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ARCHAVE: A Virtual Environment for Archaeological Research

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Abstract:

ARCHAVE: A Virtual Environment for Archaeological Research

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We will present an interactive system to perform archaeological analysis with site features, topography, architecture, artifacts and special finds from the Brown University Excavations at the Great Temple site in Petra, Jordan. The system is significant because it allows a user to interact with three dimensionally referenced excavation data in a CAVE - CAVE Automatic Virtual Environment [Cruz-Neira, 1993] (a 3m x 3m room where users are immersed in a virtual environment through stereoscopic projection on three walls and the floor). Through user studies, we will investigate the types of analysis archaeologists can perform in the system and compare it to standard analysis methods using a database and maps of the site and excavation trenches.

Key Words:

Virtual Reality, CAVE, 3D Database, Spatial Analysis, GIS, Reconstruction

Introduction:

The SHAPE Lab was created with a grant from the United States National Science Foundation in 1999 in an effort to develop scientific tools useful in archaeological site and artifact reconstruction and analysis using data from the Brown University Great Temple excavations in Petra, Jordan [figures 1,2] [1]. It is a multidisciplinary endeavor and involves the departments of Computer Science, Engineering, Applied Math, Old World Archaeology and Art and Anthropology at Brown University.

One of the key projects that the lab has been collaborating on is ARCHAVE, a software system that utilizes a virtual environment as an interface for archaeological research and analysis. We will present the system we are currently developing and user studies we plan on conducting to test the functionality of the system in several virtual reality environments.

Archaeology:

The basic goal of the excavation process is to collect and analyze as much physical evidence as possible to answer questions about the site and related culture. However, one of the biggest problems the archaeologist faces in completing this task is that of cataloguing and storing the plethora of artifacts removed during the excavation process. Later, during analysis proceedings, modeling aspects of the data and establishing necessary relationships between architectural finds, stratigraphy, site features and different artifact types is also problematic.

The database of finds for the Great Temple excavation contains more than 200,000 entries, recovered during excavations that commenced in 1993. On site, architectural finds are surveyed in their in situ positions. Artifacts are located and recorded in the site database in their relative positions by loci/trench with a number of feature attributes such as object type (bone, pottery, coin, metal, sculpture, etc.), use, color, size, key features, date given, etc. In some cases, architectural finds, sculpture and other objects that are particularly notable are photographed and drawn for further analysis and comparison with other objects.

Current Analysis Method:

As the excavation proceeds there is a strong need to correlate all the objects to observe patterns within the data set and perform standard analysis. Methods for this type of analysis vary widely depending on site features, excavation strategy and data.

A quantitative analysis of all materials grouped and sorted in various ways was employed in The Great Temple five-year report published in 1998. The generated reports show statistics about the percentages of different artifacts and their find locations i.e., ‘‘pottery by phase, pottery by area, frequency of occurrence of pottery by area,’’ etc [2]. This type of analysis is informative because it can help archaeologists do a variety of statistical analyses using fairly comprehensive information from the database. It can also allow the archaeologist to quantify obvious patterns within the data set. Unfortunately, there are many factors that cannot be represented well in a traditional database and in reports generated from it. Specific attribute data, location and relational data between artifacts and site features cannot be represented in this method. For example, architectural features that have physical clues (stucco finishes, construction irregularities, evidence of building additions, etc.) may be useful only when viewed in a context with associated finds and site features.

Besides obvious conclusions that can be made when objects are correlated spatially, combinations of artifacts when viewed by a trained eye, together in their original spatial configurations, can yield important and unlikely discoveries. Lock and Harris suggest:

> ‘‘*Vast quantities of locational and thematic information can be stored in a single map and yet, because the eye is a very effective image processor, visual analysis and information retrieval can be rapid [3].*’’

Although the idea of processing information visually would seem to be a more intuitive and thus effective way of processing 3D data, it has not been proven. More graphical methods of analysis have been explored in GIS systems that overlay multiple types of 2D graphic representations of data such as maps, plans and raster images together with associated attribute data in an attempt to present relationships between spatial data. However, it is strongly suggested that GIS systems are not sophisticated enough to provide a thorough description of z dimension (height) relationships.

> ‘‘*The spatial relationships between the artifacts, other artifacts, site features, other sites, landscape elements and environmental aspects present a formidable matrix of alternative individual categorizations and cross-combinations to be searched for information [4].*’’

A system or method that can allow formal analysis that uses the data in all three dimensions and can link important attribute data may resolve some of the analysis issues noted.

What We Propose:

The Great Temple artifact and site recording methodology will allow analysis of the findings in three dimensions because it maintains the x, y, and z coordinates for its objects. Therefore, in the system we are developing, we will assess the usefulness of analyzing three-dimensional characteristics and associated attributes of the objects and features of the Great Temple site. Also, following what Forte proposes[5], we believe that a virtual environment will be particularly useful in helping the Great Temple researchers understand their data to develop new conclusions and hypotheses about the history and evolution of Nabataean culture.

