Multimedia in Three Dimensions for Archaeology; Information Retrieval With Interactive Models.

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ABSTRACT

An interactive three-dimensional model is an effective tool for the display of archeological data. Spatial data from a site can be directly visualized as the central model, while much of the non-spatial information can be presented with text, sound, animations or other such tools. The close relationship between the spatial and non-spatial data (i.e. an artifact and its name) allows tight coupling between the model and other displays, to the point where they may blend into the model itself. The resulting application makes the data easy to reference, understand and remember. We discuss the structural and cognitive (learning) advantages of this approach and present our three examples: The Temple of Isis, The Temple of Horus and the Tomb of Lady Hao.

Keywords: Cyberspace, Archaeology, multi-media, Virtual Environment, Visualization, Education, Reference, Visual Query

1. INTRODUCTION

The display of interactive three-dimensional scenes (virtual worlds) on inexpensive computers has created new opportunities for the communication of knowledge. [5-7] One way to use this new technology is to create a virtual object (model) to as a literal or metaphorical representation of real artifacts, either in the state in which they were excavated or as representations of how they might have originally appeared. It is also possible, and very important, to attach non-spatial information to objects in the model in a vivid and concise way.

For example, the virtual world might contain a virtual model of a sword, which could tell users what the actual sword looks like, but that won't tell us its materials, history or ownership. Even the idea that it is a weapon is not obvious from the model, but a cultural expectation. The author can attach other presentation tools to the virtual model, such as text windows, hyperlinks, flat animations, autonomous or interactive agents, sounds, control panels, and many other multimedia devices.

A slightly different strategy is to deliberately abstract the model and more closely embed these other displays (I.E. Text.) or to add visual enhancements. [3]

The Advantages

Models of an artifacts, be they literal or abstract, are usually straightforward and intuitive. They show, rather than tell. Users access the information encoded in the model by traversing the virtual space in which it resides. They may also refer to related knowledge by activating the other displays, explicitly or implicitly.

For example, the user may click on a representation of a fountain to see a text about how the fountain was used, who used it, and where the water came from. Or the activation can be implicit--the users hear the sound of splashing water when they approach it within a certain distance. This makes the interface a powerful tool for information access and user recall, because they are rarely more than two (mental) steps from the model to any piece of data. Furthermore, user interaction with the model creates event sequences which the they can store in episodic memory [text]. We theorize this should work especially well with literal models, because they are more naturalistic.

Why Archaeology?

Archaeological sites are information dense and aesthetically rich, as only a real living culture could produce. At the same time, most users will be unfamiliar with the artifacts, so they will have a minimum of pre-conceived notions about their nature and use. Finally, a substantial portion of the information in an archaeological site can be represented as a virtual object and nearly all of the non-spatial information is closely related to it.

Three Examples

We present three applications, which we authored, in whole or in part. They are the Temple of Isis (literal), the Temple of Horus (prototypical) and the Tomb of Lady Hao (abstract). All three are web-based and will be freely available at:
www2.sis.pitt.edu/~jacobson/temples.html

2. TEMPLE OF ISIS

The Temple of Isis application is a virtual model of a temple in the city of Pompeii, which was buried in volcanic ash in 79 AD by the eruption of nearby Mount Vesuvius. Since it was built for display at a museum, accuracy and detail were crucial. Therefore, a great deal of research was done to determine what the temple might have looked like just before it was buried. And because it was shown in a popular museum rather than a traditional educational institution, its interface was the most "literal" of the applications provided here. **See figure one.**

Modeling this temple as a virtual object , at this degree of literalness ensured that the representation had no unintentional gaps. Questions like, "What would the ceilings have looked like?" have to be asked to build the model. Moreover, once the model was built, it can be used to discover new knowledge that is not available from scholarly sources. Questions like "Which of the murals would have been visible to worshipers standing in front of the main altar?" can be answered with ease. Most importantly, the users can get a sense of moving at will through the architectural space, with its interplay of lines of sight and light and shadow. This experience is central to understanding what the temple was like; it cannot be had from still images, textual description, or even walk-through animation.

