

Digital Public Mortuary Archaeology via 3D Modelling: The Pago del Jarafí Cemetery (Granada, Spain)

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Abstract

One of the main goals of the MEMOLA research project's open-area excavation at Pago del Jarafí (Lanteira, Granada, Spain) was to promote knowledge socialization by means of imparting information and public participation. The site, a multi-phased rural settlement with cemeteries of different chronologies and cultural affinities, was subject to a complete 3D photogrammetric survey, a tool which served to develop virtual models both to interpret the excavation and subsequently transmit the results to the public. This method raised levels of public engagement via social networks and websites. Burials, in particular, are features that attracted the local population to the site and aroused both a demand for information and site preservation. 3D modelling of the burials were thus a digital resource bearing a high scientific and social potential when integrated in a strategy reaching beyond the technical aspects. This article therefore, considers the 3D modelling of burials as an innovative form of digital public mortuary archaeology.

Keywords

3D modelling, virtual archaeology, funerary context, general public, Pago del Jarafí, MEMOLA project

Introduction

Archaeological projects that implement digital technologies and methodologies enhance the transparency and communication of information to both scholars and the general public. Accurately recording the totality of the elements of a site, including monuments and mortuary features, skeletons, disarticulated bones, or others type of objects and processes related to cemeteries and rituals, provides a new interpretive means with multiple possibilities to bolster archaeological research and public engagement.

From a scientific perspective, a complete three-dimensional (3D) survey of the stratigraphic sequences of an excavation allows recording the site's phases of construction and subsequent abandonment, possible reuses, and other functional modifications. In the case of mortuary environments, this method enriches the understanding and interpretation of how the features were built, used and reused. In the case of cemeteries, 3D digital records assist interpreting differences in burial orientation, rituals aimed at preventing post-mortem disturbances, or post-depositional processes.

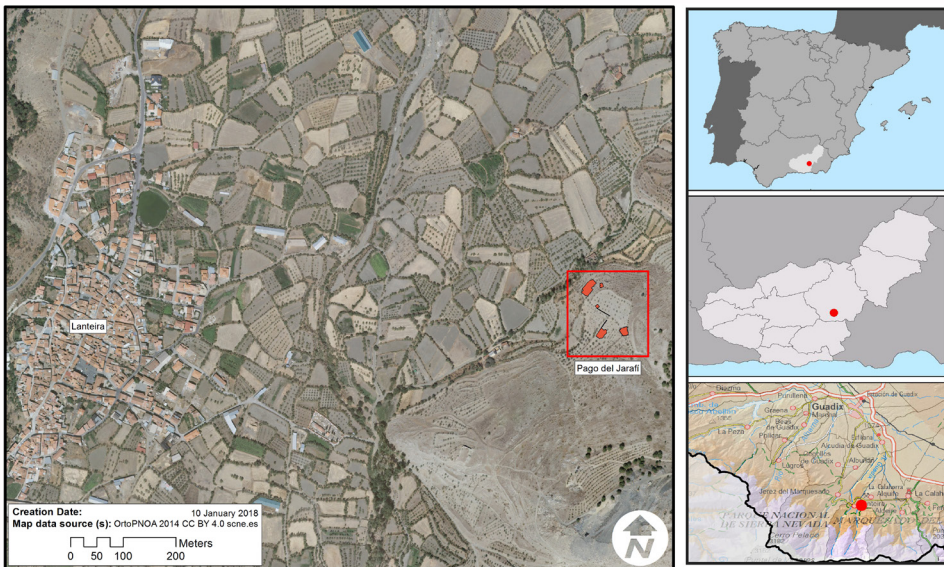


Figure 1: Location of the Pago del Jarafí archaeological site in south-eastern Spain.

The current study concerns the archaeological excavation of Pago del Jarafí (Lanteira, Granada, Spain) (Figure 1), a site benefitting from 3D modelling that was found to be very useful in interpreting the multiple settlement and funerary phases. The excavation was carried out in the framework of the multidisciplinary FP7 MEMOLA Project which focuses on mountainous cultural landscapes throughout the Mediterranean and the historical study of two resources essential to the development of agrosystems: water and soil.

Four archaeological excavation campaigns (2014–2017) were carried out in the framework of the project. The site of Pago del Jarafí, located between the northern slopes of Granada Province's Sierra Nevada and the High Plateau, comprised an Islamic village (eighth to thirteenth centuries AD) superseding a seventh-century AD settlement linked to the end of the Visigothic period. Despite carrying out geophysical surveys preceding the excavation, there was no prior indication of the presence of two cemeteries adjacent to the settlement. Although the fieldwork's main focus was to identify productive features and processes, and the relationship between the settlement and the nearby irrigated fields, the cemeteries have become a significant aspect of the excavation and have attracted considerable interest from the local population.

Although the excavation comprised a total of seven sectors, this paper focuses exclusively on two: Sectors 30.000 and 70.000. The first (S 30.000), the largest covering a surface of 442.64 m², brought to light the most complete archaeological sequence with the greatest number of structures. Its stratigraphic sequence ranges from a depth of 9 cm to the east to 100 cm to the west, with two well-differentiated phases of human activity. The first stretches from the second half of the eighth century AD to the outset of the eleventh century AD when the area served for production (in spite of the absence of domestic features), as evidenced by underground silos and a pottery workshop cut into the bedrock.

The second phase of occupation dates to the middle of the thirteenth century AD. After this second phase, the quarter was abandoned and subsequently transformed into an agricultural terrace. The structures linked to production, and the houses, silos, hearths and the small mosque, were all abandoned during the first phase. A mausoleum was then raised adjacent to the mosque that

probably gave rise to a *maqbara* (cemetery) in the eleventh century (Martín Civantos et al. in press).

