techno-morphological distinctions within EUP-PAC technology, different phases of EUP-PAC shows distinct spatial patterns. The early phase of EUP-PAC is distributed in the west rather than the north-east of the Palaeo-Honshu Is., and there are notable assemblages in Kyushu and neighboring Islands. Those results suggest an alternative western- or southern-route, indicating a close relationship with Southern China and Taiwan. According to the reconstruction of palaeo-landmass, a major part of Yellow Sea and the north-western part of East China Sea were possibly traversable and habitable during the presence of EUP-PAC. Therefore, there might be multiple pathways connecting the potential areas for departure and the Japanese Archipelago. In addition, our findings correspond to the most recent genetic studies that reveal a southeastern origin of Jomon, the descendants of the Japanese Upper Palaeolithic population (McColl et al. 2018).

Discussion

Our case study demonstrates a GIS-based approach could give insights into modern human migration to the Japanese Archipelago by incorporating geographic and spatial data. This study also highlights a shift from a comparative cultural history approach on lithic technology and typology to a quantitative analytical approach. Moreover, our approach can be applied to other region with similar geographic context of island setting to understand migration in general.

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ID number: 108

Digital Ecosystems in Archaeological Science: A History and Taxonomy of R packages in Archaeology

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Abstract:

Introduction: The digital ecosystem of a research community is important to understand because it reveals what is possible, what is common, and what unrealised opportunities exist for future work. The recent growth in the use of R in archaeological science is of especial interest because it is a free, open source, and highly extensible programming language that any researcher can contribute to by writing a package and sharing it for others to use. In this presentation we present the results of a study of how archaeologists use R packages, and how archaeologists write them for other researchers to use. We ask: what are the patterns in R package use and production among archaeologists, and what packages are yet to be developed that might satisfy the specific needs of archaeological scientists?

Methods and materials: We have two data sources for this study: (1) a list of packages written by archaeologists, and (2) a list of 150+ scholarly publications that include R code. Both datasets are openly curated at https://github.com/benmarwick/ctv-archaeology To answer our question about how packages are used, we will extract all the packages referenced in the 150+ papers that include R code. We will classify these packages according to keywords in their title to identify the types of packages that are often used by archaeologists, and how they associate with journals and archaeological topics. We will study co-citation patterns to understand what packages tend to be used together, and for what types of data. To answer our question about archaeologists produce packages, we will use our dataset of packages authored by archaeologists and analyse data on dates of first publication, usage data from CRAN downloads and citations, and co-citation patterns. We will also examine software engineering attributes, such as the presence/absence of vignettes, tests, continuous integration, dependencies, etc. to understand how archaeologists adhere to modern package development conventions ,

Results: The analysis is underway and results are not available yet.

Discussion: Our results will be the first empirical study to examine the frequency of R package use for the reported analyses of archaeological data in publications. We will also report on patterns of R package production by archaeologists. We expect that our results will be useful for archaeologists looking to begin using R but feel overwhelmed by the 10,000+ packages currently on CRAN. Our results will show the most commonly used packages, which will guide archaeologists towards packages that will probably be a good choice for their data analysis needs, assuming a strong frequency-based bias in software choice. In looking at how archaeologists product R packages, we will reveal where current effort has been concentrated, and recommend where future effort be directed. We will also report on the best practices currently in use by archaeologists writing R packages, to inspire and motivate future package authors to produce high quality software that will be used and cited by the research community

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ID number: 109

The deep end of the FAIR principles – making legacy GIS documentation from excavations interoperable and reusable

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Abstract:

During the past two decades, Swedish archaeologists have to a large extent been documenting archaeological excavations digitally. A large part of that work has been done using the GIS-based system Intrasis, developed by the Swedish National Heritage Board. Since the data have been produced with the same software, formats and data structure are fairly similar. To allow archaeologists flexibility in how they describe and document excavations, no standards or vocabularies have been imposed for how archaeologists produce data using Intrasis. Consequently, while Intrasis databases in Sweden often have exactly the same schema, the process of archaeological knowledge production may be radically different. As long as each site was considered separately, this had limited impact on the usefulness of the data and, while many archaeologists highlighted the importance of standards, there were no attempts at changing this practice. However, when data from different projects are combined for aggregated regional analysis, the limitations of the flexible approach to describing data becomes apparent. This paper will present some of the work of the Urdar project, which is working on making 3000+ Intrasis databases FAIR, with the purpose of making it possible to reuse the information in research. While the common format of all data makes cross-queries of all data possible in theory, the limitations of the data become clear when attempts are made at interrogating the data with more specific questions from a research perspective, such as understanding settlements and houses. In the presentation, we will demonstrate how we have worked with the data using both scripted methods for extracting relevant information, and also been going back to the original reports of the excavation for making it possible to reuse information and aggregate results.

ID number: 110

Applying automated object detection in archaeological practice: a case study from the southern Netherlands

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Abstract:

Introduction

To cope with the ever-growing set of largely digitally and freely available remotely-sensed data, new strategies to detect archaeological objects within these datasets are needed. The last decade has seen an increase in the development of research strategies that either rely on crowd-sourced and expert-led manual brute force methods or on computational approaches to (semi-)automatically detect archaeological objects in remotely-sensed data (Casana 2020). Recent applications of the former mainly involve the use of citizen science, while within the latter a trend towards Deep Learning Convolutional Neural Networks (CNNs) can be observed (Lambers, Verschoof-van der Vaart, and Bourgeois 2019). Within archaeology, these algorithms have successfully been implemented to detect a wide range of archaeological objects, including barrows, charcoal kilns, and hollow roads (e.g., Verschoof-van der Vaart et al. 2020).

However, these approaches are generally tested in an (ideal) experimental setting, but have not been applied in different contexts or 'in the wild', i.e., incorporated in archaeological prospection, although the latter is the main aim of most research initiatives (Lambers, Verschoof-van der Vaart, and Bourgeois 2019). Furthermore, research has shown that when these approaches are used beyond an ideal experimental setting, the performance decreases (Verschoof-van der Vaart et al. 2020). Therefore, studies 'in the wild' and in different environments are important to investigate the true potential of automated approaches for archaeological practice.

This paper explores the applicability, knowledge discovery—on both a quantitative and qualitative level— and efficiency gain resulting from employing an automated detection tool within (Dutch) archaeological practice.

Method

In this research, the Deep Learning tool WODAN (Workflow for Object Detection of Archaeology in the Netherlands; Verschoof-van der Vaart et al. 2020), developed in one area of the Netherlands (the Veluwe), has been used to detect two classes of archaeology (barrows and Celtic fields) in the Dutch Midden-Limburg area, which differs in archaeological record and research history, topography, geo(morpho)logy, and land-use from the Veluwe. The results of the automated detection were compared to the documented archaeological record and a manual analysis, conducted in the framework of this research, of the same area.

Results

The results show that WODAN was able to detect barrows and Celtic fields in LiDAR data from the Midden-Limburg area, and can therefore generalize to this new situation while being

about eighth times faster than the manual analysis. Many previously unknown potential archaeological objects were detected, including more than 35 potential barrows (an increase of more than 50% of the known burials mounds in the area). While prior to this research only one demarcated area of Celtic field was documented in the region, WODAN detected circa 36 new potential Celtic field areas, thereby greatly increases the coverage and extent of these field systems. This significantly changed our view of the Midden-Limburg landscape in later prehistory, which was previously considered to be lacking Celtic fields due to various reasons. The results facilitated the investigating of trends within the distribution and interrelationship of archaeological objects in the landscape, the emerging of large-scale patterns between different types of objects, and the structuring of the landscape in the past. For instance, the discovered distribution of (potential) barrows in the northern part of the research area seems to indicate a predetermined placement of the barrows in the landscape, and a general concern with movement and visibility. Moreover, the results offered insight into biases within the current archaeological research practice, which has a primary reliance on fieldwalking, resulting in an uneven distribution in both site type and site location.

Discussion

The research showed that WODAN is able to detect archaeological objects although it still has room for improvement, especially when compared to the (expert-led) manual analysis. Based on this difference between human and computer performance, the question arises what level of competence is acceptable from an object detection tool before it can be implemented in archaeological practice. While this is obviously dependent on the (envisioned) users (see Verschoof-van der Vaart et al. 2020), the intended task of the tool and the incorporation of the tool (and its results) within the wider archaeological research framework are also of importance (Lambers, Verschoof-van der Vaart, and Bourgeois 2019). When automated detection is used independently as the sole source of information, high levels of performance are required. Therefore, we argue for combined computer-human strategies, in which automated detection has a complementary, rather than a substitute role, to manual analysis, in which a certain degree of exclusion can be afforded. In these strategies, automated detection can either be used to help target limited manual inspection or is used in conjunction with a manual analysis, to enhance the results, This can offset the inherent biases in manual analysis, based on the expectations, experience, knowledge, and observational abilities of the interpreter(s). Furthermore, it deals with one of the caveats of current automated detection methods in that these tools can only detect objects similar to the pre-defined target class(es) while other objects are ignored (Lambers, Verschoof-van der Vaart, and Bourgeois 2019). Besides, a certain degree of involvement from an archaeological expert is and should remain necessary, in the least to interpret the automated detection results, as the goal of these methods is not to entirely replace the archaeological expert.

Based on this research the incorporation of automated detection in desk-based assessments within archaeological prospection seems beneficial and feasible. Especially when these tools are not used as the sole source of information, but instead are one of the multiple consulted data sources, which form the basis for subsequent fieldwork. The results of automated detection can be regarded as showing highlighted areas of interest—containing potential archaeological objects that require (field) verification—and can be used to enhance and add detail to existing archaeological predictive maps.

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ID number: 111

Using Supervised Machine Learning for Modelling Early Neolithic Survival Probability: a Bayesian Networks approach

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Abstract:

Context

The present study explores the application of supervised machine learning approach to archaeological studies. The goal is the development of a supervised machine learning model based on Bayesian networks with a dual purpose: on the one hand, it will be a predictive model to assess the probability of survival (equivalently, the risk of disappearance) of an early agropastoral community. On the other, the model will allow us to understand the importance and the relationships between factors affecting a subsistence model of early farming (ca. 5500-4500 BC approximately) in the northeast of the Iberian Peninsula. Our work embodies multiple factors relevant to understand social and economic decision making in a prehistoric community, associating archaeological observations with theoretical parameters, and offering new insights into socioeconomic and technological systems of early Neolithic societies.

The paper also offers an innovative account of the very idea of causality. The novel development and implementation of Artificial Intelligence in archaeology have urged the need to re-examine the concept of causality to understand past societies. Causality is a type of ‘bottom-up’ cognitive mechanism to understand the way what we see in the present at the archaeological site was generated by human action in the past. With this aim, the machine learning approach based on Bayesian networks has proved to be a very useful tool to model the relationships (causal or not) between variables affecting the phenomenon we are interested in, in an environment of uncertainty, and to make inferences, even when some data entries are missing.

Main arguments

There is currently a vibrant debate among researchers regarding the nature of causal inference of probabilistic relationships to understand the processes and changes that occurred in the past. Causality can be defined as an event or a condition that is responsible for an action or result, which encodes the invariant elements in the environment and produces visible evidence of this action. Early agropastoral societies just like modern, were complex systems ‘with large networks of components with no central control and simple rules of operation which gave rise to complex collective behaviour, sophisticated information processing, and adaptations via learning and evolution’ (Mitchell 2009, 13). Systems frequently exist in far-from-equilibrium conditions with non-linear interactions which makes it necessary to examine and classify each unit and identify what sort of systems are embedded because of their interactions, instead of considering abstract variables.

The accurate examination of these systems is certainly important for the archaeological interpretation and several statistical methods have been proposed to evaluate the probabilistic relationship among causal conditions. For example, parametric methods (e.g., ANOVA, linear regression tests) have been largely employed with this purpose, despite their assumption of normal distribution among the elements examined. Consequently, it is not feasible to test non-linear relationships or the conjunction of different types of variables typically present in the archaeological record with these methods. To overcome these limitations, other methodologies encompassed in what has become known as machine learning can be and have been used, as the Bayesian networks (see Pearl 2000 for an introduction to this methodology in the context of causality). A Bayesian network can be described as a graphical model of the probabilistic and causal relationships between the variables that affect a phenomenon of interest. We can say that this model is made up of a pair of elements, one of which is a DAG (directed acyclic graph), using nodes representing variables and directed edges entailing the relationships of conditional independence/dependence between the variables, by the Markov Condition. The other element of the pair is the set of parameters of the model, which are the conditional probabilities of any of the variables to its parents in the DAG (the parents of a variable are the source variables of an edge that ends in the variable). There are a few studies in archaeology using this methodology and, although its use is still very little spread, they have proved its suitability in analysing subsistence and socioeconomic systems in past societies (Barceló et al. 2015).

To investigate how survival was possible in early agropastoral societies living in the northeastern Iberian Peninsula, all the relationships between variables defining a Neolithic settlement will be modelled through a Bayesian network to offer a coherent representation of cause-effect relations and (conditional) dependence and independence relations. The aim is offering a probabilistic sound handling of uncertainty in the way archaeological observables can be linked to the social actions and events having caused them. Environmental and natural productivity factors will be considered for modelling subsistence production and consumption while social aspects such as cooperation and labour investment and technological efficiency will also be relevant structures in the system. The ultimate result is the development of a Bayesian network model which will encode probabilistic relationships among variables of interest for the survival of early farming societies and that will contribute towards a better comprehension of the causal relationships (causal or not) between them, and hence can be used to predict potential consequences of different scenarios.

Applications

Bayesian networks offer a wide variety of relevant applications in archaeology. They represent a tool to develop schematic models of the relationships between the relevant variables in complex systems in contexts where randomness plays a role. This represents a step forward into the application of statistical machine learning methods to model the past, as Bayesian networks can be used to develop theoretical frameworks to be used in conjunction with in-silico experimental models such as agent-based modelling. Another relevant input of this methodology is its capacity to deal with incomplete datasets. This is certainly a key feature for the archaeological application. The Bayesian networks will contribute towards a better comprehension of early farming societies and, more broadly, complex systems present in the past.

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ID number: 112

No Dragons Here: recording the absence of archaeological remains during field survey

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Abstract:

One of the more fundamental problems encountered by the authors when designing a CIDOC CRM extension for systematic archaeological field surveying is the seeming inability of an ontology (“a branch of metaphysics that deals with things that exist in the social world”) to handle things that are absent. In the case of systematic field surveys, some part of the surface of the selected landscape or region is investigated to determine the locations and character of any archaeological remains, but the concomitant observation that (within given confidence boundaries) such remains are NOT present is equally important – for both scientific and heritage management reasons. We therefore explicitly record the absence of surface finds in specific spatial units in our geodatabases, but have no ontological concepts to describe this reality. This paper is intended as a contribution to the session discussion about possible solutions to this problem. We also briefly wish to discuss a subsidiary problem that is more directly appropriate to the session abstract, namely, how to handle the provisional nature of any recorded absences of surface archaeology: obviously, a more intensive survey or a resurvey under more favourable visibility circumstances could well result in the recorded presence of archaeological remains.

ID number: 113

IndusVillage. Modelling cropping strategies and climate change in rural settlements of the Indus Civilisation

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Abstract:

We present the Indus Village, an agent-based model addressing the potential diversity of agricultural strategies adopted by rural settlements in different socio-ecological scenarios. This work is part of a multi-disciplinary project focused on untangling the relationship between climate change and the emergence and decline of the Indus Civilisation's urban phase (c. 2500 to 1900 BC), which spanned areas with extraordinarily diverse and variable environments. The abandonment of most Indus urban settlements at the end of this period has been associated with the regional-to-local consequences of the 4.2 ka BP climate change event. Therefore, modelling the socio-ecological mechanisms acting in this makes the Indus Civilisation an opportunity to examine how early complex societies responded to climate change events.

The Indus Village model aims to assess the implications of different food production strategies for the sustainability of the urban population and the resilience of these in the face of changes in the intensity and variability of winter and summer water availability (Petrie and Bates 2017). We are particularly interested in exploring how Indus farmers coped with diverse and changing environments and how climate change could impact regional food production levels required for maintaining urban centres. The model was constructed following a modular philosophy and combines modelling contributions from many fields and methodological backgrounds (e.g., Jones 2007, Zhao et al. 2019).

As suggested by its name, the Indus Village model represents all processes at a local scale (5-10 km2) and a single rural, food-producing settlement (i.e., a village). The model represents (1) a population structured in households with explicit individual-based variables and dynamics, (2) a landscape where weather, soil conditions, and human actions converge into a multi-crop system, and (3) an algorithm representing hypothetical decision-making rules regarding the selection and modification of cropping strategies.

We present the results of various simulation experiments, highlighting the capacity of the Indus Village model to generate insights on the resilience of pre-industrial food production systems to the diversity and variability of environmental conditions and particularly climate change. Specifically, our experiments focus on the interplay between diversity and maximisation of crop yield, and how it relates to environmental scenarios and population size.

Moreover, the potential utility of this model goes beyond the goals of our project. We believe it could serve as a reference or template for the modelling community in history and

archaeology. In this sense, our constant concern is to make all materials related to the Indus Village accessible and reproducible to future generations.

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ID number: 115

GIS-based landform classification of settlements in the Pantelis Valley (Sitia, Crete) to assess water management, from the Classical to the Venetian periods

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Abstract:

Introduction

This paper aims to detail some of the results of the research program, entitled Spatial Dynamics and Settlement Patterns in Eastern Crete from the Classical to the Venetian Period. Begun in December 2018, it is hosted at the Laboratory of Geophysical – Satellite Remote Sensing & Archaeoenvironment of the Institute for Mediterranean Studies - Foundation for Research and Technology, Hellas, in Rethymno. This project aims to highlight the developments of the settlement patterns in Eastern Crete from the Classical to the Venetian period, through an interdisciplinary approach, combining geomorphological, historical and archaeological evidence with fieldwork and the spatial analysis offered by the application of new technologies in archaeological research.

In this paper we will focus on the Sitia area, located on the northern part of far eastern Crete, and specifically on the Pantelis valley, a river flowing towards the north coast. The Pantelis river, its creeks and springs have always been the main water resources in the northern part of the Sitia plain. Its valley covers more or less an area of 60km2 from the inland ancient city and medieval village of Praisos, where the river finds its source, to the coastal city and harbour of Sitia, where the river outfalls.

Historically, the region is far away from administrative centres, major cities, busy harbours and communication networks. A few coastal settlements have been studied and/or excavated (for the Minoan and Hellenistic/Roman periods) but the inland occupation remains unstudied. Furthermore, very few scholars have focused their research on post-Roman (Byzantine and Venetian) Sitia.

The main objective of the research presented here is to understand how and in what way local topography (altitude, access to water resource, to arable lands...) influenced human behaviour in terms of settlements. And among these topographical features, to bring information on the interrelationships between the water resources and the proximity of the settlements.

Methodology

In recent years the development of computers and the increase of their functionalities to various scientific fields lead geoinformatic approaches to provide a powerful tool to decision makers regarding the evaluation of the archaeoenvironment and the management of cultural heritage. In this study, Geographical Information Systems (GIS) techniques will be acknowledged to discriminate the landform types and derive geomorphometric information for the characterization of the landscape. The Topographic Position Index (TPI) landform

classification will be acknowledged producing 10 classes: streams, mid-slope drainages, local ridges, valleys, plains, foot slopes, upper slopes, upland drainages, mid-slope ridges and high ridges (Tagil & Jenness, 2008). The identified landscape features can provide insights regarding their interrelationship with human behavior through time, such as understanding the water management.

In essence we will produce through the Multi-Criteria Decision Analysis (MCDA) procedure a cost surface raster taking into account geomorphological, water permeability and geology, to make visible the areas potentially rich in water resources and the number of settlements that seem to depend on these vital water access zones.

Through these geographical analyses the final goal is to reveal the reasons for the distribution of sites in the hinterland of the Sitia gulf, so as to connect archaeological data to its physical environment. Results highlight the settlement dynamics of the region, for each chronological period, depending on the archaeological data available.

Discussion

There is very little paleo-environmental data available for Crete, resulting in a knowledge gap which makes it difficult to associate them to interpretations made about the factors driving the variations in the settlement distributions, from the Classical to the Venetian period. Nevertheless, the methodology presented here can provide useful spatio-temporal analyses, at district scales, for future studies to examine at local scales, with associated studies of palaeo-environmental conditions or archaeological predictive modelling. In addition, this study offers valuable information for further research, where socio-economic or political factors can be considered for settlement hierarchy assessments.

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ID number: 116

outlineR: An R package to derive outline shapes from (multiple) artefacts on JPEG images

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Abstract:

Geometric morphometric methods (GMM) in archaeology are experiencing a sharp increase in application and popularity since the last decade or so and seem to be more popular now than ever. In general, they constitute a major advance vis-à-vis earlier qualitative descriptions, typological assessment, or linear measurements of artefacts. GMM approaches can be divided into methods that use landmarks, and those that use trigonometric descriptions of whole outlines. The bulk of archaeological applications of GMM have so far relied on landmark-based approaches, although a surge of recent studies is demonstrating the utility of whole-outline approaches using so-called elliptical Fourier analysis (EFA; Kuhl and Giardina 1982) and cognate approaches. Landmark approaches offer a straightforward way of delineating homologous structures, but their application also incurs a significant loss of shape information. In addition, the a priori identification of homologous landmarks on artefacts can be difficult and inherently subjective unless unambiguous theoretical expectations are available. Therefore, outline approaches offer an alternative, robust and information-rich way of capturing artefact shape data. Accurate artefact outlines can also be extracted efficiently from widely available legacy data, especially from artefact line drawings. There currently exist various standalone software applications as well as some R packages for the extraction and analysis of landmarks and whole-outlines. However, the extraction step always involves a considerable amount of manual processing and manual tracking of either the landmarks or whole-outlines, which proves to be the definite bottleneck of many studies.

In this paper we introduce the R package outlineR that allows for a fast and efficient extraction of whole-outlines from multiple artefacts on images, ready to be analysed in the Momocs (Bonhomme et al. 2014) environment. We give insight to the workflow and how it compares to existing methods of whole-outline extraction thus showing the advantages and savings in time when using outlineR for the digitization of large amounts of legacy data, such as artefact photographies or drawings. Finally, we present a case study using a large dataset of Late Neolithic/Early Bronze Age projectile points from Northwestern Europe extracted using the outlineR package to showcase the possibilities of whole-outline GMM regarding the creation of typologies and inference of chronological information.

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ID number: 118

Maritime mobility across the Neolithic seaways of North West Europe

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Abstract:

Maritime mobility has always been central to questions of prehistoric human dispersal, migration, occupation of islands, and exchange and trade in all its forms. Mobility presents itself in various scales, from frequent short-range travel to intermittent and long-distance voyages. Its particularities, however, are difficult to unpick. Movement leaves ephemeral traces in the archaeological record, the identification of which can be made more challenging by depositional and post-depositional processes. What seems clear, however, is that mobility is the nexus of interaction and connectivity, the texture of which, through modelling and digital applications, we have the potential to explore. This paper demonstrates the use of digital tools within an interpretive framework of analysis to generate space-time textures of maritime mobility across the north-western European seaways during the Neolithic.

The dynamics behind the development of the Neolithic in Britain and Ireland has been a topic of debate for over one hundred years. At its heart lie a series of different conceptions as to the nature of connectivity across the seaways of North West Europe (Garrow and Sturt, 2017). Neolithic practices in Britain are evidenced c. 1000 years later than their arrival in north-west France. This delay has at times been explained by seeing the surrounding seaways as a barrier to movement. The material record, however, implies otherwise, with multiple lines of evidence indicating maritime mobility taking place over this period.

Such maritime mobility is explored here at 4000BC in the north-western seaways of Europe. Taking an ensemble approach, we integrate results from sea-level, palaeo-tidal modelling, and navigational variables to generate new perspectives on old problems. We argue that by adopting an open method, and not expecting a definitive result, it is possible to be challenged by the modelling process, forcing a more considered approach to the record as a whole.

Maritime mobility modelling has seen many advances thus far. This is mostly due to the accessibility of datasets, and the proliferation of new software and tools armed by strong processing power and easy-to-manipulate user interfaces. However, while the discussion on space and computational applications in archaeology began engaging with digital and critical cartographic and spatial theories, primarily concerned with mediation, engagement, and experimentation (Gillings et al. 2020), equivalent uptake in maritime mobility studies has been limited. This is primarily due to the challenge of modelling a fluid environment and capturing human practice and experience within its framework. Nonetheless, the ever fluid state of the maritime world and the mobility it gave rise to begs for a multitude of approaches and explorations pushing against the multifaceted humanised perceptions of maritime space.

In this paper, we present a methodology to model maritime space of prehistoric navigation in the north-western European Seaways that builds on our earlier work applied to the Bronze Age eastern Mediterranean (Safadi and Sturt, 2019). The approach incorporates a palaeo-tidal dataset for the time in question, representing the magnitude and direction of surface

currents. Using the location of known Neolithic sites on the coast of Britain and Ireland, a GIS model of maritime travel generates the speed of a paddled boat according to hourly change in tidal currents. This in turns feeds into producing the time of travel per 18 bearings of movement from known coastal sites. Geographic distances are then transformed and distorted to depict navigation time and portray the emergent temporality of maritime space constrained to the model’s input.

The results of this exploratory modelling approach to prehistoric maritime mobility demonstrate the impact of seasonal variation at various tidal cycles, e.g. neap and spring tides, on the temporal accessibility across the seaways of North West Europe. They also begin to pave the way for a more nuanced understanding of maritime Neolithic mobility and the context in which it occurred. Most importantly, the results highlight the challenges in modelling prehistoric maritime mobility and reinforce the need for innovative and multifaceted digital approaches that merge both general and localised maritime textures, and quantitative with qualitative methods.

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ID number: 119

Challenging Students and Teachers with Interdisciplinary Projects

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Abstract:

At Saxion University of Applied Sciences we have been teaching practical archaeology for over 10 years. During this period the number of students starting each year has increased from 7 in the first year of our existence, to more than 160 in 2020-2021. Teaching digital archaeology has always been an integral part of the Bachelor-curriculum. The digital basics are covered within the first two years of the 4 year course. The following years more advanced digital tools were taught, but only for those students that choose the specialization digital archaeology (Visser et al. 2016). In addition, we do expect our students to develop their skills further during assignments or projects. Recently, we have revolutionary changed our educational model, moving away from traditional single small courses (3 ECTS) teaching practical skills by exercises and class room examples towards a more holistic and integrated approach that teaches (digital) skills and knowledge in real world projects.

Last CAA in Krakow I have discussed the first results and the experiences for both teachers and students. We have seen that Project Based Learning (PBL) encourages the integration of skills and knowledge and increases the understanding thereof by the students. Teachers have also gained a lot of experience and knowledge from PBL. During the first two years of our four year Bachelor our students learn about practical archaeology. In their third and fourth year students can choose to do four semesters in any chosen order: Internship, Minor, Smart Solutions Semester and an individual BSc thesis/project.

In this presentation I would like to present our experience with our interdisciplinary PBL semester. The majority of the various studies at Saxion participate in this so called Smart Solutions Semester (SSS: https://www.saxion.edu/business-and-research/collaborate-with-saxion/smart-solutions). During a semester 6-8 students from at least three different study-programs work together on a real world problem for a real client. The aim of SSS is that students find an innovative solution to the problem, while learning from each others experience and background. This leads to students from Archaeology cooperating with students from for example Gaming, Tourism, Chemistry, Forensics or Nursing. The tutor of each group can have a background from any of the study programs participating in SSS. This leads to various challenges, such as comparing research methods or approaches, working with a client and different people. This year the Covid-19 situation presented some extra challenges and possibilities. The common language during SSS is English, because of international students participating. Online cooperation due to Covid-19 made it even possible for students stuck abroad to participate in the group work. The use of the English language improves the students’ English, because they are generally taught in Dutch. In addition, each discipline had his own jargon and working together makes students aware of this. This includes the tutor, because (s)he is also learning from the experiences and disciplines. This paper will address various of these challenges, but also show the successes of different projects. It is amazing what wonderful innovative ideas can come from people that had never worked together and had sometimes never even heard of each other discipline!

ID number: 120

3D Restores the Lost — Application of 3D Digital Restoration in Taiwan Archaeology

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Abstract:

Based on the colored POINT CLOUD capture technology, the archaeological unearthed relics are 3D-digitized with considerably high precision and resolution and then used as the basic data for the overall application. In the part of 3D modeling, the point cloud data is extracted by the 3D scanners and used for alignment. After confirming the accuracy and completeness of the data, the 3D model is built and finely edited at the final steps. The high-precision 3D model of the cultural relics is completed with at least 5 million points of point cloud data on a surface area of $150cm^2$.

Most of the relics from archaeological excavations have been damaged during the burial process. The traditional method of repair is mainly to use gypsum to fill the broken or missing parts. 3D digital repair provides a faster and more convenient way. Compared to the traditional methods, it reduces the EMIC impact of the restorers. Through the high-precision 3D model of the artifact for copying, flipping, aligning, repairing, etc., it can complete the damage repair, merging, restoration of the pieces, and trimming of the ornament. Last but not least, the missing or broken parts outputted by the 3D printer can be closely attached to the original artifacts. Since it is capable of virtual restoration and integrating the real objects, it surely can output a complete artifact as well.

The prehistoric artifacts are fragile and precious. By the use of 3D technology for digital restoration, the original appearance of the cultural relics can be restored not only for all the people to view without restriction but also for the researchers to study without being constrained by space and time, so the preservation and maintenance of cultural assets can be promoted more effectively by means of that.

ID number: 121

Exploring visual signalling networks of Medieval strongholds in Garhwal Himalaya, India

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Abstract:

Hundreds of strongholds are dotted throughout Garhwal Himalaya, Uttarakhand, India, occupying elevated positions on ridges and mountain tops in the Central Himalayan region. It is generally assumed that the fortification phenomenon in Garhwal has its origins following the downfall of the Katyuri dynasty around the 11th century and continued up to the 15th century AD when one of the rulers of the parmar dynasty Ajaypal, consolidated the entire region of garhwal (Dabral 1994: 79).

In a recently published paper (Rawat et al. 2021) we show that new survey data allows for more complex theories about the fortification phenomenon in Garhwal Himalaya to be addressed for the first time, and we will focus in particular on theories concerning visual signalling: the use of fire, smoke or light for communicating between Medieval strongholds in this Himalayan region. Do sets of strongholds form communities of small local-scale communication networks and can these be identified as small administrative units or independent chiefdoms? Can an integrated visual signalling network have existed to allow for efficient communication throughout the entirely of Garhwal Himalaya? Do those sites interpreted as major forts play an important role in this network as hubs or mediators?

We formally represent and explore these theories using geographical information science (GIS) and network science. Our computational method consists of five steps: (1) we create a range of line-of-sight networks in GIS with differing maximum viewing distances (Floriani et al. 1994); (2) the structure of these networks and the role of individual strongholds is studied using exploratory network science techniques (degree, betweenness, density, isolates, components); (3) the sensitivity of these results to the possible non-contemporaneity of many forts is statistically evaluated (Costenbader and Valente 2003; Peeples 2017); (4) we count network configurations representing theorised visual signalling patterns (Brughmans et al. 2014); and (5) we explore these counts’ significance using Bernoulli random graph simulation (Brughmans and Brandes 2017).

Our results show that much of the region excluding the westernmost part could have functioned as an integrated visual signalling network, and that crucial clusters of short-distance visual signalling networks exist in the border regions in the directions from which enemy invasions into the region have been historically documented.

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From Major Tom to Ground Control and back again: an almost circular argument

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Abstract:

In its beginnings, the Western Scotland Megalithic Landscape Project, used traditional viewsheds created using GRASS and ArcView to answer questions about the scenes surrounding megalithic monuments and to clarify whether or not monuments of a certain class had the same or various views, linked to direction but also to other viewing qualities, such as views towards the sea. These viewsheds created maps of areas as viewed from a location above the earth - a ‘space station’ perspective and we used the data of such viewsheds to test specific hypotheses. We also used ascii data of the viewsheds to determine whether or not other monument locations fell within the viewsheds of each of these monuments. Finally, in relation to a monument axis orientation, we determined if there were any monuments located along these orientations between each monument and its visible horizon, whether or not the monuments could be seen. The data was also used to determine the probabilities of the outcomes.

Whilst such innovative spatial analyses situated within this ‘God’s-Eye’ framework have given us significant insights into the past, the model assumes that all agents in it, have complete spatial information. That is, they can ‘see’ everything around them, there are no restrictions on shared information and the decisions they make are not limited by their immediate frame of reference. In this sense, then, they do not correspond to real-life realities or visual experiences. And this limits us as archaeologists if we are querying how the visual world around a particular set of people, or even individuals, was seen or how it affected them.

In order to create models that more closely mimicked such real visual experiences, then, it was determined that individual immersion-type models were likely more applicable. The use of such models meant that we could not only more readily discover what people saw, but also, perhaps, gain some understanding of what might be significant within this visual landscape, for specific groups of people, from specific locations. Therefore, we argued that megaliths were grounded landmarks for people in the past, and that they embodied information about the landscape as these people saw it. In this way, then, megaliths, like standing stones, can be proxies for a single point of view as well as the constructed physical embodiment of collective information, and the use of such monuments can be termed the ‘landmark’ perspective and is comparable to a ‘fixed frame of reference’ (Kitchin and Blades 2002).

Such theoretical assumptions allowed us to apply 3D GIS reconstructions based upon agent-based modeling as investigative aids for examining and testing archaeological problems. This ‘permit(ted) not only reconstruction, but also deconstruction and alternative interpretations’ (Hermon 2008, 42) rather than just outputs which ‘illustrat(ed) knowledge already gained once serious scientific investigations had been concluded’ (Forte 2008, 22). Thus we see visual geospatial applications as tools for investigating archaeological problems not just as illustrative images: for us ’there is no doubt that a 3D model, be it of a landscape or of a monument, can add information and thus insight to what we already know, at least if the model is correctly built’ (Forte 2008, 22).

Having worked with tools that make 3D GIS reconstructions, we now find ourselves needing to return to a satellite perspective for reasons connected to extended project goals and methodological expansion. We present two approaches that we have begun to work with in our current project. For the first approach, our satellite perspective is assisted by the recent development of a useful visualization tool that itself is based upon using the output capacities of Horizon. This tool creates detailed visual perspectives that can be layered upon one another as well as onto satellite images of the landscape to discover more about the visual worlds that past people inhabited, as indicated from the purview of the monuments. Specifically, it produces ‘God’s-Eye’ viewsheds using LiDAR elevation data from government sources in Galicia and Britain, which is first converted to use in Horizon. Then horizon data (distance and elevation) is extracted using the software Horizon, where the visible horizon is calculated according to variables such as human vision capabilities and atmospheric conditions etcetera. This elevation data is far more detailed and accurate than that we had access to at the beginning of the project. One of the advantages of these viewsheds is that they only create a very thin border of the viewshed instead of ‘filling in colour’, opaque or otherwise, and covering the topography contained within viewshed. (Figure)

Using these viewsheds, the final composite images created by our new ‘basic’ visual tool provides informative answers to the following types of enquiries: exactly which parts across the landscapes do the viewsheds fall; across which topographical features do the viewsheds fall, where precisely do the viewsheds of different monuments overlap in the landscape and which landscape features or monuments do they visually share. The advantages these have over the software Horizon is that we can see more clearly which landscape forms exist within the viewshed as well as those encountered along the orientation of the axes of a monument or between monuments, but which do not actually form the horizon of the first site. Relevantly to our work, astronomical paths connected to the dates of monument construction can also be added disclosing which topographic or water features maybe connected to astronomical phenomena Further developments to be included are the examination of such viewsheds layered onto remote sensing images containing palaeo-channels as well as topographic predictive path models across all of western Scotland and Galicia. This will assist in revealing the reasons behind monument location and the place(s) they played in the lives and cosmology of past communities. Where cosmology is the greater belief system that explains the reasons behind a community’s existence and its place in the Universe at large as well as its place within those worlds of shared cultural traditions.

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ID number: 125

Technologies and archaeological site inscription (knowledge claim) mutation

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Abstract:

The popular perception of discipline is unmistakably still influenced by Indiana Jones. If we remade it in contemporary time how would he look? In this ‘technology meets archaeology’ era. Probably Indiana Jones meets the iron man (of course without the suit). So he would not just a rogue adventurer but will be a geeky guy with technologies. However, both Indiana Jones (past, contemporary) are romanticised. Does that mean there is no truth about the role that technologies are playing in the field of Archaeology? Probably truth relies somewhere in-middle. Where does the truth lie? How far and how effectively do technologies contribute to archaeological claims? Do the knowledge claims proclaimed by the technology are true? Do they enable mutations in knowledge claims or it’s oversimplified notion?

Query and methodology:

In this backdrop, present paper looks into the technologies based archaeological site exploration project. Paper enquires into the possibility when technology/ies act as enablers of a notable shift in the knowledge claim. Paper adopts a reflexive observation through Actor-Network perspective on the process of knowledge claim generation to answer the research enquiry. The present paper is part of an ongoing PhD research work focused on exploring mutations in existing archaeological knowledge claims (Site inscriptions) when technology as an actor is recruited into the actor-network . Researchers engage themselves to plan and apply a four-set of multi-disciplinary technologies - satellite analysis, Lidar, geophysical explorations, simulation with specific objectives intended to compare archaeological claims of the past excavation activities at Śṛiṅgaverapura. The careful documentation of the process flow of each intervention serves as an observation ground for the present paper.

Site:

Śṛiṅgaverapura is a village on the left bank of River Ganga, Allahabad (district), Uttar Pradesh, India. The excavation was carried from 1977 – 78 to 1985 – 86 for nine consecutive seasons. On Mound 4 (SVP – 4), around 230-meter-long interconnected backed-brick constructions were excavated and interpreted to be an interconnected ‘Flood Water Harvesting and storage system’ from 100 BC.

Observation & Discussion: Technology was engaged in four interventions. Three relating to tank and one to identify the possible extent of the site by identifying surface subsurface anomalies. Faced challenges are briefed below for each intervention; implications mentioned further.

a. Satellite image analysis

Site being an alluvial plane with least elevation variance made SRTM-DEM useless. As SRTM’s data did not align with the need of the project the DEM became a secluded and obsolete actor.

However, other data sets and analysis tools aligned well - captured tools, type of data, analysis soft-wares, output formats with objective leading to the mutation in acknowledge claim regarding site expanse.

b. Lidar

Lidar was used for two purpose –visual documentation and to explore the possibility of extracting 3D details on the structure for simulation. Though it met first intention; the second one failed due to incompatible data formats. Thus did not impact existing knowledge claim.

c. Geophysical technologies

Geophysical exploration was intended to explore the possibility of the hereto unknown structural members of the tank system from its unexcavated portions. Initially, GPR was used but was not successful due to brick pebbles scatter ground coupled with an uneven surface. Request to level the surface for an extent of 2-to-3 inches failed due to conservation policy. Along, the think alluvial deposit depth of 8 metres was difficult to penetrate with the GPR equipment making these findings obsolete. Then a set of surveys - Micro-gravity, magnetic gradiometer, very low frequency were executed. A total of ~330 data points were measured to delineate the subsurface continuity of the unknown buried walls of the tanks. Because of the site surface variations levelling the magnetic gradiometer equipment’s was difficult and in certain cases were excluded. However, Micro-gravity analysis results seem to guide the exploration towards a new understanding of the tank structure. Further analysis is in process.

d. Simulation

The Tank system 3D was created using measurements by the excavation report and from our measurements from the site. As simulation needed a 3D virtual structure with two spatial volumes (positive volume – Tank structure; Negative volume – water flow space) tank 3D was constructed using solid works. We did not find a previous reference in archaeology about such past hydrological structure simulation we simulated the tank function in ANSYS with different flow rates reiteratively. As we changed flow rates fine-tuning of meshwork needed a high computing system. Though the facility was compatible and reduced errors; the organizational policy regarding HPC users queuing did not contribute any way in reducing simulation time.

Implications:

Through our engagement, we have observed that the use of technologies in archaeological activities doesn’t ensure the mutation in site inscriptions. That doesn’t imply that they don’t have potential to mutate the knowledge claims. It depends on their degree of interactions and negotiations in the actor-network. The possibility to enable mutation depends on their specific characteristic facilitating alignment with other technologies and objectives otherwise fail to mutate the site inscriptions (though they perform). To enhance their effectiveness, they need to,

- record and process large amount of data with minimal computational power and time
- be built to facilitate collaboration and corroboration among multiple technologies failing which it becomes obsolete
- be enabled to store data at each processing level making it possible to revisit and realign as and when needed

- flexible to adapt to site terrain
- be considerate about needs of newly excavating, excavated, as well as sites guarded by conservation policies

Technologies are effective to the extent they are made to (a) in their production; (b) in their usage (c) in the disciplinary practice (d) in the interpretation of their results.

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ID number: 126

Three Approaches to the Sharing and Re-use of Survey Data

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Abstract:

In the Mediterranean theater, fieldwalking surveys are the main source of large-area archaeological distribution data. Projects such as MAGIS and its successor, FASTI Online Survey (http://www.fastionline.org/survey/), attempt to make individual survey projects, of which there are hundreds if not thousands, findable and, in some cases, their data accessible. However, the vast majority of survey data is not available for re-use because it has either never been deposited in a digital repository, or has not been sufficiently documented to allow re-use to take place. This poster presents the authors' ongoing efforts to explore three approaches to the rescue of legacy survey data and the creation of standards for future survey data, with the aim of making these data suitable for online sharing and analysis:

- semantic description using the CIDOC CRM standard;

- 'opportunistic' merging of datasets by mapping to a shared vocabulary;

- standardisation of field and lab documentation protocols.

ID number: 127

What‘s in store? Normalized Artifact Databases from 3D-Acquisition Campaigns

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Abstract:

Pottery, clay tablets, sealings, architectural remains and many other important small and often fragmented findings are increasingly captured as 3D-models using Structure from Motion (SfM) or Structured Light Scanning (SLS). Both technologies have advanced in accuracy while entry level costs have decreased. With the renaissance of artificial intelligence due to the success of Convolutional Neural Networks in raster image data like used in LiDAR analysis, we began to investigate the new frontiers of Geometric deep learning posing numerous challenges in adapting Convolutional Neural Networks as well as feature detectors [1]. Another challenge for developing methods in deep learning for geometry data is the sparse availability of datasets for benchmarking and training. 3D-mesh data is rarely available for archaeological findings. Even if it exists in thousands at heritage organizations, which lack any Open Access dissemination [2] or use exotic file formats, low resolution and/or licenses prevent their use and re-use like well-known commercial platforms for 3D-datasets. There are scientific databases e.g. for vessel shapes [3] implementing FAIR principles and Creative Commons licenses. However, there is a tendency to withhold full/high-resolution datasets and the use of strict attributes like Non-Commercial, which can be hindering for reasonable activities e.g. use within Wikipedia or other semi-commercial Open Access offerings like OA publications with print-on-demand.

Therefore, in past work, we began experimenting with the publication of 3D-datasets in 2015 with a small batch of 3D-scanned sealings of the Heidelberg Universities founding documents, which were kindly provided by the Heidelberg Universities archive for this purpose. Together with the Heidelberg Universities Library we identified, (i) the HeiDATA dataverse as the most versatile publication channel, (ii) the Stanford Polygon (PLY) file format, with its open specification and de-facto standard for 3D-measurement data, as most portable, (iii) accompanying high-resolution renderings of the 3D-data as Portable Network Graphics (PNG) images, enables a quick inspection of the data without the need of a 3D-viewer, and (iv) the CC-BY(-SA) license for easy dissemination. Furthermore, HeiDATA holds and provides Meta-Data for other library services enabling an automated dissemination on the European level. Each of the sealings also received a Digital Object Identifier (DOI) making the datasets quotable and their links persistent. These very first 3D-dataset publications have proven useful for a number of small tasks, e.g. linking with Wikipedia as well as within traditional publications. Additionally, some of the sealings have been used for visualization and 3D-printing in public relations.

Currently, in 2018 the Hilprecht Collection of the University Jena released almost 2.000 cuneiform tablets acquired with high-resolution SLS as the Hilprecht Archive Online (HAO) using the CC-BY license (https://hilprecht.mpiwg-berlin.mpg.de). This is a data treasure trove, as these tablets contain large amounts of texts using a Script in 3D, providing additional to challenges to methods of analysis like classification of shapes, damaged surfaces, sealings, iconography of decorations, etc. As the HAO Website features very basic access on an per-

object basis to the 3D-data, with images already gone missing, we decided to scrape the 3D-models to be remixed as benchmark and training dataset for machine learning. This task quickly become time-consuming in human labor and computing time, because the 3D-models were not orientated script to front, preventing an automated rendering of the common side-view images known as fat-cross. The meshes itself had some defects causing visual artifacts for high-contrast rendering of the Script in 3D based on the Multi-Scale Integral Invariant (MSII) filtering of our GigaMesh software framework (https://gigamesh.eu).

We adapted the digital workflow with GigaMesh introducing highly automated commands performing cleaning tasks, MSII filtering, rendering high-contrast fat-crosses and re-coloring the meshes. Solely the orientation of the tablets had to be performed manually. This step is performed within seconds on an optimized keyboard layout, done together with an obligatory check of the datasets by a human, as some mesh defects, e.g. wrongly filled holes, are not easy to be determined by an algorithm. For the fat-crosses it was also key to use the same coloring throughout the whole collection using a uniform resolution in (dots per inch) DPI. There are two types of fat-cross renderings: (i) with virtual light to enable compatibility for e.g. transfer learning from photographs and (ii) high-contrast MSII filter based renderings for learning tasks on images with a maximum of details. Furthermore, the 3D-data with the vertex based feature vectors representing Gaussian and mean curvature for scales from 0.1 to 1.5 mm are provided to be used for (future) Neural Networks capable of handling the irregular mesh data in 3D. This dataset was published in HeiDATA as Heidelberg Cuneiform Benchmark Dataset for the Hilprecht Collection (HeiCuBeDa Hilprecht, https://doi.org/10.11588/data%2FIE8CCN) consisting of a small number of large ZIP archives. Additionally, we compiled a smaller database using a mixture of rendering with virtual light and MSII filtering achieving a representation useful for traditional scholarly autopsy of the tablets. This alternate dataset was published in HeidICON as Heidelberg Cuneiform 3D Database - Hilprecht Collection (HeiCu3Da Hilprecht, https://doi.org/10.11588/heidicon.hilprecht) providing a search interface and other browser-based tools useful in humanities research.

Additional meta-data, photographs and retro-digitized line drawings were added for approximately 1/3 of the tablets within the HeiCuBeDa from the Cuneiform Digital Library Initiative (CDLI, https://cdli.ucla.edu). These contain information about e.g. time-period, language, type of document, sealings. Most importantly 707 tablets have a transliteration with line numbers. This makes tablets weakly annotated, which will be transformed in future work into a more proper labeling by matching the transliterations as well as the retro-digitized line drawings for the given lines. Within our presentation we sketch the new and highly automated workflow to compile normalized images and clean mesh data. Furthermore, we will discuss the different means of publication, by dataverse and image database, including the considerations for license choices and meta-data mapping. This was done in respecting the needs of different user groups, making this data treasure as easily accessible and usable for research in humanities and computer science alike. An outlook for a related project in pottery fragments, excavated and 3D-acquired by the DAI Bonn in Honduras, will be given.

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ID number: 128

Prospecting archaeological archives in South Africa through hyperspectral image processing and field spectroscopy

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Abstract:

South Africa and the province KwaZulu-Natal play an important role in prehistory of Homo sapiens. Modern human archaeological record of the Middle Stone Age (MSA) and Later Stone Age (LSA) is known to be exceptionally rich and detailed in rock shelters, although the total number of sites is very low. While open sites are abundant in Southern Africa, the stable and old surfaces (African surface and Post-African I) bear little contextual information and render dating difficult. This is not the case for the Late Pleistocene Masotcheni Formation, which covers the area from the Drakensberg Mountains in southern KwaZulu-Natal, through the Free State Province and into Eswatini. The colluvial deposits accreted at the footslopes of mountain ranges during multiple phases throughout the Late Pleistocene and are interbedded with layers of buried soils. This gives not only a valuable insight into the geomorphic history of the region and cyclical climate changes, but makes this formation also a well-datable archaeological archive populated with MSA/LSA artifacts.

We present a method to map this landscape feature through hyperspectral remote sensing and digital landscape analysis. Therefore, we sampled the spectral properties of local surface and soil profile materials in situ through field spectroscopy (250-2500 nm wavelength), yielding high resolution reflectance curves that give insight to their physio-chemical properties. Thereupon we developed spectral indices, which enable the discrimination of different surface types and applied these to VIS, Near Infrared (NIR) and Shortwave Infrared (SWIR) reflectance bands of WorldView-3 to map the formation based on its specific spectral properties. Finally, we demonstrate how we used UAV and historical aerial imagery to estimate the age and erosion rates of soil degradation affecting the Masotcheni today, thereby affecting not only the archaeological archives but also the livelihood of the modern population.

ID number: 129

Estimating the Age and Sex Composition of Zooarchaeological Assemblages with Bayesian Mixture Models

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Abstract:

Introduction

An animal’s sex and age play central roles in determining its body size and behaviors, affecting its desirability under different hunting and herding strategies and thus the likelihood to be incorporated into faunal assemblages produced by these human activities. Reconstructing the age and sex composition of a faunal assemblage is thus central to interpreting past human-animal interactions. This task is made difficult by the disaggregated nature of zooarchaeological remains; fully articulated remains are rare, making it difficult to relate elements that are morphologically distinct between sexes to more common elements. Biometric variation in faunal remains is typically used to separate sexes across a variety of postcranial elements, as most relevant taxa exhibit sexual dimorphism; mixture models represent an improved method for identifying sex probabilistically compared to earlier, threshold-based methods (Monchot and Lechelle 2002).

The methodological improvements of mixture modeling are limited, however, by overfitting and an inability to restrain algorithmic results to biologically relevant values. These issues are exacerbated by the typically small sample sizes of faunal assemblages; the use of size indices can alleviate this problem somewhat, but introduces other complications due to allometric scaling. Biometric models are further limited by the inclusion of immature animals in the assemblage, which are animals that died before reaching adult body size but are included in the measurement assemblage because they are unfused specimens or on specimens that exhibit post-fusion growth. To fully address these limitations of mixture model algorithms, we need methods that can build on the vast amount of prior knowledge about animal biometry and variability within populations.

This paper presents a Bayesian multilevel mixture model for reconstructing the age and sex structure of an animal bone measurement assemblage. Prior distributions of relevant biometric parameters (e.g., size difference between males and females, standard deviations of immature, adult females, and adult males) are derived from a known-age, known-sex population of Shetland sheep (Popkin, et al. 2012). The model’s multilevel structure allows it to fit mixture models for different measurement types separately, rather than aggregating all measurements together, taking advantage of partial pooling to improve element-specific parameter estimates (Wolfhagen 2020). Further, the mixture model takes advantage of relevant demographic information (fusion and morphological sex data) that provides additional information about the overall demographic parameters of the assemblage.

Methods/materials

To test the effectiveness of the Bayesian multilevel mixture model, a series of simulated assemblages derived from the Popkin, et al. (2012) are modeled. The simulated assemblages

are constructed to vary in underlying demographic information (proportion of immature, adult female, and adult male animals) and have their overall biometric values manipulated to show how the model performs for identifying gross biometric differences between assemblages. Simulation of the assemblages is performed in R, while Bayesian inference is performed using Stan.

Accuracy of the model is evaluated in two ways: at the level of model parameters and individual specimens. First, credible intervals for posterior distributions of assemblage-level and assemblage + element-level parameter estimates are evaluated against true values. Next, the accuracy of the models is evaluated by evaluating the average membership probability of the specimens and simulating the age and sex composition of the assemblage. The true composition of immature, adult female, and adult male specimens in the assemblage is accurately estimated by the mixture model assemblage (i.e., true values are within the 95% confidence intervals for every group- and measurement-specific estimate). These cannot be directly compared to previous analyses of mixture modeling, which estimated a misclassification rate purely from parameter values (Monchot and Lechelle 2002). The accuracy rates compare favorably to element-specific discriminant function analyses, though, Popkin, et al. (2012: Table 13) show overall accuracy rates ranging from 80-95% for elements included in this analysis. However, their analysis (1) did not focus on a sample and instead reported cross-validation rates, and (2) only used fused specimens, while this analysis included fusing and unfused specimens. Thus this method extends the utility of classification methods without sacrificing the ability to accurately describe the composition of assemblages.

Discussion

The Bayesian multilevel mixture model uses Bayesian inference to improve our methods for reconstructing the age and sex composition and biometry of zooarchaeological assemblages. This improvement allows not only for more refined examination of sex-specific harvesting profiles and inter-site trends in biometric values, but also provides a direct way to test hypotheses by using the posterior distributions of the model parameters. Within an assemblage, the model results can inform simulations of sex-specific diets through stable isotopic analyses or explore sex differences in the representation of animals deposited in different parts of a site.

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Intersite analysis based on intrasite contexts in the museum database

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Abstract:

Intersite analysis based on intrasite contexts in the museum database

This paper will highlight the potential of 3D analysis of the distribution of finds from Stone Age excavations in South-East Norway. The material used in the analysis is from excavations around the Oslo fjord and registered in the UniMus database and the ADED infrastructure. These form together a national infrastructure created through a cooperation among the Norwegian university museums.

The Museum of Cultural History, University of Oslo started to use the UniMus database for all artefact cataloguing in 2006. The database has more than 800 000 entries (as of January 2021), and the major part of these are consecutively published online at unimus.no for free access. A selected subset of the metadata can be downloaded and can be used freely.

