Sharing Practices

Archaeological 3D Visualisation in the Netherlands

Archon Winter School

20-22 February 2020

RCE Amersfoort
University of Amsterdam

Program and abstracts

ARCHON research school of archaeology

AHM

Amsterdams Universiteitsfonds

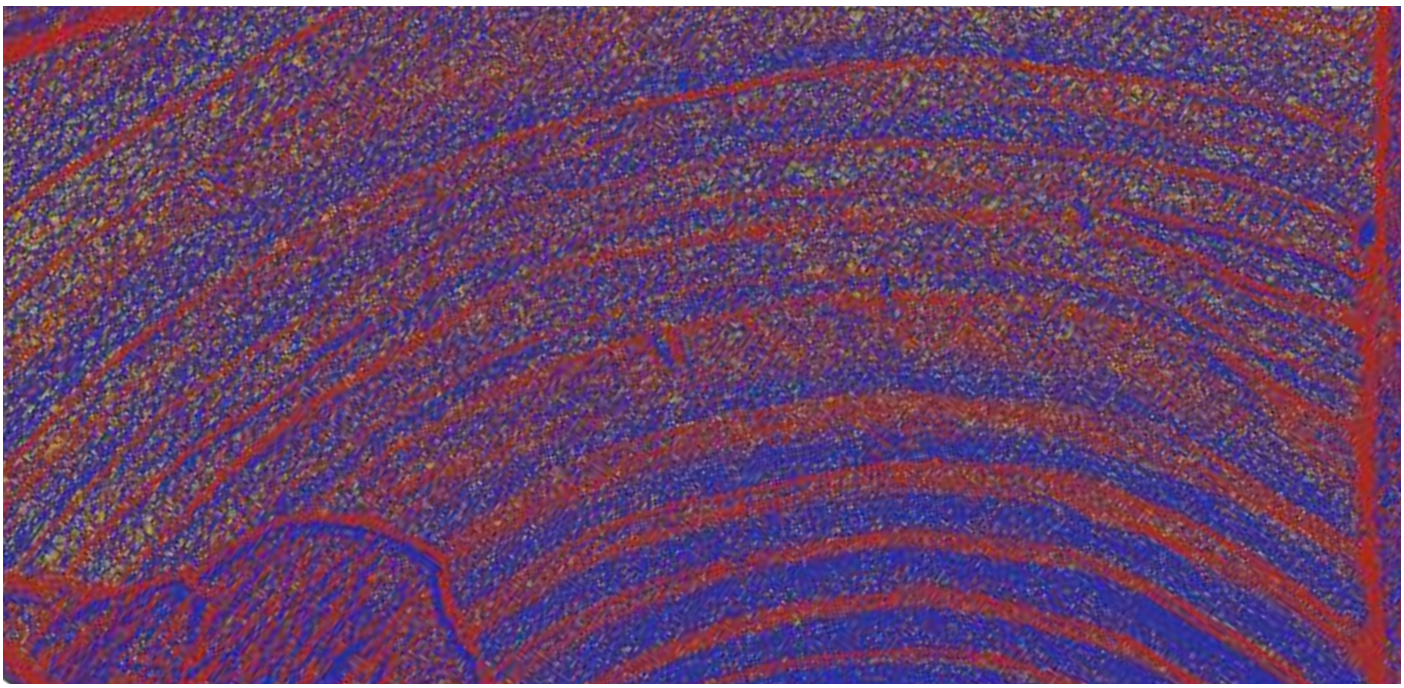
Universiteit Leiden

ACASA

PTW

UvA

4D Research Lab



Introduction

The 2020 Archon Winter School *Sharing Practices: Archaeological 3D Visualisation in the Netherlands* aims to move beyond traditional research boundaries, and seeks to establish a community of practice for young researchers in the Netherlands with a shared interest in 3D visualisation of (archaeological) heritage. Archaeologists from both academic and commercial settings will contribute to the symposium by sharing their work in the form of oral presentations and/or interactive posters that will be showcased during the three-day event. All contributions gathered promote the development of an established set of standards, guidelines or methodology of the use and deployment of 3D technology in archaeological research.

Background & Aims

The wide range of specialisms within the broad field of academic and commercial archaeology that have adopted 3D technology to implement their research often have limited opportunity to connect and engage with each other. Specialists using digital tools in archaeology, however, should share a common ground in order to visualize historical processes and build explanatory models, no matter whether they are dealing with lost medieval houses in Amsterdam or potters' strategies in the Mediterranean Bronze Age. To reconcile such a wide variety of applications, the three-day Winter School will lay down the foundations for a best practice in archaeological visualisation, elaborating further on the general guidelines provided by the London Charter and Seville Principles. In particular, the workshops, symposium and roundtable will attempt to put forward solutions for visualizing uncertainties and gaps in available (historical) data, to elaborate guidelines for the documentation of the course of research (i.e. choices made, selection procedures, assessment of data, also known as paradata) in order to safeguard transparency, and lastly to address common issues concerning data archiving, sustainability and accessibility.

Structure & Schedule

Day 1 (Thursday 20 February): Workshops

Location: RCE, Amersfoort

The three-day Winter School kicks off with a full day dedicated to several workshops running in parallel sessions. Topics range from the application of 3DHOP (**WS1** organised by Dr. M. Callieri, ISTI-CNR), when and how to use the Extended Matrix (**WS2** organised by Dr. E. Demetrescu, ISPC-CNR), to dynamic data visualisation in Blender (**WS3** organised by the 4D Research Lab, UvA) and how to exploit 3D printing as educational and public outreach tool (**WS4** organised by the TPW team, UvA). The day will be closed with a lecture by 3D visualisation pioneer Prof. Dr. Paul Reilly (University of Southampton).