The levels explored in the second sector (S 70.000), covering a surface of 191.31 m², are associated chronologically with the first two phases spanning the Visigothic (Late Antique) and Emirate (Islamic) periods (seventh–ninth centuries AD). The first is characterized by several rock-cut burials. The second, most likely from the Emirate (Islamic) period, is probably linked to iron smelting due to the presence of slag. The two groups of inhumations are grouped according to their orientation: five aligned W–E (head to the west) and five aligned S–N (head to the south). The burials in both cases were in supine position suggesting they were Christians (Jiménez Puertas et al. 2011; Román Punzón 2004: 137–40). However, it cannot be ruled out that those aligned S–N were early converts to Islam, as this orientation is characteristic of Islamic funerary rites (Martín Civantos et al. in press). The initial phases of the Islamic domination in the region must have yielded a variety of new burial rituals in terms of orientation, grave structures and corpse position.

The intention from the project's inception was to open the excavation to the public as it sparked plenty of interest in the region, especially after the discovery of the first cemetery. This resulted in a large influx of daily visitors, many curious to follow the progression of the archaeological work. The project's openness prompted reticence among some of the archaeologists who feared trespassing and pillaging outside of working hours. However, the open and welcoming approach, enhanced by guided visits during working hours and at weekends, generated a great awareness among the local population who assumed the role of caretakers when there were no archaeologists or volunteers diggers. This change of perception of a large part of the locals resulted in that many adding the site in their daily walks. In sum, throughout the four campaigns, the site received as many as 800 visitors as part of the official guided tours alone. Many travelled from different parts of the region and elsewhere in the Province of Granada (Figure 2).

Furthermore, the results of the 2014 excavation campaign were presented on 15 March 2015 to the local community. Besides information regarding the preliminary archaeological

and anthropological results, the audience viewed a documentary (MEMOLA 2014) that included 3D models of the site and the excavation process of a funerary structure. The positive comments elicited by the audio-visual material were numerous and encouraged the archaeologists to continue sharing 3D models of the excavation.

As a result, in 2016 we launched a campaign entitled *Archaeologist for a Day*. Although the initiative was initially open to everyone, access subsequently had to be limited to a local women's association. This decision was based on their willingness to book all the available days of the programme of activities and their great interest in participating in all the sessions. During these sessions, they worked with archaeological finds, and learned about medieval and Late Antiquity pottery.



Figure 2: Photograph taken during a guided tour of the Pago del Jarafí archaeological excavation.

The media, radio and newspaper also disseminated the results of the archaeological work throughout the region (MEMOLA 2018a). The combination of these activities led to widespread familiarity with the project among the local populace and an awareness that the site formed part of their social heritage. The site became an even more popular visitor attraction and many demanded it be preserved and converted into a museum (Delgado Anés 2017: 366–67). Moreover, due to this method of open communications applied by the archaeologists (Delgado Anés 2017), the locals became conscious that the individuals buried at the site were their ancestors: the founders of their village and the masterminds behind the current irrigation infrastructures.

This surge of interest and public demand for conservation and musealization is a striking phenomenon, and one of the most important outcomes of the excavation. Due to the clamour, and so as to attain an even wider audience (rendering the site more accessible to a public that cannot visit it), a number of 3D models were developed depicting some of the funerary contexts and excavation sectors. These were published in the MEMOLA project website (MEMOLA 2018b) and shared by social media (Sketchfab, Facebook and Twitter).

3D modelling therefore has become a very important tool serving to disseminate information collected on archaeological excavations. It requires, nonetheless, to be integrated in the strategic planning from the inception of the project. This strategy at Pago del Jarafí was only possible because 3D photogrammetry techniques with topographic support were applied throughout the entire excavation process (Romero Pellitero and Martín Civantos 2017). The strategy is also based on the use of virtual archaeology, which yields very precise graphic information. Another dimension of this strategy was to carry out a complete digital management of the archaeological data and develop participative approaches to dissemination beyond the excavation itself. This allowed the depiction of the stratigraphical levels and other features that were destroyed during the excavation process. As mentioned, virtual archaeology offers the opportunity to attain new audiences that cannot, or will not, be able to physically visit the site. In addition, it offers the option to apply new resources and interactive tools.

Virtual archaeology and funerary contexts

Virtual archaeology was originally the outcome of a reflective process on the suitability of 3D representations of reality, the problems faced when translating it into bi-dimensional media and on the complexity of interpretation for non-specialists (Reilly 1991). The Principles of Seville, drafted in 2011, defined virtual archaeology as 'the scientific discipline that seeks to research and develop ways of using computer-based visualization for the comprehensive management of archaeological heritage' (Principles of Seville 2011: 3). Currently, virtual archaeology is a scientific approach that generates resources and offers a higher level of engagement with heritage and instruction via virtual tools (Delgado Anés and Romero Pellitero 2017).

This discipline includes the acquisition of 3D models through photogrammetry, a technique that records the features of the cemetery. The major advantage of this technique is that it is founded on technological advances such as *Structure from Motion* (SfM). This technique, based on photography, obtains complex 3D models in a simpler, more accurate and efficient manner, avoiding the metric errors of traditional drawing (Doneus et al. 2011; De Reu et al. 2013). It is, furthermore, one of the cornerstones of the fieldwork carried out in the MEMOLA project (Romero Pellitero and Martín Civantos 2017) (Figure 3).

This technique captures a high degree of morphological details of mortuary features. These include, besides the human remains, artefacts, ecofacts and structures, and a wide range of artistic and architectural (at times monumental) memorials to the dead (Meyers and Williams 2014: 152), as well as their spatial relationships. It has the potential to create 3D models that can be displayed to the general public via the internet so as to offer additional information about the tombs and burial practices. 3D documentation thus preserves information that might be lost, or otherwise consigned only to an archive and never disseminated to a larger public. This conforms to the philosophy of the excavation and, in particular, supported the recording of its burial features since '... the essentially destructive and unrepeatable nature of excavation ... makes [it] imperative to employ recording systems that are as sophisticated and accurate as possible...' (Campana 2014: 7). The technique of

3D photogrammetry is therefore currently very effective, affordable and, at the same time, accessible to the non-specialist.

