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IMMERSIVE TECHNOLOGIES TO EXPLORE THE CYRENE TREASURY AT DELPHI

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ABSTRACT

The *Ashes2Art* project, an interdisciplinary undergraduate seminar offered every spring at Coastal Carolina University, has developed digital 3D models and other web-based resources related to the ancient site of Delphi, Greece since 2007. In 2012, the focus was on an archaeometric reconstruction of the 4th century Cyrene Treasury in the Sanctuary of Apollo. The following year the program expanded to explore the development of a comprehensive platform for synthesizing and integrating these disparate sources through an enhanced immersive landscape that leverages geospatial information, state-of-the-art consumer graphics, and gesture-based and audio navigation and interaction. A prototype for this natural user interface driven interactive platform was recently developed by students and faculty in the *Ashes2Art* program, utilizing a student-constructed 3D digital model of the Cyrene Treasury at Delphi as a test case. Using a virtual reconstruction of the Delphi landscape as a jumping-off point, users can explore the 4th century BCE site and its reconstructed monuments and cultural features. As a user approaches individual models, options allow them to explore the interiors and access interactive features to delve further into related media, scholarly primary and secondary sources, and additional high-detail models. The platform's natural user interfaces also allows for multiple users to interact with the platform simultaneously, allowing for instructor-student interaction and collaboration.

KEYWORDS: virtual models, reconstructions, Delphi, Cyrene, treasury, gesture-based, Ashes2Art

1. INTRODUCTION

As virtual archaeology and virtual 3D reconstructions of archaeological sites and ancient structures become more commonplace, interest has turned to developing interactive platforms that can allow the exploration of these reconstructions within a larger landscape context. Such immersive virtual platforms can be designed to extend the user's experience of the virtual landscape by embedding and linking digital scholarly information and multimedia that can illustrate the sources used to develop 3D reconstructions, animations of the reconstruction process, links to resources and data sets, photographs, and other related materials (Bergeron 2011; Harris et al. 2011).

In 2012 undergraduate students in the *Ashes2Art* program at Coastal Carolina University completed a block-by-block digital model of the 4th century BCE Cyrene Treasury at Delphi, Greece based extensively on the archaeological reports published by the French School in 1952. That model was then exported to an intuitive, user-friendly interface for gesture-based and voice-based interaction within an immersive virtual Delphi landscape. Options allowed users to explore the interiors and access interactive features to delve further into related media, scholarly primary and secondary sources, and additional high-detail models.

2. ASHES2ART

The *Ashes2Art* program at Coastal Carolina University in Conway, South Carolina began humbly in 2005 as an experimental, upper level undergraduate seminar offered each spring that aimed to fuse teaching with research and technology across various disciplines. From 2007 to 2009 Coastal Carolina University collaborated with Dr. Alyson Gill and students at Arkansas State University on the first stages of examining the ancient site of Delphi, Greece (Flaten 2009; Gill 2009). Faculty at both universities led students to Delphi and various Pan-Hellenic sites (Nemea, Corinth, Olympia, Delos, Aegina) over consecutive summers to document the sites with photographs, digital panoramas, and GPS.

Our collaboration was supported by the National Endowment for the Humanities in the United States, the Hellenic Ministry of Culture, the American School for Classical Studies in Athens. In addition, Dr. Elena Partida at the Delphi Archaeological Museum provided invaluable assistance to the project.

We have reported on various aspects of the *Ashes2Art* project regularly in journals and conference proceedings (Flaten 2009; Gill 2009; Gill and Flaten 2008), and our students have presented about our theoretical framework, our successes, and our failures at conferences in Australia, Beijing and Washington (Garofalo 2013; Rudolph 2013). Fundamental to *Ashes2 Art* is the concept that all materials are designed, built, coded, and implemented by undergraduate students, including digital models, web design, photography, digital panoramas, lesson plans, research essays, animation, and educational videos. Three principles have guided our study: 1) Precision does not imply accuracy; 2) Uncertainty is a crucial component of knowledge; 3) Questions are more important than definite answers.