Day 2 (Friday 21 February): Symposium

Location: RCE, Kinderdijkzaal, Amersfoort

The symposium opens with a brief welcoming address by the organisers, followed by a fully packed schedule of both oral presentations and interactive posters and demos. The day will close with a keynote lecture delivered by digital humanities specialist Prof. Dr. Sarah Kenderdine (École polytechnique fédérale de Lausanne). The symposium aims in particular to:

- Reflect on the information examined and put in practice during the workshops;
- Offer greater theoretical embedding of 3D visualisation methods;
- Assess their role in knowledge production.

Speakers with ranging specialisms will present their approaches and theoretical reflections on these matters, adding to current knowledge and fostering best practices in both education and research realms.

Day 3 (Saturday 22 February): Roundtable

Location: Potgieterzaal, University Library, Amsterdam

The last (half) day is dedicated to a roundtable discussion that will reflect on the outcomes of the first two days, ultimately translating practical and theoretical into a community of practice of (Dutch) professionals working with 3D technology to visualise archaeological heritage.

Themes Addressed

The symposium revolves around three main interdisciplinary themes, including the use of 3D technology as a research and teaching tool, the formalization of the virtual reconstruction process, and the accessibility and publication of digital archives. All contributions provide innovative insights into these macro-themes, often touching upon one or more in the same paper, showing how intertwined these topics are.

In particular, contributions focusing on methodologically embedding 3D technology within the research process, illustrate how such technology forms an active part in the production of new knowledge, insights, and results. The deployment of innovative technology should thus move beyond the mere automation of the traditional process, the accumulation of more data, or the sake of efficiency, to considerations about how the technology actually contributes to knowledge creation and research outcomes.

A large part of the contributions collected are methodology-driven and bring forward a critical, reflexive stance on the role that 3D visualisation techniques could play in the process of reconstructing the past, being either taphonomic processes, distribution models or reconstructions of lost architecture. These processes are the most valuable and productive part of research, and the vast meta- and paradatasets should be recorded and saved in an effective way. Yet, they often stress the lack of a shared best practice of Dutch 3D archaeological visualisation. In this light, the works presented at the symposium will provide valuable information about such recording strategies, and by comparison show or contribute to the formulation of shared practices and formalisation of multiple and diverse documentation methods.

Lastly, several contributions deal with the longstanding issue of storing and publishing web archives. Assemblages recorded through 3D technologies not only require a massive storage space, but also interoperability and re-use of different file formats and accessibility of their underlying meta- and paradata, which are still a challenge. Digital archaeologists very often face limited publication possibilities, where 3D data need to be adapted to the flat surface of paper or in case of online sharing, limited bandwidth or technological possibilities. The greatest challenge lies, however, in changing the academic mindset of publishing on paper in a linear way, and instead presenting large datasets and processes in a versatile, scholarly peer-reviewed digital environment.

Papers & Interactive Poster Presentations

To emphasize the inclusive character of the event, the Archon Winter School brings academic and commercial worlds together, as we believe that by sharing digital practices the learning options increase greatly. Both academic and commercial archaeological parties have been invited to showcase their technological solutions, products and methods at the Winter School and/or present a paper.

(R)MA students have been encouraged to submit a poster proposal to showcase their projects on one of the touchscreens (serious games, interactive posters, Augmented or Virtual Reality or any other 3D approach that was undertaken as part of a project or thesis) or bring their own digital solution (hologram projectors, 3D scanning solutions, interactive devices, and so on). These projects will be introduced by 5-minute lightning talks.

Lastly, we are exploring the possibilities to publish individual papers in a thematic issue of an open access journal that will be introduced by a co-authored, reflexive contribution outlining the outcomes of the presentations and the results of the roundtable discussions. This editorial endeavour may form the beginning of a Dutch community of practice of professionals working on 3D visualisation of archaeological heritage.

Showcases

Prof. Dr. Patrick Randolph Quinney will give a short demonstration of handheld small object scanning using a structured light Artec Spider scanner as well as a demonstration of a VR platform for archaeological engagement with examples from cave sites in California and virtual skeletal remains.

Prof. Dr. Jan Paul Crielaard and Dr. Maurice de Kleijn will present the Knowledge Hub, a database in which all known settlements, important roads and routes over land and sea in Euboia, are stored, and supplemented with new data provided by field surveys and remote sensing research carried out by the SESLR project. This data is visualised through a 3D viewer, which enables specialists and other stakeholders to easily analyse large quantities of spatial data.

Acknowledgements

This Winter School is made possible by the generous contributions of the national Dutch research school for archaeology Archon, the Amsterdam School for Heritage, Memory and Material Culture (University of Amsterdam), the Department of Archaeological Sciences (Leiden University), the Amsterdam University Fund, the Tracing the Potter's Wheel project and the 4D Research Lab (University of Amsterdam).

We are especially grateful to Dr. Chiara Piccoli, whose support and expertise on the subject was essential to realise the Winter School, and also many thanks to Dr. Costas Papadopoulos, for his insights and substantive contribution.