The ADED infrastructure is a collection of detailed excavation documentation from Norway. The university museums decided in 2011 to use the same program for excavation documentation – Intrasis, and this was a good starting point for making all excavation documentation freely available at one web site.

The Museum of Cultural History is in charge of prehistoric rescue excavations in the ten counties in East and South Norway, and over the last decade a large number of Stone Age sites has been excavated due to motorway and railroad constructions. The large-scale projects have yielded a series of separate publications, all of them also published online at duo.uio.no, together with all other excavation reports from minor smaller projects.

The general methodology at Stone Age excavations at the Museum of Cultural History is to dig in 10 cm spits in a 100 cm grid, and register the finds within 50 × 50 cm squares. This will naturally limit the possible scale levels of analysis, but at the same time opens a possibility to analyse the material as voxels rather than two-dimensional squares. The fact that principally the same methodology has been used for a large number of sites, creates a basis for inter-site analysis.

The database has the essential information of both artefact description and context registration. This is the reason why the database can function as a working tool in the post-excavation work. The necessary information will be extracted from the database and combined in analysis and visualisation with GIS and other tools.

A certain degree of standardisation of the artefact description is vital, so the classification follows the schema published by Helskog, Indrelid, and Mikkelsen (1976) the knapped lithic materials. This gives a better chance for uniform cataloguing across single projects and individual archaeologists.

The database has two levels of context information. The broader is the geographical position of the site. This includes cadastral information as well as geographical coordinates. The coordinates are followed by metadata giving the precision level. The narrow level of context information is the intra-site coordinates. This can include the unit of excavation: grid and square number, xyz coordinates, and layer. It is also possible to register an ID-number for contexts from the excavation documentation system, Intrasis.

Earlier discussions have concentrated on the distribution of typologically dated, single finds of large stone tools as axes, sickles, and daggers in relation to landscape types (Matsumoto and Uleberg 2018). This paper will widen the scope and include small and expedient stone tools from excavations and surveys. The excavations generally produce a relatively high number of artefacts within a limited area. The time frame may be narrower as C14-datings will complement typological dating. Material from surveying will generally be several minor concentrations within a limited geographical area, while the single finds will have a wide distribution. These different categories can also be the result of different relations to the landscape. The more prestigious items may be deliberately deposited at special places in the landscape, perhaps at special occasions like offerings or burials. Expedient tools, on the other hand, will in general be reflections of everyday activities and unspecific movements.

The visualisation of the sites we will discuss challenges offered by different scale levels of varied artefact contexts. One scale concern the dating, where the sites will be categorised within narrow and broad chronology levels (Capecchi et al. 2016: 518–519). Some sites have been occupied repeatedly, and some typologically dated sites will only have a broad chronology level. Other scales will be the number of artefacts and material variety at the sites. This presentation will explore the possibilities inherent in the 3D documentation of sites and the potential of comparing inter- and intra-site distribtions. These aspects will contribute to a further refined discussion on the quality of the information in the database, method development for user-friendly downloading of raw datasets, and above all the meaning of free online infrastructures for cultural heritage studies for everyone.

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DIGITAL IRON AGE: DATA ANALYSIS USING MYSQL, QGIS, AND R

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Abstract:

The interdisciplinary e-learning project "EisenzeitDigital” (EZD) or "Digital Iron Age" collects data of Iron Age sites in Bavaria in a MySQL database and studies their distribution and settlement dynamics using different plug-in tools. These include the programs QGIS for visualisation, (My)SQL for analysis based on algorithms, and R for statistical analysis. Over the past four years the project has twice been funded by the Lehre@LMU, a scheme aiming to support the development of digital training courses to modernise and improve learning at the LMU Munich.

Both the database and the analysis tools are accessed via a virtual platform called "Digital Humanities Virtual Laboratory", which has been developed as a teaching platform as part of the initiative “Digital Campus of Bavaria” (Digitaler Campus Bayern). Beyond usage of the database the project also makes use of a WordPress-Environment as part of an inverted classroom approach. Here, lecture content is shared with the students as pre-read material in video or text format, while classroom time is purely dedicated to discuss topics in greater depth and to clarify open questions. In this setting both lecturers and students share their work and have the opportunity to comment and interact in a non-hierarchical way. The teaching approach therefore combines two goals: (1) Training students in the handling and use of databases for scientific purposes, and (2) Studying the dynamics of Iron Age settlements in Bavaria between the eighth and first centuries BC.

The database is fed by different sources, including the information system of the Bavarian State Office of Heritage (Bayerisches Landesamt für Denkmalpflege, BLfD), the Bavarian Atlas of Monuments (PhD thesis Peer Fender, 2017), and peer reviewed journal articles. Free Web Map Services (WMS) data provided by different state and federal institutions contain additional pedological, hydrological and geological information.

Mapping of the Iron Age sites in Bavaria revealed a bimodal distribution of settlements during both the Hallstatt and La Tène periods. Most sites are located along the rivers Danube, Isar and Main, as well as in and around the modern agglomerations. This site distribution is hardly surprising since large river valleys have been densely populated ever since Neolithic times. Areas with good soils generally yield high agricultural returns making them favourable locations for settlements. However, the site distribution may be biased by different factors such as the location of modern urban areas, industrial zones, and infrastructure; the modern agricultural land use; the execution of rescue excavations; the activities of voluntary collectors, professional archaeologists, and looters using metal detectors. Also, different building techniques and burial procedures of variable preservation potential dominated in different periods of the Iron Age. In addition, there is a general increase in the number of sites at the end of the Pre-Roman Iron Age, especially since 150 BC, which is linked to the overall population increase through time.

Since the start of the project in 2017 students of three consecutive classes have discussed the impact of these biases, studied the settlement dynamics and tried to understand the land use strategies that prevailed in Bavaria during the Iron Age. Learning how to use the programs MySQL, QGIS, and R, and combining them to critically assess archaeological data were the key skills our students acquired during their work on the project. Furthermore, having used a virtual platform for several years enabled us to quickly transfer this technology to other courses when the COVID-19 pandemic hit in early 2020. This allowed for a smooth transition from classroom to online teaching, and has avoided significant disruption of the learning progress of our students in the affected academic terms.

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Modelling cooperative gathering behavior of early hominins, using comparative recent hunter-gatherer behavior

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Abstract:

The development of the complex foraging behavior we can observe in recent hunter-gatherer is still under debate (Schuppli et al., 2016; Desantis et al., 2020). Early hominins are considered to behave like recent apes still do, with little cooperation between individuals (Chapais, 2006). At some point hominins should have started to increase cooperation among the members of a group thereby establishing joint central places (Saladie, 2011).

The goal of our study is to establish a model which could illustrate potential changes in the foraging behavior. As a first step we require a functioning model of foraging hominins. The agents correspond to individuals, each individual gathering resources to fulfill a daily energy demand. We allow the agents to cooperate by sharing knowledge about the distribution of resources.

The agent-based model:

The model considers a variety of environmental factors, e.g. climate and resource distribution, and group structure of the foraging agents. To evaluate the results we adapted an existing system to monitor the behavior of hunter-gatherer societies (Kelly, 1983). The foraging success is monitored by counting the number of residential moves per year.

Environment: The agent-based model is situated in the Sangiran area. The environment is a 2.500 km² large area fragmented into 1 km² cells. We used precipitation data to estimate the monthly net primary productivity in the area. We implemented three kinds of stationary resources which differ in the energetic value and seasonality. Two of the stationary resources occur on land, one has a higher energetic value but is scarcely distributed, the other one is less valuable but widespread in the area. The high value resource could correspond to fruits, the second one to underground storage organs. The respective amounts per cell depends on the net primary productivity. They are randomly distributed across terrestrial patches. A third type of resources is bound to freshwater bodies.

Agents: The agents represent individual foragers, all members of a single group. They are characterized by a set of attributes like daily energy demand, maximum load or movement speed. These parameters are adjustable and currently set to values representing the characteristics of Homo erectus in Sangiran one million years ago.

Agent behavior: The agents perform gathering trips and carry resources back to a central place. They gather mainly for themselves but may also gather additional food to share with other group members. If the shared storage is empty and one individual is not able to cover its daily energy demand the group moves to a new area. The agents start gathering trips by deciding to move into a random direction until they find an exploitable patch. The movement

is limited by time. All members have the same abilities to forage. We permit a certain part (or all members) of the group to cooperate with one another by sharing knowledge on the distribution of the available resources. The agents use the knowledge by deciding about the patch to be exploited at the onset of a foraging trip. The decision depends on the available biomass, the distance and the remaining time. This results in two different strategies pursued by the agents: a planning forager directs its foraging trip according to the knowledge on the environment; a random forager heads in arbitrary directions.

Simulation results:

The two different strategies allow us to analyze the effect cooperation has on the foraging success of the group. We expected an increased foraging success of the group with the higher number of cooperating agents. As the group should be able to exploit the surrounding more efficiently resulting in extended stays in a specific location.

Instead our results identify a different optimum. Groups in which 25 % of all agents cooperate are able to remain longer in each location. Extreme groups without cooperation and/or in which 100 % of the agents cooperate, need to move the residential camp more often.

In order to explore our model further, we analyzed the logistical behavior during the first four weeks at particular location. The better represented strategy exploits the resources closer to the camp while the followers of the less well represented strategy forage further away from the camp. This behavior is caused by the individual intent of minimizing the foraging costs. The two foraging strategies are both able to exploit near-by resources successfully.

However, the foraging success of both strategies in exploiting distant resources differs. Cooperating agents seem to be able to exploit distant resources more successfully. They are able to share knowledge about the distribution of the resources and calculate which patches are worth heading to. As a result the entire group forages most successfully when cooperating agents exploit distant resources while uncooperating members of the group forage closer to the location of the camp.

Conclusion

Our model allows us to analyze the impact of cooperation and may thus be applied to examine complex behavioral patterns. We could focus on improving the complexity by implementing different subgroups. Each small group could have different skills and goals that would determine and effect the strategy they perform. The Group could exist out of different genders and generations, each with individual strengths and weaknesses. The challenge for the agents would be to organize the process of food collecting and maximizing the yield.

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Automated Segmentation of Hieratic on Papyri

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Abstract:

Ancient Egypt is known among others for its monumental hieroglyphic characters. In addition, however, the Egyptians made use of various cursive scripts, such as Hieratic which existed beside the hieroglyphic script for over 3000 years. It was mostly written with a reed brush and carbon ink on papyrus, linnen, leather, wood, and pottery.

The hieratic script has never been systematically explored, neither in terms of their peculiarities in orthography, abbreviation, functions, uses, and historical development, nor in it’s comparison with the monumental hieroglyphic script. For the first time the project “Altägyptische Kursivschriften. Digitale Paläographie und systematische Analyse des Hieratischen und der Kursivhieroglyphen” of the Mainz Academy of Sciences and Literature undertakes basic research on the ancient Egyptian cursive scripts, especially Hieratic and cursive hieroglyphs. Based on a methodology of computer-aided research, cursive handwriting is studied based on digital facsimile drawings of the texts on papypri. Within these facsimiles the exact position and shape of the signs is annotated manually by researchers, resulting in vector graphics that exactly document the tracing of the area covered with script. The individual signs, groups of signs, and selected word spellings are extracted and organized in a database that supports both traditional and computational analysis for comparative study of the development of the writing.

In this work, we introduce an approach for the automated segmentation of ink in written lines from digitized hieratic papyri. The exact annotation of areas proves to be an excellent source of ground truth necessary to train a classifier capable of discrimination between (a) the background consisting of the papyri texture, damaged or missing regions, and even non-textual (e.g. accidental) ink placements, and (b) the foreground (inscription) consisting of sometimes faded or partially damaged script.

We make use of the U-Net [1] network topology where the intermediate results of repeated convolutions and max-pooling of the input are later recombined with with stages of de-convolution and un-pooling. In this way, the resulting segmentation of U-Net makes use of both a narrow passage of spatial information forcing a spatially de-correlated encoding of context and intermediate results of lower abstraction yet more spatial information resulting in a pixel-precise segmentation. Instead of processing the complete digitized papyri for segmentation (which have in excess of 50 megapixels), as usually performed for U-Net tasks, we sample quadratic patches overlapping by half from the document. This method increases our training data and prevents overfitting to the location of visual features in the highly regulated photography acquisition setup of the papyri. We also remove batch normalization layers and replace ReLU layers with tanh layers to stabilize training. While these modifications

increase computation time, they allow us to use only few training samples to achieve high accuracy.

Our data consist of scanned papyri and manual tracings of the ink coverage of the inscription. We rasterize the tracing layers to same resolution as the raster scans of papyri and generate binary labels of foreground and background. We extract quadratic image patches of 512 x 512 pixels resolution from both the training data and the label data. Training images with color are separated into three layers. The binary label raster patches are separated into two layers, one encoding the foreground with enabled pixels and the other one encoding the background with enabled pixels. The network consists of six down-sampling stages of convolution, convolution and max-pooling with 32, 32, 64, 64, 128, 128 feature layers respectively. The central bottleneck has the dimensions 4x4x128.

Each down-sampling stage retains its intermediate results. Then, six stages follow where intermediate results are concatenated to the bilinear up-sampling of the previous lower level followed by two convolutions. We train with the ADAM optimizer using a learning rate of 0.0001 for 500 epochs. We report an accuracy of 96% for the resulting segmentation masks. A close inspection of the results shows that the neural network learns to predict inked areas depending on the presence of surrounding script. Signs that have a long descender – sometimes spreading over two or three lines of an inscription – cross borders of a prediction patch. Hence, they are (falsely) not identified as script, just as any modern Arabic numerals are (correctly) not identified. We deduce from this behavior that the neural network performs more than simple adaptive thresholding of the scanned document colors. The network necessarily needs to encode basic shapes of Hieratic script to correctly deduce the surrounding context of a prediction allowing it to suppress both Arabic numerals and areas of stray ink not intended as script by the ancient scribe.

As the goal of the project is a complete, systematic and digital paleography of the cursive handwritings in ancient Egypt, the automated and pixel-precise segmentation of script enables large-scale computational analysis and population of the paleographic database with candidate characters in as yet not transcribed papyri. While our approach currently does not tokenize script into characters, the underlaying expert created ground-truth contains precise character level shape outlines, enabling us to also automatically learn character boundaries in future work.

In addition, the presented method could serve as a starting point to carry out a data-driven basic research that is lacking especially in questions of scribal formalization habits, layout composition, and economy of writing that supersedes the morphological analysis of individual sign forms. Furthermore, it enables enhanced binarization techniques, which are necessary for the processing of ancient papyri, since common methods fail due to gray level variation induced by texture and materiality of the fibres.

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ID number: 134

Historic maps as a multifaceted LOUD resource

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Abstract:

This paper will address some of the problems and potential solutions relating to the use of digitised historic Survey of India maps in archaeological research. We explore the issues encountered when working to follow best practice in meeting the dual aims of a) producing an open access, interoperable resource that links across different repositories; and b) meeting the archaeological research aim of extracting, analysing, and recording geospatial data. We explore how historic maps as data objects might adhere to LOUD principles in their generation, curation, analysis, and dissemination. This case study stems from a collaboration between the Mapping Archaeological Heritage in South Asia Project and two UK Legal Deposit libraries. The aim is to make digitised and georeferenced Survey of India maps available openly, while serving the cataloguing and research needs of the participating organisations.

Wider research aims:

Pakistan and western India are extremely rich in archaeological and cultural heritage sites, 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 the level and rate of site loss is not being monitored.

The Mapping Archaeological Heritage in South Asia (MAHSA) project aims to develop heritage management tools and expertise that will work towards addressing these threats to archaeological sites and monuments. The MAHSA project aims to document the endangered archaeology and cultural heritage of the Indus River Basin and the surrounding areas, and to publish this information in an Open Access Arches geospatial database. It aspires to become sustainable by being the default management database for local heritage stakeholders through a programme of collaboration and training.

Work with digitised historic maps is one strand of the MAHSA project, which integrates three approaches to identify archaeological and cultural heritage sites, document them, and then make these data openly available. These are: i) to collate and systematise the existing published data on archaeological and cultural heritage sites; ii) to use historic maps, remote sensing and automated site detection methods to identify and document previously unidentified archaeological and cultural heritage sites; and iii) to collaborate with local stakeholders and offer training in GIS, methods of site detection, recording of sites on the ground, and documentation.

Digitised historic maps:

Previous research has shown that the colour maps issued by the Survey of India from 1905-1941 document the location of thousands of historical map mound features (Petrie et al. 2019). Generated as a legacy of Britain’s colonial past, paper copies of these maps are held in UK Legal Deposit libraries, which house hundreds of these historic map sheets, many of which remain available only in paper form, or as text-catalogued digital images (as opposed to georeferenced map objects). The extent of the overlap between the collections is currently under review, but together these collections represent a vast dataset, currently existing largely as bibliographic objects with their own historic and visual value, but with the potential, once fully digitised and georeferenced, to offer detailed geospatial data about archaeological sites and monuments, predating much of the development and land use changes seen in recent decades.

The research team are thus faced with the following problem: once digitised and georeferenced, maps exist as images in their own right, as holders of bibliographic and historic information, as signposts to larger datasets, and as containers of geospatial data. With paper copies held and curated in nationally important library collections, the digitisation process must therefore serve a wide variety of end users, with the resulting output of digitised maps following best practice in meeting the data standards of all stakeholders as linked data (Hyland, Atemezing, and Villazón-Terrazas 2014).

Methods and materials: potential solutions

We propose an approach to address this problem through making these resources available through the International Image Interoperability Framework (IIIF). IIIF aims to facilitate open access to images, by bringing together the growing silos of image-based digital repositories around the world that could previously be only accessed through tailored and specifically developed applications. IIIF provides such standards by making use of JSON-LD, linked data and standard W3C web protocols (Babcock and Di Cresce 2019).

When using digital images of historic maps for the identification of archaeological sites, an intermediate step of georeferencing these maps is introduced, where the related real-world geographic coordinates are generated. A typical way to store these coordinates is 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. The need for this has already been felt and highlighted by the larger IIIF community and extensions of IIIF capabilities for linking and storing geographic information with digitized maps through the inclusion of GeoJSON-LD context is underway.

We use this case study to examine the implementation of best practices in both workflow and data standardisation when working with multiple stakeholders. We evaluate aspects of effectiveness, efficiency and satisfaction of such requirements as addressed by existing solutions and case studies, and explore how to feed the lessons learned during so far with our own particular case study back into the improvement cycle for LOUD-compliant data solutions.

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Linked Open Data Vocabularies and Recognizing Intellectual Contributions via ORCID

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Abstract:

In 2018, the classical archaeology-oriented Archaeological Institute of America (AIA) issued an “Addendum, Guidelines for the Evaluation of Digital Technology and Scholarship in Archaeology,” recommending that departments should evolve their positions on the recognition of the intellectual effort involved in digital research and publication (3D/VR, databases, Geographic Information Systems, etc.) with respect to tenure and promotion, stating that a “digital product should be considered to be of the same value as a paper publication since it must undergo a rigorous vetting process just as its print counterpart (AIA 2018).” Similarly, earlier this year, the Society for American Archaeology published similar documentation for departments of archaeology and anthropology in the United States, extending beyond the scope of the AIA’s proposal to include Public Archaeology as well (SAA 2019). These are the two most prominent archaeology membership organizations in the United States, and it is clear that computation methodologies in scholarship and dissemination are increasingly in the mainstream in archaeology as a whole, and no longer a niche within certain departments; digital tools are inseparable from analog ones in cataloging and analyzing information and publishing new knowledge.

In order to remain apace of these changes, it is also incumbent upon digital publishers to alter their workflows so that the scholarly profile of an academic can be populated and each contributor recognized for his or her work. Indeed, this is particularly important for the often neglected student participants looking to strengthen their CVs and any junior faculty member seeking promotion and tenure. Kerameikos.org, an international, collaborative project to define the intellectual concepts of Archaic and Classical Greek pottery in accordance to the principles of Linked Open Data (LOD), has made recent progress in this area by formalizing contributions to the project through current standards for scholarly communication.

This paper will document Kerameikos.org’s Linked Open Data creation workflow, beginning with the derivation of vocabularies (comprising shape, artist, production place, style, period, etc.) from Oxford University’s Beazley Archive Pottery Database and subsequent OpenRefine reconciliation to external systems, such as the Getty Art & Architecture Thesaurus and Thesaurus of Geographic Names, Pleiades Gazetteer of Ancient Places, and Wikidata.org. The term lists are then structured into Google spreadsheets to be supplemented with well-researched definitions written by University of Virginia graduate students and vetted by Kerameikos.org project leaders, Smith and Gondek. Furthermore, German translations have been provided by colleagues at the Österreichisches Archäologisches Institut. These spreadsheets are transformed into RDF representing both the LOD concepts (in SKOS, the Simple Knowledge Organization System) and associated provenance metadata (in the W3C PROV ontology). These metadata link to the source Google Sheets as well as Kerameikos.org URIs representing the concepts’ editors (e. g., http://kerameikos.org/editor/abradford).

Further, each contributor is additionally connected to a scholarly profile in ORCID (https://orcid.org/).

Through our partnership with the University of Virginia Library, we mint a Digital Object Identifier (DOI) via DataCite for each editor that represents his or her intellectual effort to the project. DataCite automatically populates ORCID profiles with these “datasets”, which appear alongside more traditional publications, such as journal articles, forming a sort of comprehensive virtual CV. These datasets will propagate elsewhere as well. Dataset metadata are published to DataCite, and thus searchable through that site and its various APIs, enabling these data to proliferate into the hands of researchers interested in ceramics taxonomies who may otherwise not have stumbled upon Kerameikos.org directly. Our data then become more FAIR (Findable, Accessible, Interoperable, and Reusable) as a result.

Although it is becoming increasingly common to generate DOIs for scientific datasets within institutional or external commercial or noncommercial repositories (e. g., Figshare or Zenodo), it is a less common practice for humanities data. We hope that Kerameikos.org’s model for formalizing contributions to the cultural heritage LOD cloud might influence other Digital Humanities projects to undertake similar steps in making the labor of junior faculty and students more visible through DOI and ORCID integration.

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Linked Art for Archaeological Data Exchange

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Abstract:

Linked Art (https://linked.art/) is an emerging community of museum and information science specialists working to establish a common profile for the exchange of cultural heritage data by means of current Linked Open Data (LOD) and Application Programming Interface (API) methodologies. Building on similar principles outlined by the International Image Interoperability Framework (IIIF: https://iiif.io/), Linked Art is a particular implementation of the CIDOC Conceptual Reference Model (CRM) rendered in the JSON-LD syntax. Linked Art aims to strike a balance between completeness and usability, and while not all possible permutations of human knowledge are intended to be represented in the Linked Art profile, the minimum level of detail, with respect to both the data model and controlled vocabulary integration, is greater than more generalized aggregation models, such as those used for Europeana (https://www.europeana.eu) or the Pelagios Network (http://commons.pelagios.org/). The aim of Linked Art is to achieve Linked Open Useable Data (LOUD), lowering the barriers for developers to reuse data for a variety of research contexts.

Many of the member institutions of the Linked Art steering committee hail from fine arts museums, but there exists some overlap between several members and archaeological materials, particularly among encyclopedic museums and research institutes, such as the Getty Museum and Smithsonian. The American Numismatic Society is among the earliest of implementers of the Linked Art API specification, extending the open-source Numishare software framework for its online collection of coins and similar objects to output JSON-LD conforming to a numismatic model proposed by the author.

In a similar vein, the Kerameikos.org project has aligned its aggregation model nearly completely with the Linked Art CIDOC-CRM profile. Kerameikos.org is a collaborative effort to define the intellectual concepts of ceramics studies following the principles of Linked Open Data, focusing initially in Archaic and Classical Greece (c. 700-330 BCE) (Gruber and Smith 2014, 205-214). The project is developing workflows to incorporate vase data from across archaeological and museum datasets in order to facilitate new types of query and visualization. This paper addresses recent developments in the harvesting and normalization of Linked Art-compliant JSON-LD data into both Kerameikos.org and Nomisma.org’s LOD ecosystems.

Findspots for Greek vases implement a proposal to the Linked Art community based on the ARIADNE Plus model that extends CIDOC-CRM for archaeological context (PIN 2019; Gruber 2019). While many artifacts held by museums were not scientifically excavated and cataloged according to modern standards for data recording, the database records for these artifacts may still include very basic metadata corresponding to the place of finding and general context of the place (e.g., a tomb) or techniques used (metal detecting, as is the case for many coin finds). The prototype of this data harvesting system in Kerameikos.org was built primarily

upon test data provided about several Greek vases held by the Indianapolis Museum of Art at Newfields; one of these has a findspot of Vulci, an Etruscan settlement in Italy, which would serve as a proof of concept for processing the Linked Art implementation of the ARIADNE archaeological data model. This paper details the intricacies of this workflow: 1) using XForms to request and process JSON-LD, 2) coreference concept URIs in the JSON-LD (typically, Getty vocabularies) with applicable Kerameikos.org ones, 3) normalize gazetteer URIs associated with findspots to Wikidata.org entities, and use Wikidata APIs to extract geographic coordinates and hierarchy (following the CIDOC-CRM spatiotemporal extension), and 4) serialize these data into CIDOC-CRM RDF/XML and post into the Kerameikos.org SPARQL endpoint. This is an extension of the data integration workflow developed in Nomisma.org in 2015, and the processes outlined in this paper may be of interest to others working to aggregate data in other sectors of cultural heritage.

In conclusion, this paper is a demonstration of the development of a bridge between museum and archaeological data best practices. While Linked Art continues to evolve toward a version 1.0 specification, the application of ARIADNE’s principles for CIDOC-CRM representation of archaeological context will hopefully enable museums to align their digital collections to the research questions of researchers who are interested in the patterns of distribution of materials over time and space. Likewise, the JSON-LD oriented approach to the Linked Art API may serve as a use case to the archaeological community to promote optimal data reuse through increasingly common serializations of Linked Open Data.

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ID number: 137

Pompeii within Ancient Virtual Skies: From Urban Orientations to 3-D Visualisation

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Abstract:

Quantitative methods in the study of Mediterranean cities are here approached within the topic of urban orientations and computer-based visualisation. Scanned 3-D models of urban archaeological remains are placed within a virtual landscape and skyscape reality with a given accuracy to provide an additional interpretative key for the research question. In particular, the computational astronomical visualisation software Stellarium is used to go back in time to simulate the Pompeian sky of the 7th-6th century BC.

Around ancient Campania, spanning from the river Volturno to the Sorrentine peninsula, many settlements arose in their proto-urban and urban form starting from the 8th cent. BC towards a process of consolidation in the 4th cent. BC. The study of the builders’ choice of orientating urban streets can be telling under many aspects. It may show a theoretical design behind the planning, as well as an accurate consideration for the environmental constrictions in the area, such as river beds, mountains, elevation slopes, solar irradiation, wind directions as well as religious and political factors determinant for temples orientation. Awareness of local winds and the sun thermal factor for urban morphology were already exposed in ancient texts such as Hippocrates’ On Air, Water and Places and Vitruvius’ De Architectura.

This research project started by investigating orientation data in form of azimuth and declination values to question if any astronomical pattern can be inferred. However, a multitude of orientations can be attested diachronically in the built environment and in the land division organisations which requires an accurate valuation of a single pattern-model and its variations. Preliminary results for Pompeii showed an urban morphology oriented towards the solstitial positions of the sun, as inferred from the analysis of digital (GIS, DTM, Satellite Images) and on-site (TS) measurements. Altitude values were measured from digital terrain models converted into horizon profiles for each view point to recreate the natural skyline. The streets sightline were projected on the celestial sphere and compared to the sun declination in 600 BC, time of foundation of Pompeii. The on-site fieldwork (TS) has proved the compatibly of direct data with the digital astronomical and landscape models.

As outcome for this analysis, several urban roads and templar structures resulted directed towards the position of the rising sun at summer solstice between the Archaic and the Hellenistic period, with a variable divergence of 1°-2°. The best fit is resulted for Via delle Terme, oriented with the position of the midsummer solstitial rising sun within 0°.5, in respect to Via dell’Abbondanza with 1°.2 of error, whereas Via di Nola has a divergence error of 1°.3 (Cristofaro and Silani 2020). The sighting of the sun above the local horizon for orientating the decumani is attested in the word of the Roman agrimensor Frontinus, stating the practice of using the sun as a point reference for decumani in urban planification.

In the case of Pompei, apart from the urban fabric and all the monuments conditioned to it, there is another relevant Archaic structure oriented towards summer solstice, this time towards the setting sun, that is the Doric temple. To confirm the intentionality of such astronomical orientations, a statistical test was carried out. The co-existence on the same site of two important solar positions, one in the urban grid and the other at the Doric Temple, suggests that the probability that this is coincidental is 0.2%.

The intention of assuring an equilibrate solar irradiation along all the year could be one explanation for the specificity of such urban morphology to be further tested with the aids of virtual reality. This precise choice of orientation may be interpreted through the lens of Gaetano Vinaccia’s theory, where microclimatic aspects were decisional criteria for ancient planning. Pompeii's grid reflects Vinaccia’s orientation of the equisolar axis for temperate climate, as the criteria to guarantee the best solar irradiation even for the north facing sides of buildings (Vinaccia 1939). Therefore, such results on the orientation of Pompeian streets appeared appealing to be tested by combining a geo-referenced 3-D archaeological model within the desktop planetarium software Stellarium and its Scenery3d (Zotti 2019). More insights can be achieved with virtual reality which are not possible from visual inspection alone, such as the correction for the higher tilt of earth’s axis in antiquity. Observing today’s sky over old ruins just does not provide the sky contemporary to the buildings. The long-term variability of the ecliptic obliquity from the city foundation to nowadays has shifted the position of the rising sun of half a degree. Thus, 3-D visualisation is adopted to cast light and shade on the Pompeian streets from a virtual sun testing its seasonal positions between the Archaic to the Hellenistic period. This will question the scientific interpretation achieved by numerical data, as well as provide an immersive tool for outreach purposes.

In conclusion, the impact of sunlight during its course across the year and across the local horizon can be regarded a determinant factor in the ancient Campanian urban planning. This precise urban morphology produces an ecological, rational, functional idea of the concept of city in the Archaic period also related with the observation of the celestial vault, where the religious and ritual aspects of setting boundaries and diving space according to cosmological principles should not be seen in contradiction with its functionality, but in complementary dichotomy. In Pompeii foundation, orientation and morphology can be read as part of an environmental and ecological design related to criteria for a rationalised sun exposure, now further explained with the tools of 3-D simulation.

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ID number: 138

Reassessing reflexive digital archaeology - a modest proposal

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Abstract:

Context

In archaeological research, the ideals of reflexive and self-critical practice are well established. While some innovators (e.g. Hodder, 2000) have tested and documented procedures aimed at filling out the context of knowledge construction in archaeology, my own research indicates that while researchers may have taken on board the importance of such concerns, in practice the digital tools they use have not evolved sufficiently to support them, and this kind of activity is far from being integrated into the mainstream.

No doubt this is as much down to the sometimes intangible benefits associated with the creation of paradata, and a lack of clarity around deciding which aspects of process are useful to capture and share, as it is to do with any deficiency in software technologies and their development.

The starting point for this project was sympathy for concerns stated in the literature that cultural heritage research visualisations and knowledge representation techniques mostly fail to adequately reflect the nuanced philosophical positions of cultural heritage research theory, and instead tend to reflect the concerns of a positivist outlook. Drucker (2014) argues that in their formal emphases on objectivity and universality, conventional representation techniques tend to marginalise uncertainty and the subjective experience and influence of the researcher. For Drucker this is an issue of the implementation of visualisation elements such as graphs and illustrations. In my research frame, knowledge representation encompasses visualisations but also narrative style, sharing of process, the ontological structuring of data, and opportunities for interaction and engagement.

Main proposal

I suggest that this is an appropriate time to reconsider what reflexive archaeology might look like in the context of contemporary digital technology and the web – not least because we are seeing an increasing emphasis on the values of transparency and reproducibility in the scientific disciplines and this is manifesting itself in concrete technological applications such as digital lab notebooks and the online preregistration of research papers. I propose that such initiatives are just as vital for cultural heritage research, but that tools developed for the documentation of experimental laboratory work are not in themselves sufficient for the cultural heritage context, which must accommodate the interpretation of complex social systems and gaps in evidential records.

The adoption of reflexive practices, including the use of paradata, is highly dependent on the epistemological foundations on which research is built. For some knowledge construction approaches, the inclusion of paradata and implicitly, therefore, the acknowledgement of alternative possible approaches, is undesirable. For others, it is to be embraced and explored.

In my research project I develop a conception of the latter, under the title of 'epistemological modesty' and consider what the characteristics of digital archaeological tools which embody this philosophical approach might consist of.

Epistemological Modesty

Generally speaking, as a discipline, archaeology has evolved from one trying to write a grand narrative of human history to one more concerned with the study of specific cultures, their practices and mutual influences (Lucas, 2012). This has led, at least in some quarters, to an emphasis on multivocality when describing the world, both past and present, and openness to multiple interpretations of archaeological evidence, as well as to critiques of previous practice, from, for example, feminist and post-colonial perspectives. As archaeology is a subject which tries to understand historical cultures and their development, it must be transparent about the cultural perspectives it uses to make sense of these. Which lens and set of filters are used to capture our impressions of the world, and which distortions or limitations do they introduce to the field of view? In drawing together my conception of epistemological modesty, I find commonalities in lessons from science and technology studies and studies of interdisciplinary collaboration as well as pragmatic archaeological philosophy. The conventional choice between positivism and relativism is seen as a false dichotomy. Instead, the 'best case' is made using all available means, including scientific data, but with an openness to alternative perspectives and reinterpretation. Putting epistemological modesty into practice in digital archaeology entails the enactment of some key principles, including: recognition of the situated nature of knowledge; documentation of research context and process; access and openness; space for parallel narratives; scope for digital malleability and reuse; and working at a human scale. I argue that the affordances of web technology open up new opportunities for this shared work.

Applications

In my research I explore the use of digital research journals and their publication in interactive web formats, alongside more conventional research outputs, and look to test their potential in the context of real-world archaeology projects.

It is clear that web technologies have the potential to support innovative reflexive practice. A key question for the advancement of such initiatives is whether there is a real appetite for integrating the consideration of the limits of knowledge into cultural heritage research.

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ID number: 139

Documenting types and absence of types using the CIDOC CRM

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Abstract:

In a typical database environment two approaches are generally adopted: a) the open world assumption where the lack of a record does not mean non-existence of evidence and b) the closed-world assumption where the lack of a record does mean non-existence of evidence. This paper examines an in-between state for a database of a partially complete world where lack of some types of records can be safely interpreted as lack of evidence whereas the rest remain under the open world assumption. The paper takes a case study of survey forms for the description of the material and techniques of medieval bookbindings. It begins by examining the types of data entered in a database based on the form from an information science point of you. It identifies the data which should be considered under the open world assumption and discusses whether the records about non-existent things fall within this category or belong to context-specific closed worlds. The paper continues with testing this categorisation against the survey methodology and the kind of observations done on bookbindings. It concludes with recommendations on the interpretation of the form structure and survey principles.

ID number: 140

Title

Using Spatial Storytelling Platforms for Public Archaeology, Open Data, and Scholarly Publishing

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Abstract:

Introduction

Archaeologists have ethical obligations both to publish and to engage with the public. These responsibilities are both facilitated by the increasing availability of digital — including spatial and three-dimensional — datasets that are regularly collected by archaeological projects. Online platforms for publishing of Open Data can allow for the contextualization of archaeological finds within their context along with interpretations of excavators, a connection often lacking in traditional publications (Opitz 2018). These platforms also provide for levels of engagement beyond the scholarly, providing a Public Archaeology aspect to archaeological publishing (Opitz 2018). Thus, online publishing platforms are inherently-suited to hypermedia in which users can determine their own level of accessibility based on interest or expertise. Grounding this type of digital publication in its spatial context is both logical, given the importance of space for archaeological interpretation, and well-precedented, given the popularity of the Deep Mapping concept in the Digital Humanities. However, hypermedia and Deep Mapping are underutilized in archaeology as a framework for data sharing and outreach (Earley-Spadoni 2017). These concepts easily integrate with digital archaeological datasets. As such, given the widespread collection of digital spatial data, arguably the majority of archaeological projects are well-positioned to publish linked digital archaeological data online with public or scholarly-facing interpretations. ArcGIS StoryMaps is one platform that facilitates online data sharing, contextualized both spatially and with storytelling (Howland et al. 2020). Thus, this platform provides valuable opportunities for digital public archaeology and contextualized open data. This paper provides a case study using data from Iron Age Faynan, Jordan, of how ArcGIS StoryMaps can be used for these dual purposes

Methods and Materials

Like many other archaeological projects, the Edom Lowlands Regional Archaeology Project (ELRAP) in southern Jordan's Faynan region collects a great deal of digital data during normal processes of excavation. These include data collected through both cutting-edge methods of digital archaeology, including low-altitude aerial photography, digital photogrammetry applied to sites and artifact models, and satellite remote sensing, and standard data recording practices, e.g. use of a Total Station to record artifact proveniences and description of contexts recorded as digital text. These datasets are all either spatially-referenced or describe spatially-referenced data. As such, they are well-suited for inclusion in GIS databases, including online spatial data hosting services. ArcGIS Online is one such (proprietary) platform, among other online map-hosting services, allowing users to produce maps and share them widely. Maps produced on this service and others like it can be interactive, allow for the provision of spatial context within an archaeological site or region, and also have hypermedia capability as users can click on datasets within the map to learn more or follow links or view pictures associated with the spatial data. These platforms are sufficient for providing open spatial data in archaeological context. However, a full interpretation or framing of the data within a public-oriented narrative is not supported. Fortunately, ArcGIS StoryMaps (also proprietary) allows for the provision of fully-interactive maps, situated within a text-based narrative, along with the possibility of including other media such as 3D models, videos, images, amd embedded web apps. As such, scholars can provide open access to their contextual spatial data through ArcGIS Online and situate these datasets within ArcGIS StoryMaps. The platform is suitable for both public-oriented storytelling and for the non-traditional digital publication of digital data or excavators interpretations.

Results

Demonstrating the utility of ArcGIS StoryMaps for these purposes are four StoryMaps describing the archaeology of Iron Age Faynan, Jordan. Two of these digital publications are public-facing hypermedia deep mapping applications, allowing public users to read about the ancient copper-producing society of Faynan in either English (https://storymaps.arcgis.com/stories/b441a28ea5844d7bafbd47d3471166c9) or Arabic (https://storymaps.arcgis.com/stories/fadfbcb0c1ed447bb272eced3140f004), catering to both international and local audiences. These platforms have been relatively popular since their launch with over 2,500 viewers, ca. 40% of which live in Jordan, viewing the StoryMaps as tracked through Google Analytics. Two other StoryMaps provide a scholarly-facing avenue for open data sharing of 3D models, via Sketchfab embed in StoryMaps, of the full assemblage of diagnostic ceramic sherds recovered from one excavation in Faynan. These sherds are grouped and categorized in one case by their spatial context through using interactive digital maps from ArcGIS Online supplemented by written context descriptions (https://storymaps.arcgis.com/stories/bf0c203dbf7c45ac95c862d644e75b7c) and in another case by preliminary classification of the type of ceramic form (https://storymaps.arcgis.com/stories/d33f7e32f50748afb373b5752217312d). The popularity of these StoryMaps is not yet proven, though few archaeological projects provide the full assemblage of sherds in 3D as open data. In total, these four StoryMaps demonstrate the range of capabilities for ArcGIS StoryMaps to share and contextualize digital archaeological data for a range of audiences.

Discussion

It is imperative that archaeologists develop new modes and models for archaeological publication (Opitz 2018). This includes the obligation to interact with a public audience, especially stakeholding communities, and to share the results of excavation as open data under a data stewardship model in which datasets are no longer considered the exclusive right of excavators. ArcGIS StoryMaps provides one excellent framework for publishing fully-contextualized data in both of these avenues. Future work can build on these results to develop standardized formats for publishing through ArcGIS StoryMaps or find viable open source alternatives to the platform.

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ID number: 141

Using VR to analyse GeoPhysics data - a case study.

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Abstract:

The acquisition of geophysical data is expensive, often difficult, and occasionally dangerous. These data are therefore valuable and it is always important to get the most use from them. In many cases, the geophysics data are combined with other forms of data; including topographic, geologic and remote sensing datasets, amongst others. GIS has provided the tools to co-ordinate spatial datasets and, more recently, tools have become widely available to geolocate data in 3D space. The construction and use of 3D ground models have greatly enhanced our capability to assess, analyse and interpret complex combined datasets. However, these 3D models are generally viewed and edited in 2D on a screen, which is limiting for the operator and difficult to communicate to clients and collaborators. The export of these 3D models to print format for reports and publications is rarely satisfactory.

This talk presents a case study from outside the archaeology community where the ground model was edited, assessed, and interpreted using newly developed virtual reality software (ViRGiS) that allowed the operator to actively inhabit the model. The interpreted rockhead surface was edited within VR – a process that proved much more intuitive, accurate and rapid than editing on a 2D screen.

The case study covers a recent shallow geophysics project required the investigation of clay-filled dolines formed in the Mississippian Bee Low Limestones Formation at Dowlow Quarry, Buxton, Derbyshire, UK. The client required a good model of the limestone rockhead to allow the design of a facility to use the doline to inject excess clean water into the aquifer, away from the quarry. Frequency domain electromagnetic survey, electrical resistivity tomography and ground penetrating radar were used to provide the dataset and the rockhead modelled based on a picked boundary between low resistivity (interpreted as clay-rich fill) and high resistivity (interpreted as unweathered limestone).

The results of the case study showed that using the VR "total immersion" approach was a faster process than previous methods, produced a more geologically realistic surface with less artificial artefacts from processing whilst also giving the practitioner a deeper and more intuitive understanding of the model.

ID number: 142

SNA and ANT in the study of local identities: central Italian centres and their cemeteries

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Abstract:

In this paper I will discuss the joint use of the Social Network Analysis (SNA) and Agent-Network Theory (ANT) in the study of central Italian centres from the Early Iron Age to the Hellenistic period.

In archaeology the researchers applying SNA and ANT seem to take different kind of approaches: whereas SNA-users interpret the distributions creating graphs and applying different centrality indexes (e.g. Fulminante 2012), ANT-users theorise and conceptualise different kinds of chaîne opératoires, related processes, relevant to their materials (e.g. in van Oyen’s (2016) study of the terra sigillata and other Roman pottery productions). I will see how Latour’s (2005) constellations can be approached using SNA methods and how this type of reasoning can be compared to inductive research procedure.

I will take a long-term approach to the study of the main cemetery areas in central Italy in order to study identities and mental distances applying network approach. I will look at the tomb types in different communities along the Tyrrhenian and Adriatic Seas and how this category of evidence can act as a proxy in defining identities and socio-political networks. I will analyse the burial grounds in southern Etruria, Latium, Umbria, Campania, Samnium and Picenum in order to consider the mental distances, the relative closeness and distance, reflected in the regional and supraregional networks. In the analysis the access will show to be a key aspect and the different burial customs can be seen as shared in bordering areas that show closeness. The Iron Age pit and trench tombs had both distributed networks. The closeness indexes show that the early funerary networks are small world networks with some local developments and the scale-free network with Rome as a centre is the result of the Roman homonisation of burial practices in the first century BC. Rome was not a key site at the beginning, but it rose in importance.

As part of the theoretical and methodological discussion, I will assess the usefulness of different software meant for the analysis of social networks (Pajek, UCINET and ORA) and consider which one is most user friendly in order to reveal connections across the central Italy. The different aspects of UCINET and ORA functionalities will be praised.

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ID number: 143

APE – ArboDat Pangaea Export

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Abstract:

The publication of research data is an important point to ensure the reproducibility of scientific results. The MS-Access tool "ArboDat", developed at the State Archaeology of Hesse for recording archaeobotanical macro remains is widely used by European archaeobotanists. In 2016 it was transferred to the Lower Saxony Institute for Historical Coastal Research to ensure its continuity and further development. For the long-term storage and easier access of the archaeobotanical data the web app "APE - Arbodat Pangaea Export" was developed. With the help of the app, ArboDat datasets can be easily exported and converted in a standardized way to be submitted to and published open access in PANGAEA. In the talk APE and the workflow to publish the datasets in PANGAEA will be presented.

ID number: 144

But why here? Deciphering the past choices with the use of GIS methods. The Orońsko flint mining area case study

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Abstract:

Orońsko flint mining area is located in central — southern Poland, Masovian voivodeship, between Warsaw and Kraków, in the northern margin of the Holy Cross Mountains region. The state of research indicates that the region was continuously occupied since the final Palaeolithic and is covered by more than two hundred sites registered in the national field survey program — Archaeological Map of Poland.

The recent research in the region (2016-2020), the Orońsko Flint mines project, shows that the region is not only densely covered by sites, but it is a vast mining landscape with dense scatters of artefacts, related to the mining of "chocolate” flint, its processing and settlement activities of different periods of the Stone Age and Bronze Age. Thanks to an intensive field survey program conducted in the region we were able to move forward from the artefact distributions to the sites and characterize flint mining and processing in a broader context.

The goal of the paper is to try to decipher past choices related to the mining of chocolate flint, processing with the use of GIS methods in the Orońsko region. The research concentrates on the developing of multivariate regression models on the basis of geology, geomorphology, topography and hydrology which then are compared with the results of statistical analyses of settlement distribution of specific periods and functions.

ID number: 145

Reflections of history: An approach to enhanced documentation of cultural heritage.

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Abstract:

Designing a new data model is always an adventure. First you have to dig in the raw data and discover their meaning and the connections between them. Then you have to make crucial decisions about which data are relevant to your application, which model to apply, which external links to create etc., while following, to the best of your ability, the standards and principles you believe in. In the case of archaeological data those decisions become even more difficult. You can end up with significantly complex models that are not easily handled either by the software developers or by the experts that need to validate your schema and, ultimately, populate the database. Furthermore, going a step further, you easily end up with models that may hinder, rather than promote the re-use of the modeled data in applications beyond archaeological research.

We recently had to face these challenges in the context of a research project. Its primary goal is to document and promote Cultural Heritage Monuments. The data include both archaeological sites and artefacts. Apart from supporting the basic aspects of archaeological documentation, a significant requirement for our model was to enhance the documentation in order to illuminate aspects of the monuments that usually remain unseen and to promote their re-usability for a wider range of purposes and different stakeholders, including the use in digital storytelling experiences for the visitors and in formal and informal educational contexts.

We decided to model our data as Linked Data, following the LOUD and FAIR (Thiery 2019) principles to the best of our abilities. Instead of creating our own ontology, we chose to rely on widely used models thus enhancing the connectability of our data with the cultural data already published on the Web. We chose to base our model on Europeana’s EDM ontology, with additions from the CIDOC CRM. We also relied on existing vocabularies to control the range of values of documentation fields, whenever deemed necessary. Finally, through the model itself and through continuous interaction with the cultural heritage experts in our team, we encouraged the creation of links to external resources.

An important part of the designing process was to decide how to model the enhancement of the documentation. To this end, we started by targeting user groups from disciplines that could potentially be interested in re-using cultural heritage data for purposes other than archaeology-related research. Through a series of interviews and by gathering different perspectives on the matter we recognized a common need for a simple way to bring history closer to modern life people, a way to reflect on the differences and similarities between the past and the present and to establish historical empathy. To address this need we designed our model to support these objectives.

The purpose of this presentation is to share our experience with gathering requirements to design our model, as well as present its current state, in the hope that it will provoke interesting conversations and chances to exchange opinions and gather feedback from other experts in the field on its improvement.

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ID number: 146

Towards a workflow for documenting, processing and archiving large excavation contexts on-the-fly. Challenges and lessons learnt at The Palace of Nestor Project, Pylos

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Abstract:

The use of photogrammetry and 3d documentation in research excavation is now quite ubiquitous in Mediterranean and Greek archaeology (e.g. Katsianis et al. 2017). Recording contexts in 3d produces accurate models that both enhance other forms of documentation and can provide a high-accuracy alternative to more time-consuming processes.

Photogrammetry and 3d spatial analysis constitute a key part of the excavation workflow for The Palace of Nestor Excavations (PONEX), Pylos, Messenia, Greece (University of Cincinnati). Since May 2018, the PONEX project has been engaged in the excavation of two monumental stone-lined circular tholos tombs (‘Tholos VI’ and ‘Tholos VII’), a process which has required since then almost round-the-clock work both by a core team and a rotating group of specialists. Each tomb is documented using full high-resolution photogrammetry every few days (i.e. to a degree of accuracy for which centimetre-accurate point data can be read; Loy, Stocker and Davis 2021), and the total number of models generated by the project now numbers in the 100s. These models are combined in GIS with point and polygon data taken in the field, and they are also used within the main project workflow to generate accurate sketch plans and photo-realistic sections.

This discursive paper will discuss the particular challenges faced by the PONEX project and the solutions adopted to use 3d documentation more effectively in our particular case. The first challenge is one of scale. With diameters of 12m and 8.5m respectively —and ‘dromoi’ (corridors cut into the natural rock leading to each tomb) several metres long— the tombs currently under investigation are much larger single-context excavation structures than trenches usually documented by photogrammetry in other projects. This presents challenges for producing on a regular programme a set of models that are accurate and of a sufficiently useful quality: both technological challenges (balancing processing time vs model quality) and practical challenges (needing to survey large areas of the site without disrupting the work of the excavation by the field team). The goal of the project is to process all 3d models ‘on-the-fly’, such that there is no backlog of processing left at the end of excavation seasons. This ensures that the models produced can become tools actively used in the excavation process (cf. Dell’Unto et al. 2017) —the models are not simply pieces of documentation to be archived after the end of the excavation. This paper will discuss how different software parameters and field protocols have been tested and adjusted to meet the requirements specified above.

This second challenge concerns division of labour. The PONEX project engages a highly international team, of which none of the spatial nor database team work full-time for the project. To maintain the high standards of documentation required by the project and given

the limitations on personnel time, the project has begun to compartmentalise tasks and train non-specialists to gather data or run basic data processing tasks when a specialist is not present. Field data gathered on site by non-specialists (e.g. rounds of photographs taken with a DSLR camera) can then be processed by specialists at a later date or remotely. This compartmentalised workflow has become very important during excavation conducted in the covid-19 pandemic, as it has become even more difficult to have 3d modelling specialists present throughout the whole excavation. The other challenge in this area is data archiving. The huge spatial dataset of the PONEX project must be archived regularly both as part of the regular backup procedure but also to free up processing power of the project computers. Backups and project archives are co-ordinated and stored at the University of Cincinnati: this necessitates the transferring of data both virtually through cloud-based server and physically via the shipping of backup disks. In all cases, though, challenges presented by the issue of labour division are most effectively managed by discussing and documenting process on the project’s internal discussion forum ‘Basecamp’, and through the rolling training of personnel to complete small and repeatable tasks.

The PONEX project is just one of many that now use photogrammetry documentation, but the wider implication of this case study is in demonstrating how and why workflows can be adapted according to the specific needs of a project’s scope and workforce. The balance between speed and accuracy is one that has been considered carefully in the PONEX project, such that ‘on-the-fly’ photogrammetry can be a tool actively employed within the excavation day-to-day. We will also advocate on the basis of our experience a model that compartmentalises digital excavation processes and provides training opportunities for non-specialist personnel. This is a model which we see has already worked in a research archaeology context; but we wonder whether the division between data acquisition, data processing, and data archiving by different on-site and remote-working staff might be a model that could be beneficial to rescue contract archaeology in Greece.

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ID number: 147

Integrating legacy archaeological data into an ontology based on Human Ecodynamics: the case of the NABO archaeological reports in the DataARC Project

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Abstract:

This poster explores an attempt to create FAIR and LO(U)D archaeological data by extracting information and ideas from archaeological reports and mapping them to an interdisciplinary ontology. The results of this experimental work, presented here, include a prototype dataset, conceptual mappings, the process for decomposing archaeological reports into FAIR and LO(U)D data, and a theoretical framework developed to contextualize this process which blends Latourian Actor-Network Theory and some basic ontological principles (in the theoretical-philosophical sense) drawn from Human Ecodynamics.

This experiment was carried out in the context of the DataARC Project (https://www.data-arc.org/). The project has been developing a cyberinfrastructure whose main tool is a computational ontology. We try to include in this ontology diverse conceptual models (from archaeological and historical, to ecological or geological data) from different grey sources. These conceptual models, and the data associated with them, are, in one way or another, the product of over 25 years of research carried out by NABO (North Atlantic Biocultural Organisation) and related research communities and projects in the North Atlantic area. Human Ecodynamics are of special importance for NABO and, consequently, for the DataARC project (Maher and Harrison 2014; McGovern 2014). Our computational ontology, therefore, had to be developed for representing Human Ecodynamics in a rigorous and efficient way, yet capable of engaging a broad audience.

Because the project’s ontology tries to represent knowledge about Human Ecodynamics, the different datasets in use have to be managed and interlinked in a concrete relational manner. This forces us to develop an ontology capable of representing very abstract themes while representing small details that affect these ecodynamics -all of which, of course, is interconnected.

This experiment within the DataARC Project specifically addresses the challenges of dealing with archaeological data when we, archaeologists, attempt to integrate our data as it is expressed in archaeological reports -and the reports’ underlying conceptual ontologies- with data and concepts from allied disciplines working in a Big Data framework. The problems are not only in the plain and strict sense of dealing with the mechanics of data cleaning, archival preparation, or general knowledge. Rather, the main issue is the creation of knowledge using multiple datasets that comes from grey literature sources.

