

Learning in a Highly Interactive, Low-Resolution Virtual Environment; The Tomb of Lady-Hao

Jeffrey Jacobson

goshen@cmu.edu

Dept. of Information Science, University of
Pittsburgh, 135, Bellefield Ave, Pittsburgh, PA,
15213 USA

+1 412 521-6662

Jane Vadnal

medart+@pitt.edu

Dept. Art History, University of Pittsburgh.
135, Bellefield Ave, Pittsburgh, PA, 15213 USA

+1 412 521-6662

ABSTRACT

We are interested in users learn, classify and recall spatial and attribute information about objects in a virtual environment which is highly interactive, but built with minimal detail. The Hao Tomb application represents spatial relationships between objects with two-dimensional images (billboards) which are embedded in a three-dimensional model. Information about these objects, (i.e. materials and function) are represented through a visual query mechanism.

Given the task of learning certain attributes of the objects found in the tomb and their spatial layout, test subjects using the Hao Tomb application did better than subjects given high-quality printed information. Given the small number of subjects, these results are preliminary. They are part of the lessons learned in a larger pilot study, which has paved the way for a more in-depth study.

INTRODUCTION & BACKGROUND

The purpose of the Hao Tomb application itself is to make a body of knowledge more accessible through the use of an interactive, spatial interface. Archaeologists studying documentation off a dig need to know what items were found and where they were located. The application presents a subset of key objects found in this particular tomb and allows the user to perform visual queries on their primary attributes. It is our belief that the objects' orientation in three-space are best learned by looking at a three dimensional model. Also, the ability to perform interactive visual queries on the attributes of the objects should enhance learning of those. Neither idea is new. □□□□□

Our primary innovation is use billboards, simple one-dimensional icons that always face the user. While they have been long used in virtual environments, hence a specific name for them, it has usually been to represent a distant object, or out of necessity or simply to enhance performance. Most developers, and especially those of archaeological simulations, prefer to render all objects in a scene in a full three-dimensions, with as much resolution as possible. While this is desirable for many

reasons, it requires a lot of computing power and developer time. Instead the time and cycles saved by using simply billboards could be used for greater interactivity and the make the application more widely available. The goal of the Hao Tomb project is to prove that this is a desirable strategy.

Source Material

The virtual model represents objects found in the Bronze Age tomb of Lady Hao, a principal wife of Wu Ding, a famous Emperor of Shang dynasty China. It is the only intact royal Shang tomb excavated (in 1985) using modern archeological methods. Spatial relationships are particularly important in it because the objects were found in several distinct layers, which scholars believe corresponded to phases the Shang burial ritual.

Dr. Linduff's contention [] is that Lady Hao was not only a warrior, and probably a general, but that she was probably not Chinese. Both assertions are controversial and current among scholars, and the 23 objects represented in the application were chosen to make the point.

THE HAO-TOMB APPLICATION

The Hao Tomb application is a web page with a large VRML component. All of it is freely available at "<http://www.sis.pitt.edu/~goshen/Net-Hao/>".

The initial page contains two main panels, where the right contains the VRML model of the tomb. (Fig 1) The actual "tomb" was really a large pit, filled in with eight layers of dirt and roughly 1500 objects placed at each level. This model only shows three layers and 23 objects. The layers appear as "floors" of a translucent mesh. Billboards represent the items on each level—small images 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.

