A-Frame to Represent Archaeology Heritage in an Open Source Virtual Reality Platform

Alberto Polo Romero

In recent years, virtual reality has evolved exponentially, making it possible to represent more ideas and concepts in different areas of research. In the case of historical and archaeological heritage, technology has made it possible to recreate and represent many of the creations that have occurred throughout the history of humanity. The importance of 3D representation for dissemination has made it possible for us to get to know works at first hand. Thanks to technologies such as photogrammetry and recreation in immersive virtual reality environments, it is also possible to include factors such as interaction and the design of narratives in space.

However, in many cases, proprietary software such as UNREAL Engine or others are used. It is essential to create workflows that enable complete processes with open source software. The use of A-frame, free software, is proposed as a very good alternative for the creation of extended reality materials.

The current project is a recreation 3D in virtual reality that is accessible from a web browser. The documentation is carried out using photogrammetric techniques and open source technologies, such as A-Frame, are used in the process of generating virtual spaces so that the user can get to know the heritage. An environment is designed in which the user can see at first hand, at real size, the space where it is housed, and where sound and interaction are also used to show the digitised heritage. Examples of research materials in the medieval necropolis of San Nicolás (La Sequera de Haza, Burgos, Spain) and of megalithic and rock art sites used to insert the extended reality into the university classroom will be shown.

Against Our Better Nature: Engaging Audiences with the Historic Environment in "Natural" Landscapes Through Social Media Analysis and Citizen Science

Lawrence Shaw

Government, managing bodies and researchers have all identified the importance of engaging young people with the "natural environment", particularly that of National Parks, which are created in areas of particularly significant 'natural' environments. Yet, as Hoskins notes in his seminal 1956 book, The Making of the English Landscape, much of which we consider today to be 'natural' is the product of millennia of human interaction and modification. The engagement of young people with the historic environment upon which the "natural landscape" sits is equally important. Still, the natural environment sees much greater recognition when compared to its historic counterpart. To date, approaches to facilitate improved engagement have relied on insight gained through questionnaire surveys, typically responded to by visitors and older demographics. This paper will present PhD research which assessed the role that the social media platform Instagram can play in improving the understanding of young people's perceptions of the historic environment of one National Park, namely the New Forest. Additionally, the research proceeded to develop bespoke citizen science projects that utilised the interpretation of social media posts, as well as the media platform itself, to deliver citizen science projects that aimed to improved

participation when compared to more traditional approaches. The paper concludes with an assessment of the benefits as well as misconceptions observed through the methodologies delivered within the research and how they might influence local and national approaches to communication, engagement (both passive and active) and understanding.

An Analysis of the Atlas of Hillforts of Britain and Ireland
Mike Middleton

The Atlas of Hillforts of Britain and Ireland (Lock & Ralston, 2017) was a huge undertaking, gathering 244 datapoints against 4147 hillforts. The data is published online and made available via an ArcGIS REST service which can be imported as a layer into a GIS project. Accessing and exporting the data for analysis and restructuring requires a certain level of GIS technical capability which is potentially a barrier to the reuse of this data. This analysis removes this barrier to reuse and provides a detailed preliminary data analysis for both technical and non-technical users. It provides a comprehensive reusable technical analysis in Python that can be repurposed for alternative projects or used by hillforts researchers to measure the impact of new research. Schmidt & Marwick, 2020, argue that there is a measurable increase in citations where archaeological data has been analysed in open-source programming languages, with the data and analysis then made available as open data. Borgman, 2012, suggests reuse of data is an important tool verifying the reproducibility of publicly funded research and enabling new questions to be asked. This analysis uses six online Jupyter notebooks, that together contain 546 figures and output 14, open data, reprocessed data packages. It reviews, cleans, plots, transforms and adds to the Hillforts Atlas data, with the aim of facilitating interpretation and reuse. In addition, the analysis aims to restructure the Atlas of Hillforts data so that it can be easily used in machine learning applications, such as predictive modelling or similar data-driven analysis. For those that are not confident in the use of online coding environments, the notebooks are also made available as static online html webpages and all outputs have been made available in a GitHub repository pending archiving, in a trusted digital repository.

Ancient History of Indigenous South America: Augmented Reality and Digital Archaeology at University Museum of Archaeology and Ethnology at Federal University of Rio Grande do Sul, Brazil
João Vinícius Chiesa Back

The present proposal is based on the extroversion of the archaeological heritage of the University Museum of Archaeology and Ethnology at Federal University of Rio Grande do Sul (MUAE/UFRGS) through the creation and use of 3D digital simulations of archaeological artifacts related to the Ancient History of Indigenous South America (Rio Grande do Sul, Brazil). Rio Grande do Sul, the southernmost state of Brazil, is known for having been one of the main targets of an intensive European immigration project (mainly Germans and Italians) carried out during the Empire of Brazil (1822-1889) and the First Brazilian Republic (1889-1930) between the 19th and 20th centuries. This phenomenon obscured, at least in part, the history of the indigenous peoples settled in the region before, during, and after this period. Considering this, this paper highlights the history of the formation of the museum's

archaeological and ethnographic collection, as well as previous theoretical and practical experiences related to Digital Archaeology. Finally, it showcases potential uses of Mobile Augmented Reality through a Public History product aimed at disseminating part of the museum's archaeological collection (six artifacts attributable to indigenous peoples from different regions of the mentioned context from periods prior to European colonization) to the general public and explores discussions carried out by History, Museology, and Archaeology, delving into cyber-archaeology and digital humanities. The aforementioned digital (re)constructions were created using 3D modeling software, specifically Blender 3.4., and have contributed to increased socialization, dissemination and appreciation of the communicative potential of the collection.

