"Please, Touch the Exhibits": 3D Archaeology for Experiential Spatialisation

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1 Introduction

Recent advances in image capturing and 3D scanning technologies, along with their significant reduction in production costs, have brought to the general public handheld devices equipped with several useful sensors and data collection instruments. As a result, large numbers of artifacts and spaces are 3D digitized. When one moves beyond the "coolness" factor of a 3D model, though, how do they harvest its abundance of information, exploit their digital physicality productively, ultimately reexperiencing the object not through the lens of history but as a "tangible" object? Furthermore, this renewed physicality intrudes in and affects our sense of space, thus making historical artefacts more approachable while also enriching our actual spatiality. Foucault explored this concept of heterogeneous emplacement in his work *Of Other Spaces*. This chapter discusses the mission of digitization projects and particularly the Digital Epigraphy and Archaeology Project (DEA) (www.digitalepigraphy.org) and its collection of 3D digitised material and applications of virtual and augmented reality alongside the Foucauldian notion of heterotopia and heterochrony. I argue that digital archaeology affords us a transcendent understanding of the ancient and the modern world, as it enables us to move beyond ourselves through virtuality while extending ourselves and our perception via augmented reality and advanced physicality. Ultimately, the goal of the chapter is to contextualise epigraphy and archaeology within the concept of spatialisation and open a discussion of the possibilities for "physical contact", reappreciation of the concept of physicality, and the study of digital artefacts.

The chapter first lists briefly a number of digitisation projects of various types that focus on different types of material, eras and areas, all indicative, though, of

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scholarly attempts towards preservation and dissemination. They all endeavour to answer people's unequivocal need to situate themselves closer to and more meaningfully alongside historical objects, thus necessitating a more consistent and conscious approach to space. The second section explores the significance of space, focusses on the theory of space as a concept and an actuality, and presents Foucault's philosophy to emplace virtual and augmented reality in our experience domain. The following section then discusses the DEA project as a case study. The project's digital repositioning of the 3D artefacts in their original physical context increases accessibility and "tangibility" through interaction design, virtual and augmented reality, and 3D printing, thus reconceptualizing space and reappreciating the user's place within the ancient and modern world. The three *foci* of the project discussed are: 1. natural interaction, 2. spatialised contextualisation and 3. physicality. Advanced interaction design aims at recreating the circumstances of physical interaction with an object, albeit on a digital level, namely, on a computer or a tablet. With regard to contextualisation, an artefact is a mere vessel of a whole gamut of experiences and is intrinsically connected to its findspot. To this end, we work with virtual and augmented reality to reposition the objects back in their surroundings or simply "in front of" the scholar to enhance the possibilities for thorough analysis and better apprehension of their actual role in the history of a place. Finally, concerning physicality, the project reauthenticates the 3D model and reinstitutes its existence, as we consistently resort to 3D printing, offering the possibility for hands-on study of and engagement with the artefacts.

2 Spatialising Archaeology

High-resolution cameras can be found in smartphones along with several user-friendly software applications that process the captured video sequences and produce photorealistic 3D models through photogrammetry without the need for additional expensive equipment. Additionally, low-cost handheld 3D sensors (such as the Structure Sensor by Occipital, Inc.; the RealSense camera by Intel, Inc. and others) can be mounted on portable electronic devices and produce accurate 3D scans of historical objects and other articles of interest.

In this industry-led 3D digitization revolution, hundreds of humanities scholars, such as archaeologists, historians, classicists and conservation specialists as well as enthusiasts, digitise on a regular basis a large number of historical artefacts and publish their 3D digitisation-related findings (Ramírez-Sánchez et al. 2014). The 3D artefacts populate online collections that host thousands of digitally preserved objects of historical significance. In order to understand the magnitude of these industry-led crowd-sourcing initiatives, we could group these projects into two categories: (A) Individual and institution-based initiatives that create and maintain focussed and typically smaller online collections of historical objects. (B) Online repositories of high-resolution and high-polygon-count 3D digitised objects not necessarily

focussed on archaeology, such as Sketchfab and Glovius. I briefly mention here some representative projects.

