

BEFRAIL WEBINAR SERIES 2026

Digital frailty: the role of 3D
modelling in bioanthropology,
archaeology and heritage

PROGRAMME
BOOKLET

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Welcome page

The BeFRAIL team welcomes you to the third installment of our webinar series, this year under the title 'Digital frailty: the role of 3D modelling in bioanthropology, archaeology and heritage'.

The FCT funded BeFRAIL project¹ 'Porto in Times of Cholera and War: A Bioarchaeological Approach to Human Frailty' takes a holistic and interdisciplinary approach to human frailty in the past by investigating the archaeologically excavated burial site of the 3rd Order of Our Lady of Carmo in Porto (Portugal), in use between 1801 to 1869. You can find out more about the project at <https://www.befrail.org/>.

Every year since the start of the project our team has hosted a series of online talks aimed at exploring topics relevant to this project. While previous editions in 2024 and 2025 focussed on various topics in bioarchaeology and anthropology, as well as ethical and social aspects of this work, this year's edition is all about 3D modelling with talks spanning a wide range of interesting and timely topics from archaeological documentation, osteological studies, heritage preservation, digital collections and ethical aspects.

The series features four invited speakers who will draw on their depth and breadth of experience in their respective fields to bring their perspectives on the current state, critical challenges and future perspectives of 3D modelling applications in bioanthropology, archaeology and heritage.

To complement this lineup we ran an open call aimed at students and early career researchers, and are most grateful for the number and quality of submissions received, which enables us to welcome talks by seven junior researchers to the webinar series.

We are fortunate that so many of this year's speakers have agreed to the recording of their talks. Therefore, following the online meetings the talks will be available open access to the public on the [BeFRAIL Educast channel](#).

¹ The BeFRAIL project is funded by Fundação para a Ciência e a Tecnologia (FCT) (ref.2022.02398.PTDC/; DOI: <https://doi.org/10.54499/2022.02398.PTDC>) and CRIA's Strategic Development Plan (UID/04038/2020).

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Information on the organisers

Steffi Vassallo is a Biological Anthropology PhD student within the BeFRAIL project at the School of Social Sciences and Humanities (NOVA FCSH), NOVA University Lisbon (Portugal), where she specialises in palaeopathology, 3D modelling and emotions. She holds a BSc (Hons) in Anthropology from Durham University (UK), an MSc in Anatomy & Advanced Forensic Anthropology from the University of Dundee (UK) and a DipFMS from the Worshipful Society of Apothecaries (UK).

Anne Malcherek is an Archaeology PhD student at NOVA FCSH - NOVA University Lisbon and is part of the BeFRAIL team. With the aim of exploring human fragility and resilience in the face of mortality crises, her project develops a comparative analysis between burial sites and mortuary practices in the city of Porto. Anne holds a BSc in Forensic Anthropology from the University of Dundee (UK) and an MA in Archaeology from the University of Warsaw (PL).

Carlos Moreira is a PhD student in the joint doctoral program at the University Institute of Lisbon / NOVA FCSH - NOVA University Lisbon and is part of the BeFRAIL team. With prior training in Anthropology and Mechanical Engineering, he is developing a project with an ethnographic approach to the ethical issues raised by the use of digital models of human remains.

Zélia Rodrigues is a PhD student in Archaeology at NOVA FCSH - NOVA University Lisbon and is part of the BeFRAIL team. Her research focuses on the contextualised study of human remains in secondary depositions. With 20 years of experience as a bioanthropologist in the field of safeguarding archaeology, she holds a degree in Anthropology and a specialisation course in Human Evolution and Bioanthropology, both from the University of Coimbra (PT).

Francisca Alves Cardoso is the PI of the BeFRAIL project. She holds a PhD in Archaeology (2008), specialising in Biological Anthropology, from Durham University (UK). She is a Tenured Research Fellow at NOVA FCSH, the coordinator of the Laboratory of Biological Anthropology and Human Osteology (LABOH) at CRIA - Research Centre in Anthropology in Portugal and a collaborator of the Department of Anthropology at NOVA FCSH. Her research addresses the study of socio-economic, cultural and health inequalities mediated by the study of human remains and mortuary contexts, as well as the ethical issues related to the study/use of human remains in scientific contexts and their impact on society.

