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Interpretation at the Controller's Edge: Designing Graphical User Interfaces for the Digital Publication of the Excavations at Gabii (Italy)

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Abstract: This paper discusses the authors' approach to designing an interface for the Gabii Project's digital volumes that attempts to fuse elements of traditional synthetic publications and site reports with rich digital datasets. Archaeology, and classical archaeology in particular, has long engaged with questions of the formation and lived experience of towns and cities. Such studies might draw on evidence of local topography, the arrangement of the built environment, and the placement of architectural details, monuments and inscriptions (e.g. Johnson and Millett 2012). Fundamental to the continued development of these studies is the growing body of evidence emerging from new excavations. Digital techniques for recording evidence "on the ground," notably SFM (structure from motion aka close range photogrammetry) for the creation of detailed 3D models and for scene-level modeling in 3D have advanced rapidly in recent years. These parallel developments have opened the door for approaches to the study of the creation and experience of urban space driven by a combination of scene-level reconstruction models (van Roode et al. 2012, Paliou et al. 2011, Paliou 2013) explicitly combined with detailed SFM or scanning based 3D models representing stratigraphic evidence. It is essential to understand the subtle but crucial impact of the design of the user interface on the interpretation of these models. In this paper we focus on the impact of design choices for the user interface, and make connections between design choices and the broader discourse in archaeological theory surrounding the practice of the creation and consumption of archaeological knowledge. As a case in point we take the prototype interface being developed within the Gabii Project for the publication of the Tincu House. In discussing our own evolving practices in engagement with the archaeological record created at Gabii, we highlight some of the challenges of undertaking theoretically-situated user interface design, and their implications for the publication and study of archaeological materials.

Keywords: Design, Intra-site applications, Close Range Sensing, Virtual Reality and Cyber-Archaeology, Digital Publication

1 Introduction

A growing number of excavations are using various technologies to create detailed and accurate 3D models of stratigraphy and structural remains in the field. For example, the excavators at Çatalhöyük have implemented a program of laser scanning and structure-from-motion photogrammetry (SFM) to record the

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archaeological remains uncovered in some of their trenches (Forte et al. 2012). At Pompeii an extensive program of laser scanning has been carried out by the Swedish Pompeii Project (Dell'Unto et al. 2013). In the heritage management sector we see a similar trend (De Reu et al. 2012), as the practical benefits in speed of work and cost savings have a clear appeal. At the Gabii Project (Figure 1) (Opitz and Nowlin 2012), since 2009 individual stratigraphic units have been documented using SFM, and stratigraphic sequences are assembled digitally in the project's GIS environment or ad hoc using various 3D modeling packages.



Figure 1. Gabii is located approximately 18 km east of Rome in central Italy. Ongoing excavations by the Gabii Project (University of Michigan) are the source of materials for the digital publication project and interface discussed in this paper.

At present, the means and strategies of creating 3D models vary between projects, and will likely continue to do so as the method matures. In all cases, however, graphical user interfaces (GUIs) are the basis of interaction for the software and applications used to interpret, share, and interact with the results of 3D field documentation. In general, user interfaces entail the aspects of a computer system or program with which users interact, including onscreen displays, command prompts, characters, and even physical objects like mice and keyboards (Landsdale and Ormerod 1994). In their graphical form, user interfaces rely on the use of icons and condensed representations of complex systems. Today, GUIs are ubiquitous in our daily lives, providing interaction for websites, games, mobile applications, and nearly every other form of media (Hashimoto 2013, Ishi 2008). Consequently, they are practically invisible, yet their design can play a subtle and crucial role in our engagement with digital materials, including those used by archaeologists (Brödner 2013, Dorst 2006, Oswald 2013, Perry 2015, Quanjer 2013, Sengers et al. 2006). In this piece, we attempt to illustrate how a theoretically informed approach to designing GUIs can help mediate between “raw”

data and the researchers who wish to interpret it, and can encourage a slower, more reflective, embodied interaction with the 3D digital versions of archaeological materials.

Our efforts toward theoretically-informed GUI design operate in the context of the concern among some archaeologists that the efficient production of accurate 3D models is rapidly becoming an end in itself (Caraher 2015, Carlson 2014, Dallas 2015, Demetrescu 2015, Hermon 2008, Hermon and Kalisperis 2011, Kansa 2015, Reidel and Bauer 2007). This concern is embedded in a broader anxiety about the role of digital technologies in archaeological practice. As stated by Dallas (2015, p.177), echoing sentiments found in Huggett (2012 and 2015), “It is not accidental that digital archaeology is thus laid open to critiques of being technocratic, apolitical and indifferent to social and cultural concerns and of relating poorly with ‘theoretical orientations currently found in archaeology,’ giving rise to an ‘anxiety discourse’ that considers it ‘under-theorised’ and casts doubts on the value of its broader theoretical import.” While we acknowledge the importance of efficiency and accuracy in field documentation and the role of 3D documentation in achieving these ends, investment in these methods should not preclude our use of 3D data and models to create an archaeological record that is well-theorized, complex, dynamic,” and of a “profoundly human character” (Kansa 2015). We suggest that GUIs should be employed to contextualize 3D data and models, with their apparent precision and completeness, within the fluid, sometimes messy process of archaeological interpretation, and that their design is an opportunity to provide theoretical orientation for digital projects. Watterson (2015, p.122) points out in her discussion of visualizations and visual media that “digital archaeology needs to move forward as a discipline and establish a more productive approach to making and consuming [these] images and consider the ways in which they can influence and aid in the creation of new knowledge.” We suggest that a well-designed, theoretically-informed GUI can aid archaeologists toward a more sophisticated engagement with these media.