Archaeological archives – the issue of storage, space, and curation
Love Eriksson

An age-old problem caused by the very nature of archaeology is that of archiving and curating finds and documents. In the past this often revolved around practical storage space, bookshelves, and drawers that are now replaced by hard drives, folders, and formats. However, the technological revolution has posed yet another mounting problem related to archives.

Today an institution or department may manage and curate their archives individually or on a locally shared server. This local server provides flexibility and adaptability as long as it is kept concise and organized. Other archives may be regional, national, or international based on the many ongoing digitalization and database projects where e.g. ARIADNE, SEAD, and SwedigARC aim to provide a digitalized archive of museum and laboratory materiel. Whether a digitalization project is local or international it may prove straining due to the increased number and types of documents and photos produced during archaeological digs and surveys than before. As such the selection process and preparation for such data may prove a difficult task for even the best of curators.

Another issue presenting itself is storage space. Should the institution server close or break down it could mean a potential total loss of data. Other times this may be presented as an external cause if the digitalization projects receive less funding or sees its funding cut, hence a lot of data may be lost in this way as well. An example here is the many pollen databases in Europe. In this talk some background and issues will be presented about digital archives in relation to the new ways of documentation and the problems that arrived with digital archives.

Assessment and adaption of urban cultural heritage assets as touristic destination towards the impact of UHI
Nerxhana Tallushi

Preserving cultural heritage sites has always faced many challenges in a rapidly growing and changing world, mainly in urban areas [Dastgerdi et al., 2019]. Overall, the urban environment faces imminent risks due to climate change, which are amplified due to extensive anthropogenic activities, development, and land-use changes [IPCC, 2014a]. In

development strategies, urban planners consider not only the differences in UHI magnitude between urban and rural but also the different levels within the city [Wicki and Parlow, 2017]. Historic towns retain unique urban forms, which are hard to analyse compared to modern and contemporary development and despite that there is a lack of studies in this aspect.

A local climate zone (LCZ) can display the scale of UHI impact in various parts of the city depending on the build-up types, and these LCZ classes depend on morphological parameters [Steward and Oke, 2012]. This scheme works well in cases of homogenous development types in the U.S but is less effective in the case of European cities, whose old core consists of organic development patterns with narrow streets and irregular urban forms. Therefore, in the case of Edinburgh, the morphological parameters were calculated in the high-resolution grid (15m) from different sources. Land use / Land cover was introduced as a parameter needed to classify the LCZ classes. The combination between LULC and morphological parameters was not completed fully as the thresholds of different LCZ classes overlap, so the mean values were used. LULC representing the characteristics of cultural heritage assets of Edinburgh are recommended for future combination.

UHI can affect different sectors in a city due to the direct relation to outdoor thermal comfort. Tourism is a crucial sector for income in Edinburgh, with the world's fourth-highest tourist-to-local ratio in 2019. The thermal comfort at New Town, an important World Heritage tourist destination, is overcoming improvements by the City of Edinburgh, which will affect the tourist's experience. This study measures the implications that new improvements, such as materials with a high albedo, can bring to thermal comfort. In case of a heat wave, the new implementations will lower the air temperature, but apart from new shaded areas, the thermal comfort (PET) can worsen compared to the actual state. The improvement of thermal comfort and adaptation of climate-sensitive solutions in cases of World Heritage properties are burdened by guidelines to preserve the integrity and the authenticity of the cultural asset.

Beyond Traditional Maps: Immersive Visualisation of Maritime Heritage Data using Virtual Reality Geographical Information Systems (VRGIS)
Laura O Connor

"In the era of rapid technological advancements, the fusion of Virtual Reality (VR) and Geographical Information Systems (GIS), termed VRGIS, has emerged as a promising approach for visualising and interacting with geospatial data. This research, undertaken as part of an MSc in Heritage Visualisation, aimed to explore the efficacy of VRGIS in delivering immersive experiences in cultural heritage. Using maritime data, as evident on the Unpath'd Waters, Canmore and Admiralty data portals, a VRGIS prototype was developed via the ArcGIS Maps SDK for Unity. This application visualised fourteen German High Seas Fleet shipwrecks located in Scapa Flow, Orkney, which were deliberately scuttled in June 1919.

The user testing process involved five participants and was designed to gauge the potential of VRGIS in enhancing the understanding of cultural heritage. Results indicated a significant appreciation for the immersive experience, with users noting a richer understanding of the

wrecks, especially when compared to traditional 2D maps. Notably, the integration of multibeam sonar scan data, audio, and satellite imagery augmented this immersive experience. Participants acknowledged the potential of VRGIS as a valuable tool for both educational purposes and conservation management.