- African Fossils: http://africanfossils.org/search.
- Archaeology Data Service (ADS). ADS provides a viewer for rendering and interacting with 2D and 3D data: http://archaeologydataservice.ac.uk/archives/view/amarna_leap_2011/downloads.cfm?obj=yes&obj_id=38819&CFID=46546&CFTOKEN=FDFFB482-1807-4B58-91F2D23D46220951.
- Cultural Informatics Research Group: http://www.culturalinformatics.org.uk/.
- Digital Libraries for 3D Documents, Institute of Computer Science II, Computer Graphics, Universität Bonn: http://cg.cs.uni-bonn.de/en/activities/digital-libraries-for-3d-documents/.
- Dotty View: http://dotdotty.com/.
- Glovius: https://cloud.glovius.com/.
- London Charter for the Computer-based Visualization of Cultural Heritage: http://www.londoncharter.org/.
- MorphoMuseum: http://morphomuseum.com/.
- Scan the World Initiative that is a collection of printable 3D models: https://www.myminifactory.com/scantheworld/.
- Spatial Models of Great Buildings: http://www.greatbuildings.com/types/models/spatial_models.html.
- The Annual Conference of Museums and the Web in 2016 addressed these very issues. http://mw2016.museumsandtheweb.com/paper/collections-cubed-into-the-third-dimension/.
- The Digital Epigraphy and Archaeology Project: www.digitalepigraphy.org.
- The Dynamic collections project at Lund University, which is based on 3DHop technology, was developed by the ISTI Visual Computing Lab, an open-source solution to upload and create WebGL-like 3D contents: https://portal.research.lu.se/portal/en/projects/dynamic-collections(9a034d5a-e9e0-4688-93d0-ec272beaee1e).html?fbclid=IwAR009Jnt5ORd7_xpHp_Qv70gLl6w2jNvH0e98hHloOrLpWcmCzUc_ck0wrE.
- The Smithsonian has a 3D data collection (https://dpo.si.edu/) featuring Autodesk's x3d viewer.
- The Stanford 3D Scanning Repository: http://graphics.stanford.edu/data/3Dscanrep/.
- The University of Michigan Online Repository of Fossils: http://umorf.ummp.lsa.umich.edu/wp/.
- 3D Heritage Online Presenter with an open-access viewer: http://3dhop.net/.
- There are commercial services (by Google, SketchFab, Autodesk, Verold, etc.) for hosting and sharing digital models that do not restrict their content in any particular topic such as archaeology. Nevertheless, collections of 3D models of archaeological artefacts can be created within such services with free and unlimited uploads/downloads.
- Contrary to the aforementioned free commercial services, the Digital Archive Record (tDAR) is a paid service for the storage and preservation of archaeological

research meant to improve access to these data. tDAR is developed and maintained by Digital Antiquity. Currently, the user can pay to upload files with metadata or browse and download files for free. However, tDAR provides no functionality for viewing or interacting with this kind of data online, limiting the potential reach of these materials.

The mere number of developed projects indicates the magnitude of scholarly efforts to engage with artefacts more closely and, in the case of archaeology, preserve antiquity. Initially, such projects were exciting for the possibility of engaging with technology and determining whether it could accommodate traditional humanities fields and objects that, under any other circumstances, would have been considered diametrically opposite to technological devices. The significance of the collaboration and its results rests in the simple irony of the coexistence of two, by definition, disparate research *foci* and scientific methodologies. How does one not only bridge the chasm between an object that embodies the human record, essentially a part of life that no longer exists, and an object that redefines daily existence but also creates a space that needs both the above to bring about a meaningful experience? This very experience or reexperience, if you will, signifies the elimination of time and place barriers, thus effectuating a heterotopia and heterochrony for historical artefacts alongside their recreators.

3 Digitisation and Virtuality as Heterotopias

In this section, I discuss 3D digitisation and virtual and augmented reality as forms of a body-centred approach that does not mean to replace the real artefact or simply enhance reality. I argue instead that such an embodiment—both on behalf of the user and the object—brings about a sense of the Foucauldian heterotopic and heterochronic reality.

What makes space as both a concept and a reality so important and so multi-modal to have been politicised, legitimised and illegitimised, glorified and condemned to infamy? Space engulfed in and beyond its ubiquity cannot avoid its existence and the bearing it has on human existence. There have been several philosophical problematisations and explorations of the concept of space—internal and external, social, public and private. Bachelard (1994) examines interior space and intimate spaces, such as the house, as a means of prefiguring and understanding the soul. Blanchot, in *The Space of Literature* (1989), presents language as creating and constituting space.[1] Heidegger (1927) and Ingold (2000) present geographical space. And Harvey (1991), following Schivelbusch, credits the role of transportation systems for the shaping of space and time. Lefebvre (1992) discusses space as a social construction of capitalist societies. Low (2014) considers culture spatialisation and space as social production and social construction. McKittrick (2014) discusses space along racial and sexual

[1] Bakhtin also discusses space in literature and introduces the concept of chronotope in *Theory of the Literary Chronotope Reflections, Applications, Perspectives*. Gent: Academia Press. 2010.

lines, and Woolf (2005) criticises and problematises gendered space in A *Room of One's Own*. This chapter focusses on Foucault's theorization, as it accommodates a consideration of the real and unreal that then, in turn, makes us rethink established knowledge and, during this process, creates new knowledge as well. Against this backdrop, I argue that 3D digitised worlds constitute their own space—reviving a world that used to exist differently and now survives both through a recreation but also within contemporary reality as an actual place.