However, the use of new technological tools does not necessarily imply a greater understanding of the archaeological context. In addition, the determinants of archaeology require a balance between research needs and the pace of work, limiting information collection and dissemination options, factors that likewise have to be limited to the public due to restricted access to work spaces for reasons of safety and security (Ramírez Burgos and Martín Civantos 2016).

Archaeological excavations, by definition, result in the destruction of part of the historical record. However, excavation is not the only threat, as there are also external issues that endanger heritage such as pillaging, urban development, and construction devoid of adequate archaeological oversight. Funerary contexts are especially delicate spaces due to their organic component. Their study is highly conditioned by the degree of preservation of the burials, modifications during corpse treatment, and features of the tomb itself (existence of a backfill or not, compacting, the presence of vegetable matter, etc.), the environment, and disturbances provoked by biotic elements (Ortíz 2010: 13). An accurate recording of all the stratigraphic sequences allows each burial to reveal its details (e.g. MEMOLA 2018c) (Figure 4). Many aspects can be gleaned throughout the course of the excavation and during the subsequent analyses carried out in the laboratory that offer data to reflect on aspects of the burial and on the best way of managing the information that will form the core of explaining the fabric of past societies (Ortíz 2010: 10).

Obtaining 3D models through photogrammetry does not only represent an advance in accuracy, but it also introduces greater possibilities for experimenting with the data. Furthermore, it affords the possibility of verifying interpretative hypotheses empirically and repeatedly. 3D models also offer a means of depicting archaeological features that otherwise would be far too complex to represent. 3D digitalization of skeletal remains, for example, allows the creation of replicas, and offers resources of great educational value to museums, research projects, universities and other venues (Neumüller et al. 2014; Wilson et al. 2017).

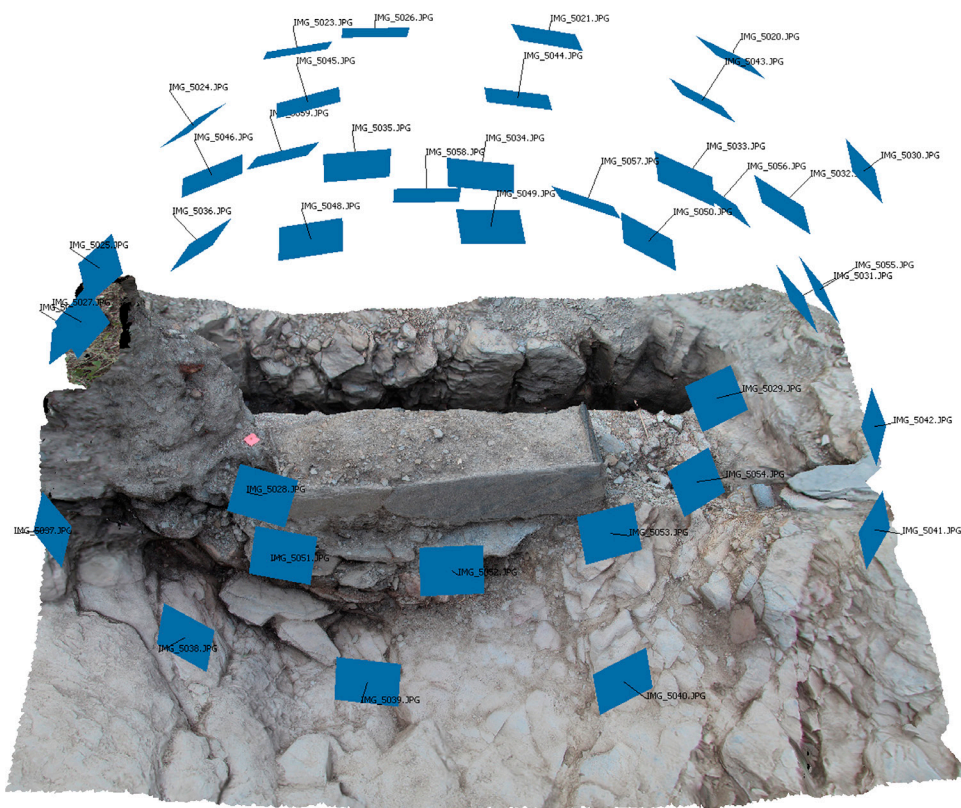


Figure 3: SfM methodology. Camera positions are in blue.

Thus, 3D environments stand out due to the simplicity of data capture and editing as well as their great potential for dissemination and communication. They allow depicting geographic, volumetric and morphologic information beyond the possibilities of bi-dimensional representations. Therefore, they can multiply the opportunities to share resources, information and comments among scholars, stakeholders and the general public. Moreover, the Internet in broad terms, and social media specifically, offer tools that link archaeologists with a much larger and more diverse public. These media, in fact, allow immediate showcasing of the archaeological advances and interpretations, and yield a more transparent workflow, which can benefit progress and knowledge socialization.