However, while VRGIS proves promising for cultural heritage interpretation, challenges such as data accuracy, standardisation, and technical complexities persist. For an optimal and reliable VRGIS, data dissemination and best practice guidelines are essential. As VR technology becomes even more prevalent, further research is needed to explore how cultural heritage can effectively leverage the capabilities of VRGIS.

CHRoMA: Cultural Heritage Review on Map Accessibility. Towards a consistent FAIR map key for data observed from archaeological fieldwork
Peter McKeague, Ceri Binding, Doug Tudhope, Fabio Crameri

Historic Environment Scotland holds a range of survey material from its own field survey and airborne mapping programmes. The private sector, academia and community groups also undertake numerous surveys for a range of purposes but, as archaeology is highly deregulated, there is no consistent approach to collecting and sharing data beyond the project lifespan.

A fundamental element to developing data consistency is using terminologies consistently. Features in the HES data are classified with terms from the Scottish monument thesaurus (published on Heritagedata.org and used widely in Scottish archaeology including Canmore, most Historic Environment Records and in project reporting through OASIS. Terms are grouped into eighteen top-level groups that could inform a map key for displaying data in a GIS or web map. However, the poly-hierarchical nature of the thesaurus introduces inconsistency in how terms map to those groups. The results are cartographically unsatisfactory as the map key is unnecessarily complicated and fails to adequately present the story of the archaeological landscape.

A further challenge when defining the map legend is to address colour vision accessibility particularly as the background Ordnance survey or orthoimagery is already rich in colour. According to Colour Blind Awareness, about 4.5% of the UK population (about 1 in 12 men and 1 in 200 women) have difficulty distinguishing shades of colour – known as Colour Visual Deficiency (CVD). Many others with challenges to vision may find it difficult to clearly interpret map keys and heritage sites marked on maps. The colour rich background layers of orthoimagery or the Ordnance Survey map base which already takes account of CVD users, add further complexity to the challenge.

As part of Historic Environment Scotland's Equalities Action Plan, CHROMA will address these challenges through improving the effective reuse (interoperability) of primary data collected in the field across a range of archaeological techniques. This will be achieved by formally mapping the individual monument terms to a Collection) of eleven categories. The colour palette will be reviewed by a colour science expert and those values stored against the revised groupings.

Coloring sunstone

Christine Ren

The project named 'coloring sunstone', focusing on exploring the impact of virtual restoration with multiple interpretations through projection mapping on visitors' learning processes of Govan Stones that own a number of uncertainties and ambiguities when it comes to heritage interpretation. This is an installation projecting virtual layers on Sunstone that is one of the most representative stone in Govan Collection. This research combined Photogrammetry, historical evidence collecting, virtual restoration including 2d iconographic proposals and 3d modelling creation, video making, and installation setting. There were five interpretations of the hunting scene panel of Sunstone presented in three days in Govan Old Parish Church, allowing visitors to have a vivid view of the possible pastness of Sunstone. From the data analysis outcomes, visitors had an open mind to accept multiple interpretations and were amazed by the colorful virtual restorations. Meanwhile, there was interest from visitors that they were willing to learn Govan Stones through this in-situ innovative, interesting installation. This research emphasizes the property of virtual restoration that it has no physical intervention on objects is different from traditional physical restoration that usually provides one possibility, brings the life to ancient stones with changeable virtual presentations.

Comparing Least-Cost Path and Circuit Theory Analysis for Modelling Maritime Mobility Across the Roman Levantine Basin
Celia Prescott-Decie

GIS cost surface analysis has become the standard method for modelling past mobility. The most popular form of cost surface analysis is least-cost path analysis, which uses cost surfaces to chart single optimal paths between a set source and destination point. The limitations of least-cost path analysis are well-documented, and novel methods for modelling maritime mobility have been proposed to address them. The aim of this research is to apply one such method, circuit theory analysis, to the modelling of ancient seafaring over the Roman Levantine basin. More specifically, the purpose of this dissertation is to first apply circuit theory analysis to an archaeological context it has not been applied to before, and compare the results of this method to those of least-cost path analysis. Cost surfaces are prepared using wind data and representing the cost of sailing from the Roman coastal site of Berytus to destination points in Cyprus, Anatolia, Egypt and the Northern and Southern Levantine coastlines for the months of April, July, October, and January. These cost surfaces are then used to produce least-cost paths and current maps depicting maritime mobility across the Levantine basin. By modelling several potential pathways, current maps represent connectivity as occurring in fluid zones rather than over strictly-defined routes. The 'blurriness' of current maps means they are more capable of addressing common difficulties in modelling maritime mobility. However, least-cost paths and current maps react differently to differing weather conditions throughout the year, with the former showing far more variation in sailing routes. The implications of this research are then that the real strength of these methods is their use in complement. By continuing to apply new methods of modelling human-environment interaction in original contexts, and by setting them against

more popular ones with known limitations, the newer methods are refined; their specific strengths and weaknesses identified so that their methodology can be continually adapted. Comparing methods of analysis forces the archaeologist to examine their biases when confronted with results that do not match, and thus understandings of connectivity in the past are further expanded.