Historical Content

We usually think of Isis as an Egyptian goddess, but she was also worshiped by the Greeks after Alexander the Great conquered Egypt. When the Romans conquered both Egypt and Greece itself, the worship of Isis spread throughout the Roman Empire. She was venerated as a loving mother goddess who promoted fertility, oversaw the changing of the seasons, and healed the sick. There were temples dedicated to Isis and her brother/husband Osiris throughout the Greco-Roman world. These temples were the sites of elaborate daily and annual

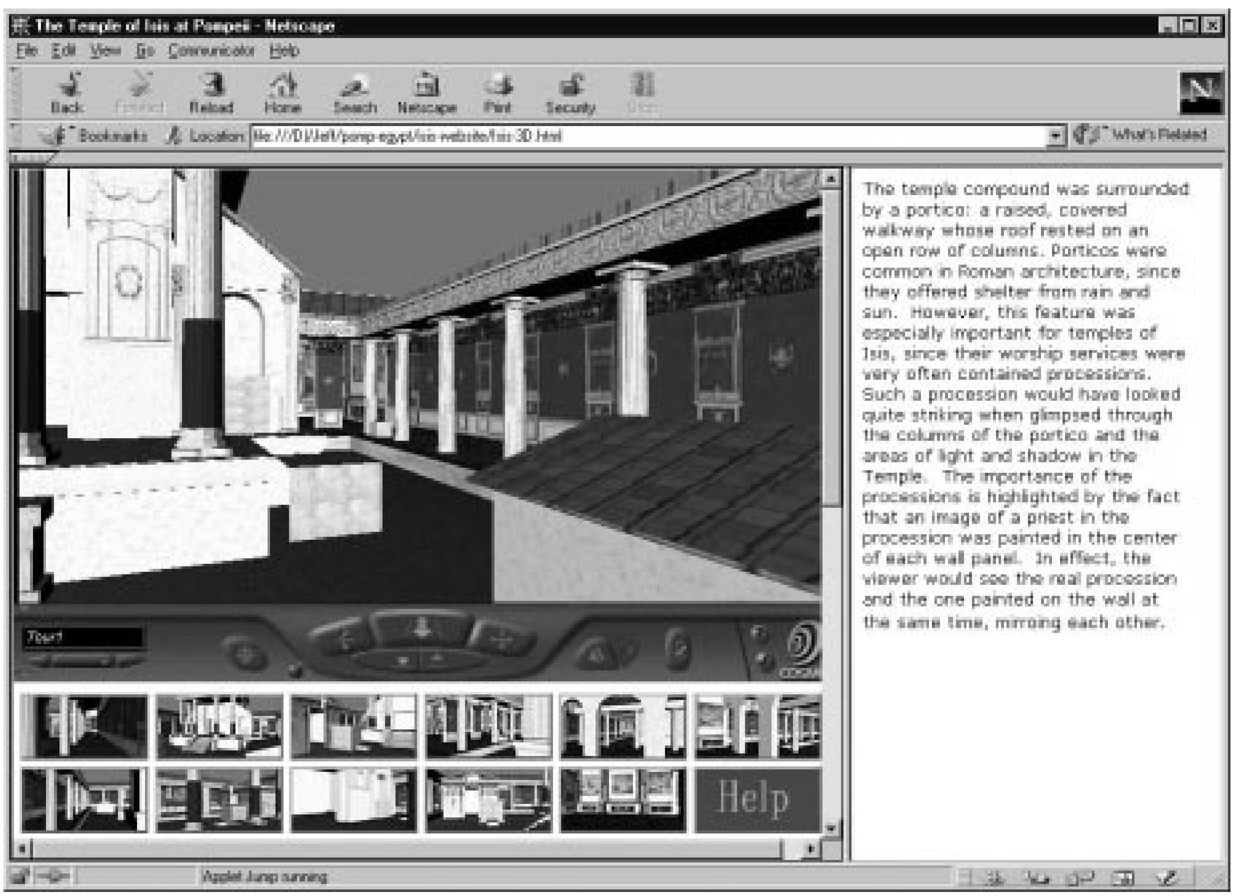

Figure One: The Temple of Isis, 1999 VRML version.

rituals and were administered by an educated priesthood skilled in music and medicine.

The Temple of Isis in Pompeii was small but ornate. At the center was a small rectangular temple on a high platform with a pitched roof and a deep, columned porch. The priests of Isis probably performed the morning and evening rituals on this porch for the worshipers who were gathered in the courtyard below. The temple was set in a small garden, and the entire complex was surrounded by a high wall, with a covered walkway around the inside.