We illustrate our approach to the design and use of GUIs through our prototype interface for the Gabii Project’s digital long form publication series (Figure 2), specifically for the publication of the mid-Republican phases of the house from area B, known as the Tincu House. This interface is an experiment in design for archaeological publications which seek to integrate long-form narrative text and interpretation with rich data publication, specifically including 3D models. Its development has served as a practical exercise in attempting to carry out theoretically-engaged interface design based on the principles discussed below.

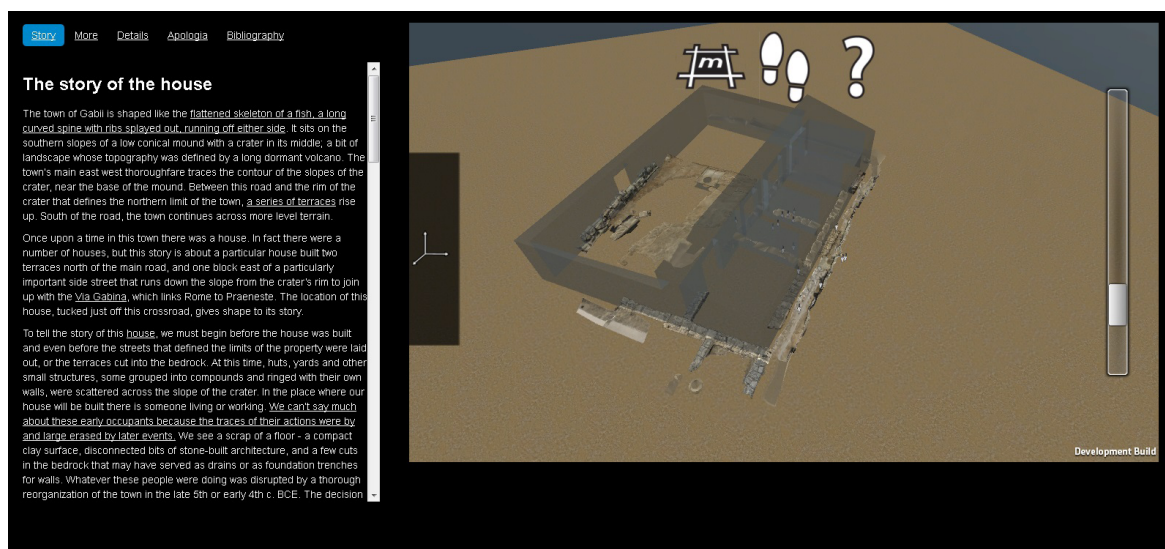


Figure 2. A prototype of the format of the digital publication shows narrative text on the left, with hyperlinks referencing the interactive scene, shown on the right, and linking to the project’s data repository. The interactive scene contains detailed 3D models, reconstructions, and short textual descriptions. The interface discussed in this paper allows the reader-player to navigate between narrative text, data repository, and the 3d scene.

2 Principles

2.1 The “Slow” Approach

Recently, archaeology has seen a growing criticism of the relationship between 3D field recording and what some perceive to be an industrial approach to creating archaeological knowledge. While advances in laser scanning and SFM provide for faster and more cost-effective field documentation, they also risk encouraging “the ‘mass-production’ of interchangeable, standardized, and fungible outputs” (Kansa 2015) over intellectual engagement with the materials being documented. Caraher’s recent call for a “slow archaeology,” for instance, advocates for a framework which, rather than remaining fixed upon the accuracy and efficiency of digital tools, connects their outputs with the “complexity of archaeological landscapes, trenches, and objects” (Caraher 2015). Kansa (2015) presents a similar vision of “slow data” in archaeology, and adds that an increasingly “industrial” approach to documentation is just the latest effect of neoliberal thought, which strongly values productivity and management, on academia (Kansa 2015). As a counterpoint to the industrial approach, Kansa stresses the need for the “thoughtful digital curation” of archaeological materials, showing that a slow approach, in addition to enriching fieldwork, is important during post-excavation (Kansa 2015). The rapid growth of digital data collection over the past decade no doubt informs these arguments. At the same time, they are connected to a broader tradition of criticism, with roots in Hodder’s *reflexive archaeology*, of a strictly positivist, objective view of archaeological materials which separates interpretation from data (Chadwick 1998, Hodder 1997, Hodder 2000, Hodder 2003).

In calling for a slow approach to archaeology and 3D data, Caraher and Kansa by no means ask the community to eschew digital tools altogether (Caraher 2015, Kansa 2015), but rather to be aware of the effect of digital tools on archaeological process. Archaeology is not alone in these concerns, and recent approaches in interface design, such as *reflective design*, emphasize that technology does not necessarily imply a “fast” approach to information and virtual interaction (Quanjer 2013, Sengers et al. 2006). While these concerns have been voiced, the interfaces of the most popular software choices within archaeology (e.g., MeshLab, various GIS packages) are developed with a broad spectrum of industry users and efficiency in mind (Wright et al. 1997, Sharon et al. 2004), and can’t be expected to adhere to the particular needs of archaeologists looking to encourage certain behaviors. GUIs designed for specific archaeological purposes (e.g. Lisa Snyder’s VSIM, L-P Archaeology’s ARK database framework, numerous websites and online databases hosting archaeological materials) however, are inherently linked to the questions surrounding archaeological documentation and practice. By including in their development and dissemination a discussion of design principles and goals, these exercises in design can explicitly link their interfaces with specific archaeological questions.