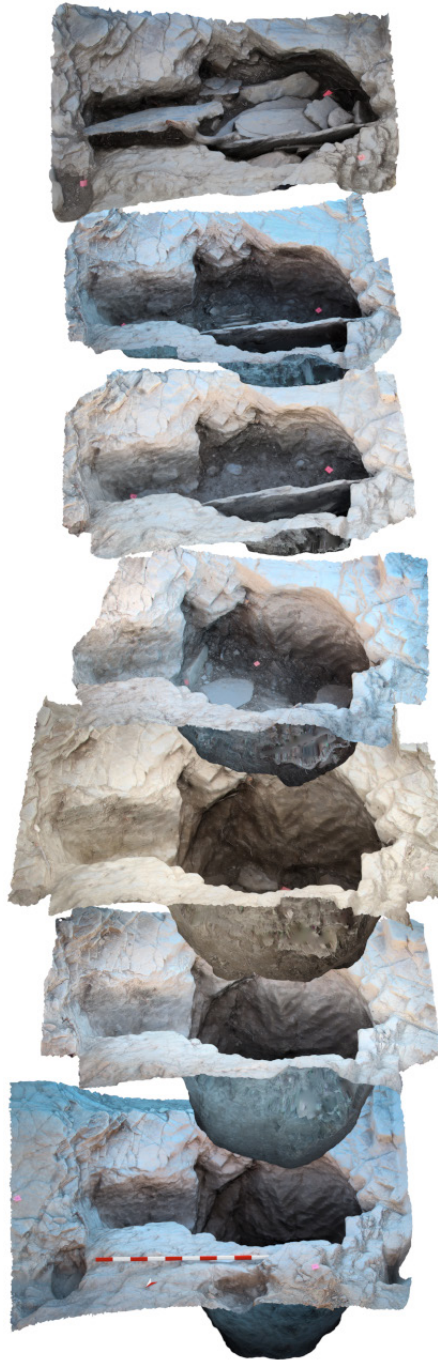


Figure 4: Stratigraphic sequence of a burial that cuts through an abandoned underground silo.

This is the viewpoint of a number of research institutions and groups implementing this discipline in their programmes, and the perspective espoused by the MEMOLA project.

Today, the main social media network for 3D models is Sketchfab. Institutions such as the British Museum (2018a) and the National Archaeological Museum of Spain (2018) maintain a profile on this social network, as does the MEMOLA project. This platform allows these institutions to share many funerary 3D models with the public. It is noteworthy that this practice of sharing does not hinder museum attendance. On the contrary, it allows showcasing parts of their collections and creates expectations among potential audiences, improving communication beyond the museum itself.

The Pago del Jarafí archaeological record

The development of new software, algorithms and 3D modelling techniques such as the SfM simplify the task of archaeologists to obtain higher quality and more accurate digital images, attaining resolutions of more than 1 mm/pixel (Romero Pellitero and Martín Civantos 2017: 2.1) (Figure 5). This process comprises two main work stages. The first is the fieldwork to obtain the primary digital data. This phase requires a photography capture protocol deliberately designed toward 3D modelling. This stage of recording consists of an exhaustive photographic coverage of each layer (stratigraphic unit): the basic unit of archaeological documentation. Moreover, this system conforms perfectly to the guidelines of an archaeological site applying a stratigraphic excavation methodology.

This was carried out with a Canon EOS 600D camera mounted with a Sigma DC 17-50 2.8 EX HSM lens. It is essential to that the photographs be accompanied by topographic georeferencing measurements of the position of the ground control points (GCP) that serve to precisely place the successions of 3D models in space. The tool to measure the fixed points was a Leica Flexline TS02 (Romero Pellitero and Martín Civantos 2017: 2.2–2.4)

The second stage consisted of processing the photographic data with SfM software to obtain results susceptible to analyses, interpretation and dissemination. This was carried out with Agisoft

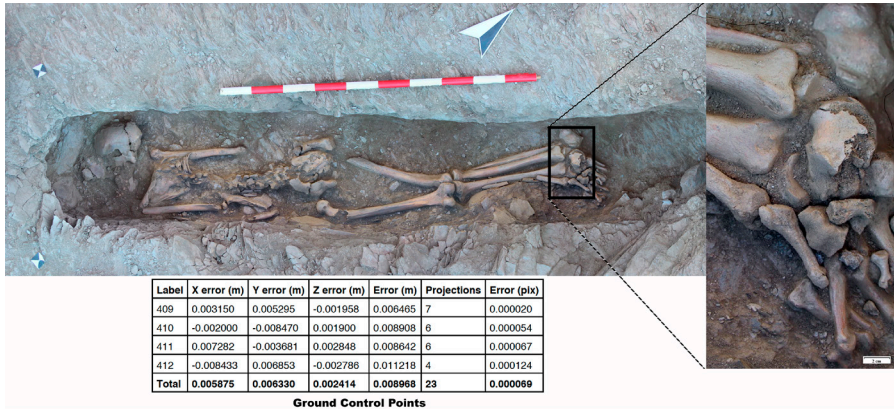


Figure 5: Burial (S 073) of Sector 30.000 together with close-up image of the feet, thus illustrating the high-resolution photography deployed during the project.

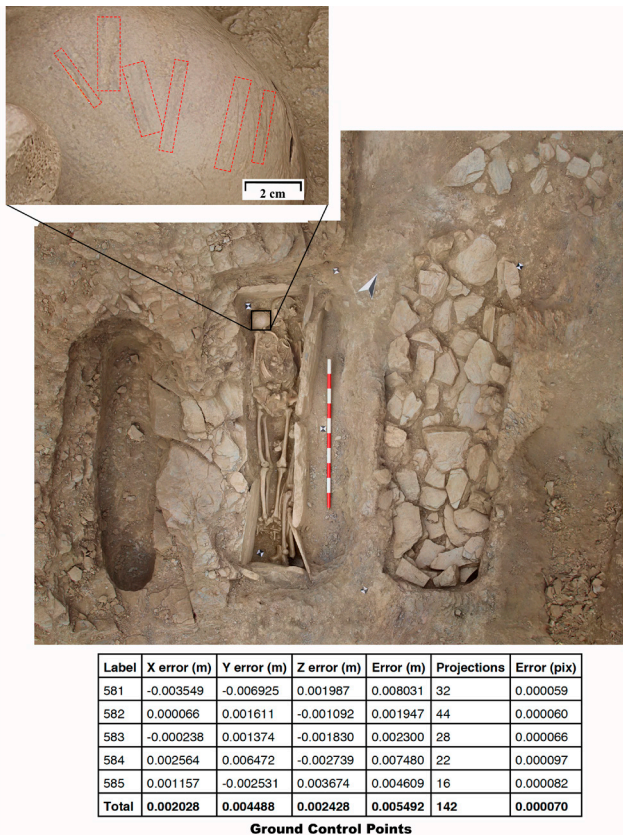


Figure 6: Burials of Sector 70.000 with close-up image of striations on the skull of a second skeleton disturbed by the interment of a second body.