Foucault outlined the concept of heterotopia on three occasions. In the preface of "Les Mots et Les Choses" (The Order of Things), he described literary space. He then discussed the topic in a radio broadcast followed by a lecture to a group of architects in 1967. In both cases, he explored the social constructions of space. The foundational precepts of this analysis did not appear until 1984 when he published "Des Espaces Autres", which was translated into English under the title "Of Other Spaces" or "Different Spaces" in 1986. Foucault redefines—or perhaps better, defines—space as not simply our emplacement in the world but also as conceived beyond sensory perception. He avoids the reductionism of locality by exploring the essence of a space and its representational and interpretational power that moves beyond the sensory homogeneity that limits us as observers. His delineation moves the person into a more participatory role, experiencing the space. According to this theory, heterotopias are spaces outside of all places, even though one may be able to pinpoint their locale. For Foucault, space is malleable and constantly constructible; it is an organic system of relations, differences, similarities, agreement, resistance and change. It is, above all, dialectical. When he defines heterotopia, he describes it as the space of the outside (*du dehors*)[2] and says that it is the space that is "outside of all places"[3] (p. 3–4). In his insightful analysis of heterotopia, Topinka also pinpoints that the concept of space in the Foucauldian universe is more meaningful when we examine it against the backdrop of his ideas about knowledge and knowledge production. Based on the philosopher's analysis of Borges' Funes and the exigency to rearrange our knowledge by inverting the operating table, Topinka argues that: "Knowledge, for Foucault, emerges in a clash of forces. Heterotopias, even as they contest received knowledge, participate in this battle, producing knowledge by problematizing order and space" (2010, 64). Johnson (2006, 78) also argues that heterotopias: "Like utopias, these sites relate to other sites by both representing and at the same time inverting them". Deleuze (1980) also embraces and explores this order of things, the production of knowledge and the need to step outside or move beyond known formations to fully understand. The "outside" or "beyond" do not necessarily denote separation, but it is the concept of comparing and contrasting, thus reconceiving and rethinking.[4] In his discussion of virtual space, Maggini comprehensively concludes that: "Late modern virtual places open new possibilities for territoriality without necessarily succumbing

[2] The concept of the experience of the outside and the role of the subject was also analysed in his essay *La pensée du dehors* (1966).

[3] I am using the translation by Miskowiec (1986).

[4] Colebrook (2003) provides a comparative reading of Deleuze and Foucault on the concept of space.

to the false dilemma of digital utopia or dystopia. Hence, fully immersive digital environments are to be experienced both as an everyday lived experience and as a challenge to it…Digital virtual places are heterotopias in the sense of Char Davies' 'changing spaces' that are at once like and unlike real ones, therefore allowing for transformational processes to take place".

According to Foucault, a mirror is a perfect example; it is a no-place (a utopia), but also a heterotopia, as it actually exists. He says: "Starting from this gaze that is, as it were, directed toward me, from the ground of this virtual space that is on the other side of the glass, I come back towards myself I begin again to direct my eyes toward myself and to reconstitute myself there where I am. The mirror functions as a heterotopia in this respect: it makes this place that I occupy at the moment when I look at myself in the glass at once absolutely real, connected with all the space that surrounds it, and absolutely unreal, since in order to be perceived it has to pass through this virtual point which is over there" (p. 4).

Foucault then defines five heterotopic principles, the third and fourth of which serve as a framework for our virtual (re)creation of objects and space. According to the third principle: "The heterotopia is capable of juxtaposing in a single real place several places, several sites that are in themselves incompatible" (p. 6). By this definition, when we recreate a space virtually, we do not simply recreate the past or leave behind the space we inhabit. There is within the user the sense of multiplicity and a set of coexisting realities. There have been extensive discussions on the authenticity of the reproduced artefact, the authenticity of experience in the cases of virtually recreated spaces and an overall impugning of augmented spaces that part of the scholarly community has defended, arguing the advantages of experiential learning and the opportunities to increase the user's perception of space, place and culture within.[5] All these are undeniable qualities of new technologies but inevitably focus on the concept of the user as an impostor. The primary goal of recent advances is to help people further their understanding of past civilisations. But what about the user as a participant? What about the coexistence of spaces of the past with the space that the user is holding at present? I believe that these technologies contribute to a much more meaningful participatory actuality that combines past and present social production in the forms of the artefacts and the historical places on the one hand and modern devices and places on the other. This mixed reality also produces a mixed social construction. Erwine (2016), in her book *Creating Sensory Spaces,* confirms the importance of sight and observation but also acknowledges what she calls "sensory homogeneity" that is incurred. She insists on the accumulation and collaboration of all the senses as well as the necessity for the individual's participatory role, stating: "As Western culture has become the culture of the eye, the separation this creates between observer and that which is observed has contributed to the culture of 'I'…This action disembodies us" (2016, 16). This disembodiment is precisely what the DEA's NUI and augmented reality options try to overcome, offering the user a wholesome and

[5] For discussions of authenticity, see Benjamin (1999), Di Giuseppantonio Di Franco's edited volume (2018) and particularly Chap. 8 for further bibliography on the topic.

consequential experience instead.[6] The project focusses on advancing the tangibility of artefacts and on reentering them into everyday experiences, thus redefining ancient artefacts within the contemporary experiential culture. Ultimately the user's sense of space is altered through interaction with objects that are not generally part of their environment through an increasingly alert, conscious, contentious, critical or even benign engagement with them.