Cracking the code of the cups: geospatial analysis of Scottish cup and ring marks
Emily Pickering, Gabriel Schussler

Today, there is emerging consensus among academics regarding the significance of cup and ring marks in their landscape setting, with theories about why and how they were used still highly contested. Many researchers have noticed an apparent association of cup-and-ring marks to contemporaneous ceremonial and burial monuments, including Richard Bradley. However, this 'association' has never been tested statistically. The proposed research attempts to correct this knowledge gap. Was there a deliberate positioning of megalithic monuments in association with cup-and-ring marks by prehistoric people? Or, is the ritual landscape merely the result of monument aggregation in certain locations over time? Preliminary results will be included.

Digging coins. Nomisma.org, a controlled vocabulary and ontology for numismatic … and archaeological? … linked open data
David Wigg-Wolf

As more or less standardised, mass-produced serial products, coins are ideally suited to digital applications, in particular in the context of databases, linked open data and the semantic web.

Since 2011 the Nomisma.org consortium has developed a controlled vocabulary and ontology for numismatics that is now widely applied in the discipline and beyond. For example, by employing the concepts of Nomisma.org, The American Numismatic Society alone hosts data on more than 500,000 coins from 86 international projects and institutions that are accessible via portals such as Online Coins of the Roman Empire (https://numismatics.org/ocre/) and the Nommisma.org SPARQL endpoint (http://nomisma.org/sparql/). Many other projects such as Coin Hoards of the Roman Empire (https://chre.ashmus.ox.ac.uk/) implement the Nomisma.org vocabulary and so are fully integrated into the wider world of linked open data.

The ARIADNE EU-FP7 project "Report on the ARIADNE Linked Data Cloud" mentioned Nomisma.org as a particular example of good practice from which the archaeological community can benefit.

Whereas work initially focussed primarily on coins from collections and typologies, coins from excavations, as well as finds made by the public, have increasingly become a focus. This not only involves resources such as the Portable Antiquities Scheme of England and Wales aligning their data with Nomisma.org, but also portals such as Numisdata (https://numisdata.org/) that publish excavation coins.

This paper will present the development and architecture of Nomisma.org, as well as the philosophy behind it. Questions addressed will include how Nomisma.org can – and can not – be a paradigm for archaeological data, as well as how it can facilitate better integration of numismatic data (and thus numismatics) into archaeological research and discourse.

https://nomisma.org/

https://nomisma.hypotheses.org/nomisma-org

Digitally crafting tactile learning experiences
Catriona Cooper & Diane Heath

Sensory experience and engagements were an essential part of learning in the late 15th century, with reduced levels of literacy we relied on other senses in addition to the visual to understand and engage with the world around us. In this paper we will discuss how we are taking these medieval engagements with and offer similar learning experiences today. Today we privilege the same visual learning experiences when other sensorial approaches can provide addition levels of engagement, particularly for those with additional needs. We will discuss how a fragment of an alabaster altarpiece (created c. 1450-1500) 3D scanned for the NHLF/Medieval Animals Heritage project was transformed in a tactile memento for handling by SEND children and as a matrix subsequently for handmade keepsakes created by and for SEND children.

Enabling Multiple Viewpoints with Digital Collaborators
Ian Dawson, Louisa Minkin & Paul Reilly

Collaboration is a process in which different perspectives matter. Who, what, why, where, when, and how, are a few registers indicating the diffractive possibilities surrounding the notion of collaboration. These imbricated factors, over which some actants have disproportionate impact, responsibility, and authority, fundamentally affect the direction projects and other matters of importance will take within these extended assemblages. Here, we endeavour to extend the knowledge derived from digitally-based collaborations into a much richer multivocality, surrounding two artefact assemblages, both held in institutional settings with restricted access. One is a carved stone, from both the Bronze Age and the Romano British period, called the Nessglyph, currently lodging in the University of Southampton. The other is a distributed assemblage of Blackfoot belongings held by several UK Museums, including the National Museum of Scotland. We helped make both these collections available to invested collaborators via digitally enabled, remote viewings employing in the first case an open crowdsourced collaboration model, and in the second we consider some of the dynamics of a closed collaborative group. The Blackfoot belongings were (re)considered by a closed group consisting of Blackfoot Elders, museum professionals, artists, archaeologists, and our digital collaborators. Such distributed cognitive assemblages embrace different modes of collaboration, something we want to investigate further. We ask: "who or what counts as a collaborator?" We conclude that both our collaborative projects require an openness that is only afforded through constant work and constant re-working as the digital artefacts and images in these projects constantly fold into their own omissions so that the work can respond to the politics and ethics of image/object making.

Exploring the Necessity and Optimal Design of an Inclusive Digital Platform for Human Remains Data of Archaeological Significance

Charalampos Georgakis, George Pavlidis, Christina Papageorgopoulou

"Over the last decades, investigations into archaeological human remains have surged globally, driven by the proliferation of methods and novel techniques for discerning biological and pathological traits. This influx of information has been pivotal in advancing the scientific domain of Osteoarchaeology.