There were also subsidiary spaces within this temple complex. In front of the temple was a large altar and a highly decorated small building were water from the Nile was stored There was a large open room which opened off the back of the portico and probably was used for ceremonies and ritual meals. The temple complex was elaborately decorated often with Egyptian subject matter painted in a Roman artistic style. Murals were painted on the inner wall of the portico and in the ceremonial dining room. Many statues of both Roman and Egyptian gods were placed in temple itself, the garden, and the portico.

The Model and Control Panel

The user can traverse the temple of ISIS using the standard VRML control panel at the bottom of the model's display window. Alternatively, she can jump between several standard viewpoints by pressing a button with a thumbnail view of what is visible from that point. Every time the user goes to a jump point, a description pops up in the text window elaborating on what the user sees. Sounds within the temple activated when the user enters a certain location. For example, chirping birds are heard near the back of the temple, and a chant is heard near the platform at the front of the temple.

2D Version

The three dimensional model has a parallel version which uses a series of screen shots, instead of the VRML model. Except that the user cannot traverse to any other points and has no VRML control panel, it is indistinguishable from the 3D model, creating a very similar effect. The localized sounds activate for screen shots taken from locations within their respective activation areas. This 2D version of the temple of Isis enables the application to adapt to computers that do not have enough power to display the 3D scene.

Project History

The Temple of Isis was developed at SIMLAB (1995) at Carnegie Mellon, and was part of the larger Pompeii Project. It showed at the DeYoung Museum in October through January of 1995-1996. The project was funded jointly by Silicon Graphics, CMU and an anonymous donor. The target platform was a $500,000 SGI Onyx-4. Today, it will run on a 300mhz Pentium with a $200 graphics card. The VRML/HTML/Java version was built in 1999 on a volunteer basis. See the web site for a long list of credits.

3. TEMPLE OF HORUS

The Temple of Horus is a prototype, [8] representing large Ptolemic (late) period Egyptian temples. It is intended to introduce the general features of such a temple in an educational setting, so combines details from several extant temples. It is loosely based on the real Temple of Horus at Edfu, including elements of Medinet Habu and the Ramasseum. Though it contains all the important architectural and decorative features of this kind of temple, it sacrifices detail for generality. The layout and structure are simplified but accurate. However, the murals and hieroglyphics on the walls are oversized to make them readable using current hardware and software. Still even this schematized version has many of the advantages of a literal model. **See figure two.**

The Model

The temple model itself has the characteristic pylons at the front, an open courtyard just inside the main gate, a "hypostyle" hall filled with columns next, and finally an inner sanctum containing the statue of the God in a shrine. (See the floor plan in the upper right hand corner of figure two.) All doors in the temple lie along a single line and are of ascending size from the shrine outward. In actual temples, the doors faced east, so the rising sun would shine through the concentric doors to the god's idol in the inner sanctum.

In some locations, localized sounds are activated when the user comes within a specified range. For example, an unseen cat lurking in the hypostyle hall meows when approached. The sounds include chants in an approximation of Egyptian and prayers said in English.

Inscriptions on the walls extol the god, praise the Pharaoh, and refer to the Pharaoh's eternal after-life. The hieroglyphics and many of the related images are greatly enlarged, so that only a few fill an entire wall. The simplification is necessary, because the temple must be rendered at a relatively low resolution. The language and content of the inscriptions and actions of the figures are accurate and appropriate.

Some of the murals are actually animations, which activate when the user clicks on them. In each case, the animation is flat, but mapped to a wall of the model. In some locations, localized sounds are activated when the user comes near enough. For example, a cat lurking in the hypostyle hall.

The Application

The full control-panel for the application is shown in figure one; it is divided into four sectors.

The upper left shows the display window for the model and its VRML control panel.

The lower left shows a text window, which looks like a scroll. When dialogue is activated in the model, the text for it appears on the scroll. To see more text, the user clicks the left coil of the scroll. To review prior text, he clicks the right side.

The upper right shows a clickable map of the temple. When the user clicks on part of the map, his viewpoint in the model is transported to a corresponding location.

The lower right shows these four buttons:

Quit: Exits the application, taking the user back to the previous web page.

Help: Creates pop-up window with instructions on how to use the application.