In the case presented here, I aim to show how to create an archaeological dataset from eight archaeological reports from one specific archaeological site. I argue that this process is important for achieving FAIR standards, mainly because these reports are in Open Access, but

their data is not open. I further argue that with the method presented here, these legacy data, now integrated into an ontology, are more LO(U)D and also FAIRer. In making this case, I emphasize that this does not mean that they are completely FAIR, and attempt to open a debate on how to achieve FAIRer standards from legacy data.

I explain the methodology employed for creating a dataset capable of representing Human Ecodynamics knowledge from reports that do not normally make explicit the different connections for understanding this topic. In this context, I explain how I developed a dataset which is capable of being interlinked with datasets of different characters (e.g. geological or numeric data). Finally, I present the theoretical framework developed to support this process, which might open new avenues for developing powerful ontologies capable of representing complex knowledge (see Fig.). Problems such as overlappings or identifying the right number of hierarchical levels will be discussed, as well as some procedures that might help in rethinking computational ontologies.

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ID number: 148

An open-source approach for the vulnerability assessment of archaeological deposits using GPR data in QGIS environment

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Abstract:

Introduction

A specific tool for GPR data processing has been designed in the context of the project RESEARCH (REmote SEnsing techniques for ARCHaeology – H2020-MSCA-RISE- 2018 n. 823987). The project addresses risk assessment procedures for archaeological sites threatened by environmental pressures, as land-use change, land movement and soil erosion, and the creation of a Web-GIS Platform able to automatically perform the risk assessment procedures (www.re-se-arch.eu). The methodology adopted by the project required data about the depth of the archaeological deposit and the distance from the ground of its most superficial layer, in order to precisely evaluate the vulnerability of buried archaeological features to threats acting on soil (in particular soil erosion). To do so, an innovative method of GPR data processing has been designed, that can automatically recognize subsurface features depth. The challenge was to implement in a GIS environment an automatic open-source tool that can replace the manual interpretation of archaeological features detected with GPR investigation by automatically working on pixel values. The study illustrates the specific methodology adopted to automate the GPR data processing procedure. The GIS-based tool was tested in the case study of the Roman town of Falerii Novi.

Methods and Materials

RESEARCH risk assessment procedure give prominence to unexcavated archaeological heritage, focusing on main buried features, such as structures (which can be more easily identified through geophysical survey) and stratigraphy. The burial depth of structures and possibly intact stratigraphy is the principle on which vulnerability values are assigned, since the more a feature is far from the soil surface, the less it is impacted by pressures acting on it, such as agricultural activities and soil erosion. The goal was to identify an interface that represents the superficial extent of the undamaged layer affected by agricultural activities, and to assign the vulnerability values on small scale, in order to more precisely evaluate the risk for the preservation of the archaeological deposit. In our study, we translated the vulnerability assessment methodology proposed by RESEARCH into specific processing steps creating in this way a GIS workflow. The whole chain of operations was wrapped into a single process, a single algorithm, in order to make it convenient to execute it later with different sets of inputs, thus saving time and effort. The algorithm resumes the entire process of pixel-based vulnerability mapping of archaeological deposits, starting from processing raster GPR time-slices to produce the most superficial layer of the archaeological deposit, up to finally assigning vulnerability values to each pixel. The tool was developed inside QGIS platform, the most popular geographic information system (GIS), Open Source, licensed under the GNU General Public License, which is part of the Open-Source Geospatial Foundation project (OSGeo). The high-resolution GPR data concerning the site of the roman town of Falerii Novi,

recently published in open-access, were used for the first testing of this procedure (Millett et al. 2019; Verdonck et al. 2020).

Results

This automated procedure allows to produce good results in a short time, with no need for manual intervention of the user, all within QGIS environment. Usually, manual interpretation of detected features mostly concerns structures, overlooking stratifications. This algorithm allows for a very detailed representation of the archaeological deposit considered in its wholeness. It also allows for the production of detailed vulnerability maps, where vulnerability values are assigned to pixel-size areas in color scale. This level of detail ensures project RESEARCH a more reliable risk assessment, where risk is calculated on very small scale, therefore with more accuracy.

Discussion

The paper presents the specific procedure designed for producing the upper layer of archaeological deposits detected with GPR, within QGIS environment, highlighting the opportunities and obstacles of this type of procedure and approach. Further development of the tool will be also discussed, such as the possibility to fully automate the procedure for archaeological features recognition and structures representation.

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ID number: 149

Modelling future developments of historic landscape character: challenges and pitfalls

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Abstract:

The simulation of land-use/land-cover (LUC) change models tend to neglect important aspects of the investigated landscapes that make them distinctive and significant for local communities. Since the 1990s, Historic Landscape Characterisation (HLC) has contributed to recording this precious information.

The conceptual similarity between HLC and LUC classification suggested that existing protocols used for LUC modelling could be adapted for the simulation of future landscape character change. As a proof of concept, we used a revised version of the Dyna-CLUE model on the HLC of the Goksu river valley (Turkey). The preliminary outcomes of the model have been used to assess the suitability of HLC for designing and simulating future scenarios of landscape development.

In this paper we use this experience to discuss the challenges of using computer modelling to investigate historic and archaeological landscapes.

ID number: 150

Managing and analysing pictorial documentation with GIS and graphs

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Abstract:

Since its creation, archaeology has largely focused on material culture (personal ornaments, pottery, burials, settlements, etc.) with an ongoing special interest shown in the 'bel objet'. Recovered artefacts and the relations they share (spatial, temporal, typological, etc.) are documented in words, numbers, but above all pictures (drawings, photographs, 3D models, etc.). As a result, archaeology has a long tradition of technical drawing (artefact drawings, x-y ground plans, stratigraphic or elevation cross-sections, etc.). Graph theory and network analysis allow one to overcome the main difficulties arising from non-georeferenced and unscaled drawings by modelling qualitative relationships when the quantitative measurements are poor. For example, for a freehand 20th century historical map of an Urnfield necropolis, the spatial distribution of goods within the burials and the spatial relationship between the burial goods can be model with a spatialized network. Besides these spatialized networks, many other types of graphs are used (implicitly or otherwise) in archaeology. The two main ones are probably the directed acyclic graph (DAG) used to model stratigraphy (i.e, Harris matrices) and the tree-like structures modelling hierarchical relations between categorical variables (i.e, typology). Graph theory is multi-paradigm (e.g, can be used for spatial and temporal modelling), multi-scalar, and graph drawing is a well-known heuristic to communicate results. This type of modelling is currently used for linked open data (LDO, e.g. JSON-LD format).

We believe that pictorial documentation within a spatial database and with graph-based methods is one of the priorities for IT development in archaeology (package creation, shared conceptual models, best practices dissemination, open software, etc.). The recent R package 'iconr' employs spatialized networks to model prehistoric graphical content at the scale of the decorated support (pottery, wall, statues-menhirs, etc.) and favours GIS data entry. Currently, the package CRAN version allows the user to tag graphical units (GUs) with attributes and to filter the whole iconographical content when two or more chronological layers of GUs are present (superimposition, diachronic structure of the representations, etc.). The next version of the package will focus on functions to create DAGs and tree-like structures.

After an introduction to the importance of management of pictorial documentation with spatial databases and graph theory (network analysis), we will provide a critical review of DAGs and tree-like R packages available in archaeology. We will then briefly present the 'iconr' package and the planned developments in future versions.

ID number: 151

Towards discovering the similarities of regular Mediterranean cities using network analysis

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Abstract:

The paper presents the preliminary results of the research project "MA-P Maloutena and Agora in the layout of Paphos: modelling the cityscape of the Hellenistic and Roman capital of Cyprus". The main goal of this paper is to show the results of research on the similarities of ancient cities urban planning.

Based on the list of significant features like the regular layout of the most important cities from this period (e.g. the nature of the relief, the period of foundation and the terrain configuration), the model cities with the greatest similarity to Nea Paphos were selected for later inference. These cities include Olinthus and Priene, among others.

For model cities, a vector form of the street network was obtained, based on previous publications describing their reconstruction (Hoepfner et al 1984; Cahill 2013; Dietrich 2016). These networks were subjected to spatial analysis using the space syntax (axial and segment analysis, connectivity, integration and integration attributes) and network analysis (analysis based service areas algorithms) methodologies. A similar analysis with the use of space syntax tools was performed for the Roman town of Falerii Novi in Italy (Battistin 2021). The Hellenistic city of Priene, constructed following Hippodamus' principles and for which a case study was made regarding space syntax analysis was also taken into consideration (Al-Sabbagh and Gorgees 2019).

The analysis of the obtained results should allow for formulating hypotheses about the mutual dependence of most important city facilities and the distribution of the different city zones accessibility (including residential ones) to public facilities and services. The results of the analysis also should allow for the identification of spatial patterns and attempts to identify the locations of buildings that have not yet been found by excavations (but have been traced in geophysical prospections) and to determine the functions of individual parts of the city. It will also be possible to indicate to what extent the use of geospatial data and the results of the spatial analysis can support the archaeological interpretation process.

The difficulty in reconstructing the Paphos urban space is the result of the relatively small number of field studies in this area. The comparison of results of spatial analyzes for different ancient cities will help to infer the urban structure of Paphos and will be used to develop and evaluate several variants of the street system by applying procedural modelling in the

CityEngine environment. Existing reconstructions of the city street network of Paphos will also be taken into account (Mlynarczyk 1990; Miszk et al. 2020).

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ID number: 152

Medieval urban sites of Iraq in the sphere of archaeological remote sensing

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Abstract:

The political and social situation of recent years has directed Middle Eastern archaeology much more into the position of a protective component of historical heritage than before. The extensive war conflicts very often prevent full-fledged archaeological research: in many cases, the only way to document and analyze archaeological landscapes is an indirect approach based on remote sensing data (satellite imagery).

Archaeological prospection of urban sites is a specific segment that differs significantly from the more common landscape prospection. The paper will present methodological differences in the sphere of remote sensing data processing between deserted and living cities in Northern Iraq (Kona Makhmur, Mosul). In the case of deserted cities, a process (a high-definition remote sensing approach), leading from the complex site analysis and urban tissue mapping to the detailed prospection of architectural structures can be followed. The high-definition approach enables the enhanced analysis of remote sensing data using all the spectral and graphical potential of multi-temporal ordered components. The analysis is based on the complementary use of a variety of overlaid imagery, augmented by data from terrestrial surveys. The extraction of feature morphology, based on the various raster visualisation algorithms (usually used in the analysis of airborne laser scanning datasets), is an important analytical tool for highly accurate feature detection. In the case of the Mosul city, a monitoring of modern urban development and a possibility of stereo analysis and DEM extraction based on the remote sensing datasets will be introduced as a tool for documentation of heavily endangered form of the historical built environment.

The role of satellite images in the archaeology of the Middle East has been on the rise in recent years, especially in terms of the possibilities of their processing. High-resolution datasets, in combination with modern field documentation methods (like unmanned aerial vehicles), allow more extensive possibilities for surveying and documenting the geomorphological aspects of the anthropogenic features than before. The urban landscape archaeology of northern Iraq, which is based on the need to work with very high-resolution data, thus has the opportunity to move from a basic survey and site documentation to the level of creation a highly accurate and comprehensive interpretation plans.

ID number: 153

Teaching archaeological agent-based modelling through replication

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Abstract:

The growth of agent-based modelling (ABM) applications in archaeology seems to be increasing. While a decade ago Lake (2010) complained that archaeological simulations were rarely cited beyond other simulation papers, that trend seems to be shifting as well. Although there is still room for improvement, more ABM papers are published in major journals and cited as credible contributions to archaeological research alongside site reports and other types of analyses. Lake also suggested that ABM in archaeology was likely to remain a minority activity due to the lack of training in computational approaches.

Here we suggest that teaching replication of archaeological agent-based models is a way forward that accomplishes several goals including the ones mentioned by Lake. While archaeology has not been hit by the same “crisis in replication” as some other disciplines, replication of previously published models provides an excellent problem-based learning context for students learning to design and implement models. Recent archaeological ABMs tend to embrace the principles of open-science by making their code available in online repositories but many older ABMs are not available and have never been replicated. Making replication a routine practice within archaeological computational approaches, including ABM, should increase their reliability and expand upon their contributions to the discipline. Replication also teaches research methods and writing by allowing students to focus on the way research methods are communicated (Marwick et al. 2020). In this talk, we discuss the benefits of replication in more detail and present a number of replications of older archaeological ABMs which are part of a new textbook focused on teaching agent-based modelling methodology to illustrate their potential for teaching and improving the use of ABM in archaeology.

ID number: 154

Integrating 3D modelling and publication for archaeological and historical research: a 3D modelling archaeologist’s perspective

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Abstract:

Proposal for an integrated data management system to streamline archaeological and historical 3D modelling research and publication.

Archaeologists, architectural and urban historians have used 3D modelling as part of their research workflows and publication since at least the early ‘90s. Although initially the modeller and the researcher were often separate individuals, one a technician, the other an academic, these roles have increasingly merged. A new generation has risen that have mastered the digital tools as well as academic approaches to study a plethora of aspects related to the material past. A 3D modelling scholar uses 3D modelling software as the centre of his or her data collection, organisation and interpretation. This is possible thanks to the immense flexibility and feature richness of these software packages nowadays. We can write, annotate, place photos, drawings, visualise point and georeferenced data, all in this environment. But 3D modelling software is not always efficiently equipped to do these tasks, and often has limitations in managing other data types than 3D. It was never designed for our specific workflows in the first place. This means that data collection, processing, analysis, folder structure, modelling, annotation and text processing are still poorly supported or integrated. As a result, most of this para- and metadata is lost on publication, or published as disconnected files. Even if we produce an annotated model, this usually involves indicating a few highlights about the model on view. Annotation on online 3D models is more often used as a lowkey storytelling device than to provide access to the complete data set and argumentation structure behind the 3D model. But making the entire 3D model integrated with all the meta- and paradata, ready for publication, requires a considerable time investment. Time we prefer to spend on analysis and producing meaningful research output. A scholarly edition of a 3D model should therefore not just offer a standard for online publication, but also a way to smoothly integrate it with our 3D modelling workflows. In brief we need a 3D information system, similar to GIS, but with the 3D modelling program at its core. Features of such systems exist in various programs and fields, like BIM, CAD or 3D GIS, but these do not have a complete solution to match the specific workflows of the 3D modelling archaeologist or historian. Moreover, the system should have an easy export or publication function that automates the laborious process of organising and linking project files to each other and to parts of the 3D model. In this presentation I will do a concept proposal for an integrated system that allows 3D modellers to organise and link their meta-/paradata, and export it using a standardised format that can be published easily on the internet. Such a system can be efficiently developed on top of existing packages, and by modification of existing file formats.

ID number: 155

Surveying with non-humans: challenges and opportunities

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Abstract:

On the eve of automation in landscape archaeology, we need to approach AI systems not merely as (more or less) neutral tools but as a social actor with particular behavioural patterns and ecology.

The "machine behaviour studies", the study of AI behaviour, are pointing to the broad, unintended consequences of AI use as AI agents that can exhibit behaviours and produce effects that are unanticipated by their creators. One of the main risks is the so-called "feedback loop", where the systems just reproduce existing situations, existing knowledge.

Archaeological survey, which, in the most elementary form, is performed from the mobile body, which moves around the landscape (either on foot, on the flying platform or scrolling and panning the remote sensing image), and, upon encounter, identify and label the feature, the shape they have encountered. These perceptual decisions are based on many cues, including size, shape, or variation of colour and texture. The narrative then re-arranges the labels into a sequence, a narrative. The other striking about the process of the archaeological survey is its sheer materiality. Our encounter with the past is conditioned by a host of non-human agents and equipment, from the rich materiality of the landscape itself to the equipment and tools: platforms, sensors, visualisation techniques, and ultimately, the deep-learning algorithms. Human and non-human are continuously merged and mixed in the production of narratives.

Deep learning algorithms work by presenting a neural network with thousands of images that either contain or do not contain archaeological features. The system finds patterns in that data, which it then uses to decide how best to label an image it has never seen before. The network's architecture is modelled loosely on that of the human visual system in that its connected layers let it extract increasingly abstract features from the image.

This delegates the events of encounter to the non-humans, to the deep learning algorithms. The identified labels are then used as wayposts to guide the human around the landscape,

However, the system makes the associations that lead it to the recognition of an archaeological feature through a "black-box" process that humans can only try to interpret after the fact.

There are still considerable differences between what we think networks should be doing and what they actually do, including how well they reproduce human behaviour. The human visual system prioritises shape over texture. There is a link between language, learning and human preference for shapes. Humans, from a very young, are trained to associate shapes with words. We tend to perceive the world in terms of shapes that we label and name and put in a – linguistically expressed – relations with the other objects.

Recent studies of deep feed-forward neural networks behaviour are changing our understanding of they perform visual recognition. It seems that they prefer the texture over the shape. The fine-scale is easier for the system to latch on to; the number of pixels with texture information exceeds the number of pixels that constitute an object's boundary. The first steps involve detecting local features like lines and edges.

However, the preference for texture over shape makes sense, as the texture is shaped at a finer scale. Texture can be described as groupings of image segments with similar properties.

There is a rich literature that discusses the perception of textures, which is derived from Alois Riegel's seminal discussion of the haptic sense. While the optic experience is based on the spatial perception of a figure against the ground, the haptic is a quality of visual perception comparable with that of touch. It is an experience of texture and material solidity without three-dimensional visual depth.

The haptic way of looking at the landscape, thus involves a different kind of looking. When eyes move across a richly textured surface, occasionally pausing but not really focusing, making us wonder what we actually see, they function like organs of touch. The haptic visuality is lacking depth; it suggests closeness, intimacy and touch. The haptic is pre-linguistic; it does not produce definitive labels. This lack of certainty of the object, the "less complete" nature of objects require the viewer to understand the image as a material presence rather than a set of easily identifiable "features".

The textures themselves ability to characterise the fine-scale morphology and local topographic surface texture of large areas. Surface texture is strictly linked to active geomorphic and anthropogenic processes and has archaeological significance. Haptic visuality is a mode of vision that "understands materiality" and focuses on the "stuff" of the landscape rather than things or features in the landscape. Textures blur the nature/culture divide and emphasise the material and temporal nature of the landscape.

We argue that deep-neural networks ways of seeing the landscape are much closer to the haptic than optic. It is easy to assume neural networks solve tasks the way we humans do, but there are other ways of looking at the landscape. There are other ways of looking at the data, remote sensed images, and the data exert more biases and influences than we believe. The landscape texture can be a bias and noise or the information in itself.

Instead of prematurely crystalising poorly known processes of classification and recognition into "black boxes", we should focus on their internal complexity and the ways they "see" the same data. Deep learning algorithms allow us to see different and new aspects of the landscape; in this way, we can understand our human ways of approaching the landscape better.

ID number: 156

The Living Archive of Çatalhöyük: investigating the in-/transparencies of archaeological knowledge production

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Abstract:

In archaeology data are stored in ways that reflect the strategies of research, and conventional archives dedicated to the long-term storage of research data mostly solidify the original database within this initial storage logic. While recording research in rigid environments seems convenient in practice, during the lifetime of research projects, the interpretation of primary evidence changes. Along the way, some data will be scrutinized while other data may be neglected; some ideas will evolve while others will be discarded. It thus becomes difficult for later researchers with different research questions, to make sense of highly codified, static archives fossilized in their own starting assumptions. Understanding how we interpret archaeological evidence is key to understanding how our knowledge of the material past is formed.

An example in point is the data gathered by the Çatalhöyük Research Project. During the 25 years of archaeological fieldwork, research into the origins of settled agricultural life, the rise of civilization, emergence of religion and cognitive change has led to the accumulation of a dense record of multidisciplinary information: full text and taxonomically organized descriptions; specialist databases recording a range of scientific treatments of the collected material; images and geospatial information. As in other archaeological research projects, at Çatalhöyük data have been stored and processed in ways that reflect the initial strategies about how to conduct research, established when the project was originally conceived.

In response to the intricate relation of scientific knowledge and the context of its production, research at Çatalhöyük followed a ‘reflexive’ process whereby information about the project itself is incorporated into the database archive in order to allow for re-interpretation, understanding and critique. An important aspect of this approach has been the decision to ‘document the documentation process’ (Lukas et al 2018), that is to provide an additional layer of information, specifying how data have been gathered and indicating the questions that have been asked. Reflexive data include excavation sketches, video recordings containing information on the context of archaeological practice and an intra-site GIS, which was designed with the intention of promoting a series of digital practices to enhance the reflexive ethos on site (Taylor et al 2018). Although it might appear contradictory at first, the idea to add a whole new level of data to a already complex archive, this additional layer of information is best understood as a layer of transparency to render the making of knowledge increasingly accessible.

After a set of iterations, beginning with a preliminary prototype in 2015 (Engel/Grossner 2016) and a second prototype in 2017, the "Living Archive" has now been developed to provide access to the data gathered at Çatalhöyük while responding to the requirements indicated above. In order to make the genealogy of interpretation transparent, the web-application makes use of semantic modeling techniques to reverse-engineer the interpretive process and

reveal the underlying patterns in the development and/or abandonment of concepts and ideas. The datasets originally stored in distributed archives are now aggregated following the principles of Linked Open Data.

On a technical level this has been achieved by transforming the different traditional databases into a semantic database, where stored data are enriched with information concerning the meaning and role that the data have within the research project. The semantic data are stored in rdf format, organized via an owl-ontology mapped to a set of relevant domain ontologies (e.g. CIDOC-CRM, FMA, EOL) and specialist thesauri (e.g. Art and Architecture Thesaurus), hereby reflecting the multidisciplinary background of research at Çatalhöyük. As has become increasingly common, access to the data is provided via a web-application as well as a REST API.

The Living Archive has been developed for researchers as well as non-experts to examine research results at Çatalhöyük by using common, widely used definitions or ontologies, and by allowing new data to be produced from within the application. In consequence further interaction with the data and the addition of information allow for continued generation of knowledge within the same framework. In this way the Living Archive responds to the bare need to make research data available while enabling theoretical discussion of how changing assumptions and underlying concepts condition research and the production of knowledge.

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Ontological behavior modeling and reasoning to capture tool use among primates and hominins

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Abstract:

In this paper, we explore the use of a knowledge processing system based on ontologies. To contribute to current discussions on the complexity of primate and hominin tasks we explore if ontologies are helpful in illuminating external and internal planning and planning depth of tool tasks.

Hominins and primate tool use can be described in terms of the sequences of actions needed to perform the overall action, using for example Petri nets or chaînes opératoires (Carvalho et al. 2008). However, the sequences alone provide no insight into the depth and the complexity of a given task. We investigate a potential solution by the way of ontologies, that are hierarchical and relational descriptions of concepts in the domain of tool handling. Concepts such as Macaque, Quartzite, and Tool, are linked together by relations such as material, performedBy, and handMovement, but also subsumption relations: a wild bearded capuchin is a capuchin, a stone anvil is an anvil. Concrete descriptions and reconstructions of behaviour are also managed directly within the ontology using predefined concepts and relations. Ontologies thus provide structure to data obtained from literature in a unified framework that supports both taxonomical information and finer knowledge as with non-directed labelled graphs.

Ontologies and ontology languages such as OWL (Web Ontology Language) are widely used to facilitate knowledge discovery and reasoning in domains, such as medical bio-informatics (Disease Ontology, Gene Ontology, Orphanet for rare diseases), linguistics (BabelNet, WordNet), chemistry, computer science, etc. In robotic control, sequences of actions can be obtained given a specified goal to reach, after a reasoning process based on formal logic techniques used in, e.g., theorem proving, expert systems, and automated planning. We investigate the potential of modelling hominins and primates as embodied perceptual agents in a robotic system and generating such sequences of actions using KnowRob (Tenorth and Beetz 2013), a novel open-source system that has been successfully applied for, e.g., solving planning tasks in retail and handling home chores.

We built a novel ontology from published descriptions and reconstructions of lithic tool use behavior involving hammers and anvils by primates and early hominins. The hammers and anvils are used for meat, bone, nut and plant pounding (Carvalho et al. 2008, de la Torre et al. 2013). Using Formal Concept Analysis, a formal mathematical method to analyze the features of lithic tools, e.g., function, size, shape, user features, etc., we extracted a starting taxonomy of tools. This we extend to capture more complex relations between them, such as places of origin and use, and tool handling. Using KnowRob augmented with a PDDL (Planning Domain Definition Language) planning engine, we automatically extract sequences of actions and propose measures for their complexity. For instance, the existence of several sequences

of events that an agent could use to reach one goal, may be interpreted as requiring cognitive flexibility. This might be further confirmed by the distinction between tool procurement and tool use. In primates, this can be interpreted as a form of planning, e.g., carrying a heavy branch up to a tree to use as a hammer for nut-cracking in-tree.

With this paper, we explore the use of ontology and ontology-based reasoning to answer primatology and archaeology questions related to the complexity of tool use planning. We concluded that ontologies provide a human-readable, dynamic, way to handle knowledge obtained from literature.

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ID number: 158

Good digital tools do not make or break field survey - but they sure help!

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Abstract:

There is nothing better than moving to a different country when you wish to figure out who you are or how good your tools are. The cancellation of fieldwork in 2020 let us reflect on the realities of digital field recording in two recent survey campaigns.

We have been using the open-source FAIMS Mobile platform (www.faims.edu.au) for field data collection in Bulgaria since 2017 (Sobotkova and Weissova 2020). During January 2020, we found ourselves doing reconnaissance around the Archaic- and Classical-period Sanctuary of Hera Akraia in Perachora, Greece, having been granted permission a mere month earlier. The weather was unseasonably good, making intensive survey possible contrary to our expectations. We decided to document the fieldwork using an established digital toolkit from Bulgaria and observe how the new team and the digital system respond to the pressure of new environments and new fieldwork.

The benefits of the 'offline-first' system were noted immediately upon arrival at a mostly abandoned summer resort as the internet turned out to be slow and unreliable. Low-power functionality likewise proved crucial during frequent power outages. Without this particular hardware and software, we would not have been able to systematically collect field data digitally. New generation of Garmin GPSs turned out less useful as they required a good internet connection to download data. Other challenges we encountered were typical for pilot projects. We did not know what to expect, we had no established routine, our approaches were reactive and emergent. Compared to the Bulgarian landscape, the suburban setting next to a significant Classical sanctuary was littered with artefacts and features, whose precise function we were often unable to determine until further study. We adapted digital modules from Bulgaria to Perachora-specific cultural heritage and activities (Nassif-Haynes et al. 2019, Nassif-Haynes, Sobotkova, Hermankova, and Stevanovic 2020). Validation and automation saved us from errors and released us to focus on field observations, team leading, and the important task of getting everyone across the rugged terrain without harm.

The novel conditions of a pilot project were nonetheless stressful. While our reliable toolkit helped, we still needed to have an adequate skillset to administer it whilst being mostly offline. Data processing required constant supervision. Fast rotation of teams among the many different activities of intensive survey, feature verification, photogrammetry, site clearance and pottery processing kept us so occupied with devising protocols and supervising that little time remained for reflection and fine-tuning. As a result, we did not make as much progress on the study of the results as we usually did during fieldwork in Bulgaria. In Bulgaria, we focussed on a single workflow of feature registration. The amount of tasks for rotation was limited, which made volunteers quickly expert at the full lifecycle of data production. Automated data syncing and labelling released them into considerable leisure, which they filled with additional research activities. We, in turn, had been able to search for shared interpretive understanding of field phenomena (what defines a ploughed up burial mound

boundary?) and finesse the recording systems. In Greece, FAIMS helped us avoid data loss but we never had the time to study the materials whilst monitoring core data-wrangling and verification tasks.

Good choice of digital tools can do more than save our skin: robust tools can help us produce analysis-ready dataset even from a pilot project, and transform future fieldwork from hectic into a more finely managed operation, thus creating space for productive reflection by the directors and safe learning by the participants.

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ID number: 159

Stable results from spatial interaction models: was this settlement really popular?

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Abstract:

Over a short period between the fourth and the first century BC, an unprecedented process of urbanisation developed in non-Mediterranean Europe. By focusing on trade interactions, we question the links between the observed hierarchy of grouped settlements and long-distance economic flows over the territory. The aim is to assess the extent to which long-distance trade networks and the economic flows they involve may have had an influence on the emergence, the prosperity and the hierarchy of grouped settlements identified in central-eastern Gaul.

To address these types of questions despite the partial nature of archaeological data (Rhill and Wilson, 1987) proposed to use the Harris and Wilson (HW) urban retailer model. This simple dynamic interaction model estimates ‘flows’ between ‘centres’ from their geographical positions and can be used to predict the development of large agglomerations favoured by their location in long-distance traffic flows. Since this seminal work, the HW model has been applied successfully in numerous archaeological studies. For instance in (Bevan and Wilson, 2012), it is used to study the hierarchy of towns in Bronze Age Crete. Interaction models are useful in particular to test hypotheses such as the influence of a given settlement over their global hierarchy, the effects of travelling costs of interaction flows, etc.

We study in this communication the sensitivity of the Harris and Wilson interaction model to its inputs (geographical aspects) and to its parameters, in the context of a large-scale experimental exploration of the urbanisation processes of central-eastern Gaul between the fourth to the first century BCE (309 identified grouped settlements). By sensitivity we mean the tendency of the model to produce quite different results when applied to close configurations.

In the Harris and Wilson (HW) model, the flows between settlements are computed using as input the travel costs between those settlements. A simple approach consists in using straight line geographical distances as travel costs, but this disregards the actual landscape. A more realistic solution consists in computing shortest (least cost) paths between settlements, using a terrain related cost model (Bevan & Wilson, 2012). Sensitivity of the model to the position of the settlements or to their existence is a desirable feature that can be leveraged to test simple archaeological hypotheses. However least cost paths calculation involves parameters that can be difficult to set based on evidence. Then sensitivity to the variations in the paths induced by changing their calculation can be more problematic.

The HW model uses two numerical parameters. The first parameter alpha represents the importance of dominant settlements: it is well known for the HW model that increasing the value of alpha will decrease the number of dominant settlements (and vice versa), with a phase transition in alpha=1. The second parameter beta controls the effect of the travel costs on the flows: a small value of beta enables long distance exchanges while a large one reduces those opportunities. Apart from those general considerations, theoretical results on the effect of the parameters on the outcome of the model are scarce. Practitioners generally use trials

and errors to compare several configurations, using visual representations of the flows and some associated aggregated values (such as the number of terminals, which are settlements that receive more incoming flow than settlements to which they send some flow).

We propose to use a more systematic approach for exploring the results of the HW model when both inputs and parameters are varied over a large collection of possible values. Our approach is based on the use of additional aggregated values computed on the outcomes of the HW model and on the search of stable results.

For instance, we enhance the terminal based analysis used in e.g. (Bevan and Wilson, 2012). For a given geographical input (travel costs), the subset of the settlements identified as terminals depends on the numerical parameters. We extract the most frequent subsets over the parameter space and consider them as stable results for the given travel costs. In addition, we associate to each settlement its “popularity” among stable configurations: for a fixed number of terminals, the popularity of a settlement is its frequency among the sets of terminals of the given size. Using those tools, rather than considering all outcomes with say 10 terminal settlements as identical, we can distinguish between a true dominant situation with only a single 10 terminal subsets and a more complex situation with numerous comparable but distinct 10 terminal configurations. In the latter case we can identify “super” terminals: settlements that appear in all of the possible 10 terminal configurations.

Using the proposed methods we study the sensitivity of the model with respect to its parameters but also with respect to its inputs. We use bimodal least cost paths to compute travel costs between settlements, integrating both terrestrial movements and fluvial ones. We compare results obtained with and without the fluvial mode, as well as the effects of the parameters of the least cost path calculation themselves (for instance the cost of embarking on a river).

Our experiments confirm the sensitivity of the model, in particular regarding the variability of the terminal subsets even for a fixed number of terminals (see e.g. Evans and Wilson, 2013). They also show important effects of variations in the input. As expected, including fluvial transport changes significantly the least cost paths and as a consequence the results of the HW model. More subtle modifications, such as changing the ratio between the downstream fluvial cost and terrestrial costs can also have large effects on the results. Interestingly, most of those effects do not manifest on simple aggregated metrics such as the number of terminals, but are only visible when we focus on stable terminal configurations.

Our work confirms the need for a systematic exploration of the parameter space of the Harris and Wilson model (and of related models) beyond simple diagnostics based on aggregated values. We show also that travel cost models can have a strong effect on the results. A systematic exploration of the parameter space of those travel cost models is therefore also needed.

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ID number: 160

On the calibration of least cost path models: a large-scale simulation of boat and wagon transport in late Iron Age Gaul.

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Abstract:

The explosion of medium and long-distance contacts at the end of the Iron Age reflects major economic changes and the emergence of European societies increasingly dependent on trade. However, beyond the numerous discoveries of products of distant origin and a few textual indications (by Strabo, Diodorus of Sicily or Caesar), we know very little about the concrete organisation of these exchanges, the routes taken and the flows of people and goods that travelled through them.

In order to bring new elements to the understanding of the modalities of these ancient exchanges, we seek to estimate realistic costs of transporting goods between the Gallic agglomerations on the basis of their location in the landscape. To do so, the classic solution consists in approximating the transport network by the set of least cost paths (LCP) between the sites based on the constraints of geographical space (relief, wetlands, etc.).Such routes must, however, take into account the multimodal nature of old transport, linking land transport and inland waterway transport on navigable rivers. The aim of this communication is to present the methodological contributions of this work in the framework of least-cost path analysis.

The study area is located in the centre-east of Gaul (260,000 km²), and the paths that run through it are reconstructed using a digital terrain model with a resolution of 90 m. Different time slices are used to reconstruct the connections between the 309 grouped habitats identified in central-eastern Gaul between the 4th and 1st centuries. BCE.

The land portions of the least cost paths are calculated from the cost function proposed by I. Herzog (2013) for wheeled vehicles. Inland waterway transport is permitted on the navigable sections of the main rivers of Gaul, differentiating between upstream and downstream navigation.

The articulation of costs between these three transport possibilities is addressed through the transport cost ratios proposed in the literature (De soto 2019, Scheidel 2014). However, the literature does not provide any indication for estimating the costs of changing modes: (dis-)embarkation and river crossings.

Uncertainties related to parameters (e.g. costs of changing modes) and methods (e.g. method of calculating directional or smoothed slopes) are investigated using complementary procedures :

- By comparing the calculated paths with a set of control sites (newer, smaller or badly dated sites). The hypothesis is that some of these sites may have developed close to some of the paths that we are trying to reconstruct.

- Through the systematic use of sensitivity analyses, which make it possible to specify the behaviour of each parameter and the influence of their modification. We introduce several aggregated comparison metrics to highlight differences between the sets of paths computed for each configuration of the parameters. These analyses allow us to identify ranges of insensitivity of the model to the parameters, to exclude ratios which induce unrealistic behaviours and to identify plausible ratios.

An added difficulty is the inherent coupling between those parameters. For instance, the river crossing cost is not independent from (dis-)embarkation costs: if the crossing cost is too high, LCP will simply embark and then disembark to cross a river. Another typical coupling is between (dis-)embarkation costs and terrain to river cost ratios. Indeed an increased interest of fluvial paths should be compensated by a comparable increase of (dis-)embarkation costs to avoid LCP with multiple short river segments or LCP with unreasonably long detour to catch a river.

This work brings new elements to some of the still very topical challenges of least cost path calculations, such as the consideration of several modes of transport and the development of calibration procedures for certain parameters.

The costs of transportation on these reconstructed paths are then used for the restitution of the extent of economic interactions between the conurbations at the end of the Gallic Independence. Taken together, these models provide new insights to assess the level of economic integration of these changing societies.

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Developing an efficient and “sustainable” method for 3D stratigraphic documentation: issues and advantages of a digital process. The case study of the medieval site of Vetricella, Italy

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Abstract:

Developing an efficient and “sustainable” method for 3D stratigraphic documentation: issues and advantages of a digital process. The case study of the medieval site of Vetricella, Italy

Since 2016, the ERC nEU-Med project, headed by the University of Siena, has conducted extensive excavation activities on the site of Vetricella, located in the plain of Scarlino (southern Tuscany, Italy). Vetricella was an early medieval fortified site made of perishable material features, dated to between the 9th and 11th centuries AD, and characterized by three enclosing circular ditches.

Three excavation campaigns have been conducted applying various fieldwork strategies which included, alongside the main method of single-context excavation, numerous trenches and test pits opened in selected areas of the site.

3D stratigraphic recording was carried out extensively with digital photogrammetry, documenting more than a thousand contexts over a 2.500 square meter area. The choice of employing a 3D method for stratigraphic documentation as the main form of archaeological documentation presented a series of theoretical and practical issues which will be discussed in detail.

The main purpose was to develop a standardized methodology compatible with the strategies, timings and needs of the excavation, without overlooking important archaeological aspects such as data accuracy, reliability for successive post-excavation analysis and the chance to generate data for more rapid on-field interpretation.

The central element of the methodology is the stratigraphic unit (SU) which is the smaller feature forming the stratigraphic deposit; each SU was recorded separately with a specific 3D model, assisted by precise on-field boundary detection. Offering a higher level of detail to the stratigraphy allows for a better representation of the complexity of the stratigraphic and spatial relationships, although this practice increases the time needed for data acquisition and processing.

We experimented a method to balance the use of 3D models at the trowel’s edge. This has contributed to the transferal of significant archaeological interpretations from field evaluation process to 3D models in the digital environment, while keeping the times necessary for the processing of documentation compatible with the needs of a such large and complex excavation. This task, accompanied by a total station to assist archaeological interpretation measuring a trail of points tracing the unit’s boundaries and the relevant archaeological

features, was achieved by processing every SU during fieldwork activities. At a second stage, points will be used as guidelines to perform model cutting and interpretation in the process of post-fieldwork record management without losing the relationship between the relevant on-field interpretation phase and the digital environment documentation.

A further issue arose as to how to incorporate such a highly specialized form of documentation in a working environment composed of students and researchers often unaccustomed at handling such technologies. The procedure was therefore divided into sub-tasks: one that could be managed by field archaeologists and others carried out by qualified staff. Task separation allowed to speed-up the data-acquiring process, redistributing the workload without losing data accuracy and reliability, while at the same time enabling the use of this form of documentation even across such a large-scale excavation area divided into several working sectors.

Another important issue that influenced the development of this methodology was the possibility of obtaining volumetric data from the generated models. In fact, models created with digital photogrammetry are 3D surfaces that register the physical discontinuities in the stratigraphic record. By using the surfaces as input data in the digital environment, it is possible not only to reconstruct the physical space occupied by each context but also to calculate its volume. Conventional documentation standards require the production of cross-section profiles, but the visual reconstruction of the volumetric space occupied by each SU is much more effective in displaying the stratigraphic sequence for research purposes and in inspecting the spatial relationships between the models. Two different procedures for volume calculations based on 3D surfaces will be explored and compared in terms of accuracy, quality of the visual outcome and timing.

The first method is based on “watertight meshes”, elaborated by extrapolating the upper and the lower surfaces of each SU. Unlike methods that use polygon extrusion between surfaces, watertight meshes are more suitable to represent irregular shapes and complex stratigraphic relationships, as for example in the case when contexts do not perfectly overlap. The second method relies on 2.5D volume calculations with raster method, which does not result in a visual product but rather in the sole volumetric measurement. This method is particularly time efficient and may prove useful when dealing with several calculations for analytical purposes only, while at the same time maintaining a high degree of measurement accuracy.

From an analytical point of view, volume can be introduced as a further variable when comparing SUs with substantial difference in extension, as for example in the case of trenches defined by arbitrary artificial sections, providing also additional support to archaeological interpretation.

By relating the number of each context’s finds with its volume we can obtain a “find density”, a value that is totally unrelated to the size and the extent of the contexts and helps formulate hypothesis on the formation processes of each context. Find density value was calculated for the MNV (Minimum Number of Vessels), producing information to support the current stratigraphic interpretation in relevant excavation contexts. Using 3D models, it was possible to obtain this value with a high degree of accuracy even in challenging situations such as irregular shaped SUs, for which calculation accuracy is crucial.

The case study of Vetricella has demonstrated that it is possible to develop a fully digital documentation procedure for SU in complex large-scale excavations. This application has introduced a number of innovative solutions that make the procedure not only feasible but also sustainable when compared to the needs of the archaeological excavation, without losing the relationship with the archaeological interpretation that takes place in the field. The 3D models enable the reconstruction of the volumetric space of the SUs, highlighting complex spatial and stratigraphical relationships within the deposit. Furthermore, the volumetric measurements obtained by making use of a rapid fast-processing procedure have contributed in generating valuable information in support of the archaeological interpretation.

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3D shape of past human activities: the paradigmatic example of mining landscape

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Abstract:

Introduction

Mining archaeologists are field researchers who, by studying the activities of exploitation of mineral resources, reconstruct what is missing in the landscape. We individuate that lost positive element from its negative matrix left to investigate, in other words, that bite out of the cake.

When we talk about mining and quarrying in the past, we shall imagine one of the most impacting human activities. Its outcome is still tangible as a 3D presence, made of absences. That is why the application of 3D modelling helps at the cognitive transformation of the empty space left into the ancient exploitation action, in terms of volumes, type of activities and socio-economic environment. This makes mining archaeology very complex. Furthermore, the mines themselves have countless variabilities, connected with the geology, the kind of mines (subterranean or open-cast), and dump heaps, which are the most concrete testimony of the exploited and translocated material. Besides the direct traces of ancient exploitation, the necessary infrastructure, like settlements and routes, impacted the landscape.

So mining archaeology is a type of landscape archaeology that shall be mainly beneficiated by a systematic application of 3D modelling, declined in macro and micro-scale. The topography of a 3D model of the mining landscape tells a lot about the morphology, size and type of exploitation activities. Furthermore, the use of 3D models of underground structures helps to imagine the development of the structure in the depth of the rock by making it a transparent medium. Also the mining tools are tricky items, often very raw, almost only stones with traces of use, whose identification depends on the level of experience of the researcher's eye. For their characterization, the identification of raw traces left on their surface by hammering, grinding etc., is crucial, and 3D modelling helps in their reading. A meaningful 3D model summarises its relevant characteristics, so an enhanced representation of it, free from the non-significant elements. The same can be said for the tool traces left on the walls of the mines: the study of their distribution and angulation in the high-resolution 3D model helps to understand the gesture and the tool of the miner.

In the past, the mining archaeologist was also a technical surveyor who made the effort of reconstruction with the support of analogue methods using 2D-planimetry and -sketches and profiles. However, the three-dimensionality can currently be rendered in georeferenced space, supporting the archaeologist in converting spaces into digital outputs and requiring them new geomatics and computer graphics skills. In this transition, we are currently working: mining archaeology is the frame of action while the systematic use of 3D methodologies is the tool.

Methods and materials

The study of ancient mines and quarries must be addressed preliminary with field investigations. During the field surveys, the structures are recorded and documented with analogue and digital methods (GPS, measurements with distance-meter, total station when possible, sketches). Besides these methods, which create 2D outputs, the 3D-documentation became standard practice in mining archaeology in the last years. An expensive device is the 3D Laser scanner, while a cost-effective method that does not require the use of specific equipment, other than the camera, is SFM, which is very versatile, especially in narrow undergrounds. The case studies of 3D spatial analysis on exploitation structures, tool marks and stone tools come from different mining and quarrying areas in Europe and Western Africa.

LIDAR and aerial/ satellite photogrammetry are widely used for the small-scale study of mining landscapes in disparate fields. The example of the exploitation of local tuff in Rome in Roman times, where the urban texture is currently fully covering the residual traces, will be discussed. Several DEMs from a dataset of historical photograms will be compared with more recent DEMs from satellite images to understand the evolution of the local morphology.

Results

The 3D spatial analysis aimed at the study of details in microscale is applied to understand the interrelations between tools and tool-marks at the walls. The shape and direction of tool-marks allow reconstruction of the kind and form of the tools and their use. Conversely, the study of working traces on the stone tools enables the comprehension of their function.

The spatial analysis of models of underground structures aims to understand the exploitation technique and gather hypotheses of chronology.

Digital models, especially 'historical models' of the terrain of large areas, for the representation of the mining landscape in currently urbanized areas will be presented to discuss their altimetric quality assessment. Furthermore, the use of the models in evaluating the type of exploitation allows obtaining technological information.

Discussion

In this contibution, we want not only to state the importance of using 3D spatial analysis to interpret interrelated elements in mining archaeology, but we also want to discuss further development proposals. The efficacy in the distinction between natural and artificial marks on stones, already aided by the modelling, would gain additional bettering of performance by applying machine/deep-learning. This method can be employed only for repeatable classes of traces, for creating simplified groupings of types of tool marks on the walls. Regarding stone tools, this technique would help distinguish between a simple stone and a tool. It would help to strengthen interpretative hypotheses, which are very often subject of discussion, about the utilization function of the "ugliest" tools. 3D spatial analysis for landscape cannot be easily supported by artificial intelligence, as there is no actual repeatable structure in mining landscapes. Customized approaches in the study of local morphologies, for example, by the use of special visualizations of DEMs, would support the classification of a different kind of structure in the model and the unravelling of the distribution of varying mining activities (exploitation, separation, pyro-metallurgical processing and other related activities). In our opinion, a critical, non-generalized, reasoned application of such digital approaches to specific questions will help to decrease the level of ambiguities in this discipline.

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ID number: 163

Patterns of Trauma - A proof of concept using AI to distinguish interpersonal violence from accidental injury

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Abstract:

There has been much hype on the use and applicability of Machine Learning and AI but it has rarely been applied in bioarchaeological research. The classification of patterning in human remains is complex and often more conventional methods (e.g. cluster analysis) do not provide enough statistical power. Furthermore the application of spatially constraint algorithms is often complicated and much of the original multidimensionality of the data is lost. So far, only Machine Learning and AI are capable of not only recognising but also generalising patterns in a sample and are especially useful if data is unstructured, ambiguous, and clear parameters cannot be defined. Their power derives from a sufficiently large tagged training dataset which is evaluated. They generate models based on known attributes and organise themselves by iterative steps to increase their sensitivity in order to predict more accurately.

In our proof of concept we analyse a dataset of bioarchaeological cases of violent and accidental injury patterns. This task is often undertaken by pathologists and osteologists and therefore a reliable tagged dataset can be produced.

Skeletal reports across time and space were compiled in order to generate a bioarchaeological database of trauma. Due to availability issues reports from Great Britain are overrepresented in the sample, as the Wellcome Osteological Database was a primary source. Furthermore individuals from war related contexts were specifically targeted in order to gain a deeper understanding of patterns of sanctioned violence across time. Where possible, homicides were also included as non-combat related interpersonal violence often displays more random aggression and is commonly represented by blunt force trauma and -depending on the region-projectile trauma. Similar patterns can be observed in cases of physical abuse and human right violations, however individual reports are very rare. The methods were tasked to distinguish individuals having suffered from interpersonal violence from those whose fractures were most likely of accidental origin. This distinction is of great concern to forensic pathologists, however archaeological data allows for a proof of concept without the usage of sensitive information of contemporary human remains.

Only articulated assemblages presenting the data per skeleton were included. A statement of the bones present at the time of analysis was not mandatory. Whilst previous studies by the main author indicate a medium effect size if crude instead of true prevalence is used, it was statistically insignificant. Therefore data entry made no note of the preservation of an individual but stated estimated age at death and sex, trauma location as well as type, the involvement of lethal violence, cause of death (if known), presence of canonical burial, burial context, time period and location. All types of trauma, including soft tissue trauma (avulsion and ossified haematoma) and fracturing trauma (blunt, sharp and projectile force as well as

compression and fractures of undetermined origin) were included. Surgical interventions were excluded. The data was stored in a categorised colum format as an R tibble, however the entire dataset as well as sub-sets were converted to binary values to perform the analyses.

The collective features and known properties of the graves sites and individuals can be matched in order to generate new knowledge on fracture patterning.

We intend to use several Machine Learning Models, as the data used for these models is not in the form of that of financial institutions, the data we have is neither clean nor truly big. As a result, we will use ' opaque' and 'transparent' techniques in synergy with osteological interpretation.

Using a range of machine learning methodologies - 'opinions' - with this type of data, it becomes explorative and heavily involves human experts, which will be crucial in moving collaboration forward between digital and traditional humanities. Previous attempts and possible frameworks (e.g. Vellido, Martín-Guerrero, and Lisboa 2012) to integrate interpretability of machine learning have been explored, it is our hope that this methodology will serve as an exploration and calibration against those working in the field and the archaeologist.

The database serves as a tagged data set to test several Machine Learning models, initially Generalised linear models and decision trees- which both have higher interpretability and 'transparency'. We will also use Random Forest techniques (bootstrap aggregated decision trees) and other more 'opaque' algorithms. We hope that the "stack" of learners in this preliminary study will be able to spot context and patterns which will be useful to archaeologists inferred from previously categorised site data.

Whilst differences in age and sex are more commonly examined as further line of evidence in the evolution and chance of scales and structures of social organisation, the investigation of non-accidental injuries in bioarchaeological samples is more complex than in forensic cases. No specific pattern can be considered fully diagnostic (e.g. Love 2014) and the different expressions of direct and indirect trauma allow to transition from a mere pattern analysis to the possible detection of interpersonal violence. Machine learning is a methodology to spot patterns in data that may be missed by humans - spanning large numbers of cases or with subtle patterns. It is here where we can use these methods to help researchers uncover and explore new hypotheses.

If an AI in our proof of concept is capable of replicating this divide between accidental and lethal interpersonal violence because the cultural and temporal preferences for assault (e.g. Martin and Harrod 2015) are different enough, the project aims to expand its transdisciplinary research to the distinction of patterns of interpersonal violence.

We also hope this study can demonstrate the use of machine learning techniques in a “pinch of salt” manner, where things are taken with context and provide models that will give some perspective on individuals. We however will readily concede that these will not be perfect.

It is our desire that we can use such a multi model methodology to aid Archaeologists in spotting patterns in data. We could look at also issuing the user with similar sites, which the archeologists can review and see if these are relevant to the situation at hand. With all the flaws and assumptions of Machine Learning it is still possible to use this tool to spot patterns across large data sets and draw subtle insights and understanding.

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ID number: 164

Evaluating an Ancient Landscape Using Remote Sensing: The Kotroni Archaeological Survey Project (KASP)

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Abstract:

Introduction: background

KASP is a survey project initiated in 2019 under the auspices of the Greek Archaeological Service and University College Dublin (Andrikou et al in press; in prep A, B). The project explores the Aphidnian landscape, encompassing and surrounding the citadel (Kotroni) near Kapandriti and Lake Marathon in Attica, Greece. It systematizes piecemeal information about the landscape and non-destructively augments the record by means of historical documents, intensive survey, remote sensing, airborne LIDAR, geophysics, and geological/geomorphological analysis. Its goals are to enhance the archaeological record through detailed documentation and to expand it by placing the citadel in its broader environmental, topographic, and regional context.

Methods and materials

We used multispectral and panchromatic satellite images from Google Earth©, Landsat 5 TM, Landsat 7 ETM+, Sentinel 2A, Sentinel 2B, Orbview and Worldview-2, some of which had been acquired earlier as part of a Digital Globe Foundation grant. Archive grayscale aerial images (1962, 1970) were procured from the Hellenic Cadastral Service. Ready products were also used, such as the CORINE Land Cover dataset (2012, 2018). A temporal analysis at a four-interval was selected for visualization purposes. To better understand landscape changes through time, we also carried out visual interpretation of the archive aerial images of 1962 and 1970. Subsequently, vegetation properties were extracted using the very high-resolution Worldview-2 imagery (0.46 m). The Normalized Difference Vegetation Index (NDVI) and the Tasseled Cap transformation (K-T algorithm) were utilized. The last step of image analysis was the characterization of vegetation and soil proxies used for the detection of buried archaeological remains.

We also acquired airborne LIDAR data with an approximate density of 35 points per m2, a first for Greece. The data were processed using the package LAStools, firstly by tiling the data into 0.5 km2 blocks using LASTile, incorporating a 10 m buffer at the edge of each tile to counteract edge effects. Tiles were processed using the package Relief Visualization Toolbox (RVT). Conventional hillshades were prepared in QGIS and visualized through the construction of a virtual raster. RVT was used to create 16-direction hillshade, SkyView Factor and simple Local Relief Model tiles using default parameters. Following best practice, potential archaeological features were mapped using a combination of visualization methods, primarily a semi-transparent sLRM overlay draped on either the SVF or multi-direction hillshade in a grid-wise fashion.

Hundreds of high-resolution aerial images (~230 MB each) were acquired in tandem with the LIDAR data. They served as the base data for initial photogrammetry processing using Agisoft Photoscan. After camera alignment, a sparse point cloud of raw three-dimensional data was created. From the two-dimensional photos, points in three-dimensional space were created to provide the base data for the site terrain. After the sparse point cloud data was generated, the dataset was refined through iterative optimization of interpreted camera positions and point generation to produce a dense point cloud data consisting of the high-resolution raw three-dimensional data. From this data, a meter-resolution mesh model with applied photo-quality color texture was generated.