As the project has grown, so has the number of buildings we have digitally reconstructed, the level of complexity in each model, and the methods employed to explore, archive, disseminate, and interact with information. In addition to the reconstructed plunge bath and gymnasium by undergraduate students at Arkansas State in 2007 (Gill and Flaten 2008), Coastal Carolina University undergraduate students modeled the Tholos of Athena Pronaia, the Athenian Treasury, and the Temple of Apollo, among others between 2007 and 2011 (Flaten 2009). These last three structures are perhaps obvious choices for virtual reconstruction: well-known to tourists and scholars, and well documented in most cases. The Siphnian Treasury might have been a logical choice for the next project, as the frieze and caryatids are standard to

most surveys of Greek architecture and sculpture. We chose, instead, to investigate something more esoteric and turned in 2012 to the Cyrene Treasury.

2.2. Treasury of the Cyrenes

The digital reconstruction of the Treasury of the Cyrenes at Delphi was fascinating for several reasons: 1) it is largely absent in the scholarly literature; 2) its half columns are atypical of treasury design; and 3) the mathematical principals and implications behind the structure's design are disputed, as is its precise location. The Cyrene Treasury received comprehensive study in the *Fouilles de Delphes*, and we had access to those volumes (Bousquet and Fomine 1952). In addition, the Treasury of the Cyrenes had not, to our knowledge, been the focus of a 3D virtual reconstruction.

The Treasury of the Cyrenes at Delphi was built in the 4th century BCE by the prosperous Greek colony of Cyrene, which had been founded in 630 BCE when Grinnos, the king of the island of Thera (modern Santorini), was directed by the Delphic oracle to establish a port city in Libya. The site quickly established trade with various Greek cities, and became the chief commercial center for ancient Libya (near modern Benghazi). Herodotus described the city's founding and its history, and it appears in the Old Testament and sundry ancient texts. Cyrene was the locus for a famous school of philosophy founded by Aristippus, a student of Socrates. After the death of Alexander the Great, Cyrene became subject to the Ptolemaic dynasty in Egypt and it later was consumed by the Roman empire. The archaeological site of the city of Cyrene in Libya reveals that it included a temple of Apollo, perhaps built as early as the 7th century BCE, a temple of Demeter, a temple of Zeus Ammon, and a large necropolis.

The Cyrene Treasury at Delphi was located to the East within the walls of the main sanctuary of Apollo. There is some disagreement as to which foundation should be associated with this building (Bousquet and Fomine 1952; Dinsmoor 1957; Laroche 1988; Partida 2000): Dinsmoor favored foundation 302 (Atlas XIV) early in the century, but he revised his decision in his review of Bousquet's text and concured that the Cyrene Treasury was adjacent at foundation 203 (Atlas XIII). Laroche (1988) argued that Dinsmoor's original placement was correct and Partida (2000) agreed in her survey of Delphic treasuries. The two sites are next to each other, but faced different directions (203 faced Southeast; 302 faced Southwest) (Fig.1).

Figure 1. Cyrene Treasury location, Delphi (Photo credit: A. Flaten)

If we follow the argument of Laroche (as well as Partida and early Dinsmoor), the treasury was built into the northeast wall of the Delphi sanctuary and its entrance faced the Athenian Stoa and the Sacred Way (Laroche 1988; Partida 2000; Dinsmoor 1957). Its priveledged proximity to the Temple of Apollo and the Sacred Way was impressive. Laroche (1988) also argues convincingly that the structure was built between 334 and 323, revising earlier scholars' suggestions that construction on the treasury began ca. 373 BCE, was interrupted in 338 for the Battle of Chaeroneia, and was completed shortly thereafter. Their treasury at Delphi is certainly indicative of Cyrene's wealth, but it must be understood more specifically as an offer of thanksgiving to the Delphic oracle who di-

rected that city's establishment on the shores of North Africa in the 7th century.