Photostan combined with Blender, a free and open source 3D creation suite serving to edit 3D models and create elaborate infographics.

There are limitations, nonetheless, to the application of 3D models in research. In many cases, the resolution and detail of the data prevented carrying out palaeodemographic studies to determine the age of death, sex and other the information. These types of studies must be conducted in the laboratory with sterile material. It is also worth mentioning that this data is more readily observable when recording skeletal remains individually and not in groups (Figure 6).

As mentioned above, 3D recording and social networks such as Sketchfab (MEMOLA 2018d) offer the option of presenting excavation processes to the general public. This technology also provides access to a whole new means of sharing information that, until now, was restricted to specialists. Hence the MEMOLA project website (MEMOLA 2018b) and seven other social networks feature 3D images of Pago del Jarafí.

The online presentation of 3D models therefore stems from the methodology adopted for the excavation, and responds to the demand of visitors who expressed an interest and desire that the site be converted into a museum, an option that is financially prohibitive.

The intention was also not to develop unidirectional communication but to offer the possibility of receiving feedback, collate information from colleagues and clarify any doubts or queries. A case in point is the publication of a structure (S 045) that did not contain a complete skeleton, but only the skull and jaw of an adult woman (MEMOLA 2018e). The skull was clearly an intentional deposition as it was placed in the middle of the grave and featured three flat stone blocks set at its back to prop it up. In addition, the orientation of the grave, facing south, differed from most of the others. This feature, although a single event, is significant as it differs from the Muslim rite penned in the Quran that requires all members of the community to be buried whole (<https://skfb.ly/67psx>) (Figure 7).



Figure 7: Medieval burial S 045 is an rendered image that shows the possibilities of analyzing 3D models from any perspective.

In the MEMOLA Sketchfab profile, the 3D model with the greatest number of visits is the stratigraphic sequence of a burial that cuts through an older abandoned silo (Figure 4). It received 509 views and 23 likes from 26 April to 3 September 2017. An identical model on Facebook (the project's main social profile) reached 1744 individuals and has currently received 83 reactions, comments and shares (also shared by the town of Lanteira and other local institutions). Although these social networks do not allow identification of the profile of the public interested in each post, they undoubtedly help to determine the interest of the public in ancient funerary contexts. Hence this type of 3D model has attained a higher number of reactions than other archaeological models depicting pottery or storage structures. For example, the final archaeological plan of excavation of sector 30.000 received 410 views and 16 likes. This 3D archaeological plan recorded three different elements in a sequence ranging from the seventh to the twelfth century AD: four silos (three still sealed), part of a large house with three construction phases and an Islamic cemetery with twenty-two burials.

The MEMOLA project, whose main objective is the study of Mediterranean mountainous cultural landscapes, has indeed attracted a larger participation at the sites where local communities

and the general public demonstrated interest in the activities. Hence, in the case of Pago del Jarafí, social media has offered those interested in the digital projects the option of participating in the fieldwork (Delgado Anés 2017: 369). The excavation findings also indicate that the local communities are more interested in the cemetery than other aspects of the site. This factor could be explained by the ease of the general public to identify with humans. In fact, the working methods applied at the site have resulted, as noted previously, in local communities recognizing the past populations as their ancestors and the founders of their town.

Other projects related to burial 3D modelling

There are a number of archaeological projects that apply technological advances that open doors to new approaches to the study of burials and their rites. These include 3D modelling, a procedure that can be made accessible to the general public.

Projects serving as references for the notions advanced in this paper are, for example, '3D Epigraphy' (3D 2018) of the National Archaeological Museum and the National Museum of Roman Art that includes digitalized Roman funerary inscriptions. Other examples of 3D photographic recordings of funerary inscriptions are the British Museum's marble funerary cinerary chest of Marcus Pilius Eucarpus for his wife Pilia Philtata (British Museum 2018) and the burial of King Richard III (Archaeological Services (ULAS) 2018). A Canary Islands Museum project, *Mummies. 3D Biographies*, has been online since May, 2017. It displays a 3D modelling of three mummies (El museo canario 2018) combined with data from an earlier bio-anthropological study with the aim of showcasing the most relevant information of the life and death of the Canarian indigenous population. However, there are still no projects that systematically present all the data of their investigations. Most simply offer one or several funerary aspects such as the stratigraphical sequence, a single burial or the epigraphy.

It is noteworthy that museums appear to be reluctant to showcasing the deceased online. Many of these platforms, in fact, do not offer images of the dead. The number of official

entities that do publish these types of images is less than that of individual researchers. Williams and Atkins (2015) state that this could depend on unease related to de-contextualizing the human remains. Ulguim (2016), by contrast, affirms that certain organizations prefer to run their own platforms, as is the case of Digitised Diseases (2018) and the Smithsonian's 3DX (2018) rather than upload data to third party sites. As noted above, the current study has not identified any researcher profiles willing to publish models relevant to bioarchaeology and funerary archaeology. An example is Ulguim (2016) who showcases skeletal elements, their corresponding medical and archaeological reference materials, and models of remains recorded *in situ* in excavations or funerary spaces devoid of context.

Furthermore, not every published model is accompanied by information of the burial context such as measuring scales, descriptions, and supplementary photographic and/or audio material. A great number, in fact, provide no information thus limiting their communication and didactic potential, as well as their critical analysis. These circumstances require posing the following questions: what is the objective? What is the target audience? Is it ethical to showcase a burial? No specific guidelines, in fact, are available in any country as to displaying burial contexts and a common methodology and standards are needed to improve the use of new digital tools in archaeology, specifically during excavations.