In her ethnographic work, Setha Low defines social construction as referring to: "Spatial transformations through peoples' social interactions, conversations, memories, feelings, imaginings, and use—or absences—into places, scenes and actions that convey particular meanings" (2014: 35). Mixed realities—the amalgamation of digitisation and augmented virtuality—could fit the above description. Engagements with exhibits in more casual settings can bring about ferments between the past and the present but also procure a set of current experiences that relate to the user's understanding of the self, giving another dimension to the artefact and/or the historical construction. This aspect of involvement then breaks the time continuum and brings us to the fourth principle of Foucault's heterotopia, namely, heterochrony, which is defined as: "Beginning to function at full capacity when men arrive at a sort of absolute break with their traditional time…there are heterotopias of indefinitely accumulating time, for example, museums and libraries. Museums and libraries have become heterotopias in which time never stops building up and topping its own summit…yet the experience is just as much the rediscovery of time, it is as if the entire history of humanity reaching back to its origin were accessible in a sort of immediate knowledge" (p. 7).[7]

In the cases of individual databases and projects that provide advanced digital sensory exploration and apprehension of objects, these digitised realities substantiate exactly that, namely, the condition of the rediscovery of time through and against the backdrop of the rediscovery of space(s). Essentially no geographical place or place in time has a standalone existence. Instead, they all acquire their essence through and in relation to one another, transcending not only boundaries but also substantialising themselves thus. Foucault describes this as "simultaneity", a notion that summarises the interconnecting realities of post-structuralism. Albeit written several decades before the birth of these technologies, the French philosopher notices the changes in technology and people's inherent interpretational socio-cultural constructions of

[6] Similarly, Harding et al. (2002) present a method to explore multi-sensory data in geospatial visualisation. Also, Betts in her edited volume *Senses of the Empire* (2017) daringly attempts to summarise methodological efforts to recapture the sensorial attributes of the Empire based on historical sources and archaeological findings. She does admit, though, that: "Recapturing sensory data is difficult since '[t]he senses seldom leave a direct imprint in the archaeological record and most typically must be implicitly inferred' …in both qualitative discourses and quantitative analyses the evidence from textual and visual sources can be combined with archaeology to construct multisensory interpretations of particular aspects of Roman life" (2017, 7–8). On the exploration of the senses towards reconstructive and more experiential archaeology, see also Pellini et al. (eds.) (2015). See Skeates and Day (2020) for scholarship on sensory archaeology and culture studies.

[7] Radford et al. (2015, 733) explore the library against the backdrop of this Foucauldian concept and argue that: "Drawing together the constructs of heterotopia and serendipity can enrich the understanding of how libraries are experienced as sites of play, creativity, and adventure".

place and time. At the beginning of his treatise, he says: "We are in the epoch of simultaneity: we are in the epoch of juxtaposition, the epoch of the near and far, of the side-by-side, of the dispersed. We are at a moment, I believe, when our experience of the worlds is less that of a long life developing through time than that of network that connects points and intersects with its own skein" (p. 1).

4 Digital Databases: Preserving, Validating and Completing the Archaeological Record

Preservation and dissemination of archaeological material is, of course, a *sine qua non* for the experiential spatialisation I discussed above. However, there are existential issues that hinder this type of meaningful engagement and have also contributed to archaeology's distance from contemporary audiences. On the one hand, the focus usually turns to highvisibility sites and constructions. Such choices validate and consequently may also invalidate certain aspects of the archaeological record, as they "condemn" certain types of objects.[8] On the other hand, the fragility of the material is a prohibitive factor. As a result, as such material is housed in museums, libraries and institutions worldwide, their location significantly thwarts their accessibility. Technology, high-resolution 2D pictures and electronic databases attempt to overcome the aforementioned limitations. However, issues that put projects and databases at a disadvantage are the use of cumbersome or expensive equipment as well as the fact that they are not designed as dynamic databases that can cater to the needs and questions of each user. Moreover, the lack of contact with the physical object as a tridimensional structure still significantly obstructs research.

The Digital Epigraphy and Archaeology group (DEA) argues the significance of dynamic digital libraries of 3D digitised artefacts enhanced with an advanced Natural User Interface (Barmpoutis and Bozia 2016). The project focusses both on ektypa and other historical objects. The significance of ektypa (squeezes, *Abklatsch*, *estampages*) lies in their inherent qualities as media and mediators of culture and literature. However, due to their location on other artefacts (statue bases, columns, etc.), they can be overlooked, an oversight that is, in turn, reductive to the entire artefact. However, their study is more often than not the way *par excellence* to contextualise the artefact. It is also a unique way to bring cultural understanding through language. Therefore, preservation and thorough analysis of ektypa are the unequivocal means to breaking the space-time continuum that obstructs our appreciation of the past by means of its expressive verbal powers. It should also be pointed out that ektypa, albeit copies of inscriptions, are themselves artefacts, and, in cases when the original inscription is lost or severely weathered, they preserve a better record of the inscribed text.

[8] For instance, ektypa have not been considered important carriers of information or worth preserving when compared to the actual artefact. So, there are not many projects focussing on their digital preservation and/or study.

Regarding other kinds of artefacts, archaeologists tend to focus on the digitisation of sites or larger constructions as the means for cultural appropriation of ancient civilisations. The DEA has refocused scholarly attention on reexamining fragments of those civilisations and emplacing them within our everyday surroundings. Thus far, under the auspices of the project and its collaborators, the Rosetta Stone,[9] collections of renaissance statues, British coins of the age of Henry III, lace[10] and embossments on Abraham Lincoln's letters, among other objects, have been digitised and offered for modern analysis and contextualisation. Moreover, advanced visualisations, virtual and augmented reality, and 3D printing have repositioned them, making them accessible for closer study. At the same time, the users familiarise themselves with them and appreciate them as carriers of the aura of the past while situating them within their cultural context.