The Organising Committee

Loes Opgenhaffen, University of Amsterdam

Hayley Mickleburgh, Linnaeus University

Martina Revello Lami, Leiden University

Thursday 20 February 2020 **WORKSHOPS**

PROGRAM

09:00 - 10:00	**Registration and coffee***		
10:00 - 10:20	**Welcome and opening** (*Kinderdijkzaal*) by J.W.H.P Verhagen (Archon) and L. Opgenhaffen (UvA)		
10:20 - 10:30	Workshop practicalities		
	10:30 - 16:15 **Workshop 1** Kempen-zaal	**10:30 - 13:00** **Workshop 2** *Woudagemaal-zaal*	**10:30 - 13:00** **Workshop 3** *Stelling van Amsterdam-zaal*
11:45 - 12:00 **Coffee break**	***The application of 3DHOP***	***When and how to use the Extended Matrix***	***Dynamic data visualisation in Blender***
	Organised by: Dr. M. Callieri (ISTI-CNR)	Organised by: Dr. E. Demetrescu (ISPC-CNR)	Organised by: 4D Research Lab (UvA)
13:00 - 14:00 **Lunch break**			
		14:00 - 16:15 **Workshop 4** *Stelling van Amsterdam-zaal*	
15:00 - 15:15 **Coffee break**		***3D printing for research and education***	
		Organised by L. Opgenhaffen and Dr. M. Simons (UvA)	
16:15 - 16:30	**Break**		
16:30 - 17:30	Keynote lecture (*Kinderdijkzaal*) ***Provenance illusions and illusive Paradata: when artistic and archaeological practice meet in the phygital*** Dr. Paul Reilly (University of Southampton, UK)		
17:30 - 19:00	**Drinks** at Brewery '*De Drie Ringen*'		

* ***Registration, breaks and lunch will be in the foyer***

SYMPOSIUM

Friday 21 February 2020

09:30 - 10:00	**Registration and coffee***
10:00 - 10:15	**Welcome and opening** (Kinderdijkzaal) by J. Bazelmans (RCE) and L. Opgenhaffen (UvA)
10:15 - 10:35	***3D Modeling for Education and Research in Archaeology*** A. Walsh (Leiden University, NL)
10:35 - 10:55	***Different Dimensions*** N. Dell'Unto (Lund University, SE)
10:55 - 11:15	***AI, automation and the future of 3D reconstruction interpretation in archaeology*** I. Lanjouw (University of Amsterdam, NL)
11:15 - 11:30	**Coffee break**
11:30 - 11:50	***Machines of Knowledge: Virtual Worlds as Scholarly Editions*** C. Papadopoulos (Maastricht University, NL)
11:50 - 12:10	***Estimating sex in juvenile skeletons using 3D models*** M. Langevoort, M. Hoogland and S. Schrader (Leiden University, NL)
12:10 - 12:20	***Lightning talks***
12:20 - 13:30	**Lunch**
13:30 - 13:50	***Enabling 3D Visualization of the Archaeological Record: Method, Theory, and Practice*** G. Nobles and C.H. Roosevelt (Koç University, TR)
13:50 - 14:10	***Visualizing 17th century Amsterdam interiors: towards a methodological framework for creating and publishing annotated 3D reconstructions*** C. Piccoli and H. Huurderman (University of Amsterdam, NL)
14:10 - 14:30	***Reconstructions in 3D for the benefit of science and enjoyment. Examples in underwater archaeology and heritage management*** R. de Hoop, M. Manders and J. Opdebeeck (RCE, NL)
14:30 - 14:50	**Coffee break**
14:50 - 15:10	***From artefact to landscape: Multi-scalar approaches to 3D modelling and visualisation of archaeological contexts and material culture*** P.S. Randolph-Quinney (University of Central Lancashire, UK - University of Johannesburg, ZA)
15:10 - 15:30	***Knowledge hub for Archaeological Heritage Southern Euboia, Greece*** J.P. Crielaard, M. De Kleijn and C. Lucas (Vrije Universiteit, NL)
15:30 - 16:10	***Showcases***
16:10 - 16:30	***Bonify 1.0: evaluating virtual reference collections in zooarchaeological teaching and research*** C. Çakırlar, G. Nobles and N. de Boer (Rijksuniversiteit Groningen, NL)
16:30 - 16:50	***Archiving and sustaining research data*** V. Cillissen (DANS, NL)
16:50 - 17:00	**Break**
17:00 - 17:45	Keynote lecture ***Repertoires for archives: reperforming histories in the public domain*** Prof. dr. Sarah Kenderdine (EPFL, CH)
17:45 - 18:45	**Drinks** in the foyer of the RCE
20:00	**Conference dinner** at Jackie Brown

Workshops

Workshop 1
The application of 3DHOP
Organised by **Dr. M. Callieri**, ISTI-CNR (I)

This workshop will present the 3DHOP tool from ground up. Features such as multiresolution streaming, configurable viewer, and integration with webpages will be covered. We will look at some viewers made with 3DHOP for different projects, and will comment on their implementation. In the second part we will take a look at the practical use of the tool, from a simple example to more complex functionalities such as loading models, creating scenes, navigation settings, changing visibility/color and rendering options, setting the integrated tools, and creating an interface. Lastly, we will learn how to use the Visual Media Service to simplify the publication.

We will provide 3D models and example files to experiment with the tool. To try the examples and follow the tutorials, you will need a notebook with Chrome installed (or a local web-server). It is easier on a Windows notebook, but MacOS and Linux will do too.