The use of digital technologies and applications to record cultural heritage began to be introduced in Spain as early as the 1970s by Almagro Gorbea (1973). Since then, the use of photogrammetry has been developed significantly, rendering 3D techniques accessible to archaeologists. Despite the increase of use by scholars and professionals, no initiative can be compared to that of the UK organization Historic England that promotes a guideline applicable to the technique (Historic England 2017). In the Spanish context, the methodologies were established through scientific production and a professional educative offer. There is, for example, the possibility of acquiring an MA in Archaeology and Virtual Heritage, promoted by the SEAV (Spanish Society for Virtual Archaeology), or the postgraduate course in Digital Technologies for Geometric

Documentation and Heritage Representation organized by the CSIC (Spanish National Research Council).

Why publish 3D models of funerary contexts?

The materiality of death is perceived differently according to the identity, culture and religion of the observer. For this reason, there is extensive debate regarding the ethics of displaying archaeological remains of dead individuals in museums, on the Internet, in videos, and in other media (e.g. Meyers and Williams 2014; Sayer 2010; Sayer and Walter 2016; Williams and Atkin 2015). The benefits of digital methods in analyzing the dead are being applied increasingly to early periods. This is the case of four mummies from the Canary Islands in the National Archaeological Museum (MAN) of Madrid that were studied by 3D-scanning to gather data as to their conditions of life, cause of death and funeral rituals. The technology in these cases also led to reconstruction of their faces. Yet it is worth reflecting on what would occur if a researcher or institution created a 3D model accompanied by written and graphic information of human remains from the Second World War or the Spanish Civil War? Even bearing in mind the display's scientific or educational intention, it is possible to imagine that descendants of these individuals would object to their display in either social media or in a museum.

In the discipline of archaeology, both excavating and exhibiting human remains are considered a legitimate and integral part of research by universities, museums and other sectors when subject to correct guidelines that grant appropriate respect (Meyers and Williams 2014: 154). In fact, social researchers bear the ethical duty to disseminate the results of research to society, and, within this scope, mortuary archaeology provides an unusual amount of information about societies and their cultures.

Along these lines, many documents emphasize the scientific value of human remains in research and affirm that it is necessary to foster and exhibit the results. Key examples are the *Vermillion Accord on Human Remains* (WAC Inter-Congress 1989), *The Tamaki Makau-rau Accord on the Display of Human Remains and Sacred Objects* (WAC Inter-Congress 2005), and the *Code of Ethics and the Code of Practice of the British Association of Biological*

Anthropology and Osteoarchaeology (BABA0 2010a and b). There are also other documents espousing the same premise but focused on the professional code of ethics. This is the case, for example, of the ICOM for museums that stressed as far back as 1986 the professional responsibility of specialists concerning human remains and sacred artefacts as highlighted in paragraph 4.3 regarding the exhibition of sensitive materials:

Human remains and materials of sacred significance must be displayed in a manner consistent with professional standards and, where known, taking into account the interests and beliefs of members of the community, ethnic or religious groups from whom the objects originated. (ICOM 1986: 25).

This subject matter is pertinent as one of the main topics of the First Museum Congress of the Canary Islands in 2016 focused on the ethics of exhibiting human remains and whether it was acceptable to showcase the corpses of indigenous Canarians. The interest of members of the general public to view these bodies besides factors of education or curiosity, could amount to reasons approaching morbidity.

Therefore, 3D visualization of mortuary contexts should demand that viewers be more than a mere spectator. This type of viewing must offer supplemental textual and graphic information to contextualize the model so that the viewer identify, learn and interpret heritage. The authors of this paper therefore concur with Ulguim (2016) who argues that without the contextual data, there is no justification or ethical value in sharing these types of models.

Taking account of all these notions, a 3D digital record of the morphology, spatial distribution, colourimetry, and volumetry of human remains requires concomitant data as to burial context, building elements, artefacts and topography (Figure 8). This last element is also important, as it is not possible to differentiate burial practices from the way in which past populations interacted with their surroundings. Hence, it is the task of professionals not only to offer visualizations of the human remains, but also to explain and describe the behaviours, living conditions, diet, rituals and beliefs of ancient populations.



Figure 8: Infographic elements of burial S 023, illustrating how 3D models can afford the fuller contextualization of human remains.

In sum, the potential of 3D models to bolster archaeological communication and engagement among the general public is beyond doubt. Digital applications and visual representations are now essential tools for communication and education as culture is now very visual. Pictures and films in numerous formats are currently the most common way of transmitting a vast array of messages, information, knowledge and values (Pérez Báñez 2017). This is a challenge for archaeology and the methods this discipline use to socialize knowledge. Certain institutions recognize the growing value of Cultural Heritage and Digital Humanities. The MEMOLA project and the research laboratory of the authors of this study have gone to great lengths to improve communication, participation and public engagement by means of both formal and non-formal educational resources. Therefore, digital tools, and particularly 3D modelling, are key elements in the strategy of the project that continues to develop and explore the potential of virtual archaeology, musealization, gamification and social networks.

3D modelling allows sharing complex visual information and reconstruction of all the information of an excavated cemetery. Moreover, virtual reconstructions can be developed and disseminated without altering the integrity of the contexts and sites (Angás and Uribe 2016: 92). Digital models are tools that can serve at the site itself via mobile devices or informative panels, as well as off-site at conferences or schools, museums or digital exhibitions. They can also be embedded into online media such as MOOC (massive open on-line course), blogs and social media. They have a great potential to engage new audiences (in terms of age, gender and religious faiths) including those whose interested in the past, burial rites and death (Williams and Atkin 2015). 3D models hence represent an integral dimension of project communication strategies. In the case of Pago del Jarafí they were readily adapted to the unforeseen discovery of the cemeteries.

3D presentations of burial scenarios also allow both scholars and the general public access to data that might otherwise be less accessible or available via two-dimensional plans and stratigraphical sections that are more difficult to 'read' by non-specialists. Moreover, they offer the potential to foster debate between differing interpretations of the evidence involving

academics and professionals, as well as amateurs and members of local communities.

