Hellenic Cultural Heritage through Immersive Virtual Archaeology

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Abstract. Virtual Reality is a novel and innovative technology which allows us, through its applications, to experience abstract concepts and ideas, visit spaces that are unreachable or no longer exist, and examine objects from diverse and unique points of view. Virtual archaeology refers to the use of 3D computer models of ancient buildings and artifacts visualized through immersive technologies. In this paper we explore issues involved in creating immersive cultural heritage projects enhancing our perspective and understanding of the environments in which our ancestors lived and worked.

1. Background

Research in virtual reality (VR) and archeology is a relatively young field which has shown considerable growth in recent years, as the development of new interactive technologies has inevitably impacted the more traditional sciences and arts. This is more evident in the case of novel interactive technologies that fascinate the broad public, as has always been the case with virtual reality. The increasing development of VR technologies has matured enough to expand research from the military and scientific visualization realm into more multidisciplinary areas, such as archeology, education, art, and psychology. Consequently, virtual reality interfaces, interaction techniques, and devices have improved greatly in order to provide more natural and obvious modes of interaction and motivational elements. In spite of various concerns and objections regarding the appropriateness and educational efficacy of virtual reality, there remain compelling reasons for believing that virtual heritage projects warrant serious investigation and can provide strong tools for learning. Institutions of informal education, such as museums, research, and cultural centers are in a better position to make use of such advanced systems and investigate their educational potential while effectively shaping how they deliver public entertainment and education. This paper describes the interactive virtual environments developed for learners of all ages in such an institution of informal education, and discusses the issues involved in developing immersive interactive virtual archeology projects for the broad public.

2. Introduction

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. The goal of the Foundation is to create 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. The Foundation's Cultural Center 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.

3. Infrastructure

At FHW the virtual reality team aims at utilizing virtual reality technology to advance the research and understanding of Hellenic culture. Activities focus both on the establishment of an infrastructure and the creation of educational and exhibition content. The goal is to put together an innovative immersive environment for the display of the Foundation's educational programs and 3D reconstructions. To this purpose we have employed two immersive VR systems. The first is an ImmersaDesk™ (Figure 1) running on a Silicon Graphics® Octane® visual workstation with 2 R10000 processors at 250Mhz. It consists of a 2m x 2.38m back-projected panel tilted at a 45˚ angle. 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.

Figure 1: Children exploring heritage sites on the *Magic Screen* (ImmersaDesk™)

The second system is a ReaCTor™ (Figure 2) a 3m x 3m x 3m cubic immersive VR system 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.

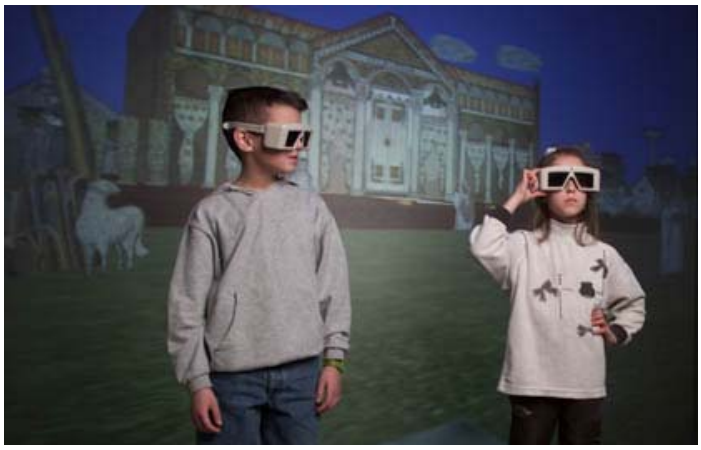

Figure 2: Young visitors immersed in the virtual learning environment.