About: Creates a pop-up window with a long list of credits for the project.

Paths: Obsolete.

Screenshots Version

As with the Temple of Isis, there is a parallel version of the Temple of Horus application, which uses only screen shots, instead of a VRML model. It is intended for use on machines that do not have enough power to handle the 3D model. The appearance is exactly the same, except that the VRML control panel is missing, and of course, the user can navigate **only** by clicking on the map. The

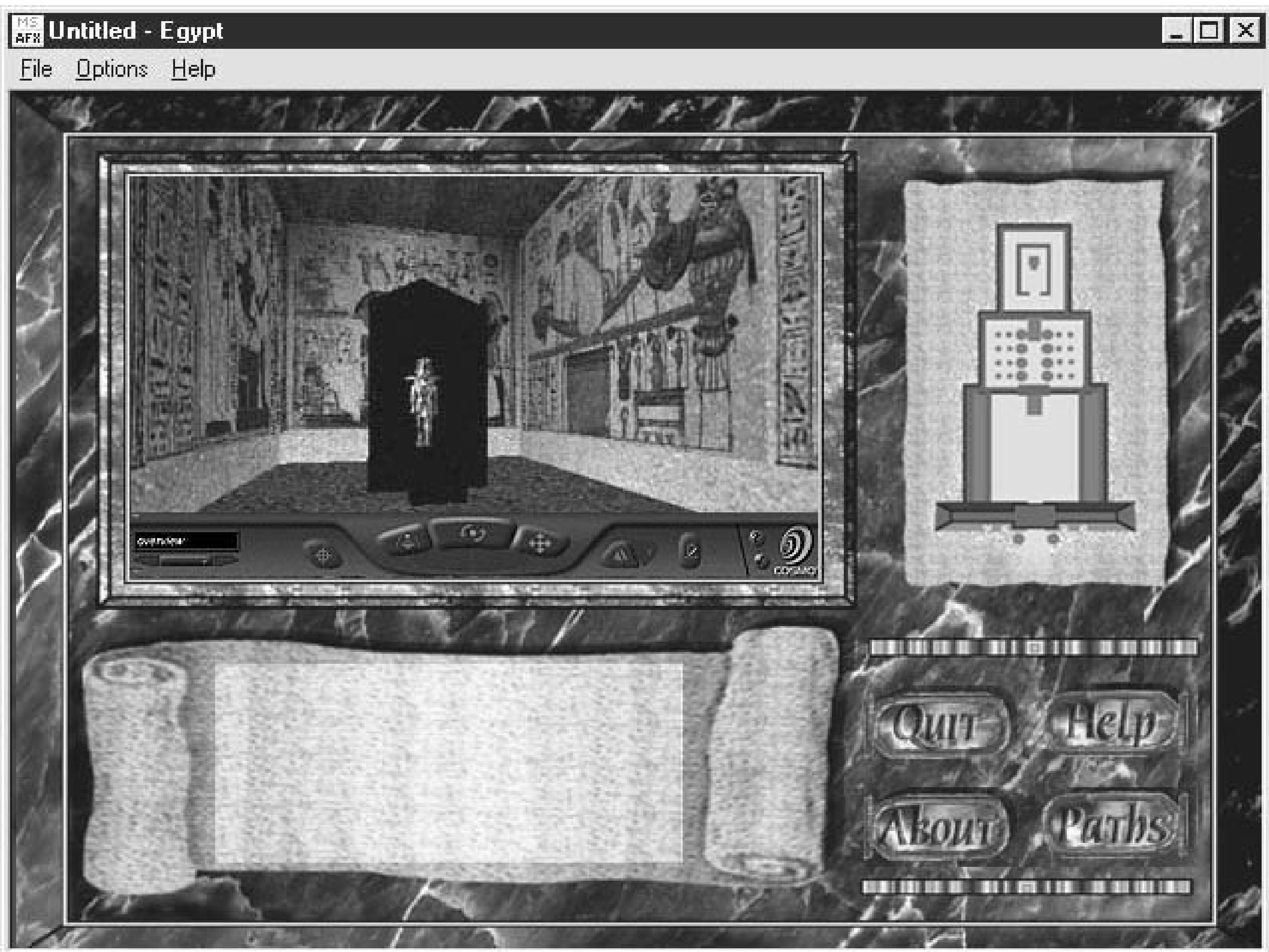

Figure Two: The Temple of Horus application, showing view of the inner sanctum as the user walks through the door. The VRML version of this application was not functional at the time this paper was written, so interface you see is a non-functioning prototype. (The original Windows-NT version cannot be distributed.)

