Modeling the Past Online: Interactive Visualisation of Uncertainty and Phasing

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Abstract. This research and educational project aimed to create an interactive website featuring virtual 3-D walkthroughs of three buildings from the ancient city of Marion in Polis Chrysochous, Cyprus. The earliest structure dates from the Cypro-Geometric period (10th–9th century BCE) and the latest was destroyed in 312 BCE in the early Hellenistic period. The project builds on models presented at EuroMed 2012 and aims to complement a long-term exhibition on Cyprus and presentation on the web. In a joint Computer Science and Art and Archaeology seminar at Princeton University in the spring of 2014, three groups of students created reconstructions and populated them with 3-D scanned objects. Each group proposed a visual metaphor that conveys uncertainty and phasing in these 3-D visualizations and created an online concept for manipulating the models. Scholars and the public can experiment with and learn from these visual recreations that are consistent with archaeological data.

Keywords: 3-D digital modeling, 3-D scanning, archaeology, Cyprus, excavation, exhibition, Marion, museum, Polis Chrysochous, public, students, websites.

1 Introduction

In 2012 Smith and Rusinkiewicz presented a paper at EuroMed about an interdisciplinary 3-D visualisation project, Modeling the Past [1], in the form of a seminar that is part of an archaeological expedition to Polis Chrysochous, Cyprus. In 2014 the project addressed long-term aims cited in 2012: to develop a website with flexible hyperlinking and user interaction for scholars and the public, to find clearer ways to represent uncertainty visually in 3-D recreations, and to integrate such a tool into museum exhibitions. In 2012 the end product was a film [2] that was featured in a special exhibition [3]. In 2014 three proposals for such an interactive site were designed and integrated for use online [4]. A version of the site is intended for use on a touch-screen at the Local Museum of Marion and Arsinoe in Polis.

2 Modeling the Past

The modern town of Polis Chrysochous in northwestern Cyprus lies above the ancient city of Arsinoe (ca. 270 BCE to 1500s CE) and the even older city-kingdom of Marion (founded ca. 800 BCE, destroyed in 312 BCE) [5]. The spring 2014 seminar focused on the earlier city, Marion [6], and aimed to develop models that showed in detail changes in built space over time and the degree to which evidence supports each reconstruction. The enrollment included three undergraduate students of Computer Science, three in Engineering (Chemical and Biological, Electrical, and Mechanical and Aerospace), one in Chemistry, and one intended Woodrow Wilson School major.

The seminar format, readings, and assignments were similar to those in 2012 [1], [3], with topics adjusted to include those needed for ancient Marion, such as palaces, and to remove others pertinent only to the later city. A class debate emphasized uncertainty in 3-D modeling; students discussed the scholarly contributions of a model of the site of Qumran [7] and concerns that such a model obscures the original data [8]. Team members Nassos Papalexandrou and Mary Grace Weir, who are publishing two of the buildings, visited the class as specialists to consult with students. One class session took place in the Princeton University Art Museum. Students used the same equipment and standards as in 2011 [1], [3] to scan Cypriot sculptures and learned about the relative uses of high and low resolution object scans.

3 Interactive Visualisations of Uncertainty and Phasing

Each building from the excavations of ancient Marion is preserved only as high as its foundations. Each is unique in its specific form with greater or lesser use of cut limestone blocks (ashlars), rounded igneous and sedimentary river stones and reused stone or ceramic objects (rubble), mudbrick, lime plaster, and rooftiles. In 2014 we sought to retain the detail-oriented approach to modeling developed in 2012 [1], [3], but also to include a greater range of structures from Marion, to represent more phases of single buildings, and to rely less on photorealistic textures for all surfaces so as to develop more intuitive ways of representing uncertainty through visualisations. We wanted to retain scholarly accuracy and to develop sites that would engage those less familiar with digital modeling, both scholars and the public, in an entertaining way that might be suitable in a museum context [9]. By moving beyond the linear script required by a single video for a special exhibition display, this project was able to explore multiple proposals for visualising uncertainty and phasing.