This linking of media and theoretical orientation is not new to archaeology: the field has a long history of using visual representation to communicate and encourage direct reflection on archaeological materials (Adkins and Adkins 1994, Carlson 2014, James 2015, Moser 1992, Piggott 1965, Piggott 1798, Perry 2009, Perry and Johnson 2014, Reilly 1989) and recognizes the critical role of visual media in the production of archaeological knowledge (Boast and Biehl 2011, Molyneux 2013, Pavel 2012, Shanks 1997, Shanks 2012, Smiles and Moser 2005, van Dyke 2006). Interactive digital media use GUI systems to perform this same mediatory function. How might we creatively connect the loose conventions of digital interfaces in general with our archaeological goals? In our case, in order to provide a “slow” and reflexive post-excavation experience with digital data, our archaeological interface must not only provide an accurate model of the dataset in question, but also interpretations generated throughout the excavation process. At the same time, our interface should be intellectually rewarding to use and explore, involving users in the process of critiquing and creating meaning out of field data, helping to achieve a “slower” post-excavation experience by providing reflective, embodied engagement with the archaeological record via 3D representation.

2.2 Reflective Design and Reflexive Archaeology

In the field of design studies, one approach which underscores the significance of user interpretation and criticism is reflective design (Sengers et al. 2006, Scollan 2007, Quanjer 2013), mentioned above. At its core, this approach encourages critical self-awareness of the “unconscious values embedded in computing and the practices that it supports” (Sengers et al. 2006, p.1). Reflective design emphasizes intellectually rewarding user experiences, and is critical of the task-oriented, efficiency-driven approach to design advocated by more traditional models within design studies (Landsdale and Ormerod 1994, Quanjer 2013). In fact, it is partially a deliberate response to the centrality of the concept of “work” within interface design, and sees task-oriented approaches as running the risk of “making all of life like work” (Sengers et al. 2006, p. 1). In attempting to challenge efficiency-driven design, reflective designers will often focus on slower, less deliberate ways of carrying out tasks which provide ample opportunity to users for self-examination, and this is clearly akin to the general sentiment expressed by Kansa and Caraher.

Reflective design also shares a deep theoretical affinity with reflexive archaeology, and we situate our design principles in relation to both reflexive and slow archaeology (Caraher 2015, Kansa 2015, Hodder 2000). Reflective user experiences support “users in reflecting on their lives,” as well as “skepticism,” dialogic engagement,” and “interpretive flexibility” (Sengers et al. 2006, p. 6-7), all of which resonate with the central values of reflexive archaeology (Hodder 1997). Both emphasize a multi-vocal, fluid approach to meaning-making, as well as a recursive relationship between producers and users of knowledge and interfaces. While reflexive archaeology begins the interpretive process “at the trowel’s edge,” it also involves a closer integration of interpretation with data, and the critical awareness supported by reflective design can be helpful for achieving this. We thus consider reflective design a fitting starting point for creating slower, more critical user experiences with archaeological data.

2.3 Embodiment

If archaeological interface design is still a nascent concept, the field of game design has long been concerned with creating compelling forms of interaction with 3D environments. Game design continues to develop a rich critical tradition and awareness of the cultural impact and theoretical implications of video games. Furthermore, the intersection between games and archaeology/cultural heritage studies has become a recent area of academic interest (Frost 2012, Kapell and Elliott 2013, Kateros et al. 2015, Kyriakou and Hermon 2013, Lercari et al. 2013, Reinhard 2015, Travis 2015). Game critics like Keogh (2014) and Shinkle (2003) stress that the phenomenon of *embodiment* is central to the way individuals engage in gameplay and virtual interaction. According to the model of embodied gameplay, players are not physically distinct from, but a component of the video game as text. Swink (2008) argues that gamers do not simply respond to visual feedback, but are “caught up in a circuit of organic, technological, and representational actors and materialities” (quoted in Keogh 2014), and their corporeality is thus “redistributed across the circuit” which starts with their physical bodies, moves through the controller, to the game console, and finally to the onscreen interface. What results is an intuitive sense of embodiment, partially rooted in but also distinct from the player’s physical being.

The notion that interfaces can facilitate embodiment clearly challenges the idea that virtual environments are too ocular-centric, and thus “amputate” the majority of the sensory range (Chrysanthi et al. 2012). For Shinkle (2003), overemphasis on the visual aspect of digital representation is rooted in Renaissance notions of perspective and, influenced by the pervasiveness of the Cartesian ideal in western thought, suggests a self which is distanced from the body. Ultimately, however, it is rash to assume that visibility can account for the entirety of gameplay’s combination of “semiotics, actions, and systems” (Keogh 2014). Far from advancing a view of “amputation” during gameplay and virtual interaction, the frameworks developed by Keogh and Shinkle show that all interfaces require some form of bodily interaction.

We are primarily interested in embodiment as a component of interface because of the way it can provide a unique form of interaction with digital materials in archaeology. For example, free exploration

of a set of 3D models using a “game-like” first person controller can elicit an innate sense of a site’s spatial context. As users navigate an environment in real time they become actors in a system of space, movement and, archaeologically speaking, contextual features and materials. Direct interaction with this system, which is necessarily more than sum of its constituent parts, is itself a compelling way of communicating archaeological information. In other words, the multi-sensory, kinesthetic aspects of game-like interfaces can elicit a distinct form of proprioception and self-awareness among users (Keogh 2014, Swink 2008). We consider this beneficial to a slower approach during post-excavation. Embodied action is a more thorough, sensorily engaging way of interacting with a site than strictly visual, disembodied forms of representation (e.g., a 2D site plan). It can also help us be more reflexive, since increased self-awareness and non-linear exploration can encourage the “de-centering of the author” and involve users in the process of interpretation and critical examination (Hodder 1997).