The Treasury of the Cyrenes at Delphi was similar in many respects to other treasuries there. It was a windowless rectangle constructed of Pentelic and Parian marble measuring 3.3m x 4.6m. The plan was relatively simple: a modified distyle-in-antis with engaged Doric half columns flanking the two Doric columns at the entrance. Half columns are not typical of treasuries from the period and region, but their appearance on the treasury at Delphi may represent the Cyrenes themselves. The University of Manchester Expedition to Cyrene in 1952 observed that the proliferation of half columns on numerous monuments at Cyrene, to be understood as a local symbol or emblem, was first established with the treasury at Delphi (Rowe 1956).

According to Bousquet, the treasury was designed to validate or explore the mathematical theories of Theodorus of Cyrene, a pupil of Plato. Bousquet asserted that the treasury's design demonstrated answers to several mathematical problems, including the famous "squaring the circle" conundrum. Dinsmoor's review of the publication agreed with the attribution of the building to the Cyrenes, but was highly critical of Bousquet's conclusions concerning its mathematical properties, as was Cook's evaluation (Dinsmoor 1957; Cook 1954). Haspels and Plommer, on the other hand, agreed with Bousquet's mathematical assertions (Haspels 1953; Plommer 1954). Little has been written on the topic in over half a century. Professors at Coastal Carolina University in Mathematics and Art History are planning a complete review of the various aspects of the initial argument and its rebuttal, but that is not our present focus.

2.3 Virtual Cyrene Treasury

The aim of virtually reconstructing the Cyrene Treasury was to focus on historical accuracy and visual authenticity, as had been the mission for the Temple of Apollo and our earlier models.

A senior undergraduate student participating in the *Ashes2Art* course focused on modeling the Cyrene Treasury, utilizing Trimble SketchUp. Our primary source for the model was the *Le Tresor des Cyrenes* (1952), authored by Jean Bousquet and illustrated by Youry Fomine, and part of the extensive *Fouilles de Delphes* excavation report series. Even if the foundation location of the treasury is contested, the reconstruction of the treasury by Bousquet and Fomine is by far the most comprehensive and is universally admired.

We decided to individually construct each block represented in the *Fouilles de Delphes* report, not just the superficial dimensions and larger polygons associated with many reconstruction projects. The most important drawings for rebuilding the Cyrene Treasury were located on Plate XXXIX- Observations of the Technique (Bousquet and Fomine 1952). Those drawings provided much of the necessary information to accurately model nearly every block of the treasury, with detailed illustrations of the orthostates, metopes, triglyphs, and cornice blocks. The surprising Ionic features of the treasury--the cyma reversa and ovolo on the cornice blocks, the cavetto on the metopes separating each triglyph, and the backs of the triglyphs--were absolutely crucial to the reconstruction model.

Following those drawings and the text, the initial modeling of the Cyrene Treasury was completed using SketchUp, and the model was optimized wherever possible to allow for export and use in other applications (Garofalo 2013) (Figures 2 and 3). *Ashes2Art* frequently begins models in SketchUp and then exports them to 3D Studio Max and MentalRay for textures, lighting, animation, etc. We plan to export the model, add textures and lighting for a flythrough video during the Spring 2014 session.