As in 2012 [1], [3], all three groups worked from the excavation data and paid close attention to details derived from site plans, field notes, and photographs. Each includes text that discusses the images shown, with reference to publications and data derived from the excavation database. Each aimed to create an intuitively user-friendly interactive site that would clearly detail aspects of uncertainty and phasing in the buildings of the ancient city of Marion. They used the open source software modeling packages of SketchUp Make [10] and Blender [11] in addition to the custom software, SOS, created by Rusinkiewicz for merging 3-D meshes [12]. In all cases the websites were written in HTML, JQuery, and JavaScript and used Twitter Bootstrap and Cascading Style Sheets (CSS) for styling. No site requires the user to

download special software in order to access the site features, a frequent problem for websites with interactive features [13]. Instead, each group included some level of interactivity through the X3DOM framework [14], an XML mark-up language, which allows one to pan, zoom, and rotate 3-D objects online. This works in HTML5 web pages that are WebGL-enabled, thus Google Chrome and Mozilla Firefox, unlike Internet Explorer and Safari, require no extra features to be enabled. All groups modeled first in SketchUp, exported the models as Collada (.dae) files to Blender for textures and lighting, and then exported them as .x3d files for use in the X3DOM framework in which they made additional edits. This process allowed them to take advantage of the each program's strengths. The sites are best navigated with a mouse.

3.1 Proposal 1: Evidence First and Videos for Area A.H9 at Polis-Maratheri

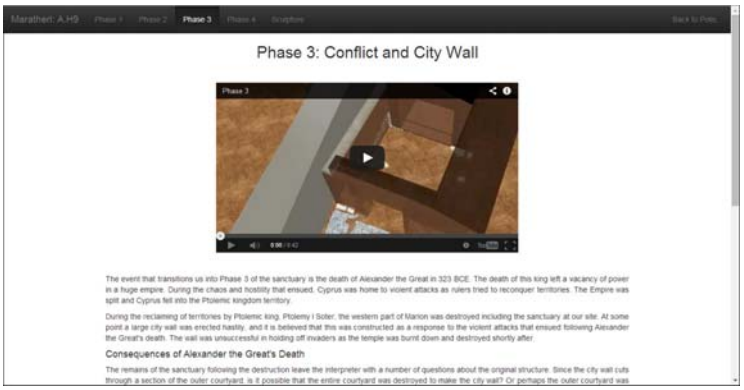

Fig. 1. A view of the website for Area A.H9 in August 2014 with a still shot taken from a video rendering of a Blender model for Phase 3. The site plan is modeled in 3-D with photo-realistic textures for ashlar and rubble stones. The reconstructed city wall and temple are in material-appropriate solid colors, with transparency used for uncertain features. Texts appear below.

One group focused on the sanctuary in excavation area A.H9 at Polis-Maratheri [15] (Fig. 1). This sanctuary had been modeled in 2012, focusing on the main period of the temple's use and the erection of the city wall near the time of the sanctuary's destruction by the troops of King Ptolemy I Soter of Egypt in 312 BCE. In 2014 the group modeled four phases of architecture, starting with the site's form before the Ionian revolt of 498–497 BCE, the height of the sanctuary's use in the 5th and 4th centuries BCE until the death of Alexander the Great in 323 BCE, the unrest when his generals fought over territory ending with the site's destruction by Ptolemy I, and the use of the site in the later Hellenistic period as funerary space, which shows that this area was then outside rather than within the newly established city of Arsinoe.

The group emphasized an evidence-first approach, realizing that the viewer's first impression often leaves an indelible image in the mind. Thus the site encourages viewers to start from the known details of the site and then consider possibilities for the site's reconstruction. To this end, the site plan was modeled in 3-D in SketchUp and exported to Blender where photo-realistic textures were applied to distinguish

ashlar blocks from rubble and lime floor from earth. In Blender, reconstructed features are shown with material-appropriate colors. Two levels of certainty were distinguished with remains of greater certainty shown as solids and less certain details shown as transparent structures. The tomb was created by carving a rectangular form into a shape defined by the cross-sections of the tomb on the x, y, and z axes. It was exported from SketchUp into Blender and then located within the model.

The group included objects in the model, including a statuette of Aphrodite that suggests the nature of the cult practiced in the temple and a terracotta antefix that provides evidence for a gabled tile roof. Each of these objects also appears in an objects gallery tab in which one can manipulate the model uploaded in X3DOM to study its form. The 3-D object meshes were exported from the SOS custom software as .ply and saved as .wrl format. Using the InstantReality "aopt" command-line this format was converted to .html. For the building models, however, the group chose instead to use videos with narration uploaded to YouTube to introduce viewers to each phase and the levels of certainty in their reconstruction. Information about the models and the objects also appears as text next to or below each image frame. A narrative thread that runs through the site merges political history, architectural change, and sculptural style to reveal the changing face of ancient Marion.