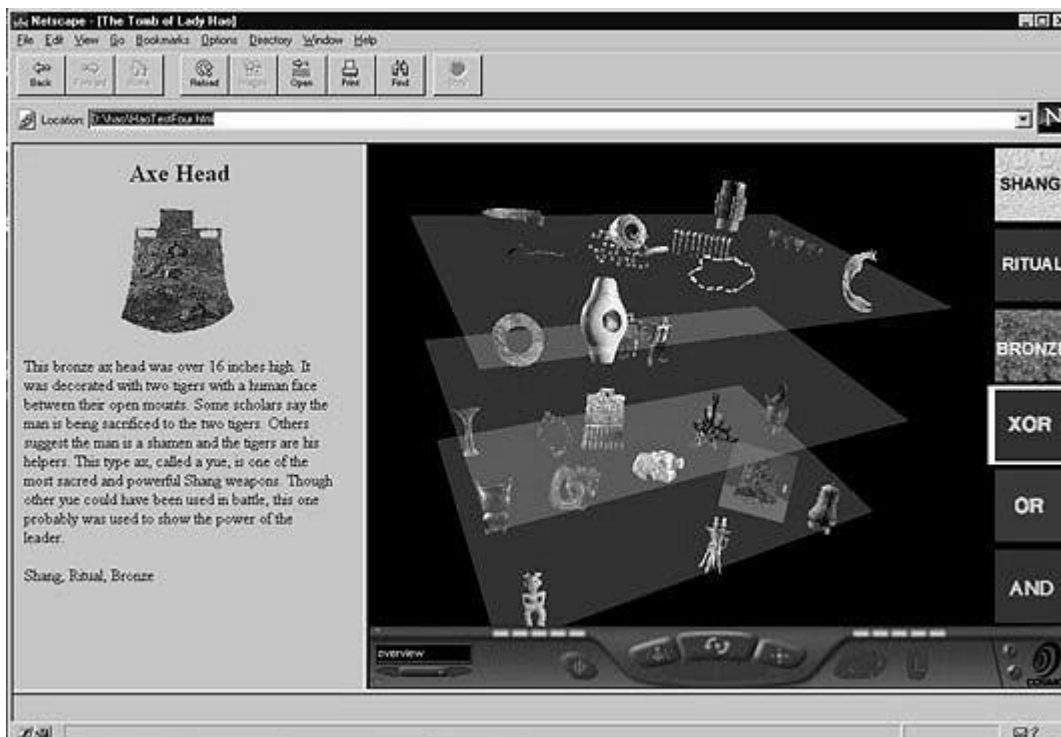


Fig 1: Snapshot of Hao Tomb application. The “Axe Head” object on the bottom layer (right, front) has been selected. In this greyscale image you can see the highlight as a grey square with the axe head image in it. The associated summary page appears on the left and the “Shang”, “Ritual” and “Bronze” buttons appear on the right. The “XOR” button is active, as shown by the white outline around it.

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 figure. At that point, the user can click on it, which causes two things to happen:

At the bottom of this window are the standard navigation controls for the COSMO browser. Full instructions are available at: ["http://cosmosoftware.com/support/player/docs_21/frames-help.html"](http://cosmosoftware.com/support/player/docs_21/frames-help.html). Controls are set to “examiner” mode, which allows the user to rotate the entire tomb to any angle and to zoom in on any part of the model.

- In the left-hand panel of the page, a larger image of the item and a short paragraph of information about it appears. (Fig 2)
- 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 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, as shown in figure one, three buttons appear, marked "Shang", "Ritual" and "Bronze", as shown in figure one. These are its primary "attributes". (Fig 1)

The attribute buttons themselves can be used to make logical queries, in concert with the three permanent buttons in the lower right. They are labeled XOR, OR and AND, respectively. (see Figs 1 & 2) When the XOR button is active, (surrounded by a white border) 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, including the mace-head itself. (Fig 2)

- While the application is in XOR-mode (XOR button 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. The button click will become active and all objects sharing new attribute will be highlighted (in green). (See Fig 2)
- When the OR (logical OR) button is active, more than one attribute at a time may be active. Objects which share **at least one** of the attributes selected will be highlighted in green.
- When the AND (logical and) button is active, more than one attribute button at a time may be active. Only object that share **ALL** of the attributes selected will be highlighted.

In this way, the user is able to make simple visual queries on the composition of tomb objects and to group them by types and combinations of types.

