VIRTUAL HERITAGE: FROM THE RESEARCH LAB TO THE BROAD PUBLIC

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The use of immersive Virtual Reality (VR) technology accounts almost a decade of research performed exclusively by the academic, military, and industrial research and development communities. However, as VR technologies mature, research is expanding from the military and scientific visualisation realm into more multidisciplinary areas, such as education, archeology, art, culture, and the humanities. As representative institutions involved in the research and presentation of these fields, museums and cultural heritage centres may be in a better position to make use of advanced virtual reality technologies and contribute to a broad-based public acceptance of technology as a tool for the study and presentation of the past. Nevertheless, the prohibitive costs and inaccessibility of immersive VR technologies, coupled with theoretical issues and issues of usability, user training, operation, and maintenance, continue to present practical drawbacks, especially for the cultural and educational use of VR. This paper explores some of these issues through examples of immersive virtual heritage applications for the broad public.

1. INTRODUCTION

Virtual Reality (VR) is – still – a novel and innovative technology which, through its current applications, has proved to be a useful visualization tool for a variety of domains, especially those that involve the visualization of abstract concepts and ideas, spaces that are unreachable or no longer exist, or objects that must be examined from diverse and unique points of view. Research in virtual reality and archeology is a recent application which has lately shown considerable growth, as the development of interactive computer technologies has inevitably impacted even the more traditional sciences and arts.

The increasing development of VR technologies, interfaces, interaction techniques, and devices has greatly improved the efficacy and usability of VR, providing more natural and obvious modes of interaction and motivational elements. This has helped institutions of informal education, such as museums, media research, and cultural centers to embrace advanced virtual technologies and support their transition from the research laboratory to the public realm. Furthermore, the use of these advanced systems for the implementation of heritage programs in public spaces, enables these institutions to investigate their educational potential while effectively shaping how they deliver public awareness and entertainment.

Further in this paper we will describe some examples of interactive virtual heritage environments developed for learners of all ages and discuss the issues involved in developing immersive and interactive virtual archeology projects for the general public.

2. VIRTUAL HERITAGE

The broad term "heritage" refers to the study of human activity not only through the recovery of remains, as is the case with archeology, but also through tradition, art & cultural evidences, narratives, etc. There are two points that are often brought up in the discourse and study of heritage and archeology and must be emphasized when speaking about their visualization and representation. First, the issue of validity of information, commonly referred as authenticity. Second, the importance of accuracy in the representation of this information. Authenticity and accuracy are characteristics that archeologists, historians, and museum people strive to achieve and that the general public comes to expect from them. On the other hand, technologists dealing with the visualization of certain content are more concerned with the technical issues that pertain to implementation of the visualization and less concerned with authenticity and accuracy of the content itself.

To virtualize heritage means to actualize it digitally, to simulate it using computer graphics technology. Practically speaking, virtual archaeology refers to the use of three dimensional computer models of ancient buildings and artifacts visualized through digital interface technologies that offer some degree of immersion and/or interaction with the content. Virtualization, as experienced today, is a technological condition that is generalized much beyond what we understand as virtual reality. In this sense, virtual heritage involves the synthesis, conservation, reproduction, representation, digital reprocessing, and display with the use of advanced imaging technology.

Although virtual reality suffers immensely from media hyperbole and thus has not lived up to its promises, the development of VR systems has matured enough to find its way out of the research realm and into public settings (Figure 1). Digital tools and techniques are emerging from academic, government, and industry labs to offer new hope to the often painstakingly complex tasks of archeology, historic research, conservation, and education (ADDISON 2000).

Nevertheless, despite its popular culture image, VR is still an experimental technology while its primary development space remains within the few research and industry labs worldwide. This is why perhaps some of the best examples of virtual archeology projects are a product of university research laboratories (FRISCHER *et al.* 2000). Even so, the examples that we have of virtual reality applications in archaeology and heritage are frequently identified with the