4.1 Procedural Facilitation

Thus far, several projects, including but not limited to the EAGLE consortium, the Center for Epigraphical and Palaeographical Studies at Ohio State University; the Aleshire Center at the University of California, Berkeley and the US Epigraphy Project at Brown University, among others, feature digital libraries of squeezes. Also, 3D digitisation projects have been undertaken by museums, including the Epigraphic Museum of Athens (Papadaki et al. 2015; Sullivan 2011), Museo Arqueológico Nacional de Madrid (Ramírez-Sánchez et al. 2014), Museo Nazionale Romano di Palazzo Altemps (Barmpoutis et al. 2015), Museo Geologico Giovanni Capellini di Bologna (Abate and Fanti 2014), St. George's Hall in Liverpool (Cooper and Sportun 2007), the Archaeological Museum of Milan (Gonizzi and Guidi 2013) and several other museums and institutes (Landon and Seales 2006; Levoy et al. 2000).

Additionally, several novel methods for scanning, processing and analysing 3D models of inscriptions have been developed, including methods for text extraction from inscriptions (Aswatha et al. 2014; Sullivan 2011), accurate 3D scanning of inscriptions (Papadaki et al. 2015), visualisation of inscriptions (Bozia et al. 2014), 3D visualisation for better contextualisation (Greggio and Salemi 2016) and 3D digitisation of rock surfaces (Vavulin et al. 2019) as well as 3D applications for other archaeological artefacts (Babeu 2011; Esteban and Schmitt 2004; Malzbender et al. 2001; Pollefeys et al. 2001). Comparative studies of 3D scanning methods for cultural heritage can be found in (Pavlidis et al. 2007; Wachowiak and Karas 2009; Böhler and Marbs 2004).

The DEA project has addressed the issue in its foundation by developing and exploring cost-effective methods for digitisation. More specifically, the project employs the shape-from-shading (SFS) 3D digitization of ektypa, using a flatbed scanner, various visualisation modes, and options for measurements and analysis of

[9] Amin et al. (2018).

[10] Farmer et al. (2015).

lettering techniques and constructional characteristics, respectively, depending on the artefact (Barmpoutis et al. 2010). Such options facilitate dating, attribution, fragment identification, text or even structure reuse. Jameson (2004) eulogises the inclusion of images of manuscripts in digital databases. She states: "The images dramatically increase access to source materials, reduce the power of the scholar as 'gatekeeper', expose the scholar's judgments to wider scrutiny, and make it more likely that readers or users will actually collaborate in the work of perfecting the state of scholarship". The DEA espouses this precept, as the database is not only meant as a repository of artefacts but also aims at disseminating the ektypa and inviting new readings of the inscribed text.

For the digitisation of other artefacts, we have used the Structure Sensor™ by Occipital, which was attached in front of a tablet computer (iPad Air™ by Apple). The resolution of the depth sensor was 640 × 480 pixels at 30 frames per second and was calibrated so that it records depth in the range from 0.4 to 3.0 m, which is adequate for capturing life-size statues. Another depth sensor, Kinect™ by Microsoft, has also been used in our depth fusion experiments, which were performed on a 64-bit computer with an Intel Core i7™ CPU at 2.80 GHz and 8 GB RAM. Both Kinect and Structure sensors had a similar resolution, range of operation and field of view.

In all cases, the equipment utilised is not financially burdensome. The DEA constantly explores methodological approaches and devices that can be accessible to all users. The main goal is not only to explore technological advances but also to achieve a sustainable machine user interaction/dependency that can ultimately bring about more projects and digitised artefacts.

4.2 The User as a Participant in the Archaeological Record

Another feature that contributes to active engagement with the artefacts is the option to virtually imitate actual physical interaction between an epigraphist, scholar or student and the paper copy of the inscription. Thus, the user can better visualise the object of study and reexamine weathered parts of the ektypon by manipulating the perspective and the lighting. These methodologies do not enhance physicality and tangibility in the traditional sense, but increase interactivity with the artefact. The user should also be able to engage in a dialogue with the objects and ultimately pursue their study and understanding from their scholarly perspective without being impeded or guided by technological constraints. The artefacts' metadata record is an integral part of their contextualisation and the cultural understanding they can afford. To this end, the DEA database includes all the relevant (contextual) fields of information about the inscription and links to all other online resources containing information about the artefact. The user also has the option to add any field from a drop-down menu list. Additionally, the editable metadata fields provide more options for each database.[11] Being in the position to have a collective record of the ektypon

[11] http://research.dwi.ufl.edu/www.digitalepigraphy.org/edit.php?heightmap=4uk52idgb0a3xlnf.

and the inscription, the researcher has the opportunity to pose new questions or old questions on a new basis. So, instead of a simple hyperlink that guides the user towards other resources and has been described by Bodel as crude contextualisation (Bodel 2012, 280), one can comprehensively study the artefact. Compiling such records also facilitates comparative studies of large numbers of artefacts.