Results

No significant urbanization or land use changes or building were attested. During the period 2012-2018 there are some land cover changes, from sparsely vegetated areas (2012) to transitional woodland-shrub (2018), and from sparsely vegetated areas (2012) to sclerophyllous vegetation (2018). The historical imagery is invaluable, depicting the condition of the citadel prior to the construction of the road leading up to a chapel there. Several linear features can be seen on the west, southwest and south slopes. The condition of the Agioi Saranta area before that chapel was renovated and of the tumulus area can also be seen. These historical images demonstrate dramatic change in landscape cover since that period. While the construction of the dam in 1927-1931 flooded an 100-800 m wide zone on either side of the Marathon river and undoubtedly boosted vegetation in the surrounding areas, the sparsely vegetated appearance of the Aphidnian landscape in the 1960s-1970s is probably also to do with livestock grazing. The highest NDVI values (seen as blue/dark green) and the RGB pseudo-color composite corresponding to brightness (red), greenness (green), and wetness (blue) helped identify drainage zones and areas that were off-limits to field walking during the intensive survey. Interesting initial results include a sizeable rectangular structure on a spur immediately southwest of the citadel probably less than 1 m below the surface. A circular form was also identified east of the known tumulus upon histogram enhancement and filtering. Most importantly, the NDVI and the historical aerial images combined confirmed the location of Sam Wide’s Middle Bronze Age tumulus.

The majority of the features mapped using LIDAR were linear remains, including a large number of terrace fragments especially in the region of the citadel, but also on other hilltops in the area of data available. Some of these were extremely well-preserved and most likely recut from earlier features. However, others hidden in dense vegetation are likely to be of greater antiquity. Initial desk-based inspection identified several possible structures, including subtle rectilinear anomalies north of the lake. A series of small knolls near the tumulus may indicate additional funerary mounds in that area.

Discussion: implications

These data in combination, made available on a cloud GIS on tablets, serve as a springboard for forming and testing hypotheses in the field. We have used the data to query natural outcrops, terraces or possible archaeological structures possibly concealed by vegetation ahead of intensive surveying. The LIDAR data especially proved invaluable in getting insight on terrain covered by thick vegetation during fieldwork (namely the citadel slopes where habitation on terraces is reasonably expected, especially along the less precipitous east and higher south slopes). We will continue to refer back to imagery as the survey progresses and the distribution of finds and architectural remains are explored in more detail. The ultra-high resolution terrain model has also been used to formulate and test hypotheses about detected or suspected archaeological sites in the landscape as field exploration continues.

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ID number: 165

Only the end justifies the means: past and future practice of landscape archaeology and analytical earthwork survey

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Abstract:

In the past few decades advances in surveying technology have brought enormous benefits in terms of ease of achieving accuracy and rapid coverage of large areas. But it is crucial that these – sometimes expensive – technologies are used proportionately and appropriately. Most importantly, we must ensure that they achieve the results that we, as archaeologists, require – that they lead to better understanding of the physical remains of the past, the traditional goal of landscape archaeology and analytical earthwork survey (Bowden 1999; Historic England 2017); this may be an obvious statement but it is one that we have to bear in mind. To that end we must also ensure that new generations of archaeologists are properly trained to undertake survey to the highest standards.

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ID number: 166

CAA-GR online community practices during the pandemic: Outcomes of the first series of online roundtable sessions

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Abstract:

After the postponement of the regional CAA-GR conference in 2020, due to the COVID-19 pandemic, the board of the Greek National CAA Chapter organized a series of weekly online roundtable sessions (1 ½ hours duration each) that ran during October 2020 [1]. The invited speakers and the participants had the opportunity to exchange knowledge and experiences on digital archaeology in the Eastern Mediterranean and their vision on future directions.

This paper summarizes the outcomes from this series of online ‘sessions’. The sessions provided the opportunity for the CAA-GR to bring its members together; albeit virtually, providing them the floor for interaction and discussions among them, thus allowing their experiences’ sharing, highlighting, at the same time, related problems, and solutions. The sessions’ platform became a knowledge transfer tool of expertise for the speakers and the participants. Most importantly, the sessions gave the floor to all experts and practitioners in the domain, regardless of their not being members of the CAA-GR, thus bringing together ideas from all around the world.

The focus of the first online session, entitled Research and Innovation, included topics such as the level of digital scholarship in educational institutes, challenges in adopting digital curricula, managerial problems in digital projects and how to tackle them. In the second session, the focus shifted to Foreign Missions and Projects, and particularly on conducting or managing digital archaeology projects in an Eastern Mediterranean country. In the third session on National Policies and Directives, the participants discussed the impact of digital transformation and how states evaluate archaeological projects, particularly large-scale projects, and how and why state archaeological services and departments adopt some digital tools and reject others. In the fourth session, a Synthesis of all discussed topics was conducted, and included an open discussion on how digital archaeology will/should be a part of the future of Eastern Mediterranean.

Regarding the statistics of the ‘sessions’ event, approximately 100 participants enrolled and participated at least once in a session. The primarily targeted countries, Greece, Cyprus and Turkey dominated the presence but there was also significant participation from the USA, UK, Austria, Italy, Germany and also Australia, Canada, France, Hungary, Ireland, Lebanon, Pakistan, Poland, Portugal.

The board of the CAA-GR would like to express its sincere thanks to all invited speakers and the participants for their support during this series of online ‘sessions’.

[1] CAA-GR 2020 Sessions – “Greece, Cyprus, Turkey”, 9, 16, 23, 30 Oct. 2020. Current Status and the Future of Digital Archaeology in the Eastern Mediterranean, https://gr.caa-international.org/2020/09/24/caa-gr-2020-sessions-greece-cyprus-turkey/

ID number: 167

Copernicus Earth Observation and Big Data for Cultural Heritage Management

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Abstract:

ince 2015, the Sentinel-1 and -2 sensors systematically provide radar and optical images, that can be accessed and processed by the end-users. This initiative is strongly supported by the European Commission, and a free and full open access (FFO) policy is applied. However, the use of these satellite datasets has not yet fully adopted by the archaeological community. This is partially due to the lower resolution of the Sentinel and other similar sensors (in comparison to the high-resolution optical satellite data, and the different demands of the end-users. Nevertheless, this is a unique opportunity for the archaeological community to gain access into an extensive multi-temporal satellite repository. In this respect, big data cloud platforms are essential for facilitating these images' processing.

This paper presents, through various applications, the benefits and limitations of multi-temporal change detection analysis using multi-source radar and optical medium resolution satellite datasets for supporting heritage disaster risk management cycle. In specific, the use of Sentinel-1 and Sentinel-2 sensors and Landsat images are processed in the Google Earth Engine cloud platform. The analysis includes a temporal trend investigation over archaeological sites in Cyprus, through integrated harmonized Landsat observations (Landsat 5 TM; Landsat 7 ETM+ and Landsat 8 OLI), as well as supervised Random Forest classification for monitoring urban sprawl and land-use changes. Vertical sprawl over the archaeological site of Amathus in Cyprus using the Rapid and Easy Change detection in radar TIme-series by Variation coefficient (REACTIV) algorithm, are also presented. Finally, disturbance mapping and multi-temporal vegetation indices and Tasseled Cap coefficient trends are provided.

The results of the research here presented make part of an ongoing project, entitled "Copernicus Earth Observation Big Data for Cultural Heritage", in short NAVIGATOR (under the grant agreement EXCELLENCE/0918/0052). The project investigates novel methodologies for monitoring natural and anthropogenic hazards, employing Copernicus and other related satellite products, and using big data cloud platforms. Overall, the use of satellite data as a tool that provides support to archaeological challenges, is highlighted.

ID number: 168

ArchaeoCosmos. Historical Geography of the Mediterranean and the Near East from the Prehistory to Late Antiquity

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Abstract:

The ArchaeoCosmos Portal is a hub where parallel and collaborating research programs of the members of the Department of History and Archeology of the National and Kapodistrian University of Athens (Greece) and other researchers are hosted, with an open philosophy and structure. It is being implented on ArcGIS Enterprise and PostgreSQL. Its main aim is to create an interactive digital map, which will eventually contain all archaeological sites (from Prehistory to Late Antiquity) in the Mediterranean area and the Near East. Already a total of 33,669 sites have been edited and reviewed. Since 2020 ArchaeoCosmos is part of the Center of Excellence "Digital Humanities" of National and Kapodistrian University of Athens (Greece).

ID number: 169

Virtual Vaka: A Computational Tool for Thinking About Seafaring

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Abstract:

Seafaring has had a profound impact on human history and is a fundamental component of many narratives of the deep past. But while ancillary signals of seafaring are widespread in the archaeological record, direct evidence for ancient seafaring technology and knowledge is scarce, leaving a great deal of uncertainty about past maritime activity. This uncertainty lends itself to a model-based approach, which is manifest in a long history of computer simulation studies of ancient seafaring, particularly in the Pacific (e.g. Levinson, Ward, and Webb 1973; Irwin, Bickler, and Quirke 1990; Fitzpatrick and Callaghan 2013; Montenegro et al. 2016). Changes in data availability, computing technology, and modelling philosophies have shifted the role of computational modelling in the historical sciences (Bevan 2015), encouraging a diversity of approaches to address a wider range of questions at an increasing scale and complexity.

Here, we discuss our efforts to develop computational models of seafaring in the past as ‘tools to think with’ (Davies and Bickler 2015; Davies 2018): technologies that can be deployed in the iterative process of theory-building. We describe the latest version of our agent-based simulation, Virtual Vaka, with a new on-line capability can be used to send vessels out with a variety of navigational and technological capabilities anywhere on the globe. The model draws on environmental data obtained from a range of open sources, allowing for exploration of voyages using real weather conditions from the last 70 years, while also maintaining the capacity to use modelled data for both weather and bathymetry to simulate past journeys as far back as the Pleistocene. Drawing on multiple case studies, we illustrate how the simulation can be accessed by a user-friendly, web-based interface for use and adaption to a range of projects. By keeping the software scalable and flexible, this project provides a space for researchers to explore ideas about seafaring in the past.

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ID number: 170

LiDAR and RGB airborne orthophotos coverage and visualization and automatic recognition of archeological findings in Kephissos /Phokis

Christos Kontopoulos

Abstract:

Abstract

In 2016 the landscape archaeological program “Topographic investigations in the Kephissos valley (Phokis)” started as a joint collaboration of the DAI with the Ephorate of Antiquities of Fthiotida and Evrytania. The integrative collaborative program includes, besides archaeological investigations, aerial imagery (LiDAR, analysis of historical aerial photos), geophysical surveys and geomorphological investigations. In 2018, via a funding from the Fritz Thyssen Foundation, the whole area under consideration around Elateia, Tithorea and Modi (around 145 sq km) was covered with LiDAR and RGB airborne orthophotos, the largest LiDAR coverage of an area up to now in Greece. The visualization, recognition and interpretation gave valuable information on new findings of human made structures (urban, fort, man-made and horizontal fields). For the LiDAR and all imagery photogrammetrical processings have been implemented resulting to the orthoimage production. 1278 processed images were used. The orthophotos for the complete AOI were generated after the exploitation of the LiDAR point clouds as the reference DTM. This exploitation maximizes the resulting accuracies as the measured LiDAR points provide the best Ground surface model available. The resulting orthoimages were combined to a merged orthomosaic and then tiled to the 500x500m map sheets. The mosaic generation procedure includes many radiometric and geometric filling processing steps for the best optimized result. The resulting tiles orthomosaics and LiDAR point clouds were then combined to produce the final RGB-Coloured point clouds, coming again to 500x500m map sheet blocks. The GSD was set to 0.08 m. The deliverables set include:

- the resulting orthoimage of the complete area of interest
- orthomosaics tiled, named and distributed in blocks of 500x500 m
- coloured LiDAR point clouds tiled, named and distributed in blocks of 500x500 m

The point clouds were subsequently processed to various DEM-based derivatives of 1x1 km size, most notably Multi-Hillshade and Simple Local Relief, and all the informations including the orthoimages, the rectified historical aerial photos etc. integrated into a GIS. Thus >2.700 anomalies possibly relevant to archaeological features were identified, most of them unknown and difficult to see via regular ground surveys due to dense vegetation or other physical barriers. The sheer amount of possible archaeological structures will keep archaeologists busy for the coming years, verifying their relevance and investigate them further.

ID number: 172

Reflecting on the use of facilitated dialogue to support user centered design in digital heritage

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Abstract:

User-centred design (UCD) as a methodology has been integrated in the workflow of product designers and marketing professionals. UCD is described as a “multi-stage problem-solving process that not only requires designers to analyze and envision the way users are likely to consume a product, but also to validate their assumptions with regard to the user behavior through testing” (EduTech Wiki 2016). UCD is an essential approach for designing experiences for the cultural heritage sector. Experience designers need to employ UCD in two phases: while co-designing with heritage experts and whilte validating with the end users. Dialogue as a key aspect of the design process is not a new concept, as previous works (Lopes 2006) have explored the notion of design understood as a process of dialogue and explicit knowledge sharing between designers and users, “a communication process between all the participants and elements of design” and “a conversation between designer and user”. In digital heritage we add the conversation between designer and expert, as an interdisciplinary approach to advance the essential need of understanding discipline-transcending terminologies and to benefit from the provided knowledge-sharing and the generated feedback. Especially since the design of digital storytelling experiences for museums and cultural settings in general, has been characterized as a multilayered creative process requiring interdisciplinary authoring groups (Roussou et al. 2015).

The expectations are that through the implementation of meaningful dialogue with experts and end-users in the design process, content creators and designers will be able to move beyond difficulties of communication and prejudices, towards perspective taking and joint meaning making, while cultivating a better understanding of how to improve their work to achieve higher quality digital heritage experiences.

We support this argument through two use-cases, based on facilitated dialogue, which guarantees that a smooth and cohesive conversation between all participants takes place. In the first use case, dialogue is achieved by a human who assumes the role of the facilitator with the help of a mobile application and prompts visitors to engage in conversation. In the other, a chatbot acts as a facilitator and guides users through a dialogic experience about specific topics.

ID number: 174

Data augmentation of iberian pottery collections for DeepLearning based classification

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Abstract:

Background

One of the most frequently found archaeological artifacts are ceramics. They can be used to distinguish between chronological and ethnic groups, and to reconstruct the economic history to show trading routes and cultural relationships, especially in the case of ceramic vessels (Orton, Tyers, and Vinci1 , Kampel and Sablatnig2). Unfortunately, ceramics are fragile and therefore most of the vessels recovered from archaeological sites are broken, so the vast majority of the available material has the form of fragments. Therefore, the available databases of complete vessels are too small to be analyzed with Deep Learning techniques, especially in the case of wheel made vessels, which are all different. Therefore, we need mechanisms that allow us to generate sets of profile vessels that mimic real ones, taking as reference the existing databases.

Subject

We present a method for obtaining 2D profiles using 2D Generative Adversarial Networks (GAN) (Creswell et al.3), a deep learning technique which allow us to generate objects from a probabilistic space, characterized by the starting vessel collection. The scheme is composed by two competing neural networks. The first one (generator) learns to generate fake profiles, and the second one (discriminator) learns to distinguish between legitimate and fake vessels. At the end of the process, the generator is able to cheat the discriminator.

In this communication we will present a geometric analysis and pipeline implemented for generation of synthetic Iberian wheel made pottery from various archaeological sites of the upper valley of the Guadalquivir River (Spain). The available dataset (composed of 1133 classified images) consists of images in a profile view of the pottery. Fig. 1 shows all the steps and the tools used in each case, from the design and training of the GANs to the cleaning and landmark extraction from the generated profiles. Finally, a 3D model can be created by rotating the profile.

Discussion

The network has been implemented in Python, with the help of several programming libraries (pytorch, scikit-image, visdom, etc). The generated vessels have been validated by an expert panel from the Research University Institute for Iberian Archaeology. Our main goal of augmenting our vessel dataset is to build in the future Deep Learning networks to perform fragment identification and vessel reconstruction. We have generated a new dataset of 10000 profile vessels that, once rotated and converted in to 3D models, can be decomposed into a large set of virtual fragments, valid for training such networks.

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ID number: 175

Archeometry, Science and Technology Applied to the study of rupestrian architecture. New Conclusions About The rupestrian monastery of St Pedro of Rocas in the Ribeira Sacra (Galicia, Spain)

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Abstract:

St Pedro of Rocas is one of the most emblematic archaeological and historical places of the Ribeira Sacra territory (in Galicia, northwest of the Iberian Peninsula). We are before a rupestrian hermitic complex whose origin goes back to the second half of the 6th century, transformed into a Benedictine monastery adapted to the coenobitic life in the 12th century.

Analytical techniques applied to Historical and Archaeological Heritage are a core element in the interdisciplinary research project (called Petra Sacra) we are developing since three years ago in St. Pedro of Rocas. We have obtained a large amount of data through the application of this methodology that offers a very different image of this singular place. The use of aerospace remote sensing and geographic information systems (GIS), combined with Laser Scanner (3D and BIM) and the application of Infoarchitecture (3D representation, Photogrammetry and Orthophotography) have allowed obtaining a real vision of the architecture of the rupestrian worship complex. The images from the Laser Scanner show the existence of at least one phase prior to the construction of the three chapels carved out of the rock.

Archeometric analysis has provided data on the characterization of materials, construction processes and techniques. The analysis by thermoluminescence of a fragment of mural painting mortar has made possible to date its completion to the middle of the 11th century (between the years 1050 and 1080), correcting significantly the traditional dating. Using the scanning electron microscope (SEM-EDS) and microanalysis by optical microscopy has provided us information on the identification of mortars, pigments, strata, artistic techniques, elaboration procedures, chronological analysis and execution phases in regard to the wall painting. Applied Sciences and analytical technologies have been crucial in defining and determining the material reality of this rupestrian complex. Let's not forget that this place had been studied and interpreted to date only from the information provided by the written documentation and through the History of Art.

The chronology, vision and interpretation of this rupestrian complex have completely changed thanks to the new data. The monastery was previously interpreted as a church with three naves, but in reality St Pedro of Rocas is an architectural hermitic complex known as laura, a large area with defined spaces, cells and access areas that make up the rupestrian settlement. The ecclesia with liturgical, cult and devotional function and the space destined for funeral burials coexist spatially and temporally integrating both spaces. From this 1st period (during the Late Antiquity and the Early Middle Ages), we can document several singular architectural elements: the hagioscopes for liturgical use, the funerary chapels, the arcosolia with

devotional and memory character, the cells dug in the rock and a set of functional and symbolic elements (channels, silos, stairs, passage areas, access terraces and platforms).

We are facing an Early Medieval architecture characterized by the combination of carved rock and wooden structures. It is also necessary to highlight the presence of: a significant number of inscriptions (epigraphs and graffiti); many reused architectural elements of a missing Early Medieval construction and the existence of a funerary mural painting with the representation of a World Map dated in the middle of the 11th century. The calculated orientation of the worship area and the extraordinary precision in the design of the architecture, both based on acoustics and visibility, show that the rupestrian complex was perfectly planned, organized and executed.

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ID number: 176

The study of the Christian origins of the Ribeira Sacra (Galicia, Spain) through New Technologies. Geophysical Prospecting and Photogrammetric Survey.

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Abstract:

Lacks from an archaeological research in the strict sense, the study of the Christian origins of the so-called Ribeira Sacra (Galicia, Spain) is based to date on isolated findings of various constructive and/or decorative elements (inscriptions, sarcophagus fragments, columns, liturgical pieces, etc.) linked to the existence of Late-Antique and/or Early Medieval churches.

As an essential prior step to subsequent archaeological interventions, we have selected four representative religious buildings in this territory, all of them related to the origins of Christianity and the expansion of the anchoretic-hermitic movement, in which we have used some of the methodologies and techniques of the New Technologies applied to the study and management of Cultural Heritage.

The selected places were the churches of St María of Temes (Carballedo, Lugo) and St María of ‘A Ermida’ (Quiroga, Lugo) and the monasteries of St Xoan of Camba (Castro Caldelas, Ourense) and St. Pedro of Rocas (Esgos, Ourense). Geophysical surveys were carried out for the first time in the churches of Temes and 'A Ermida' and in the monastery of Camba, both in the interior and in the surrounding territory of the three religious buildings. Specifically, they have been made: longitudinal profiles using Ground Penetrating Radar (GPR) in squares; profilometer (EMP) in squares and aerial photography by micro-drone with RGB and IR camera.

The geophysical study has consisted of: taking data in situ through of linear radagrams, electromagnetic profiles and aerial frames; processing the data collected in the field work to a depth approx. -3.0 m. with GPR and -7.0 m with profilometer. The following equipment has been used to carry out these works: GPR GSSI SIR-3000 with 400 Megahertz antenna; RADAN 6.5; GEOPHEX GEM-2 profilometer; and DJI P-2 drone with RGB/IR camera.

The results have been conclusive and very revealing in the three religious buildings, confirming the existence of two possible Late Antique (4th-5th centuries) mausoleums of considerable size and constructive entity in Temes and 'A Ermida', as well as constructive structures of great dimensions and extension in Camba, evidencing the presence of a possible Early Medieval monastery (9th-10th centuries). In the case of the Rocas monastery, the photogrammetry combined with the Laser Scanner has made it possible to reveal the previous constructive phases and its morphology, related to the hermitic origins and the installation of a group of anchorites in this place. It is the first time, for the whole territory of Galicia, that it is possible to materially visualize the architecture, organization and structure of a hermitage complex.

The application of geophysical prospecting techniques, photogrammetry, the micro-drone, and the laser scanner in these four places has radically changed our vision of them. The data obtained will make it possible to determine the subsequent actions, being able to carry out

archaeological interventions in those areas that have revealed the existence of construction structures prior to the current ones. These techniques are therefore a fundamental instrument for archaeological research and for the management of Heritage by public administrations.

ID number: 177

Between two worlds. Implementation of various survey methods and their impact on the research process on both sides of the Vistula river in Lesser Poland.

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Abstract:

The implementation of new technologies and research methods results in significant changes in both the field research methodology and process as well as in the post-process related to data analysis. The emergence of new prospective methods has significantly expanded the possibilities of researching large areas, obtaining big data that not only broaden the knowledge but also constitute an element that plays an important educational and social role. This is particularly significant in spreading knowledge within local communities. However, this fact is not equally true for all areas and sites. Those are located, after all, in the various geographical and geological conditions and moreover, have differentiated characteristics resulting from specific cultural models of different archaeological units.

The paper will aim in answering the question, how the use of new prospecting and excavation methods influenced the research process and the image of archaeology within two neighbouring but highly diversified geographical regions. We will focus on the presentation of the research results within the Lesser Poland Upland and the western part of the Sandomierz Basin. Both of these regions are adjacent to each other and are separated only by the Vistula valley. While the first of these regions is a fertile highland, the second is a flat area with watercourses and oxbow lakes. The field surveys carried out in recent years, including aerial photography, geophysical surveys and other research methods, has brought spectacular results. It allowed the discovery of the various types of archaeological sites distinguished by their size compared to those known so far. Those results changed planning, the process of research as well as possibilities of analysis of larger data sets. An important observation, however, is the fact that, regardless of the progress in technology, the results of the conducted research are still much more dependent on the conditions under which the research is conducted. The results of the work depend on the combination of these two variables. It is quite clear that while the prospections conducted south of Vistula resulted mainly in the discovery of production sites (mainly connected with the pottery production in the Roman period), the same methodological approach north of the upper mentioned river led to the discovery of the sites of different characteristic. In the Lesser Poland Upland, large settlements and burial grounds with megalithic structures are recorded. Those factors affect not only the research process but the research aims in the first place.

ID number: 178

Reconstructing Bell Beaker funerary practices and burial taphonomy: applying digital 3D tools in the re-analysis of old field documentation from the site of Oostwoud-Tuithoorn, West-Frisia

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Abstract:

Introduction

Three-dimensional applications are increasingly used in bioarchaeology and the study of death and burial in the past. We explore how they can help reconstruct death and burial practices in a Late Neolithic/ Early Bronze Age community (2500-1700 BC) in Oostwoud, West-Frisia, the Netherlands. We show how the post-excavation application of these tools to re-analyse old (2D) excavation documentation can reveal hitherto unexplored information, and aid reconstructions of past funerary practices and burial taphonomy.

Site context and materials

In 1956-1957 Prof. Dr. A.E. van Giffen excavated two low burial mounds on arable land in Oostwoud-Tuithoorn. The excavations by Van Giffen and subsequent excavations by De Weerd in the early 1960’s resulted in an exceptionally detailed archive of field documentation, although relatively little was published on the site at the time. In recent years comprehensive re-analysis of the original excavation data and materials as a part of Fokkens’ Farmers of the Coast project has revealed the significance of this site in furthering our understanding of Bell Beaker population mobility and genetics (Fokkens et al. 2017; Olalde et al. 2018). The site yielded 12 well preserved skeletons which have been the subject of earlier research, but recent scientific and technological advances prompted a series of new analyses of the skeletal remains, including biological profile assessment, pathological analysis, stable isotope analysis and ancient DNA analysis (Fokkens et al. 2017; Olalde et al. 2018).

Most of the burials consisted of shallow pits in the lower mound. Cases of missing and displaced body parts of some of the individuals have raised the question whether secondary treatment of the human remains was practiced, or whether ploughing of the site not long after burial could have been a cause (Fokkens et al. 2017). While preservation can be ruled out as the cause for the missing body parts, other taphonomic processes and possibly loss during excavation could have contributed.

Methods and workflow

In order to reconstruct the funerary practices and taphonomic processes of human burial features at Oostwoud-Tuithoorn, and to test the hypothesis of secondary funerary treatment of the remains, we used archaeothanatology (an archaeological science method for the reconstruction of grave formation processes) (Nilsson Stutz 2003) together with photogrammetry and 3D animation. This paper explains the method we used in the case study of the burial feature of an adult male (26-35 years old).

Burial 228 was photographed from various angles during its excavation in 1956, and these images depict objects and structures with known real-world measurements and perpendicular straight lines, such as the excavation units and the bones of the skeleton. The images were used as references to position the 3D bone models in their original spatial configuration, using a method known as camera mapping, which allows 2D images to be projected over low polygon 3D geometry. We used Maxon’s Cinema 4D R20 studio to create low polygon meshes of portions of the depicted excavation units, including the unit plan and profiles, and the elevated portion on which the skeleton of burial 228 was positioned, based on measurements taken from the field documentation (profile drawings, plan drawings). Individual images of the excavation unit and burial 228 during excavation were imported into Cinema 4D and using camera mapping the 3D model was subsequently rotated and positioned using the perspective, known measurements and perpendicular straight lines visible in the reference image, to match the orientation shown in the images. Three-dimensional models of the individual bones of burial 228 were created using Structure from Motion photogrammetry, and subsequently imported into Cinema 4D and placed in position using the projections from different angles, providing a digital 3D reconstruction of the burial feature in its final position “B”. To estimate the initial “A” position of the freshly buried body, we conducted post-excavation archaeothanatological analysis, and then used a rigged anatomical reference model of an adult male human skeleton with soft tissue body volume developed by MotionCow to replicate the original body position.

Once the bone positions A and B had been established, bone movements were animated by setting keyframes on the animation timeline for each individual bone at certain positions. Motion paths of the bones were examined individually and in conjunction with other movements, to examine physically possible motion paths, without bones colliding. This permits identification of the sequence and trajectories of all movements (i.e., specific duration, path and sequence), and made it possible to visualize and analyse various potential movements and scenarios.

Results and conclusion

The combined use of archaeothanatological analysis of the original 2D excavation documentation and the 3D reconstruction of the burial and displacement of bones resulted in the reconstruction of a scenario in which the male individual was buried in a shallow primary placement. The remains were subsequently disturbed during ploughing of the arable mound area, and the disturbed body parts were intentionally re-deposited in non-anatomical position. Retrieval of the missing body parts of burial 228 as a part of secondary funerary practices was ruled out, since the spatial displacement of the bones of the remaining skeleton concur with the expected displacement pattern cause by a plough relatively recently after death and burial.

This case study demonstrates that the combined use of methods from archaeothanatology with 3D digital tools provides an effective means to analyse and visualize taphonomic processes in archaeological human burials, which in turn form an essential source of information in the reconstruction of funerary practices in the past. Moreover, the digital workflow we have developed represents an efficient and versatile manner of (re-)analysing 2D traditional excavation data and enabling comparison with 3D digital data that are nowadays collected using modern documentation techniques in the field.

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ID number: 179

Virtual Knapping with Neural Networks: A Proof of Concept

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Abstract:

Stone tool manufacture has been a staple of human behaviour for at least 2.6 million years. Due to their longevity and prevalence through a large period of hominin evolution, stone tools are a valuable source of evidence for archaeologists. For most of prehistory, stone tools were made percussively by striking a core with a hammer stone to produce a flake with cutting edges that could be used for various purposes.

One important method for understanding in greater details how stone tools were made is the experimental replication by modern knappers. Archaeologists can use the insights gained from lithic experimentation to draw inferences about various aspects of human evolution, such as past human behaviour, cognition, biology, and landscape use.

However, replication experiments can require considerable time and raw materials. Lithic experiments themselves are also difficult to replicate, as it is difficult to control many important knapping variables. Some researchers have tried to address these issues by using standardised core shapes or by using a computer-controlled machine to knap (Dibble and Režek 2009), but these methods also require additional resources.

A computer-based model for fast and accurate virtual knapping simulation (validated against an archaeological or experimental dataset) could allow lithic experiments at a fraction of the time and resources. In addition, a virtual knapping program would permit experiments to be more easily replicated, allow more effective data sharing, and provide the possibility of generating large lithic assemblages that could be studied and compared with archaeological and experimental data.

Here we present a proof of concept for a virtual knapping program, capable of accurately predicting the length, width, volume, and overall shape of flake removals from the core surface alone. To obtain a training dataset for our proof of concept, we generated a dataset (n = 2010) of 3D cores, with shapes based on those from previous machine knapping experiments (Dibble and Režek 2009), and removed computer-generated flakes from them, whose shapes were based on flakes removed from the same experiment (Dibble and Režek 2009). In addition, some flakes were removed from already-knapped cores, thus obtaining cores with multiple flake scars, adding variability to the core morphology in our dataset.

We captured the 3D surface information of the core surface from which the flake was detached and the surface of the flake itself, and encoded it into 2D images with the use of depth maps. Depth maps of the intact and the modified (i.e. knapped) core surfaces were taken, and a depth map of the difference between the two was calculated. By having the depth map for the intact core and the difference map, we could calculate the modified core

surface and its respective depth map, as well as the 3D shape of the flake. Therefore, if we can predict an accurate difference map from the core surface depth map alone, we can obtain a predicted flake and predicted modified core. When generating the depth maps, we align the location of the point of percussion on the core to the centre of the image, and we adjust the maximum depth depending on the distance between the core edge and the point of percussion, thus encoding these variables into the image itself.

The depth maps are used to train a conditional generative neural network (CGAN), an architecture designed for image-to-image translation (Isola et al. 2017), or the generation of a predicted image that matches a specific input (e.g. generating a photorealistic picture from a line drawing). We trained the neural network to use the depth maps of the intact core and predict the matching difference map for the predicted flake removal, which would allow us to re-create a 3D flake and modified core. If successful, this process would result in a form of knapping simulation.

We split the dataset with 70% (n = 1407) for training, and 30% (n = 603) for holdout testing. The testing dataset was not seen by the neural network during training. We analysed the prediction accuracy by comparing the depth maps of the actual flake removals and the predicted flake removals. We compared the length, width, and the cube root of the volume (calculated as sum of the all the values in the raster), and we calculated the difference in flake shape by calculating the difference in values of each pixel, and using these to calculate the RMSE for each flake prediction. We then calculated the mean RMSE across all flake predictions. In addition, we calculated an NRMSE by taking the mean RMSE and dividing it by the range of values of the testing dataset.

Training took approximately 90 minutes, whilst the prediction of all 603 flake removals took less than two minutes; an average of less than 200 ms per prediction. The neural network had a high prediction accuracy in flake length (R^2 = 0.85), volume (R^2 = 0.77), but had lower accuracy when predicting flake width (R^2 = 0.58). For the prediction of overall flake shape, however, the model remained accurate, with a mean RMSE of 0.028 and an NRMSE of 3.7%.

The results suggest our virtual knapping framework was successful in accurately predicting the shape of flake removals by observing only the core surface depth maps. Our model was accurate even with the varying morphology in core surface, obtained by removing computer-generated flakes from already knapped cores. We have shown that neural networks can be used to simulate knapping, and we can begin evaluating our model’s performance on actual core and flake pairs. The creation of such a dataset will require considerable effort, but will provide the model with additional validity (Lin, Režek, and Dibble 2018). This framework, trained on the new dataset, could serve as a very important tool for lithic analysis, and provide more robust results with which to understand prehistoric stone tool production, and thus, human evolution.

ID number: 180

From archaeological to digital data: a holistic reflection on the design of a serious game for users’ engagement

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Abstract:

Over the last decades, video games have become a pervasive part of society and one of the biggest sectors in the entertainment industry. Moreover, in the last years, they have proven to have a clear potential to support the experiencing of cultural heritage by the large public, complementing the current tools and practices based on tangible goods such as museums, exhibitions, archaeological sites. Serious games – video games designed for educational objectives – appear as a new tool to learn cultural content in an engaging way, to attract new publics and to enhance knowledge, awareness, and cultural tourism. In this paper, I will illustrate an ongoing project concerning the presentation of the Archaeological and Technological Park and Fortress of Poggio Imperiale in Poggibonsi (Siena, Italy) and underline how and why the design of a serious game for this specific site – and in this specific time of global pandemic - is to be considered as the last fragment of a very long and precise project aiming at enforcing a multi-level public outreach and heritage enhancement strategy on the site. The CAPI project, within which the serious game will be developed, fits perfectly in the previous outreach activities since it comes after more than 20 years of archaeological research, technological experimentation, public engagement, and successful outcomes tested on the site. It represents the last step of a very long journey in which the scientific rigour of the archaeological data together with the application of innovative tools, technologies, and new dissemination “languages” has been the essential core of every action, from the creation of the archaeological park to the building of the open-air museum called Archeodromo which pursues an in-progress full-scale reconstruction of the 17 structures found during the excavation of the Carolingian Age village. The CAPI project proposes additional experimentation in which immersive technologies such as virtual environments and augmented reality, but also video games, begin to be implemented in public outreach strategies. Translating the archaeological materiality into digital and immersive applications, test a promising new tool in a context such as Poggibonsi where data are rigorous and, at the same time, there is always space for experimenting, represents both a challenge and a great opportunity. In this paper, the choices linked to the design of the serious games in terms of users identification and content translation for the selected public will be stressed along with the long-lasting archaeological project and public outreach.

ID number: 181

Productive Paddies: Understanding the Spread of Rice Farming during the Yayoi Period in Japan through Modelling of Productivity and Habitat Suitability.

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Abstract:

The introduction of rice and millet farming to Japan, during the Yayoi period (2,800-1,750/1,700 BP) marked the beginning of a period of rapid cultural change in the archipelago. This change in subsistence strategy produced major shifts in settlement patterns and demography via interaction between incoming migrants and incumbent populations 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. This geographically diverse response to the continental subsistence economy is generally assumed to be reflecting 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 are required to elucidate the diversity of local responses.

This study aims to contribute to this research agenda by combining several modelling approaches to explore the geographic variation in the suitability and productivity of wet and dry rice farming in the Japanese archipelago. In this specific paper, both ecological thermal niche modelling and spatial autoregressive models will be tested. The former models spatial extent where the cumulative temperature required for rice growth is met, and examines its variation over time using paleo-temperature reconstructions. The latter consists of fitting a spatial autoregressive model on historic agricultural yield census data from mid-late 19th century Japan and estimating productivity of wet and dry rice agriculture under environmental conditions during the 1st millennium BC using a range of paleoclimatic variables. We evaluate the benefits and the limitations of the two approaches by comparing their estimates against each other and their relative fit to the archaeobotanical fossil record and discuss implications on the wet rice driven introduction of agriculture narrative in prehistoric Japan.

ID number: 182

Evaluating the Effects of Randomness on Missing Data in Archaeological Networks

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Abstract:

Missing data are an omnipresent problem in archaeology. Network analysis can be heavily affected by missing links and nodes. New methods are required to mitigate these difficulties, but the fragmentary nature of the archaeological record makes it difficult to evaluate and quantify the accuracy of network reconstructions. Prior studies have addressed missing data and missing nodes (e.g., Gjesfjeld 2015); however, missing data used to define links between nodes is less frequently addressed. The development and evaluation of new methods are best undertaken using a mix of controlled conditions and real case studies. This study uses an agent-based model to simulate archaeological datasets that can be used to evaluate the effects of missing data and provide test datasets to develop and test new methods that minimise the impact of such effects. Ceramic data from the CyberSW database (CyberSW.org) are also used to explore the effects of missing linking data on an archaeological dataset. This database contains data on millions of ceramics from across the U.S. Southwest/Mexican Northwest.

Agent-based models are computer simulations of autonomous agents who operate according to specific—often simple—procedures. These models have been used successfully to study social networks (e.g., Brughmans and Poblome 2016). The agent-based model detailed in this study can be used to create unique datasets with known parameters that can be tailored to match a variety of real-world archaeological datasets.

A pressing concern in archaeology is whether samples of a population are random. This is because many situations result in nonrandom samples of a site’s total archaeological assemblage: surface sampling, the limited area of potential effect in cultural resource management, environmental effects that remove a portion of a site, looting, etc. The purpose of this study is to compare the effects of data loss at random and at nonrandom intervals on social network reconstructions using material culture.

Our analysis of simulated and archaeological assemblages demonstrates that data used to construct links that are removed at random rarely affect network structure, but non-random removal (i.e., the removal of a related sequence of data) has a nontrivial effect on network structure and must be accounted for. Our intent is to draw awareness to this issue, and we are optimistic that greater attention to this problem will lead to the development of robust solutions.

Model Description

This model is part of a larger project aimed at exploring social networks using agent-based modeling. It is a generalized model containing camps, agents, and a variable environment. Agents make artifacts (a pot or a projectile point), trade artifacts, visit other camps, acquire new friendships, or go on group hunts. Each interaction introduces the potential for cultural transmission, which changes the style of an artifact made by the agent. For each time step, there is a possibility the agent will discard the artifact. This simulates breakage and discard in the archaeological record. Artifacts discarded at the location of a camp are recorded in the camp’s assemblage, therefore, camp assemblages can include nonlocal artifacts as a result of trade or discard while other agents are visiting. Artifacts record the time step and camp they are made in along with their stylistic traits. The assemblage is the primary output of the model for this analysis. Numerous parameters built into the model allow for testing different scenarios.

Methods

To analyse the model output, artifacts were classified into discrete categories based on similarity, and a distance-based adjacency matrix was calculated using manhattan distance. Manhattan distance is the inverse of the Brainerd-Robinson coefficient of similarity—one of the most common methods of creating networks from material culture. The ceramic data from the CyberSW database was already classified into ceramic types, and they were also converted into a distance-based adjacency matrix.

For this analysis, we compared one network constructed from the full dataset and a second network based on a sample of the data. Samples were taken either randomly or nonrandomly by picking a starting point in the assemblage and removing a consecutive sequence of artifacts that belong to a similar period of time. In the simulated data, artifacts were sorted by the time step they were created to simulate data loss among artifacts made around the same time. The CyberSW database contains primarily site-level data. Each assemblage for a site was divided randomly into three groups to simulate subunits of a site and decrease the odds that an entire type of ceramic ware would be removed.

Many methods can be used to compare networks depending on the analytical needs. Here we use a Laplacian spectral distance that has proven effective in tests of network comparison methods (Wills and Meyer 2020) but is also relatively straightforward.

Results and Discussion

Figure 1 demonstrates the results of 1600 simulations using, in this example, ceramic data from the CyberSW database. The random removal of artifacts does little to change the structure of the network compared to the original network. Smaller samples increase the distance between the networks, but even a sample size of 10 artifacts per site is remarkably close to the original network. The results are considerably different for nonrandom data removal. The network comparison distance is significantly higher at every sample size compared to the random sample, and the comparison distance is highly variable. These results closely match the simulated datasets from the ABM.

This analysis indicates that network results should be treated cautiously if the data cannot satisfy random sample criteria. This agent-based model can be adapted to fit many different network types and sizes and should prove useful in evaluating and testing new and current methods for handling missing data.

ID number: 183

From field drawings to artifact data extraction using an object oriented methodology

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Abstract:

Archaeological excavations can span several years or even decades and the progressive data acquisition is often subject to changes in data recording protocols over time. Over the 30 years of excavation at the Acheulean site of Cagny-l'Épinette (Somme Valley, France), data recording and management have progressively moved towards digital recording techniques. Thus, the excavation is currently documented through a combination of both digital and analog legacy data. The aim of this research project is therefore to collate these complex archives into a unique, coherent and consolidated dataset.

As part of this research, the software ArcGIS was paired with the OBIA software eCognition with the purpose of producing interoperable quantitative data. Our OBIA-GIS protocol is a standardized data production tool that enables reliable digitization, archiving and morphometric documentation of collections of artifacts excavated over a very long period of time with field teams or analog methods and digital systems that have evolved significantly over time. This protocol was applied to CAD versions of the manual field drawings to enhance the archaeological dataset with automated measurements of the artifacts. Thus, this research is part of Archaeobia, the methodological concept of object-oriented image analysis applied to archaeology proposed by Lamotte and Masson (2016), who first applied an OBIA processing to archaeological artifacts (Davis 2018; Magnini and Bettineschi 2019).

The results are that the OBIA-GIS approach allows turning CAD documents into robust, enriched datasets adequate for geostatistical analyses. With one single algorithm, eCognition measures multiple descriptive attributes, which would need complex work-flows with other software or could not be calculated manually. These new spatial (Cartesian coordinates and orientations) and morphometric (dimensions and geometric indices) attributes of the OBIA modeled artifacts can be analyzed in any GIS interface. The outputs are exported in shapefile format with an accuracy of 100% compared to the CAD documents, due to the initial digitalization of the field drawings into binary images (i.e., with only two colours) from which eCognition can unambiguously extract image objects.

This presentation will highlight the potential of the Archaeobia concept as a contribution to the toolbox of digital humanities applied to artifact descriptive analysis and modeling as well as archive data curation in archaeology.

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ID number: 184

Treasured hunters? The application of amateur archaeological datasets from North-Western Europe in spatial analysis

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Abstract:

For many people, metal detecting provides a unique opportunity to experience a landscape through walking, searching and mapping (Winkley 2016, 1). While the hobby is growing both in popularity and scale, it is tackled differently by the various national governments and heritage authorities in Europe. The contested and divided approaches towards private metal detection – including how to deal with the data produced – continues to be an issue in archaeology. With the steady increase in the number of finds being recorded, several European countries have developed databases to handle the large amount of data. Although the finds recovered by private metal detectorists and other members of the public present an “enormous and unique research potential” (Dobat 2013, 717), gaining a comprehensive picture of the datasets is a challenge. This is further complicated by the need to understand what impacts the data if we want to use it for research purposes.¨

In order to estimate the usefulness of private surface finds in archaeological research, I compared archaeological datasets collected by members of the public in the Netherlands, Denmark, England and Wales. These countries are generally considered to have adopted liberal approaches to private metal detecting and have developed national databases for the registration of finds. Metal axe heads were chosen as a study category to look at changes through time and space in more detail. The work consisted of exploratory data analysis using QGIS version 3.4 “Madeira” as well as density-based calculations with R version 3.5.2 (R Core Team 2018), which included different functions from the spatstat package (Baddeley et al. 2021). This allowed me to characterise the datasets, compute ‘hotspots’ of metal axe heads, spatially relate the amateur archaeological datasets to protected archaeological sites, and statistically capture environmental properties of the finds.

Future research on the different aspects of private metal detecting in archaeology has been called upon to be more transnational, empirical, quantitative and evidence based (Deckers et al. 2018, 331). My analysis in QGIS and R enabled the identification of areas in each country where the environmental conditions produce higher densities of metal axes. The workflow also illustrated how data derived from field research conducted by the public can be used to deliver results when archaeology is forced to move online, as the research was concluded at the start of the first lockdown. While my transnational approach proved helpful for gaining an impression of larger trends, it really struggled to capture local trends, patterns or deviations. Furthermore, compatibility between the databases remains a substantial issue that needs to be solved in order to better facilitate international studies.

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ID number: 185

A small blurb about my R skills

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Abstract:

I classify myself as an 'apprentice' in R: not quite a beginner anymore but still very much learning. After doing an introductory one-week course on R as part of my postgraduate degree, I decided to employ my new skills in a 6-month research internship. The experiences I gathered from this work later became the basis of my postgraduate thesis, where I performed spatial and statistical analysis in R. Now I am working as a data analyst and I use R in many areas of my work. Most of my knowledge comes from learning by myself; I can also imagine that I have picked up a few bad habits! Participating in the workshop would be great more about package development, how to organise my scripts and just in general work more professionally.

ID number: 188

Experimental archaeology in immersive Virtual Reality: a 3D reconstruction of a mortuary structure of Tomb 21, a Bronze Age mortuary structure from Ayios Vasileios, Greece

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Abstract:

This paper demonstrates the role Virtual Reality has within experimental archaeological practice and the possibilities this presents for 3D spatial analysis. The subject of this paper surrounds a so-called ‘built tomb’ found in the early Mycenaean North Cemetery of Ayios Vasileios (in use approx. 1700-1420 BC), on the mainland of Greece. In 2015 the whole cemetery was recorded using Structure from Motion (SfM), including Tomb 21, a dataset we could return to in order to ask further questions. This study focused on Tomb 21, where key questions remained:

1. What was the most likely roof design?

2. How did the roof collapse?

3. How was the tomb made accessible for additional internments?

Unable to answer these questions solely through the use of traditional documentation methods like field drawing and photography, we turned to Virtual Reality technology. This virtually enabled experimental archaeology afforded us the opportunity to revisit the tomb following its excavation and experiment in rebuilding the tomb (Outram 2008).

For this purpose, we brought the Structure from Motion derived surface model of the excavated tomb into a fully immersive Virtual Reality (VR) environment, facilitated through the HTC Vive. The handheld controllers enabled the team to grab, move, tilt and let go of the photogrammetrically recorded collapsed stones when they are in position, as if in real life. The use of the physics (gravity) function added an option for further considerations. The benefits of using immersive VR afforded us three main advantages:

1. It allowed us to scrutinise the standing architectural remains after completion of the excavation in a virtual environment in three dimensions and from any angle.

2. The excavation sequence could be reproduced: by comparing the excavation photos of the various stratigraphic layers to the 3D models of the individual stones, it was possible to recognise specific stones. These could then be placed back as accurately as possible into the position they were in when they were excavated. This allowed us to visually assess the way the stones have fallen inwards (i.e. the destruction/collapse) by observing their depth, orientation, angle, and position in relation to other stones. Whereas during the excavation one can only examine the stones per layer, within the VR-environment the different layers can be reconstructed and analysed at the same time.

3. Using the insights gained from the above analyses, the stones could be restacked interactively in an attempt to recreate the original appearance of the tomb and explore, or refute, different theoretical postulates.

Archaeologically, our interactive virtual reconstruction suggests that the tomb was covered by a stone cairn, supported by a number of horizontally placed wooden beams, which broke due to natural decay and caused the stones to tumble inwards. We also argue that the tomb was entered from above and therefore that the roof of the tomb was dismantled and rebuilt with each addition of new burials (25+). Rather than speculate on the design of the tomb’s roof, the application of immersive VR made it possible to test research hypotheses, and as such exemplifies that digital techniques can help answer strictly archaeological questions (Huggett 2015). Through this approach, we were able to perform experimental archaeology in a digital environment.

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ID number: 189

Poster: An exploration of NLP and NER for enhanced search in osteoarchaeological and palaeopathological textual resources

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Abstract:

Background:

The advent of Big Data represents an ever-increasing opportunity, particularly in the world of Archaeology. Archaeology is a destructive process; text-based reports are written to document the site and the resulting ‘grey literature’ contains a wealth of information for scholars and researchers. This information becomes part of data archives such as the Archaeology Data Service, but currently, there is no effective way to navigate the content of these reports, meaning that these databases become labyrinths containing huge amounts of information that are difficult to access. The technology used to navigate the Big Data within these archives is ever-improving in its accessibility. These improvements include the use of Natural Language Processing (NLP) to create enhanced metadata and these are mapped to controlled terms using Named Entity Recognition (NER) (Richards et al. 2011, 31-56). The work represented in this poster is the continuation of projects carried out by the Archaeology Data Service and Talboom (Meghini et al. 2017, 1–27; Talboom 2017).

Subject:

This poster will present the two technological approaches of NLP and NER to increase the accessibility of palaeopathology and osteoarchaeological data. These have been analysed for accuracy and usefulness by professional bioarchaeologists, students and laymen. From the results, despite some limitations, it will be shown that there is real potential in the use of NER and NLP to allow osteoarchaeology and palaeopathology information to be accessed more easily, thus unlocking the information trapped within Big Data. The results further indicate that the use of the technology will generally allow the average layman to better connect to the resources. This is verified by a quantitative survey of experts, students and laymen of osteoarchaeology and palaeopathology. The survey included a selection of five 7-point Likert scale questions, addressing factors such as time-saving, reliability, accessibility, usability and usefulness, Thus these technologies may hold the future of connecting archaeology to the public and encouraging further public engagement.

Discussion:

The results, therefore, show the implications of the application of NER and NLP to osteoarchaeological and palaeopathological records. They enable the records to be accessed by all, despite being held in previously inaccessible archives. It also reveals that NLP has the potential to become an incredibly useful tool to address the Big Data created by archaeological projects. If such methods were regularly implemented, research questions regarding specific details from many sites could be answered with greater speed and accuracy. These technologies will, therefore, be central to the future of archaeological research.

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ID number: 190

Documenting and monitoring the impact of dams to cultural heritage from space. Tuning satellite data collection to meet archaeologists' needs

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Abstract:

In recent years satellite imagery has been extensively used for cultural heritage risk assessment worldwide. However, the majority of studies focused on selected types of damages such as looting, natural-hazards and conflicts-related that were generally deemed as the most dangerous ones (Zaina 2019) or that were more consistently covered by the increased flow of information and media attention in response to the events occurring in different regions. This narrative has been recently tackled by studies shedding light on other equally or more dangerous but under-considered threats including ploughing, construction of roads and buildings or even large infrastructures. Among the latter, the construction of dams resulted in the flooding and destruction of thousands of archaeological sites in different places of the world. Despite this pervasive effect, specific regulations, as well as tailor-made methodologies to document, preserve and monitor this type of damage to cultural heritage, are yet to be codified (Marchetti et al. 2020).

Current counteractions are spotty (i.e. not applied in all the dams) and suffer from a lack of coordination by international and national authorities, while support from ad hoc legislations is also missing in many countries. Moreover, mitigation strategies mostly rely upon ground-truthing activities and, in some cases, aerial imagery. The tangible limits of these strategies include: 1) incomplete research methodology, which does not consider the potential of remote sensing for sites identification; 2) limited timeframe, as ground-truthing allows only to identify the latest types of damages that are visible at the time of in-situ surveys; 3) incomplete geographic coverage, as confirmed by many archaeological surveys in prospective reservoir dams; 4) low level of detail, as ground-truthing does not allow to appreciate anomalies visible for space.

These shortcomings could be effectively overcome by integrating the use of satellite imagery to ground-truthing activities. Over the last decade, archaeological research methodologies highly benefited from the growing availability of open-access satellite imagery and their accessibility through different online platforms including Google Earth and Bing Maps (Agapiou 2017), thus opening new exciting research avenues, including their application for archaeological damage assessment and monitoring.

However, the use of satellite data is not yet an established practice across the community of archaeologists. This may be due to the underestimation of the real potential of this tool, the lack of necessary expertise of most archaeologists to access, process and interpret evidence from satellite imagery, and the fact that many archaeologists still privilege bespoke aerial imagery. The lack of understanding of the different potential use of the wide array of satellite missions that are currently available may also be slowing down the spread of this practice. For example, while early Landsat and SPOT missions as well as SRTM and Sentinel-2 satellites are more effective in the analysis of landscapes due to their lower resolution, COSMO-SkyMed,

Quickbird or World-View allow the detection of small scale archaeological features. Whereas multidisciplinary collaborations are showing the way forward to tackle this issue, the majority of archaeologists are still neglecting the use of satellite imagery as a crucial component in the study and protection of the past.

This paper aims at showing the potential of multidisciplinary collaboration and an integrated approach in the assessment of the impact of dams on cultural heritage including satellite imagery. Building from the three protocols system proposed by Marchetti et al. (2020), we explore the potential of remote sensing of satellite imagery applied to the first protocol, named Pre-Construction Archaeological Risk Assessment (PCARA), consisting in the quantification of archaeological evidence located within the prospective reservoir area before dam construction.

The integrated methodology consists of a preliminary manual identification of archaeological features conducted by an archaeologist with experience in remote sensing, followed by an automatic identification of signals and patterns extracted from different types of satellite imagery that can be used as proxies of archaeological features and sites. This would be then validated in the field through ground-truthing activities.

In order to provide the most accurate identification, it is essential to consider two types of variables that can influence the detection of the archaeological site: 1) temporal variable; 2) environmental variable.

The temporal variable relates to the timeframe of the dam construction and how satellite data can provide sufficient temporal coverage of the different phases (i.e. pre-, during and post-construction). Therefore, this variable influence the selection of the number and type of archive and new images to be acquired. In particular, in the case of an area with few archive images, a new acquisition campaign has to be carried out. Conversely, the need for new acquisitions may be more limited.

The environmental variable regards the physical properties of the natural setting where the dam is constructed that may impact on the visibility of archaeological features and sites in the satellite data. Above all, seasonality. Indeed, high vegetative landscapes may limit visibility. Therefore, if the prospective reservoir area is located in an arid or semi-arid region, seasonality may not be a constraint for satellite images collection. On the contrary, humid regions may require specific satellite data tasking during either low or high vegetative periods.