Webinar series schedule

Invited speakers

5th May, 13:00 - 14:00 WEST

Pinar Durgun

After-lives: Digital, Physical, and
Ethical Copies of Mortuary Remains

13th May, 13:00 - 14:00 WEST

Paulo Bernardes

From Excavation to Digital
Continuum: 3D Modelling as a
Strategy for Documenting Fragile
Archaeological Contexts

27th May, 13:00 - 14:00 WEST

Rute Rebocho

Exploring 3D Modelling for
Documentation, Preservation, and
Engagement in Cultural Heritage

3rd July, 13:00-14:00 WEST

Maria Giovanna Belcastro

Human Remains in Anthropology:
Legacy, Challenges, and Perspectives

Webinar series schedule

Open call speakers

5th June, 13:00-14:00 WEST

Sofie-Kristin Schendzielorz

When Bones Go Digital – Rethinking Biomechanical Adaptation Studies Through 3D Modelling

Luna Beerden

3D Modelling and Activity Level Analysis: Case Study of Predynastic Egypt and A-Group Nubia

19th June, 11:00-12:00 WEST

Dario Pérez Vidal & Mireia López-Bertran

Technical evaluation of 3D generative AI web platforms applied to the virtualization of Iberian Edetan ceramics

Karen M. Cooke

Quantification of periostitis through confocal laser scanning microscopy and roughness analysis

26th June, 15:00 - 16:00 WEST

Dejing Du et al.

Craniofacial Effects of Prepubertal Castration: A 3D Reconstruction Study of Ming–Qing Eunuchs from Beijing

Webinar series schedule

Open call speakers

8th July, 13:00-14:00 WEST

Varsha Warriar & Tanuj Kanchan

Creating virtual CT repositories for under-represented populations: Enhancing Forensic Age estimation and Human Identification

Teresa Nicolosi et al.

The digitization and ethical management of the Documented Human Osteological Collection of the Certosa Cemetery of Bologna (Virtual DHOC)

Invited speaker

After-lives: Digital, Physical, and Ethical Copies of Mortuary Remains

Pinar Durgun 1

1 The Morgan Library and Museum, New York, United States of America

What becomes of the remains of the dead in an age of infinite reproducibility? Building on my previous work on archaeological replication and the politics of copying, I explore the “after-lives” of mortuary remains as they circulate in various forms including digital scans, photos and photogrammetry, casts, and 3D prints. Copies are not secondary or derivative objects, but active participants in knowledge production, institutional (even national) authority, and ethical negotiation. By situating reproductions of mortuary remains within broader debates about authenticity and ownership, this paper argues that copies can generate new after-lives for the dead, which need to be embedded in infrastructures of science, education, care, sovereignty, and ethics.

Keywords: copies, archaeological reproductions, ethics, politics of copying, mortuary remains

Invited speaker

From Excavation to Digital Continuum: 3D Modelling as a Strategy for Documenting Fragile Archaeological Contexts

Paulo Bernandes 1,2

1 Archaeology Unit, University of Minho, Portugal

2 Lab2PT – Landscapes, Heritage and Territory Laboratory, University of Miho, Minho, Portugal

The increasing adoption of 3D modelling technologies in archaeology has significantly reshaped the documentation, analysis, and interpretation of fragile archaeological contexts. In complex funerary environments, such as multi-layered burial sites, digital recording is not merely a visualization tool but a methodological framework that supports stratigraphic interpretation, spatial analysis and long-term preservation.

This lecture will discuss the role of photogrammetry, LiDAR-based reconstruction, and integrated 3D workflows in the documentation of archaeologically sensitive contexts. Particular attention will be given to the concept of “digital fragility”: while digital models enhance preservation and accessibility, they simultaneously introduce new vulnerabilities related to data standardization, metadata integrity, technological obsolescence and long-term sustainability.