We wish to be clear that the embodied nature of interfaces is different from the embodied nature of physical interaction with archaeological materials. Virtual interfaces require us to overcome the challenge of thinking archaeologically in an unfamiliar setting (i.e., the virtual environment). When archaeologists make observations and interpretations on-site, they are acting within a set of familiar daily routines. The performance of archaeology as a social, sensory, and interpretive action activates personal memories and lessons-learned, helping excavators to predict outcomes and relate new stratigraphy to previous experiences. In a virtual environment, on the other hand, the familiar cues of these daily actions are absent. Especially for archaeologists who are not accustomed to navigating and scrutinizing virtual or game environments, the embodied component of 3D representation can be visually jarring and spatially disorienting. For now, we can offer that when exploring a 3D representation of an excavated site, GUIs can provide some of the structure provided by context sheets, tapes, cameras and other tools that guide our on-site routines. GUIs can be designed to keep basic tools of the trade near at hand: descriptive and analytical information for different features, photos and charts, and connections between contexts. In this way, 3D interfaces act as a post-excavation complement to the tools and routines used during excavation.

2.4 Digital Media and Archaeological Scholarship

The design and functionality of our interface draws on a tradition of experiments in digital publication format in archaeology. These publications use alternative formats and the flexible nature of digital interfaces to encourage reflexivity on the part of the reader, and a deeper engagement with the archaeological materials and their interpretations. The importance of these experiments has been highlighted by Dallas (2015) in his discussion of the work of Jean-Claude Gardin, arguing for, “the centrality of processes of representation in the formation of the archaeological record and the construction of archaeological knowledge,” and noting that, “Gardin differentiated sharply between two kinds of archaeological works: ‘compilations’ for example, catalogues of finds, or excavation reports – concerned with material remains of the past and their attributes, and ‘explanations’ for example, synthetic monographs and interpretive studies – concerned with ancient societies, their history and mode of life,” (Dallas 2015, p.181-182) – a distinction many data + synthetic publications seek to elide. The work of Ruth Tringham, and her students and collaborators, is notable in this context for the use of hypertext to encourage multi-scalar interpretations utilizing the Chimera Web (Wolle and Tringham 2000; see also Joyce and Tringham 2007, Morgan 2009). Hypertext, in archaeological and humanities publications more broadly, encourages the reader to explore connections between aspects of an argument or facets of a narrative, and between data elements and story.

Beyond the use of hypertext to link parts of an interpretive publication, we have seen a growing number of publications that are effectively hybrid data publications – synthetic interpretive publications, which use hypertext to link data to interpretation, and back again. Journals like *Internet Archaeology* have played an important role in providing an academic-approved venue for these hybrid works. *Internet Archaeology* has made the use of more reflexive interfaces leveraging digital technology an explicit part of its mission, stating that the journal, “explores the potential of electronic publication through

the inclusion of video, audio, searchable data sets, full-colour images, visualisations, animations and interactive mapping,” (<http://intarch.ac.uk/>). Leveraging a close collaboration with the Archaeological Data Service, the journal is succeeding in encouraging a data + publication model and other independent initiatives, e.g. L-P Archaeology’s Prescott Street Project are self-consciously promoting a, “reflexive, open and participatory” archaeology (Dallas 2015; Morgan and Eve 2012; Sanchez 2013). Our publication project builds on this model, combining the release of the project’s stratigraphic database for the area with the synthetic publication.

The implications of digital media, and implicitly interfaces, for publication have been discussed explicitly (Biehl 2004, Kansa 2011, Morgan and Eve 2012, Perry 2013, Shanks 2007, Shanks 2010, Watterson 2015) for over a decade. The blurring of individual authorship and the rise of the collaborative research paradigm are highlighted as consequences of the inclusion of 3D media as part of publication interfaces. Projects, notably Çatalhöyük, The Swedish Pompeii Project, and MayaArch3d (Dell’Unto et al. 2013, Forte et al. 2012, Landeschi et al. 2016, von Schwerin et al. 2013 respectively) including 3D models and interfaces in academic publications have described them in explicitly analytical terms. MayaArch3D describes their interface as a “3D GIS”, implicitly (and perhaps unintentionally) forming an abstracted engagement with 3D digital data. The authors of these publications have emphasized the role of 3D in providing a more direct link to the archaeological remains, encouraging more participation in the archaeological process and allowing for a multiplicity of interpretations, explicitly operating on the analytical and abstracted level. Our interface shares these intentions, and aims to add an embodied layer of engagement with the 3D digital media to the analytical, abstracted one, primarily through the deliberate use of a first person navigation mode.

The VSIM Project, led by a team at UCLA publishing aspects of the Karnak Project excavations, shares our use of a first person controller as the primary mode of navigating their 3D data in the context of scholarly publication (Snyder 2014). Numerous museum and heritage projects intended for a general public audience (Andreoli et al. 2005, Fuchs and Eckermann 2001, Kateros et al. 2015, Kyriakou and Hermon 2013, Lecari et al. 2013, Loizides et al. 2014, Woolford and Dunne 2013) likewise use first person controllers as the main mode of exploring a 3D digital representation. While these projects share the use of FPC navigation, the connection between their chosen interface design and archaeological concerns with embodiment and reflexivity remain implicit.

In explicitly discussing the links between theoretical orientations and design principles, we wish to emphasize that a well-designed GUI can help expose the 3D models produced in recording an excavation’s stratigraphy, structures, and objects to critical scrutiny. GUIs help provide communicate *ideas* about 3D representations, much in the way that the visual language of drawing conventions communicates essential information in traditional illustration (Adkins and Adkins 1994, Moser 2012, Opitz and Limp 2015, Perry 2013, Watterson 2015). In this way, they enable digital 3D content to act as an intermediary between researchers and the materials they study. This is important for archaeology, a discipline closely engaged with the material world and things, but also with people and societies past and present.