More specifically, the DEA database features an editor where the user can add, delete and work on metadata fields according to the available information, of course, but also their research focus. The editor is also provided in different languages so that the user may not have to choose between the technological facility and language fluency. The *foci* of the metadata are the following:

1. Preservation of the traditional nature of the data—terminological accuracy along with the possibility for keyword search.
2. Accommodation of every type of format of the data—both the digitised and the metadata.
3. Providing an all-encompassing database that will not direct the type of research one can conduct but will instigate new questions instead.
4. Effective communication between computer scientists and humanists to find a common point of reference between creating efficient algorithms and databases while retaining the nature of epigraphic and archaeological studies.
5. Option to add all existing information about the digitised artefact that could highlight other or even broader cultural and political aspects. So, the user can include images, scans of the monument, or the site where the artefact is/was located, museum information and other data that will generate a holistic record of the artefact.

Finally, the DEA facilitates the dissemination of the 3D digitised objects by providing users with an embeddable 3D viewer, which can be easily imported into third-party databases, collections and personal websites (Fig. 1).

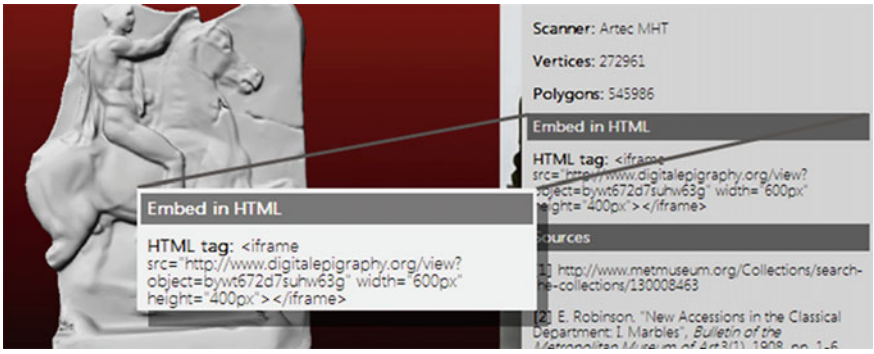

Fig. 1 Screenshot of the DEA metadata environment

4.3 Bridging the Gap Between Users and Usability

The DEA also attempts to remedy issues of usability, as there seems to be a notable disconnect between the research on these technologies and the actual use in the professional epigraphic and archaeological practice, and it has been hard for non-technology-oriented audiences to handle and manipulate tridimensional data, using conventional computer equipment (Barmpoutis and Bozia 2016).[12] Under such circumstances, one cannot fully utilise all the additional information that a 3D model affords, making technology a mere fancy addition without obvious advantages. To this end, the DEA provides an interface that allows the users to naturally "hold" digitised inscriptions and interact actively with them as if they were real physical objects. They also interact with metadata and multi-modal data, such as text and images.

Technological advances alone, though, cannot guarantee enhanced research possibilities, as usability is concomitant with the human factor. So, the DEA is also concerned with enhancing user facility and gearing technology towards imitating natural human interaction. The DEA team has been interacting with adopters of the toolbox, users, scholars who are uploading their collections, and finally, students, inquiring about the movements that accompany actual physical interaction with artefacts. How does one handle an ektypon? What does it take to read it more closely? How close does one need to be depending on its letter size or even its condition? What are the most common statues' postures, and how can we spot a renaissance copy from a Greek or Roman original? The goals of our interaction were threefold: (a) study the various forms of physical interaction that epigraphists and archaeologists have with their object of study as a real physical object; (b) expose scholars to a digital interface that imitates their interaction routine, using digital replicas of physical objects and (c) explore the kinds of questions that researchers ask to design interactions and options that open up their fields of inquiry. The three main types of interaction are 1. Change of point of view: Observation of the artefact from different viewing angles enables the scholar to better understand the shape of the inscribed letterforms and structural patterns. 2. Change of lighting conditions: Relighting the artefact by introducing natural and/or artificial light and shadows from multiple angles reveal perspectives that may otherwise have remained obscured and unnoticed. 3. Magnification of the artefact: Close observation of any region of interest brings a new appreciation and opens new avenues for fragment identification and observation of constructional characteristics. 4. Several levels and types of 3D and 2D visualisations as edge, height or fingerprint maps or with the image of the actual squeeze (in the case of inscriptions) superimposed. It should be noted that in addition to the above four types of interaction, there are two additional interactions. More specifically, the physical object can be either portable, such as a small fragment or a large rigid object. In the first case, the inscription can be moved with respect to the fixed observer or the fixed light source, while in the case of large rigid objects, the observer and the light

[12] http://www.digitalepigraphy.org/museum/collection/draghi-E-leoni/.

source move with respect to the fixed inscription, thus maintaining a more intuitive engagement with the object or area of interest.

According to the above analysis, in the case of digitised inscriptions, a Natural User Interface (NUI) should provide the means for an epigraphist to create and enjoy an experience that closely resembles real physical interaction, thus eliminating assumed time and spatial barriers. Ultimately, such interactions effectuate renewed experiences—new lives for the artefacts and enhanced conception of the objects, the space, and the self. The type of physicality the project promotes transcends the notion of reality, as the user experiences an enhanced tangible interaction with the digital artefact. The DEA is not concerned with the sensory aspects of physicality but with the latter's reconsideration through digital methodologies. It is not a matter of replicating the physical object along with its tactile attributes but of reestablishing the concept of the tangibility of the object and reexploring its potential through a virtual environment. To the same end, the DEA is also working with 3D printing with a view to reconstituting the "tangibility" of the digital object.