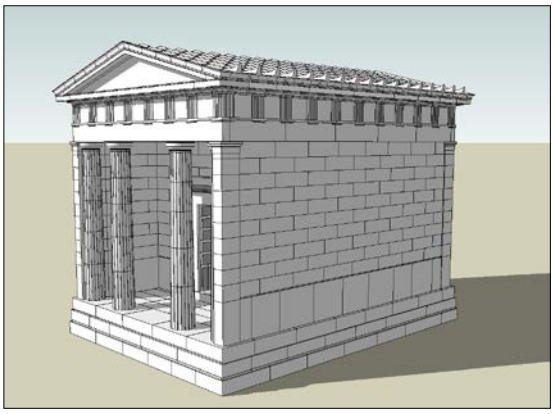

Figure 2. View of Cyrene Treasury model in Trimble SketchUp

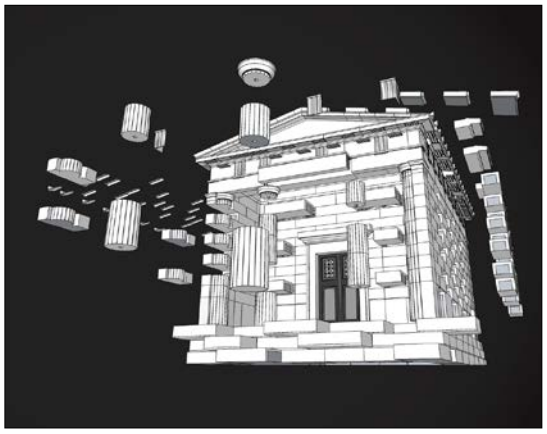

Figure 3. Exploded view of Cyrene Treasury 3D model.

Fomine's reconstruction drawings--sections, elevations, moulding details, and floor plans--are exquisitely detailed and address almost all the extant architectural elements based upon excavation artifacts. In total, some 39 plates of drawings were published.

In some instances, however, the stated measurements of the drawings needed to be verified with scale rule measurements of those drawings...and the two sets of measurements did not always agree (some of the drawings were corrected in Bousquet's text). This process of redundant measuring, however, ensured correct spacing of elements such as the triglyphs, metopes, mutules, regulae, guttae and cornice blocks. It was also useful in obtaining accurate angles for the column capitals, pilaster molding, cornice blocks, sima blocks, geisons, gutters and roof tiles. Based on Fomine's drawings, the corresponding text, and our measurements we concluded that the raking sima, roof tiles, gutters, spouts, and doorway moulding lacked sufficient evidence for exact modelling. Either a drawing from a crucial vantage point did not exist, or the details were unclear. Comparanda of Doric temples and treasuries of the 4th century provided useful clues to model those elements.

The blocks of the raking sima presented the greatest modelling challenge due to the odd angled cuts which lock them together. Fomine's illustrations did not provide sufficient guidance to build the complicated geometry of these elements. Looking to contemporaneous sources, the Temple of Apollo at Bassae, among others, offered a helpful parallel. Had we relied exclusively on Fomine, there would be no way to understand the engineering or to appreciate the sophistication of the design. These types of problems do not manifest themselves unless one builds each stone or component individually, and they necessitate accurate (or at the very least, workable) solutions to complete a 3D model of a structure like the Cyrene Treasury.

Other complex architectural components, such as the lionhead rainspouts, were modeled in Autodesk's Mudbox, software which facilitates the sculpting of organic forms. The file size for each lionhead was larger than the entire Cyrene structure combined. Because of the extraordinary number of polygons associated with the shape of the lionheads and the Ionic door molding, those architectural features were not included in the 3D virtual reconstruction of the treasury that was utilized in the implementation of the prototype immersive gesture-based environment.

3. INTERACTIVE ASHES2ART PLATFORM

The fusion of architecturally precise models, such as the current Cyrene Treasury, with a virtual landscape reconstruction and linked data is not groundbreaking. However, emerging gesture based learning

technologies, such as Microsoft's Kinect, are changing how we interact with information within a virtual landscape environment (Richards-Rissetto *et al*. 2013). This newest component to the larger *Ashes2Art* project was born out of the desire to physically interact with digital technology in a humanistic manner free from extraneous hardware limitations such as 3D glasses, joysticks, keyboards, or virtual reality headsets.

In addition, the design and development of the prototype interactive Ashes2Art platform was driven by student interest in leveraging new technologies to bring a more dynamic, humanistic perspective to working with the myriad sources and types of information related to the structures and site of ancient Delphi. Students wanted to go beyond viewing individual models in a limited viewer, and develop an immersive, interactive environment that could provide not only a landscape context for the virtual reconstructions, but also contextualize the digital information that was developed during the 3D modeling process.