3.2 Proposal 2: Interaction and Used Space for Area B.D7 at Polis-Peristeries

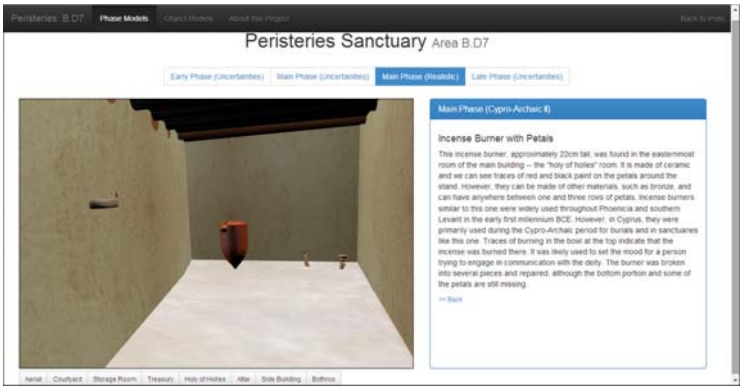

Fig. 2. A view of the website for Area B.D7 in August 2014. Shown here is a view from the Phase Models, Main Phase (realistic) tab, when the button below the view frame labeled "Holy of Holies" has been clicked. The text panel to the right details an incense burner, here the right-most object in the room shown where it was found, because the user has clicked on the object.

A second group focused on modeling the sanctuary in Area B.D7 at Polis-Peristeries [15] (Fig. 2), a locality east of Polis-Maratheri. This site was modeled in 2012, focusing on the main period of the sanctuary's use and the many votive terracotta sculptures found in the destruction layer from ca. 500 BCE, possibly from the time of the Ionian revolt. In 2014, the group modeled three phases of the sanctuary's architecture, omitting the earliest period that dates back at least to the 10th century BCE from which there are only two tiny parts of non-joining rubble walls. In addition

to the main period of the sanctuary's use in the Cypro-Archaic II period (ca. 700/650–475 BCE), the group modeled less-well-understood earlier architectural remains that may represent an aggregate of two building periods, the later of which dates to the Cypro-Archaic I period (ca. 800–700/650 BCE). These were an addition to scant earlier remains from the end of the Cypro-Geometric period (ca. 925/900–800 BCE). This group also modeled remains from the early 5th century BCE when a single-room temple was built over the remains of main phase structures.

This group sought to emphasize an interactive experience in which viewers can click and learn as they navigate the models. They considered it important for users to understand the ancient sites as used spaces in which objects and people interacted in structures that were altered over time. This group consisted of two rather than three students; thus, they worked in part from the model of the site made in 2012 and concentrated on modeling phases and including a greater range of objects in 3-D. This group identified the potential of the X3DOM framework for incorporating 3-D models into an HTML page. Four tabs allow the visitor to interact with schematic early and late phase models as well as a "realistic" and a schematic version of the main phase. The schematic versions include three levels of certainty with known features of the site remains colored according to their material, plausibly reconstructed features colored solid green, and entirely hypothetical features colored solid purple. The user is not free to pan, zoom, and rotate the "realistic" model due to its size. Instead, buttons below the view frame take the viewer to preset views created using camera viewpoints in Blender. Once exported to X3DOM each was given a unique ViewPoint tag and a button that were bound together with code written in JavaScript. One can click on the buttons in any order or take a tour by clicking them sequentially. Navigating a fully interactive model takes some practice; this approach was intended to reduce the frustration level of the user.

Within each view, the viewer can click to learn about objects, an action that brings up new information in the text panel to the right. Here in the X3D inline tag in the HTML file each component has a namespace defined for it and is defined with an IndexedFaceSet tag containing the data of the object's 3-D mesh. JavaScript thus can access these components and its "onClick" event handler calls up the text. In a gallery of objects one can interact with the objects, each exported from the custom software, SOS, as a .ply file and imported directly into Blender where it was textured and then exported to X3DOM. Pottery modeled from drawings in SketchUp were exported as Collada (.dae) files, imported to Blender for textures, and then exported to X3DOM.

3.3 Proposal 3: Build Your Own Model for Area B.F8-9 at Polis-Peristeries

A third group focused on modeling a building in Area B.F8-9 at Polis-Peristeries [6], [16], [17] (Fig. 3), just southeast of the B.D7 sanctuary. This site had not been modeled in 2012. The building has been damaged in the modern period through military trenching, bulldozing by developers, and the construction of a Primary School. Even so, the building is impressive. It stands at the edge of the Peristeries plateau at the junction with the main road that leads to the copper mines at Limni to the east. It includes many large ashlar blocks in its construction, thick walls, and two courtyards with a thick lime floor. For these reasons, the building is often referred to as a palace; its design is similar to other contemporary buildings thought to be palaces

[18]. Its use is largely one phase in the latter part of the Cypro-Archaic II period, thus being contemporary with much of the 6th century BCE material from the destruction of the sanctuary in Area B.D7. This group also chose to model Tomb 124A from the edge of the plateau to the north of the building [19]. Its contents date to the Cypro-Archaic I period, predating the palace; the shapes and local style of its ceramics are predecessors of local wares found in a cistern in the palace. In this way the group was able to include some degree of phasing in their project.