Despite this progress, the use of a wide and diverse range of recording methods encountered in the existing literature, limits the opportunity to further utilize published data for comparative purposes or potential meta-analyses that can contribute to a deeper understanding of past populations. Various forms and, later, databases have been created for the standardized recording of osteological data, each exhibiting distinct strengths and weaknesses concerning aspects like open access, customization, covering researcher's needs and data storage.

Advocating the transformative influence of Osteoarchaeology and its transition into the digital realm, this study underscores the significance of using a local, European and possibly global standardized resource for recording and sharing macroscopic data, as well as results from biochemical analyses on archaeological human skeletal remains.

To achieve that, the study outlines the scientific and technical requirements for the creation of a web-based input platform tailored for the meticulous recording of morphological features, pathological conditions, and other essential data points, based on bibliographic research and unstructured interviews with fellow osteoarchaeologists in Greece.

Lastly the study also introduces the conceptual working interface that has been specifically designed for deployment within an Osteoarchaeology laboratory and shares insights on the next steps for the development of a platform that could contribute to standardized data collection, subsequent data sharing, and the integration of digital tools."

GIS applications to Roman Limes in Germania Inferior

Raffaele Rizzo, Vincenzo Ria

The roman limes can be considered and studied as the result of fossilization a contact line between two or more conflicting forces (Maggi 2011). In the case of the province of the Germania Inferior (corresponding to today's Netherlands and part of West Germany), the roman limes come to coincide with the course of the river Rhine, a natural barrier. In the specifics of this investigation, it was decided to apply some spatial analysis to demonstrate how the Roman forts responded to specific requirements, like visual control of the surrounding area and capacity and timing of movement.

The use of GIS and spatial analysis can be useful for understanding the Roman fortification system, like communication networks or hierarchical relationships, as well as for hypothesizing the position of unknown forts.

This model can also be useful for reconstructing the ancient landscape of the area and the impact of Roman Empire. This model has been partially analyzed in a recent article (Ria, Rizzo 2023), in the present contribution we intend to extend the results to all the forts located along the limes.

How FAIR is bioarchaeological data: with a particular emphasis on making archaeological science data reusable
Alphaues Lien-Talks

Bioarchaeology, including the study of ancient DNA, osteoarchaeology, paleopathology, palaeoproteomics, stable isotopes and zooarchaeology, is producing ever-increasing amounts of data due to advancements in molecular biology, technology and publishing techniques. These studies are often invaluable in the analysis of the lives of human ancestors.

As archaeology is a destructive process, and the data itself is generated from a finite amount of material, bioarchaeological data is of paramount importance but is currently not always easily Reusable. To ensure the long-term Reusability of this data, a possible route is to ensure that the data is FAIR. The focus of this research was to investigate this need as well as potential strategies to ensure that the data produced and curated by bioarchaeology is Accessible and Reusable to academics, researchers and the general public.

Machine Learning for Shipwreck Detection: A Computer Vision Approach in Maritime Archaeology
Cal T. Pols

The efficacy of machine learning in archaeology has been well established by many terrestrial studies; however, these methods remain under-utilised in maritime archaeological research, especially in relation to underwater site detection. The majority of previous machine learning studies in maritime contexts have primarily used either side-scan sonar data (SSS) or aerial/satellite imagery as the basis for object detection. This research aimed to assess the performance and potential of machine learning methods for the detection of shipwreck sites in open-access bathymetry data from the United Kingdom (UK). Manual identification was completed to act as a baseline detection level and used to evaluate the performance of a pre-trained shipwreck detection model (esri) and two custom detection models. The custom models were trained to detect shipwrecks using high-resolution (1m) bathymetry data and using hillshade visualisation, based on a Single Shot Detector (SSD) model type with a ResNet50 backbone. Both detection models achieved a high average precision score (0.77) from a training dataset of known shipwreck instances, which used data augmentation to effectively increase the number of training samples.

The shipwreck detection models created for this research highlight the feasibility of implementing machine learning workflows into maritime archaeological research. As the challenges of Big Data begin applying to marine survey, manual analysis of these datasets seems to be increasingly untenable. For the soon-to-be reality of global seabed mapping, machine learning methods offer effective, systematic, and efficient ways to analyse vast

datasets for a variety of purposes including archaeological potential. Going forward, these methods can also help develop underwater cultural heritage management strategies and aid field-based investigations through site identification, classification, and initial assessment.

Mapping desertification in Southern Morocco using Google Earth Engine
Louise Rayne

Earth observation is increasingly being used for recording ancient water management systems and monitoring land degradation. This research aims to assess the desertification rate in the southern Morocco, identifying areas of former, traditional cultivation which supported long-term oases since at least the medieval period. Traditional water technology can be resilient and can be linked with scientific methods (IPCC 2022).

In this paper, an open-source cloud procedure was developed to map desertification in the Ourzazate-Drâa area. We used Google Earth Engine (GEE) to apply this to a large data stack of over 200 Sentinel-2 and Sentinel-1 images and their derived products. The technique tasselled cap was applied to the Sentinel-2 data to divide it into brightest, greenest and wettest components. Training data for 5 landcover classes (Desertified, Builtup, Bare, Treecover, Cropland) was produced and a Random Forest algorithm applied to the combined data stack. We compared this data to the location of traditional and ancient water management features digitised using high-resolution imagery. The region was investigated on the ground and the data validated in the field in November 2021 and 2022.