3DHOP has been designed to be used by non-programmers, but still requires a basic knowledge of HTML and possibly a bit of JavaScript.

Workshop 2:
When and how to use the Extended Matrix
Organised by **Dr. E. Demetrescu**, ISPC-CNR (I)

This practical workshop will present a complete workflow for the creation of virtual reconstructions in archaeology using the Extended Matrix and open source software (Blender, EMtools).

The Extended Matrix is both a method and a software frame-work for creating, managing and publishing virtual reconstructions in archaeology (http://osiris.itabc.cnr.it/extendedmatrix/).

If you are interested in:

– Transforming archaeological data from excavations or 3d survey into virtual reconstructions;
– Creatig collaboratively validated 3D models;
– Publishing your 3D data with effective visual impact.

Whatever you are:
– An archaeologist without 3D skills
– A 3D modeler in the Cultural Heritage domain
– … or simply interested in exploring a new area of digital archaeology, this is the right workshop for you.

Workshop 3:
Dynamic data visualisation in Blender
Organised by the **4D Research Lab**, University of Amsterdam (NL)

The advantages of rendering in 3D modelling programs remain largely unexplored in archaeological research. In current approaches the go-to software for analysis and data visualization of terrain models is GIS software. But GIS methods are relatively static and non-interactive, while 3D modelling programs with modern real-time rendering capacity offer a more intuitive work-flow. In such programs, shaders and light sources can be edited on the fly, giving immediate feedback to the user. This fast feedback cycle in interactive 3D space can help to improve perception of surface properties of any 3D model. Moreover, 3D modelling software allows the user to share these insights by making animations of light and surface colorization, advancing our capacity to illustrate our archaeological research.

This workshop offers some tips and tricks for handling archaeological datasets, such as LiDAR, in open source 3D modelling software Blender. You will learn how to import various types of data, visualize them in different ways using shaders and light sources, and export an animation of the result.

Workshop 4:
3D printing for research and education
Organised by **Loes Opgenhaffen** and **Dr. Madelon Simons,**
University of Amsterdam (NL)

What do a 16th century house from Amsterdam and a Minoan conical cup from the Bronze Age have in common? They can each be printed in 3D. They are printed in 3D to reveal the hidden complexities of the building and the pot respectively to either students in archaeology and art history, while they simultaneously contain the possibility to demonstrate ongoing research to museum visitors in a playful way. In this workshop not only the potential of 'additive manufacturing' for research and in (higher) education and public outreach will be demonstrated, but also a practical hands-on experience with 3D prints of pottery and architectural elements will be provided.

3D printing, also known as rapid prototyping and additive manufacturing (AM), is increasingly accepted as a valuable method to valorise archaeological research to a general audience. In research and education, however, it

remains a still largely underexplored area and even if deployed, it is mostly to demonstrate finds that otherwise would remain out of reach and intangible. The workshop presents a new way of engaging with material through additive manufacturing by two case studies: 1) the (3D) construction of a late medieval house from Amsterdam by Dr Madelon Simons, art historian at the University of Amsterdam; 2) 3D models and prints of forming traces in pottery, developed by Loes Opgenhaffen and Dr Caroline Jeffra, University of Amsterdam.

In the first case, a digital 3D reconstruction of the flexible wooden construction and relative proportions of a house of around 1500 is 'shaped'. Kept beside the preconceptions of the work-shop practice of the 16th century painter, an interesting dialogue can be started. Yet, it appears that realistic and detailed 3D visualisations are not enough to demonstrate a real sense of space to peers and students, whereas a tactile and concrete approach by means of a 3D print of the digital reconstruction, could actually provide for this.

In the second case, 3D prints of forming traces of pottery will help students and other interested parties to recognise traces that correspond to different forming techniques of pottery. To reach this, individual forming traces were digitally extracted from 3D scanned material, which were then manipulated and enlarged in order to print. As such, participants can touch, handle and explore the individual traces, which are accompanied QR codes to a 3D reference collection with additional information, such as tagged 3D models and videos of the manufacturing of a pot. After learning through handling the 3D prints, a ceramic example will be provided: can you now understand with which forming technique the vessel was once produced?

The workshop introduces a novel approach to teaching and public outreach, while encouraging critical thinking and creativity through a material interface.

Abstracts

Illusions And Illusive Paradata: when Artistic And Archaeological Practice Meet In The Phygital

Dr. Paul Reilly
Visiting Senior Fellow in ACRG, University of Southampton (UK)

Provenance, provenience, and paradata are closely related concepts pertaining to assemblages (or parts thereof) of culturally produced artefacts. They describe, amongst other things, the objects themselves, their metadata, their origins, location, the circumstances under which objects 'emerged', and other attributes that are deemed important to establishing the authority, authenticity and ownership of the artefact or assemblage. These concepts enable researchers to construct and attach biographies to objects, buildings and places, and are therefore themselves integral parts of the assemblage. However, assemblages are to a greater or lesser extent moveable and so may also have significant itineraries attributed to them. As such, components of assemblages may participate in any number of discrete or overlapping spatio-temporal assemblages and spawn a multiplicity of provenances (biographies) and associated paradata.

Increasingly, cultural assemblages are being virtualised, meaning that they may exist digitally as well as physically, or as combinations of both, that is phygitally. This paper argues that objects and assemblages may become ontologically itinerant within a phygital nexus. In so doing, the interplay between biographers, biographies and itineraries, assemblages, and the paradata associated with them, may be radically reconfigured, and indeed severed.