A careful analysis of these variables allows to efficiently tune satellite data collection to meet archaeologists’ specific needs. In this regard, a valuable support has been recently provided by Synthetic Aperture Radar (SAR) and multispectral imagery (i.e. Sentinel-2) of the different space agencies’ constellations (Tapete and Cigna 2019). These open-access images integrate each other providing both landscape (multispectral imagery) and small scale archaeological feature (SAR) identification, global spatial coverage, high temporal revisit and ease of data handling.

We tested the feasibility of this methodology on two representative case studies, the small planned dam of Halabyeh in Syria and the large, currently under construction Grand Renaissance dam in Ethiopia.

The first case is an arid region poorly covered by archive satellite imagery (mostly by Sentinel-2). Therefore, besides the use of already available open access dataset, a robust acquisition strategy of SAR imagery is necessary to integrate the dataset. To this aim, we tuned the satellite acquisition schedule by programming the full Italian Space Agency’s COSMO-SkyMed constellation to collect high-resolution images to meet the needs of archaeological research.

In the second case, we chose a humid region well documented by both SAR (COSMO-SkyMed) and multispectral imagery (Sentinel-2) prior to the reservoir filling. The temporal acquisitions collected over this area by different satellites cover both low and high vegetative periods.

The successful application of this methodology will allow answering some of the key questions of this CAA session including, 1) Which requirements and expectations archaeologists have and would like to see addressed by current and future satellite data, so they can use these images as a resource for their daily practice? 2) How observations from satellite images can be fed into archaeological interpretation and understanding of anthropogenic processes (e.g., damage mapping)?

Far-reaching implications will include the integration of this methodology in a detailed PCARA protocol to be used in the development of ad hoc policy papers for international and national stakeholders to protect archaeological sites threatened by dams.

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ID number: 191

Archaeology of Spaceless Places

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Abstract:

The lives people live in digital environments has been a topic of fascination for decades and a focus of analysis for nearly as long. A meaningful “place” where people interact might not always correspond to a specific physical space. Relationships are shaped, power is deployed, and culture unfolds in places that are imbued with cultural value through human activity. Anthropologists now incorporate digital ethnographies, online tracing, and other methods for understanding behavior in digital environments. In the field of social computing, the notion that meaningful places may exist without a corresponding physical space instigated a paradigm shift away from spatial models more than twenty years ago (Harrison and Dourish 1996). In these and other disciplines, new methods of understanding our lives online have rapidly proliferated. The translation of archaeological methods for use in spaceless places is a vital step for the advancement of archaeological science, and a promising new avenue of exploration.

Archaeological methods encompass the many ways that we derive meaning from the traces that people leave behind. These include the footprints, the rubbish, the spent tools and broken bits. Ours is the science of learning about people who have left the room, using any reliable means we can imagine. Anthropological archaeology is uniquely positioned to expand our understanding of ancient cultures by analyzing the residues of past behavior and explicating the relationships between sweeping social structures and an individual’s daily practice. Archaeological methods enable us to describe the cultural, biological, and technological constraints on daily lives, and to detail the myriad ways that human beings exercise their agency despite these constraints. When we want to understand how and why technologies or social organization have changed over centuries, or how these parallel processes are in fact manifestations of the same cultural developments, we turn to archaeological methods. For the past four decades, archaeology has been used to contextualize contemporary practices with regards to larger social systems and historic processes. Behavioral archaeology explains how cultural and economic forces led to the early 20th century dominance of the combustion engine. Garbagology provides a window into the relationship between consumption of perishable goods and economic stress in the United States today.

As a field, archaeology rests on a foundation of potsherds and lithic fragments. Archaeological methods derive from the analysis of physical artifacts. Their power is evident in the inferences we draw from analyzing these assemblages. Archaeological theory explores the nature of relationships between humans and the places and things that matter to us, sometimes waxing philosophical about the very thingness of things and the placeness of places (Hodder 2012). In the twenty-first century, people use immaterial objects in their daily lives. In the next hour, I might coordinate family dinner plans using a group chat, work with a colleague on another continent to collaboratively edit an academic paper, or visit an in-game “location” to see if friends are “around” so that I can “spend time with” them. These metaphorical places offer opportunities to experience meaningful encounters with people who play important roles in

my life. Cultural anthropologists readily understand them to be culturally significant second and third places. Activities that take place in spaceless places include relationship building, information sharing, teaching, learning, participating in local and global economies, politics of all sorts, factionalism of many kinds, planning and other collaboration, actual construction of digital artifacts, and identity-crafting. The traces of these activities are largely intangible. Archaeology has only begun to account for some of these new ways of living.

These new spaceless archaeological sites require that we translate our methods and extend our theory to understand behavior in the contemporary world. We can imagine a distinction between two different kinds of digital archaeological sites. Some digital places look like three-dimensional spaces. Many videogames, for example, require navigating apparent landscapes and encountering landmarks, participating in social encounters, and engaging with digital objects. Other digital places have no apparent landscape. Chat rooms, for example, may have a spatial metaphor without a visual component: individuals enter, interact, and leave. Meaningful interactions take place here, but there is no illusion of space.

Digital landscapes that are designed to resemble the natural world invite archaeologists to imagine virtual excavations, survey projects, and other traditional archaeological field methods, rendered in virtual archaeological sites. The place can be mapped, the activities that take place “within” the “site” can be located (eg, Reinhard 2018). But the distinction between these two kinds of digital environments is only a difference in the metaphors we can use to describe them. A long trek toward a distant in-game horizon may lead, inexorably, to the place where it began. A doorway in a virtual room may open into the room it also exits. Bodies may not decay. Objects may disappear. No digital environment is governed by the same physics, or bound by the same depositional processes, as the sites for which archaeological methods were developed. Analysis of archaeological sites has always depended on our understanding of geology and ecology, but analysis of intangible artifacts and dimensionless archaeological sites requires us to trade these sciences for a new set of rules imagined and instantiated by other contemporary people.

Cultural processes, however, do extend into spaceless places. Archaeology is uniquely positioned to make sense of human culture and to contextualize the use of these new kinds of places within larger social systems and long-term change. For example, chaîne opératoire is used to reconstruct technique, power differentials, and collaborative labor through the analysis of debitage and other physical artifacts. Chaîne opératoire can be effectively applied to collaborative writing by quantifying, classifying, and carefully analyzing editorial changes and other artifacts of labor in an Overleaf or Google document. An archaeology of spaceless places is necessary to make sense of the relationships of power and trajectories of technological change in the recent past. Archaeology of digital environments is a developing body of method and theory that will open new avenues for applied and collaborative archaeological inquiry, especially in emerging domains such as the design of virtual worlds.

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Reviewing 3D GIS in Archaeological Research, does it really exist?

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Abstract:

At CAA Oslo I presented ‘The Road Ahead’ for 3D Spatial Analysis, this led to a part 2 presented at CAA Tübingen, and resulted in the van Leusen and Nobles 2018 publication. This was all very theoretical, however through collaboration with the Kaymakçı Archaeological Project (KAP) over the past 3 years the theory has been put into practice (for results see: Nobles and Roosevelt in review, Scott et al. in review). During this time and over recent years we have seen a plethora of 3D GIS studies emerge, however, despite attempts, archaeology is yet to define what we mean by 3D GIS as a research avenue. It has become a catch all colloquial term applied to anything with a spatial element which we can perceive as 3D, from point clouds to voxels. This lack of definition often puts archaeological research in conflict with the definitions from Geographic Information Science (GISci), particularly in terms of true 3D Geometries and geographical coordinate systems.

This paper reviews the state of archaeological ‘3D GIS’ research, highlighting some of the avenues we are taking and those archaeological studies that have engaged with concepts of 3D GIS, this draws on case studies from the authors own collaborative research as well as the work by researchers worldwide. The various concepts are collated to see the natural diversions in 3D research. The purpose of this exercise is to demonstrate the divergence between archaeological 3D research and GISci approaches, with the various research avenues defined it opens up the debate regarding the merits of each and every avenue. A fundamental problem regarding the use of 3D GIS in archaeological research is that 3D GIS itself does not yet exist.

This may be viewed by some as a controversial statement, however this position is defended through the collation of a 7 point criterion offering a GISci compatible definition for true 3D GIS. The benefit of taking a critical stance on this emerging field is that it enables a broader discussion regarding the merits of the established direction(s). While highlighting the excellent work across the discipline self-reflection is enabled, we can consider the various directions we can take ‘3D GIS’ within Archaeology, contextualise the various directions with our own requirements and desires, ultimately bringing a structured clarity and opening up untapped research directions. Through the combination of examples from case studies with blue sky thinking, this paper challenges the core of our perceptions, values, and understanding when it comes to 3D archaeological research. It concludes with an initial attempt to map out potential research directions, offering some suggestions of how this could be achieved.

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ID number: 194

Multiscalar Approaches to Digital Documentation of Archaeological Sites. The case studies of Flavian Amphitheater, Temple of the Divine Claudius and the Theater of Marcellus in Rome

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Abstract:

Introduction

Specific research objectives or priorities as well as unanticipated opportunities and challenges in the field often dictate that each aspect of an archaeological site might not be documented at the same level of detail or via the same documentation modality. Either by design or by circumstance, data can vary greatly in terms of scale and, consequently, density or resolution. With the widespread adoption of photogrammetric techniques, new issues of data quantity and quality have come to the fore. This research, starting from case studies such as the Flavian Amphitheater, Temple of the Divine Claudius and the Theater of Marcellus in Rome, explores topics related to massive data acquisition, scalar diversity, and creation of hetergenous models. Digital images are commonly integrated into data acquired from laser scanning for the purposes of validation or texturing. This research investigates the potential benefits and limitations of integrated multiscalar approaches, evaluating the effectiveness and efficiency of practices currently in use.

Methods and Materials

In recent year, different survey campaigns are performed in the area of Flavian Amphitheater (2000), Temple of the Divine Claudius (2009) and the Theater of Marcellus in Rome (2019). The survey operations were conducted by integrating the methods of selective acquisition by topographical survey with those of massive acquisition by 3D laser scanner and digital photogrammetry. The result of the acquisition and processing of the data was a multi-scalar point cloud, in which the quantity of data acquired for each element depends on the scale of representation required in order to study it.

Given this multidimensional environment, identifying, distinguishing and analyze different elements (the types of masonry, metrological aspect, conservation state of surfaces, etc.) gives rise to a continuous and organic process of interpretation.

With an experimental approach, information from topographical and architectural survey are integrated with photographic images in a unique digital space. This single 3D virtual environment pushes the boundaries of interpretation beyond the perception of the physical evidence and makes it possible to jointly represent the actual state of the analyzed case studies.

The study of this huge documentation requires a multidimensional visualization of the archaeological data in order to understand their relationship with the geomorphological features of archaeological elements in the monumental context of the city of Rome.

Discussion

The paper focuses on the integration of archaeological and architectural methods and analysis aimed at a multidimensional visualization of three sites construction processes. The potential offered by the use of new survey tools for massive data acquisition, allows us to study the depth characteristic aspects of the artefacts, with a level of detail and a resolution that was an unimaginable up until a few years ago. The archaeological architectural understanding pass through the construction of integrated digital model. This process currently is at the centre of a transformation related to survey technologies and methods to building 3D/2D model, which in recent years has become more and more developed.

Results

The study experimented the visualization of point clouds as platforms for the production of three-dimensional information systems linked to the field of archaeological architecture. Numerical models are generally seen as the first available output of the surveying operations. With respect to the research presented, they become the virtual container of multidimensional data and information connected to the real object, supporting the processes of interpretation.

ID number: 195

Multiproxies modeling to support new insights in landscape archaeology: the case studies of Pecora and Cornia valleys in Southern Tuscany, central Italy

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Abstract:

Alluvial plains, with their fertile agricultural soils and flat pathways, have always been an attractive location for human settlements. Despite the increasing diffusion of geomorphological studies, enhanced by the widespread use of high resolution Remote Sensing (RS) data (LiDAR, Multi/Hyperspectral images, aerial flights), archaeological landscape reconstruction in this type of environment is often problematic due to a typically high level of anthropization, the impact of modern agricultural systems and, in some cases, recent land reclamation activities. In order to overcome these obstacles, using multiple proxy data can help determine the multiscale environmental factors that have impacted the archaeological record (Petřík et al. 2019).

This contribution will discuss how the environmental complexity of two alluvial coastal plains of southern tyrrhenian Tuscany (namely val di Cornia and val di Pecora) has been tackled within the ERC nEU-Med project (www.neu-med.unisi.it) through the combined use of RS data, on-site geochemical analysis, statistical analysis and archaeological records. In particular, we will focus on the integration of different proxies as a tool to describe environmental dynamics, soils, landforms and settlement patterns at different scales. The integration of these different information has allowed for a new understanding of the landscape evolution and a contextualization of the archaeological record.

The first case study focuses on a territorial sample of the Pecora valley, surrounding the settlement of Vetricella (8th-12th AD). Geomorphological analysis identified an almost flat alluvial fan fed by the Pecora river, subsequently eroded by the drainage network which created alternating convex and concave landforms. Modern land reclamation activities, including the construction of drainage ditches and the artificial diversion of the riverbed, have deeply modified the area from the beginning of the 19th century. On this territorial sample, a geochemical extensive survey has covered approx. 140 hectares, with over 2.800 georeferenced pXRF measurements taken on a regular 20m grid. The survey was aimed at determining chemical soil fingerprint possibly related to anthropization and more specifically to archaeological sites. At the same time, the chemical soil response was used to detect discontinuities in soil classes, as a possible consequence of local geomorphological processes, pedogenesis and other natural events. These relationships have been evaluated using data spatial visual assessment in GIS and statistical validation with outliers detection, PCA analysis and logistic linear regression. The result of the analysis has demonstrated the potential of soil’s chemical response to differentiate geomorphological landforms and to detect chemical anomalies related to local physical modifications, metal contamination areas, and the impact of modern agricultural transformation (Dallai, Volpi and Carli 2020).

The second part will be focused on the preliminary results achieved by the development of predictive models for geochemical concentrations using RS data and Machine Learning algorithms. In the alluvial and coastal plain of the Cornia valley, the pXRF geochemical survey collected approx. 8000 measurements over some of the most representative contexts of the area for the study of the diachronic archaeological record. In this case study, the environmental reconstruction is even more challenging, due to the presence of large lagoons historically attested along the coast, and flooded-swampy areas predominating in its distal part, until the reclamation activities undertaken at the beginning of the 19th AD. The relevant extension of the area under investigation required the implementation of predictive modeling tools for the geochemical proxy that would allow the geochemical variable to be extended from the selected samples to larger portions of the lowlands. Through the use of multispectral satellite data, morphometric variables and Random Forest regression modeling, we achieve a relatively good prediction accuracy for some of the most useful chemical elements concentration (Ca, K, As, Ti, Fe, Mn, Rb, Zr). Extended geochemical maps were then used to characterise landscape forms, identifying environmental dynamics and relating them to soil nature or anthropic activities. At the same time, the results show that a defined sampling strategy and a proper spatial validation procedure is fundamental to determine reliable model accuracy and to reduce overfitting of spatial variables as well as extrapolation issues (Hengl et al. 2018).

To sum up, thanks to the combination of several survey techniques applied to selected territorial samples, it was possible to propose a remote geomorphological and morphometric reconstruction of the Val di Pecora and Val di Cornia (southern Tuscany), supported by geochemical characterisation. The use of the identified variables, verified through statistical validation and combined with the archaeological record, greatly helped in understanding some of the environmental dynamics that have influenced the study area over time. From an operative point of view, the use of predictive modeling has resulted of great help in planning onsite research and reducing the time-cost of an extensive survey campaign. Moreover, this approach can be used as a preliminary evaluation tool to select areas of specific interest and to address additional analysis. Finally, the identification of these variables is extremely significant for a correct interpretation of the archaeological 'invisibility' and consequently for a better assessment of the archaeological traces.

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A Web-service for dynamic least-cost-maritime-path analysis and visualization within the context of seafaring in the Eastern Mediterranean during the Classical period

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Abstract:

Seafaring can be defined as the use of the sea by humans for traveling and/or transportation purposes; it is primarily governed by the purpose of travel (which is translated into route planning), environmental conditions, marine technology, as well as human navigation capabilities. Modelling seafaring has received increased attention within maritime archaeology, as well as in the broader context of human mobility and human/environment interactions. Seafaring modelling approaches have already been developed within the context of Geographical Information Systems (GIS), and are typically based on Least Cost Path (LCP) analysis. Existing maritime LCP applications, however, typically employ average weather conditions, and thus do not account for the variability of such conditions that might have been encountered during maritime travel.

Previous work by the authors within the context of the H2020-funded iMARECULTURE project: “Advanced Virtual Reality, Immersive Serious Games and Augmented Reality as tools to raise awareness and access to European Underwater Cultural Heritage” – https://imareculture.eu – has led to the development of an LCP model for dynamic fastest maritime route computation in the Eastern Mediterranean. The model employs time-varying wind speed and direction information and can accommodate user-provided sailing diagrams postulating ancient vessel response to wind conditions; the model has been embedded in the implementation of the “Seafarers” serious game (Poullis et al. 2019).

The current research pertains to the development of a Web-based service offering access to the implementation of the above dynamic LCP model, including the visualization of its resulting maritime routes in the Eastern Mediterranean. The developed Web-based dynamic LCP modelling service was inspired by Orbis: The Stanford Geospatial Network Model of the Roman World, which furnishes possible maritime paths for the Roman Era (Scheidel 2015). Our service differs significantly from that of ORBIS in terms of the input weather information which is here derived from public-domain numerical weather predictions from a mesoscale model, as well as the ability to account for arbitrary user-supplied sailing diagrams such as the one implied in Leidwanger (2013).

The implemented Web-service offers users the ability to visualise paths and isochrone contours by taking (or not) into account cabotage, supporting at the same time route visualisation in 3-hour intervals, as well as the possibility to display and compare either two paths/contours or more on a monthly basis. The current implementation includes sailing diagrams corresponding to Kyrenia-Liberty ship and to Leidwanger’s model; the former was

obtained from actual sailing experiments performed during the period of January 2003 to January 2008 (archive of Glafkos Cariolou).

Through multiple maritime travel scenarios (pairs of origin and destination locations, as well as departure days/time and sailing strategy), this paper illustrates the ability of the resulting distribution of estimated travel times to bracket historically-reported times made under similar conditions and settings.

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ID number: 197

The pictorial decoration of terracotta in the archaic workshops of Capua: from color to texture

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Abstract:

The paper aims to illustrate the implications and results obtained through the use of new technologies applied to the taxonomic study of a huge group of antefixes of the Archaic period, coming from excavations started in 1845 in a private fund today located in Curti, near Caserta, named ‘Fondo Patturelli’.

These materials covered the wooden structures of sacred buildings roofs, that formed a huge sanctuary whose oldest phase, to which most of the archaeological remains are ascribable, is dated to the 6th century BC.

Nowadays, finds are preserved in the ‘Museo Provinciale Campano’, located in Capua, partly exposed in the rooms and mostly unpublished and preserved in the warehouse of the museum.

These materials consist of a corpus of about nine hundred elements, previously studied and classified according to the pre-established scientific criteria that characterize all serial productions and filed in a database created ad hoc.

The classification foresees a first articulation in groups, which differs for the subject of the central field; a further division consists in identifying the type, based on the chronological period of belonging; finally, the division into series identifies the group of materials as made from the same mould.

Will be extrapolated some prototypes from the groups whose antefixes present, as their main subject, the female head placed within a nimbus, a lotus flower, or the gorgonic masks.

The groups from which will be extrapolated some prototypes are those whose antefixes have as their main subject the female heads within the nimbus, those within a lotus flower and gorgonic masks.

Through the creation of 3D surveys carried out on part of these materials, through the 3D modeling of the same and through the integration by interpolation of any lacunas in the geometries in a virtual environment, almost all the prototypes of the identified series have been reconstructed.

This contribution will explore the processes related to the last reconstructive phase of a prototype of antefix: the terracotta painting.

Inside a shop of the 6th century BC. the application of color was done at the end of the firing processes and the craftsman had a pre-established repertoire of pictorial variants for each module of the slab, which he combined together alternatively in order to decorate the roof of a building.

Thanks to the support of previous studies relating to the composition and original color rendering of the pigments found on some antefixes, through the data from the 3D reliefs carried out on the realia and through comparisons with other corpora of contemporary materials from the Campanian area, the range of tones used in the workshop has been identified and reproduced.

Once the color palette has been obtained, it is possible to reproduce the coloring path of a sample of prototypes in a virtual environment.

Through the use of 3D and 2D software programs for the processing of textures, it is possible to combine chromatic data of fragmented antefixes pertaining to each series and rework them by integrating them, to offer an overview of the main decorative combinations that adorned the roofs of the buildings of the sanctuary of ‘Fondo Patturelli’.

These kinds of technological experimentations contribute to diversify our memory transmission modes.

They offer the chance to create digital and implementable catalogs, useful for a dynamic documentation of the archaeological heritage, but also and above all, fundamental tools for the monitoring, conservation and fruition of the corpora analyzed.

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An Open and Shut case? Towards Shared Standards for Stratigraphic Data and Heritage Linked Data or LOD

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Abstract:

The Matrix project (AHRC AH/T002093/1) is investigating how digital data from archaeological excavations can be made more consistent and useful thereby more interesting and cost-effective to a range of users and audiences. It is working towards a shared plan and methods to get such data more consistently recorded, analysed, disseminated and archived in a way that is Findable, Accessible, Interoperable and Re-useable (FAIR).

The Matrix project has four key areas of activity:

1) Digital Standards;

2) Characteristics of digital Heritage Data;

3) Stratigraphy Standards;

4) Research Tools;

Areas for investigation in the project include enhancing the recording of implicit and explicit spatio-temporal and temporal relationships in the digital stratigraphic records of archaeological investigations and the use of LOD vocabularies to deduce or make explicit temporal Periods and/or other types of reference data. The project also reviews current stratigraphic matrix analysis activities, including stratigraphic and temporal recording and analysis processes, digital stratigraphic data archiving, and requirements for chronological modelling and reuse of data.

The Matrix project aims to address 2 major research questions:

1. How can we encourage the sharing, linking and interoperability of archaeological data and information, particularly information derived from the commercial development funded archaeology sector in order to maximise public value and enhance the research potential of archaeological data?

2. How can we ensure the consistent development, application and enforcement of existing technical information and data standards and their promotion to others?

The Matrix project is addressing the current problems caused by the lack of standardized approaches to digital archiving of archaeological data using the particular case study of stratigraphic and phasing data. Stratigraphic data form the backbone of all the related archaeological records from each excavated site and are essential for integrated analysis, wider synthesis and accessible archiving of the growing body of archaeological data and reports generated through the commercial archaeological sector in the UK and internationally. The stratigraphic record, usually in the form of a stratigraphic matrix, with associated relationships and data, acts as a primary, if not the primary piece of 'Evidence' for

how, and in what order, the site was excavated. As such the stratigraphic matrix is the key mechanism that enables anyone less familiar with the site, to re-visit the excavation records, understand what data is most relevant for any particular research questions, or problems encountered, and piece together the underlying details of how the interpretations by the excavator(s) were actually arrived at. However, such records are often only held on paper or scanned copies of matrix diagrams that cannot easily be re-used with associated data. Often the key phasing data needed for synthesis work and interpretive understanding is not well documented or archived consistently, if at all, in written reports. This results in key records being unsearchable or remaining unconnected to other data and at best usually requires lengthy and wasteful re-keying if any one wishes to work with the archives from such sites. The focus of digital archives and museums is now switching from simply providing better access to digital archives, to questions of how users in commercial units, curatorial organizations and academia, along with the general public, can make best use of this growing body of digital information and data.

A number of research projects in the last 10 years have attempted to draw together archaeological archives from different excavation teams to analyse the temporal sequences and use the stratigraphic relationships recorded on site to cross-search for artefacts and structures from related phases (e.g. STAR project Tudhope et al 2011). But a lack of consistent practice in digital deposition of such records has placed severe limitations on the amounts of archaeological records available for such analyses. For Chronological modelers of archaeological data these problems are exacerbated by a lack of standardized approaches to the archiving of stratigraphic data, often held in hard-copy matrix diagrams or inconsistently structured database tables. The outcomes of the Matrix project will help inform decisions on digital archiving standards and best practice for stratigraphic data deposition and re-use, so that such digital data can be held and re-used in a form most suitable as input for Bayesian calibration software such as BCal, OxCal, or Chronomodel. The use of such Bayesian chronological modelling techniques has become critical in the more accurate dating of archaeological sites and phases in the last 10 years, but the way such information is analysed is quite painstaking and often involves many hours of laborious manual data preparation for key staff involved (Dye and Buck, 2015). The techniques this project develops will considerably reduce the inefficiencies in this process.

This paper will present interim results on several topics relevant to this session, including:

- A process review carried out by the researcher to understand and model existing processes for digital stratigraphic recording and analysis by major archaeological contracting organizations and research funded bodies (across the UK and those using stratigraphic methods elsewhere).

- Considerations of interchange and potential archive formats for stratigraphic data derived from Analysis and Phasing processes.

- Exploratory development of a spatio-temporal matrix phasing methodology that enhances the Harris Matrix methodology by incorporating implicit temporal relationships and Phasing relationships using Allen temporal operators (Allen 1984) and/or temporal primitives (Papadakis 2014) as used in the CIDOC CRM (ISO 21127:2014) and the CRMarchaeo extension for the archaeological excavation process.

- A prototype tool developed to explore the potential for converting legacy stratigraphic matrix data from archives for export and re-archiving.

- The project outcomes aim to improve the re-usability of stratigraphic data for Bayesian chronological modelling and thereby the accuracy of Bayesian chronological modelling techniques and tools along with increasing the FAIR-ness especially interoperability and synthesis of archaeological data.

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Mathematical modeling of spreading processes on archaeological networks

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Abstract:

Real-world systems are often modeled as networks, where nodes of a network represent entities of the system and edges describe interactions between these entities. Analysis of such networks has lead to valuable insights about the underlying systems coming from many different areas: sociology, biology, technical sciences etc. In particular, archaeological network analysis has gained a lot of attention in recent years, as using graph structure can enrich historical data with additional relational information. However, many of the existing approaches rely either on directly adapting perspectives from network science without taking into account the archaeological context or vice versa. Cross-disciplinary collaborations that would offer a common view on the challenges arising in archaeological complex systems are still largely missing.

In this talk, we will present a new mathematical framework for modelling and simulation of spreading processes on archaeological networks [1,2]. Our approach combines a data-driven dynamics of human movements with a time-evolving network for possible social interactions. In particular, we are using not only relational data in the form of a network, but also incorporate spatio-temporal information, geophysical knowledge and existing material traces provided by archaeologists. We will demonstrate the applicability of our model on an example of wool-bearing sheep spreading in the Near East and Europe, between 6000 BC and 4000 BC (Figure: Snapshot of one realization of the wool-bearing sheep innovation spreading in ancient times). Our work within this context offers an instructive way for studying of the qualitative effect of different aspects on the speed and spatial evolution of spreading processes in ancient times, such as: geographic, climatic and cultural aspects.

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ID number: 200

Assessment of soil erosion processes on archaeological sites using the SIMWE Model and GRASS GIS: The Case Study of Amathous, Cyprus.

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Abstract:

Soil erosion by water is a significant factor in physical and chemical destruction and degradation of archaeological structures and artefacts amplify the natural deterioration and reduce the capacity of the soil to maintain cultural heritage. In recent years, Remote Sensing has been recognized as a suitable tool for monitoring soil properties and the corresponding soil erosion phenomena. Thus, the main aim of the present study is to develop an integrated approach for estimation and simulation the spatial pattern of erosion, sediment transport, and deposition caused by a single intense rainstorm event (mm/hr in min) on the archaeological site of Amathous in Limassol district (Cyprus). The variability of the terrain and the slope of the study area impose various degree of soil erosion to the different part of the site. For the estimation of soil loss in the study area, the SIMulation of Water Erosion (SIMWE) model was used in combination with open source GRASS GIS as the modules r.sim.water and r.sim.sediment and medium and high resolution Earth observation data. The SIMWE model’s implementation requires various spatial datasets, like those of meteorological data (rainfall intensity), soil, land cover and geological data, the Digital Elevation Model (DEM). The output is water depth, flow velocity, and discharge maps. The model is based on the Monte Carlo method of bivariate water and sediment flow continuity equations, and provides modeling with spatially variable resolutions. Also, multi-temporal Landsat images for the years 2001 and 2017 were obtained and then, two pixel-based supervised classifiers random forest (RF), and classification and regression tree (CART) machine learning algorithms on Google Earth Engine (GEE) were applied in order to investigate and map land use change.

The overall results show that the transport limited erosion-deposition ranges from 0.0150 kg/ms2 to -0.05699kg/ms2 where the positive values show the erosion and the negative values the deposition. The highest rates of both the erosion and the deposition are predicted in areas with high concentrated sediment flow. High sediment flow rates were observed in middle and northern parts of Amathous and varying flow rates in adjacent areas. Final maps of simulated erosion/deposition indicate that with the increasing number of iterations, the values of erosion/deposition in the place of flow concentration in northern parts of the area are increasing, too. In the literature few studies have been conducted by applying the SIMWE model, however no comparable applications on archaeological sites have been recorded.

ID number: 201

XRchaeology: The Pros and Cons of AR/VR/XR Learning Tools in Archaeology Education

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Abstract:

Archaeology educators are exceptionally well positioned to draw the past to life through contemporary 3D modeling and mapping, augmented and virtual reality, and the dynamism of interactive web-content. Whether teaching archaeology digitally, or teaching with digital archaeology, we are faced with the ongoing questions of how multi-layered data can be used to engage learners, build online communities, and how to assess learning. Is it possible to mobilize the ‘wow’-effect of modern technologies to transform archaeological data into issue- or problem-based learning tools for critical inquiry and innovative problem-solving? Can integrity of assessment systems and skills-building be maintained? What role does technology play in this process and what are the implications?

We aimed to bring real-world problems of social inequality and marginalization to life using digital materials and virtual 3D interactions. Unfortunately, our first attempts at mobile learning tool development met with several unforeseen challenges including cross-platform incompatibility and inaccessibility of our materials to users with outdated technology. Implementing innovative multi-dimensional content in robust and holistic ways, however, was a vital part of our project that could not be left behind. Today, with several cycles of classroom and online implementation behind us, we share insights gained from both our successes as well as failed attempts that necessitated re-envisioning of how we interact with multi-dimensional digital archaeological remains.

XRchaeology project began with the intent to overcome obstacles that arose through traditional means of accessing archaeological collections in museums or archives, and the more specific need to focus on materials not suitable for exhibition but which are highly relevant for understanding complex archaeological settings. Rather than beautiful artifacts, we focused on reconnecting ‘ugly’ quotidian and incomplete objects to the physical settings and situations from which they were derived, thus making use of robust archaeological data normally hidden in curation archives. We also aimed to overcome the governmental restrictions from exporting and sharing objects from international fieldwork by creating digital object replicas and virtual experiences that could be used remotely by multiple users.

On one hand, the XRchaeology project presented an opportunity to introduce archaeological concepts and engage learners in immersive digital environments in ways that move beyond “technology-enhanced traditionalism” in the social science classroom (DeWitt 2007). In contrast, XRchaeology modules require learners to construct knowledge and apply concepts to new and novel situations as they develop the skills necessary for inquiry-based decision making in the social science curriculum (e.g., Brush and Saye 2009). This project is part of an emerging field of instructional design and scholarship in social science education that seeks

ways to transform the teaching and learning experience (e.g., Wright-Maley, Lee, and Friedman 2018). When considered through the SAMR (Substitution-Augmentation-Modification-Redefinition) framework, this project implements ways digital learning environments can move beyond mere “Substitution” to transformational levels of “Modification” or “Redefinition” of the learning process (Puentedura 2013). It also presented an opportunity to use archaeological data for active learning and assessment, as opposed to passive information presentation and grading in classrooms, in multiple modalities.

The role of learning assessments has become a central focus in North America and other parts of the world (Buyukkarcı 2014; Fulcher 2014). Assessment is a valuable part of the educational process as it defines the quality of the experience, learning objectives themselves, and the impact of learning opportunities provided to students. The recent focus on assessment has reshaped student learning and, consequently, instruction and assessment processes in all disciplines. If new assessments are to be implemented in classrooms, however, educators need to reassess their classroom-assessment practices and promote student learning. XRchaeology is accompanied by a rich system of assessment to help students develop skills necessary for inquiry-based decision making. While developing XRchaeology learning materials, we encountered several unforeseen obstacles:

1. Finding the best tool for reconstructing 3D artifact and site replicas took more time than expected, given that users would need to view and interact with models from different platforms and devices.

2. 3D objects rendered in the standard .obj or .fbx formats are still not fully compatible with most Learning Management Systems without an interface.

3. The expense of sharing interactive immersive and 3D content with multiple students in large classrooms using VR headsets was not a feasible option.

4. Even with the growing adaptability (interoperability) of heterogeneous platforms like traditional computers, mobile devices, and VR headsets that run different operating systems, it is challenging to develop digital learning tools that are accessible for everyone.

Despite these limitations, conveying richness of the archaeological record in new captivating ways remained a central theme. To enrich the process of critical inquiry, we moved beyond conventional teaching strategies and focused on immersing learners into interpretive and full-bodied experience. Foundationally, we were determined to prioritize access to interactive content that was not restricted to any single platform. Rather than developing multi-user virtual experiences, we ultimately chose a web-based application solution to achieve cross-platform functionality, while maintaining opportunities for immersive engagement (Agugiaro et al. 2011; Doyle, Dodge, and Smith 1998). Our immersive approach teaches the importance and significance of even mundane items of material culture while using multi-dimensional experiential media to make real-world connections to the past, present, self and community.

In the end, XRchaeology mobilizes new media to capture the attention and imagination of learners. Like their in-field counterparts, our simulated object-based learning modules not only transform “how students think about archaeology, history, and the past”, leaving a lasting impression upon those who experience them (see Henderson and Levstik 2016). The two applications we have developed so far use a combination of traditional web technologies such as HTML, CSS, Javascript, and a new widely adopted WebGL library for efficient rendering of 3D objects in a web-browser across all platforms (Jackson and Gilbert 2021). Using these technologies and with special attention toward responsiveness, screen size and method of interaction, we developed a cross-platform, and multi-functional learning tool for engaging learners in equitable, inclusive ways, although they are quite different from initially expected.

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ID number: 202

On the Emerging Supremacy of Structured Digital Data in Archaeology

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Abstract:

While the epistemological affordances and varied impacts of different media on archaeological knowledge production have been scrutinized by many practitioners in recent decades, sources of digital structured data (e.g. traditional relational databases, content management systems, online data infrastructures) have seen far less critical enquiry. Structured digital data are often venerated for their capacities to facilitate interoperability, equitable data exchange, democratic forms of engagement with and widespread reuse of archaeological records, yet their constraints on our knowledge formation processes are arguably profound and deserving of detailed interrogation. High-quality sources of digital structured data are representations like any other (e.g. books, video games, TV shows, scientific reports, etc.), and as such they demand that we ask questions about what, by the very nature of their structure, they enable and resist. In this presentation, then, we discuss what we call the emerging supremacy of structured digital data in archaeology, seeking to question its ubiquity and destabilise claims about its objectivity. We ground our argument in a case study of a range of texts produced by practitioners working on the Çatalhöyük Research Project, attempting to map these texts to structured data via CIDOC-CRM. Specifically, we draw upon raw observational data (diary entries), grey literature (archive reports), formal academic publications (monographs), as well as more public facing interpretative outputs (i.e. heritage interpretation narrative). This exercise of mapping texts to structured data in CIDOC-CRM allows us to make preliminary observations about the representational affordances and resistances of each. Ultimately we argue that the push to create more and more structured and structure-able data needs to be tempered by a more inclusive digital practice that protects difference, incommensurability and interpretative nuance. Borrowing from Arturo Escobar (Designs for the Pluriverse, 2018), we must be proactive in shaping a world where many worlds fit.

ID number: 203

Dealing with an unbalanced dataset in Archaeology: a case study in the rock art archaeological sites of the Pajéu Watershed, Pernambuco/Brazil.

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Abstract:

The use of predictive models in Archeology (PMA) has earned space in archaeological research, especially in activities related to infrastructure projects. According to Verhagen and Whitley (2020), the models applied until today can be separated between induction (data-driven) or deduction (theory-driven), the first being guided by statistical implementations and the second is based on pre-conceived or already established information, without necessarily having any type of metrics that can evaluate these models.

There are many criticisms regarding the PMA, one of the most pronounced, is in the fact that, some researchers, overestimate areas predicted as high probability, to the detriment of others, especially in CRM contexts. A model, even if accurate, it must be tested not only statistically, but also in the field, with a well-defined prospecting, which can attest, be contested, and even provide more information to given modeling.

In addition to this aspect mentioned above, most PMA tend not to work with socio-cultural data, the information used is based on current databases, and there is also, especially in deductive models, a researcher bias, since he defines the variables to be used from conjectures and weights.

Because of the problems listed above, one of the alternatives in PMA applications is Machine Learning (ML) algorithms, which according to Barceló (2009), appear in Archeology with the ability to make machines learn from inferences and errors. ML algorithms can provide more graduated answers to the archaeologist, removing much of the bias, since it does not require the definition of variable weights and, moreover, it provides techniques for feature selection, making the models be trained with different attributes and then perform a filter that can work only with the most statistically significant elements.

Archeology, like many real-world cases, poses a major methodological challenge in the application of ML algorithms. This occurs because, in addition to the data referring to archaeological sites, there are predictive models in which absences are taken into account, in other words, places that were visited during a survey, but no vestiges were found. Therefore, there is a disparity in the quantity of data from these two classes that make up the model, as there are many more absences than presences, configuring an unbalanced model.

This work intends to bring some methodological applications that can be done to work with unbalanced data, using archaeological sites with rock arts from the Pajeú Watershed Region, in the state of Pernambuco, in the Northeast of Brazil. This area was practically not the result of any in-depth scientific study, except for the survey carried out during a project called “Projeto de caracterização e documentação dos sítios rupestres no semiárido de Pernambuco” (Pessis et al. 2018), which provided the data for this research.

The data referring to rock art sites were inserted in the GIS, together with the data that represents the absences, obtained through navigation GNSS equipment during the Project mentioned above. Also, environmental data (slope, aspect, total insolation, visibility index, TPI ...) were inserted, mostly extracted from SRTM satellite images (30m), and lithology and geomorphology data provided by Brazilian government agencies.

The data referring to archaeological sites and absence were transformed into polygons and from there the zonal statistics were extracted for each of them, as from the environmental variables. After that, the information was exported in tabular format for proper processing in the Python programming language, to run the model itself.

Python includes several libraries for the creation of Artificial Intelligence models, one of the most used is Scikit Learn (Pedregosa et al. 2011; Buitinck et al. 2013), which was chosen for the development of the models. In addition to the aforementioned library, as we are dealing with unbalanced data, the Imbalanced-learn (Lemaiître, Nogueira, and Aridas 2017) library was essential for the application of techniques that could decrease the problems generated by this kind of data sets.

The data set was separated into three packages, for training, validation, and testing, and several models were created, with different implementations. Firstly, a resampling technique called Synthetic Minority Oversampling Technique (SMOTE) (Chawla et al. 2002) was applied, which seeks to equate minority classes (sites) with majority class (absence), through interpolation between several similar instances that are nearby (Fernández et al. 2018).

A clustering technique was also used, even before applying the model, using a K-means (Arthur e Vassilvitskii 2007) method to identify the imbalance of classes with different patterns of environmental characterization and, consequently, balance them, keeping the proportionality of these patterns. After that, resampling methods were applied, such as SMOTE or the Adaptatative Synthetic Sampling Approach (ADASYN) (He et al. 2008), thus aiming to insert synthetic samples from classes of lesser representativeness and, therefore, more difficult to be learned by Machine Learning methods.

Logistic regression, artificial neural networks, decision trees, random forests models were applied, all of them based on the data already resampled. The Imbalanced learn library also allows the application of algorithms already appropriate to work with unbalanced data, such as the case of Balanced Random Forest and Balanced Bagging. In addition to these, an anomaly detection model was also applied, using an Isolation Forest and a One-Class SVM, which seeks to find data that does not correspond to the model's target, which in this case were the sites.

We had quite interesting results, especially after applying clustering together with the resampling techniques cited above. The Recall and F2, metrics widely used to evaluate unbalanced models, had results above 80%, in the logistic regression, weight random forest, balanced random forest and balanced bagging models (Figure 1), giving an excellent subsidy to outline a field strategy to attest the model's effectiveness.

ID number: 204

Digitizing Delphi: A Case Study in Virtual Reality Pedagogy

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Abstract:

Digitizing Delphi: A Case Study in Virtual Reality Pedagogy

The recent pandemic has accelerated the investment in and development of remote, online, and virtual instruction methods. This paper presents a personal case study of one such shift, from an in-person course in which honors students wrote a traditional essay to a remote course in which this same group engaged in the 3D virtual reconstruction of an archaeological site: the Panhellenic sanctuary of classical Delphi.

The adoption of virtual reality methods in the classroom is, of course, not entirely new. Recent studies have presented a variety of potential benefits to employing virtual reality as a teaching tool (Liu et al. 2017) These benefits include increased interest and engagement in course content, improved creativity, and greater cultural competence. In particular, in the realm of archaeology and history, virtual reality provides students with the opportunity to virtually visit international sites, explore world class museums, and engage with the material past in three dimensions (Gartski et al. 2019). Similar studies have also noted significant obstacles and drawbacks to the implementation of VR pedagogy, including the cost of hardware and software, the physical nausea that can arise from VR headsets, and the difficulties in gaining pedagogical benefits beyond the novelty of the technology (Allison 2008).

This case study presents the results of employing a virtual reality honors project as part of my general education course “Meet the Ancients: Gateway to Greece and Rome.” The course itself enrolled 300+ students of which 15 (about 5%) were honors students. To earn honors credit for the course, students had to complete five tasks culminating in a digital reconstruction and exploration of the ancient Greek site of Delphi. Meetings were held once a week for approximately half an hour within the Engage VR program that facilitates teaching and conferencing within a 3D virtual reality space. The assignment progression was as follows:

• First, students began by reading secondary sources about the history and layout of the site, and each student chose a monument to focus their project on.

• Second, students read the ancient primary source account of Pausanias’ trip to Delphi in the early 2nd century CE, constructing a written response based on this text regarding what a visitor would have experienced when visiting the Temple of Apollo and traversing the Sacred Way.

• Third, students conducted research on their monument and developed a 3D digital model of the monument using SketchUp Free. SketchUp Free was chosen to (a) provide a no-cost way for students to begin modelling, and (b) due to it’s relatively gentle learning curve compared to more powerful 3D modeling software (e.g., AutoCAD).

- Fourth, the class worked together within the program Engage VR to articulate their monuments according to an archaeological plan of the site, recreating a rough model of the site within the virtual reality setting.

- Finally, students progressed through the site along the Sacred Way, with each student presenting their work as we moved collectively through the virtual space.

The goal of this project was to provide students with an active role in the reconstruction of an ancient site and provide an immersive experience for exploring a key religious site in the ancient Greek world. Along the way, I hoped they would develop a greater degree of digital literacy and learn the basics of 3D modeling, which may be of use outside the field.

Based on the feedback from the honors students, results of the project were mixed. Students who purchased VR headsets thought the experience was immersive and a “cool” way to learn about antiquity, but half the honors students did not purchase or rent headsets due to the high cost, choosing instead to participate through the Engage VR desktop client, and this subset of students was less keen on the project. Moreover, even students who used the headsets suggested that more frequent use would have improved the project. The 3D modeling portion of the project also received mixed reviews, with some students really getting into it, while others found the technology to have a steep learning curve. Individual responses ranged from “this is the coolest thing ever” to “can’t we just put together a PowerPoint instead?”.

In many ways, the results of this case study seem to echo many of the prior studies on VR pedagogy. For students comfortable with technology who actively immerse themselves in the experience, it can be a powerful tool. However, barriers – whether financial or physical or technological – are real for many students, and these pose a challenge to large scale adoption in the classroom. Many of these obstacles to pedagogical VR and AR adoption have been noted in other archaeological lab-based contexts (Nobles et al.). Based on my experiences with this case study, I would encourage the use of VR technologies as a potential “opt-in” opportunity for motivated students, whose a priori interest in the course material or technology may lead to a powerful intellectual engagement, while mitigating some of the drawbacks from students who are less interested in the VR experience.

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ID number: 205

Technologies of Resilience, Climate Disaster, and Maritime Networks: A Case Study of Cycladic Small Worlds

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Abstract:

This paper explores the uses of the sail as a technology of resilience among maritime communities facing climate disaster in the Cycladic islands, Greece, during the Aegean Bronze Age. The marginal environment of the Cyclades, small population size, and microdiversity of the islands meant that even under normal circumstances, island communities would have been dependent on one another in times of hardship. In the event of acute climate disaster, such as the eruption of the Theran volcano in the late 17th century BCE, islanders could have called upon existing small world networks to aid them. The persistence of social ties would have the secondary effect of maintaining the long-term resilience of the overall maritime network. However, this contrasts with an earlier climate disaster, the 4.2 kya event in the Early Bronze Age, during which a combination of factors including the unavailability of sailing technology contributed to the collapse of small world maritime networks. The maritime interaction model in this paper was developed using Esri ArcMap and consists of a series of isochrones indicating how far it would be possible to travel by boat to settlements in the extant archaeological record. This method expands upon Leidwanger’s (2013) model of Roman seafaring routes by including monthly data, comparing change across chronological phases, calculating isochrones rather than reconstructing routes, and considering different types of sailing technology. The conceptual framework of technologies of resilience is compared to ethnographic case studies, particularly in the Pacific Islands, where the use of maritime technology during times of climate disaster or other environmental extremity facilitates the mobilization of small world networks for short-term support and long-term resilience.

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ID number: 206

A report of failure and understanding: The introduction of GIS and Open-Data as a stand-ard for documentation and archiving in rescue excavations

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Abstract:

Introduction

The number of rescue excavations in Baden-Württemberg has increased significantly in recent years. Consequently, archaeological heritage management has had to adapt to this situation in a number of ways. In 2013, the “Pilot Project Flexible Prospecting” was set up for the rapid preliminary investigation of areas intended for development and since 2016 commercial excavation companies have been licensed in the state to carry out the majority of rescue excavations.

The Problem

In the course of the reorientation of the rescue excavation system, a reorganization of ex-cavation documentation has become necessary, the goal of which has been to ensure high quality standardization of the data collected on the excavation or created in their evalua-tion. Open standards are largely used, as they are per se suitable for long-term archiving. There has also been a clean break with earlier documentation methods. Proprietary CAD software, in particular, which had become very expensive, and subject to increasingly re-strictive to license practices, was subjected to a critical review. As a result, it was decided that prospection and excavation the graphic representation and evaluation should be com-pletely switched to GIS systems. The written documentation comprises of standardized text files and the entire documentation is stored in a normalised form and content.

Starting Point

The initial situation was – and we are very sure of this - comparable with a large number of archaeologically active institutions in Germany and beyond: there were few to no stand-ards, many different actors were involved in documentation with differing means and methods. The state of digitization differed widely. Most plans were created in CAD and findings often recorded using photogrammetry but the creation of hand drawings was still common practice. There was no consistent, systematic archiving system. The filing in the archive, as far as it happened at all, happened according to the principle: “We take what comes”.

From this starting point, the goal was to establish logical, high-quality primary documenta-tion in non-proprietary formats as a standard. The data should be "Findable, Accessible, Interoperable and Reusable" [2]. The use of OSS should be made possible throughout and ultimately the data should be ready for immediate long-term archiving, in terms of content, technology and legal compliance.

Implementation proved (and still proves) to be fundamentally difficult. The underlying prin-ciples has been the creation of a set of binding documentation guidelines, which on the one

hand formulate precise target specifications (data types, formats) with reference to pre-existing recommendations (e.g. IANUS) and on the other leave the data creators the greatest possible freedom in their methods of data collection and processing.

In their first version, the guidelines for the design and standardization of GIS projects and documentation were heavily influenced by previous CAD methods. This not only led to numerous problems in practice, but also caused projects to become cumbersome and intransparent. The aim of the introduction of GIS was thus initially missed. It has also be-come clear that some archaeological issues cannot be easily mapped with GIS. Examples might be the complex stratigraphies urban or wetland archaeology. After three years of practical use, it has become clear that a simplification and stringent implementation of the GIS requirements has become necessary to address these problems.

From CAD to GIS – Summary

This paper presents our experiences in implementing GIS and open data as a standard for documentation and archiving in rescue excavations, describing the successes and some disappointments experienced along the arduous path from CAD to GIS and linked data in Baden-Württemberg. The focus is less on technical details than on the presentation of the systemic superstructure and substructure in the statewide implementation of GIS as a standard.

An outlook presents work planned for the future such as the incorporation of legacy documentation, provision of data for supra-regional processing or long-term archiving.

[1] https://www.denkmalpflege-bw.de/index.php

[2] https://www.force11.org/group/fairgroup/fairprinciples

ID number: 207

User-centered design for digital applications on Underwater Cultural Heritage

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Abstract:

Underwater Cultural Heritage (UCH) is a rapidly evolving field of digitally assisted management of Cultural Heritage (CH). A substantial number of digital applications are being designed and promoted every year in various parts of the world in an effort to facilitate research, enhance protection strategies and promote interaction between UCH and the public. As in any case of digital development, in order for them to be successful, there is the need to understand the motives that drive these endeavors and the context within which they are going to be used; in other words, to understand the users. Most often, every developing project is focused on the study of the particular users involved, seeking information in order to cover mostly practical issues that derive from the special underwater environment involved and the impediments it produces to CH management. However, a holistic approach to the matter of user experience (UX) in the creation of digital applications for UCH can provide a wider view on the subject and elaborate more on the theoretical aspects of this procedure. Introducing a discussion that confronts theoretical issues on the content, the overall interaction of the public with this unique cultural capital and of course the various aspects of Digital Cultural Heritage (DCH) theory, this presentation will provide a general theoretical framework for approaching UX in the context of UCH.

ID number: 208

Politia II: a Virtual Tour Management System

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Abstract:

The educational use of virtual tours in museums and cultural sites has been well studied in the past. This kind of remote interactive dissemination and participation encompasses a plethora of benefits, while allowing the visitor to become part of a lifelong learning community [1]. Additionally, the option of visiting a virtual exhibition contributes in overcoming many limitations existent in tourism, such as time and economic constraints, location accessibility and language barriers. There have been plenty implementations on the Web, many of which lack the aspect of content adaptability after the inaugural creation of the scene [2, 3].

The lack of standardization in this field results each project and research team to comes up with a new idea, method and approach, in order to implement a tool for creating virtual exhibitions, which is usually tailored to address domain-specific requirements. There is also no standardization to the analysis of the user engagement and the fulfillment of their needs regarding their visit i.e., the way a user interacts and is satisfied with the showcased content within the virtual exhibition. Among the most challenging issues in implementing a virtual exhibition system are (a) the GUI design, (b) the dynamic input of content, (c) the management of content, and (d) the analysis of the visitors’ experience based on their interactions with the virtual environment.

A Virtual Tour Management System called Politia II VTMS that combines a web-based management interface with explorative worlds created by modern game engine technologies is presented in this paper. Through the web interface, the web site manager is allowed to dynamically manage the exhibition’s resources, control the content reachability with respect to the visitor’s profile (e.g. language, cultural background), examine the tour’s impact by accessing analysis tools and finally promote the exhibition employing advertisement channels like social media.

Additionally, through an authoring environment, the practitioner has the flexibility to insert points of interest and assign to them content retrieved from other cultural repositories. This content assignment is allocated in real-time within the exhibition’s virtual world. To ensure the virtual tour follows its creator’s conceptual layout, the authoring environment offers functionality similar to the one of the external visitors/users. On the other hand, the visitor receives training in a more stimulating and attractive way by immersing into an interactive virtual word. Modern game engine technologies offer outstanding graphics, thus exploring the scene can be converted to an entertaining activity. From the technical point of view, game engines are able to render demanding 3D scenes, which offer the opportunity of creating

many, albeit complex, virtual exhibitions. To this end, Politia VTMS provides a complete management interface, in which anyone can easily create, customise and manage virtual tour exhibitions. The concept can be easily adapted to educational demands as it is demonstrated by different case studies presented in this paper.

This work was supported by the project ‘‘POLITEIA II” (Politismos-Technologia, New Technologies in the Research, Study, Documentation and Access to the Information for Cultural Heritage Objects and Monuments II) (MIS 5002478) (implemented under the ‘‘Action for the Strategic Development on the Research and Technological Sector”) funded by the Operational Programme ‘‘Competitiveness, Entrepreneurship and Innovation” (NSRF 2014-2020) and co-financed by Greece and the European Union (European Regional Development Fund).

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ID number: 209

Computer Vision Understanding of Narrative Strategies on Greek Vases

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Abstract:

In this presentation we tackle the problem of understanding complex relationships and cultural references within artworks of Classical Antiquity by Computer Vision techniques using Machine Learning. Therefore, we approach the open challenge of understanding the semantics in images beyond the automated recognition of individual objects, by computationally identifying general formal schemes of human interaction.