Areas of abandoned traditional fields were correctly identified by the algorithm. They were particularly distinguishable in the tasselled cap image, allowing them to be mapped using unsupervised classification. The Sentinel-1 data allowed areas of sand dunes and natural bare soil to be separated from the desertified fields. A small number of false positives were detected, generally representing areas of disturbed and natural sediment beside streams and roads. When combined with archaeological field data, our algorithm allowed us to detect both areas of fields which were recently desertified, and those which were abandoned prior to the oldest satellite imagery available (1960s-80s).

Modelling a new understanding of prehistoric rock art in Scotland
Tertia Barnett, Joana Valdez-Tullett

Prehistoric rock art is one of the most abundant yet poorly understood monument types in Scotland. Between 2017 and 2022, Scotland's Rock Art Project (ScRAP) created a coherent and detailed database for rock art from across the country through co-production with trained community teams. Our overarching aims were to conduct research that would enhance our understanding of this enigmatic carving tradition, whilst engaging with local communities and raising awareness more widely. We developed a multiscalar methodology which we applied to the large ScRAP database. The methodology comprised detailed assessment of 3D models produced for each carved rock, together with a range of computational, spatial and statistical analyses. This allowed us to investigate the character of the rock art, as well as inter-regional differences and similarities in the nature and contexts of the carvings. The results of our study generated a renewed understanding of prehistoric rock art in Scotland, and enabled us to challenge previous interpretations while exploring

new patterns in the data. This talk will focus on some details of the methodology we used to research this rock art tradition, and will discuss the main findings of the project, specifically regarding cultural transmission and connectivity.

One Big Jigsaw: Challenges in Disseminating 3D Data from the Former Curzon Street Station Yard
Valeria Carrillo

"As the UK's largest linear infrastructure project, High Speed Two's archaeology programme, offers a unique opportunity for preserving and sharing valuable insights into Britain's modern history. This presentation delves into the challenges encountered while disseminating 3D data from the Former Curzon Street Station Yard, a significant historical site that stood as a testament to Britain's industrial past before the construction of the new high-speed railway.

In 2020, excavations at the site of the new Birmingham Station unearthed the world's oldest locomotive roundhouse, designed by renowned railway engineer Robert Stephenson. This historical find prompted the creation of plans, digital photographs, 3D models, processing reports, and site records, all of which were deposited at the Archaeology Data Service (ADS) earlier this year.

Archiving 3D data from this site posed significant challenges due to the complexity of the data itself. Large files, inconsistent naming, information overlap, and extraneous geometry presented obstacles to manipulating data and understanding the roundhouse properly.

This presentation delves into the preservation of 3D models derived from photogrammetry workflows, emphasising the use of preferred formats and safeguarding raw data for future researchers. The discussion will extend to the rationale behind disseminating models enhanced by the ADS, which would facilitate access for the general and specialised public, inspiring engagement and future research.

The talk will also cover the method used for 3D data post-processing, which involved eliminating noise and errors and aligning the deposited models; an essential clean-up effort for making sure all models came together seamlessly, painting a complete picture of the early railway terminus.

The impact of this work will be highlighted showcasing how the correct dissemination of 3D data can open new research avenues and enrich the study of cultural objects and sites through their 3D reconstructions.

In conclusion, the Former Curzon Street Station Yard archive serves as a valuable case study in digital preservation and archiving of 3D data derived from Structure-from-Motion workflows. This presentation provides insights for archaeologists, digital preservation practitioners, and depositors, hinting at the archive's forthcoming release and promising further discoveries in HS2 archives and similar projects in the future.

Online dissemination of 3D bioarchaeological data: an exploration of ethics, user preferences, and contextualisation in an official repository archive setting
Solange Bohling

The Archaeology Data Service (ADS) is a UK-based, CoreTrustSeal accredited digital repository for archaeological and historic environmental data. As digital recording technologies such as photogrammetry become more frequently used in archaeological excavations, the ADS will increasingly receive archives that include large volumes of digital bioarchaeological data (e.g., 3D models of in situ burials). This poster summarises an MSc project which explored how potential ADS users prefer to be presented with this type of data and investigated how these preferences can inform the ADS's protocol for the dissemination of digital bioarchaeological data.

A Qualtrics survey was designed and shared online with relevant audiences (344 participants included). A majority of respondents thought that 1) a content advisory should appear prior to viewing human remains (66.0%), 2) contextual information should accompany 3D models of human remains (94.2%), 3) archive-specific ethics statements should be included (50.9%), and 4) users should be reminded to reuse digital bioarchaeological data with respect before downloading 3D models (65.1%).