These assertions will be illustrated using a number of case studies in which artistic and archaeological practices are diffracted through one another in the phygital to reveal how essential elements of an assemblage can disappear in an illusion underpinned by paradata.

Repertoires For Archives: Reperforming Histories In The Public Domain

Prof. Dr. Sara Kenderdine
École Polytechnique Fédérale de Lausanne (CH)

In 1889 the curator G. B. Goode of the Smithsonian Institute delivered an anticipatory lecture entitled 'The Future of the Museum' in which he said this future museum would stand side by side with the library and the laboratory.[1] Convergence in collecting organisations propelled by the liquidity of digital data now sees them reconciled as information providers in a networked world. The media theorist Lev Manovich described this world-order as "database

logic," whereby users transform the physical assets of cultural organisations into digital assets to be uploaded, downloaded, visualized, shared, users who treat institutions not as storehouses of physical objects, but rather as datasets to be manipulated.[2] This presentation explores how such a mechanistic description can be replaced by ways in which computation has become 'experiential, spatial and materialized; embedded and embodied'.[3] It was at the birth of the Information Age in the 1950s that the prominent designer Gyorgy Kepes of MIT said "information abundance" should be a "landscapes of the senses" that organizes both perception and practice.[4] This "felt order" should be a source of beauty, data transformed from its measured quantities and recreated as sensed forms exhibiting properties of harmony, rhythm and proportion.[5]

Archives call for the creation of new prosthetic architectures for the production and sharing of archival resources. At the intersection of immersive visualisation technologies, visual analytics, aesthetics and cultural (big) data, this presentation explores diverse digital cultural heritage experiences of diverse archives from scientific, artistic and humanistic perspectives. Exploiting a series of experimental and embodied platforms, the discussion argues for a reformulation of engagement with digital archives at the intersection of the tangible and intangible and as a convergence across domains. The performative interfaces and repertoires described demonstrate opportunities to reformulate narrative in a digital context and they ways they support personal affective engagement with cultural memory.

[1] Goode, G. B. (1891). The museums of the future. *Report of the National Museum*, 1888–'89, 1(1), 427–445.
[2] Pepi, M. (2014), 'Is a Museum a Database?: Institutional Conditions in Net Utopia', *eFlux Journal*: December 2014).
[3] Berry, D. & Dieter, M. (2015), *Thinking Postdigital Aesthetics: Art, Computation and Design*. Palgrave Macmillan.
[4] Kepes, G. (1956), *The New Landscape in Art and Science. Chicago*: Paul Theobald: 24.
[5] Halpern, O. (2014), *Beautiful Data: A History of Vision and Reason since 1945*. Duke University Press: 14.

Jazz Luminaries (2019): an interactive fullldome application based social network constellations of jazz greats from the UNESCO Memory of the World Montreux Jazz Archive, this installation cuts, remixes and replays 5400 artists and 13000 videos.

3D Modeling for Education and Research in Archaeology

Alicia Walsh
Faculty of Archaeology, Leiden University (NL)

In the last decades, 3D imaging technology has been gaining popularity in the field of Archaeology. However, the use of digitally replicated artifacts as resources within classrooms is currently under development.

"The Future of Experiencing the Past" – a pilot project coordinated by Dr. Rachel Schats, Drs. Martina Revello Lami and Prof. dr. Marie Soressi at the Faculty of Archaeology at Leiden University – goes in this direction. Within the framework of The Center For Innovation's SALT SWAT initiative (Spaces for Active Learning & Teaching, Support With Active Teaching), the project aims at creating a digital reference collection for the benefit of both instructors and students.

By creating 3D models of artifacts held in the Faculty's collections, this digital

archive will assist instructors in teaching about various materials and techniques when availability of artifacts is low, or they are too fragile to be handled. Furthermore, it will enable students to study the material record by viewing and manipulating models in class and at home.

In this talk, I will present and discuss the workflows implemented to carry out such a project, and will describe how the choice of methods, hardware and software can be influenced by the object in question.

During the course of this project, ceramic, bone and stone tool artifacts were 3D modelled by using either photogrammetry or laser scanning. I will describe how not only each artifact can require a unique methodology, but also how the ultimate purpose of 3D models (e.g. research or education) can impact how a model is rendered, post-processed, stored, and displayed.

Different Dimensions

Dr. Nicoló Dell'Unto
Dept. of Archaeology and Ancient History, Lund University (SE)

Technology is changing our society at an incredible speed, the inclusion of digital devices in our lives is having an irreversible impact on the way we perceive and interact with reality. Every day we send in and out information through the cloud, feeding the community with data which are used by others to accomplish specific tasks.

As well as in other disciplines, archaeology was strongly affected by this revolution and due to its interdependence with technology, in the last decades, several discussions concerning the role of digital tools in support of archaeological practice were undertaken. Today spatial and communication technologies are considered indispensable part of the archaeological toolkit and are used extensively in the field to carry operations of data recording, archiving and analysis as well as to expand the boundaries of the archaeological excavation, reaching specialists and scholars behind any geographical limits.

Advances in geomatic, visualization and hard science allow discovering more information about the past, providing archaeologists with an incredible amount of details to process and include in their interpretations. How are we going to combine these shreds of evidence together? Where and how these data should be reassembled? And for who?