Drawing from interdisciplinary case studies in archaeological documentation and virtual reconstruction, the presentation will explore how 3D modelling can function as a bridge between excavation, analysis and public dissemination. Emphasis will be placed on methodological rigor, reproducibility, and the importance of aligning digital recording strategies with research questions rather than technological novelty.

Finally, future perspectives will be addressed, including the integration of AI-assisted segmentation, semantic enrichment of 3D datasets and interoperable digital heritage ecosystems.

Keywords: 3D modelling, digital preservation, archaeological documentation, photogrammetry, digital fragility, virtual reconstruction

Invited speaker

Exploring 3D Modelling for Documentation, Preservation, and Engagement in Cultural Heritage

Rute Rebocho 1

1 Rectory of NOVA University Lisbon, Lisbon, Portugal

Digital documentation and preservation have become essential in cultural heritage research and safeguarding, and constitutes a way to complement traditional conservation methods. As heritage institutions face increasing challenges related to material fragility, accessibility, and long-term preservation, digital tools offer new possibilities for documentation, analysis, and interpretation.

This presentation examines how 3D modelling contributes to addressing these challenges, extending our capacity to study, conserve, and communicate the past beyond the limits of physical intervention. To illustrate these applications, I will present a series of case studies from my professional experience. These examples highlight how 3D modelling has been used to test reconstruction hypotheses without affecting original objects, create immersive and contextualised virtual environments, and develop digital archives that protect cultural memory while increasing accessibility for remote audiences. The case studies also demonstrate the use of augmented and virtual reality to engage and educate the public, as well as the production of 3D-printed facsimiles that allow tactile interaction with fragile artefacts, providing a practical insight into the diverse potential of digital heritage technologies.

These examples provide insight into how digital modelling complements traditional conservation, fosters interdisciplinary research, and how it can shape future directions in cultural heritage documentation and preservation.

Keywords: digital heritage, 3D modelling, virtual restoration, virtual reconstruction

Invited speaker

Human Remains in Anthropology: Legacy, Challenges, and Perspectives

Maria Giovanna Belcastro 1

1 Department of Biological, Geological and Environmental Sciences, University of Bologna, Bologna, Italy

The term 'human remains' encompasses a wide range of items, including skeletons, mummied persons, digital copies, biological samples and any material containing human 'traces'. They are fundamental to scientific research in evolutionary, bioarchaeological, and forensic contexts, providing essential evidence for understanding past populations, health patterns, mobility, and biological diversity. Many collections originate from archaeological excavations, exhumations, scientific expeditions, exchanges and donations. The methods by which many of them were assembled, particularly those from non-European contexts, are often intertwined with racialised, Eurocentric and colonial scientific frameworks. Furthermore, human remains evoke the long-standing symbolic and intangible meanings since prehistoric times and play a crucial role in the construction of identity and collective memory. This raises complex questions regarding the classification of human remains as cultural property, as well as issues of ownership, restitution and heritage value. The evolving concept of cultural heritage as a participatory, socially embedded process has a further influence on matters. This hybrid and critical scenario has a profound effect on the practice and social responsibility of science. As ethics is an ongoing and dynamic process, the scientific and anthropological community must engage in transparent dialogue and respond responsibly to the cultural and civic contexts in which it operates. The project 'Colonial Legacies of Universities: Materialities and New Collaborations' (HE - Proposal No. 101177706) addresses some of these issues.