The survey results informed the development of a series of suggestions for how the ADS might proceed with regards to providing content advisories, prioritising contextualisation of individuals, addressing ethical considerations specific to an excavation/project, and including a reminder requesting users to consider the human behind the data. Some archive enhancement was performed on an unpublished ADS archive. This focused on improving contextualisation by linking 3D models with excavation photographs and context sheets and served as a case study for how the ADS's workflow can be modified in the future. Since completion of the MSc project, further progress has been made with regards to improving individual contextualisation. Currently, an interactive map interface which provides grave location and individual-specific funerary and archaeological information is being developed. The suggestions formed in this project can help repositories around the world work towards disseminating digital bioarchaeological data in a more ethical and respectful manner.

Post-Human Metalithic Postcards sent during the Pandemic
Ian Dawson & Paul Reilly

We present a series of Art/Archaeology digitalised 'postcards' developed by the authors while working - physically separated - on a transdisciplinary collaboration during the lockdowns of the coronavirus pandemic. These postcards track and trace the initial act of discovery and the subsequent registration, analysis, and (re)presentation of a silica artefact initially made in the mesolithic period, and the contemporary setting and its place of discovery, through silicon-based new channels of re(dis)covery.

Through a series of recursive post-human imaging projects, archaeological and artistic practices are diffracted through one another, and through human and machinic ways of vision. The 'strange loops' of perception we produce through our diffractive approach forces

us to radically reconsider and (re)present the scale, materialities and temporalities of the original artefact and its setting in new thought-provoking physical, digital and indeed both combined (i.e. phygital) Art/Archaeology assemblages that disarticulate, repurpose and disrupt traditionally safe institutional modes of interpretation and narration. We try to free both the human and machinic practioners (Flusser's 'functionaries') from slavishly following anachronistic practices. We describe these digitalised new|old objects as 'metalithic'.

Each postcard is composed of a captioned image, a diffractively contextualising quotation (i.e. a viewpoint offering an interesting different perspective), which is supported by a deeper account of the main diffractive insights obtained at key stages of the project.

Practice based research: The efficacy of an interactive, multimedia approach to communicating archaeology through the use of virtual reality, 360° film, and participant agency
Dushyant Naresh

The potential for innovative storytelling and interpretation within digital archaeology continues to grow as new technologies evolve and become more accessible. The applications of virtual reality, in particular, have been at the forefront of dialogue around archaeological representation. An Avebury Story, a VR "choose your own adventure" experience built specifically as part of this dissertation, is an example of practice-based research, where the creative process serves as a data point for understanding and assessing the affordances of VR/36️° film as a storytelling medium in the heritage sector. Members of the public were invited to test the project and complete a survey. This dissertation first analyses the use of emerging technologies for archaeological interpretation and storytelling, focusing on immersion, agency, representation, and empathy. Then, through practice-based research, results from the creative process behind An Avebury Story are compiled and analysed along with the survey data. Lastly, a cohesive discussion synthesising the literature, methodology, and data analysis is presented. Findings from the project suggest that heritage practitioners have the tools and capabilities to build an immersive story in VR, though technological and financial roadblocks faced during the creative phase may be initially intimidating. While many factors were detrimental to immersion, results from the survey exhibited an overwhelmingly positive response to the project. High levels of immersion and engagement were recorded, and numerous respondents enjoyed the ability to choose their own path. Participants largely noted that they would like to see a similar project at other heritage sites.

Spatial Analysis of the Saxon Shore Forts on the Southern Coast of Britain
Madison Paige Scrabeck

On the southern coast of Britain, several highly fortified coastal forts were constructed in the 3rd century CE. This series of forts, known as the Saxon Shore Forts, were long interpreted as a single unified military system by scholarship; however, due to excavations in the 70s and 90s the primary function of these shoe forts has shifted towards being interpreted as 'logistic' rather than purely military (Cotterill 1993: 238; Milne 1990: 82-84, 2008: 22; Wood 1990: 93-97; Walsh et. al 2022). The major aim of this research was to determine if the

currently accepted theory of the Saxon Shore Forts having a role as a logistic facilitator of commerce was an accurate representation; therefore, computational modelling using Accumulated Cost Surfaces (also known as friction surfaces) and Least-Cost-Pathways were employed to examine rural interior site accessibility potential, overall shore fort distribution and coastline coverage, and affordance of least-effort pathways to urban centers. The definition of 'logistic' for the parameters of this paper was set as 'enabling the process of coordinating and implementing complex movement of resources', as scholarship had not previously defined what 'logistic' meant in terms of their research. The research herein found that the Saxon Shore Forts coastal distribution and accessibility to interior sites afforded an ability to support several types of systems at once: piratical defense, imperial defense, and facilitation of imports and exports into the province. This paper further suggests that the focal purpose of each shore fort may have been different dependent on the location and interior site accessibility rates, rather than all sharing a main function altogether.

Storied Lands: Developing immersive interpretation for landscape-scale storytelling
Nicole Smith, Gareth Beale, Lizzie Robertson

Our paper will outline a current project between the University of Glasgow and National Trust for Scotland to develop a new design methodology for immersive landscape-based interpretation. We will talk about the motivations behind the project and showcase some current prototypes. The presentation will be an opportunity to discuss initial findings with the CAA-UK community around how we can create opportunities for archaeologists to work with communites to inform interpretation design that is inspired by new and emerging digital technologies and informs some of the key challenges for heritage and archaeological landscapes.

