Immersive Interactive Virtual Reality in the Museum

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Abstract. The use of immersive Virtual Reality (VR) technology is a relatively recent trend enjoyed almost 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, art, culture, and the humanities. As representative institutions involved in the research and presentation of these fields, museums, cultural centres, and entertainment venues may be in a better position to make use of advanced virtual reality technologies in order to investigate their educational potential while effectively shaping how they deliver public education and recreation. This paper will discuss the issues involved in using state-of-the-art interactive virtual environments in cultural public spaces by presenting the virtual environments developed for learners of all ages at the Foundation of the Hellenic World (FHW), a cultural heritage institution of informal education located in Athens.

Virtual Reality in the Museum

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 blending of disciplines and the evolution of techniques has brought forth the need for better modes of communication. 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. Nevertheless, the prohibitive costs and inaccessibility of VR technologies, coupled with issues of usability, staff training, operation, and maintenance, present important drawbacks for the use of VR in public spaces, making it difficult to incorporate in dwindling museum or school budgets. In spite of these concerns and objections regarding the appropriateness and educational efficacy of virtual reality, there remain compelling reasons for believing that VR environments for the broad public warrant serious investigation and can provide strong tools for learning. Institutions of informal education, such as museums, research, and cultural centres 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.

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 [5]. 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 [8].

When used for cultural heritage purposes, a virtual reality exhibit may give scholars 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 [3]. In addition to the fairly 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 virtual reality programs: 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 content displayed in VR exhibits is 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 an ancient city, museum visitors 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 with the use of simple devices such as a joystick.

Although virtual reality suffers immensely from media hyperbole and thus has not lived up to its promises, the development of VR systems is evolving and gaining territory in the museum world for many of the reasons mentioned above.

An example case

The Foundation of the Hellenic World (FHW), based in Greece, is a non-profit cultural heritage institution with a mission 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 bring together archaeologists, historians, computer scientists, and artists in order 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. This cultural center also houses some of the most advanced virtual reality exhibits that are open to public worldwide.

The virtual reality activities developed by the FHW serve a central role in the successful realization of the Centre’s overall mission. Virtual reality technology is used 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 innovative immersive environments for the display of the Foundation's educational programs and 3D reconstructions. To this purpose FHW has established 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 InfiniteReality2™ 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 structure and the programs developed are 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.

Figure 2: Visitors immersed in the *Kivotos* system (ReaCTor™)

Audio is enabled through the use of loudspeakers.

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.

Applications

At the FHW's cultural park, VR applications function in two basic ways: as an educational/entertainment tool and as an instrument of historic research, simulation, and reconstruction. Our core belief is that the best exhibits drive visitors to actively participate and truly experience the landscape, architecture, and culture of ancient Greece 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 from unique pints of view. Some of the main 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 Temple of Zeus at Olympia, a series of interactive educational environments that bring to life the magical world of Hellenic costume, and more. Other programs include productions to complement or highlight important events that shape our time, culture, or everyday life as well as experimental environments and innovative collaborations with scientists, universities, and artists, that allow to gain insights on the creative use of technology.

Figure 3: A view of the Temple of Zeus at Olympia in virtual reality.

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 "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, visitors 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 young visitors 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 iperformance decrease

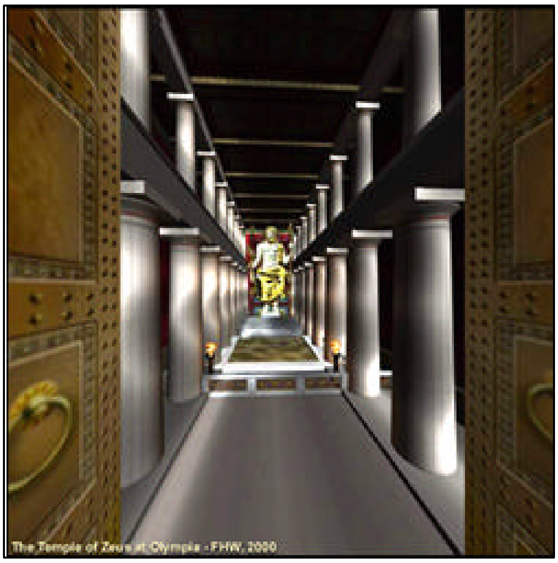

Figure 4: The famous statue of Zeus at Olympia as seen through the doors of the temple.

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 order toestablish 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.