By presenting several case studies, this talk will discuss the impact that 3D spatial and visualization technologies are having in archaeological field practise with a specific focus on the way visualization technologies are expanding our capacity to detect and combine archaeological pieces of evidence.

Ai, Automation And The Future Of 3D Reconstruction Interpretation In Archaeology

Tijm Lanjouw
4D Research Lab, ACASA, University of Amsterdam (NL)

Theoretically, a computer program can easily solve the 3D reconstruction problem. For instance, rule based reconstruction, procedural modelling, has been applied successfully to archaeological cases. An advantage is that the rules are logically constructed, and explicit, which satisfies our criteria of verifiability and transparency. To this we add the current capacity of AI to process big data, recognize patterns, and learn to apply those patterns to procedurally model anything. Fed with the right data, AI can develop an understanding of all that is known about human architecture in the blink of an eye and make much more informed choices than we could, and certainly do it much, much faster. Our work made easy, right? Can we sit back and have AI interpret and teach us our past? This paper reflects on what it means to interpret ("3D reconstruct") an archaeological site as a human being, and the effect AI and automation is going to have on our field. I will finally give in to the seduction of reiterating some age old intuitive truths, and conclude what we already know. Or do we?

Machines of Knowledge: Virtual Worlds as Scholarly Editions

Dr. Costas Papadopoulos
Faculty of Arts and Social Sciences, Maastricht University (NL)

The increasing number and types of digital scholarship being produced in the last decade, including audiovisual content, multimodal interfaces, and different forms of visualisation have started challenging established mechanisms of evaluation and publication, not only in archaeology, but in the Arts & Humanities, as a whole. These new forms of scholarship have either to be adapted to conform to established evaluation and metric models or rather not get recognised as scholarly outputs. As a result, much of this highly innovative scholarship, when considered for tenured posts or evaluation frameworks, has to be downgraded into a supplementary file or an appendix to a monograph or journal article. This paper discusses a particular form of interactive scholarship, 3D (re)construction, that despite its long tradition in archaeological research, is still faced with scepticism and hesitation, not only because of the constant technological shifts and exigencies and the fragile ecosystem within which such projects are being developed, but also due to their non-conventional nature that does not adhere to established academic practices and metrics. This presentation will problematise the future of publishing 3D archaeological (re)constructions by proposing a new framework, that of a 3D Scholarly Edition, that allows archaeological 3D (re)constructions to be seen as knowledge sites that communicate the results of that scholarship

within a single, interactive, spatio-temporal environment that is immersive and multisensorial unlike conventional forms of dissemination (e.g. monograph, journal article).

Estimating sex in juvenile skeletons using 3D models

Marijke Langevoort, Dr. Menno Hoogland and Dr. Sarah Schrader
Faculty of Archaeology, Leiden University (NL)

Osteoarchaeologists generally do not estimate the sex of juvenile individuals because of the lack of sexual dimorphism before puberty. Digital methods, however, have been shown to be reliable in the estimation of sex in juvenile skeletons. Recent research by Wilson and colleagues applies geometric morphometrics (GMM) to assess the curvature of the iliac crest. This curvature is a trait on the pelvis that is used in sex estimation, and typically shows a stronger s-shape in adult males. For this project, the goals were to test the repeatability of Wilson et al.'s analysis and assess the user-friendliness of this particular method.

The whole process proved more difficult than initially assumed; up to five different pieces of software were used, paired with a relatively expensive piece of hardware (NextEngine 3D scanner). The elements were scanned using a 3D scanner, after which the curvature and 41 landmarks were extracted. The position of these landmarks relative to the midplane of the curvature (sinuosity values) were used for two different statistical analyses. The first, a K-mean cluster, had relatively little success, which is possibly due to the imbalance between the two sexes in the already relatively small sample (n=31). Furthermore, these differences may be the result of factors other than sex, but this was not further explored in this study. The second analysis, a discriminant analysis, proved more promising; whereas the overall crest showed a low success rate of only 57.7%, the most posterior set of landmarks (section 5) had a success rate of 71.4%, indicating that this area may show enough sexual dimorphism to estimate sex in juveniles. Further research is necessary to confirm or refute this, as well as to improve the user-friendliness before it could be widely applied.

Enabling 3D Visualization of the Archaeological Record: Method, Theory, and Practice

Dr. Gary Nobles and Dr. Christopher H. Roosevelt
Research Center for Anatolian Civilizations, Koç University, Istanbul (TR)

The Late Bronze Age hilltop settlement of Kaymakçı in the Gediz Valley of western Anatolia (modern-day Turkey) has been investigated by the Kaymakçı Archaeological Project since 2014. From the start, the team employed state-of-the-art methods for recording all excavation contexts in high-resolution, 3D

detail, enabling the visualization of on-site archaeological practices through virtual reconstruction of excavation context volumes.

In this paper we review the challenges of reconstructing truly 3D datasets from archaeological excavations, presenting a newly established method for the effective recombination of surface point clouds into closed-volume contexts representing excavation units, with all the complexities of their 3D geometries. We discuss various GIS geometries and their associated data types, highlight those which are suitable for excavation data, and indicate under which archaeological situations they are best employed. With datasets easily termed "Big Data", we highlight what we see as Big opportunities as well as Big problems with 3D practices going forward. As a research-driven excavation, we are privileged to be able to evaluate and develop new methods. Such bespoke solutions need to be assessed for their suitability within development-led commercial archaeological practice, however, if they are to be fully accepted by the archaeological community.