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 tools such as Silicon Graphics IRIS Performer™ [1] and OpenGL®. 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. Such a programming approach however would have kept away artists and archaeologists from being able to do much direct work beyond creating raw materials (models and sounds). Furthermore the amount of time and effort needed from the engineers to develop code and tools from scratch each time would be considerable. In many cases a simpler programming system is needed. Model deploying in 3D space, picking up objects, animations, sounds and navigation of the environment are some of the simple actions that are usually required. XP [2], an authoring tool for virtual environment applications was designed to alleviate these problems.

The XP framework grew from software developed for the "Multi-MegaBook" [3] project and was further refined during the development of "Mitologies" [4], applications that were both large-scale environments. Now it is being used for "The THING Growing" [5]. It includes many of the features common to virtual environments and allows engineers to reuse tools and code between various applications and at the same time incorporate new features. XP allows artists to participate more actively or even develop entire applications on their own adjusting the final virtual environment to their needs. The framework was developed using C++ and is based on IRIS Performer™ and OpenGL® for the graphics, on the CAVElib™ library for transparent access to the virtual reality hardware and stereoscopic rendering, and a customary developed sound library for playing audio (Figure 3). The system is divided into two major components; the scripting language which describes the scene as a collection of nodes and their connection via events and messages, and the low level core C++ classes that implement the features and interpret the scripting language commands. Thus authors have to create scene files (simple text), where a description of the world using the scripting language is stored.

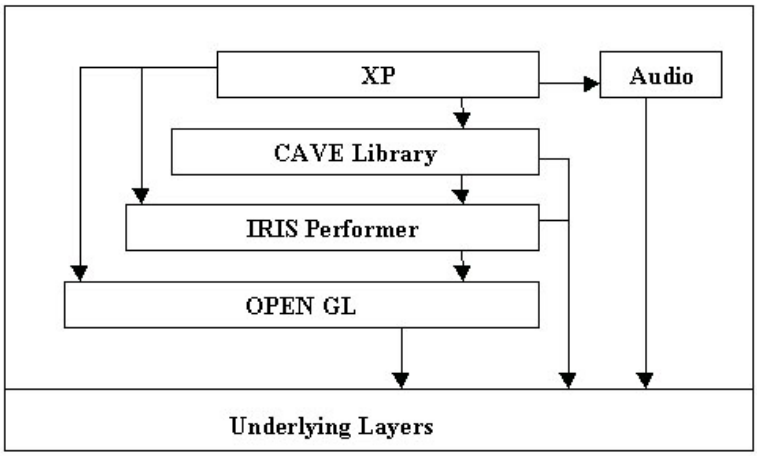

Figure 3: Schematic of the XP framework.

The virtual environment is described as a scene graph which essentially is a tree (directed acyclic graph) representation of the visual database. The leaf nodes of each tree contain data such as geometry and light sources, and the internal nodes provide special features such as grouping, transformations, messages, events and selection. Events and messages define user interactions and behaviors involving multiple nodes. Events can be anything that a particular node class is interested in detecting and signaling others about and messages can be send from one node to another in response to events. Navigation nodes, which allow the user to move through the virtual world, are constructed automatically by the framework. Teleporting to a specific location, following a path or attaching to a moving object of the scene are valid modes of navigation. Collision detection between the user and the objects is also provided by default. Currently the XP system is designed for single user applications. There are however extensions to further support networked, multi-user worlds.

The VR team at FHW has successfully used the XP system for all its immersive applications. The basic system has already been extended with a lot of new features and was customized to the needs of the applications. Such features include particle systems, local lighting, morphing, dynamic texturing, and water representations, level of detail, billboards and dynamic scene loading. The scripting language of the XP framework made the scene construction cycle shorter and more intuitive. Furthermore missing features that might be needed can be added by the programmers easily and reused many times in other projects.

4. Current Projects

The major projects undertaken by the VR team at FHW include the reconstruction and virtual journey through the ancient city of Miletus by the coast of Asia Minor, the Ionian city of Priene and an interactive educational environment that brings to life the magical world of Byzantine costume. Other programs under development 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, universities, and artists, that allow to gain insights on the creative use of technology.