Similarly, the Ionian city of Priene, 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. Another recent virtual reality experience highlights the splendor of the temple of Zeus at Olympia (Figure 3), 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 (Figure 4).

"The Magical World of Byzantine costume" (Figure 5) 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 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. Similarly, the reconstruction of a traditional olive oil press that can be operated virtually by the visitors follows the same interactive, experiential approach.

The problems

The introduction of high-end or virtual technologies in public settings runs up against a number of issues that must be considered. Specifically, interactive learning environments must take into account the physical context of the public space, support the conceptual and aesthetic standards of the learning purpose, and be functional and accessible to its intended group of learners. Whether it's the novelty of interactive technology and virtual reality exhibits or the compelling nature of the applications themselves, visitors flock to see things that are new and cutting edge, even if the content remains relatively unchanged. This generates added worries to educators and technologists alike who must design keeping their educational role in mind, yet providing the added novelty, accommodating an increasing range and types of educational experience, and enhancing motivation [6]. The uniqueness, cost, size, and fragility of VR aggravate these problems. VR technology will be deployed in considerably fewer numbers than personal computers; the existent application base is almost non-existent; there is no standard staff development curricula or off the shelf courseware; and technical support requires very specialised expertise.

Clearly, another important point of particular relevance to this kind of high-end technology is usability. Public viewing must be considered in the context of hundreds of people who will visit the immersive virtual reality site each day, more so if the site is set up to welcome visitor interaction.

Figure 6: Usability issues must be considered when using immersive virtual reality with children.

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 (Figure 6). 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 and mostly custom-made interaction devices; special ties must be used to hold stereoglasses on children's' heads; and in some systems it is may even be necessary to deploy support systems for smaller users to stand up higher in order to achieve the correct viewing angle.

Good sight lines, ample seating where applicable, comfortable viewing for extended periods, good field of view, and ergonomics are some of the issues that must be addressed when designing a unique, high-end environment. The interactive experience must also have an easy to learn and simple to use interface, which is accessible to a wide range of skill levels and requires virtually no visitor training.

Projection-based virtual reality systems overcome some of the limitations imposed by older technology: users wear less and lighter gear and are not isolated from their real surroundings; virtual spaces are naturally blended with real objects, such as the user's hands and body; and multiple users can simultaneously share the same virtual experience [7]. More specifically, CAVE-like systems offer unlimited opportunities for the exploration of virtual worlds, while projection tables are ideal for interaction with single objects and applications. Immersive displays utilising curved screens are appropriate for walkthroughs and can be well suited for public presentations as they require no special viewing skills. Moreover, they are capable of providing real-time experiences for large groups, including guided tours, group telepresence, and interactive simulations [7]. On the other hand, projection-systems are much more complex than other VR systems such as head-mounted systems. They integrate a variety of technologies that are not hidden from application developers and require expertise on how to connect and integrate different devices and programming environments, such as viewer-centered perspective and stereoscopic viewing. Although the concept of viewer-centered perspective is attractive, head tracking can be a real headache when only one or some of a group of users are tracked while all others view the same virtual world, as is the case with CAVE-like systems. The person who is tracked must be central to the rest and keep head and body as immobile as possible, otherwise both the angle and the movement can cause nausea to the others. In the case of museums, the only way to decrease this problem is to employ a trained guide who understands how to provide the best experience for all.

Along with the problems caused by the larger and diverse audience throughput, issues of high cost and maintenance of VR technology, and difficulty in content development present important drawbacks for public venues. Prohibitive costs of VR technologies and concomitant staff development, operations, and maintenance can find no place in dwindling museum or educational budgets overwhelmingly dominated by human resource costs. To overcome the current development cost and limited accessibility of immersive VR systems, some educational projects are forced to move development to platforms of broader use, abandoning immersive VR and using less costly alternatives instead.

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™ 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. The development of authoring environments, such as the XP framework used at FHW [4], help to alleviate some of these problems by allowing engineers to reuse tools and code between various applications and at the same time incorporate new features. Ideally, with well-designed such tools, artists or educators can also participate more actively or even develop entire applications on their own adjusting the final virtual environment to their needs [1][2].

As museums 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. No one yet knows what will be successful or how the public will ultimately use and interact with these emerging environments - the contours are just now starting to form and become visible. It is thus important to strengthen our efforts and continue to accumulate guidelines that will be turned into a useful resource for sound development and evaluation of interactive technologies.

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