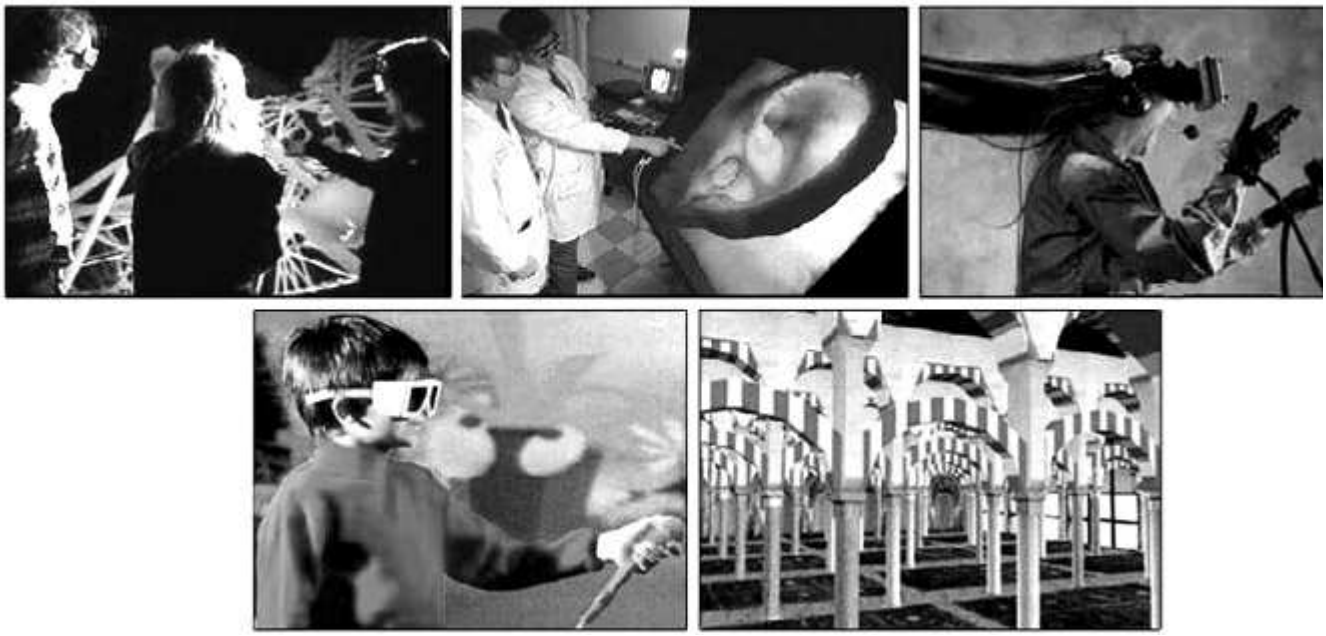

Figure 1. *Virtual Reality application domains: military - scientific visualization / representation - industry - entertainment - education. Images courtesy of the University of Illinois at Chicago,* NASA *Ames, and Maria Roussou.*

photorealistic reconstruction of ancient sites in the form of 3D models for desktop viewing (BARCELO, FORTE and SANDERS 2000).

In order to extend virtual heritage research out of the labs and into the public agenda, the educational, presentational and even recreational aspects must be emphasized. The key issue is not only to visually *represent*, in a photorealistic manner, places, monuments or landscapes that do not exist, never existed, or may not be easily experienced but to *present* these in a meaningful and engaging way, to add the extra touch that will render the representation an experience. The research itself accounts for part of the public experience. The way that the research is presented accounts for the rest.

Nowadays, virtual reality technology has evolved its systems into high-end projection-based presentation platforms with inherent properties that can prove important tools for the enhancement of public awareness. Specifically, current VR technology fortifies the main characteristics of VR as a medium: the sense of immersion and the capabilities of interaction. Immersion is the illusion of being in the projected world, being surrounded by the image and sound in a way, which makes you believe that you are really there. It offers a "better than real life" or "better than being there" experience. Interaction refers to the fact that members of the audience are not mere viewers of the realistic scenery, but can actively participate in the program and, through their actions, determine their own experience. Since the imagery displayed in a high-end VR theatre is not predetermined or pre-recorded, but generated in "real-time", the audience is able to interact with the programs and define their behavior.