The premiere program, "A Journey through Ancient Miletus" (Figure 4), 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 "walk" 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 life of its architectural glory, its people and their customs, habits, and way of life. With the use of the navigational device, children are free to choose 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 3-D models fade into layers of higher detail, enabling the participants to experience an accurate reconstruction. Our next step in enhancing the educational experience is to add construction ability, where the children can switch between elements and compare the evolution of style through the evolution of time in the city.

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. We are technically trying to achieve better performance without compromising quality and detail before we can add the ability for a more constructionist and interactive perspective.

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 1868 and continued by the German archaeological institute of Constantinople from 1899 until today. Collecting their findings and converting the data to digital usable form is the first step. The GIS team uses the terrain information to create low polygon views of the city in VRML [6] format 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.

Figure 4: View of the Bouleuterion; a public building of Miletus.

"The Magical World of Byzantine Costume" (Figure 5) is the second world created and 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 in this program is different from the one above in that an accurate reconstruction is not sought; rather an interactive, magical experience with less detail and more interactivity is attempted. It brings to life aspects of the Hellenic culture through an experiential educational world created for young children.

Figure 5: View of the Magical World of Byzantine Costume.

The Ionian city of Priene (Figure 6), a very good example of the Hellenistic style architecture, is the second ancient city currently being developed into a virtual reality experience. The digital reconstruction of the landscape 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.

Figure 6: Early view of the Priene world.

Finally, our latest virtual reality experience highlights the splendor of the temple of Zeus at Olympia, providing visitors with the opportunity to experience the sheer glory of the

famous statue of Zeus, one of the seven wonders of the world, of which nothing remains today.

5. Why Virtual Reality?

We believe that the best exhibits drive visitors to actively participate and truly experience the essence of their own cultural heritage. At FHW the landscape, architecture, and culture of ancient Greece can be experienced in an extraordinary new way. Using highly advanced 3D technology, the stunning virtual reality installations let visitors take virtual tours through detailed reconstruction of heritage sites, enabling viewers to explore them in a way never achieved before. A virtual exhibit gives 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 [7]. Hence, hundreds of amazed children and their families engage daily in a journey into history, kept alive through the creative and innovative use of the state-of-the-art VR technology. A Journey that would have otherwise been impossible as what remains of these cities today does not do them justice.

In addition to the photorealistic representation of places, people, and sites that do not exist, never existed, or may not be easily experienced, there are two basic advantages offered by the virtual reality walkthroughs; the immersive experience and interactive capabilities that characterize this medium. 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 merely a viewer of the realistic scenery, but can actively participate in the program and determine what their experience will be. Since the graphics displayed in the VR theatre are not predetermined or pre-recorded, but generated in "real-time", the audience is able to interact with the programs and define their behavior. If, for example, the program exhibited is the journey through the ancient city of Miletus, the audience can choose the path through the city just as in a real tour. They may also "knock" on doors to enter buildings, or fly up high to view the city from above - all this with the use of simple devices such as a joystick.

Of particular interest to museums in the use of virtual reality displays and computer-generated interactive experiences is the fact that they can allow visitors to travel through space and time without stepping out of the museum building [8]. 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 a necessary component in the arsenal of tools to educate, entertain, and dazzle [9][10]. 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. At the Foundation's Cultural Center approximately five hundred students visit the VR exhibits daily in groups of ten or less. The duration of their experience in the systems ranges from 10 to 20 minutes. The numbers are large considering the experimental nature of the technology, a fact that proves for a promising technology.

6. Conclusion

We are still at the early stages of using immersive virtual reality systems for experiencing Hellenic cultural heritage. Virtual environments, such as the ones we aim at developing, can provide rewarding aesthetic and learning experiences that would otherwise be difficult to obtain. Despite the high cost and restrictive format of these installations -a typical experience may end up being controlled, structured and brief- we believe that it is well worth investigating the added value and potential that virtual reality can bring in the public domain. Encouraged from what our visitors have to say, we are working towards further development of cultural and educational experiences.

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