The idea was the brainchild of two undergraduate students at Coastal Carolina University, who proposed to leverage a consumer videogame interface device, Microsoft's Kinect controller, and develop a custom interactive exploration environment. This platform would combine the ability to explore 3D virtual reconstructions of the structures and landscape of ancient Delphi with functionality to delve more deeply into the scholarship of individual structures and monuments through embedded multimedia and database links.

3.1 Cyrene Treasury Case Study

In order to implement a working prototype of the interactive Ashes2Art platform, a case study 3D model and associated multimedia and scholarly sources were assembled. Since one of the students who initiated the project to design and develop a gesture and audio-based interactive platform had recently completed the research and modeling of the Treasury of the Cyrenes, this structure was chosen as the focus of the prototype demonstration. The students worked extensively with the immersive spatial experience engine (Bergeron 2011) platform to write audio commands, code gesture-base commands, import a basic topography of Delphi, and import a simplified model of the Cyrene Treasury.

Ideally, all information from the *Fouilles de Delphes* on the Cyrene Treasury, including 113 pages of text, 39 plates of drawings and 12 photographic plates (Bousquet and Fomine 1952), would be embedded into the dynamic model and made accessible online, as well as other articles, primary sources, and commentaries. Such a "smart" model would allow access to legacy data consisting of traditional scholarship, a detailed report of our reconstruction methods, and various digital media. The supporting material would then serve as a virtual bibliography to support the work represented in the three dimensional reconstruction, and users would be able to cite this material for academic use.

We can read about the Cyrene Treasury and see the engineering expertise of its builders represented in a virtual reconstruction, but having the ability to manipulate scale and perspective enhances the experience significantly. Users want the freedom to remove a column drum with their hands, for example, and rotate it to examine the flutes of the shaft. They want to see how high the triglyphs are by simply looking up. They want the intrigue or interaction of an immersive first-person camera based video game coupled with the research capabilities of a university library. Our template, still in its early stages, attempts to create a gesture-based learning platform with academic research capabilities.

3.2 Developing the platform

One of the students' main goals in developing their prototype was to define a basic set of relatively intuitive Kinect gestures and voice commands to create a more dynamic platform for presenting infor-

mation about the ancient monuments of Delphi that also fosters collaborative discussions and active participation by students and instructors. The prototype developed for this pilot project accomplished these goals by combining an immersive virtual landscape reconstruction with informational screens and multimedia to delve further into the archaeological and scholarly evidence used to develop each reconstruction (Bergeron 2011).

The Ashes2Art interactive platform is built on a common videogame design that utilizes a series of screens that are loaded when the application runs and then accessed as needed through gestures, voice commands or, if needed, keyboard or controller input. Opening screens provide an introduction to the project and give the user (whether student or scholar) information needed to get started with the application.

3.3 Screen Design

Following the informational opening screens, the user is given a menu of options, including the choice to enter an immersive virtual landscape representation of ancient Delphi and its reconstructed monuments or a choice to explore interactive 3D architectural views of individual monuments.

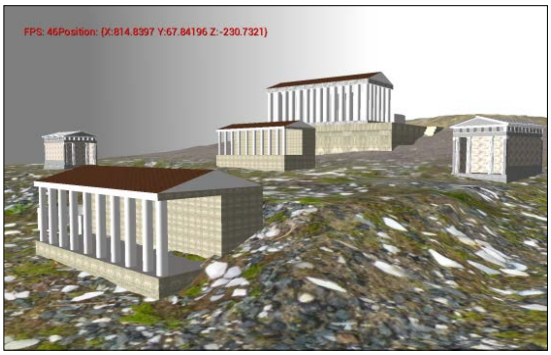

Figure 4. Detail of virtual Delphi landscape development in custom designed XNA platform

For the first phase of prototype development, the ancient Delphi landscape reconstruction was not the main focus, and was developed using only simple block models of the major monuments and a generalized terrain (Fig. 4). Voice commands and simple Kinect gestures were added to keyboard and controller navigation input to give users a range of options for exploring the immersive Delphi landscape.