The two key issues of authenticity and accuracy mentioned above are epitomized in the case of public institutions such as museums. Within the museum, the public expects to experience a collection of objects of undeniable value, that are gathered, researched, analyzed and carefully placed there as a result of the intense study of specialists and scholars that comprise the timeless authority of the institution. The "unassailable institutional authority" of the museum (WESCHLER 1996) that is solely authorized to collect and preserve our cultural artifacts is also one of the reasons that keeps some people out of museums altogether. Nowadays, all museums are under considerable pressure to make their collections more accessible to the public. There are major developments underway worldwide to create archives and large-scale digital resources that provide enhanced access to the public (THOMAS and MINTZ 1998). In general this is a response to the recognised need for better understanding of, and education about, history and heritage of different cultures in a pluralist, multi-culture world. In parallel with their attempt to reach out, museums and public education spaces intensify their attempt to attract. To this end, the potential to transcend the physical location of the built environment and the growing sense of the educative function of the museum juxtaposed with the commercial pressure has lead museums to consider virtual reality as an attractive component in the arsenal of tools to educate, entertain, and dazzle (ROUSSOU 2000). Of particular interest in the use of virtual reality exhibits (displays and computer-generated interactive experiences) is the fact that these can allow visitors to travel through space and time without stepping out of the building (ROUSSOU and EFRAIMOGLOU 1999).

Additionally, a virtual exhibit can give us a completely new way of communicating the scientific results of archaeological investigation within the scientific community, improving also the way in which these results are communicated to the public (NICCOLUCCI 1999). A well-designed virtual heritage application can benefit the public education or recreation institution on multiple levels, such as:

- Visualize and provide "access" to places and sites that no more exist, are unreachable, geographically remote or are a result of speculation (time, distance, scale, safety, cost factors).
- Present multiple, alternative representations and visualize different theories
- Keep interest alive and make strong motivational impact, especially for the young
- Aid distance learning and special education
- Better enable informal methods of education – interactive, collaborative, responsive.

3. COMBINING ACCURATE REPRESENTATION AND ENGAGING PRESENTATION

Beginning from virtual reconstruction that is as accurately created as possible, the emphasis of our VR work at the Foundation of the Hellenic World involves the creation of meaningful and stimulating virtual *experiences*.

The Foundation of the Hellenic World (FHW), based in Greece, is a non-profit cultural heritage institution working to preserve and disseminate Hellenic culture, historical memory and tradition through the creative use of state-of-the-art multimedia and technology. Its aim is to promote the understanding of the past and to synthetically and comprehensively present the history, life and values of the Hellenic world in its broader geographical evolution. In addition to approaching the broad public, the Foundation is also active in creating a forum for archaeologists, historians, scientists, and artists to visualize their ideas and utilize the highest level of technology and resources for research and education within the context of Hellenic cultural heritage. To this purpose it uses the best of contemporary museum theory, developments in computer science, and the use of audiovisual media and interactive exhibits. These activities are housed at "Hellenic Cosmos", the Foundation's Cultural Center, which stands on the site of a former industrial area that has been converted into an attractive contemporary complex of buildings located in Athens. The overall design, architectural, electrical and acoustic plans of the complex make it one of the most modern and well-designed cultural centers in Europe.

FHW's VR Sector, established in 1998, uses VR technology as a means to advance the research, understanding and dissemination of Hellenic culture. The Sector is a major interface between the general public and FHW's archaeologists, historians, scientists, educators and artists. Its main activities focus both on the establishment of an infrastructure and the creation of the educational and exhibition content. Hence, its main functions are:

– to create educational and exhibition content for projects, exhibitions and educational programmes.
– to create innovative immersive environments for the display of FHW's educational programmes and exhibitions.
– to maintain and develop its infrastructure and to foster collaborations with other institutions, national and international.

In terms of the infrastructure, the goal is to put together an innovative immersive environment for the display of the Foundation's educational programs and 3D reconstructions. To this end, the FHW has installed two immersive virtual reality systems – exhibits.

In the Spring of '99 the first VR exhibit – and the first projection-based VR system in Greece – opens to the public.

Figure 2. *Children explore the virtual representation of Ancient Miletus on the* Magic Screen (*ImmersaDesk™).*

The exhibit is named "Magic Screen" due to its setup. It is an ImmersaDesk™ with a 2m x 2.38m back-projected panel screen tilted at a 45° angle running on a Silicon Graphics® Octane® visual workstation with 2 R10000 processors at 250Mhz. Stereo viewing is achieved using lightweight liquid crystal shutter glasses. The system provides head and hand tracking, user input through a lightweight hand-held device, called a wand, for interaction, and audio from loudspeakers.

The first program on the "Magic Screen" was an initial version of the reconstruction of the ancient city of Miletus (Figure 2). This pilot presentation was shown to approximately 5000 visitors. Although the presentation was not complete when presented and remained crude for a few months while implementation was in progress, the visitor response provided us with the first indication of the popularity of VR with the public.