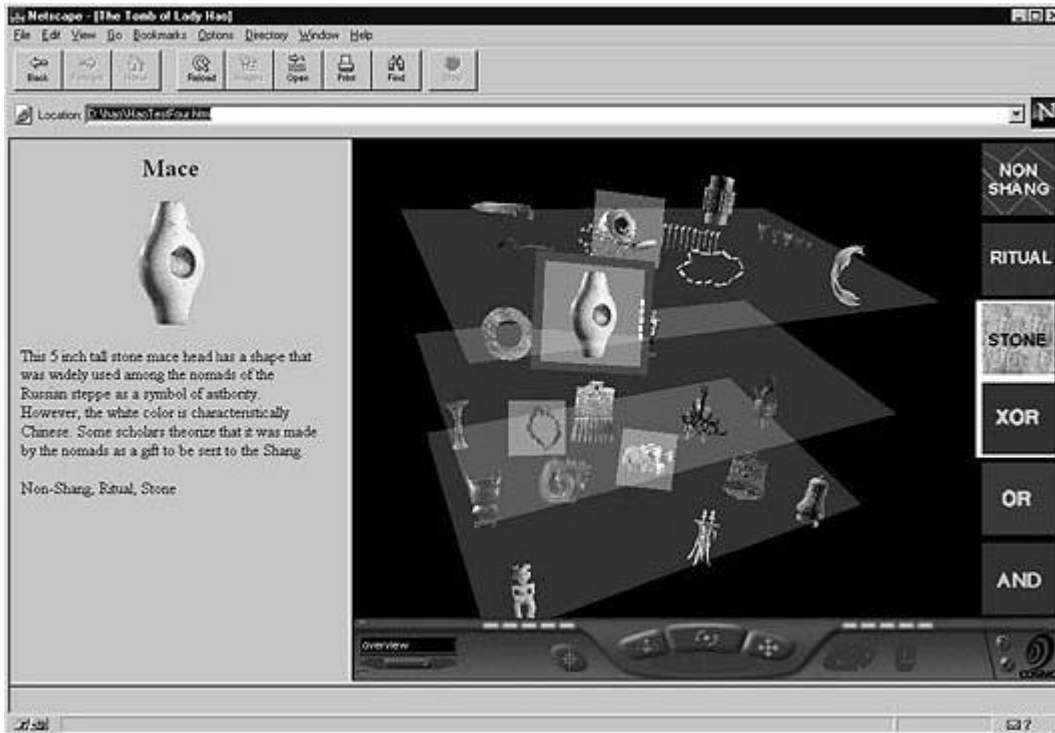


Fig 2: Snapshot of Hao Tomb application. The “Mace Head” object on the top layer (left, front) has been selected. In this greyscale image you can see the highlight as a grey square with the mace head image in it. The green highlight is a darker grey outline around that. All other stone objects are highlighted in green, because the “stone” button has been selected. This appears on the mace head as a darker grey outline around the “red” highlight and on the others its simply a grey square.

EXPERIMENTAL METHOD

Subjects were recruited from the PITT and CMU community and randomly assigned to test groups and a control group¹. Both groups were given the same introduction to the archaeological materials, similar to the short description of Lady Hao’s tomb in this paper.

The control group was given written information only. This was a set of full-color printouts of the small web page for each objects, which normally appear in the left frame of the Hao Tomb main web page. There were also three maps; one for each level, showing where the objects are located, again as full-color maps. The maps were labeled top, bottom and middle and the written instructions clearly described that these were maps of the three layers of the tomb, showing the relative positions of the objects.

The fourth test group used the fully enabled application described in the previous section. The tester tutored each subject on how to use it for roughly five minutes. Each subject was given twenty minutes to study the available materials. They were told to learn all they possibly can, with no specification.

Next, each subject was given a list of outlines of the object found in the tomb. By each one, there was a

checklist of all possible attributes. This outline, for example, is of a jade bird plaque, used for ritual purposes.