3D modelling and virtual archaeology are also useful tools in teaching and transmitting notions about burials to counteract morbid curiosity and foster rich and detailed arguments as to diversity of attitudes and practices surrounding the topics of death and the dead. Yet technical and ethical challenges require confrontation in this regard. Archaeologists should initiate the process by attempting to define an online collaborative culture and by considering communication as another of their everyday tasks. In a more general manner, and beyond the specific topic of burials, there are numerous ethical challenges to the field of digital public archaeology, as discussed by Richardson (2018).

The MEMOLA project has integrated knowledge socialization and transmission as one its main goals. Cemeteries are attractive for the public during the excavation. 3D modelling allows us to extend these effects and visualize an archaeological context that has disappeared. Dissemination of this data can be prolonged over time by reaching out to a wider national and international public, thereby facilitating a broader access to the findings of archaeological research.

As the use of these technologies becomes more extensive, digital 3D models are increasingly common in funerary scenarios. They represent an excellent opportunity to directly share detailed information. The challenge, however, is to focus on how to present these features, and to determine what information to include for a varied audience. In line with the argument of Ulguim (2016), this study concludes that the task of archaeologists is to find ways to share accurate three-dimensional models and, more importantly, determine why create them and for whom, as they offer deep insight into the rituals of the past and a better understanding of modern-day burial customs.

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References

- 3D 2018. 3D Epigraphy. Retrieved on 30 July 2017 from WWW <http://www.epigraphia3d.es>
- Almagro Gorbea, A. 1973. Documentación fotogramétrica en ruinas y monumentos, *Bellas Artes* 73, 45–46.
- Angás Pajas, J., Uribe Agudo, P. and Bea Martínez, M. 2016. Método y técnicas de aplicación de sistemas drones o RPAS en la investigación arqueológica. In J.I. Lorenzo Lizalde and J.Mª. Rodanés Vicente (eds), *I Congreso Arqueología y Patrimonio Aragonés*. Teruel, Colegio Oficial de Doctores y Licenciados en Filosofía y Letras y en Ciencias de Aragón, 541–49.
- Archaeological Services (ULAS) 2018. King Richard III's grave Retrieved on 10 June 2018 from WWW <https://sketchfab.com/models/00d23c7defd0476db1a36c08728fa60f>
- BABAO. 2010a. The code of ethics. Retrieved on 30 July 2017 from WWW <http://www.babao.org.uk/assets/Uploads-to-Web/code-of-ethics.pdf>
- BABAO. 2010b. The code of practice. Retrieved on 30 July 2017 from WWW <http://www.babao.org.uk/assets/Uploads-to-Web/code-of-practice.pdf>
- British Museum 2018a. Sketchfab profile. Retrieved on 6 April 2018 from WWW <https://sketchfab.com/britishmuseum>
- British Museum 2018b. Burial chest. Marcus Pilius Eucarpus grave Retrieved on 10 June 2018 from WWW <https://sketchfab.com/models/35126f1504ae43998234ceef2cd956e7>

- Campana, S. 2014. 3D modeling in Archaeology and cultural heritage - theory and best practice. In F. Remondino and S. Campana (eds), *3D Recording and Modelling in Archaeology and Cultural Heritage Theory and Best Practices*. Oxford, BAR International Series, 2598, 7–12.
- De Reu, J., Plets, G., Verhoeven, G., De Smedt, P., Bats, M., Cherretté, B., De Maeyer, W., Deconynck, J., Herremans, D., Laloo, P., Van Meirvenne, M. and De Clercq, W. 2013. Towards a three-dimensional cost-effective registration of the archaeological heritage. *Journal of Archaeological Science*, 40(2), 1108–21.
- Doneus, M., Verhoeven, G., Fera, M., Briese, C., Kucera, M. and Neubauer, W. 2011. From deposit to point cloud—a study of low-cost computer vision approaches for the straightforward documentation of archaeological excavations. *Geoinformatics FCE CTU 6*, 81–88.
- Delgado Anés, L. 2017. *Gestión, comunicación y participación social en los paisajes culturales de Andalucía*. Tesis doctoral. Universidad de Granada. <http://hdl.handle.net/10481/47164>
- Delgado Anés, L. and Romero Pellitero, P. 2017. La arqueología virtual, generadora de recursos para la comunicación y participación. In L. Bocanegra Barbecho and A. García López (eds), *Con la Red / En la Red: Creación, Investigación y Comunicación Cultural y Artística en la Era de Internet*, (2017). 191–214. Granada, Universidad de Granada; New York, Downhill Publishing. DOI: <http://doi.org/10.5281/zenodo.1134128>
- Digitised Diseases 2018. Retrieved on 10 June 2018 from WWW <http://www.digitiseddiseases.org/alpha/>
- El museo carnario 2018. Native mummies of Gran Canaria Retrieved on 10 June 2018 from WWW <https://skfb.ly/6qnTU>
- Historic England. 2017 *Photogrammetric Applications for Cultural Heritage. Guidance for Good Practice*. Swindon, Historic England.
- ICOM. 1986. Code of Ethics for Museums. Retrieved on 30 July 2017 from WWW http://icom.museum/fileadmin/user_upload/pdf/Codes/ICOM-code-En-web.pdf