The System.

The ARCHAVE system displays all the components of the excavation in the context of an architectural reconstruction of the Great Temple or, if the user prefers, an in situ model of the architectural remains [figure 3]. Like the excavation site, the virtual site is divided into the grid of excavation trenches representing the different areas that were excavated over the last seven years [figure 4]. Each trench is modeled so that the user can look at the relative layers or loci the excavator established during the removal of debris in that trench. As the user dictates, information about artifacts can be viewed in the locations where they were found.

For example, a user can see bulk pottery finds in a trench or group of trenches. Bulk pottery finds will be indicated by a color range where the darkest color represents the highest concentrations throughout the site [figure 5]. In addition to viewing bulk pottery finds, it may be helpful to see relevant coin finds, bone, glass, stone, metal, architectural fragments or special finds also. Additional object types such as bone shown with pottery are defined by range of texture along with the existing color range. As new information is added, the user can start to form hypotheses or make conclusions about the relationships between the artifacts and the architecture or site that could not be made otherwise.

A task we envision for the system is to establish the building chronology or phasing of the Great Temple by using artifact attributes such as relative dates and grouping them with architectural elements and other site features. We believe that such a task can be achieved better in the system because it is easier to associate objects in all three dimensions. Therefore, objects that cannot be related in 2D map-based GIS systems can be accommodated here. We will test the user's ability to do such a task by an interactive method that combines queries of the artifact and architectural fragments database.

As the system is developed, we hope to integrate functions that will allow the user to mark areas and elements that have been analyzed for a cumulative effect. When the user comes to conclusions in the virtual site, it can be annotated to aid the user later or to key other users.

In a fully developed environment, a researcher will be able to study the site by navigating through different stages of the excavation or important historical phases of the building.

He or she will also query the database of artifacts using speech recognition, gesture-based commands, or automatic query generation depending upon the state of the user in the virtual site.

User Studies:

As Doug Bowman proposes, In an effort to compare results from the system and analyze the usefulness of various VR interfaces, we are designing user studies that utilize the following virtual environments: a Cave, Barco Baron table, head-mounted display and the desktop [figures 6-9][6].

In testing this application we hope to answer the following specific questions: What virtual reality environment, if any, performs better in giving archaeologists the adequate interface and contextual information they need for analysis? What context is necessary for performing archaeological tasks? Which interaction techniques allow the user to navigate through an archaeological site and access a database of artifact information? How do we display the results of those queries in a way that he or she can gain maximum insight about the data?

We will test the system by allowing users to view and interact with the find information in the VR environments. As they do this, they will be asked to answer basic questions about their findings in the system. Users will also be asked to attempt to answer similar questions using the traditional site database and maps available in Filemaker Pro on the desktop.

From a number of informal tests and demonstrations, we have observed that users get a good sense of immersion in the system and those who have visited Petra report that using the system is similar to being at the actual site. However, we have also observed that, because the Great Temple is large and they are navigating inside the system at full scale, users want to look up to see important parts of the edifice. In the CAVE this is problematic because the ceiling is not a display surface. Another problem we have detected is that scale is hard to convey accurately. We are currently developing a pilot user study to compare how important this factor is in the different platforms and how it affects the archaeologists studying the site.

Conclusion:

The system we have described is significant because it allows archaeologists to preserve and visualize the data they collect in three dimensions. Implementing the system in a VR environment allows Archaeologists to better understand the context of the excavation data and correlate the large quantity of artifacts with features of the site and architecture.

Through user studies we will gain insight into the way users interact with ARCHAVE and the differences between analysis performed in the system and more standard analysis using available databases, maps, photos and drawings.

References:

[1] Any opinions, findings, and conclusions or recommendations expressed in this paper are those of the author(s) and do not necessarily reflect the views of the United States National Science Foundation.

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Figures:

Figure 1: Aerial of the Great Temple site in Petra, Jordan.

Figure 2: Aerial showing the Temple Proper area of the Great Temple precinct after the excavation season, 1999.

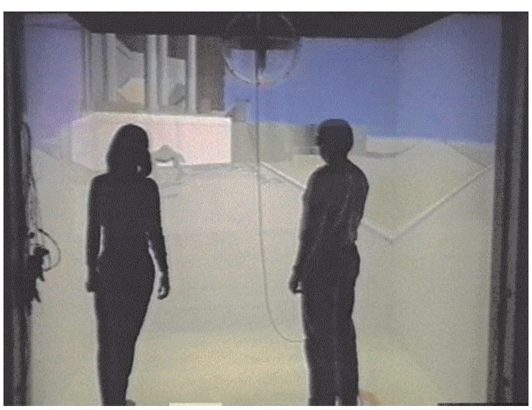

Figure 3: Users in the CAVE virtual environment navigating through the temple reconstruction.