This object is made of:
(choose one)

Stone ____

Bone ____

Bronze ____

Jade ____

Its function is
(choose one)

Personal ____

Ritual ____

Its culture is
(choose one)

Non-Shang ____

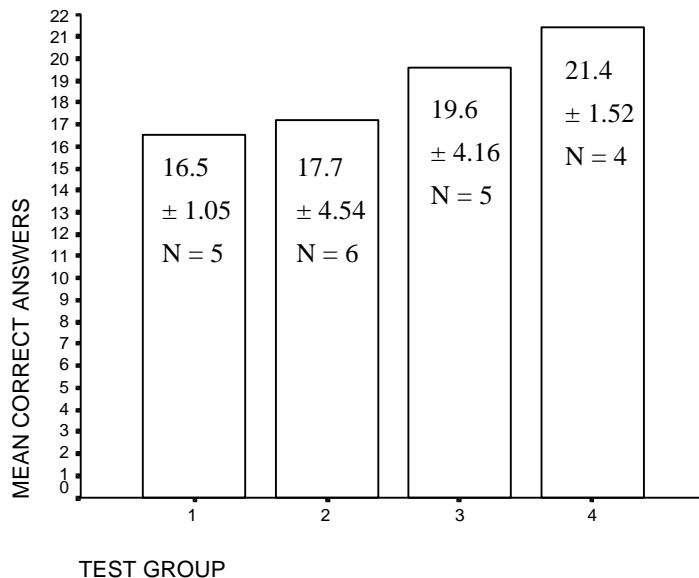
Shang ____

The subject simply checked off the attributes he or she could remember that applied to the object outlined on the left.

¹ Again, this paper discusses only part of a larger study; there were other groups not discussed here.

RESULTS AND ANALYSIS

We compared first part of the checklists, where people marked the object's primary material. There appear to be differences between the number of correct responses between the four test groups. (Fig 3) Figure three shows their mean performance, after removing outliers—subject whose score was more than two standard deviations away from the mean.



Because of the very large standard deviations in the middle groups, a four-way ANOVA did not yield a statistically significant result. Still, this suggests that the presence of each query mechanism improves the users' learning.

A strong, significant difference was found between groups one and four. ($p = 0.00$)

However, the subjects in the control group reported fewer years of computer usage than those in group four, a significant difference ($p < 0.328$). This, despite the fact that the subjects really were randomly assigned. Bad luck. Obviously, this is a confounding factor, but to what extent is not clear. How many years does it take to reach a level of computer literacy to gain full advantage of the Hao Tomb application? In our next study we will control for this.

Interestingly, the same groups (one and four) showed essentially no differences in their answers to the function or culture questions. We can speculate that this is due to materials being more familiar—something one might infer from the image and feel more confident with. Nevertheless, the superior performance of the

group using the application is encouraging; we will look at this more in further study.

FUTURE WORK

We acquired a great number of suggestions during the testing. We welcome yours! Some of them are:

- Make the ruler part of the large image on the web page, rather than the thumbnail on the billboard.
- Show the billboards in differing sizes that correspond in some way to the objects' actual sizes. If they are shown in their precise relative sizes, we are concerned that the small ones may be difficult to see—perhaps they could be enhanced in some way.
- Show a front and back for the tomb, even if it is arbitrary, to help viewers orient themselves in the virtual space. This could be done with rods or stilts, which connect the different layers or arrows or a vertical plane along the "back".
- Other, static points of reference would be helpful, such as the location of Lady Hao, herself.
- Introduce an uncertainly shape or cloud around each object, perhaps one that appears when it is active. It been at the actual dig **or** in the original burial.
- A variety of minor not-so-minor bug fixes, which are not worth listing here.
- Place the center of navigation at the center of the tomb itself, rather than off to one side, as it is.

Suggestions to improve the experiment:

- Take much larger samples, and possibly restrict the study to two groups.
- Possibly control for subjects' level of computer literacy. Either through depending on the larger sample, or attempting to balance users' average years of computer usage.
- Instead of outlines in the checklist and the map-making task, show full-color images.

We welcome reader to visit our web site at www.pitt.edu/~jljst15/Hao to examine Hao tomb. The VRML & HTML code is freely available, and all comments are welcome.

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