- Jiménez Puertas, M., Mattei, L. and Ruiz Jiménez, A. 2011. Rituales y espacios funerarios en la Alta Edad Media: las necrópolis excavadas en la roca de Martilla y Tózar (Granada). In M. Jiménez Puertas and G. García-Contreras Ruiz (eds), *Paisajes históricos y arqueología medieval*, Granada, Alhulia, 141–75.
- Martín Civantos, J. M., 2007. *Poblamiento y territorio medieval en el Zenete (Granada)*. Granada, Universidad de Granada.
- Martín Civantos, J.M., Ramírez Burgos, M., Romero Pellitero, P., Bonet García, M.T., Pérez Fernández, A. and Fernández Moles, R. in press. Intervención Arqueológica Puntual en Lanteira (Proyecto MEMOLA). Granada. In *Anuario Arqueológico de Andalucía*. 2014.
- Martín Civantos, J.M., Ramírez Burgos, M., Romero Pellitero, P., Bonet García, M. T., Pérez Fernández, A. and Fernández Moles, R. in press. Memoria final de II Campaña de excavación arqueológica en el Pago del Jarafí (Lanteira, Granada) incluido en el Proyecto General de Investigación: Estudio de los paisajes históricos de Sierra Nevada. In *Anuario Arqueológico de Andalucía*. 2015.
- Martín Civantos, J.M., Román Punzón, J.M., Corselli, R., Rouco Collazo, J., Romero Pellitero, P. and Bonet García, M.T. in press. PGI Estudio de los paisajes históricos de Sierra Nevada: II fase. Informe preliminar III Campaña excavación arqueológica en el Pago del Jarafí (Lanteira, Granada). *Anuario Arqueológico de Andalucía*. 2016.
- MEMOLA 2014. Archaeological excavation Pago del Jarafí documentary (2014) Retrieved on 13 June 2018 from WWW <http://memolaproject.eu/es/file/1416>
- MEMOLA 2018a. Media Coverage Retrieved on 10 June 2018 from WWW <http://memolaproject.eu/media>
- MEMOLA 2018b. MEMOLA project (2014-2017) Retrieved on 10 June 2018 from WWW www.memolaproject.eu
- MEMOLA 2018c. Stratigraphic sequence of a burial in a silo. Retrieved on 10 June 2018 from WWW <https://sketchfab.com/models/517627ce7233454bb79af3452e94379c>

- MEMOLA 2018d. Sketchfab Profile. Retrieved on 15 April 2018 from WWW <https://sketchfab.com/memolaproject>
- MEMOLA 2018e. S045 Burial 3D model Retrieved on 02 March 2018 from WWW <https://skfb.ly/67psx>
- Meyers, K. and Williams, H. 2014. Blog bodies: mortuary archaeology and blogging. In D. Rocks-Macqueen and C. Webster (eds), *Blogging Archaeology*. Landward Research, 152–78.
- National Archaeological Museum of Spain 2018. Sketchfab Profile Retrieved on 3 April 2018 from WWW <https://sketchfab.com/man>
- Neumüller, M., Reichinger, A., Rist, F., and Kern, C. 2014. 3D printing for cultural heritage: preservation, accessibility, research and education. In M. Ioannides and E. Quak (eds), *3D Research Challenges in Cultural Heritage*. Berlin, Springer, 119–34.
- Ortíz, A. 2010. Dimensiones de estudio de los depósitos funerarios: una perspectiva de estudio multivariable e integrada. *Extracta crític: revista d'arqueologia* 4, 9–21.
- Pérez Bañez, M. 2017. Cultura audiovisual un lenguaje para el siglo XXI. *Making of: cuadernos de cine y educación* 132, 32–37.
- Principles of Seville. 2011. Retrieved on 15 August 2017 from WWW <http://smartheritage.com/wp-content/uploads/2015/03/FINAL-DRAFT.pdf>
- Ramírez Burgos, M., and Martín Civantos, J.M. 2016. ¿Cuánto perdemos en las intervenciones urbanas? Homogeneización, análisis y cuantificación de la documentación arqueológica de Guadix (Granada). *Arqueología y Territorio Medieval* 23, 183–203.
- Richardson, L.-J. 2018. Ethical challenges in digital public archaeology . *Journal of Computer Applications in Archaeology* 1(1), 64–73. DOI: <http://doi.org/10.5334/jcaa.13>
- Reilly, P. 1991. Towards a virtual archaeology. In R. Lockyear and S. Rahtz (eds), *Computer Applications and Quantitative Methods in Archaeology 1990*. Oxford, BAR International Series, 565, 133–39.

- Román Punzón, J. 2004. *El mundo funerario rural en la provincia de Granada durante la Antigüedad Tardía*. Granada, Universidad de Granada.
- Romero Pellitero, P. and Martín Civantos, J. M. 2017. From 3D to GIS. A comprehensive methodology for recording stratigraphy and its application in the MEMOLA Project. *DISEGNARECON*, 10(19), 2.1–2.16.
- Sayer, D. 2010. *Ethics and Burial Archaeology*. London, Duckworth.
- Sayer, D. and Walter, J. 2016. Digging the dead in a digital media age. In H. Williams and M. Giles (eds), *Archaeologists and the Dead, Mortuary Archaeology and Contemporary Society*. Oxford, Oxford University Press, 367–95.
- Smithsonian's 3DX 2018. Retrieved on 10 June 2018 from WWW <https://3d.si.edu/about>
- Ulgum, P. 2016. Models and metadata: how are 3d models of human remains and funerary Archaeology shared on a digital platform? Retrieved on 30 July 2017 from WWW <https://bonesburialsandblackcoffee.wordpress.com/2016/04/01/models-and-metadata-how-are-3d-models-of-human-remains-and-funerary-archaeology-shared-on-a-digital-platform/comment-page-1/>
- WAC Inter-Congress 1989. Vermillion Accord on Human Remains. Retrieved on 30 July 2017 from WWW <http://worldarch.org/code-of-ethics/>
- WAC Inter-Congress 2005. Tamaki Maku-rau Accord on the display of human remains and sacred objects. Retrieved on 30 July 2017 from WWW <http://worldarch.org/code-of-ethics/>
- Williams, H. and Atkin, A. 2015. Virtually dead: digital public mortuary archaeology, *Internet Archaeology* 40. <http://intarch.ac.uk/journal/issue40/7/4/index.html>
- Wilson, P. F., Stott, J., Warnett, J. M., Attridge, A., Smith, M. P. and Williams, M. A. 2017. Evaluation of touchable 3D-printed replicas in museums. *Curator* 60, 445–65.