A few months later the second exhibit followed. The exhibit is named "Kivotos" (Figure 3). The virtual reality system behind it is a ReaCTor™, a 3m x 3m x 3m cubic immersive VR display (similar to a CAVE®) with four back-projection surfaces powered by a Silicon Graphics® Onyx2™ with eight R12000 processors at 300Mhz and four InfiniteReality2E™ visualization subsystems. Up to ten people can participate in the experience at the same time wearing special lightweight stereo glasses, which allow them to see both the virtual and the physical world unobtrusively. The system is fully interactive providing individual visitors with complete freedom to control their movements through the use of the wand, and so develop a completely unique interactive experience. Audio is enabled through the use of loudspeakers.

Figure 3. *Immersed in the virtual worlds of the "Kivotos" exhibit, a CAVE®-like virtual reality display.*

The duration of the experience in the "Kivotos" ranges from 10 to 20 minutes for each group of visitors. Each group is always guided by a trained museum educator. Approximately five hundred people visit the VR exhibits daily while over 100.000 visitors have experienced the "Kivotos" since its opening in November of 1999. Most visitors are school children between 6 and 15 years of age. The numbers are large considering the experimental nature of the technology, a fact that proves for a promising technology but also presents a number of issues and problems.

4. VIRTUAL HERITAGE AND EDUCATION PROJECTS AT THE FHW

The two exhibits mentioned above host a whole variety of virtual worlds – of interactive, educational experiences – for the visitor to discover, learn about and explore. The virtual reality productions function in two basic ways: as educational/entertainment tools and as instruments of historic research, simulation, and reconstruction.

The major projects undertaken by the VR team at FHW include accurate three-dimensional reconstructions and journeys through ancient cities and sites as well as heritage-related interactive educational environments. Other programs include productions to complement or highlight important events that shape our time, culture, or everyday life, such as the Olympic Games and Cultural Olympiad, as well as experimental environments and innovative collaborations with scientists, researchers, and artists, that allow to gain insights on the creative use of technology.

The premiere program, "A Journey through Ancient Miletus", propels visitors on a voyage of discovery to the city of Miletus as it was two thousand years ago; the temple of Apollo Delphinius, the Council House, the Hellenistic Gymnasium, the Ionic Stoa and the North Agora are some of the public buildings that can be experienced. Participants can navigate through or fly over the accurate three-dimensional reconstruction, "dive" into the harbor of ancient Miletus, explore the city as it unfolds through time, and experience the details of its architectural glory. With the use of the navigational device, visitors are free to choose, from an unlimited number of directions, their own path in visiting important public buildings. They can examine the architectural details and landscape from many different perspectives, practice their orientation skills and get to understand the sense of scale, proportion, and space used by their ancestors. If they choose to fly close up to the columns, the architectural elements of the 3D models fade into layers of higher detail, enabling the participants to experience a more accurate view. A next step would be to enhance the educational experience by adding construction ability, where the visitor can switch between elements and compare the evolution of style through the evolution of time in the city.

To reach the aforementioned architectural detail several steps are required. Our knowledge of the topography of the city and the history of its settlements is based on the systematic archaeological research begun by the French archaeological mission in AD 1868 and continued by the German archaeological institute of Constantinople from AD 1899 until today. Collecting their findings and converting the data to digital usable form is the first step. The GIS specialists use the terrain information to create low polygon views of the city in order to establish a concept. The 3D Graphics team uses the scientific data for the accurate and high detail digital reconstruction of the buildings. The data is then passed to the VR team where depending on the complexity of the models, polygon reduction and model simplification is performed to allow for a real-time and interactive virtual world. The final experience is not a simple presentation of data but an entire scenario developed by a scriptwriter who understands the medium and writes to this purpose.

The Ionian city of Priene, a very good example of the Hellenistic style architecture, is another ancient city currently being developed into a virtual reality experience. The digital reconstruction of the landscape, public buildings and houses is already underway. The plan is to digitally reconstruct the entire city, not just the important public buildings, as is the case with Miletus. Hence, from a technical point of view, it should prove to be a challenging project. Similarly, another recent virtual reality experience highlights the splendor of the temple of Zeus at Olympia (Figure 4), providing visitors with the opportunity to experience a visualization of its famous frieze and the sheer glory of the famous statue of Zeus, one of the seven wonders of the world, of which nothing remains today (Figure 5).