3 Practice: The Tincu House Interface

3.1 Platform

The creation of the Tincu House interface included a series of concrete decisions about the design of the GUI in order to accommodate a combination of visual, spatial and textual information. The structure in question is a mid-Republic Roman house, recorded during the excavations of the Gabii Project in 2009-2011. In the 2009 season, surveyors with the project began documenting features using SFM. This technique is a cost-effective way of producing high-resolution models and textures of materials (Dell’Unto et al. 2013, De Reu et al. 2013, Kjellman 2012, Lerma et al. 2010, Opitz and Nowlin 2012). More importantly, the models produced using SFM are easily rendered using a tool like a game engine, which allows for the creative design of purpose-made user interfaces. While the series of models produced between 2009-2011 is not

fully comprehensive (not every stratigraphic unit or architectural feature was documented using SFM), it is representative enough to form the basis of an interactive representation of the Tincu House, as excavated. In addition to SFM recording, the limits of each stratigraphic unit were surveyed and logged into a GIS, while data from context sheets for each stratigraphic unit was entered into the Gabii Project's Ark database, where it continues to be hosted on the web.

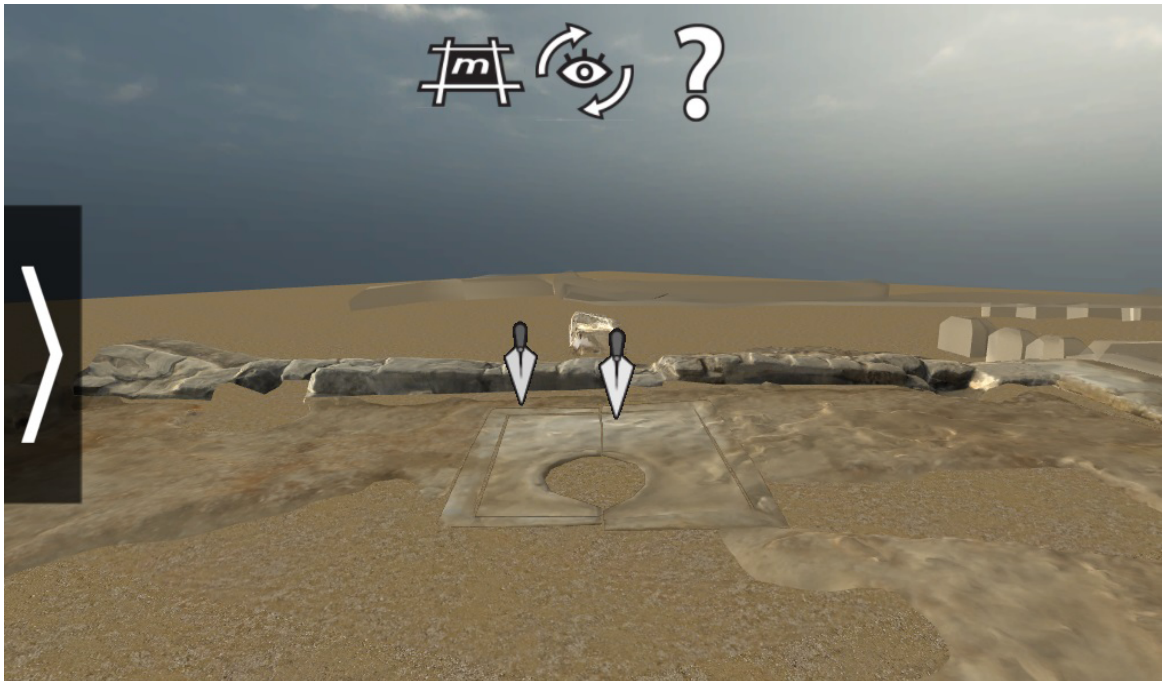
The game engine Unity 3D (henceforth Unity) was chosen to build the interactive 3D visualization component of our interface. Unity's capacity for lighting, rendering, and texture mapping 3D models allow for a visually appealing and tidy representation of field data. Its ability to accommodate the diversity of our dataset and the extensive options it provides for building first-person and alternative navigation systems make it a flexible toolkit that can accommodate the unique needs of an archaeological interface. The content we have produced with Unity serves as the central hub of our online publication interface, linking between a side-by-side presentation of the game-based 3D environment, a synthetic narrative text containing hyperlinks which interact with the game environment, and the Gabii Project's online database, accessed in a separate browser tab or window (Figure 2). Central to the design of the GUI and the engagement of a reader-player with the publication is the manner in which navigation is handled in the game-environment, and between the game environment and other interface elements. In treating navigation as a primary element of the GUI, we are implementing the design principles discussed above, and adding to a growing set of approaches to digital publication interfaces in use in archaeology, taking an approach that foregrounds an embodied engagement with the archaeological record.

3.2 Adding Digital Embodiment

Our interface actively promotes an embodied engagement with the archaeological materials through the use of a first-person-controller (FPC) as the default mode of navigation within the 3D portion of the interface. Digital embodiment is obviously not the same as physical embodiment, but, as we have shown above, it serves a complementary role. The interface consciously uses movement through the space as part of the process of linking text and data: to go from the synthetic narrative to the granular data a reader-player must move within the 3D space. Access to information about a distant feature requires moving toward it, as the icons providing links to the granular data are triggered by proximity of the reader-player. In short, the interface makes movement and navigation in the space, virtual embodiment, a prominent part of engaging with the record.