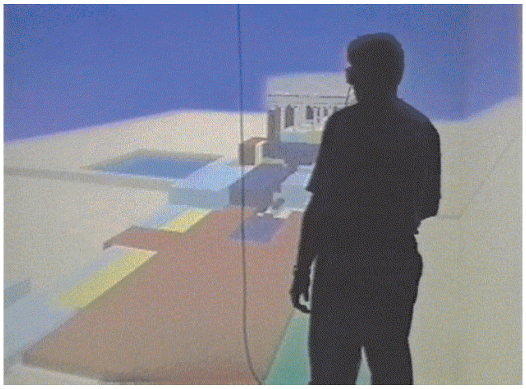

Figure 4: User in the system showing the excavation trenches from all years with the architectural reconstruction of the temple.

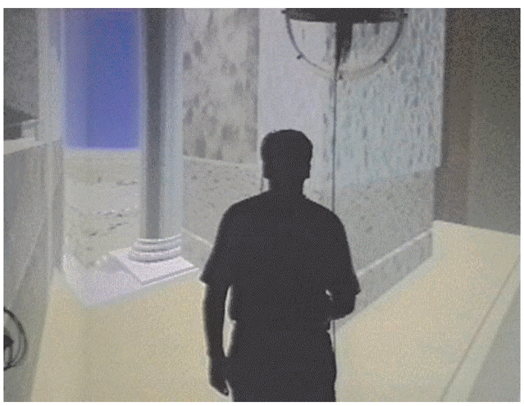

Figure 5: Immersion in two excavation trenches with multivariate visualization of pottery concentrations and bone.

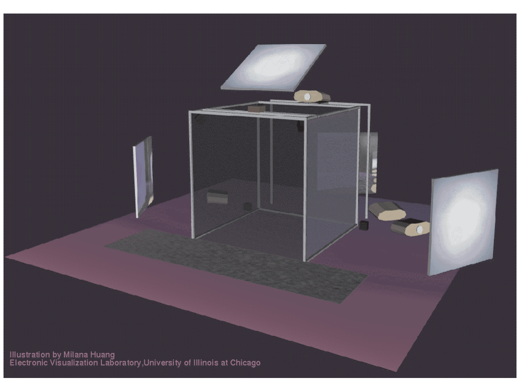

Figure 6: CAVE virtual reality environment

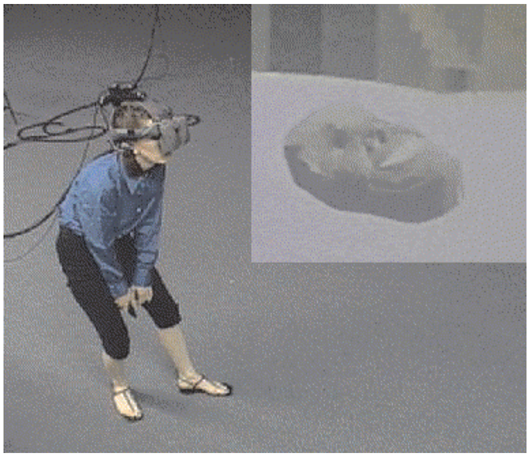

Figure 7: User using a head mounted display to investigate artifacts in the system.

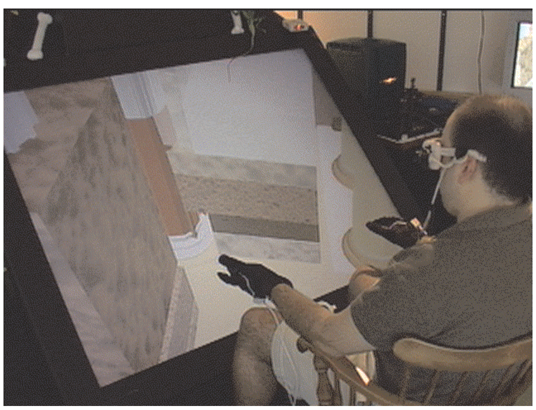

Figure 8: User navigating through trenches using the Barco Baron workbench system.

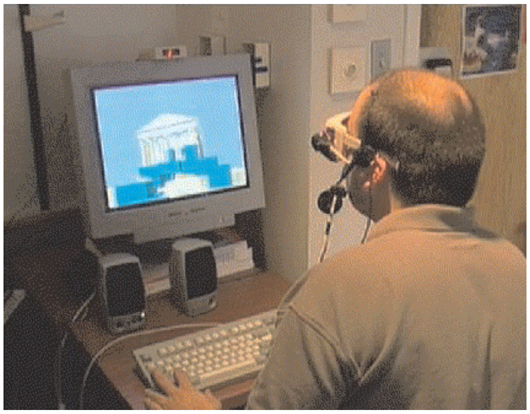

Figure 9: The desktop VR system.