Our dataset consists of several thousands of images of Attic vase paintings from the 6th and 5th century BC. The specific case of vase paintings presents us with a very promising material basis because the understanding of iconography and visual narration in ancient imagery is a main focus in the scientific field of Classical Archaeology. Due to the fact that during this time the vase painters did not illustrate a textual version of myth, we have to look at the specific visual means they applied to narrate a story and to make it understandable for the viewer. These images make extensive use of highly meaningful and repetitive formal schemes as well as narrative elements. Both were used in order to characterize the individuals within the story as well as to make the situations in which these protagonists interact comprehensible for the ancient viewer [1]. On the one hand, the interaction and relationship of the figures is outlined by significant postures and gestures (schemata) in order to illustrate key aspects of the storyline. As these schemes are not limited to certain iconographies, visual links between different images and different image contexts occur [2]. Due to their familiarity with these schemes the ancient viewer was already able to identify the general meaning of the image and to understand the main components of a narration. On the other hand, however, other characteristic elements are needed to determine a depiction as, for example, a specific mythological story and to add further aspects of the narration. Hence, narrative elements such as attributes of gods, a certain surrounding or other significant objects in the image, are also essential to understand specific narrative contexts.

Visual similarities are therefore the key for interpreting vase paintings. By comparing a large number of images, scholars usually study, at length, specific elements that help to narrate the stories. Although valuable insights are gained in terms of understanding the significance of the image relations for the cultural meaning of the vase paintings, unveiling links between images (mainly between non-narrative images – e.g. wedding scenes – and narrative ones) contributes even more details to our interpretation of these images and helps to comprehend their cultural meaning. Therefore, we aim to develop computational methods in order to support human research on the questions of archaeological image studies by Computer Vision and Deep Learning. Fresh perspectives on yet unidentified image relations and quantitative results by handling a large number of images are the main foci of our research, based not on the textual metadata but on the visual characteristics of an image.

A selection of popular schemes in Attic vase paintings was chosen in order to answer the questions raised above: 1. Leading the bride, 2. Abduction, 3. Pursuit scenes. These schemes

were deemed suitable as, for example, the scheme of leading the bride in Attic vase paintings is characterized by a significant leading-gesture (χεῖρ’ ἐπὶ καρπῷ – hand on wrist / hand on hand)that sets the bride and groom in non-mythological wedding scenes. However, scenes of Helen and Menelaus make use of this scheme to show that Menelaus leads Helen home from Troy like a bride after regaining power over his wife. Therefore, not only the interaction scheme between the two figures must be recognized but also the narrative elements, i.e. Menelaus dressed as a warrior and his weapons, have to be identified in order to name the figures.

We approach this problem of recognizing specific visual attributes using state-of-the-art object recognition algorithms in Computer Vision [3]. We present a novel approach using convolutional neural networks which maps the attributes occurring in these images into a deep representational space, through Deep Learning techniques. This representation maps the inherent variations in the representation of any particular attribute into a joint space. We recognize these objects using this embedding. However, attributes depicted in the narratives alone do not suffice. The gestures and poses of the characters highlight their role and importance in the narration. We model these characteristics of the protagonists in the deep neural network in conjunction with the recognition of the attributes. This also helps the network to recognize the narratives being displayed. Another novel method is developed that uses this representation space along with the context of the narrative for a better understanding of the depicted scene in the artwork. Here, we use the main theme of the scene (e. g. leading the bride or pursuit scene) as a context. We analyze the model performance with abstract classes where we combine multiple similar attributes into a single abstract class. This model learns a generic representation of the attributes through these abstract classes. This new approach has important applications, including the retrieval of semantically similar artworks and, in a more generic sense, contextual understanding of works of art in Classical Archaeology.

Preliminary results of the recognition of attributes are promising. The network is able to predict most of the attributes present in the scene whose labels are available, and quite often predicts those attributes whose labels are missing. This is remarkable and a good representation of the generalization of the network, and serves as a proof of concept of our techniques mentioned above. To date, our proposed methods therefore have good potential to work towards the semantic understanding of the vase paintings. Due to its innovative and experimental approach we would not only like to present our first results to the audience, but particularly to discuss the occurring problems and especially the further potential of the applied methods as well.

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ID number: 210

Roads and rivers. The importance of regional transportation networks for early urbanization in central Italy (1000-500 BC)

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Abstract:

Ancient regional routes were vital for interactions between settlements and deeply influenced the development of past societies and their "complexification" (e.g. urbanization). For example, terrestrial routes required resources and inter-settlement cooperation to be established and maintained, and can be regarded as an epiphenomenon of social interactions. Similarly, navigable rivers provided a complementary inter-settlement connectivity, which conditioned the development of roads and pathways.

In this sense, fluvial and terrestrial connections can be seen as the two layers of an integrated regional transportation system, which was the product of social relations and of the interplay between past societies and environment. This paper discusses transportation networks and interaction in central Italy (1000-500 BC ca) at a time of changes and developments in the Italian Peninsula, which led to the creation of regional ethnic and political groups and to the formation of the first city-states in Western Europe.

To better understand the emerging Latin and Etruscan urban polities and the mechanisms underlying their variable success, we adopt a novel network approach (modelling, multiplex networks). The results shed new light on how the Latin and the Etruscan polities emerged and functioned, and also suggest potentially why, in the end Rome prevailed over its rival.

ID number: 211

Making Meaningful Models as a Digital Novice: Modelling Bronze Age Food Vessels from Archeological Illustrations in Maya and Mudbox

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Abstract:

For all of the democratizing rhetoric of early digital archaeology, the 3D digital medium remains a space of great reticence for many archaeologists. This trepidation has been at least partially exacerbated by a publication climate that preferences high-quality, project-culminating digital 3D models; those only achieved with the application of a suite of software, hardware, and digital skill sets. This trend extends into Digital Scholarly Editions as well. While these high-quality reproductions are both valuable and necessary, they exist (or appear to exist) so far beyond the reach of many heritage professionals as to discourage engagement with 3D modelling. Yet high-fidelity reconstruction is hardly the only level at which 3D modelling can be useful for archaeological engagement. Not only can 3D models be produced with a fairly limited skill level, data set, and hardware processing power, but these “low-fi” reconstructions can be effectively deployed to meaningfully engage with archaeological material. Thus, not only is it vital create a body work that contextualizes large, complex archaeological models, but also more basic applications as well; both as a point of entry to 3D modelling by the non-expert and as a means to unpack the affordances of existing software.

This project presents a series of models produced from illustrations of British Bronze Age food vessels published by Allison Young in the 1950s (Young 1951), Derek Simpson in the 1960s (Simpson 1965) and Alex Morrison in the 1970s (Morrison 1971). At the time of the project, the Coronavirus pandemic meant that no primary and very limited secondary access was available for these artefacts. Moreover, given that some of this data was already 60-70 years old at the time of publication, several of the vessel illustrations could not be traced to objects in modern collections (or the original objects had been outright lost). Illustrations alone were available to produce 3D digital replicas and as such, the accuracy of these models was limited by the constraints of illustrative method. Moreover, the hardware available for this project (a smartphone camera and a 2015 Macbook Air running the notoriously recalcitrant MacOSX Cortana) further limited the level of modelling and rendering that could be attempted. Nevertheless, using the Autodesk suite, a novice modeler was still able to produce and sculpt approximate reconstructed digital meshes based on the visual data provided in the illustrations. Though it was not possible to achieve photorealism in the models produced, they could still be deployed to address theoretical questions beyond exact replication.

Modelling archaeological illustrations proved effective in expanding the capacity of the original dataset. At the most basic level, rendering in 3D offered greater ability to explore dimensional elements such as shape, volume, form, size, and shadow. On an experimental level, the digital medium offered a context to remotely experiment with chord impressions, postulate skeuomorphic correlations, and explore the movement in decorative elements produced by fluctuations in light. But perhaps most interestingly, the medium allowed for a visual exploration of sensory and affective aspects of these objects. By integrating posed bodies, changing material presents, and playing with lighting levels, it was possible to visually

explore themes of heft, temperature, reflectivity, incandescence, colour perception, drape, and emotional resonance. By purposefully and explicitly departing from exact replication as the representational goal of the images produced, more avenues of study were made available. Indeed, not only did the affordances of the modelling software allow for new visual explorations of archaeological material, but they often inspired these new approaches. The act of modeling encouraged playful and creative approaches to the data presented in the 2D illustrations, giving new life to old illustrations.

Digital peri-literacy (or even digital reticence) need no longer disbar archaeologists from meaningful and creative engagements with digital 3D modelling. The process of cultivating enskillment in 3D modelling encourages new ways of looking at objects and generative approaches to problem solving in producing digital meshes. Yet the issues raised around presentations of 3D models often specifically conspire against these early-level applications. Building a more robust, diverse, and transparent infrastructure for 3D study in archaeology is as much a democratizing project as it is a practical one. Without clear paradata, particularly around digital methods, potential modellers are denied even the most nebulous understanding of practical digital materiality. Without presentations of digital models that are broadly accessible by quotidian users and systems, many (if not most) researchers are denied a basic understanding of the possible outcomes of digital software. In focusing on new and advanced applications in 3D modelling (VR, 3D printing, photogrammetric interfaces, etc.), basic affordances of established, easy-to-use technologies are easily overlooked.

3D scholarly editions go some way to address this information imbalance, but many still focus on advanced applications. In order to build a truly robust digital practice, is essential to project the practices of 3D scholarly editions down the enskillment ladder, focusing on the decision chains of even the most basic models. In this way, methodological rigour need not be the reserve of the technologically proficient but an inbuilt standard of transparency that can meet archaeological modellers at their individual skill level and project needs. Modeling is becoming an ever more accessible means of creative visual engagement with archaeological material: whether as a surrogate for inaccessible objects, a heuristic tool to explore archaeological data, or as a means to answer theoretical concerns. What was once the bastion of practiced artists and digital specialists now lies at the fingertips of a quarantined graduate student with a few wrinkled photocopies.

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ID number: 212

Bayesian models of compositional data: the case of pre-Hispanic goldwork in Colombia

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Abstract:

Introduction

With the increasing availability of large legacy datasets of compositional data, archaeometry is facing new opportunities and challenges in the building of large-scale narratives for technological innovation, transmission, and adaptation in the past. In archaeometallurgy, for instance, a multitude of factors have been used to explain differences in alloy compositions across assemblages, including the accessibility, vicinity, and types of raw material sources; the functional requirements and use of different metallurgical technologies; and cultural choices relating to, for instance, colour symbolism. In order to test for these hypotheses, we propose the use of beta regression as a novel method for accounting for the nature of compositional data that both falls within a fixed interval and typically exhibits both asymmetric and heteroskedastic distributions. We draw upon a case study of pre-Hispanic metallurgy from Colombia to show how beta regression can shed light upon which factors influenced the size and importance of artificial alloying additions in the past, and suggest that similar methodologies can have wide-reaching applications in archaeology, in particular compositional modelling in archaeometry.

Finally, we use the same case study to explore in how the archaeological modelling of spatio-temporal datasets, insufficient attention has been paid to the development of methodological approaches that account for complexity of large legacy datasets, which are influenced not only by sampling biases, but also exhibit varying degrees of variable/sample interdependence. We suggest the adoption of multilevel modelling as a tool for pooling information across different clusters in the data, e.g. different analytical techniques, recovery locations, laboratories etc., while allowing variability within each to be modelled, highlighting major sources of uncertainty in the dataset. In the case of compositional datasets, we suggest this is adopted alongside using the beta regression structure when modelling for a univariate response.

Methods and materials

The data used in this study consists of compositional and other attribute data on pre-Columbian metal artefacts (n=2,260) from Colombia. These have been collated into a single database over the past few years, from a number of sources, but with the vast majority originating from the archives of the Museo del Oro in Bogotá. Previous research has shown that the alloys are typically ternary Au-Ag-Cu alloys, where the silver naturally originates from the native gold deposits used, and therefore the proportion of artificial alloying additions can be modelled by either copper or argentiferous gold alone.

We use regression modelling to gain insight into factors influencing decisions regarding the size of artificial alloying additions and consider additional object attributes (e.g. forming method), geospatial data (e.g. recovery location) and/or archaeological data (e.g. context type) as independent variables influencing composition. Beta regression, designed for modelling a continuous response variable that is restricted to the open interval (0,1) (Cribari-Neto and Zeileis, 2010), is well suited for modelling the proportion of artificial alloying additions in our assemblages, i.e. the normalised proportion of copper by weight, owing to the following reasons:

a) Beta distributions are highly flexible in displaying different-shaped densities, including highly skewed and flat distributions. Using the beta distribution as the basis of the regression structure allows for the relationship between the independent and the dependent variables to vary accordingly, while restricting the fitted values to the standard unit interval. The parametrisation used in Cribari-Neto and Zeileis (2010) for beta regression modelling also makes the model naturally heteroskedastic.

b) While allowing for skewed and heteroskedastic outcomes, the beta regression does not necessitate transformation of proportions but maintains them in their original scale, aiding interpretation.

We apply the model using a Bayesian framework, which will, importantly, allow for flexibility in incorporating a hierarchical structure to the model in the future.

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ID number: 213

Creating a Digital Data Story, Proof-of-Concept and Early Lessons

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Abstract:

The Alexandria Archive Institute's 'Digital Data Stories Project' is a three-year endeavor promoting an increased focus in archaeological education on digital data literacy. Through the use of open datasets, the project is creating a series of exercises teaching the principles of digital data literacy alongside methods in archaeological analysis. These combined code and theory practicals illustrate the confluence of quantitative and qualitative investigations in collected data on the past, while providing easily replicable tutorials for 'skilling up' in digital archaeology methods.

In this presentation, researchers from AAI discuss the process of developing a 'data stories' proof-of-concept deliverable. Definitionally, 'data' within the data story refers to "the primary documentation of our research—including our field notes, images, and 3D models, as well as the entities modeled, described, and organized in our GIS files, spreadsheets, and relational databases" (Kansa and Kansa 2021). The 'story' within the data story references the role of narrative creation in the process of archaeological analysis, drawing on the concept of "the imaginative, emotional encounter commonly associated with the archaeological process" (Hearne 2019, 155). The data stories approach promotes multiple levels of engagement with archaeological datasets, linking data-driven narratives with the key analytical and interpretive steps used to ethically analyze, visualize, and present research data. Crucially, it fulfills a pedagogical need within the discipline, providing a venue for "archaeologists to acquire the computational skills necessary to enable reproducible research" (Marwick 2017).

The entire process of utilizing a data story is detailed, from how to obtain a dataset via those available on Open Context, to how to apply data literacy skills to reading, analyzing, and creating visualizations out of that dataset, to how to use annotated data to create evocative, engaging narratives that illustrate archaeological findings for different audiences. The proof-of-concept demonstrates how a single dataset can be used to create data-rich narratives of engagement through multiple theoretical lenses; a hegemonic archaeological narrative is presented alongside narratives illustrating key principles of feminist archaeologies, queer archaeologies, and meta-archaeologies.

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ID number: 214

Tales From Two River Banks? Is there an increasing digital divide between Development Funded archaeological practice and Research Funded archaeological practice?

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Abstract:

The focus of digital archives and museums is now switching from simply providing better online access to digital archives, to questions of how users in commercial archaeological units, curatorial organizations and academia can, along with the general public, make best use of this growing body of digital data, information and better help the synthesis and integration of related knowledge.

The Matrix project (AHRC/UKRI funded AH/T002093/1) is investigating how digital data from archaeological excavations can be made more consistent and useful, thereby more interesting and cost-effective, to a range of users and audiences. It is working towards a shared plan and methods to get such data more consistently recorded, analysed, disseminated and archived in a way that is Findable, Accessible, Interoperable and Re-useable (FAIR).

The Matrix project has four key areas of activity:

1) Digital Standards;

2) Characteristics of digital Heritage Data using the case of archaeological stratigraphic data;

3) Stratigraphy Standards;

4) Research Tools;

Areas for investigation in the project include working with the commercial archaeology sector to review existing practice; developing a high-level process model reflecting best practice in stratigraphic recording and data analysis; establishing the sectors additional requirements for guidance on archiving and re-use of stratigraphic data from archaeological excavation projects. The process model will also help identify where common good practices can be highlighted, shared and promoted as part of Data Management Plan (DMP) preparations and best practice guidance.

The project use cases have also Identified several significant measures that could help improve the sign-posting of archives for re-use to potential researchers. The aim is to identify coherent and 'frictionless' data packages that would enable finding and re-use of relevant data within archives e.g. a data package for stratigraphic and chronological. This work is informing the development of a prototype tool for stratigraphic analysis that could help those archiving processes and improve re-use of archaeological data by other users such as Bayesian chronological modellers.

The Matrix project aims to address 2 major research questions:

1. How can we encourage the sharing, linking and interoperability of archaeological data and information, particularly information derived from the commercial development funded archaeology sector in order to maximise public value and enhance the research potential of archaeological data?

2. How can we ensure the consistent development, application and enforcement of existing technical information and data standards and their promotion to others?

An overview of a presentation could include the following:

1. The problem – The lack of consistency and/or interoperability in archaeological archive records is restricting re-use of the data

2. Development project funded data vs Research project funded data

3. How can Process Modelling for Analysis activities help?

4. Review of data derived at different stages in the Archaeological project Process –

a. Recording

b. Analysis

c. Publication

d. Archive

5. Interim results from The Matrix project The Matrix

ID number: 216

UNDERGRADUATE EDUCATION TOWARDS DIGITAL ARCHAEOLOGICAL PRACTICE

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Abstract:

Introduction

In this study, I assess the preparedness of current archaeology education towards digital practices in Turkey. I argue that, while digital archaeology is an effective solution to document, store and analyze archaeological data and make it available to large audiences, there is a risk of digital archaeology becoming a domain for a limited audience due to digital illiteracy and lack of access to computers and software. Joyce and Tringham (Joyce and Tringham 2007)described digital technologies as mediums that enable diverse perspectives and overcome hierarchical boundaries. On the contrary, the COVID-19 Pandemic revealed that accessibility to digital mediums is creating inequality among students.

As a country with archaeological fieldwork history going as early as the development of the archaeology discipline itself, Turkey has also a historical and strong background in archaeology education. While the majority of archaeology programs in undergraduate education were limited to metropolitan cities until the end of the 1990s, beginning from the early 2000s current government established universities in each city. As of 2021, there are 46 archaeology departments with undergraduate programs. For the 2020-2021 Academic year which is completely online, 1587 new students registered into archaeology programs (YÖK 2021).

Now, 75% percent of those departments offer introductory level classes on computer technologies and the majority of the first-year computational technology classes are online. Following the first year, 33% of those departments offer another computer-related course. These courses range from simple processing software programs to more sophisticated drawing, data management, and Geographical Information Systems software. While these numbers might seem like a good start in integrating digital practices into archaeology, the COVID-2019 Pandemic demonstrated that the reality of access to computational technologies and availability of internet connection for practicing digital archaeology is far from this optimistic situation.

In Turkey, after a brief hiatus on how to respond to the pandemic, institutes of higher education adopted digital learning platforms. Few universities had the online infrastructure to support massive online education and for those with online teaching platforms, the most common problems included lack of computers and access to an adequate internet connection to follow online courses. This situation revealed that with similar positions to Turkey, catching up with digital archaeology might be a difficult task to follow.

Method and Materials

One way to overcome these inequalities is to define actual problematic areas, thus, in this study, first I demonstrate the current level of teaching in archaeology that directly focuses on the use of digital technologies in Turkey. Second, I will outline the main obstacles in integrating

digital practices in archaeology education based on an online survey to be conducted among archaeology students. The survey will be conducted after permission of the Ethics Board of the author’s current academic institution.

Discussion

The Pandemic revealed that while digital archaeology aims to be more comprehensive, to be trained in digital archaeology one needs to overcome another set of inequalities. This brings us to the question that Morgan and Eve (Morgan and Eve 2012) critically asked almost a decade ago regarding archaeologists’ efforts to create reflexive, open, and participatory archaeology on both the institutional and the individual level. This type of information might help us to improve the education curriculum and accessibility towards mediums that are necessary for training in digital archaeological practices. These measures might support digital archaeology to be a more democratic realm.

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ID number: 217

Grading minion to the rescue

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Abstract:

The BSc Archaeology curriculum at Saxion University of Applied Sciences consists of a wide range of courses (see also Visser et al., 2016). In the first two years the students learn about most aspects of practical archaeology and digital archaeology is an important part thereof. Over the last couple of years we have had an steady increase in the number of new students. While we started with a small number of students in 2007, the number of new students increased to 75 in 2011. In 2015 over one hundred new students registered and in September 2020 around 160 fresh(wo)men started studying. This increase in students also increased the workload in grading exams and papers for the teachers. Since burn-out is common among teachers - on all educational levels about 20-30% struggles with burn-out related symptoms - it is important to keep the workload as low as possible. For many courses, we reduced the workload of a single teacher by sharing the grading work with multiple teachers. An introductory course in database, spreadsheet and statistics the grading of the exams was (semi) automatized with the help of a minion to reduce the time needed. During a two hour exam students have to answer open questions using as word processor, use databases (e.g. queries, table design, enter data) and perform several actions in a spreadsheet (e.g. functions, calculations, graphs). Due to the variation in the use of the spreadsheet or text documents, this is still manual labour. However, the use of queries, the insertion of data in tables and the design of tables is highly standardized. This is where the grading minion comes in. Since, we are teaching the using Microsoft Access, the minion is based on forms, queries and VBA. Some parts can be graded fully automatic, with relative little human interferences. This makes the grading process more objective at the same time. Other parts of this exam still need a human to assess the students answer, because there are sometimes several options to, for example, write a query and many possible mistakes. The amount of programming needed to address all variations does not warrant a fully automatic tool. In addition, some manual grading helps a teacher to understand what needs to be better explained in future courses.

The grading minion saves a lot of time and makes it possible to grade many databases in a short period of time. In this lightning talk, I will show the tool and workflow, explain the method behind it, share some code, and hopefully this will benefit other lecturers to save time grading large collections of digital exams.

ID number: 218

My little Linked Open Data Ogham Minion: visualising graph data connections using SPARQL endpoints

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Abstract:

In addition to relational data structures other data modelling structures such as graphs are entering archaeology. Modelling in graphs allows for adding semantic information to relations and creating interoperability using standards, e. g. the Resource Description Framework (RDF). This is a good requisite for creating interlinked RDF data; which is called Linked Open Data (LOD). LOD, published in community hubs, e.g. Wikidata or custom triplestores are published more and more in cultural heritage research.

But there is a lack of user-friendly and easy to use Free/Libre Open Source Software (FOSS) tools for LOD technologies. In order to address this issue, the SPARQL Unicorn comes into play: a user-friendly tool series that was initiated in order to assist researchers who are working with Wikidata and other related Linked Data repositories. SPARQL Unicorn’s aim is to help researchers from the humanities or geospatial domain to use community data to make the data accessible to those without expertise in SPARQL or LOD. The SPARQL Unicorn principles were envisioned and are brought to life by the Research Squirrel Engineers network (Thiery et al. 2020), a group of LOD enthusiasts who aim to create tools for researchers without any prior knowledge of Semantic Web technologies. In our minion talk we will introduce a SPARQLing Unicorn minion that queries distributed SPARQL endpoints and visualises the data and their connections using JavaScript libraries as a map (Leaflet) and a graph (vis.js). This approach can then be transferred to specific use cases.

For our talk we will be presenting the use case example of Celtic Ogham stones, a group of monoliths inscribed with the Ogham (ᚑᚌᚆᚐᚋ) script, erected in Ireland and the western part of Britain (Wales, Scotland, Cornwall, Devon, Isle of Man) between the 4th and 6th century. These stones contain several inscriptions which are an important source for archaic or proto-Irish language and society. The findspots are not well documented. Different sources show several ambiguous locations, which makes mapping challenging. The standard work on Ogham inscriptions is the Corpus Inscriptionum Insularum Celticarum (Macálister 1945), which indexes the stones in the widely used CIIC numbering scheme. Next to the Corpus Inscriptionum Insularum Celticarum (CIIC) catalogue, a number of print publications and online databases from different Ogham research projects exist; they are all using their own numbering systems and do not always reference each other bidirectionally. Ogi Ogham is a project that was created in 2019 by members of the Research Squirrel Network in order to create LOD from distributed sources and interlink them to create an Ogham knowledge graph in the Linked Open Data Cloud. The project is currently funded by the Wikimedia Deutschland Open Science Fellows 2020/2021 Program within the Irish ᚑᚌᚆᚐᚋ Stones in the Wikimedia Universe project. For the Squirrel Ogham projects, the CIIC, the Celtic Inscribed Stones Project (CISP) and the 3D Ogham Project are especially important. These distributed data sources are available but not published in a semantically modelled standardised format, e. g. RDF, and not

interlinked with each other. This is where the Irish ᚑᚌᚆᚐᚋ Stones in the Wikimedia Universe project comes in. Within this project, the data will be imported into Wikidata, as well as transformed into RDF triples, according to a custom ontology (Thiery 2021), and stored in a custom triplestore.

This minion talk focuses on a little web-based Ogham Minion, which visualises connections between distributed Ogham sources and different numbering systems as an interactive graph, as well as displaying them on an interactive map to show the distribution and different information on findspots.

ID number: 219

Clearing the clearance cairns: an object/pattern/scenery recognition case-study from the Highland of Asiago (Eastern Pre-Alpine area-Italy)

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Abstract:

The "Piana di Marcesina" is a vast plateau located in the North-Eastern part of the Highland of Asiago at an average altitude of 1350 m above sea level and represents one of the widest (15 sq km) and more spectacular grazing-areas of the whole pre-alpine Veneto Region.

The present morphology is the result of a long-term evolution of an original crionival paleo-valley finally modelled by last glacial (Würm) and post-glacial geomorphic processes. The quite exceptional environmental and biological richness (flora, fauna, especially migrant birds and rare amphibious species in the diffused peat bogs and water-fed formations induced by numerous, ephemeral karstic springs) has gained a special European (EAA) protection status.

An anthropogenic impact on the area is attested since Paleolithic times, starting with rare Musterian lithics and continuing with more widespread Upper Paleolitic and Mesolitic seasonal settlements: the most internationally famous one being the so-called Riparo (shelter) Dalmeri (Epigravettian), with an extraordinary fossil surface very rich in arte/eco-factual and (infra)structural evidence and an exceptional instance of paleolithic painted art on pebbles in a clearly ritual spatial layout. Rather surprisingly, distinct sources of paleo-ecological evidence (especially carpological/palynological and micro-faunal), converge to suggest for the contextual post-glacial Allerod climatic oscillation an environment quite similar to the present (where a long-term anthropogenic deforestation process accounts for a comparable opening of the local landscape): this takes the form of an open prairie with some pine woods and few thermophylous broadleafs of mixed oaks.

The "Piana di Marcesina" is now entirely devoted to seasonal pasture with a diffuse presence of seasonal dairy farms ("malghe") and an even more frequent occurrence of traditional blockbau buildings (both abandoned - in various stages of residuality - and re-used for tourism) that used to host generations of woodcutters.

The specific focus of our research is represented by the impressive presence of possibly thousands "clearance cairns" with a quite variable form, size, status of conservation (from buried by soil to open-air), a probable equally various age of formation, and different spatial settings (from random to linear to cluster). These kinds of structure, still rather neglected in the Italian (ethno)archaeological literature, are of a potentially enormous importance for understanding landscape formation processes: it is often one of the very first interventions (with others like slash-and-burn, "trous-monticules" of tree roots eradication, "reaves" and terraces…) to be activated during the opening of a landscape for successive cultivation or grazing. "Cairn-fields" can also occur in equally important key-phases of expansion-intensification or in a context of post-abandonment reopening. In addition, the "fossil soil" sealed by cairns is normally a precious container of paleo-ecological evidence, often easily datable (e.g. traces of the above-named slash-and burn activity).

The importance of cairn-scape formation analysis is even more relevant when, as in our case-study, quite specific boundary conditions are present. In fact, the Piana di Marcesina offers an extraordinary instance of a “frontiers and boundaries scenario”, having represented a long-term (probably since Bronze Age) liminal and highly contentious ecotonal band between a “Pre-alpine” and a proper “Alpine” region, with quite distinct ethnical, linguistic, cultural and political traditions and backgrounds. On the base of cumulated sources of evidence coming from strictly comparable but better known near-by areas (such as the highlands of Vezzena-Luserna-Lavarone where we are conducting a thirty-years old research project), we expect three major phases of landscape opening (for cultivation, grazing or metallurgical activities) that could correspond to: a)Middle to Final Bronze Age; b)XIII-XIV sec. d. C. (with the colonisation by “Cimbrians”, basically an allochthonous, Bavarian population speaking an “Altdeutsche Spache”); c) XVIII-XIX sec. d.C., with a more recent climax-period of mountain de-forestation).

More specifically, for the Piana of Vezzena we can rely on a rather detailed documentary history of boundary conflicts (quite often bloody) and conciliations (mainly related to grazing rights), starting from the XVI century and culminating with the key, final land division devised by the Austrian Empire and the Republic of Venice in the year 1752.

We are just at the really beginning of a multidisciplinary and longue-term research project devoted to the archaeology (including Ethnoarchaeology and Archaeology of War) of Marcesina and the “Clearing Cairns” sub-project itself is equally at its first stage of remote to field implementation.

It seems nevertheless rather interesting to present to the conference some preliminary advancements.

As for our immediate research target, the automated recognition of cairn-objects, we have been following a critical path by performing a crucial number of preliminary operations of image processing before accomplishing the final task with a devoted GEOBiA software of Object/Pattern Recognition (eCognition-Trimble). Specifically, we have used a robust time series of aerial photos (both vertical and oblique) at variable level of resolution starting from WWI (1918) military reconnaissance to the present HiRes orthophoto, as well last generation satellite images (mono to multispectral), LIDAR (1m res.) and SfM-derived DTM (centimetric) coverages. The goal was to feed the A.I. engine of eCognition with a wide range of purposely “enriched” layers through image enhancing and noise removal procedures (from Intensity transformations and spatial filtering to Fourier transform to multi-resolution and morphological processing and to preliminary image segmentation). To the LIDAR data in particular, the full RVT package of visualization has been applied, but, rather surprisingly, the simplest map-algebra differencing of DSM an DTM has given, at the price of some residual noise, a quasi-automatic edge detection of cairn objects: this is due to the fact the cairns themselves in the cloud points filtering are already interpreted as artifacts and therefore lowered to soil in the DTM.

The final OBIA processing has been quite easily been able to make an optimal use of the multi-layered pre-processed information on the base of a detailed, expert ruleset suitable to manipulate all possible lines of evidence (spectral, textural, morphological and spatial-contextual) and to produce a properly automated object/pattern/scenery recognition of the target clearance-cairns domain.

We also aim at implementing, in the immediate future, a covering taxonomy of cairn variability and a tentative seriation. In addition, we plan to establish reliable and diagnostic relations both spatial (e.g. with local features, structures and infrastructures such as ecotones, slope classes, land-divisions, connectivity network, “malghe”) and temporal (with macro phases or hi-res “events” like the above-mentioned boundary definition of the year 1752) within our critical knowledge-base.

A lateral ongoing experiment is now just starting that would like to confer added value to the remote sensing recognition by applying a “data-sonification” algorithmic process: the goal is to “transform” the enhanced RS “landscape” into a heuristic “soundscape” endowed with the capability of converting recognized object and patterns into diagnostic sound signals giving a critical “alarm” when the image of a cairn or group of cairns is touched on a multi-touch computer screen.

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ID number: 220

Petri nets for modeling non-linear dynamics of ancient adhesive technology systems

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Abstract:

Several definitions of complexity have been used in the analysis of differences in complexity of technology systems, and currently there is no ground to prefer one definition over other. Furthermore, ancient technology systems do not show consistent positive linear relations between definitions of technological complexity and possible drivers of change like population size or environmental risk (Vaesen et al. 2016). This evidence suggests that each complexity definition may be capturing a different kind complexity, and that linear models do not facilitate the analysis of ancient technology systems, because these systems likely included heterogeneous subsystems that acted independently and shared resources to produce technologies through non-linear dynamics. For example, today, environmental settings, population dynamics, social contexts, and available technologies operate as components or subsystems in the production, use, and discard of other technologies. The complexity of these modern systems is expressed in different dimensions, such as size, workloads, elements involved, and technological options. These dimensions have different implications for societies and individuals that produce modern technologies. It is reasonable to expect that something similar occurred in the past. A formal modelling approach that can express these components as interconnected modules and captures differences in several dimensions of technological complexity is needed to create a more complete picture of ancient technology systems. Therefore, here we explore the use of Petri nets to model such systems.

Petri nets are a modelling language with formal notations, grounded in mathematical graph theory (Reisig 2013). Petri nets are directed, bipartite graphs with three basic elements: transitions, places, and arcs. Transitions represent events or activities that change states or conditions in a process. Transitions are graphically represented as squares or rectangles. Places are passive elements and can represent a communication medium, buffers between changes of events, activities, locations, or conditions. Places can also represent the initial, intermediate, and final states after the completion of an event. Places are graphically represented as circles. In Petri nets two transitions or places cannot be directly connected. Arcs connect transitions and places, and they are graphically represented as arrows. Arcs always have directionality and can be weighted. Arcs form logical connections between transitions and places, they indicate the flow of the system, and the causal relations between transitions and places. In addition to the three basic elements of petri nets, the different states of the system are represented using tokens, which are elements subject to change, such as physical objects, information, or indicators of states or conditions. Tokens are drawn as black dots; they are contained in places and consumed and produced by transitions. Petri nets are used to model complex systems as discrete events. Ancient technology systems can be modelled in this way to understand the evolution and complexity of these systems, for

example, to study the implications of the occurrence of asynchronous events, parallelism and interaction between events, or events that can occur out of order (concurrently). Petri nets have methods to study these properties, calculate process performance, and compare requirements and different dimensions of complexity.

We apply our modelling approach to study ancient adhesive technology systems. Early advanced cognition is often recognized in the archaeological record through the presence of these technologies. Three possible Neanderthal tar production methods—Condensation (CON), Pit Roll (PR) and Raised Structure (RS)—were modelled as petri nets based on observational data from birch tar manufacturing experiments. We measured three dimensions of complexity: a) Cognitive load generated by the attention of multiple sources of information at the same time; b) Behavioural complexity expressed as the different paths that a process takes to reach its product; c) Understandability of a production process as a mechanism used to acquire or share technologies. We used three metrics formulated for process analytics as proxy for these dimensions of complexity, respectively: the Density metric (DM) (Mendling 2006), the Extended Cyclomatic metric (ECM), and the Structuredness metric (SM) (Lassen and van der Aalst 2009).

The differences in the DM values indicated that the CON method imposes the largest cognitive load of all three methods and this load occurs in the production process after the use of fire. The cognitive loads of the PR and RS methods resulted in lower values for the DM and were related to the possibility of concurrent actions before the use of fire. The CON method had the lowest ECM score with most of its behavioural complexity found after the use of fire. The PR method showed a higher value for the ECM probably caused by the possibility of concurrent actions before the use of fire. The RS method showed the highest value for the ECM. The behavioural complexity of the RS method is generated before, during and after the use of fire by the existence of concurrent actions and cycles. The RS method scored the highest in the SM, while the PR method scored the second highest in the metric, and the CON method scored the lowest of all three models. The SM values suggested that the net structure of the RS method requires more previous knowledge about the elements involved and the production process itself than the PR and CON methods.

Taken together, these results suggest that there is an association between the use of fire and the complexity of the production process, where the use of fire is a bottleneck for how and which solutions to produce adhesives can be implemented. Working memory and concurrency are two viable solutions that can be preferred or combined to solve the production processes of adhesive technologies. The models also showed places and transitions that can connect the production process models with other subsystems of the adhesive technology system. Additional modules representing subsystems such as environmental settings, social contexts, or population dynamics can be modelled and connected to study technology systems in greater detail.

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ID number: 221

Do water soil erosion phenomena threat cultural heritage sites? The case study of Chania, Crete, Greece.

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Abstract:

Background

Cultural heritage monuments and sites, as an integral part of the human-built environment, are completely exposed to natural hazards' adverse actions (Ravankhah et al., 2019). Hence, the identification of the sites being exposed to soil erosion can be considered as a crucial need. In this framework, this study's main objective was to identify archaeological sites susceptible by soil erosion, taking the case study of Chania prefecture, Crete. Remotely sensed and other available geospatial datasets were analyzed in a GIS-based empirical model, namely Unit Stream Power Erosion and Deposition (USPED), to assess the spatial distribution and intensity of water-induced soil erosion of the study area. Specifically, Landsat 8 satellite imagery data (30 m) were utilized to develop Land Use/Land cover maps, ASTER Dem (30 m) for modeling the topography, LUCAS land use/land cover data by the European statistical authority, as well as precipitation data from 90 meteorological stations in total.

Subject

The USPED empirical model was implemented under the integration of a set of erosion-influencing factors. Due to its spatial flexibility, USPED allows modelling the physical processes of erosion in a GIS environment. The model can provide an estimation of the average annual soil loss and deposition rates, which can be correlated to the topographic location of the archaeological sites.

Chania prefecture was found to be significantly affected by both soil loss and deposition. In fact, by increasing the runoff velocity, the steeper slopes of its mountainous terrain favour the detachment of sediments (soil loss). These sediments are then accumulated (soil deposition) close to or along the stream network because of low transport capacities. However, among the two processes, soil loss can be characterized as more intensive by influencing a larger part of the prefecture, especially towards the west. This can be also justified due to the fact that spatial variability of rainfall in Crete manifests a decrease from west to east (Grillakis, Polykretis, & Alexakis, 2020) and its correlation with higher erosion levels to the west confirm this finding (Polykretis et al., 2020).

Discussion

From the perspective of cultural heritage, this study revealed that soil erosion could highly contribute to the degradation of the archaeological sites of Chania prefecture, with both soil loss and deposition processes influencing them. In particular, a significant amount of cultural heritage sites (in total, 37%) appear to be established in areas of extreme soil loss and deposition. The majority of these sites were found to be mainly located in the western part of Chania prefecture.

The present study presents a cost-efficient methodology to determine the soil erosion hazard of a given region and identify the cultural heritage sites being exposed to it. Through the identification of the threatened sites, cultural resources manager can be aware of the archaeological sites that need greater attention and protection and take preventive preservation measures and develop specific risk mitigation strategies. The current study provides experimental evidence that the integration of GIS with remote sensing technologies can be very useful in constructing risk maps for cultural heritage preservation.

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ID number: 222

iSEGMound – a Reproducible Workflow for Mound Detection in LiDAR-derived DTMs

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Abstract:

Introduction

Quantitative methods have accompanied Archaeological Science since the end of the 19th century and became more and more part of its methodological approach. Today, Quantitative Archaeology is indispensable as one of its core competences. Archaeological science and its many ‘Archaeologies’ borrow various elements of their working methods from other disciplines and is thus a very dynamic, interdisciplinary continuum which is constantly and perpetually changing.

This interdisciplinary view and diverse methodical toolbox lead to the crystallization of Archaeological Remote Sensing, which’ beginnings varies from region to region. A major push was given by the public availability of digital satellite data, although first it was mainly the satellite specialists who introduced automated methods (Traviglia, Cowley and Lambers 2016). These new data sources (including geophysical platforms) led to the necessity to handle (archaeologically speaking) big spatial data. The sophistication of airborne platforms, sensors and imaging technologies, such as LiDAR, hyper-spectral imagery and drone derived (multispectral and hyper-spectral) imagery facilitated the diversification of the tool set of Archaeological Remote Sensing. These new technical developments push specialists again and again to look for and borrow new methods to analyze this new kind of archaeological big data, leading to automation – that is automating workflows and analysis – at least to a certain part. This tool-driven revolution – or revelation is transforming Archaeological Remote Sensing, slowly but surely. Since the first application of automated analysis from the mid-2000s a multitude of studies have been published, their methods visibly evolving according to the needs of new sensors. After more than two decades of ‘automation’ (depending on where we start) – where do we stand? Do we have ‘best practices’ to address specific problems which re-occur in certain research questions? Can we learn from previous studies and how? How transparent are workflows? Are workflows reproducible or even replicable? Can we build on them or do we have to start from scratch (again)?

Materials and Methods

To make a point, all published papers that use automated analysis to detect patterns or objects in remote sensing data were reviewed in terms of the method, variables/morphometric parameters, target objects/patterns, scale of the study area, software (FOSS or proprietary) and what access there is to any parts of the study (worfklow, flowchart, equations, rulesets, data, code) to get a comprehensive picture of reproducibility. Subsequently, paper dealing with the detection of mounds were selected as peer-group. The repeatedly used and quite well documented method 'iMound' (Freeland et al 2016, Davis et

al. 2019, Rom et al. 2020) and the reproducible workflow of Niculiţa 2020 were taken as examples to build a reproducible workflow.

Based on these two methods the reproducible workflow was developed in R by building a Research Compendium (Marwick 2017, Schmidt and Marwick 2020), using the rrtools package (Ben Marwick 2017).

Results

This research concept is applied in a Master’s thesis, which aims to detect burial mounds in DTMs derived from LiDAR data.

A 180 km² area around Marburg was chosen as research area, where according to Dobiat 1994 originally more than 250 barrows may have been dispersed in several groups. The research area was visually examined for burial mounds and compared with the find lists in Dobiat 1994. Based on this visual examination, one training DTM, one training area (the training DTM + 4 adjacent tiles) and 5 test areas were selected. A 1x1 km tile was used as a training DTM, which shows the largest variation of barrow sizes. Two different data pre-processing methods (no processing vs. MTPI) and two different segmentation methods (watershed vs. region growing) were tested on this training DTM, i.e. a total of four different workflows. These four workflows were then tested on the training area to understand how the individual settings behave on a larger area. Subsequently, the workflow found to be the most successful was applied to the 5 test areas. Based on the geomorphological conditions of the area and the poor preservation of the barrows (~ 0.5 m in height), the 'iMound' method was combined with a subsequent segmentation to detect the barrows using descriptive measures of the segments. Apart from using packages from the R ecosystem, also tools from SAGA (via the RSAGA interface) were used.

Discussion

The main point of the thesis and the workflow is to create a reproducible workflow from already existing knowledge (e.g. ‘iMound method’ and the workflow of Niculiţa 2020) and also to use Open Source oftware and tools in a controlled environment – that is in a reproducible way. In addition the idea is to be able to generally apply the workflow to LiDAR data which can be obtained for scientific use from any State Office for Land Management and Geoinformation in either LAS/LAZ or even DTM form.

Tool-driven Reproducible Research opens the field for and facilitates Open Science, that is Open Access and Open Data and transparent methods which of course exist in different dimensions and degrees (Marwick et al. 2017). There is a long and probably bumpy road ahead for open science but it is the way to go for reproducible and collaborative science.

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ID number: 224

Insular Interconnectivity in the Viking Age: A View from Norse Jarlshof, Shetland Islands, UK

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Abstract:

In recent years, archaeologists have argued for the investigation of coastal landscapes, islands, and seascapes using concepts such as maritime cultural landscapes, insular interconnectivity, or social seascapes. Terms such as these were developed in order to better conceptualize and structure the ways in which past peoples have perceived, experienced, and exploited the dynamic coastal, insular, and maritime environments in which they lived. This paper will consider the potential of tailoring landscape archaeological techniques to not only insular and coastal sites, but also to past seascapes. The goal is the development of a GIS based intervisibility model that more accurately depicts the experiential use of and interaction between past landscapes and seascapes while maintaining a quantitative approach. The case study for this process will be the Scandinavian Diaspora into the North Atlantic as it relates to the coastal Norse farmstead at Jarlshof, Mainland Shetland, UK.

Due to the nature of islands, accessibility from other locations typically is facilitated, whether for the purpose of settlement, trade, resource acquisition, or conflict, through the use of some form of seafaring vessel. Over the course of the Scandinavian Diaspora a level of cultural and economic interconnectedness was maintained between mainland Scandinavia and the North Atlantic region. This shared link with Scandinavia contributed to the development of local connections which developed between other islands within the broader diasporic network (Jesch, 2015). Jarlshof is located on a promontory near the head of West Voe Bay at the southern end of Mainland. This research seeks to determine the potential for intervisibility between a mobile sailing ship entering the mouth of the bay and the Norse farmstead. The views of both the subject and observer can change drastically if the subject or observer moves through their respective environments as a result of the built and natural landscape, an individual's visual acuity, or other distance related or environment factors such as weather conditions (Lock et al. 2014).

All visibility analyses are based on DEM raster data for southern Mainland Shetland UK. For the land-based perspective, 6m wide activity based viewsheds are oriented around each doorway within the settlement and designed to account for approximate observer height. These provide a relatively static viewing platform based on architecture orientation, but also take into account zones of potential motion by past actors. In order to determine the view from the ship, a fuzzy cumulative visibility analysis, (FCVA) will be performed using GIS software at designated intervals as the ship proceeds along a set path. Said path is determined using a form of wind based Least Cost Path or anisotropic spread analysis (discussed below). A FCVA is a modified form of total viewshed where visibility is restricted to a specified scale of analysis, typically the range of standard human visibility (Lock et al. 2014). This method has traditionally been employed to model pedestrian motion because it simulates the gradual appearance of objects throughout space with way points or prominent landscape features appearing as the movement of the observer persists in a given direction (Lock et al. 2014). In

this case, the viewshed would be based on an individual standing on the viewing platform, that is, the deck of the ship.

Both of these visibility analyses are dependent upon the movement of the sailing vessel prior to its arrival at the settlement. Identifying an ideal path for the ship to enter the bay requires establishing a sea surface model. Indruszewski and Barton, (2006) tested the application of both Least Cost Path (LCP) analyses in GIS and anisotropic spread analysis (ASA) for use with GRASS GIS to simulate sea routing based on wind conditions in order to establish least-cost path on a dynamic, multidirectional surface. ASA had traditionally been used to simulate wildfires, so both of these methods rely primarily on wind parameters to model motion. However, there is no reason another methodology could not be employed to serve as the propulsion method for the ship-based viewing platform. Similarly, three dimensional (3D) simulations using GIS or other 3D software applications could be applied to the base model to provide a more immersive experience. As such, there is no reason the selected case study should be viewed as constraining towards the application of this model in terms of either geographic location or time period provide that coastal changes overtime are considered.

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Digitally Re-creating the Assembly Church: Using 3D Modeling to Enhance Archaeological Research

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Abstract:

3D visualization during the excavation process often focuses on techniques, such as photogrammetry, to record detailed information about a site’s archaeological features as they exist in reality. Virtual modeling to depict missing parts of the site, such as above-ground architectural and landscape features, usually begins after all of the excavation data have been collected. However for complex archaeological sites undertaking both 3D reality-based and virtual modeling in conjunction with field work can strengthen the excavation process.

In 1607, settlers established what would become the first successful English settlement in North America on Jamestown Island, in what is now Virginia, USA. Excavation of the James Fort site has been ongoing since 1994, and most recently has focused on three of Jamestown’s 17th-century churches, built one on top of the other. The team was particularly interested in the earliest, constructed around 1617 and where representative government in English America began in 1619 with the convening of the first General Assembly. The digging of 17th-century grave shafts and early 20th-century excavation areas had destroyed key stratigraphic relationships in places, complicating the process of teasing apart which architectural features were associated with each of the three churches.

Virtual modeling, based on the GIS and photogrammetric data from the field team, started once the archaeologists had uncovered enough of the 1617 church’s fragmentary foundations to begin to develop to a structural outline. The whole team would then meet every few weeks to assess any new archaeological data and the model. Making a change to the building to align with one piece of evidence often had a ripple effect through the rest of the structure, necessitating changes to other architectural features. 3D digital modeling enabled the archaeological team to test hypotheses about how the 1617 church had been constructed and to separate the remains of three superimposed structures, while they were still able to search for more evidence when the data were unclear. Creating the model also raised new questions that could only be answered with additional assessment of the complex stratigraphic relationships in the field.

The final model of the 1617 church combines the “below-ground” 3D data collected in the field and the virtual structure to visualize both the modern archaeological site and the 17th-century church. While some features, such as window placement, remain conjectural, the model provides the team’s best interpretation, but it also can be updated if new evidence comes to light. While working hand-in-hand with archaeological evidence, historical references, and period-appropriate examples, the team was able to digitally represent their findings in a new and different way.

In conclusion, virtual modelling can be a valuable tool for archaeologists during the excavation phase, especially on complicated sites. Not only is the final model a beneficial educational

resource, it is also a powerful method for testing theories and working out the archaeological blueprint of the building. Working back-and-forth between the archaeological evidence and the virtual model, while the fieldwork was ongoing, strengthened both the field data collection and the resulting 3D reconstruction.

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Mapping World War I heritage from historical aerial photography using Convolutional Neural Network approaches

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Abstract:

In the last decades, Conflict Archaeology represented - and still represents – a prolific field of research aiming at developing new and scientific insights about our knowledge and understanding of the past conflicts. One of its most specialized domains (spatially, temporally, functionally) is the Archaeology of the First World War, a laboratory of potential new lines of research, based on several methodological approaches and techniques related to the context of investigation: in addition to classical archaeological methods, such as excavations or studies of the material culture, the First World War heritage is investigated also by using remote sensing applications.

The main goal of the Archaeology of the First World War is to analyze the conflict landscape, mapping the warscape and its features, focusing on the war impact on the territories and on post-depositional and post-abandonment processes to reconstruct - in a diachronic perspective - what preceded, what happened during the war and what followed it. The landscape represents the main domain of investigation: it is the last remaining witness bearing any traces of the war ruins, such as trenches, tunnels, bunkers and bombing craters, but also war-related infrastructures that can be associated with a war-related layer, whose study may lead to new knowledge concerning and increased awareness about all the actors involved in the war, but also about the development of the physical landscape. So as to do this, over recent years the research has focused on airborne perspective using the increasing technologic and digital advantages such as the developments in remote sensing prospection techniques (Magnini et al. 2017; De Matos-Machado et al. 2019;); in addition, also a large amount of historical sourced has been reconsidered, i.e. the Fist World War aerial imagery has been taken into consideration (Stichelbaut et al. 2017). As a matter of fact, during the war - for the first time - the aerial photography became an essential intelligence tool to recording the shelling damage, getting information about the enemy entrenchment but also detecting any movement of the enemy troops, camions, trains and finding artillery positions and ammunition storages. Therefore, the historical archives of war-related aerial imagery represent a priceless source of information to realize a holistic reconstruction of the conflict landscape aiming at investigating one of the buried layers composing the present-day landscape and thus to determinate the landscape formation processes.

To record the huge amount of archaeological military features in the historical war-related aerial imagery, specialists have to face a major issue: each aerial photograph contains a wide variety of different elements that make mapping extremely time consuming and depending on human visual inspection, hence errors and bias typical of the classical archaeological photointerpretation cannot be avoided. To make the detection of the war-related features faster and more accurate but also - and most important – replicable, this contribution wishes to offer a new point of view in mapping and in conflict landscape analyzing, testing a specific,

semi-manual, semi-automatic and automatic spatial analysis software (eCognition Developer) for Fist World War image analysis.

In order to achieve this purpose, a few historical aerial images belonging to “Archivio Piatti” (a never screened before archive) were taken into account: they capture trenches and military positions dug and build on the “Melette di Foza”, a system of mountains - Monte Fior (1824m), Monte Castelgomberto (1771m), Monte Spil (1808m) and Monte Miela (1782m) - located in the Centre-Eastern part of the Plateau of the Seven Municipalities, where, during 1916 and then 1917, bloody fighting involved Italian and Austro-Hungarian troops, and that, at the moment of the aerial image acquisition, summer 1918 (29 July), it represented the rearguard zone of the Imperial Army: these images provide a detailed and contemporary view of the conflict, and especially the landscape of the early 20th century. The study was carried out on twenty-three images of the 71st military photogrammetric survey on within the historical archive. These pictures, in form of slides, have been digitalized at 3600 dpi using a DigitDia 5000 scanner, and then catalogued. Subsequently, the data are being loaded into the ArcGis 10.7.1 software and georeferenced based on regional technical map (Carta tecnica regionale – CTR) made available online by the Veneto Region. The absolute coordinate system used is the Gauss-Boaga EPSG3003 (“Monte_Mario_Italy_01”) projection system and, for each image, at least 10 control points are being selected. The spatial resolution of the raster data is good (media cell size: X=0,35; Y=0,42 – unit: meters), allowing detailed appreciation of the war-related structures.

To map the variety of military features, a convolutional neural network (CNN) algorithm has been used. In fact, CNN is a machine learning algorithm able to take in an input image, assign importance (learnable weights and biases) to different and various objects in the image, and differentiate one from the other. For that reason, CNN is particularly successful in image analysis.

The main goal of the research focused on detecting the trenches: the ruleset was developed from the creation of a massive number of samples derived from an intensive manual data labelling. Therefore, the first step was to define image objects that represent the information within the thematic layers: to that, a vector-based segmentation has been used. Then, the objects have been classified based on the information in the shapefiles created. The generated sample patches have been used as input for the model to be trained. Then, a CNN algorithm model was created and trained with the developed samples. Finally, the CNN model was applied to the different scenes: the result of the process consists of output layers in the form of heat maps.

The CNN approach recognized many trenches that clearly appear from the surrounding mounds of dirt. In addition, this method made possible to detect some trench lines not so clear and well-defined at the human visualization and which would have been lost without an automate autopsy. Finally, the CNN workflow performed well for the research aims, but further study must be encouraged to recognize the different military feature and land cover classes composing the conflict landscape of the First World War.