Navigation is a core element of the overall interface and user experience, and has a meaningful impact on how the user views and interacts with GUI elements. Navigation is also a “transparent,” or implicit part of our interface (Bolter and Gromala 2006), in that it is not presented through a visible graphical or textual element (Figure 3). Rather, it continuously responds to keyboard and mouse inputs from the reader-player, shifting the position of the FPC. Like the majority of first-person games, our interface allows players to move the FPC throughout the scene using controller inputs. For this project, the “controller” entails the so-called W-A-S-D keyboard commands, allowing the player to walk in each direction, effectively acting as virtual feet. Meanwhile, mouse movement controls the direction the camera is facing, serving as a sort of virtual head. This combination of moving and looking suggests an embodied player, and since these features are controlled with the keyboard and mouse, they do not require any graphical representation onscreen. The result is a dynamic input-feedback loop arising between the physical actions of the user (clicking, pressing, etc.) and the movements that occur onscreen. The embodied experience a reader-player has by navigating in the 3D space provides an intuitive sense of spatial relationships not available by just ‘looking’ at an image. This sense of movement is essential to engaging the brain in spatial thinking and the physicality which the 3D models represent. The connection between movement in a space, a sense of personal embodiment and the physicality of our surroundings, and how we interpret these things is an idea that has been discussed by both game critics and archaeologists (Favro 2013, Hamilakis et al. 2002, McGowan 2006, Olsen 2010, Tarlow 2000, Tilley 1994). The standard FPC used in this publication, by providing a means of navigation, provides an experience that is embodied and archaeologically meaningful.

a)



b)

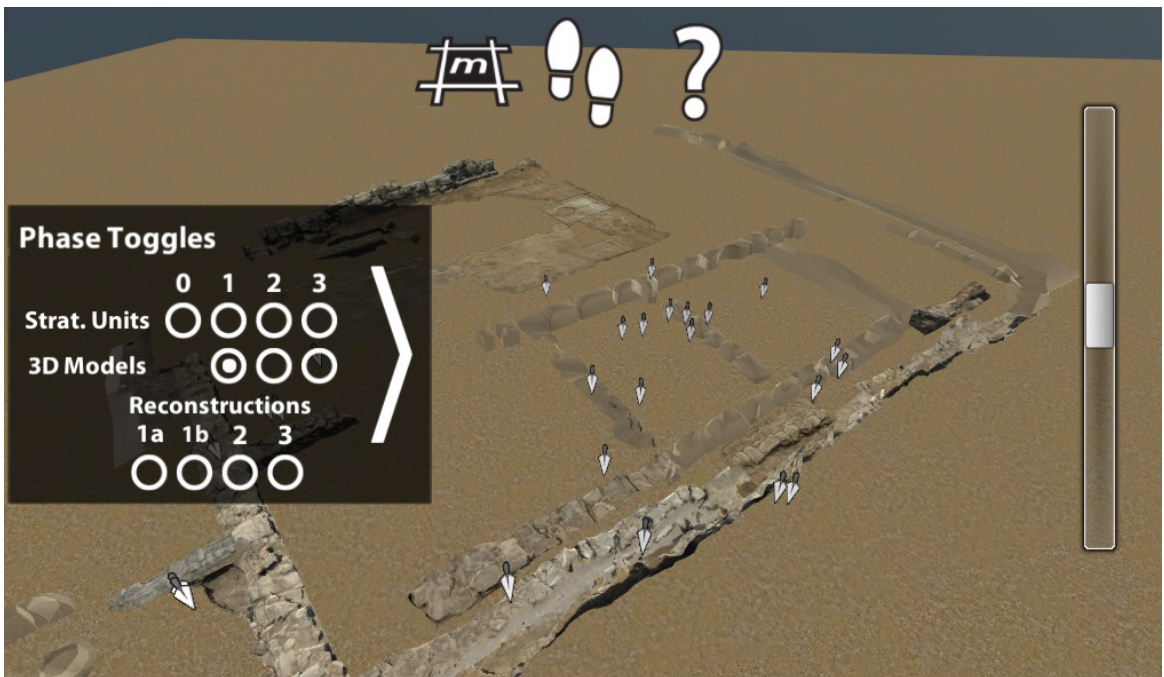


Figure 3. The 3D scene can be viewed in 'walk' mode, as if standing on the ground on the site (top image – 3a) or from an overhead plan view (bottom image -3b).

3.3 Embodiment: Collision

An important aspect of navigating with an FPC is interaction with colliders in the virtual environment. Colliders are components of 3D meshes that allow game engines like Unity to recognize them as solid objects. For example, using the standard physics settings of a Unity scene, two objects with colliders cannot pass through one another. By placing colliders on both the FPC and large surfaces like walls and floors, designers can constrain physical movement in a way that mimics “real-life” navigation. This, we hope, helps to create a sense of the physical rules of a space. In our interface colliders constrain the movement of users by not allowing them to proceed “through” walls or other things that shape where human bodies can go in a space. This conveys some of the kinesthetic properties of a site which are impossible to capture via non-interactive media like photographs or plans. Phase and state plans, which are commonly used to convey information about a stratigraphic sequence, provide a condensed, static representation. These snapshot views are essential for the rapid communication synthesizing an excavated sequence or visually sketching out connections between features. Movement, however, even the kind facilitated by virtual embodiment, allows for an experience with materials which extends beyond the purely visual and the summary information conveyed by plans.

3.4 Embodiment: Movement

Another way in which the design of the navigation system impacts the interpretive experience is the speed at which the FPC in the game-space may move. The slow moving FPC is a deviation from the standard mode of movement in games and virtual spaces, where quick movement is preferred as it conveys a heightened sense of urgency and discovery. By putting the FPC at a casual walking pace, the interface for our publication uses the design of its navigation system to invite users to spend more time moving deliberately through the space and taking the time to appreciate its complexity, a principle advocated by proponents of reflective design (Quanjer 2013, Sengers et al. 2006). Unlike reading an archaeological state or phase plan - where the eye can move rapidly between areas of a site that are actually separated by some distance - our FPC requires users to “walk” from one point to another, creating the opportunity to observe and take note of features lying along their path of movement which might otherwise have been under-appreciated.