Keywords: human remains, collections, anthropology, cultural heritage, colonial legacy, ethics

Open call speaker

When Bones Go Digital – Rethinking Biomechanical Adaptation Studies Through 3D Modelling

Sofie-Kristin Schendzielorz 1,2

1 Austrian Archaeological Institute, Austrian Academy of Sciences, Vienna, Austria

2 Department of Prehistoric and Historical Archaeology, University of Vienna, Vienna, Austria

Traditional macroscopic scoring of enthesal changes has long been central to bioarchaeology, yet it remains constrained by ordinal scores and observer bias. Recent advances in 3D imaging and surface-based morphometrics offer the potential not only to quantify skeletal morphology with unprecedented precision but also to reconsider the relationship between bodies and the material culture they interacted with. This study demonstrates how multidimensional 3D models can capture fine-scale variation in both external and internal skeletal features, enhancing reproducibility, sensitivity, and digital preservation. By reviewing studies integrating biomechanical modelling with contextual archaeological data, we explore how activity patterns and functional adaptation can be interpreted at both individual and population scales. These fine-scale digital observations suggest that the long-standing reliance on certain enthesal sites may be reconsidered, opening opportunities to identify more informative skeletal markers of past activity. By situating 3D modelling at the intersection of objectivity, subjectivity, and digital innovation, this work highlights a transformative approach to studying past human activity and the complex interplay between bodies and objects in the archaeological record.

Keywords: 3D biomechanical modelling, digital bioarchaeology, enthesal changes, body-tool relationship

Open call speaker

3D Modelling and Activity Level Analysis: Case Study of Predynastic Egypt and A-Group Nubia

Luna Berdeen 1

1 Independent researcher

The ongoing digitisation of the modern world reflects itself in several ways in archaeology and bioanthropology, with a plethora of digital applications and approaches entering the research field in recent years. Activity level analysis, traditionally performed by macroscopic assessment of enthesal changes, has noticeably changed through the development of the so-called VERA method (Validated Entheses-based Reconstruction of Activity). In the same line, other 3D-based approaches have entered the picture, particularly 3D modelling for cross-sectional geometric analysis of long bone loading histories (CSG-analysis). Here, a case study approach is taken to present the use of 3D modelling based CSG-analysis, focusing on several archaeological populations of the ancient Nile Valley (4th-3rd millennium BC). Through the use of a handheld 3D scanner (Artec Space Spider), 3D models were produced of humeri, femora, tibiae, and fibulae which were then processed and analysed using a combination of softwares and programming languages (Python, R). Possibilities and limitations are discussed, both related to the specificities of archaeological collections and currently available methodologies, and a cost-benefit analysis is made. By focusing on a sample of 58 individuals from predynastic Egypt (Tarkhan and Naqada) and A-Group Nubia (SJE sites 25, 95, 277, and 401), this presentation thus not only highlights the relevance of 3D-based approaches for activity level reconstruction of fragmented archaeological remains, but equally discusses the complex activity patterns observed in the profoundly changing political and socioeconomic landscape of the Prehistoric Nile Valley, revealing intricate patterns of asymmetry, gendered labour division and habitual loading.

Keywords: activity level analysis, 3D modelling, cross-sectional geometry (CSG), Predynastic Egypt, A-Group Nubia

Open call speakers

Technical evaluation of 3D generative AI web platforms applied to the virtualization of Iberian Edetan ceramics

Dario Pérez Vidal 1, Mireia López-Bertran 1

1 Departament d'Història de l'Art, Universitat de València, València, Spain

This study evaluates the potential of web based generative 3D AI platforms (specifically Meshy.AI) for the digital reconstruction of Iberian Edetani ceramics using archaeological 2D documentation. The research emerges from pedagogical experiments conducted within the ARSMAYA Research Group's Teaching Innovation Project at the Universitat de València, where generative AI tools were integrated into Art History courses. These experiences highlighted both the promise and the methodological challenges of AI driven 3D modelling, motivating a systematic comparison with traditional photogrammetric workflows. The testing protocol was adapted to the constraints of current generative platforms, which process only a single image per reconstruction. Instead of increasing image quantity, the study examines a broad spectrum of ceramic typologies and surface treatments, including technical drawings, inventory photographs, complete vessels, and fragmented or decorated pieces. A control table records geometric coherence, proportional accuracy, and surface realism across cases. Results show that generative AI can rapidly produce coherent 3D geometries and plausible textures from minimal input, offering significant reductions in modelling time and technical complexity. While undecorated or typologically stable objects yield the most consistent results, decorated or morphologically ambiguous pieces reveal limitations, particularly in metric accuracy and the faithful reproduction of geometric or figurative motifs. Generative artifacts and surface hallucinations remain recurrent issues. The study concludes that generative AI technologies (even in their free and openly accessible versions) do not replace photogrammetry, but offer a valuable complementary resource for rapid prototyping, teaching, and the activation of 2D archival materials.