Figure 4. *A view of the virtual Temple of Zeus at Olympia and the surrounding environment.*

"The Magical World of Byzantine costume" (Figure 6) is the first in a series of educational virtual reality programs related to the exhibition on the 4000 years of Hellenic costume, currently on view at the Hellenic Cosmos Cultural Center. The focus of this program is different from the ones mentioned above in that an accurate reconstruction is not sought; rather an interactive, magical experience with less detail and more interactivity is attempted. The program brings to life aspects of the Hellenic culture through an experiential educational world created for young children. As an interactive educational program for young users, it aims at developing an understanding of the importance of costume throughout time in an engaging, participatory manner.

Similarly, the reconstruction of a traditional olive oil press that can be operated virtually by the visitors follows the same interactive, experiential approach (Figure 7). This virtual reality programme complements the exhibition on the olive tree and its role in the development of Mediterranean culture.

An even more hands-on constructivist approach is attempted through the interactive "pottery puzzles", a series of short experiences that involve re-constructing various types of vases by connecting their broken pieces. Each 3D fragment can be picked up and placed on a virtual structure. When every piece is in the right place, the image on each vase, depicting Olympic athletes and games, comes to life and in this way rewards the young visitors for constructing it (Figure 8). This highly interactive and participatory virtual reality experience is based on the idea of "learning-by-doing", one of the latest educational and museological concepts, and through engaging play conveys facts and stories about types of pottery and the Olympic games.

The collection of programs created for the VR theaters is carefully thought out so to preserve a balance between the higher-detailed accurate reconstructions and the more free-form, interactive, and participatory productions. Our core belief is that both these directions of implementation are equally important for stimulating our audiences at multiple levels. We are working on both levels to improve, on the one hand, the performance and realism of the reconstruction and on the other, the interactive capabilities that will enable viewers to explore from unique points of view and participate.

Figure 5. *The statue of Zeus, one of the Seven Wonders of the World, of which nothing remains today.*

Figure 6. *View of the Magical World of Byzantine Costume.*

A fair amount of research effort at multiple levels may be required for the development and implementation of these immersive and interactive programs and this is why a public institution that is involved in the development of its own programs must keep close ties with the VR research community. Some of the research directions that are pursued collaboratively include: the development of efficient algorithms for realistic real-time rendering and occlusion culling that will help improve the performance of the real-time image generation; the development of techniques for the visualization of avatars, agents and connectivity for shared virtual environments; and the synthesis of natural language processing and generation procedures with virtual environments to develop the concept of personalised information objects in order to deliver multilingual, highly personalised descriptions of museum exhibits to visitors.

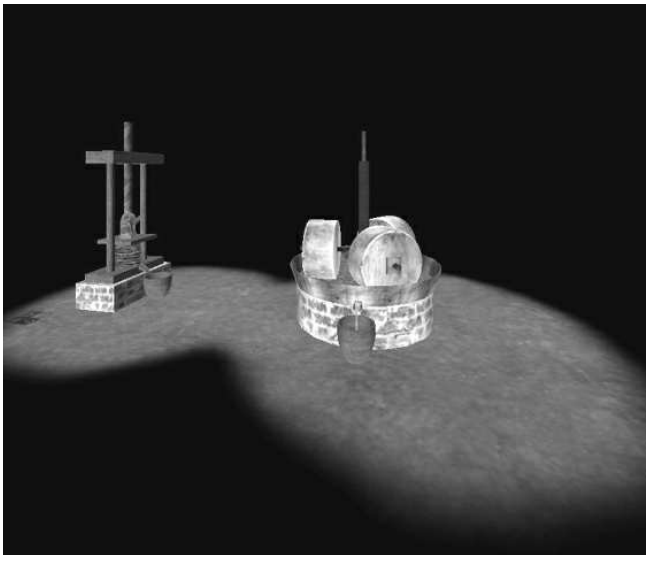

Figure 7. *Discovering Liquid Gold: an interactive program on the function of a traditional olive oil press.*

5. MAKING VIRTUAL HERITAGE AVAILABLE TO THE BROAD PUBLIC

Attention can be focused on the following set of interrelated issues which we regard as the more critical ones in the process of developing, introducing and presenting interactive virtual heritage projects in public spaces:

IN TERMS OF INTERACTIVE EXPERIENCES FOR VISITORS:

- Interactivity is controlled, structured and brief.
  One of the advantages of using large-screen stereo projection-based tracked VR systems is that these allow visitors to experience a virtual world without being isolated from the other members of the group, or in the case of a school class, their classmates or teachers (Figure 9). This is particularly important for both educators and students where education is a social experience. However, placing this technology into the real-use situation of a museum visit presents inherent limitations concerning the time that the groups can spend in the experience and their possible interaction with the environment. In the museum the experiences tend to last 10-12 minutes long and are typically handled by a museum educator. In other public situations this can vary, but it will most likely be as brief. It is important that these brief experiences be put into the appropriate context (ROUSSOU 1999).
- Conceptual & aesthetic standards are limited by the technology and do not usually relate to the learning purpose.
- Virtual heritage has become synonymous to passive walkthrough with limited interactivity thus less engagement.
- New experiences must be developed frequently to keep visitors coming.
- Work is always "in progress".

Figure 8. *Constructing and bringing to life pottery depicting Olympic athletes and games.*

IN TERMS OF RESEARCH AND STUDY:

- Virtual heritage applications are not used for heritage research. The development of virtual archeology programs may involve some computer graphics research, mostly in the area of realistic rendering techniques, lighting, shading, etc. However, the resulting virtual environment is scarcely used in practice for other research, such as the preservationist's need for documentation or the historian's for interpretation. Some successful examples exist where VR is used to help illustrate, detect and resolve archeological controversies (FRISCHER *et al.*) but these are limited and not without effort.

Figure 9. *Children interacting in the virtual reality Kivotos.*

- If practical results were achieved these would inevitably reinforce particular interpretations of the past and not multiple views (ARNOLD 2000)
- The inverse relationship between quality (accuracy) and performance forces the creation of simplistic representations thus limiting the possibilities for serious study. The use of architectural detail in immersive real-time virtual reality systems is difficult due to the technical and performance restrictions placed by the real-time image generator. Hence, increase in detail and interactivity results in performance decrease that in turn creates a less believable experience. Before one can even think of adding the ability for a more constructionist and interactive virtual environment, the technical tools must be developed to achieve better performance without compromising quality and detail.
- In reality, archeological data sets are huge – no virtual environment is functionally capable and flexible to implement appropriate applications.

IN TERMS OF TECHNICAL IMPLEMENTATION:

- Optimization of models for real time display.
- More photorealism. Photographic and cinematic representation is what the public wants and would expect from the ideal virtual reality representation.
- Simpler "scanning" sollutions are required. Building 3D models from scratch is a labor intensive and highly specialised task that could be avoided with better and more inexpensive scanning tools. This, of course, applies in the case of existing sites.
- Advanced technical skills required.
  On the software side, building interactive virtual environments involves hundreds of megabytes of models, texture-maps, audio-clips and extensive programming skills of the underlying hardware system. These factors apply especially in the field of cultural heritage, where computer graphics must be combined with exact historical representations and interactive presentations. VR applications are usually developed using object-oriented languages on top of advanced tools. Thus the need for highly trained and specialized

engineers in the field of real-time 3D graphics programming, virtual reality, and system knowledge is apparent. Furthermore, the amount of time and effort needed from the engineers to develop code and tools is considerable. The development of good authoring tools for virtual environment applications that will be designed to alleviate problems of this kind can provide a promising solution (PAPE 1999).