3.5 Breaking the Fourth Wall and Moving between Embodied and Abstracted Engagement

Our GUI uses navigation through the 3D space as a central component, but must also allow reader-users to access various types of information and means of engaging with content. For instance, the vertical nature of stratigraphy means that our interface must provide access, both visual and interaction-based, to elements that sit below other things and are hidden from mouse-touch and view. We resolve this problem by abstracting each stratigraphic unit into a GUI icon which “floats” near the context. Clicking these opens the corresponding information pop-up, and gives the user a sense of the extent of the stratigraphic unit by visually highlighting its limits. Effectively, our interface makes a reader-player repeatedly ‘break the fourth wall’ between embodied and abstracted engagements, and provides multiple paths between the two.

In this way, the use of an FPC for navigation, as implemented here, also serves another principle of reflective design: presenting familiar concepts in new or strange ways (Sengers et al. 2006). Even though first-person embodiment is somewhat suggestive of real life archaeological experiences, plans, photographs, matrixes, or other abstract, static - and thus disembodied - representations are the most common way of interacting with a site during post-excavation. FPCs, then, offer an alternative way of experiencing sites. While our interface makes navigation via an FPC central to how a reader-player engages with the publication, the GUI also integrates the static photographs, matrixes, and descriptive information that are familiar elements of post-excavation materials (Figure 4). This also creates a sort of bridge between unfamiliar and familiar ideas. Sengers et al. (2006, p. 8) argue that experiences which are overly jarring can “alienate, confuse, or simply not interest people.” Our interface’s response to this principle also involves

providing users with an alternative, perhaps more familiar way of looking at the Tincu House: a so-called “orbit camera.” This mode of viewing, which allows users to orbit their camera, at varying levels of zoom, around arbitrary points in the structure, provides a second means of navigation. An orbit camera, which mimics the way an eye moves across a more holistic, overhead view of the structure, is similar to what archaeologists are accustomed to from site plans. Alternation between these two modes of viewing and moving is facilitated by a GUI button (Figure 5). The intention behind the possibility for quick alteration between the two modes of navigation is to build connections between strange and familiar, between embodied and abstracted modes of interpretation.



Figure 4. Pop-up windows in the scene provide a synthetic view of the data about each stratigraphic unit. Further information can be accessed by clicking on the ‘ark’ button, which links to the data repository.

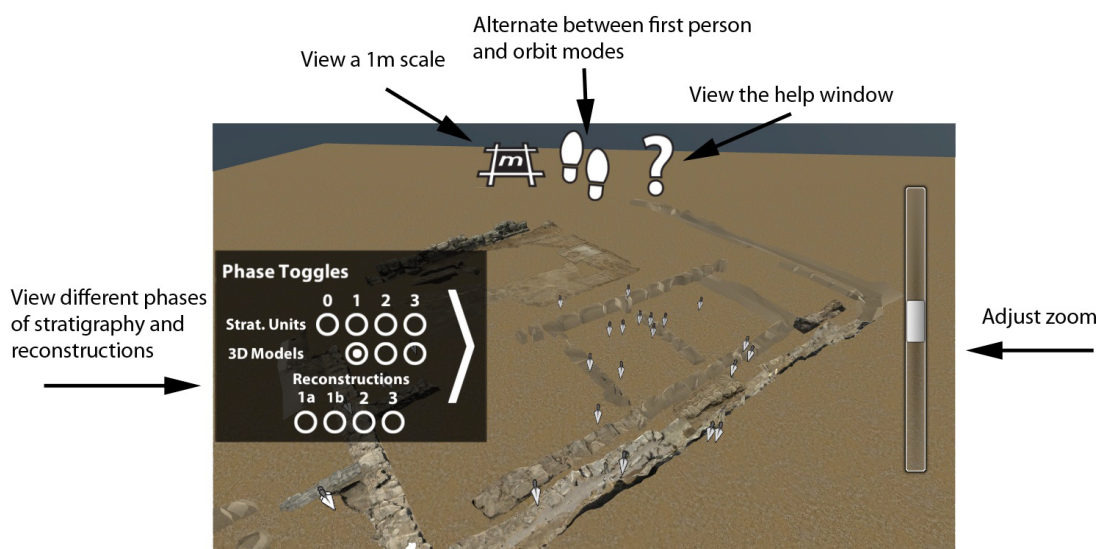


Figure 5. An annotated view of the prototype interface for the Gabii Project’s digital publications.

In addition to navigation within the game-based environment, the GUI for the Tincu House publication manages navigation between the accompanying narrative text and descriptive data windows. This navigation also constitutes a type of movement, as the eye tracks across the screen and visual attention flicks between different GUI elements. At the same time, any embodied or spatial movement or navigation fundamentally alters in character when navigation between these different windows, and different presentations of the information, begins. This interruption of the flow of exploration of the primary visual content is an unorthodox design choice because it disrupts the need for simple, readable structures which the human eye can rapidly scan and process (Landsdale and Ormerod 1994). However, this disruption is necessary because any publication of the results of an excavation must communicate basic information about what was found. Since data about finds, estimated dates, and phasing are generally concise and of a serial nature (unsurprisingly given its origin in form-based context sheets) it lends itself to a template format. In the Tincu House publication this type of information is presented in “pop-up” windows which show selected elements of the complete descriptive record when a context is selected, either from a link in the main narrative text or in the game-based environment. The complete database entry for each unit can be accessed via a link in the pop-up window.