Visualizing 17th Century Amsterdam Interiors: Towards A Methodological Framework For Creating And Publishing Annotated 3d Reconstructions

Dr. Chiara Piccoli and Dr. Hugo Huurdeman
Dept. of Media and Culture, University of Amsterdam (NL)

In this paper we discuss our ongoing work in the Virtual Interiors project, which aims to develop 3D reconstructions as geospatial interfaces to explore historical data during the period of the Dutch "Golden Age". We will focus both on the interpretative role of 3D reconstructions in contributing new insights in historical data and on the methodological questions that arise in creating such 3D environments in a way that complies to academic standards. Taking as case study the house of the Amsterdam regent Pieter de Graeff (1638-1707), we will show how the 3D model sheds lights on the use of space and the strategic placement of objects in one of the rooms thus far considered. Moreover, we will discuss the challenges we are addressing which relate to the preparation of an intellectually transparent 3D reconstruction with structured and accessible underlying data sources, the integration of annotations and representation of uncertainty in the 3D visualization, and the design of user interfaces that allow a user-friendly navigation and interaction with such annotated 3D environments. The pipeline we are developing, which is based on Open Source software and builds upon previously developed frameworks (e.g. BabylonJS), ultimately aims to create a flexible Virtual Research Environment demonstrator that can potentially be applied to any historical and archaeological reconstruction

Reconstructions In 3D For The Benefit Of Science And Enjoyment. Examples In Underwater Archaeology And Heritage Management

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Underwater archaeology is often referred to as an exciting and adventurous profession. And indeed, most archaeologists working in this field would support this thought. A problem however lies in the fact that time and visibility underwater is limited. On top of that, most instruments assisting terrestrial archaeology with the visualisation of what is investigated, do not work underwater. The search for visualisation techniques in underwater archaeology has thus developed in a somewhat different way as on land. The urge to do so was heavily felt because who else than the archaeologist working underwater was able to see all the abundance of well-preserved historical features underwater? Starting in the early 1960's with 2D photomosaic, in the 1980's 3D photogrammetry was trialled in the Netherlands. The computer systems that needed to align the photographs were unfortunately not prepared for their tasks. Through sonar techniques like single- and multibeam, but also subbottom profiling, 3D documentation of the seabed surface and even objects and hidden landscapes in the seabed can now be made. The biggest step forward however is perhaps the possibility for everybody to use simple camera's and software like Agisoft Metashape or RealityCapture to create a high resolution 3D model. The use of 3D can help archaeologists to create an environment in which they can continue their research after the dive. It also appeals to the public and as a spin off, dive experiences are being made and reconstructions of ship types in which public and researcher can walk around and compare the full shape with the archaeological record. This talk will explore the different uses of 3D visualisations in underwater archaeology and cultural heritage management.

From Artefact To Landscape: Multi-scalar Approaches To 3D Modelling And Visualisation Of Archaeological Contexts And Material Culture

Dr. Patrick S. Randolph-Quinney
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Three-dimensional (3D) space capture is now routinely applied in archaeological practice. This has often taken the form of using 3D visualisations based on photogrammetry or true 3D space capture using laser scanning (to derive surfaces), or total station survey methods (to derive Cartesian coordinates). Often these are used to record topography and spatial distributions at sites and may be used to provide a spatial archive of archaeological evidence or as an aid in visualisation for publication or heritage outreach purposes. However, there is a growing interest in the use of 3D data capture methods

for recording and analysing differing spatial levels of 3D evidence, both for purposes of recording and data sharing, but also to facilitate analyses of spatial archaeology and site-formational processes. However, the multi-scalar integration of 3D data in archaeology is a relatively new phenomenon, with little consensus on what equipment and imaging modalities are either appropriate or best to use. This presentation sets out to highlight 3D modelling approaches from object level up to landscape situation. Using multi-modal 3D capture at the Rising Star early hominin cave site, and the landscape archaeology of the Makapansgat region as examples, methods of integrating data from UAV drone imaging, structured light, photogrammetry, and laser scanning (including LIDAR) will be discussed with reference to these ongoing projects.

Knowledge Hub For Archaeological Heritage Southern Euboia, Greece

Dr. Maurice de Kleijn, Chris Lucas and Prof. Dr. Jan Paul Crielaard
Vrije Universiteit Amsterdam (NL)

In our contribution we present an innovative digital platform that has been developed within the context of a broader scientific project centering on the south part of the island of Euboea (Greece). Combining a 3D map of the region with various remote sensing data and information about archaeological find places known from surveys and excavations, it offers an interactive tool for sharing knowledge with other scholars and monitoring cultural heritage.

This project, which is funded by NWO and is titled 'The Sea and Land Routes of southern Euboia' (SESLR), aims to provide a detailed study of regional developments in interconnectivity between ca. 4000 and 1 BC and in this manner make a critical contribution to the present discussion about Mediterranean interconnectivity. An important basis for this research has been the creation of a data base of all known settlements, important roads and routes, and maritime infrastructural elements, supplemented with new data provided by fresh field surveys and remote sensing research. From the beginning the intention was to make the project's data base accessible to a larger group of potential users, including planners, heritage policymakers and archaeologists working for the state archaeological service. This Knowledge Hub is the result of this effort.