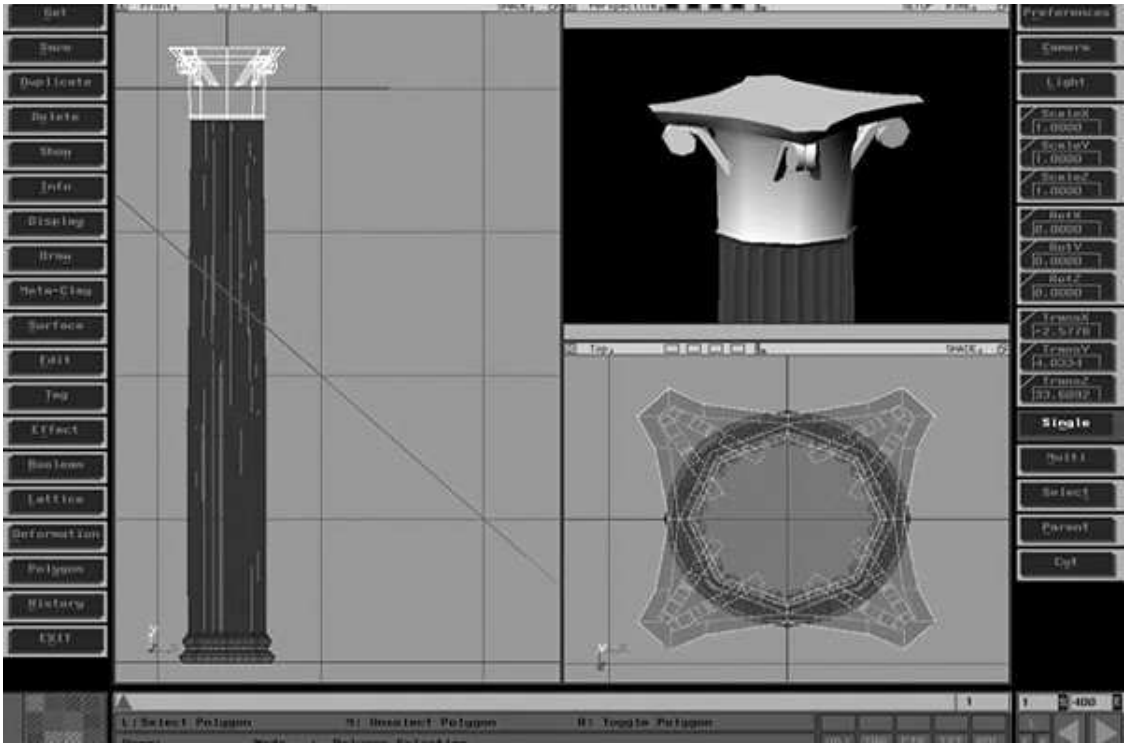

Figure 10. *Labor-intensive methods are required in order to sacrifice architectural detail that helps optimize large datasets for real-time display.*

- Digital people, digital cloth, better animation of organic bodies.
  Heritage is as much about the living and evolving place, people, and environment as it is about static monuments and landscapes (ADDISON 2000). Our experience with over a year of virtual heritage programs with the public has shown that people really like to know about their ancestors and are generally fascinated by the simple things and stories that pertain to life in antiquity. Nevertheless, it is still very difficult, expensive, and aesthetically questionnable to create organic forms and characters using the existing modelling tools.

IN TERMS OF USABILITY:

- Better image quality, resolution and detail.
- Immersive VR must become more human-centered, consistent, and "transparent" to the user. Due to the novel and impressive nature of virtual reality technology, virtual heritage applications often serve as good and "serious" demonstration programs for the technology itself.
- Do not isolate from real surroundings. What is the use of seeing an accurate reconstruction when it is out of context? However difficult, this is an area that offers exciting educational but also touristic possibilities. Although still in its early stages of research, the field of Augmented Reality is active in this direction and there are even some good examples for public use implemented with simple technologies (PLETINCKX, *et al*. 2000).
- Less and lighter gear. Practical issues and problems are especially apparent when the apparatus is not designed with novice or special users in mind, as is the case with most experimental high-end computer technology. In the case of virtual reality, for example, it is common for most systems to cause motion sickness; active stereoglasses are too large for small heads, too fragile, and too expensive to trust them with any excited visitor, let alone a child; children must use both hands to operate hard-to-use interaction devices, hold the stereoglasses with special ties, or even deploy support systems to stand up higher in order to achieve the correct viewing angle.

IN TERMS OF ECONOMIC VIABILITY:

- VR costs are prohibitive, in general. In addition to equipment cost, concomitant staff development, operations, and maintenance can find no place in dwindling museum or educational budgets. To overcome the current cost and limited accessibility of immersive VR systems, project designers are forced to choose development platforms of broader use, abandoning immersive VR and using less costly alternatives instead.
- VR attracts wider visitor demographic and tourism – at least for now
- Special staff, special space for VR infrastructure.

6. CONCLUSION

We are still at the early stages of using immersive virtual reality systems for experiencing cultural heritage content. No one yet knows what will be successful or how the public will ultimately use and interact with these emerging environments. However, despite the problems and restrictive format of these installations, we believe that it is

well worth investigating the added value and potential that virtual reality can bring to the presentation and better comprehension of archeological content. Virtual heritage environments can provide rewarding aesthetic and learning experiences, perhaps even research insights, that would otherwise be difficult to obtain. As public education spaces show more and more interest in virtual reality, we must continue to see that the insights gained through experienced use are adequately translated into the design of environments, and both inquisitively and critically examined. It is thus important to strengthen our efforts and continue to accumulate guidelines that will be turned into a useful resource for sound development of virtual archeology applications and technologies.

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