5 Augmented Reality for Epigraphy and Archaeology, or How to Bring Holograms of Artefacts to the Classroom

Hamilakis, in his book *Archaeology and the Senses,* describes the concept and, subsequently the practice of sensory archaeology as: "[Not] the rejection of thinking in favour of feeling and lived experience, but rather the reconstitution of thinking as another form of felt experience, as sensorial and affective practice, interwoven with all other embodied practices—thinking through the living and sensing body" (2013, 196).

However, most projects are limited either by the modality of the content or by the delivery mechanism of the educational material. Additionally, they lack the synaesthetic parameter that can grant a degree of reality and understanding that can be afforded through the stimulation of more senses than vision.[13] Flynn criticises the lifelessness of 3D digitised virtual replicas of places and artefacts and proceeds with an extensive discussion of the lack of embodiment that results in a lack of understanding (Flynn 2007, 354–364). Therefore, an advanced solution to this limitation that would also enhance the perception of an object within the user's space is the creation of mixed reality (Milgram and Kishino 1994), a virtual world that would also allow for the embodied participation of the users. Brondi et al. (2016) discuss mixed reality and natural interaction in two cultural heritage applications with the use of an accessible infrastructure.[14]

Such an affordance also affects the educational parameter through experiential learning. The latter is a well-studied research area, and the connection between embodied action and learning outcome has been extensively examined (Alibali and

[13] See above n. 6.

[14] See also Hervy et al. (2015) who present an interface for a scale model of Nantes' harbour activity.

Fig. 2 Interactive visual inspection of a 3D digitised inscription along with the inscription bearer. The user can view the object from different perspectives using natural motions

Nathan 2009; Eisenberg and Pares 2014, 344–8; Goldin-Meadow 1999). Several researchers emphasise the contribution of embodiment to learning (Abrahamson and Lindgren 2014; Eisenberg and Pares 2014, 347–8; Goldin-Meadow 2009). Additionally, there is substantial scholarship in different academic fields to demonstrate that mixed-reality environments enhance educational experiences, leading to better learning outcomes. Lindgren and Johnson-Glenberg (2013) discuss the advantages of mixed reality extensively and present guidelines as to how this is to be achieved within a learning environment.

To this end, the DEA interface allows for interactive manipulation of a 3D digitised inscription bearer to better contextualise both the inscribed text and the artefact. It should also be noted that the user can perform an interactive manipulation of the perspective simultaneously with the interactive relighting to achieve a more realistic interaction that causes relighting and a change of point of view at the same time. The user can also interact with the 3D object using touch gestures and select regions of interest. This action initiates other data tools, such as the image viewer or the edge filter, as shown in this example (Fig. 2).

5.1 3D Holographic Database

Aiming to reconstitute the physicality and naturalness of experience, the DEA interface has effectuated the enhanced sensorial and affective qualities of 3D digitisation and virtuality by using augmented reality head-mounted displays, such as Microsoft's Hololens glasses.

The system enables the users to browse through 3D databases of inscriptions and visualise the inscription within their actual physical space, such as an office or classroom. Once the user positions the hologram of the inscription in a particular location, such as the top of the desk, it remains there, allowing them to move around the inscription and study the artefact as a whole, up close and from different perspectives. Similarly, multiple inscriptions can be positioned next to one another, providing the opportunity for comparative readings, a profound study of lettering techniques, and the potential identification and pairing of fragments. Such

an enhanced rendering enables the user to work with their hands, "touching" the digital objects and reinstating in a way their physical presence.

In the current phase of the project, 3D models from the Digital Epigraphy and Archaeology database were imported into the Hololens Augmented Reality headset. The user can browse the 3D database of inscriptions by performing natural hand gestures, such as pointing, picking, moving and dragging. Once the user selects an inscription, they can place its hologram within the physical space, for example, on the top of a desk. The user can study the inscription by naturally walking around the hologram. Fine details of the inscription can be studied by scaling up the hologram using natural hand gestures. In addition, the user can rotate, scale and move the hologram in the real space, as well as open multiple holograms simultaneously. This feature is useful, especially for the comparative study of objects. For example, multiple inscribed fragments can be brought together as holograms on the top of a table and studied next to one another. Furthermore, the benefits of this project are numerous, as it allows the inscriptions to be studied along with their bearer, thus contextualising the inscription and providing a holistic record of the artefact to the scholar. Finally, classrooms, libraries and museums are a few examples of environments that can be augmented using the models from our database, offering a unique learning experience to students, scholars and visitors in general. A live demo of the holographic interface is available to watch at: https://www.youtube.com/watch?v=yh6MyLLFSTo.