In addition to presenting our Knowledge Hub, we wish to reflect on the potential value of spatial data in heritage management and the need for a sustainable future of digital spatial information and technologies. We will do so by discussing the steps we took and decisions we made for the development of the Knowledge Hub. We see our project as an example for future knowledge hubs but also clearly identify its threads.

Bonify 1.0: Evaluating Virtual Reference Collections In Zooarchaeological Teaching And Research

Dr. Canan Çakırlar, Dr. Gary Nobles, Nynke de Boer
Dept. of Archaeology, Rijksuniversiteit Groningen (NL)

Accessibility to zooarchaeological reference materials is a key hurdle when determining species classification, particularly in cases where the differences between two species (e.g. sheep and goat) are nuanced. Bonify is a pilot platform allowing the virtual comparison between 3D virtual animal bone models and zooarchaeological specimens. Two technologies were case studied, online web presentation and augmented reality. The two methodologies were tested by a selection of students and domain professionals. While the physical reference collection was viewed as the most usable, it was limited in terms of accessibility; the second best option turned out to be the web based interface while the augmented reality option suffered in terms of its usability.

The web interface is available at www.digitalbones.eu.

Ensuring research data quality over time and over borders

Valentijn Gilissen
Data Archiving and Networked Services, Den Haag (NL)

15 years ago, DANS (Data Archiving and Networked Services) was established as the Netherlands Institute for permanent access to digital research resources. DANS encourages researchers to make their digital research data and related outputs Findable, Accessible, Interoperable and Reusable (FAIR). The DANS long-term data archive EASY presently holds almost 120.000 datasets. Due to the formal obligation for archaeologists since 2007 to deposit their data at the E-Depot for Dutch Archaeology incorporated in EASY, over 66.000 of the datasets in EASY are archaeological datasets.

EASY allows digital research data of Dutch archaeologists to remain accessible and usable in the long term. The e-depot is meant for all digital archaeological data, from specialist research to dissertation and from coring research to definitive excavation data. DANS contributes to international best practices and sustainably archives the data as a certified Trusted Digital Repository. Furthermore, by participating in European portals such as Europeana and ARIADNE, DANS ensures better visibility of the archaeological data in EASY.

The presentation will detail the services of DANS, the role of DANS in the Dutch archaeological infrastructure and the factors that contribute to the FAIR quality of datasets.

Posters

Computational Methods For Calculating The Capacity Of Ceramics

Vasiliki Lagari
Faculty of Archaeology, Leiden University NL)

In my research, I try to apply 3D technologies on archaeological material, more specifically ceramics, with the intention of contributing to both fields. Having the iconic Bevelled Rim Bowls (BRB) and the so-called "Flower Pots" from Jebel Aruda as a study case (Mesopotamia, Uruk period, 4th millennium B.C.E.), I have compared different computational methods (3D models realized from both drawings and photogrammetry) in order to develop a workflow that can provide the most accurate way to measure their capacity. These two groups of ceramic vessels are widely spread throughout the Greater Mesopotamia, and measuring their internal volume will help to understand their importance and their dynamic during a period of great change in the Near East (4000-3100 B.C.E.). The inaccuracies in sizes in both groups (the bevelled rim-bowls were handmade while the "flower pots" were made on a slow wheel), hence the lack of uniformity in capacity, is an important factor that has been addressed since the 1970s. Their enigmatic nature has been the bone of contention among researchers, and the most prominent theories that have been proposed about their use, are bread-baking bowls, votive/presentation bowls, or ration bowls.

Most of the methods available to estimate vessels capacity are extrapolated from their profile, which relies on - and in a way requires - their axial symmetry. Software such as Kotyle and Amphoralex simply need pictures of the drawing and the right scale in order to calculate the volume. On the other hand, the user's participation is higher in software like Blender, where the drawing has to be converted to a vectorized entity. However, the material of the research in question is peculiar in nature, without standard dimensions and symmetrical sides. How useful can be the aforementioned techniques? And are the actual 3D models created with photogrammetry an alternative way, more trustworthy, in cases like this?

Using procedural systems to manage and maintain- or generate vast amounts of semantic data

Rob van Haarlem, Lars van Dorenvanck
Tijdlab, Deventer (NL)

Nothing is particularly hard if you divide it into small jobs – Henry Ford
Technological developments in archeology, and in particular in the field of 3D, offer

researchers new opportunities for answering research questions. However, the data is large and as quickly unmanageable for a suitable public outreach. Moreover, with different methods, just like with an excavation, it is very difficult to repeat the research. Luckily Procedural systems offer promising results in facing this problem on a grand scale.

Procedural systems developed at Tijdlab that operate in a node-graph fashion work, from a shallow point of view, in 3 stages. Input-magic-output.

The input can either be generated from mathematical (noise)functions or sets of data like a map, or even a blend of both.

The magic is a formal system that operates on the given input in a predictable and reliable method. For this formal system Houdini FX is used. Houdini offers an inherently parametric node based DCC solution. Nodes can perform *atomic* operations(small jobs) like; create a vertex. Or nodes can consist of a composition of atomic elements that can perform complex tasks based on programmed dependencies.

The output is naturally the desired result. Which in our case is making 3D models of settlements or cities based on historic maps and maquettes. These maps and maquettes are troves of data that can now quickly and effortlessly be digitalized while preserving archeological, historical and scientific value. The product is a refined and highly standardized model of data that can be reliably reproduced and is not comparable to commonplace artist impressions that cannot be reliably reproduced.

Notes