animations still work the same, activated by clicking, and look exactly the same as they would when viewed from the corresponding viewpoint in the 3D model. The localized sounds also work, activating when the user activates a screen shot which corresponds to a viewpoint in a given sound's activation area. Note: at the time this paper went to press,

Project History

The Temple of Horus was developed at SIMLAB at Carnegie Mellon University in the summers of 1993, 1994 and 1995. Sponsored by Intel and Sense-8, it showed at the Guggenheim and SIGGRAPH 1994. it was a finalist for the 1995 Smithsonian Awards. See the web site for a long list of credits. The target platform was the early 486 PC's and later an Intergraph TD5.

Take Note: The web versions, both 2D and 3D were under construction as the time this paper went to press.

4. TOMB OF LADY HAO

The most abstract of the three, the Tomb of Lady Hao is based on a partial representation Bronze Age Chinese tomb of Lady Hao. The application is based on a three dimensional schematic, which shows images of select objects in their proper locations. The user may perform visual queries about certain attributes of these objects and perform logical grouping operations by attribute. By limiting and stylizing what is presented, the application emphasizes a particular subset of the data on the dig, and allows for a type of interactivity that would be impossible in a more literal model. **See figure three.**

Lady Hao was the third wife of the last Shang Dynasty Emperor, but the tomb contains a number of non-Chinese artifacts found with Lady Hao's personal items. This is one of the pieces of evidence that Dr. Katherine Linduff of the University of Pittsburgh uses to argue that Lady Hao was not an ethnic Chinese, but rather was one of the nomadic "horse people" from the North of China. The functional purpose of this application is to present the objects relevant to Dr. Linduff's theory.

Historical Content

This tomb, discovered in 1973, is one of the most significant sites in early Chinese archeology. It is the only intact royal tomb from the Bronze Age excavated and documented by modern methods. It is also notable because Lady Hao was known even before the tomb was

Figure Three: The Tomb of Lady Hao application.

discovered. She was , a principal wife of the Shang-Chinese Emperor Wu Ding and a warrior-general in his army. The artifacts found in the tomb were plentiful and of excellent workmanship. They were embedded in seven layers of packed earth, 1 to 4 feet deep. It is thought these layers reflect the stages in the Shang burial ritual. Furthermore, the placement of objects is crucial.

The Application

The main page contains two main panels, where the right contains the VRML model of the tomb. For reasons stated above, only 25 specific items are represented (out of 1500) and three layers to hold them (out of 7). At the bottom is the standard VRML control panel, with which the user may rotate the model in any direction to examine it from any angle. In the model itself, the layers appear as "floors" of translucent mesh. The items on each level were rendered as "billboards" - small images (icons) of the items placed on a polygon that always faces the viewer. At present, all billboards are the same size, regardless of the actual sizes of the objects themselves. Each icon is placed in the approximate location where the object was found in the tomb. The mouse appears as a small arrow on the screen. When it is over an object's billboard, it turns into a small circular sunburst. If the user clicks on it, several things happen:

- The object is highlighted in red,
- In the left-hand panel of the page, a larger image of the item and a short paragraph of information about it appears.
- Three buttons appear in the upper right side of the VRML panel. One describes the culture that produced it (Shang or Non-Shang), a second on the its function (Ritual or Personal), and a third on its material. (Stone, Bone, Jade, Bronze) For example, if the axe head is clicked it will highlight in red, and three buttons appear, marked " Shang", and "Ritual" and "Bronze".

The attribute buttons can be used to make simple logical queries, in concert with the three permanent buttons in the lower right. The latter are labeled XOR, OR and AND, respectively. When the user selects the XOR button, it activate, gaining a white border. Then the user can click on a single attribute button to select all objects which share the attribute. For example, clicking on the "Stone" button, causes all objects in the tomb made of stone to highlight in green. When the XOR button is active, only one attribute button at a time may be active. Clicking on an attribute button will cause any other attribute button that is currently highlighted to deactivate and all the objects with that attribute will not longer be highlighted.