The main focus of the platform development, then, was in the design and implementation of the informational screens that would present the wealth of scholarly information and multimedia that explores the Treasury of the Cyrenes and its virtual reconstruction.

When a user navigating the virtual Delphi landscape approaches a monument or structure he or she wishes to explore more deeply, a simple voice command to "explore" or a hand gesture to select the structure triggers the loading and display of a main Explore Screen, featuring general information about the structure and a simplified 3D model.

This screen is the jumping-off point to additional screens that show links to multimedia and digital scholarly sources, animations and details of parts of the monument's construction, such as a column (Fig. 5).

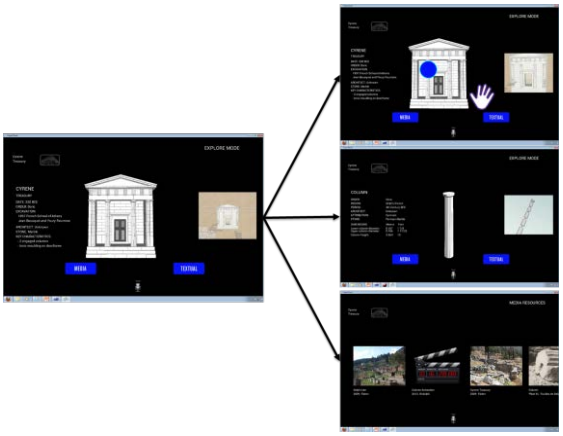

Figure 5. Interactive exploration screen within custom designed XNA platforms

Users can also interact with individual elements of a 3D model through a screen that allows them to grab and manipulate construction elements with Kinect hand gestures (Figure 6). Not only does this provide an interactive educational experience for users, but also demonstrates how the 3D model itself was developed through the

interpretation of available archaeological and scholarly sources.

Figure 6.Interacting with 3D model immersive elements using hand gestures and voice commands (Photo credit: M. Garofalo)

Users can move freely between the screens using Kinect gestures such as select to press virtual buttons, voice commands, and even keyboard and controller input if needed.

The natural user interface of the interactive Ashes2Art platform also allows multiple users to collaborate and explore the virtual environment together, as the Kinect can accept input from multiple voices and track multiple users' movements.

4. CONCLUSION

This interdisciplinary project has allowed undergraduate students to work closely with faculty mentors in a number of fields, and these students presented the results of their research, including a technical prototype, at the *41st Computer Applications and Quantitative Methods in Archaeology* conference in Perth, Australia (Garofalo 2013; Rudolph 2013). They were also chosen to present their work at the 2013 *Posters on the Hill* event in Washington, DC where they discussed their work with U.S. Senators and Congressmen. Posters on the Hill showcases outstanding undergraduate research at US colleges and universities, hosted by the National Council on Undergraduate Research.

In the future, we hope to extend the interactive Ashes 2Art platform to include an integrated search engine that would allow for additional research with a separate display to show internet search results while allowing users to remain within the immersive environment. Future applications might also incorporate social media plugins to promote platform use and product awareness. Another possible feature could be a Wiki platform with a user submission form. We still have much to do.

Our ultimate goal is to have archaeometric 3D models of every structure at Delphi placed within a GIS-based, topographically accurate virtual landscape with navigation and interaction via an immersive, gesture-based and voice-controlled environment. This platform, whose viability has been demonstrated by the Cyrene Treasury prototype, will give users access to vast quantities of metadata and multimedia with a simple pinch. Or a swipe. Or a word. At the same time that we continue work on this very large environment, we are also designing an app for smartphones and tablets to navigate the models intuitively.

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