Keywords: 3D generative AI, archaeological reconstruction, Iberian Edetani pottery, digital modeling, 2D documentation, photogrammetry

Open call speaker

Quantification of periostitis through confocal laser scanning microscopy and roughness analysis

Karen M. Cooke 1,2

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2 School of Archaeology and Anthropology, Australian National University, Canberra, Australia

Periostitis is a non-specific skeletal indicator of stress, associated with a range of pathological conditions. However, descriptions of periostitis have been limited to qualitative terminology, restricting comparisons of severity and presentation between populations and studies. This study investigated the use of non-invasive digital microscopic 3D renders of bone surfaces and periostitis using confocal laser scanning microscopy (CLSM) to both identify periostitis and quantify the severity of periosteal inflammation. Skeletal elements from the ANU Human Skeletal Teaching Collection with and without evidence of periostitis were scanned using the Olympus OLS5000 CLSM. Roughness analysis was undertaken on the topographic renders using Olympus Analysis software and included standard roughness measures including height (Sa, Sz), area (Sq, Sdr), and density of features (Sal). Elements with periostitis had higher measures of roughness across multiple variables, including Sq, Sa and Sz, compared to those without inflammation, demonstrating the ability of CLSM to quantitatively measure the surface changes of periostitis. Roughness measures varied between skeletal elements with differing severity of periostitis, proving the ability of CLSM and roughness analysis to quantify a spectrum of periostitis severity. Furthermore, this technique was sensitive enough to discern roughness variability across different long bones without periostitis, and identified instances of increased periosteal roughness missed in macroscopic observations alone. This study has demonstrated the ability of CLSM to quantify the surface changes of periostitis, allowing more detailed and objective documentation of periostitis, and its use will provide more accurate and descriptive comparisons of periostitis between individuals, populations, and pathologies.

Keywords: palaeopathology, periostitis, surface microscopy, roughness

Open call speakers

Craniofacial Effects of Prepubertal Castration: A 3D Reconstruction Study of Ming–Qing Eunuchs from Beijing

Dejing Du 1, Jonathan Bethard 1, Wei Miao 2, Linhu Zhang 3, Myriam Rodriguez 1

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Human craniofacial development is strongly shaped by the interaction of biological growth processes and social practices that alter the body during childhood. Among the most extreme of such practices is castration, which profoundly disrupts endocrine pathways but remains poorly understood in terms of its long-term skeletal consequences. This study investigates the impact of prepubertal castration on male craniofacial development through three-dimensional cranial reconstruction. The sample consists of 30 eunuchs and 30 non-castrated adult males from Ming–Qing dynasty burial contexts in the Beijing region, providing an osteological opportunity to examine how hormonal disruption during growth influenced cranial morphology. Cranial remains were digitized using an Artec Spider structured-light 3D scanner, and high-resolution 3D models were generated to digitally reconstruct overall cranial morphology in a non-destructive and reproducible manner. These models further provide the foundation for landmark-based geometric morphometric analysis, enabling the assessment of craniofacial shape and proportions that are difficult to evaluate using traditional two-dimensional approaches. Comparative analysis focuses on differences in facial bone development between eunuchs subjected to prepubertal castration and contemporaneous non-castrated males, with particular attention to midfacial regions involved in growth regulation and sexually dimorphic traits. By integrating 3D modelling with bioarchaeological and historical context, this project examines how altered hormonal pathways reshaped male facial morphology within a specific cultural setting. It demonstrates the value of 3D reconstruction as an analytical and interpretive tool in biological anthropology and heritage research, revealing the skeletal consequences of socially imposed bodily modification in past populations.