When the AND (logical and) button is active, more than one attribute button at a time may be active. Only objects that share ALL of the attributes selected will be highlighted in green. Thus, when the user clicks "Bronze" and "Ritual", all the ritual objects made of bronze are
Highlighted.

The third button is the (logical) OR (logical OR) button, which the users found to be confusing and uninformative, and which will probably be excluded from later versions. When it is active, more than one attribute at a time may be chosen. Objects sharing at least one of the attributes selected will be highlighted in green.

Project History

This application was developed as a school project by the authors in the 1997-98 school year. In our preliminary user testing, [4] the users who used the model did significantly better at remembering the placement of the objects than a control group that only had paper maps locating the objects and textual descriptions.

5. ADVANTAGES TO THIS APPROACH

For the same reason that applications of this type can be powerful reference tools, they should also facilitate the users recall of the material they present. Much of the information is stored in the virtual model, itself, which they can store in their visual memory. They can then use this mental image to access related information, such as the objects found there or activities that had to happen in certain areas. Most non-spatial information will tend to be directly related to the model, such as the name of an object. The remaining information should be little enough to be presented explicitly.

Describe by Showing

In subject matter such as Horus and Isis, particularly, one of the important things one would want to convey to the reader is what those temples looked like in their heyday. Allowing them to explore a virtual reconstruction far superior to showing them a series of images or any kind of verbal explanation. In one way, it can be a double-edged sword, however. Building the model forces the author to fill in all the gaps, to provide a truly complete description of the temple. Inevitably, the author will have to speculate to fill in gaps with information that is less reliable than for some areas. On the other hand, the author has plenty of opportunity to explain these issues in the annotations to the model, textual and otherwise.

Model as a Reference
As a reference for objects in a physical space, a 3D model makes a convenient tool for organizing those objects. As with Hao Tomb, all the objects are click-able, so the reader can quickly reference information about them. A more detailed model, like Isis, could hold a great many more artifacts. Also, the relative placement, itself, of objects can be important, as with Hao, and the 3D model shows that.

Harnesses Spatial Memory
Humans are very good at processing and remembering visual/spatial information. A reconstructed tomb, in itself, is going to be much easier to remember than a less organized set of information describing what it looks like. In the latter case, the reader will be trying to construct a mental image of the temple, anyway.

More than that, the mental image of the temple can serve as a sort of visual index to further information about it and the thing within it. Any fact about any object in the temple will be tied to the reader's mind to the image of that object and in turn within the overall image of the temple. Facts concerning its use, such as the location and nature of ceremonies will be directly related to the model and thus the memory of the model. Other facts can be more indirectly connected or perhaps not at all, but there is much that is.

Harness Episodic Memory
Also, the existence of the model as part of an interactive virtual environment allows the users to experience events or happenings. They can then use episodic memory to recall what they saw and did, and thus the artifact itself. Thus, when asked, "What are the major architectural elements of a Ptolemeic temple?" Many users would visualize their "walk" through the temple, and describe the sections in the sequence they remember seeing them. The user will also remember the actions of agents in the virtual space in the same way--all observed actions are part of a recallable narrative.

8. TECHNICAL INFORMATION

These models offer varying levels and methods of interactivity and are each part of a web-based document. The web pages are written in HTML, the controls and logic routines are written in Java and the 3D models are written in VRML (Virtual Reality Markup Language.) Using a VRML plug-in for a standard browser, the user can "fly" or "walk" through the scene (Isis & Horus) or examine the scene as a single object (Hao). In the window where the model appears, most plug-ins have a control panel for navigation; we used the Cosmo VRML browser. [1][2] Currently, a very strong computer and net connection is required for the Temple of Isis, the Temple of Horus is less demanding, and the Tomb of Lady Hao should run on most systems.

9. CONCLUSION

The use of interactive virtual models for graphical user interfaces is a promising tool for working with information in situations which have an important visual component and in which non-spatial information can be linked directly to the objects in the model. Though we used them for archeological subject matter, they can also be used for other subject matter, such as environmental, medical, and engineering applications.

We will continue to build on our work by both improving our existing applications and testing their effectiveness in helping students learn and recall information. Source materials for all our applications is available on our Internet site:
www2.sis.pitt.edu/~jacobson/temples.html

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