ID number: 227

New tools dealing with old issues: from graphical elements to semantic objects

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Abstract:

Digitizing historical maps and paper drawings is a relatively easy task to carry out. Issues arise when digital transformation requires significant information that cannot be extracted only from the existing graphical documentation. This poses a significant challenge to creating an archaeological GIS. Notably, these criticalities do not change but potentially increase base on the need to manage CAD drawings related to archaeological excavations, and in an attempt to transform vectorial data into objects. Although GIS is a mature technology with hundreds of applications in the archaeological domain developed over the past 35 years, to date there are no stipulated standards or best-practices on the transformation of archaeological features, paper or digital into GIS data. In this regard, managing these issues is most commonly left to the archaeologist in relation to the concerned research targets. Basically, the site can be a simple point in an inter-site analysis, or a schematic shape in an intra-site GIS, or a detailed map describing accurately individual features and stratigraphical layers in a 3D GIS. Another level of criticality concerns the criteria and parameters to identify, e.g., buildings: should one draw a line to trace the wall or two lines to show the thickness and how should one process geometrical primitives describing a reused structure belonging to different phases? In general, archaeologists address these issues on the basis of the available documentation. Although GIS easily integrates graphical and alphanumerical data - structured or not, there is often a profound difference between theory and practice, mainly stemming from the conceptual side. Thus, archaeologists strive to design the implementation of a GIS by considering various elements and by following an unstructured and mostly manual method. In essence, migrating 2 or 3D data to modern geodata is a task carried out frequently without a precise strategy; the aim is to combine different levels of information, geometrical and textual in order to merge the available archaeological data.

The paper deals with the approach adopted to organize and convert the cartographical resources related to the Islamic site of al-Balīd in Oman which was one of the most important ports of the Western Indian Ocean during the 13th and 17th centuries. The aim is to provide a topographical frame to anchor existing archaeological evidences and to propose an improved management and consultation system of the entire documentation arrangement since 1950s.

Over the past 70 years, several groups investigated this ancient site. From Costa (1978-1981) onwards, researchers placed their spatial data on the grid provided by the Italian archaeologist in order to determine the positioning of certain monuments and individual excavations. Based on this, these scholars sub-divided the original grid in smaller units. Jansen (1995-2001) introduced a completely 3D digital recording system with the use of total stationary and geo-referenced spatial data based on local cartographical coordinates. This means that a vast quantity of collected spatial resources can be easily imported into a GIS. In order to relate the geometrical information to the archaeological features (i.e., architectural

components such as walls, rooms, floors, etc.), it is necessary to convert the relevant spatial data into objects, by starting to identify the geometric primitives which define the archaeological object but also through the detection of lines or polygons reused in more recent buildings.

In essence, the systematization of a cartographical archive into a GIS should follow a methodical approach that considers all potential targets and possible flaws of geo-referencing and superimposition, especially if the GIS project aims to integrate historical or paper maps. Initially, the process starts with identifying the various layers which include general maps and detailed drawings. This is followed by labelling each level with an individual card that describes the year, author, the original identification/numbering of the excavation, as well as a brief report of the main findings. Next, the second step entails the outlining of the archaeological features after geo-referencing all the maps and evaluating the level of reliability and accuracy of the superimposition. In this phase, great importance is attributed to the rare descriptions provided by archaeologists; this is the only method to transform geometric data from paper maps or CAD drawings into archaeological objects (e.g., walls, rooms, windows, doors, roofs, etc.) even if these reports are frequently concise, partial and not also very explanatory. Thus, digital transformation is not a linear application for combing geometrical features but a conceptual process to integrate the knowledge behind spatial data depending on existing research trajectories. Accordingly, digitization has to start within the frame of a general reappraisal of the available data archives, including maps and all archaeological documentation.

The paper focuses on the practical aspects of the GIS implementation and in particular, the approaches adopted in different stages of the converting process. Furthermore, the approach is mostly based on intuitive work which is to address the move from spatial information into a digital eco-system by using available, although largely incomplete archaeological documentation which is also often frequently without the necessary stratigraphical data. Hence, the design and implementation of a GIS provide a profound contribution to the re-reading of the cartographical archive, even if the archaeological analysis of the spatial features of the structures and the site has been carried out by using traditional methods. Hopefully, with the resumption of current and up to date investigations, including an accurate digital survey of existing and visible archaeological structures, it will be possible to evaluate the entire digitation project and the reliability of the system in order to design a 3D GIS.

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ID number: 228

Modeling the material performance of ceramic vessels in view of their function and utilization

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Abstract:

Ceramics constituted assumedly the first materials, which were manufactured in a transformative process. They were fabricated and used by people for manifold applications and remained of paramount importance concerning the development of material culture until nowadays. Utilitarian ceramic vessels can be essentially categorized according to their function, with the main categories storage, processing and transfer (Rice 1987, p. 208-210). Different functions, though, required different material performance for example in terms of mechanical strength, toughness, permeability, heat transfer and thermal capacity. For this, the fabrication process of particular ware types was adapted to their utilization, which can be in fact observed by examination of their fabrics. The thermo-mechanical properties of ceramics are controlled by raw material selection, clay paste preparation and conditions of the firing process. Properties of archaeological ceramics can be investigated through material testing of standard shaped specimens, either cut from genuine fragments or reconstructed based on micro-structural and compositional investigation. On the other hand the material performance of an entire vessel is affected by the design of the vessel as well, taking into account shape parameters such as wall thickness, curvature, or ridges. Shape, however, in contrast to the substantial material properties of the ceramic body, is more difficult to examine by material testing as it is effectively more complex and beyond that material tests are commonly destructive. In the present paper a modeling approach will be presented simulating the performance of ceramic vessels under thermo-mechanical loads. Multiscale structural modeling of ceramic vessels using the finite element method (FEM) allows for virtual material testing on different scale levels: from microstructures representing the fabrication process over individual components up to entire objects or groups of objects (Hein and Kilikoglou 2020, in press).

The structural modeling approach will be demonstrated presenting case studies of different vessel categories, such as marine transport containers, pyrotechnical ceramics and cooking vessels. For this, digital 3D models of ceramic vessels are generated either by using digitized 2D profiles, which are virtually revolved around symmetry axes, or by 3D scanning of vessels or vessel fragments, which are digitally assembled then. For the FEM simulations material models for the ceramic properties are attributed to the 3D models based on material tests of the particular ceramics, which are verified through microscale modeling of the ceramic fabrics. For the simulation loads are applied on pre-defined areas of the model, which can be mechanical loads as in the case of transport containers or thermal loads as in the case of cooking pots or pyrotechnical ceramics. For other areas constraints are defined, such as ambient temperatures or constricted displacement. In a case study of transport amphorae, which were assumed to be stored in several layers in the cargo hold of a ship, potential mechanical stresses emerging at the contact points were investigated (Hein and Kilikoglou 2020). Scope was to assess the development of vessel design during the Hellenistic Period in

terms of damage risk during transport. Furthermore, the simulation results allowed for examining crack initiation and propagation and thus for interpreting failures and damages, which can be occasionally observed in archaeological finds. Case studies of pyrotechnical ceramics on the other hand allow for simulating temperature development and heat transfer in furnaces or crucibles. Simulation results are verified by estimation of peak temperatures within the ceramic matrix, based on micro-morphology and mineralogical evolution. In this way process parameters can be evaluated and the heating efficiency of the ceramics can be assessed (Hein and Kilikoglou in press). Heating efficiency of different cooking pot designs have been assessed in another case study. Combining thermal simulation with mechanical performance also thermal stresses and thermal shock can be investigated.

Digital modeling of ceramic vessels and simulation of their function provides insights in their fabrication process and their utilization. Technological preferences and innovations as well as the constraints of their use can be assessed taking into account different functions and applications. In this way ceramic design can be evaluated, processes, the ceramics were used for, can be investigated and observed damage patterns due to failure can be interpreted.

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ID number: 229

What can human-centred design achieve? Openness and inclusivity for enabling participatory digital heritage

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Abstract:

Today, although Galleries, Libraries, Archives and Museums’ (GLAM) premises remain closed due to the ongoing COVID-19 global pandemic, they implement digital media technologies to communicate and engage with their audiences amidst these difficult times. However, there are many open questions concerning the accessibility and re-use of digital cultural data for online engagement. The open data movement, and also in particular the FAIR guiding principles (Wilkinson et al. 2016), recently adopted by GLAMs, attempt to address the abovementioned issues. Yet, little has been discussed on what does it need to envision fair data as well, where dynamic data interoperability could potentially allow equity to be realized in the digital economy. Decentralized and distributed modes of knowledge organisation and management could be benefited by a human-centred approach and aid to the participatory aspect of the ecosystem.

On the other hand, in the so-called attention or audience economy, attention becomes a central commodity and scarcity (Celis Bueno 2017), where digital platforms and apps are competing over people’s attention more than ever. The ‘offline and online worlds’ are intermingled, creating even higher complexities to the current digital ecosystem. Hence, how can cultural data be usable and meaningful to people in the attention arena? Building on Deb Verhoeven’s work, who had inquired “Open data, or data that produces openness?” (Verhoeven 2018), this paper extends the concept to the openness of cultural data. My contribution investigates what are the qualities needed for the data to be open enough, for use and creative re-use. Moreover, it explores what are the ecosystem’s practices that would allow a human-centred design, from a macro level perspective. The proposed paper discusses how the openness of cultural data could enable opportunities for meaningful participation, in the context of a digital ecosystem that produces openness as well, and thus fosters social inclusion. The paper focuses on human-centred design, as an inclusive term to encompass the entanglements of digital and physical realm as well. The doctoral research presented here is part of the EU-funded Horizon 2020 ITN project, Participatory Memory Practices (POEM), which aims to build new concepts, strategies and media infrastructures for socially inclusive futures.

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ID number: 230

The ambiguity of the classification process in the digital environment. Typologies and quantification of shape similarity in the analysis of pottery

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Abstract:

Classification and typologies are at the heart of the archaeological methodology for handling variability in studied artefacts and assemblages. They are particularly useful when applied to large assemblages of artefacts, not only contemporary but also across periods and territories. However, the recent advances in the application of shape and pattern recognition methods in archaeology demand a closer evaluation of the ways in which typologies are created.

In this contribution, we explore the way classifications are constructed and the way these processes are "translated" into computerized methods. The main goal of this presentation is to investigate the transition between analogue and digital classifications, investigated the attributes used for typologies (both "analogue" and digitized), their usefulness and handling their vagueness, and highlight the necessity of a deep understanding of man-made processes to ensure the proper transference to the computerized environment. This topic is seemingly trivial, but it can be the source of numerous difficulties in the digitization of the process. The main problem lies in the definition of similarity between objects. Properties such as size or colour are easily quantifiable, however, the most common attribute in typologies is the shape. Although easy to understand for humans, shape as used by archaeologists, is useless as an attribute for computerized classification, due to its vagueness.

For the purpose of this study, we use the example of archaeological pottery, although we recognize that many other groups of objects face similar difficulties (e.g stone tools, various metal objects, etc.). Pottery is the most common and numerous find during archaeological excavations, and hence constitutes a good marker for chronological periods, cultural groups, sometimes even ethnicity of the people who created or used the pots. However, the study of ancient pottery requires a careful examination of the similarities and differences between the pots in one assemblage as well their relation to the pottery found elsewhere. Oftentimes the definition of whether two objects are different or similar and to what degree poses a challenge. In most cases, a written description does not carry enough information to compare two vessels, hence the basic form of communicating shape in archaeology are drawings and cross-sections. Although highly efficient and useful in a traditional study, they pose a significant challenge in the computerized generation of typologies.

This problem, of an imprecise and often vague understanding of the shape attribute, affects the newly created computerized methods of automatic classification. In this contribution, we present a discussion of the different ways of approaching this problem.

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ID number: 231

Crafting Past Places: Reimagining archaeology as usual through Minecraft

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Abstract:

This paper is a playful take on the session’s theme: it addresses archaeological work in digital spaces by taking inspiration from the way new digital places are crafted out of the past in the popular video game Minecraft. We will do so through a discussion of Minecraft and in particular a deep dive into two large-scale heritage projects we have undertaken in the past few years: RoMeincraft and MineRhondda. We will use these case-studies to reflect on how digital spaces are crafted out of the analog past and what message this practice holds for an archaeology of digital spaces.

RoMeincraft is a heritage project taking place at the Dutch sections of the Limes, the border of the Roman empire, in Minecraft (https://romeincraft.nl/; Politopoulos et al. 2019). This public heritage project is developed and hosted by the VALUE Foundation, a collective of archaeologists and historians working at the intersection of play and the past. In RoMeincraft VALUE works with members of the general public to rebuild the forts, towers, roads, farmsteads and other infrastructure of this border region in 150 AD. In contrast to the United Kingdom and Germany, no remains of the Limes are visible above ground in the Netherlands and, partially because of this, there is relatively little public awareness of this cross-national World Heritage beneath our feet. The aim of RoMeincraft is thus to present a hand’s on, and positive encounter with this relatively unknown heritage. This has been done through more than 20 pop-up events in museums, libraries, and galleries where members of the public, most of them children, used the tools and blocks provided by the game’s Creative Mode to recreate the forts, roads, and villages of their local area as they imagined it. While conceptualized as a reconstruction of the Roman limes, it soon turned out that the process was one of reimagination. The result is something that would fail any baseline natural and material reality check, let alone a historical accuracy or virtual archaeology ‘test’, but was still a resounding success.

MineRhondda is part of a larger Welsh heritage project, Unloved Heritage? (https://unlovedheritage.wales/), funded by NLHF and managed by Cadw, which offered a range of activities designed to get young people exploring the heritage world around them, and telling the stories of their explorations. MineRhondda (https://digventures.com/projects/unloved-heritage/) was part of a series of activities in the Blaenrhondda region undertaken by the Valley Kids in collaboration with archaeologists from DigVentures (with VALUE providing advice and technological support). The project focussed on exploring and rebuilding elements of the Fernhill Colliery, a coal mining site which was open from 1870 to 1945. The impressive industrial landscape has been reworked to the extent that the mine and its infrastructure is only visible as a few scars in the valley. Kids that have grown up within the landscape without an opportunity to learn about what happened at the site and the impact the industry had on their hometown. Through archives research, museum

visits, oral history and archaeology, we explored the evidence together for what the colliery would have looked like. MineRhondda provided an accessible space for the Valley kids to rebuild parts of the mine and its associated buildings, making decisions about how to create the different elements and thinking about how the valley looked when the industry was still alive. To help explain what they had built, the kids created a heritage trail within MineRhondda using a wagonway and minecarts to provide a route around the colliery for digital visitors. The project was an opportunity to work with a small group of kids over a long period of time - creating not just an awesome digital heritage site and trail, but building confidence, new skills and friendships which will continue to impact the lives of those involved.

MineRhondda and RoMeincraft are certainly not the only heritage projects of their kind. The brilliance of Minecraft, particularly of its Creative mode, is how it provides an immense and empowering sandbox to craft whatever is interesting or important to you as a player (Garrelts 2014). Heritage, whether officially recognized monuments of local or global importance or simply that special place that has importance to you as an individual or your community, is a major inspiration for this creative process. Indeed, as new, digital places Minecraft builds theoretically have no bounds, yet we see millions of slightly different Eiffel Towers, Coliseums, Big Bens, and other heritage icons. At the same time, like in RoMeincraft and MineRhondda, none of these builds is exactly alike in its design and execution to ‘the real thing’ — even if this was a desire the blocky tools of Minecraft prevent accuracy beyond the 1 meter scale. What all of these crafted places seem to share, however, is an aspiration to craft digital places as rooted in an authentic yet reimagined relation to their analog pasts.

So, what placecrafting — in Minecraft, but we suspect this could apply to other customizable digital spaces too, including or in particular non-3D ones — reveals is that our actions, things and assemblages in digital spaces can neither be framed as one to one re-constructions of existing historical, material, and social structures, nor as a full rupture with the heritage of our analog world. Instead, digital placecrafting involves a relation of commitment, attention, and care to source materials and existing knowledge of them, combined with the agency to renegotiate, reinvent, recast and, in some cases, reject history and heritage as usual. In other words, the shift is one in which the shape and stuff of things matter less than the social and cultural values they arise from and, importantly, could give rise to. In sum, we propose the underlying message of Minecraft for an archaeology of digital spaces is that, here too, we have a radical opportunity to break with things as usual in order to re-craft our discipline into something else.

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25 years of trends in digital data deposition at the ADS

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Abstract:

The Archaeology Data Service (ADS) is an accredited digital repository for archaeological and cultural heritage data that was founded in 1996. Over the past 25 years, the ADS has accumulated over 22 TB of data from more than 3 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, including CAD and GIS, produced by the profession. 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 sort of time capsule that shows what methods of documentation were being used and preserved during excavations. Over the past five years, the ADS has seen an increase in the quantity of vector data deposited and the amount of GIS submitted has decreased as shown in the figure. Further, between 2014 and 2019, the ADS received over 38,500 text-based reports via OASIS. This implies a trend of data created by practitioners never making its way into the ADS outside of a report, by which point the data held inside the report is not in an easily re-usable state. This paper also reviews some of the challenges of preserving spatial data, focussing on the development and stability of formats and the need for appropriate metadata.

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ID number: 233

On using the CIDOC CRM to model archaeological datasets

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Abstract:

The rise of the Semantic Web and the opening of research data in the Open Science dynamic are encouraging French archaeologists to apply FAIR principles (Findable, Accessible, Interoperable, Reusable data) to make their data sustainable, interoperable and reusable. This is one of the main missions of the MASA consortium (Memories of Archaeologists and Archaeological Sites) of the TGIR Huma-Num: to support archaeologists in this process by relying on a standard ontology massively shared by a large part of the Cultural Heritage actors at the international level, the CIDOC CRM.

This paper’s goal is to present how modeling with the CIDOC CRM can be adjusted according to the corpus. The richness of this ontology allows indeed to set up models at different granularities in order to reach the according objectives. We propose to compare two experiences made in two research projects: the first one relies on a generic model for several archaeological datasets within the MASA Consortium; the second one requires a more specific model for excavation data and architectural data within the framework of the SESAMES project (Semantization and Spatialization of Multi-Scale Heritage Artifacts: 3D annotation, Sonification and formalization of reasoning).

It is important to notice that both of these models are extracted from the CIDOC CRM and its extensions, without defining any new concept or property. This is a choice that we believe is required in order to be consistent with the best practices of the semantic Web and the FAIR principles.

A generic model for the whole archaeological corpus.

Bringing the different archaeological datasets of the MASA consortium to the semantic web required to set up a triplestore structured with a common model. This generic model, based on the CIDOC CRM, provides a unique and transversal query interface for heterogeneous archaeological datasets. These ones are published on the semantic Web via the OpenArchaeo platform (Marlet et al. 2019).

More precisely, the OpenArchaeo generic model is based on the CIDOC-CRM ontology and some of its extensions (CRMarchaeo, CRMsci and CRMba). This model relies on basic concepts found in most archaeological datasets (site, excavation, structure, feature, wall, burial, stratigraphic unit and artifact). While this model was designed to be as generic as possible, we find that some datasets cannot use all its concepts and relationships. In fact, only one concept is necessarily found in all archaeological datasets, that of the site. This concept, as defined in the CIDOC CRM

(http://www.cidoc-crm.org/Entity/e27-site/version-6.2.1), is the common dominator in all archeological datasets. The development of OpenArchaeo generic model is based on the work of the MASA consortium within the European program ARIADNEplus. The MASA consortium aims to enrich the ARIADNEplus platform with data integrated in OpenArchaeo.

A detailed model for archaeological fieldwork

The SESAMES project seeks to experiment and to share several semantic approaches of multi-scale built features (from the archaeological fragment to the building) in three of their dimensions (spatial, sound, ontological). By using formal ontologies, the SESAMES program focuses on the articulation of two different views of the same heritage items: that of architects and that of archaeologists.

The CRMarchaeo extension of the CIDOC CRM, the ARIADNEPlus Application Profiles and the OpenArchaeo generic model testify of the ability of CIDOC CRM to represent the archaeological approach. Moreover, its CRMba extension breaks down built structures into both functional and construction units, which can be phased according to the principles of stratigraphy (Ronzino, Niccolucci, Felicetti et al. 2016). The CIDOC is thus adapted to make the items observed by archaeologists and those observed by architects consistent with each other, while these items may be defined at different spatial and chronological scales.

While the OpenArchaeo model is generic enough to connect archaeological datasets on various scales, the model developped for SESAMES is much more detailed. Its specificity should bring together the architectural study with the building archaeology. The produced chronological interpretation shall be explicited. Moreover, beyond the design of a model fitted for built heritage, this work enables us to evaluate the relevance of the implementation of a model based on the CIDOC CRM applied at a finer scale. It is therefore completely in line with the reflection on the Application Profiles of ARIADNEplus, in particular the "Excavation Archives" one (Katsianis, Kotsakis and Stefanou 2021), whose objective is to represent the way in which data is enriched and reorganized into distinct datasets during their successive interrogations.

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ID number: 234

Defining a new paradigm for knowledge production and management within digital archaeology

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Abstract:

This paper investigates the epistemological process that takes place when interpreting the 3D archaeological records within an online environment and reflects on the impact on archaeological theory and methods of the use of web-based systems for archaeological data management.

The paper aims at defining common patterns for documenting and sharing archaeological knowledge through the presentation and analysis of Scandinavian examples. They have been used as case studies to validate and test two web-based systems developed for supporting the archaeological report writing and archaeological education of undergraduate students. This study also proves how the use of such systems affects the current practices introducing a novel paradigm in the way archaeological contents can be combined and visualized within their publication. Finally, it calls for an international and interinstitutional initiative that permits interoperability among such systems.

The advantages in the use of 3D models within the archaeological process are widely acknowledged (Dell’Unto 2018; Campana 2014; Opitz and Limp 2015; Berggren et al. 2015; Dallas 2016) and 3D documentation has become common practice in most field investigations (Dell’Unto et al. 2017;De Reu et al. 2013).

Today 3D models are employed across the entire investigation pipeline (Katsianis, Kotsakis, and Stefanou 2021) and are used for supporting archaeological analysis and data publications (Galeazzi and Richards-Rissetto 2018; Opitz and Johnson 2016; Derudas et al. forthcoming; R. Opitz 2018; Sullivan 2017). However, more research is needed to analyze the use of such systems in support of knowledge production and to investigate how these platforms impact current archaeological practice.

Since 2019 the Department of Archaeology and Ancient History at Lund University is exploring the use of 3D web interactive platforms for investigating new forms for the publication of excavation data (Derudas et al. forthcoming) and for the definition of pedagogical approaches in archaeology (Derudas and Berggren 2021). These platforms can be regarded as a 3D Digital Scholarly Editions (Schreibman and Papadopoulos 2019) and as an attempt to address different aspects of data curation (Dallas 2015).

Beyond online 3D visualization

While designing and developing the Interactive Reporting System, the focus was put on the possibility of accessing and reviewing the archaeological stratigraphy online, allowing scholars to link the 3D field records to a dynamic and interactive visualization The system proved to be very helpful when writing the excavation report of Kämpinge (Derudas et al. forthcoming). 3D models were used not as mere appendices (Champion 2017) but as the main elements around which to build the narrative and with which to combine and link other media, thereby enriching the publication.

In planning the Interactive Visualisation System for educational purposes, the main goal was to give students instantaneous online access to the complete dataset of archaeological records collected in the field, and to let them use it as a supporting tool when writing their interpretations. We assumed using the IVS would foster deep learning and critical thinking and would help to assess the effect of technology on students' education and teaching. Since we focused more on these pedagogical aspects.

Both the IVS and the IRS proved to be valuable tools allowing users to (1) reach a deeper and broader understanding of the spatial relations among the archaeological materials encountered during the investigation and to (2) promote a deeper interaction with the site documentation . The development of such systems proved the capacity of 3D web platforms to impact the process of knowledge production demonstrating how the creation of web instruments designed for supporting the work of archaeologists can enrich the final archaeological interpretations.

The 3D Digital Scholarly Edition defined by Schreibman and Papadopoulos (Schreibman and Papadopoulos 2019) can be related to the archaeological Digital Curation conceptualised by Dallas (Dallas 2015, 192-3). Both scholars identify the need for research to achieve theoretical development and extensive experimentation; they both see the combination of the embedded data and the process of knowledge production as mandatory components of such publications; and both claim that to be successful, such an effort should be part of an interdisciplinary mobilization of multiple teams of researchers. A further development of the IRS and IVS could address such orientations.

These systems, in fact, allow combining various media in an interactive experience enriched with a narrative that is both descriptive and explicative and is strictly tied with its data. Such a system has the potential to revolutionize the way excavations are carried and published. Despite the positive results gained from testing this approach in a few investigation environments, still several aspects of this approach need to be further addressed and clarified (e.g. using widely accepted vocabularies/ontologies; or structuring the data according to the FAIR data principles). New experiments are currently under development for mapping limits and potentials of this approach among the community of practitioners, with particular attention to international and interinstitutional initiatives going in the same direction.

ID number: 235

The problems of chronological uncertainty: Using Baysian approaches to investigate the demography and settlement patterns of the Jomon Period of Japan

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Abstract:

The Jomon Period of Japan was a pre-agricultural complex society that existed on the main islands of the Japanese Archipelago from as early as about 15,500 cal BP until the introduction of agriculture from the Korean Peninsula around 2800 cal BP. Over the course of this long and diverse period, a series of increases and decreases in population levels were experienced, with the most significant being a “boom and bust” that occurred during the Middle Jomon (ca. 5500-4,600 cal BP). Previous analyses conducted first uncovered this demographic event using total regional counts of archaeological sites and pit house dwellings, which were characteristic of the entire span of the period. These analyses also demonstrated that the different regions of Japan experienced the event with varying degrees of intensity and with different temporal offsets for the initiation of the event. Furthermore, some regions, particularly those in Western Japan, were relatively unaffected by the event. There is little consensus, however, as to the degree to which this demographic event represents a migration of people from one region to another, a localized change in the population growth rate, or some combination of the two. This paper contributes to the understanding of these demographic events by examining both site-level and meso-level evidence to better understand the regional-level observations of demographic change.

The source of the data for this paper is an area known as Kohoku New Town in the city of Yokohama in Kanagawa Prefecture, Japan. Kohoku New Town covers an area of roughly 13 square kilometers and was surveyed and excavated exhaustively in the 1970s and 1980s in preparation for a large construction project that was planned for the entire area. Over 100 sites from the Jomon period were excavated in Kohoku New Town, resulting in detailed records for over 2000 pit houses.These pit houses are dated primarily through pottery associated with each pit house, for which there are detailed and extensive typologies and chronologies within the Japanese archaeological literature. All of these data as well as relevant information found within the excavations have been collected from the published site reports that originally contained them and stored within a MySQL database.

Uncertainty is associated with the carbon dating of the pottery, the beginning and ending of each pottery phase, and the assignment of an absolute time to each of the pit houses, and that uncertainty must be taken into account in order to accurately depict the localized patterns of demography at Kohoku New Town during the Jomon Period. In order to account for each layer of uncertainty, a multi-level Monte-Carlo simulation was used to estimate the total pit house count over time throughout the period. In addition to estimating the pit house count over time, a similar Monte-Carlo method was employed using the pottery found at the sites within the pit houses to estimate the duration of settlements within Kohoku New Town and estimate when those settlements were established and later abandoned. By examining the patterns of continuity and discontinuity within the settlement occupation and localized

demography, we can gain insight into the underlying mechanisms that influenced the patterns observed during Middle Jomon. Therefore, the primary contribution of this paper, in addition to the contribution to the understanding of the Middle Jomon demographic event, is the development and implementation of these Bayesian methods to account for chronological uncertainty in the investigation into demographic and settlement pattern changes in the archaeological record.

ID number: 236

Introducing a stature estimation tool for human skeletal material to the public.

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Abstract:

Human stature is an individualized characteristic that results from an intricate interaction between genetic endowment, environmental and socioeconomic conditions. It is a key concept in the study of the human past, since along with the biological information (genetic variation and natural selection), it provides information about the overall trends in the standards of living. It is also an essential component on forensic identification. Therefore, the computation of accurate, stature estimations from skeletal material is of interest in many scientific fields such as biological anthropology, bioarcheology, palaeogenetics, as of various fields of practical applications, (e.g. forensics and archaeology).

Living stature from skeletal material can be estimated by applying different methods. The most common are the so-called mathematical methods. They are based on regression equations that estimate stature from long bone lengths. Nowadays there are many regression equations and the correct choice for individuals and populations of specific temporospatial setting is not an easy task. At the same time, the application of all existing methods is laborious and time-consuming.

This paper introduces a novel web application, which allows the fast and simultaneous calculation of off-the-shelf stature estimation equations. This tool is user friendly and offers (a) a variety of equations to choose from, (b) a cross-check among different equations and comparison of results, and (c) individual stature estimation but also mean stature from more individuals simultaneously. To our knowledge such a tool is absent in the current scientific community and it will be essential to the practitioners of many fields.

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Integrating digital and on-field activities in archaeological training

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Abstract:

Introduction

Opitz and Limp (2015), have discussed the role of 3D Digital models in terms of participatory engagement. In a recent contribution, Dell’Unto (2018) has highlighted the importance of 3D models in knowledge production, being the result of active participation in archaeological field investigation activities. 3D technologies allow performing fully three-dimensional reasoning (Campana 2014) and 3D models furthermore permit another way of knowing and recording archaeological features (Morgan and Wright 2018)

Through a recent project, (Garstki, Larkee, and LaDisa 2019), have demonstrated that integrating new media in archaeological education “can appeal to a wider number of students without altering the core mission of the course”. As a part of this growing interest in education connected to Digital Archaeology, this study will explore how to expand the more traditional didactic programs, designing, developing and integrating web-based systems for educational purposes within a Project-Based Learning (PBL) approach.

Project-based Learning (PBL) is considered relevant and helpful to promote the students’ deep approach to learning achieved through engaging with authentic tasks and learning by doing (Bell 2010; Helle, Tynjälä, and Olkinuora 2006). Archaeological excavations, which are authentic tasks in the form of projects by their very nature, ensure active learning and engagement. In our educational experience, we aimed at combining the PBL activity of the archaeological excavation with the use of technology as a means to boost students’ deep and active learning, and to increase students’ confidence with the latest digital methods applied to archaeology.

This study seeks to problematize and discuss the use of 3D technology in education and learning. We explore how to expand traditional didactic programs by developing a web-based system for educational purposes, basing the discussion on a field school for first-year archaeology students. The course “Archaeology in practice” (ARKA22:3), held at Lund University during the 2019 and 2020 spring terms, provides basic knowledge of archaeological fieldwork through participation in an archaeological excavation.

We will examine how technologies can be used as educational means and supporting tools during an excavation; how universities can incorporate these technologies into pedagogy; and whether and how these technologies could be used to promote and foster students’ comprehension of a reflexive approach and engagement with the interpretative process.

Methods and material

The two-years experimentation field-course took place in Södra Sallerup, an archaeological site in Malmö (southern Sweden). Here, after an introduction to the complete excavation methodology concerning fieldwork, documentation, data management and interpretation, the students excavated a Bronze Age cultural layer.

Alongside the traditional documentation, we added a digital approach including 3D technologies for the students to experience both. During the fieldwork activities, students followed a documentation pipeline that included both analog and digital approaches. We designed a simple web-based Interactive Visualization System (IVS)of the excavation components aimed at exploiting the technologies as a reflexive tool: archaeologists, in fact, can make better-informed decisions and interpretations when they have instantly available information (Berggren et al. 2015). We consider this solution is beneficial for engaging the students in a deep approach to their learning of the excavation process. Furthermore, this didactical approach is fitting for students with different technological backgrounds and experiences.

3DHOP, a versatile web3D viewer that can be tailored according to one’s specific needs, is the platform chosen for developing the Interactive Visualization System, (Potenziani et al. 2015, Potenziani, Callieri and Scopigno 2018).

Results

The almost-instantaneous availability of the web visualization made the students feel comfortable with the tool, influenced their approach to the data and allowed them to perform 3D mental reasoning in each stage of the archaeological process. Both students from 2019 and 2020 used the system as an auxiliary tool when writing their report. By analysing the reports and the results of a survey, we made a preliminary evaluation of the effect of IVS on the students' learning.

The students used the IVS to review the stratigraphy, go back to their contexts, measure and take screenshots and illustrate what they had described in the text, as well as annotate the illustrations They also used it to visualize parts of features together that were not visible at the same time. In addition, they produced illustrations which in some cases present examples of unconventional views, testifying the experimental possibilities of the system. After the 2020 excavation, we conducted a survey of the student use of the IVS, and the result was compared to the reports. Among other things, it shows the students overestimated some of the use of the IVS, even though they used the IVS to create illustrations to a greater extent.

In conclusion, the students easily incorporate 3D documentation into their toolbox for analyzing and visualizing the material and understand both the possibilities and limitations of the system. However, there are also some limitations in the use of the system made by the students.

Discussion and future development

The outcomes of this study, albeit preliminary, appear to be promising and challenging. Promising as the students have been using the visualization system and had no difficulties in its application and generally appreciate it. Challenging because, together with these promising results, new unexpected issues have arisen, for example, the chance to determine how the use of such tools affects the knowledge process of the students.

These preliminary results suggest further development and improvement of the tool, to make it more reliable and to allow students to use it during the next undergraduate courses. One of the aims is to integrate it with a tool for writing the report directly within the visualization system. This would make the tool a more complete package, including all that students’ need for effective learning, and giving teachers adequate data to evaluate them.

ID number: 238

Protection, and Valorization of Eastern Mediterranean Cultural Heritage: A role for the ERATOSTHENES Centre of Excellence

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Abstract:

The study of human activity has always been an important and challenging task for the experts of the field in understanding the past and the bonds tied upon a civilization’s origins. Archaeology is heavenly dependent on surveying, excavating and data collection for the archaeologists and researchers to acquire a glimpse at their ancestor’s way of living, while several -from time to time- hypotheses build the conceptual framework behind. Such hypotheses are usually validated through the discovery of possible patterns derived from the analysis of in-situ findings during the excavation process. Due to excavations being considered invasive techniques causing severe deteriorations of ancestral findings, modern archaeology has shifted towards a more sustainable approach [1], where non-invasive techniques (e.g., surface survey, limited test excavation, GIS, Remote Sensing, LiDAR, etc.) are used to study and better analyse the human past.

This poster presents how the EXSELSIOR H2020 Teaming project (www.excelsior2020.eu) will support in its capacity as a new, autonomous, and self-sustained Centre of Excellence entitled ‘ERATOSTHENES Centre of Excellence (ECoE)’ the management and monitoring of the cultural heritage domain through its research and innovation agenda within the Eastern Mediterranean, Middle East, and North Africa (region known as EMMENA). EMMENA is a broad geographical area spanning in 3 continents (Europe, Asia, and Africa). Not only does the region has a high strategic importance for political and military forces, but also archaeological and cultural significance due to the vast amount of cultural wealth, as a result of being an important crossroad in archaic times for several civilizations [2]. Monuments, burial places, artefacts, etc. are remnants from another era to remind us that once civilizations prospered and declined during several periods of the archaic history in the region. As the region is strategically well-placed, many war conflicts have taken place resulting to severe and catastrophic consequences at its archaeological sites, with most recent example being the war atrocities in Palmyra’s ancient city that eventually led to its destruction.

Effective, efficient, and timely Cultural Heritage (CH) monitoring can offer tremendous benefits to the region, to national governmental institutions and policy implementation bodies, towards the protection of the cultural assets. Towards that end, the use of remote

sensing data is considered integral in terms of archeological heritage analysis and protection as through the exploitation of Copernicus data (Sentinel images) along with Landsat images and data that will be gathered from repositories and services (USGS data), UAV’s (photogrammetry, orthophotos, etc.) and topography instruments, the ECoE will be in place to monitor in multispectral optical way the materials and pathology of region’s monuments and how these are affected by the climate changes (sea & land parameters, atmospheric chemistry, etc.), while the use of imaging spectrometers (hyperspectral imagery) adds value to the detection of undiscovered sites by searching for phosphor-rich aerosols or detecting crops and soil marks indicating the presence of buried structures. Complementary, the use Synthetic Aperture Radar (SAR) derived information for mapping the extend of CH areas, using interferometric capabilities to map the motion/stability of ground and to check the efficiency of SAR ground penetration capabilities (L Band) in areas rich of cultural wealth, where landslides are more than apparent, will act beneficially in assessing the risks associated to ground deformities caused naturally or due to human factor (war atrocities, land use, etc.). Furthermore, as far as the monitoring of the evolution of the natural environment of the CH sites is concerned, time series mapping using historical and actual Earth Observation (EO) data along with the derivation of bathymetrical maps and water constituent analysis around relevant CH and Natural Heritage (NH) sites will act as one of the driving shafts of the ECoE towards the successful monitoring, protection, and valorization of region’s cultural assets.

The research Agenda of the EXCELSIOR H2020 funded project, identifies cultural heritage (both tangible and intangible) as a strategic resource for Europe that is high in cultural, social, environmental, and economic value.

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Challenges and Opportunities in Cultural Heritage from the development of a Digital Innovation Hub (DIH) for Earth Observation and Geospatial Information in the Eastern Mediterranean, Middle East and North Africa (EMMENA) though the Eratosthenes Centre of Excellence

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Abstract:

There are some distinct needs and opportunities that motivate the establishment of an Earth Observation Centre of Excellence in Cyprus, the ERATOSTHENES Centre of Excellence through the EXCELSIOR H2020 TEAMING project. These are primarily related to the geostrategic location of Cyprus to solve complex scientific problems and address concrete user needs in the Eastern Mediterranean, Middle East and Northern Africa (EMMENA) as well as South-East Europe. The main concept behind the ECoE is to be a fully functional Digital Innovation Hub and a Research Excellence Centre for Earth Observation (EO) in the EMMENA region, creating an ecosystem where the state-of-the-art sensing equipment, cutting- edge research, targeted education services and entrepreneurship come together. It is based on the paradigm of Open Innovation 2.0 (OI2.0), which is based on the Quadruple Helix Model, where government, industry, academia and society work together to drive change by taking full advantage of the cross-fertilization of ideas. The ECoE as a Digital Innovation Hub (DIH) adopts a two-axis model in line with the ECoE Vision. In line with the ECoE Vision, the horizontal axis consists of three Thematic Clusters (departments) for sustained excellence in research of the ECoE, namely: Environment and Climate, Resilient Societies and Big Earth Data Management.

Cultural heritage is one of the research pillars that will be addressed under the Resilient Society Department. This paper describes how a multi-disciplinary approach is implemented to support the cultural research heritage pillar in the areas of protection, management and monitoring by integrating for example other pillars such as geoinformatics, climate changes, big data and educational and infrastructure functional areas.

More specifically, the current capabilities along with the prospects that derive through the integration of EO and geospatial analysis in the management and monitoring of CH sites are focused on:

- protecting and managing the cultural heritage sites through systematic information flow and monitoring. However, regarding the RS data that will be flowed, it is imperative to mention a significant barrier that will be taken into consideration is the resolution of the SAR

data that is lower than that of the optical imagery data, therefore a combination of these two will act beneficially towards a proper documentation and analysis of region's CH assets.

- our ability to store RS data (Copernicus, Sentinel and LANDSAT images, SAR) properly in limited space,

- retaining data in a more economically efficient way and recovering them faster. Due to current databases constrains in managing and handling big data, such endeavor will become possible by incorporating data cubes to facilitate the workflow of the research activities

- correlating simultaneously the heterogeneous information (e.g., spatial, and descriptive data)

- performing temporal data analysis of the CH sites (either are accessible or not),

- creating the conditions for the achievement of an integrated process of collection, analysis and decision making,

- responding efficiently to the analysis of the Big Data that are expected to be produced from the Satellite Ground Receiving station that will be installed in Cyprus (e.g., collection of near real time satellite data both passive and active).

Active and passive remote sensing data for archaeology, SAR for change and deformation detection, satellite monitoring for archaeological looting, hyperspectral image analysis for crop marks detection, integration of remote sensing data for protection and preservation of cultural heritage will also be highlighted during center's running years. A typical example constitutes the work conducted by center's personnel [1] to detect, quantify, and visualize the presence of the deterioration patterns on a monument's surface (Paphos Harbour Castle, Cyprus). This effort was achieved by combining both destructive material analysis and non-destructive DIP analysis for the digital mapping of the alterations. The results of the visual investigation and recording of the various deterioration patterns were successfully correlated to the analytical methods used and detected through the non-destructive DIP analysis. The supervised classification of the results of the images treated by unsupervised techniques demonstrated the potential of providing results that can be verified by laboratory analysis and the DIP procedure. The visualization of these patterns was represented through color variation intensity, and the results comprise indices for those parts of the monument requiring conservation interventions.

The Eratosthenes Centre of Excellence will also benefit from the findings of the 'ATHENA' H2020 Twinning project in which the ERATOSTHENES research group (Cyprus University of Technology) as a coordinator collaborated with DLR and the Italian CNR to establish a Center of Excellence in the field of Remote Sensing in the areas of Archaeology and Cultural Heritage. This opportunity led us to incorporate this activity within the ECoE. The experience gained from the 'ATHENA' H2020 project will be capitalised for the benefit of ECoE (cultural heritage cluster). Through the capitalisation of existing networks from project partners' consortia, the ECoE will reach significant innovation ecosystems related to CH as well as to Copernicus and GEO, in order to foster the conditions needed to unleash the potential of EO solutions in relation to CH protection and preservation implementation.

The use of geospatial technology and EO methods in the cultural sector plays a crucial role in offering not only a spatial view and understanding of the archaeological remains, but also the opportunity to discover important details (depending on case study) that often are not easily distinguishable. Fostering and building upon such developments, the proposed ECoE envisions to become an inspiring environment for conducting basic and applied research and innovation in the thematic area of Cultural Heritage in the EMMENA region, strategically important and known for its cultural wealth.

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Settlement dynamics and blank areas: the case study of the Ager Pisanus

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Abstract:

Introduction

The “argumentum ex silentio”, a conclusion based on silence or lack of specific evidence, has a bad reputation in epistemology. Nevertheless, in many circumstances, archaeologists accept inferences from the absence of evidence, even knowing that this procedure is fallible and the results are changeable or even disprovable in light of later discoveries or further analysis.

In archaeological maps, it is quite common to visualize a number of dots within a large empty area. The resulting absence is often due to archaeological sampling, low visibility conditions, or potential invisibility of archaeological evidence. Entire regions of the landscape, such as mountainous or swampy zones, are traditionally seen as ‘dark matter’ from which little or no information emerges and within which archaeologists have few means of improving their knowledge and understanding (Campana 2018).

This is the case of Pisa (Tuscany, Italy), a city located in an flood plain characterized by a strong water instability and a complex river system. Its territory has been marked by deep landscape and environmental changes that have inevitably contributed to outline urban planning and settlement choices over the centuries. Similarly, anthropization has profoundly impacted environmental transformations in a relationship of mutual conditioning.

Although the area has been largely investigated, the settlement pattern shows large empty spaces. How should we interpret this absence? Are these gaps due to the sampling bias, or do they conceal traces of other landscape features? Moreover, should we consider this information archaeologically relevant?

This paper aims to compare settlement and natural contexts knowledge of the city of Pisa and its surroundings between the Hellenistic, Roman and Late Antique periods by bridging the available archaeological evidence with paleo-environmental data.

Methods and materials

Between 2011 and 2013, the MAPPA Project (University of Pisa) has systematically collected the available archaeological and paleo-environmental data from Pisa urban area, delineating some particular macro urban-environmental trends in a multi-period perspective (Gattiglia 2014).

The current project, here presented, is broadening the research to encompass up-to-date information from both the city and its territory by looking at the global pattern and spotting presences and absences.

Aiming for a diachronic analysis extended to the territory implies a medium-term objective: the creation of a large dataset, which collects and describes the complete available archaeological framework.

The MAPPA archiving site-less system allows the collection of information both on natural contexts, and archaeological absences and presences. In this way, multivarious archaeological data from excavations and surveys are merged with remote sensing and core data.

Exploratory data (and metadata) analyses are employed to inspect the complexity of datasets, helping in the process of comparing non-standardized data.

GIS-based multi-level and multi-period maps are created for the visualization and analysis of archaeological data in relation to paleo-environmental context, highlighting the settlement dynamics in relation to the empty areas.

Finally, statistical methods are performed to find correlations in the available data.

Results

The re-aggregation and analysis of data on a medium scale set the focus on some macro-trends of the settlement distribution, while the presence of large empty spaces does not per se allows definitive conclusions to be drawn.

In a multi-layered and heritage-protected context, such as the Pisa urban area, the practice linked to development-led archaeology produces a continuous flow of data. Differently, in the rural area, building activities and agricultural practices make random findings far outnumbered. Thus, in the analysis of the city’s surrounding area, a different density of the available archaeological data and, almost paradoxically, environmental one must be considered.

On the one hand, the lower number of findings in the mountainous and hilly districts could be attributed to the lower number of interventions and/or the non-communication of every random finding.

On the other hand, blank areas in the flood plain south of Pisa overlap with potentially swampy zones, and therefore, the absence of findings could be related to the presence of these landscape features.

Discussion

“Interestingly and unlike what normally happens in other sciences, in archaeology it is usually the rebuttal of inference from absence which needs to be specifically supported by pointing to special environmental or historical circumstances that could produce such an effect” (Wallach 2019, p. 5).

In a consolidated vision of people-environment interactions, human societies create and interact with landscapes in a collective “work in progress”. Bringing the elements of the landscape back to the role of co-constituents of events, rather than passive subjects to human will, makes it possible to outline a more reciprocal vision of the relationality between all the constituent elements of the landscape.

The digitization of the numerous legacy data, too often excluded from the archaeological reconstruction, has led to a more precise and reliable estimation of the empty areas. However, legacy data are usually a "presence only" data. Information on natural contexts is often poor and occasional; moreover, the absence of information coincides with the lack of paleo-environmental data. Especially in the past, expressions like “sterile” or “without archaeological features” generically defined by negation environmental contexts that retain a value for historical reconstruction. Recognize a value of this information potential brings to a more comprehensive and plural definition of what is – or might be – archaeological evidence.

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Open archaeology: a survey of collaborative software engineering in archaeological research

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Abstract:

Archaeologists increasingly rely on specialised digital tools and computer code to conduct their research. Scientific programming languages such as R and Python are used to write, modify, comment on, review, share and reuse scripted analyses, enabling more advanced manipulation of digital data (Schmidt and Marwick 2020). This usually consists of custom scripts and project files that parse and transform archaeological data using generic functions for data manipulation, statistical analysis, and visualization. These are drawn from a range of ‘off-the-shelf’ packages, such as: the tidyverse, ROpenSci, or NumPy data analysis ecosystems; database management systems and visualisation engines; or modelling frameworks and specialised software from other disciplines and industries. Collectively, these tools support a broad set of applications common across research settings. However, as archaeological workflows are rarely explicitly accounted for in their design, they can also impose limits and force archaeologists to adapt tools in ways unanticipated by their developers.

As digital methods have become increasingly central to archaeological research, it is therefore becoming more common for archaeologists to develop software explicitly targeted at their use cases. These tools fundamentally differ from analysis scripts in that they are designed for reuse by multiple analysts for multiple applications within a given problem domain. They provide generic functions that can handle mutable inputs, rather than custom procedures tailored to a specific dataset and analysis, based on the designers’ assumptions about what data structures, processes and desire outputs are shared by the tool’s intended users. As such, building these tools evokes a distinct set of skills, shifting the developer from the role of analyst to that of a ‘research software engineer’ (Baxter et al. 2012). Although the intersection of archaeology and software engineering is not new, these contemporary projects are distinguished by their adoption of practices from open source software development. In particular, widespread use of the git version control system, associated web-based source code management platforms such as GitHub and GitLab, is a relatively recent trend, opening up a new set of workflows for collaboration between multiple developers.

In this paper, we survey the state of the art in archaeological software engineering, documenting the wide range of general-purpose digital tools currently in development. Using open-archaeo (https://open-archaeo.info/), a curated list of 300+ active open source archaeological software packages, augmented with data collected from GitHub’s API, we seek to identify emerging norms in software development and collaboration, focusing on three key questions:

1. What types of open source projects are have been developed by archaeologists over the last 5–10 years?

2. To what extent to these projects leverage the collaborative features of git/GitHub?

3. Does collaboration in software development mirror, or differ from, collaborative practices in archaeological research more broadly?

We find that collaborative open source software development in archaeology, measured both in the number of projects and discrete contributions tracked in git repositories, has seen a rapid and sustained increase beginning around 2015 (see figure). This growth is seen across a range of languages and categories of tools, but is strongest in standalone web apps and R packages. In terms of collaboration, our analysis shows an uneven use of git and GitHub’s extended features, beyond their basic usage as a version control system and repository host. The vast majority of repositories have 1–3 contributors, with only a few distinguished by an active and diverse developer base. Similarly, collaborative features such as GitHub “issues” are used in only a minority of repositories. However, a network analysis of repository contributors may point to some nascent communities of practice.

We highlight areas in which archaeologists are either pooling resources for common goals or working independently and in a redundant manner, factors that may contribute to either enthusiastic upkeep or abandonment of software development projects, how various means of communication and contribution are valued, and how GitHub is leveraged for either one-way or discursive means of engaging with relevant stakeholders. We consider these aspects of collaborative software development in relation to common structures, practices and challenges that bind archaeologists together as a distinct community, and draw comparisons with potentially conflicting underlying assumptions, attitudes and processes accounted for and encouraged by the infrastructures that archaeological software developers have come to rely upon. We demonstrate how archaeological software engineering is beginning to foster new kinds of collaborative commitments while also being rooted in established archaeological sociotechnical structures.

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From 2D documentation to parametric reconstruction of archaeological structures and procedural modelling of an ancient town.

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Abstract:

The paper presents first results of the research project: ,,MA-P Maloutena and Agora in the layout of Paphos: modelling the cityscape of the Hellenistic and Roman capital of Cyprus". The main goal of the research plan was focused on the reconstruction of the ancient town Nea Paphos by placing well documented buildings among the dwellings and monuments probably existing in the past whose remains, however, where never fully confirmed by the archaeological research. Long history of research left great amount of 2D documentation and elaboration of archaeological remains excavated during last 55 years. Over the past few years representation of 3D models from photogrammetry and 3D laser scanning was mostly used to prepare the documentation primarily for visual inspections. The aim is to implement Archaeological BIM (Bosco et al. 2020) with the combination of digital survey such as 3D point cloud or mesh with the archaeological data collected in 2D representation of historic structures, reports, images. Starting from archaeological filed documentation, chronological studies together with the geometric of architectural features, material and behavioural values 3D representation of archaeological structures bring analytical capabilities for further studies of the remains and reconstruction of possible scenarios how the site evolved during Hellenistic and Roman periods. As an example of the BIM process and its tools the particular part of the archaeological site was examined. Autodesk Revit, whose components are categorised into “family” representing particular elements of a building, was chosen as the digital environment to prepare the 3D scenes of the inventory of architectural remains and a reconstructed Eastern Portico of the Agora.To justify architectural choices for the purpose of reconstruction, the 3D models consist information on particular chronological phase of the Agora Eastern Portico and refer to the information about each individual structure and its parameters.

Except the reconstruction and analytical model for the existing structure of the most documented portions of the Paphos town, the rest of urban tissue takes advantage of a generation system called CGA shape to create large-scale 3D environments within defined rules and parameter ranges (Garagnani 2017). Even if further archaeological research is not possible for the entire ancient town of Paphos, the implementation of the typology of Hellenistic houses known from ancient town founded on regular grid street, such as Olynthus and Priene, generated a procedural shape of houses in Hellenistic insulae of Paphos. Controlling proportions, volumes and typologies, 3D spatial analysis such as the visibility, solar analysis in certain condition etc., brings new insights in not excavated parts of the ancient

town. The compatibility of the BIM object with a GIS platform, where composite architectural objects are integrated to perform complex spatial analyses, consists the crucial feature for 3D spatial analysis (Saygi et al. 2013).

Testing the BIM system in an archaeological context is no more simple three-dimensional representation of buildings and archaeological remains, but collection of information, parameters and feature of many different families, types and categories of elements (Maiezza 2019). Archaeological BIM goes beyond simply visualisation as an informative procedure, where actually 2D and 2.5D documentation has an additional role as an external link in model properties.

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Routes to Linked Open Data: Modelling FAIR ceramics based on CIDOC CRM and a regional data acquisition system

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Abstract:

The publication of data in a Findable, Accessible, Interoperable and Re-usable (FAIR) way is an upcoming standard of digital data dissemination. Especially for interoperability, the Conceptual Reference Model of the International Committee for Documentation of the International Council of Museums (CIDOC CRM) is a standard meant to enable overarching queries to local structures and the transformation of data for migration to other systems. CIDOC-CRM is explicitly not meant to prescribe how data is captured, but aims to create a read-only integration of cultural heritage data (Doerr 2003).

In neolithic ceramic analysis in northern Germany a standardised way of ceramic data capture exists, which is called “Nordmitteleuropäische Neolithische Keramik” (North middle-European neolithic ceramics), short NoNeK. It aims at standardising the acquisition of e. g. decoration, shape, building technique and temper to enable cross-collection comparison and automatised statistical analyses. NoNeK provides a database design in Microsoft Access but is not restricted to this specific database. It aims at a designated structure of the data output, for which standardised workflows and scripts for further analysis have been designed (Mischka et al. 2014).

In my recently started PhD-project, I will create interoperable and re-usable data, which are able to link into the Linked Open Data Cloud. Therefore I aim to combine the global data structures of the CIDOC-CRM approach with the NoNeK data acquisition standards. This way a database model is created, which suits my needs for standardised data capture as well as the FAIR criteria.