Along similar lines, coherent, linear, interpretational narratives are a major expectation of the archaeologically community because they are the de facto familiar mode of interaction with archaeological information and interpretation. The narrative text for this publication is displayed alongside the visualization and contains hyperlinks which, when clicked, move the user's camera to whatever feature the text is describing and opens its corresponding information pop-up (Figure 4). This side-by-side presentation directly bridges familiar and strange modes of interaction with archaeological information. The long-form text communicates interpretations and context for the information presented in the game-based environment and the pop-ups and web database. In this way, our interface facilitates two primary modes of exploration: free movement throughout the visualization and linear reading of a narrative with directed movement in the scene (Figure 2). Where nonlinear exploration can allow for unpredictable, emergent systems and interpretations, linear movement driven by the narrative provides an opportunity for the authors to tell a coherent story about the evidence and archaeology as they understand it.

3.6 Success? Evaluation and User Testing

The project of developing the Gabii publication interface attempts to use interface design as an opportunity to link theoretical paradigms surrounding the practice of interpreting the archaeological record with the creation/consumption of archaeological knowledge during post-excavation. How can we measure our success in this enterprise, and the broader success or failure to provide an effective means of communicating the data and interpretations of what is being found through the excavations at Gabii? Games and GUIs are conventionally assessed by expert heuristic evaluation or user testing, while academic publication and scholarship is subjected to peer review. An early version of the interface presented here was subjected to peer review, facilitated by the University of Michigan Press (now Michigan Publishing). The user interface was assessed through a series of workshops carried out as part of the *Gabii Goes Digital* project, with specific critiques of the interface influencing future iterations of the design. Further small-scale user testing was carried out as part of the Master's thesis of one of the authors.

Much of the heuristic evaluation by peer reviewers (here we elide academic peer review and the sort of expert evaluation which occurs in the private industry) focused on traditional concerns of academic, such as the longevity and sustainability of the materials presented and the ability to cite individual data elements (pers. comm., anonymous reviewers 2013). The feedback from users responding in workshops and online via questionnaires included suggestions for modifications to the navigation. For example, online users were asked about their preference for ‘on foot’ and ‘orbit’ modes of viewing. Most users suggested maintaining the two modes, but favored the ‘on foot’ navigation system (Johnson 2015). Users also emphasized the importance of keeping the bottom section of the 3D environment clear of icons, buttons or other visual elements, as they consistently wanted an unobstructed view of the models of the stratigraphy

and layout of the space. This content is concentrated in the bottom part of the screen, under the virtual feet of the FPC. Other workshop users and early testers, particularly practicing field archaeologists, wanted a means of zooming while in FPC mode, a feature in tension with the principle of embodied movement. This is resolved in our interface via a ‘fixed zoom’ while in FPC mode that is the rough equivalent of squatting down to get a closer look in the field.

While in general users preferred navigation on foot to explore the space, users also strongly preferred starting the scene in ‘orbit’ mode, providing an overview and a familiar view of the archaeological remains. This, we believe, not only shows that users were actively engaged in the phenomenon of virtual embodiment, but also valued the ability to connect familiar with more creative ways of exploring the environment. User feedback likewise led directly to the choice to open the publication interface with the reconstruction of the house visible, making the basic interpretation of the stratigraphy and the sense of how the space works immediately apparent, viewed from a familiar top-down perspective.

Beyond comments on the navigation system, workshop users frequently suggested additional tools or functions for the system. These suggestions typically included the addition of measurement tools and the ability to toggle on and off (visually) individual stratigraphic units (Opitz et al. 2013). Interestingly, some of these features had been implemented in earlier versions of the interface, and removed as they proved inefficient as modes of navigating the content, or graphically overwhelming and confusing.

The user and expert evaluation employed iteratively during the design process provided feedback on the effectiveness of the GUI and data presentation, allowing us to assess the success of our design of the general navigation system tools providing access to the content. The ability of the designed system to affect a (digital) embodied experience or encourage reflexivity and a slower post-excavation engagement with the archaeological record may be included in future rounds of evaluation, although reservations regarding the kinds of questions that could elicit responses on these points without prejudicing the reader-users remain.

4 Conclusions

The interface designed for the publication of the Tincu House combines highly realistic SFM models and schematic reconstructions of the main elements of the house in a game-based environment, and integrates interface elements including pop-up windows, database access, and narrative text that provide descriptive information and convey the authors’ interpretations. This paper makes the case for a thoughtful and theoretically engaged approach to the role of GUIs in archaeology, and argues for the need for reflexivity and discussion about the implications of specific design choices on user experience. Dallas (2015, p.177) suggests that “archaeology appears to be once again at a crossroads, shaped by the interaction between its evolving theoretical and epistemological horizons, and the sociotechnical infrastructures informing its increasingly digital practices.” We see interface design for archaeological publications as one of these digital practices. The design of this interface represents our sociotechnical practice, our effort to balance diverse modes of engaging with the materials, and our attempt to foreground embodiment as a key element of interfaces where 3D data and models are present.

We see GUI design as fitting into the practice of archaeological illustration and as part of a collection of experiments in publication and communication formats, arguing that like illustration conventions, interfaces provide a means of elevating superficial views of objects, in our case 3D models, to skilled representations. The result of the combination of 3D models, embodied virtual interaction, descriptive information and narrative is a distinct system of engagement. This system strongly relies on the way that collision with virtual surfaces can direct user movement and navigation and provide a sense of the physicality and spatial properties of the environment and objects in it. Equally important, the interface enables a continuous tacking back and forth between direct interaction with the models and contextual information and the authors’ interpretation of them. The opportunity to foreground the material and physical through our interface’s design allows for a form of publication particularly appealing to archaeology, a discipline that engages the past through its material remains.

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