Stratigraphic Analysis and The Matrix: connecting and reusing digital records and archives of archaeological investigations
Keith May & James Taylor

Stratigraphic laws and principles underpin the archaeological records from excavated sites and are essential for integrated analysis, wider synthesis and accessible digital archiving of the growing body of archaeological data and reports generated through the commercial archaeological sector in the UK and internationally. On most excavated sites, the stratigraphic record, most often visualized, and to a degree quantifiable, in the form of a stratigraphic matrix, 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 record 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 research questions, or problems encountered, and piece together the underlying details of how the interpretations by the excavator(s) were arrived at.

This paper will present work from The Matrix project [AH/T002093/1] which has addressed some of the current problems caused by the lack of standardized approaches to analysis and digital archives of archaeological stratigraphic and phasing data. It will introduce work being

undertaken on a new online handbook 'The Archaeologists Guide to Good Practice - Handbook' (AG2GP-Handbook) [AH/X006735/1] project. The aim of this new project is to draw together the collective expertise of the main archaeological contractors in the UK and, in consultation with other stakeholders from the sector, undertake the necessary feasibility work and organize the required collaborative activities to develop a consortium approach and online tools and resources to support best working practice for this work.

The paper will discuss challenges in handling the complexities raised by issues with data quality in archaeological records and uncertainty in dating evidence along with practical experiences of re-using stratigraphic data from digital archives deposited with the Archaeology Data service (ADS). The presentation will include demonstration of a prototype matrix and phasing analysis tool that enables cross-comparison of stratigraphic and temporal records using Allen temporal operators (Allen 1983).

The 3D Digitisation of the Honours of Scotland
David Vacas Madrid, Sophia Mirashrafi, Adam Frost, Al Rawlinson, Reed Hudson, Lyn Wilson

The Honours of Scotland - the oldest Crown jewels in Britain and among the oldest in Europe – were required to be removed from their exhibition space in early 2023 to undergo a programme of conservation works and be part of King Charles III's Coronation events. 3D digitisation of these objects was an essential and important element of the conservation process, management of the collections, the movement of the objects and their presentation. Working with colleagues in Collections, the Digital Documentation and Digital Innovation Team at Historic Environment Scotland (HES) were responsible for digitising these items. 3D data capture of complex objects is known to confound optical 3D scanning systems and introduce inaccuracies. The items presented multiple challenges to their documentation: highly reflective surface finishes and refractive materials, movable parts, and their delicate condition, requiring completely non-contact techniques. We used cross-polarised photogrammetry and structured-light scanning, as well as pre- and post-processing techniques, to ensure that we produced digital datasets that closely reflect the object geometry and albedo. In addition to high-resolution data for documentation and reference, multiple other outputs were produced from this 3D model. These were used for different purposes by different colleagues within the organization: to support conservation works, interpretation, public engagement and outreach. Project outputs included orthographic images, reprojected complex geometry, still rendered images, animations and web visualisation versions of the 3D models. In this presentation, we will talk about how we captured and processed these objects and the multidisciplinary uses of the results produced.

The Potential of Collaborative Video Games for Archaeology and Heritage
McKenna Crowe

Archaeologists have recently recognised the value of video games to create engaging and multilinear narratives about heritage. Currently, almost all archaeology and heritage games are designed to be single-player, however archaeology is a discipline that relies on the

collaboration of multiple people. This dissertation explores the use of video games that require two players in challenging and facilitating learning about archaeological practices.

A prototype of a collaborative archaeological video game was created in GDevelop. The premise and mechanics were inspired by an ethnographic observation of the University of York Department of Archaeology field school at Skipsea Castle, as well as previous archaeological and collaborative games developed. The game, "A Season at Torrem," allows two players to step into the shoes of archaeologists and excavate a site while making interpretations. A small sample of individuals of various backgrounds were given the opportunity to play the game and complete a supplemental survey. The results indicate that the game had changed some players' perspectives on archaeology, and that players experienced uncertainty, exploration, and disenchantment. Notably, the discourse between teammates during gameplay affected their personal interpretations of the fictional archaeological site. The study raises issues relating to the challenges of creating a game with limited time and resources in addition to the potential for future applications of collaborative archaeological games.

Using CRMarchaeo to combine excavation archives into FAIR resources
Stephen Stead

We have previously discussed the Swedish National Infrastructure for Digital Archaeology project (SweDigArch) and the decision to use CRMarchaeo to underpin the facilitation of the production of aggregated and harmonised datasets.

CRMarchaeo is an extension of CIDOC CRM and is designed to link a wide range of existing documentation from archaeological excavations both within and across sites. The CRMarchaeo extension has been created to promote a shared understanding of how to formalise the knowledge extracted from the observations made by archaeologists. It provides a set of concepts and properties that allow clear explanation (and separation) of the observations and interpretations made, both in the field and in post-excavation.

This paper considers the nitty-gritty of representing the content of an integrated context recording platform as differentiated observation and interpretation instance data. It will illustrate some of the critical decisions in the disambiguation process and thereby shed some light on design decisions in future recording practice.