The facility to study artefacts through this virtual physicality while having a creating and participatory role resembles Borges' table in the story of Funes, which I mentioned above. In this work, the protagonist suffers an accident that leaves him unable to forget anything. Therefore, he needs to find a non-linear form of memory and knowledge and attempts to create a new language to be in a position to examine, store and work through knowledge. Similarly, Foucault presents heterotopia as a space where one examines many spaces in one. Therefore, in addition to preservation, dissemination and the multiple other advantages of 3D digitisation and augmented reality, one needs to also reappreciate the production of new knowledge. The DEA focusses on advanced visualisations and enhanced physicality to enable the user to study the artefact closely but also reexperience it by reembodying its physical existence within virtuality that, to some extent, involves the user as well.[15] Rousseaux and Thounevin embrace Foucault's theory, on the basis of which they reconstruct virtually an abbey in Compiègne that was partially destroyed in 1790. Their approach, contrary to the DEA, chose to effectuate the philosopher's claim to the rebelliousness of heterotopy. They decided that "Anachronisms were not necessarily problematic and that an air of fiction or even scandal could be maintained" (Rousseaux and Thounevin 2009, 180). The case of the abbey, which is still part of contemporary life to some extent, and therefore is still being experienced by people,

[15] Landeschi (2019, 8), on a similar note, argues: "Considering the human body as a 'universal measurement' (Betts 2017, 23) whose physiological characteristics are almost unchanged from antiquity, it makes sense to use it as a proxy for exploring the perceptual activity of past human agents". See also Richards-Rissetto et al. (2012).

Fig. 3 On the left: a photograph captured by our holographic application, showing the hologram of an inscription rendered on top of a real table. On the right: a photograph of the physical space is shown for comparison without any holograms

may necessitate a certain degree of liberty. On the other hand, the DEA has utilised Foucault's rebelliousness more practically, as the project considers digital tangibility, physicality and the augmented degree of realism as the major immanent factors of reconsideration and rebellious reappreciation of knowledge.[16] So, the DEA focusses on a type of advanced physicality that may lack the sensory aspects of tactility but provides options for study and visualisation that are not available in real life and can facilitate and reconstitute physicality and its affordances (Fig. 3).[17]

5.2 Reconstituting Physicality Through 3D Printing

The last component of the DEA's attempts to re-physicalise the past is 3D printing, an attempt towards actual physical presence that still stems from the digital object. Benjamin's words on authenticity may be ringing heavily in our ears, but, as I have argued elsewhere, modern technologies can now claim a different type of originality (Bozia 2018). Additionally, one cannot be reductive when recreating experiences for present and future generations and finding a renewed physicality and locale for objects that would otherwise be considered simply remnants of the past and irrelevant to modern audiences. Sloan (2012), as well as Neely and Langer (2013), among

[16] Chen et al. (2013) experiment with an augmented reality information system to enhance the museum experience in Taiwan. Hoang and Cox (2017) also stress the exigency for an "interweaved reality", as they call it, where virtual reality mixes with physical environment thus: "Allow[ing] the visitors to draw the connection between the two sources of information" (402).

[17] There are haptic technologies that can recreate the sense of a physical object more closely, but such a discussion is beyond the scope of this chapter. For information on the topic and studies on haptic technologies and their advantages, see Israr et al. (2016), Ryu et al. (2006).

others, extol the contributions of 3D printing to the embodiment, engagement and understanding.[18]

The DEA has been working with the Marston Science Library at the University of Florida that uses Fusion F400s, F306s, Lulzbot Taz6, and Ultimaker 3 Extended 3D printers. The printers offer options for different materials, such as ceramics and metal. Such possibilities advance the sense of touch and reality of experience even further. The DEA, cognizant of the above analyses and the patent need for physical interaction, has been using 3D printing as another means of experiential spatialisation. Several artefacts have already been re-physicalised thus and brought to classrooms and research meetings.

As Erwine (2016, 88) points out, "When our hands probe the texture of a surface, we don't register a simple feeling of "touch." Instead, we experience an intricate combination of stimuli relating to pressure, skin stretch, vibration, temperature, etc."; and later, "As this process is extended to our participation in the built environment, we come to understand objects and structures in relation to the measure and form of our own bodies" (2016, 99). This chapter makes a case for a different type of physicality that explores other aspects of the digital object and the advantages of digital technologies. Sensorial apprehension is undeniably seminal for our understanding of the world. With this in mind, the DEA explores the affordances of a digital-physical existence and its unique sensorial presence.

6 Conclusion

In conclusion, technological advances have afforded us unique opportunities for research, teaching, preservation and dissemination. A crucial aspect that has evaded archaeological studies, though, as we have focussed solely on rediscovering and understanding the past, is that, when we view historical artefacts only as objects of study, we are being reductive to their existence and transhistorical significance. The concept of cultural presence was developed in the early 2000s and explored as a *sine qua non* for historical understanding, the notion, as Pujol-Tost (2017, 249) puts it, of: "Being there and making sense there and then together". Within this framework, the DEA aims to re-physicalise artefacts, giving them a contemporary afterlife, promoting their relevance in modern cultural understanding, and ultimately creating our own here and now and bringing the past to it.

Peter Aronsson, the European National Museums Project Coordinator, said: "A museum isn't a house. It is an idea in debate". The DEA has embraced this very premise. Enhanced visualisations, augmented reality and 3D printing enable users to connect with each object, reach their own understandings and apprehend the artefact

[18] For further bibliography on 3D printing, see Bozia (2018).

within their own culture.[19] Such a meaningful, engaged, active and participatory presence can guarantee a cosmopolitan shared future that will enrich the lives and experiences of future generations.

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