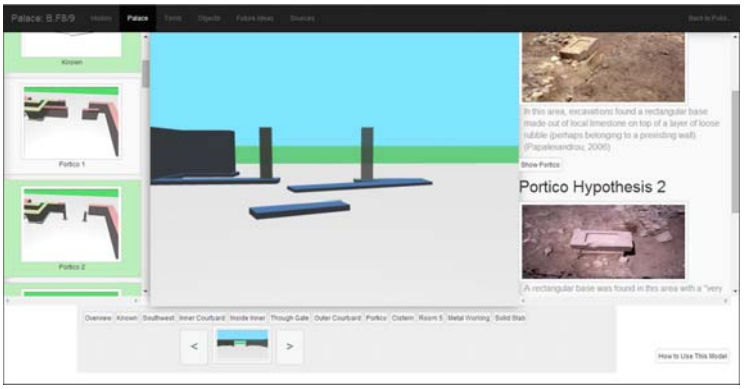

Fig. 3. A view of the website for the B.F8-9 site in August 2014. The view shows the tab for the palace with buttons below and image frames below and to the left for navigating the model. Known parts of the building are modeled in blue. Text and photographs at the right detail two options for the portico; the user has clicked the "show portico" button for Portico Hypothesis 1.

This group aimed at an evidence-first approach that would encourage viewers to ask questions and formulate their own opinions by including them in the process of building the model. Using the site plan as their base and working from photographs and notebooks, they developed a model that expressly outlines several options for the building's reconstruction and the degree of certainty for each feature. Above the foundations, colored solid blue, features that are plausibly reconstructed are a semi-transparent green and features that are hypothetical are a more transparent purple. Thus this group used no colors keyed to specific building materials or photorealistic textures and opted for schematic representations of all aspects of the structure within the model. This is balanced by the panel to the right of the model in which the viewer has access to photographs of the site and explanatory text.

The novice user can click through a series of buttons at the bottom to take a tour of the building's known and unknown features. Once one is more familiar with the site, one can click through image frames at the bottom or at the left, departing from the main narrative in order to investigate specific parts of the building. In the text and image panel at the right one can read brief text, opt to read more for more detailed discussions, and choose among options for the building's reconstruction. The evidence for the hypothesized reconstruction is described in each case. The group adapted the concept of layer controls in SketchUp, a feature also present in Blender, to develop this layered approach that allows the user to build the model. When

models were exported as .x3d files, with the X3DOM API they were able to create tours. By editing the .x3d files they gave parts of 3-D objects ids that can be referenced in JavaScript and JQuery. Thus in JavaScript they could show or hide parts of a model by changing its attributes. In the X3DOM framework the site uses regular HTML events such as “onClick” or “onMouseOver”. At each stage the viewer can fully manipulate the model. By clicking on a button, image frame at the left or at the bottom, or on an option to the right, the image in the frame returns to the preset view.

Few objects were found on the floors of the palace, but a number of fragmentary yet nearly complete Cypriot and Greek ceramic storage vessels were in a cistern at the site. These vessels and those from Tomb 124A appear in a catalogue of objects. In each instance clicking on an object maps it by making a green highlight appear in the location on the tomb plan or in its find location in the palace. At the same time it calls up text providing information about the object. To map objects to the plans the group used a JQuery plugin called ImageMaster [20]. A model of the tomb constructed according to the published sections and plans has a wire frame around it, making it a solid block that can eventually be fitted below a landscape model of the area.

4 Toward an Interactive Online Tool for Modeling the Past

A single website now draws all three proposals together [4], including both the evidence-first and fully interactive features. It serves as an introduction to the project and its publications. This site is the primary portal through which scholars and the public may access online content. As with the print records from the excavations, the digital data is archived at Princeton University. In the fall of 2014, one student, Junjun Chen, coordinated revisions to the website suggested or contributed by Smith, Rusinkiewicz, and fellow students. The revised interactive online tools draw on the strongest features of each student proposal so as to present one integrated resource useful for rigorous scholarly research and conducive for engaging the public. Challenges include the lengthy and fussy process of working in SketchUp, exporting to Blender for editing, and then exporting for use and further editing in X3DOM. In the future, more features of the ancient city of Marion could be included, such as more objects, additional buildings and tombs, evidence from geophysical survey, and the terrain. It may even be possible to geolocate an entire model of the city. At a later stage, buildings, objects, and other features from the city of Arsinoe may be added to the same website so as to model more completely the past of Polis Chrysochous.

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