Several extensions on the CIDOC CRM aim to create solutions for special data constructions that can be added and integrated as needed, e. g. CIDOC CRMdig. Brancato, Nicolosi-Asmundo and Pagano (2019) developed a CIDOC CRM- and OWL-based ontology for ceramics in Silician landscapes: OntoCeramic 2.0. Here, basic entities and classes for sherds and ceramic units, decoration, dough, periods and localisation have been developed.

My PostgreSQL ceramics-database deals with finds from the 5th mill. BC in Brandenburg (Germany) based on CIDOC CRM and NoNeK modelling standards in combination with controlled vocabularies. I will interlink the data with well-known resources in the Semantic Web, such as geospatial gazetteers (GeoNames) and space-time gazetteers (ChronOntology and PeriodO). This way the possibility is kept open to reach 5 star Linked Open Data. One way to codify semantic relations in a relational database is to create cross tables in a “RDF triple style”, in which one foreign key is the subject, the second foreign key is the object and a third column describes the semantic relationship as the predicate. This data modelling approach allows an easy transformation into Linked Open Data, and a prospective integration into a archaeological knowledge graph.

This talk will focus on how these challenges will be met and will therefore present the NoNeK specifications and its mapping on CIDOC-CRM.

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Standardized output or standardized workflow? Discussion approaches to 3D mini- and micro photogrammetry of archaeological artefacts and their scientific usability

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Abstract:

Introduction

During several years, 3D scanning and photogrammetry became a standard method of documentation ofarchaeological artefacts and archaeological sites. Unfortunately a lot of the models published to wider audience were presented with low quality or/and in quickly abandoned unique formats. Moreover, there is no standard format established for visualisations of archaeological artefacts. Only one feature is usually obvious – we try to make a digital replica as accurate and precise as possible.

At the same time, as archaeologists, we still expect all the new / different workflows, technical and software solutions to be up to date with technology to ensure best objects quality. Nowadays we have at least Open Source softwares, low budget and high-end soft and technology. But none of them are accepted and applied as worldwide standard.

The case of microphotogrammetry on microscopic level (taphonomy) and acquiring small animal bones were already mentioned in literature but most of the researches focused on paleozoological aspects (Maté González et al. 2015; Durão et al. 2018). Conclusions also present rather technological (engineering side of the process) instead of direct solutions that could be applied in archaeology.

The most pressing problem with 3D digitalization we met during our research, archiving and publishing process (apart from universality of data formats) was acquiring mini (below 30 mm) and micro (below 10 mm) artefacts into 3D models with enough high quality of shape and texture that would allow accurate measurements as on the original object.

Materials and Methods

I focus on two typical class of small artefacts like jewellery (Early Mediaeval silver beads and earrings), small animal bones and teeth (of Pleistocene mammals). Additional feature is to create universal workflow and in conclusion the most universal format for archiving and presenting data. We compare the upper level scanner (Artec), consumer low-end scanners and photogrammetry models based on macrophotography. Quite common set of tools available for most of archaeologists mentioned also by other researchers (Marziali and Dionisio 2017) (like Macro DLSR and Agisoft Metashape or equivalent soft) was used to get the results.

Results

3D models made with the mid-range solution allows, in comparison to upper level 3D scanner, to put a reasonable limit of accuracy and precision of artefacts documentation. The models I get allow to make the same classification, description and measurements as original. That

fulfils the researcher needs of artefacts functional attributes. As a result, it also minimize the necessity of direct use of artefact.

Discussion

This workflow for small objects is not unique, but more important question we should mention is if we have to create standardized output or standardized workflow? Continuing development of 3D technology will obviously still change and simplify the workflow but it shouldn’t be the most important aspect for us. If the results of different procedures give us comparable digital data, we may use any of them. Proper output of our works is a clue. But more important question which we need to answer is what storage format of 3D data might be universal for new post-covid19 digital era? Will we turn into Open Source formats or simplification of storage data?

Modern papers worldwide still seem to fracture data output solutions, as well as the workflow of the 3D data acquired into various formats. For now, the results of standardization of 3D data may remind us several similar tries in computational archaeology history, like: AML (archaeological markup language) or implementing open map formats. Also perspectives remind rather shape file or dxf/dwg story, when closed proprietary file format became an industry processing standards. Will this way be our future or just a step in 3D data acquiring and processing evolution is still up to us.

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ID number: 245

Evaluating Two Methods of 3D Spatial Analysis (UAV-based Photogrammetry and Ground-Based LiDAR) for Quantifying Erosion

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Abstract:

This paper reports on the use of UAV-based aerial photogrammetry and ground-based LiDAR (terrestrial laser scanning- TLS) to create 3D datasets used to quantify erosion and establish a monitoring program between 2016 and 2020 at a threatened buffalo jump site complex in Blackfoot Territory of the Rocky Mountain foothills in Alberta, Canada. When examining slow-moving and large-scale erosional processes, many of which are impacting heritage sites and intensified by climate change, the landscape can change so dramatically traditional methods of documentation are rendered useless. Consequently, georeferenced spatial data obtained for display and documentation can be used to determine the impact of erosional processes at archaeological sites. This means the data can move beyond use to only visualize landscape change and to quantify erosion and make predictions for areas next likely to be impacted within the landscape.

From revealing to destroying, natural erosional processes have complex and lasting interactions with heritage sites. Accurate and detailed mapping is required to determine erosional impacts to a site over time, but this can be difficult to conduct using traditional methods with shifting reference points. Modern remote sensing methods can provide a means of monitoring change and allow for the creation of detailed models over large areas that can be compared at a yearly scale. Remotely sensed technology provides a new method of documenting and quantifying landscape change and can be accomplished through non-invasive means and creates more valuable heritage monitoring practices. This case study reports on the comparisons of using ground-based laser scanning (terrestrial LiDAR) over one year and aerial-based (UAV) photogrammetry over four years for quantifying erosional change at a threatened heritage site. Through work conducted at a buffalo jump on Blackfoot territory in Alberta, this paper outlines the determination of computational distance measurements to determine change derived from the two techniques using open-source software. This paper will compare the use of two methods of remotely sensed spatial data acquisition and analysis (aerial photogrammetry and ground-based LiDAR) for monitoring slow-moving erosional impacts at a significant Buffalo Jump site over a yearly span as well as comparisons over four years between 2016 and 2020 in Alberta, Canada.

The benefits of using remote sensing technology for analyzing spatial change are threefold in that; 1) change is visualized using the high-density 3D point clouds created in order to monitor, manage, and predict future slow-moving changes impacting the site locality, 2) change detection allows for 4D modeling of spatial datasets, and the temporal analysis and multi-temporal 3D reconstruction and quantification of slow-moving change through time instantaneously (Rodríguez-Gonzálvez et al., 2017), and 3) through using these technologies we move beyond visualization and bridge the uncertainties of quantifying slow-moving processes such as erosion in ways that are relevant for heritage managers and practitioners.

For this study ground-based terrestrial laser scanning (TLS) as well as UAV-based photogrammetry were employed to digitally capture a large and at-risk Buffalo Jump site complex located in central Alberta, Canada. Through the creation of accurate and high-resolution 3D reconstructions to analyze change, continued fluvial erosional impacts at the site were monitored using these technologies. Accurate measurements were taken directly off these compared datasets and are used in 3D visualization and analyses of geoarchaeological data. Furthermore, the acquisition of multiple 3D datasets over time are used to quantify morphometric change and erosional processes impacting the archaeological site, similarly to work conducted by Yermolaev et al. (2018). In addition to the exactitude and precision of these models for demonstrating change, the value and analytical possibilities of georeferenced point clouds are in their use for documenting and visualizing change through time using open-source software such as change detection are discussed.

Comparisons of the two methods including commentary on costs, time, accuracies, required training/permitting, and other considerations including data collection during adverse weather conditions will be addressed. Conclusions on the application of the two methods for heritage documentation and monitoring will be provided with suggestions to establish remotely sensed long-term monitoring programs.

While settler structures are routinely monumentalized using 3D digital technology, Indigenous heritage within Canada is rarely documented using remote sensing technology. Yet, as prominent Indigenous Archaeology researcher George Nicholas wrote recently “the continued destruction of Indigenous sites, burial ground, and sacred places can be construed as a form of continued violence against Indigenous peoples.” This destruction can take place through inaction, in allowing for sites to be destroyed and forgotten on the landscape, thereby erasing further evidence of longstanding Indigenous histories on the land. Allowing for the destruction of cultural heritage through inaction is an example of a failure to recognize the importance of Indigenous historic places and a failure to act towards their protection. Research into digital strategies developed through collaborative partnerships with Indigenous communities aim at addressing divides in archiving threatened heritage. The use of remotely sensed digital 3D datasets are rarely used beyond the display and educational format to be used for analyses of sites. Results from this work can aid in the development of additional digital monitoring programs preservation of all heritage sites.

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ID number: 246

How to review research software in archaeology?

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Abstract:

The aim of this poster is to stimulate discussion about the content and objectives of research software reviews in archaeology and ancient studies.

The assessment of a text publication is a traditional part of academic discourse. Hence, there is an unspoken understanding of what a review should include. However, in regard to software, tools and small helpers (Minions) there is no such common ground despite their profound impact on archaeological research and instead one is confronted by a variety of challenges, like for example: What constitutes a good review of software intended for use in archaeological research? Do aspects of usability, sustainability and interoperability need to be considered? What role do technical and legal aspects play in the discussion of source code documentation or licensing? This leads to the overall questions: Does the software itself perhaps represent a scientific contribution? Which achievements of the software developers should be considered in a review?

The poster focuses on a list of questions to help with the critical evaluation of software. These questions are bundled in three sections, which align different areas of competence and knowledge. The first two sections deal with the scientific field of application, as well as the utilisation and usability from the user's point of view. The third section focuses on questions that are particularly relevant for developers and IT administrators. The result is a catalogue of questions, that entails a ranking of questions we suggest as „very important“ or mandatory, as „important“ and as „inspiring“. The ranking is the result of a collaborative and open writing exercise on Github and a final poll among the authors, who present together a broad range of experts in the field of computational archaeology, software-engineering, IT-administration and archaeological research (Homburg et al. 2021).

In modern research, it is unthinkable to work without digital tools. This also applies to historical, classical and ancient studies. With the rise of the digital humanities, software is increasingly becoming an important part of the research process and substantially affects it, both implicitly and explicitly (for archaeology, see e.g. Schmidt and Marwick 2020).

Despite the vital role that research software plays in many projects, the assessment of technical quality, usability, sustainability, fairness and ethical principles does not form a regular part of research design, nor are the achievements of those developing and programming sufficiently recognised academically (Hettrick 2016). Our poster is a contribution to raise awareness and overcome this critical shortcoming in the methodological development of archaeology.

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ID number: 247

A fuzzy approach to type formulation, definition and description.

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Abstract:

Introduction

Pottery is an abundant archaeological material category and a very rich source of information for the discipline. Pottery studies support a variety of archaeological research questions by, amongst others, providing a framework to extract chronological information or to infer social practices and cultural interactions. This type of insights usually arises from comparisons within and between assemblages and requires an effective typological arrangement to be in place. Although type descriptions are generally based on the morphological overlap and variations the sherds exhibit between them, an inherent desired property of the traditional typological model is to arrive at a classification system of selected discrete categories. The usage of distinction over continuity in type characteristics and labels makes it convenient to attach meaning to the materials, which emerges from extrinsic factors and propagate to further analyses. However, the hard boundaries rationale does not reflect the comparative nature and the fuzziness involved in the actual decision-making process of typological arrangements.

In this paper, we study algorithmic approaches that can be applied to bring back the richness of information and type membership in computer-aided typological arrangement applications. Based on a set of shape feature extraction techniques, we quantify intrinsic data of the pottery forms in several ways. We create network mappings to study the underlying structures in interrelationships and reveal the subject attributes that may create these structures, we propose groupings and test the consistency within algorithmically-defined or material specialist-defined groups.

Methods and Materials

We use a dataset of Early Roman Imperial Sagalassos Red Slip Ware, a tableware produced at ancient Sagalassos (SW Anatolia). The type class assigned by the material specialist is known but is used only for comparisons and not for analysis. We focus on the shape of rim, which serves as a diagnostic part of the vessel and on the shape characteristics of completely preserved profiles. We are implementing our approach in two aspects: first, to examine multiclass membership and second, to investigate multivocality in the functionality groups.

To quantify pottery sherds, we use technical drawings and implement information preserving methods (meaning that the original image can be fully reconstructed using the results of the quantification) and information non-preserving methods tied to measurement-based typology building. We generate distance matrices, one for each distance measure applied to the type of data retrieved by our quantification approaches of the pottery forms. With these distance matrices, we construct network mappings, to depict the high dimensional relationships in a lower dimensional projection. We study the mappings by visually inspecting the derived structure and the links between the nodes that may be (i) the technical drawing images (ii) the explicit attributes measured for the material. Provisional groups are defined

using soft clustering and the uncertainty is visualised using the continuous membership values. With the envelope plot (originally by C. Orton), we test the consistency and confusing examples that fall in more than one envelopes of the provisional type groups. We statistically test whether there is a set of attributes that contributes to the identification of the provisional types. The discovery of significant results does not automatically induce that the proposed type groups are of great utility to the archaeologists. However, by providing both the pictorial and the algorithmic representation and description, we support the material specialist in composing a verbal description and checking the utility of the computer-aided groupings.

Figure: Network embedding with the rim images or the corresponding glyph as nodes. Rims are obtained from technical drawings and quantified using their outline. Links are computed based on the Manhattan distance. The nodes are coloured by the crisp class selected by the first of maxima method and the opacity is determined by the membership value. Variations within the data can be summarised by superimposing the profiles per suggested cluster across the network embedding.

Discussion

As archaeologists, we try to collect information on past social practices, actions and interactions out of material remains from the past. To deal with myriad of forms and features in this material record, we use classifications to create structure and order that allows us to gain comprehensible perspectives. These classifications therefore constitute the very core of much of the archaeological practice.

In this paper, we consider the fuzziness in the typological classifications of material specialists and adopt overlapping instead of distinct categories using algorithmic type definition. We utilise label-free methods to reveal intrinsic characteristics of the material and subsequently possibilities of grouping using morphological data. We provide the means to form hypotheses and extract statistical analysis results while highlighting grey areas that occur in decision-making under the algorithmic solution. Inferring the meaningfulness of the proposed type groups requires a systematic study that accounts for the effects of each extrinsic factor with a meaning attached to the material culture (for instance the chronological aspect).

The prospect of adopting fuzzy as opposed to distinct type classes, not only in sorting but also in the information conveyed to further analyses, would radically change current standard techniques in archaeological applications. In seriation for example, algorithmic techniques should be enriched to account for probabilistic memberships to a type class. By dealing with fuzzy connections and decisions algorithmically, we provide additional comprehensible perspectives and tools to enrich the analytical techniques used in pottery studies.

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ID number: 248

Digital photogrammetric capture of the IS looters' tunnels under the Nebi Yunus Mausoleum, Mosul: its challenges, benefits, and further potential

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Abstract:

The Mausoleum of the Prophet Jonah (Arabic Nebi Yunus, NYM) in Mosul was demolished on 24th July 2014 by the so-called Islamic State (IS), which claimed the site to be unholy on the grounds of the "heretic" veneration of a human being inside a mosque. When razing the building, the IS found the remains of a 7th century BC Assyrian palace, which had been buried approximately 3 metres under the NYM for centuries. Between summer 2014 and autumn 2016, the IS then dug a wide network of tunnels of more than 600 metres under the NYM to systematically loot the Assyrian palace.

After the liberation of Mosul in summer 2017, a method to document the pitch-black tunnels in 3D had to be swiftly elaborated. During three archaeological campaigns organised by the Iraqi State Board of Antiquities and Heritage and Heidelberg University then, 350 metres of this tunnel network had been captured using digital photogrammetry. Georeferenced point clouds of both the mausoleum ruin and the tunnels are now being used to remotely investigate the palace for the first time in history because the NYM had previously long denied access to it. In addition, as reconstruction of the destroyed NYM is currently being planned, it is necessary to use these point clouds to define computational point distributions using the point collocation method recently developed by Jacquemin and Bordas. Such information on the damages to and its physical consequences for the palace caused by the tunnel network can help avoid accidents on the future construction site and elaborate strategies to sustainably preserve this archaeological site.

This presentation not only provides insights into the technique of 3D scanning the tunnels, but also aims at making a case for computational mechanics and its role in the recovery and preservation of this Iraqi cultural heritage in a post-conflict zone.

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ID number: 249

Strategy, tactics, supply and logistics of a Roman military intervention as a dynamic system: Middle Danube region during the Marcomannic wars

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Abstract:

Campaigning and expeditionary form of deployment of any army inevitably generates a wide range of requirements and needs. In the ancient world, particularly the Roman army excelled in supporting and sustaining substantial armed bodies dislocated and dispatched to all kinds of environmental settings. Roman-Germanic relations in the Middle Danube region during the Roman Period are characterized through the wide range of forms of interaction, oscillating between violent conflicts and diplomatic and economic relations. Despite the periods of conflict cover a considerably lesser proportion of time, some of them had far-reaching implications towards the overall relations and geopolitical situation. The most significant Roman-barbarian conflict has occurred during the reign of emperor Marcus Aurelius and is traditionally called the Marcomannic wars. The present state of knowledge gradually tends to comply with the surviving narratives describing the large-scale occupation of the region. A simple emulative agent-based model was established to address some of the featuring aspects of the Roman military intervention into the barbarian territory during the conflict. Its explicit nature comprises formalized properties of the modelled environment (e.g. geomorphology, movement friction, local population density) and several types of agents (army units, garrisons, on-land/river transportation means). Their movement is solved both using the least-cost path and spatial network. Based on the existing data and proxies (archaeology, Roman historiography, etc.) it aims to test assumption about the Roman army presence in the hostile region and its occupation, amongst others capacities to control territory and supply logistics.

ID number: 250

A null model of drift-induced maritime connectivity between Cyprus and its surrounding coastal areas at the onset of the Holocene

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Abstract:

Introduction

The elucidation of spatial patterns (and their timing) regarding prehistoric maritime mobility in the Eastern Mediterranean has attracted global archaeological attention over the past 20 years within the context of island and maritime archaeology (Dawson, 2014). The island of Cyprus occupies an important position against in this context, as Cyprus has been insular since the Miocene, and therefore any archaeological evidence of early human presence/activity on the island implies sea-borne mobility. Indeed, the onset of the Holocene (circa 12,000 years before present) is a critical period for understanding the origins of early visitors/inhabitants to Cyprus in connection with the spread of Neolithic cultures in the region. Considerable debate, however, still exists as to: (i) where these visitors/inhabitants originated from – Anatolia and/or the Levant being two suggested origins based on similarities of the material record, e.g., architecture, lithic technology, fauna and flora, and (ii) the routes they most likely followed to reach the island. Capitalising on relatively recent archaeological findings, physical modelling, palaeogeographic reconstruction, and computer simulation, this research provides novel insights into the prehistoric maritime connectivity (a proxy for sea-borne mobility) between Cyprus and other Eastern Mediterranean coastal regions at the onset of the Holocene.

Methods and materials

Simulation-based algorithms are employed for modelling drift-induced sea-borne movement, based on data and assumptions about prevailing paleo-geographical conditions (re-constructed coastline based on global mean sea level curves) and weather/sea circulation conditions parameterized by near-surface wind magnitude and direction and sea current magnitude and direction. The overarching assumption posits that general conditions of atmospheric and ocean/sea circulation during the early Holocene are not too different than present-day conditions, an assumption that has been frequently adopted in similar contexts (Bar-Yosef Mayer et al., 2015).

Under this assumption, present-day reanalysis data on the magnitude and direction of sea currents on an hourly basis and 7km spatial resolution were employed (downloaded from the Copernicus Marine Service https://marine.copernicus.eu/). In addition, present-day COSMO REA-6 reanalysis data on wind speed and direction at 10m height above the sea surface on an hourly basis and 6km spatial resolution were used (downloaded from the Hans-Ertel-Centre for Weather Research Climate Monitoring and Diagnostics of the University of Bonn https://reanalysis.meteo.uni-bonn.de/).

The paleo-coastline at the onset of the Holocene was estimated by tracing the -60m isobath (derived from global mean sea level curves for the period of interest) on present-day bathymetry data; the latter bathymetry was synthesized from EmodNet’s (https://www.emodnet-bathymetry.eu/) and SRTM (2004) bathymetry, land topography, and a recent R/V Marion survey of the Eratosthenes sea mount, integrated and sub-sampled at a 0.01 arc degree grid.

The above mentioned sea current and wind parameters, along with salinity data, were input to the OpenDrift Lagrangian particle tracking model (Dagestad et al., 2018) to simulate leeway-type, drift-induced (involuntary) sea-borne movement. The leeway of a drifting object is defined as its motion due to wind and waves relative to the ambient current. Leeway is decomposed into downwind and crosswind components, which are parameterized via linear regression models on the downwind speed based on experiments conducted at sea by the US Coast Guard Service. The regression coefficients are uncertain, due to errors associated with the wind and current measurements, as well as the inherent variation in leeway properties of objects. This uncertainty in the regression coefficients is encapsulated in their standard errors and is hereby explored by Monte Carlo simulation, resulting into a “cloud” of candidate positions for drifting objects, i.e., an ensemble of particle trajectories for a given departure location and time.

For the case study of this paper, one hundred (100) particles were released within a 5km radius from several coastal locations spread out along the Eastern Mediterranean shorelines and the island of Cyprus. Simulations were run for one (1) year, starting every day at 04:00 UTC (6 am local time) and producing hourly results for a duration of 120 hours (5 days). A set of simulation examples are shown in Figure 1. The simulation runs were used to estimate the degree of connectivity (probability of successful travel) between areas on Cyprus’s coastline and areas of its neighboring mainlands.

Results

The simulation results indicate two main periods, one in the winter and one in the summer, during which there is a significant likelihood for the ocean circulation in the region to aid postulated drifting vessels to arrive from the mainland to Cyprus, and an even higher likelihood to travel from Cyprus to the south coasts of Asia Minor.

During Winter time, the accelerated currents near the northern mainland coasts tend to push the drifting vessels over long distances, thus enabling drift-induced travel. From the north side of Cyprus, the sea currents appear very favorable for the northbound trip to the southern coasts of Asia Minor, even without any human effort requirements.

The current formations during the Summer period appear to develop barriers for the simple motion of a drifting vessel from the mainland to the open sea. During the same period, the trip from Cyprus to the eastern coasts of the Levant (present-day Syria and Lebanon) appears favorable.

Discussion

This research seeks to support hypothesis testing and archaeological interpretation regarding prehistoric maritime travel from/to Cyprus at the onset of the Holocene. To this end, a combination of physically-based models and computer simulation are employed towards modelling drift-induced sea-borne movement, and furnishing a null model of maritime connectivity between Cyprus and its surrounding coastal areas. Such a model can be used as a basis for comparing more realistic models of seaborne mobility involving paddling or even the use of a rudimentary sail (e.g., hides).

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ID number: 251

Documenting the shift in meaning over long-term archaeological project

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Abstract:

This reflection stems from my engagement in a mound monitoring project in Bulgaria, that unfolded over a period of 9 years and took the team to 4 different study areas. We visited and documented over 1000 burial mounds following a systematic guide, yet our interpretations of mounds changed as we moved from region to region. Burial mounds seem easily defined: often they are conspicuous earthen mounds that rise above the surrounding terrain and conceal burials inside. In our work, however, we have encountered submeter features that too contained burials and forced us to re-conceptualize the standard notion of a 'burial mound'. While measuring burial mounds, each team-member interpreted mound boundaries differently, producing vast differences in diameter estimates. Difficulties also arose as we tried to gauge mound condition. Whereas in one region mounds were mostly looted, making classification clearcut, in the second region mounds had been worn by elements and agriculture, blurring the line between anthropogenic and post-depositional impact. A submeter undisturbed mound would be classified as near pristine (1-2) in region one, and as damaged (3) in region two due to the different prevailing impacts. Looking back, the same digital record could point to two dramatically different features in the two different regions. We discussed these shifts in observations within the teams during fieldwork in order to maintain consistency within the campaign. Our digital system allowed us to 'scribble on the margins' and annotate data in the field, yet we have not found a good place to document these shifts in the long term. After all the outputs from different seasons are merged, all data streamlined and structured fields looking consistent on surface, how do you know that the referent has shifted?

ID number: 252

Reshaping a Roman city with GIS analyses and rescue archaeology. Palma (Mallorca, Balearic Islands)

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Abstract:

The modern city of Palma (Mallorca, Balearic Islands) has its origins in the Roman city cited by Pliny and Strabo, and lies beneath the city centre. Its remains have been partially known since centuries ago thanks to casual finds such as coins, pottery or surviving city walls. Throughout the 19th and 20th centuries some attempts have been made to propose an urban shape for the Ancient city based on the street layout and some archaeological finds: extension, street layout, city walls and different areas.

During the last 20 years, building works in many cities have lead to an equal increase of archaeological rescue excavations. In Palma, this new set of information is controlled by the Regional Government (Consell de Mallorca) and has a strong potentiality for the study of the Ancient city, sometimes helping to challenge previous hypotheses, nevertheless, many of these finds remain unpublished.

Old and new finds have been gathered together and restudied recently, together with ancient cartography, architecture and written Medieval and Modern sources. All these heterogeneous elements have been processed in order to be introduced in a single database, with coordinates, chronologies, and a reliability index, among other data. One of the main points is to guarantee data transparency of any resulting graphic material and, for example, an additional index is provided concerning topographic exactitude of every find location (e.g. geolocation with total station, archaeological plan inside a land plot, central point within a land plot, etc.).

This information is managed through a QGIS project, and it is combined with geographical analyses. These anaylises are useful to help define the ancient city through different phases. An approach to palaeotopography has been performed thanks to elevation data from the Roman period registered in archaeological excavations. These points have been interpolated with AutoCAD Civil 3D to obtain a simple, though useful, DTM of the surface of the Roman city. Hydrograhpy of the area has been calculated with SAGA Catchment Area, Watershed Basins and Channel Network sets of algorithms. The urban grid of Palma is currently complex as abandonment periods, destructive episodes (specially in the XII and XIII centuries) and modern buildworks have transformed many neighbourhoods. That is why it is important to filter the orientation of features such as streets, plots and buildings, in order to interpret the different patterns that can be identified. To do so, an orientation analysis is also performed with QGIS Field Calculator.

The main goal was to reformulate previous hypotheses and to explore new possibilities concerning the extension of the Roman city, its limits, function of different areas, ancient topography and orography. This project has to be a first step, a strong starting point towards a myriad of possibilities concerning new research on the Ancient city.

ID number: 253

Integrating legacy data for archaeological and remote survey at the 7th-15th century site of Unguja Ukuu, Zanzibar

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Abstract:

Introduction

The aim of the Urban Ecology and Transitions of the Zanzibar Archipelago Project (UETZAP) is to compare the materialities of daily life and urban ecologies through the archaeological survey and excavation of early Swahili towns in the Zanzibar Archipelago (Wynne-Jones et al 2021). A key objective of UETZAP is to map archaeological indicators of subsistence, craft, and architectural resources in the domestic spaces and surrounding landscapes of Unguja Ukuu (500-1400CE) through a combination of fieldwork and remote GIS analysis.

Despite significant technological advances over the past twenty years, researchers in or of sub-Saharan Africa still face regional fieldworking issues related to the quality of satellite imagery, signal availability and the rarity of reference stations for GNSS positioning, and seasonal monsoon conditions which limit the periods in which fieldwork can most efficiently be conducted (Klehm and Gokee 2020). Atmospheric conditions and the palimpsest tropical landscape of Eastern Africa also mean that remote sensing analysis of the Swahili Coast is a complex task complicated further by the rapid pace of modern urban growth, paucity of historic and digital mapping, and low resolution of archaeological data to aid interpretation (Pawlowicz et al 2020). On top of this, the prevention of fieldwork by the COVID-19 pandemic means that we are now restricted to a more limited dataset than planned for, with little opportunity for ground-truthing of developing hypotheses.

In response to these challenges we have explored alternative means of testing hypotheses through a re-evaluation of legacy datasets originally designed for quite different purposes, and complete with their own challenges of missing data, positioning errors, and publication in noncompliant formats. This paper describes the process of integrating two such legacy datasets to test and complement our exploratory use of remote sensing for mapping the archaeological landscape of Unguja Ukuu.

Methods and materials

Our research design is aimed at mapping historic ecologies and resource use in early Swahili towns on Zanzibar through a combination of targeted household excavations, faunal and isotope analysis, and high-resolution geochemical surveys of domestic, urban, and hinterland areas, plotted for comparison and study in a project-wide GIS. Following the onset of the COVID-19 pandemic we began to explore the use of high-resolution visible and multispectral imagery to remotely survey and characterize the resource landscape of Unguja Ukuu. Initial tests demonstrated that standard multispectral combinations calibrated for survey in more northerly latitudes and sub-tropical environments were not entirely useful in our survey area, but experimentation indicated that alternative combinations might yield better results. Without appropriate field data to ground-truth the results of this analysis, such experiments

were speculative. We have therefore digitized, extracted, and repurposed legacy data originally created to explore the core area of the site, and combined this with our own survey data to create a detailed stratigraphic model of the area. This has enabled us to begin to test our remote survey results despite the continued postponement of fieldwork and ethical issues involved in international travel for research in the near future.

Results

As hoped, the results of this remote survey indicate that with some further refinement and calibration we archaeological remains and paleolandscapes from environmental indicators across our survey landscape, work which has become particularly relevant in the context of the Covid-19 pandemic.

Our GIS analysis has led to the identification of spatial correlations of classified soil types recorded in our primary survey and buried architectural and midden materials identified in legacy data with trace footprints of possible archaeological activity zones in our experimental multispectral image combinations. We are currently investigating the use of a combination of artefact distributions and stratigraphic maps as a relative dating proxy to explore the changing density of settlement across the paleolandscape throughout the occupation of the site.

Discussion

The results of analysis so far are encouraging both in the generation of relevant data for our own project, and as a means of building an interpretative model for archaeological remote sensing in Eastern Africa. The incorporation and repurposing of disparate and low-resolution legacy datasets has enabled us to test our remote sensing surveys despite the continued suspension of fieldwork, and to identify spatial correlations of archaeological traces which had previously been overlooked. The integration and comparison of these datasets has also allowed us to improve georeferencing of earlier sources despite contemporary positioning errors or missing coordinate data, and publication of these will support future research and collaborative protection efforts by the Department of Antiquities on Zanzibar.

Apart from highlighting the continued technical challenges associated with field survey in the region, the work again demonstrates the value of drawing on a range of archaeological methods to support both in person and remote survey, and we are working towards the publication of a useful comparative dataset of potential archaeological markers in visible and multispectral satellite imagery in the context of the East African coast.

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ID number: 254

Title

Nonequilibrium dynamics in models of human palaeoecology

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Abstract:

Palaeoecological modelling has become significantly more accessible to archaeologists in recent years. New open datasets—high resolution global climate and environmental surfaces (e.g. WorldClim2, MERRAClim, CHELSA, SoilGrids), downscaled palaeoclimate reconstructions from global circulation models (e.g. PaleoView, PaleoClim), and global biodiversity catalogues (e.g. GBIF)—provide both more precise training data and wider spatial and temporal coverage than previously available. At the same time, the increasing availability of R packages for complex modelling tasks allows us to integrate models of discrete elements of the ecological system (climate, plants, animals, humans) within a single framework.

Yet these palaeoenvironmental datasets are relatively static, representing time-averaged reconstructions at a coarse spatial resolution, or “snapshots” of contemporary conditions with a shallow time depth. In reality, many ecosystems are characterised as much by variability and unpredictability as they are by their average trend. In drylands in particular, plants and animals must adapt to this unpredictability, introducing an element of instability to their ecological dynamics that contradicts the ‘equilibrium assumption’ of temperate ecosystems, and which is often overlooked in models of prehistoric human ecology. By contrast, ecologists increasingly recognise the importance of nonequilibrium dynamics in contemporary socioecological systems, where human settlement is conditional on strategies that are resilient to unpredictable environmental conditions (Briske, Illius, and Anderies 2017).

In this paper, I will sketch some strategies for incorporating nonequilibrium dynamics into models of human palaeoecology, using as a case study Terminal Pleistocene/Early Holocene foraging societies in the Azraq basin, in the arid margin of the eastern Levant. Based on a combined model of palaeoclimate, vegetation, fauna, and human subsistence, I argue that nonequilibrium dynamics are key to understanding how foragers survived and thrived in this landscape, where resources were scarce and unpredictable. Environmental instability, manifested at multiple scales, shaped the plant and animal resources available to region’s prehistoric societies, and in turn must have necessitated human subsistence strategies adapted to variability and risk. The results indicate that, although they add a layer of computational complexity, nonequilibrium dynamics may be important in understanding human ecological choices in other environments characterised by high variability.

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ID number: 255

User Experience Design of Full-Immersive Serious Games for improvement of Cultural Heritage Communication and Understanding

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Abstract:

How creative industries and immersive technologies can serve the user experience design in Virtual Archaeology and Museums? In this contribution, two use cases of Cultural Heritage are being discussed. The legendary Antikythera Mechanism is being presented through the user experience design of the homonymous full-immersive virtual museum, and the serious game in virtual reality that communicates the functionalities and interpretations of the first ever analogue computer. The combination of Oculus Rift S head-mounted display and Unity game engine provided the context for transforming Computed Tomography scans of the fragments of the Antikythera Mechanism, into meaningful three-dimensional representations. In addition, new types of full-immersive interactions in the virtual museum for the Mechanism, such as the X-rays functionality, offer to users the opportunity to understand in a unique way the inner structure of the corroded artifact. Moreover, the results of a quantitative evaluation in an heterogenous target group reflect the effectiveness of the virtual reality application. The ForumSG, a serious game for the Roman Forum of Thessaloniki is being introduced as the case study of a design and assessment framework to enhance effectiveness of such applications, in terms of user experience and learning. This framework focuses on enhancing game’s effectiveness by design, to achieve consistency along the game production phases, and also to stimulate the creators to integrate the appropriate tools into the game architecture for its formative and final evaluation. By incorporating a formative evaluation, the game takes into account the user's needs, during the gameplay, enhancing the perceived experience. The ambition of this work is to contribute to the creation of more effective cultural heritage serious games, in terms of their twofold goal, entertainment and learning, as well as to explore new ways to assess their effectiveness. Another aspect is to create applications with high educational value, exploring cognitive levels higher than information retention, such as understanding.

ID number: 256

Convolutional Neural Networks for Ground-Penetrating Radar

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Abstract:

This paper reports on current efforts to develop a self-contained image classifier for ground-penetrating radargrams through the use of various machine learning methodologies and recent advances in convolutional neural networks. This investigation presents a unique application of machine learning for archaeo-geophysics in which radargram profiles are directly classified. The novel approach is compared with the common interpretive method of analyzing radar time slice maps. Whether manual or automated, time slice analysis relies on data that has been averaged/binned and interpolated into amplitude maps and therefore does not harness the exceedingly richer data density of the radargram profiles. The case example presented demonstrates the utility of integrating traditional archaeo-geophysics and excavation with automated feature detection in order to increase overall efficiency of ground-penetrating radar interpretation and how such an approach can be used to more effectively implement excavation strategies as well as augment overall site interpretation. Additionally, the challenges involved in implementing tools like TensorFlow (via Keras) using a LeNet architecture will be discussed along with how such automation methods for radargram processing can facilitate machine-guided interpretation and new forms of rapid GPR data visualization.

ID number: 257

Digital Data Curation Model: Designing a Unified Framework for Archaeology

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Abstract:

Digital data curation is the process of coordinating the representation and management of digital information related to cultural heritage and decides how digital assets are selected, preserved, maintained, collected, and archived, possibly augmented for effective exploitation. This paper addresses the problem of the curation of digital data in the context of conservation and communication of cultural heritage. In particular, the paper provides an extensive survey of several existing frameworks, methodologies, and workflows, with the goal of yielding a global view of the concrete situations in which the digital curation process is called to operate. Therefore, we consider the topic to be relevant and up to date. In this paper, we analyze a number of frameworks with the aim of a systematic account of digital curation experience and provide a basis for sharing the best practices. After such a thorough analysis, which points out the dependence of frameworks on the specific practices of the fields addressed, we flesh out the major components that must be taken into account in an encompassing framework and examine how its potentials may foster new advancements in digital curation for cultural heritage. The final goal is to develop a unified operational digital curation model and framework relying on a conceptual model that emphasizes the semantic organization of the data.

ID number: 258

Linking datasets in Norway

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Abstract:

This paper presents challenges and opportunities in the ongoing work in Norway to connect several digital sources; the site and monuments records, the national museum artefact database, the national detailed excavation documentation, the national image database for archaeology and the georeferenced database of excavations and reports at Museum of Cultural History. MCH takes part in a project in EOSC – Nordic (Eropean Open Sciene Cloud, https://eosc-nordic.eu/about-eosc-nordic/) for Nordic Archaeology, and takes part in the EU infrastructure project ARIADNE+ (https://ariadne-infrastructure.eu/).

The Norwegian university museums have cooperated continuously in different settings to create a common database solution. The present cooperation is called UniMus:Kultur, and concentrates on a new solution for the artefacts in the archaeological, numismatic and ethnographic collections at all museums. The data is published under unimus.no, both as a portal (unimus.no/portal) and a downloadable dataset and API. Images, documenting artefacts, excavations and sites as well as exhibitions and museum work, is also at unimus.no/portal. At present, there are close to 1.5 million published entries for archaeology and more than 750 000 images. The database also includes a table of the Norwegian Cadaster mapping historic and modern administrative borders and metadata.

The Historic Environment Record, Askeladden, is maintained by the directorate for Cultural Heritage. It is published under askeladden.ra.no and in an public version at kulturminnesok.no. This dataset is also included in a project with EOSC (European Open Sciencs Cloud). The EOSC project will bring together the Norwegian Askeladden and the Danish Fund og Fortidsminder, creating one site for Norwegian and Danish sites and monuments.

The ongoing ADED-project (Archaeological Digital Excavation Documentation) creates a common National repository and open web interface for digital excavation documentation in Norway. Excavations on prehistoric sites in Norway are conducted by the university museums. They decided in 2011 to use the program Intrasis for all their excavations, and to agree on common templates for the excavations. This has made it possible to combine the datasets and present them on a common platform. The project also includes preparing and uploading existing site documentation. The data is mapped to CIDOC-CRM.

ADED will also integrate information from the UniMus databases in the web interface. This creates an opportunity for everyone to see the detailed excavation documentation, the artefact descriptions and images taken on the site and of the artefacts through the ADED portal.

Museum of Cultural History also leads the hub/node-structure HumGIS, which has established a map interface for sites, excavations conducted by MCH, artefacts, and excavation reports.

Digitized historical maps are also included in the map resources. All excavations are included in the interface, but the amount of information varies greatly. While the newer projects have a rich set of metadata and links, most of the projects earlier than 2000 have only a limited set of metadata.

The Norwegian Documentation Project published a map-based interface to the collections as early as 1995. The Documentation Project was a cooperation among the Norwegian Historical-Philosophical faculties from 1991 – 1999. The site included links to artefacts and digitized examples from the museum’s archive. Now the Norwegian HER, archaeological artefacts, images, excavation reports, and digital excavation documentation each are large datasets, and they share links that affords linking. The ID-number in Askeladden, the artefact catalogue number and the archive number for the images can all be used as links. These ID numbers have existed several years, and are therefore not globally unique identifiers, but they are unique within each resource. The ADED project has been successful in linking on a site level, but the even deeper linking, from artefact to single structures at a site has proven difficult because the fields that could be used have not been controlled in a way that secured the linking.

The data will also be shared through ARIADNE. MCH has mapped periods to PeriodO (https://perio.do/en/) and artefact names and other authoritative lists to Getty’s AAT (https://www.getty.edu/research/tools/vocabularies/aat/) as preparations to share the data internationally.

A certain realism in what can be possible to achieve is also in place. Linking at site level functions quite well, while linking to single structures within a site is more challenging. A small addition to create better links in existing datasets is very time consuming when the datasets are as large as the one we use here.

Further work to include more datasets and achieve deeper knowledge about landscapes and Norwegian history could be to include more resources from the abovementioned Documentation Project. Norwegian Medieval Documents (Diplomatarium Norvegicum) and historic sources and interpretations of Norwegian farm names are published and could be linked through the cadaster.

ID number: 259

Invisible Heritage - Analysis and Technology Platform. A multi-sensors documentation of the UNESCO listed churches in Troodos (Cyprus)

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Abstract:

This abstract intends to present the initial outcomes and results of the IH-AT (Invisible Heritage Analysis and Technology) project, led by the APAC Labs of the Science and Technology in Archaeology and Culture of the Cyprus Institute.

In an era of rapid technological improvements, state-of-the-art methodologies and tools dedicated to the protection and promotion of our cultural heritage should be developed and extensively employed to expand and enrich historical and archaeological research and possibly revise or add new information to established theories. The IH-AT project (EXCELLENCE/0918/0144, co-financed by the European Regional Development Fund and the Republic of Cyprus through the Research and Innovation Foundation) aimed to design and develop an innovative portal comprised of reliable and efficient technology-ready tools for the visualization, documentation, and analysis of the UNESCO listed churches in the Troodos area.

The project goals are to apply Non-Destructive-Techniques (NDT), geophysics, 3D modeling, and visualization methods, supported by art-historical and archaeological research, to investigate a cluster of selected churches in Cyprus.

The main aims are:

- to preserve by way of record the existing structural remains,

- to identify lost and invisible features,

-to assess the conservation conditions of their religious sites,

- highlight the evolution of the structures and particularly the presence or otherwise of buried ones,

- Identify the presence of other buried buildings and structures in the nearby vicinity of the churches.

This pilot application will enable the customization of an online platform and database from which information and data can be extracted. This can be used to inform further research and conservation projects at the specific UNESCO churches. In addition, the platform will act as a methodological example of best practice with a view to expanding these to other heritage sites in Cyprus.

Through the integration of expertise from different disciplines, the project will forge essential links and synergies for the delivery of innovative tools to tackle challenges related to the conservation, restoration, and knowledge of heritage sites.

A holistic research approach will rely on:

1. traditional art-historical and archaeological studies for context analysis;

2. reliable and efficient technology-ready tools for 3D modeling and interactive visualization;

3. state of the art non-destructive geophysical tools.

Up to date, all data have been collected by means of different sensors and techniques. Once all the information is processed it will be made available through the IH-AT platform. The latter is being built using open-source tools further implemented and customized to fulfill the project goals.

ID number: 260

Geospatial archaeological information visualization and Mixed Reality: Enhancing visitors’ meaningful engagement with archaeological sites.

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Abstract:

This paper introduces the workflow needed for presenting archaeological sites through Mixed Reality (MR) technologies and relative issues concerning how such MR applications can provide visitors with a more meaningful and active engagement with monuments. Virtual interactive worlds may reconstruct not only monuments in archaeological sites, but also simulate people, activities, and functions, as well as “tell’ stories about historical events in situ with the help of location-based smart applications. Thus, MR could be a tool for extracting cultural experience from archaeological sites and monuments, creating the premises for the sustainable protection of cultural heritage as a living part of present and future societies. As a case study we present the MR authoring tool of “Mergin’ Mode” project that is assisted by geoinformatics technologies and merges elements of the real world (i.e., current state of the building) with virtual elements/world(s) in order to present an ottoman bath in Apollonia in its original state through MR. The properties of the physical objects are acquired by photogrammetry, laser scanning, and unmanned aerial vehicles and are further processed in order to be visually displayed by utilizing Geovisualization in combination with traditional image processing techniques. The physical in combination with the animated virtual objects are presented in a Mixed Reality environment. We further explore the reasons why these applications are and should be developed and used and what are the challenges that need to be answered through them, putting emphasis on issues associated with the uses of these technologies in the field of archaeology. The prospects and the untapped potential of such MR applications as illustrated by the case of “Mergin’ Mode” for enriching visitors’ experience and all the more their understanding of the significance, value, and characteristics of a cultural site are virtually unlimited. Thus, the capabilities and the conditions under which pertinent MR applications can bolster users’ insightful encounters with the cultural past become a focal point in this paper. The workflow, development procedures, actual characteristics and philosophy of applications such as “Mergin’ Mode” provide the basis for building a framework of informational material, narratives, interactive, customizable, navigable that will underpin MR-based meaningful experiences of the historical past. This paper delineates the technological background of MR using the abovementioned project, in conjunction with ways of maximizing the actual impact on audiences/visitors in relation to the sensuous and informational context such applications can offer in order to fulfil the potential of these emerging technologies with respect to connecting people with the past through technologies that herald the future in the fields of digital heritage and archeology.

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ID number: 261

The Byzantine City of Mystras: The South West Gate to Hagia Sophia Monastery

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Abstract:

The archaeological city of Mystras, located in western Laconia, is the best-preserved Byzantine site in Greece also known as the "Castle City of Mystras" (www.culture.gr). Mystras was founded in 1249 when the Frank commander William II of Villehardouin built a castle fortress on top of Myzithra hill to control the Valley of Evrota 6km southwest of Sparta. The city passed to Byzantine rule in 1259 and expanded outside the Acropolis. Mystras eventually developed into the powerhouse of the Peloponnese, capital of the Despotate of Morea. The city flourished through a significant number of phases, different rulers and population changes (Sinos, 2009).

This study presents the challenges and resources used to create a digital depiction of the historic, topographical and architectural changes to the city during its different phases. Mystras, built over the steep hill of Myzithras with its extended vegetaion creates a demanding study area overcome using modern spatial technologies including an unmanned aerial vehicle (UAV) and a GPS GNSS for the survey. The area from Monastery of Hagia Sophia to the northern gate of the upper city is photographed with the UAV and georeferenced with ground control points, in order to be portrayed digitally through the orthophoto created from the photogrammetry software. The true orthophoto produced from the process is used as the basemap for the study area in the subsequent analysis via Geographic Information System (GIS). In the GIS environment archaeological, historic, topographical and architectural data are projected in different layers creating the visual depiction of the various historic phases of the city (Forte et al, 2020), assisting in a digital trip to Mystras evolution during the studied time period (13th - 19th c A.D.). This work follows the study and digitization of the area of the Acropolis of Mystra and the Castle fortress at the top of Myzithra hill.

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ID number: 262

Four Ways to Paddle a Canoe: Comparing the successes and failures of four different seafaring computational models to capture pre-Columbian movement in the Caribbean.

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Abstract:

Though the practice of using computational analysis to analyze past movement across the seas has grown over the past few decades, it is still an emerging field in the sense of academic output. As the community of researchers who focus on this area is still growing, much of this output focuses on the development and implementation of a model as designed by individual researchers. Not only do these models use different algorithms and methods, but they use different types environmental factors or data types on which to base their analyses. Increasingly, conference sessions, review articles (Davis et al. 2015), and several PhD dissertations (Jarriel 2017; Safadi 2018; Slayton 2018; Smith 2021) on this subject have worked to catalogue the various modeling techniques employed by these researchers over the past thirty years. These methods range from least cost pathway-based analysis to agent-based modeling, comparison of vessels that use sails and harness the wind or use current as the driving force behind their canoes, and focus on local connections between neighboring islands or on the initial peopling of islands or continents. However, there has been little effort to compare different modeling techniques for their effectiveness in approaching inter-island travel over sustained periods of time. This paper will approach a comparison of four methods that have been employed to analyze seafaring, evaluating which aspects of each method are effective, and what areas we as a community need to improve in order to better capture the past.

The methods explored in this work include those developed by Leidwanger (2013, 2018), Jarriel (2017), Alberti's (2017) TRANSIT toolkit, and the method developed and used during my PhD. Leidwanger's, Jarriel's, and Alberti's methods were selected due to the ability to recreate the method due to their description in publication and other materials, their prominent reference within the field of archaeologically focused seafaring modeling, their focus on either isochrone based directed pathway, and their use of tools like ArcGIS, which although proprietary is in common use among computational archaeologists. Leidwanger's approach looked to determine how far individuals might travel from a central point outwards in a certain amount of time (i.e. an isochrone path). The model relied on using the speed and direction as a raster base on which these one-day time bands (isochrones) could be modeled. Jarriel adapted upon Leidwanger's model, adapting the structures of underlying raster's to better fit with earlier seafaring in the Mediterranean conducted in sail-less vessels. Her work focused on further adapting the capabilities of ArcGIS to best fit seafaring modeling. Alberti's approach also uses ArcGIS as a base for this type of modeling, whereby a series of cost surfaces are created to determine the effect of wind on the movement of sailing vessels in the Mediterranean. These cost surfaces serve as similar purpose to the isochrones, bounding areas of travel.

In my PhD dissertation, my colleagues and I developed a model to generate isochrone layers, from which a directed path could be isolated (Slayton 2018). These hypothetical routes showcased the circuitous movement likely followed by canoers across the Caribbean Sea, and opened up the possibility for new questions on how seafaring modeling focused on current data could be effective in analyzing early seafaring routes in a region and how corridors of movement influence interaction on and across the sea. As my model targeted pre-sail communities, I relied primarily on current data. As other models focus primarily on wind data and my model primarily on current (though including low level wind influence), I will produce two reference points for comparison on a route – a route guided by wind data vs a route guided by current data. This may also help to represent these routes under two types of seafaring tradition, paddled vessels and sailed vessels.

This comparative approach will be applied to modeling seafaring networks or spheres of interaction around the Northern Lesser Antilles, an island chain that demarks the eastern end of the Caribbean Sea. The Northern Lesser Antilles between 400CE and 1492CE was a productive space, where the water surrounding an island acted as a super highway enabling the relatively quick movement of peoples and materials. Mapping this super highway, or multi lane travel corridors, can enable archaeologists to evaluate the social connections spawned from the exchange and movement of Long Island flint. The exchange of Long Island flint across this region was a case study of my PhD. As Leidwanger, Jarriel, and Alberti focused primarily on Mediterranean examples, this work can also provide a test of how the change region or environmental data type impacts analyses of seafaring in these computational models. I intend to compare the outputs of the Leidwanger and Alberti approach to my results in the dissertation, seeing whether my past assertions over the rise of rest areas on in-between islands acting as a catalyst for site creation holds true in the results of other approaches.

This work hopes to spark a trend in comparing results across modeling methods, to determine what forms of tools or constraints placed upon these methods lead to successful models of early seafaring. It also seeks to inspire cross-regional tests for a model’s universal application.

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ID number: 263

Uses of Sentinel-1 and -2 imagery in heritage protection and management strategies. A case study from Ostrów Lednicki (Poland).

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Abstract:

Uses of Sentinel-1 and -2 imagery in heritage protection and management strategies. A case study from Ostrów Lednicki (Poland).

The aim of this presentation is to demonstrate potential of Sentinel imagery to develop strategies for heritage protection and management in areas which are undergoing dynamic changes. In the last two decades Poland has been experiencing rapid changes due to intensive economic development. Landscape transformations related to construction works such as infrastructure, housing estates, commercial and industrial developments can be observed not only in the vicinity of urban centres (urban sprawl) but also in rural areas. An example of these processes is an area surrounding one of the most significant archaeological site in Poland. A medieval stronghold with a pallatium located on an island of the Lake Lednica was connected with the first royal dynasty of Piasts and is considered the cradle of the Polish statehood. However, the lakeland area around the site is now regarded as particularly attractive for tourism and housing, helped by an infrastructure development that links it to neighbouring towns.

The rapidity of observed changes requires application of relevant tools to monitor negative trends and develop effective strategy to protect archaeological heritage. In that respect Sentinel-1 and -2 imagery which is characterized by high frequency of data acquisition seem to offer an immediate insight into current tendencies. Thus an area of 112 km2 around Ostrów Lednicki was analysed using data (obtained between 2016-2020) and its derivatives. Spectral and radar data were analysed within statistical units which represent property boundaries and as such permitted us to construct yearly cycles of land cover changes for the whole study area and for each individual ownership plot (arable field, housing/ development plot).

Our presentation will demonstrate preliminary results from analyses of those data to identify:

1. Areas undergoing transformations which are posing threat to archaeological heritage.

This includes identification of new housing estates, an attempt to determine the pace of change (year to year analysis of increase in building areas) and observations of change in patterns of land use. At that stage radar and optical imagery were used to analyse those changes.

2. Current land use in order to select most effective methods of archaeological prospection in threatened zones.

A transformation of arable land into building plots may exclude it from further agricultural use and turn it into a wasteland. As such it may be rendered inaccessible for some prospection methods such as fieldwalking and aerial survey. On the other hand changing farming patterns clearly affect archaeological activity, leaving narrow margins of opportunity in which it is

possible to carry out surveys. At that stage NDVI analysis were used to identify changing pattern of land use as well to estimate crop developments and field accessibility for archaeological survey.

The preliminary conclusions from this research can be summarised in the following points: 1) the NDVI analysis demonstrated great potential for precise planning of field survey in a narrow period between subsequent agricultural cycles, 2) spectral analysis also seems to offer a considerable potential to monitor changes within development plots. This included detection of the topsoil removal before construction works and identification of small buildings, 3) the resolution of Sentinel-1 images was too low for the direct detection of single-family houses and for this and other factors offered unreliable/ unpredictable results, 4) owing to cloud penetration, Sentinel-1 may be regarded as a supporting dataset to monitor agricultural activities and crop harvesting for field survey planning.

Based on those preliminary result we will discuss the potential and limitations of the proposed methodology, data and obtained results. In particular we will identify issues connected with processing large amount of data, limitations imposed by data itself (in particular cloud coverage and imagery resolution) and necessity to develop user-friendly tools for non-specialist users.