Keywords: geometric morphometrics, eunuchs, 3D cranial reconstruction, prepubertal castration

Open call speakers

Creating virtual CT repositories for under-represented populations: Enhancing Forensic Age estimation and Human Identification

Varsha Warriar¹, Tanuj Kanchan²

¹ University of Derby, Derby, United Kingdom

² Department of Forensic Medicine and Toxicology, All India Institute of Medical Sciences, Jodhpur, India

Human identification and bio-profiling of skeletal remains and living individuals constitute a critical component of medico-legal, bioarchaeological, humanitarian, and repatriation investigations. Despite this importance, age estimation models traditionally used in casework are predominantly derived from global-west reference populations. When these models are applied to under-represented and insufficiently researched groups, such as contemporary Indian populations, the resulting age estimates can be inaccurate and poorly aligned with population-specific biological variation. This research was aimed at developing a small-scale virtual CT database representing a contemporary Indian population, with the objective of validating widely used age estimation methods and introducing population-appropriate modifications to enhance their forensic accuracy. Over a four-year period, clinically acquired CT scans from a tertiary healthcare centre in India were ethically collected following the informed consent approach. Each scan was systematically evaluated for six established age markers and ten commonly applied age estimation methods. The applicability, performance, and limitations of these methods were assessed for the target population. Necessary, methodological and population-specific adjustments were introduced, supported by computational modelling to refine and update traditional approaches. Virtual-specific analytical modifications were also incorporated to accommodate the imaging-based assessment of skeletal structures. The study proposes revised, population-aligned age estimation protocols grounded in both computational and methodological advancements. The findings underscore the value of Virtual Forensic Anthropology in enabling non-invasive analysis, continual testing of models on contemporary datasets, overcoming the logistical challenges of maintaining skeletal collections, and enabling the integration of AI-assisted analysis, offering a pathway toward reduced subjectivity and enhanced reliability in forensic reporting.

Keywords: forensic anthropology, virtual anthropology, human identification, age estimation, computed tomography, pelvis

Open call speakers

The digitization and ethical management of the Documented Human Osteological Collection of the Certosa Cemetery of Bologna (Virtual DHOC)

Teresa Nicolosi 1,2, Rita Sorrentino 2, Maria Giovanna Belcastro 2

1 Department of Cultural Heritage, University of Bologna, Bologna, Italy

2 Department of Biological, Geological and Environmental Sciences, University of Bologna, Bologna, Italy

Skeletal collections are a fundamental source of information for investigating human biological and cultural variability. Among them, Documented Human Osteological Collections (DHOC) are particularly valuable as known biological parameters, such as age-at-death and sex, support robust bioarchaeological and forensic research. At the same time, their study and management raise significant ethical and legal challenges, requiring careful balancing of scientific objectives and ethical responsibilities. In this context, digitization offers new opportunities for preservation and public engagement. Virtual approaches also represent an invaluable research tool for investigating human evolution and conducting morpho-functional studies. We present the Virtual DHOC of the Certosa Cemetery of Bologna (Italy, XIX-XX century), available through the 3D data repository MorphoSource. The physical collection is one of the largest in Italy, comprising 425 well-preserved human skeletons with documented sex and age-at-death. A subset of this skeletal collection has been selected to be digitized through Computed Tomography (CT), micro-Computed Tomography (micro-CT) and structured light scanning. The Virtual DHOC currently comprises 641 media representing 172 individuals. However, this number is expected to increase in parallel with the growing number of research projects based on the collection. We discuss how the collection is developed and managed, proposing best practices for the ethical use of anthropological digital twins. Clear terms of use regulate access to the 3D models and restrict it to educational and research purposes. This project represents a virtuous example of how virtual skeletal collections can promote interdisciplinary and international collaboration, while enhancing long-term preservation and public participation.

Keywords: identified human skeletal collections, 3D replicas, virtual anthropology, ethics

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A Bioarchaeological Approach to Human Frailty



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