Incorporating Immersive Projection-based Virtual Reality in Public Spaces

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Abstract

As immersive virtual reality increases in popularity, a growing number of institutions incorporate projection-based display systems in their daily function. For the most part, these institutions operate in the academic, research, and industrial domains while the users of their virtual reality systems are specially trained staff members and researchers. There is, however, considerable interest in virtual reality applications on behalf of museums, educational organizations, the medical and corporate field, and the entertainment industry. This paper examines the issues involved in the deployment of immersive projection-based virtual reality technology in museums and other public spaces. Emphasis is placed on the challenges and pitfalls of incorporating immersive projection technology in settings such as the above, settings other than research laboratories or industrial research and development departments.

Keywords
Applications of IPT, museums, interactivity, usability.

Introduction

As immersive virtual reality increases in popularity, a growing number of institutions incorporate projection-based display systems in their daily functions. For the most part, these institutions operate in the academic, research, and industrial domains while the users of their virtual reality systems are specially trained staff members and researchers. There is, however, considerable interest in virtual reality applications on behalf of museums, educational organizations, the medical and corporate field, and the entertainment industry.

This paper focuses on the challenges and pitfalls of incorporating immersive projection-based virtual reality technology (IPT) in settings such as the above, settings other than research laboratories or industrial research and development departments. These settings will be coined "non-traditional" with respect to the virtual reality field, as they involve spaces that are usually visited by the general public or by individuals and groups that may not be familiar users of high-end technology.

Non-traditional Venues for IPT Systems

Of particular interest to museums is the use of virtual reality (VR) displays and computer-generated interactive experiences that aim at allowing visitors to travel through space and time without stepping out of the museum building. 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. 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.

Technical advances have strengthened the aspects of virtual reality that lead entertainment venues, museums, and other public spaces to consider installing virtual reality systems for their purposes. Aspects of virtual reality that attract museum and visitor interest include:

- The captivating sense of immersion given by surround vision that fills our entire field of view.
- The simulation of stereoscopic viewing.
- Viewer-centered perspective, when perspective is calculated depending on our position.
- Real-time performance and interaction, when what we see is generated as we see it and responds to our actions immediately.
- The involvement of all senses: sight, sound, even in some cases tactile cues and smell.

In comparison to traditional media or computer displays, virtual reality can also offer the advantage of viewing digitally constructed worlds with basically no frame edges. Designers of virtual reality worlds have an inside-out perspective versus an outside-in perspective required by the restrictions of other media.

Finally, the introduction of projection-based VR systems has shifted the format from the one-man VR experience with bulky headsets and equipment to the slimmed down, more comfortable visual displays for multiple people simultaneously.

The use of virtual reality technology, especially projection-based systems, has increased drammatically in the past few years. Today, immersive projection systems can be found in academic, research, and industrial laboratories all around the world. The CAVERN user's list cites over 60 institutions that now own CAVEs, ImmersaDesks or similar forms of immersive projection-based displays. "In 1992 there was a single CAVE in Chicago, in 1998 there are over 80 CAVE and ImmersaDesk installations around the world," notes Leigh et al. [4]. Of these, only a couple are open to a constant flow of outside visitors on a daily basis. The majority of use remains in the specialized hands of the scientific and industry researchers. Despite clever design, these IPT systems are not completely ready for daily use in activities that require large throughput - they are still tools for scientific and engineering research of a more limited audience.

In addition to CAVE-like systems mentioned above, there are a number of large-scale immersive theaters, dome-shaped digital planetaria, and curved displays which increase the volume of publicly accessed projection-based systems. These systems, however, may not necessarily be virtual reality display platforms and for the most part do not involve interaction, stereoscopic viewing or computer-generated content.

This paper will not focus on the technical issues of IPT systems but on issues of their use in public spaces, such as museums, theaters, classrooms, offices, or even our homes. Is IPT practical, feasible, worth investing in? Is it appropriately designed for spaces open to the public, for commercial, educational, entertainment venues, for settings such as schools and community centers, for the home? These are issues that may need to be addressed more and more as projection-based virtual reality systems evolve and become commercialized.

Figure 1.Immersive projection-based virtual reality systems used in public spaces with larger audiences.

There are currently three museums worldwide where permanently installed interactive IPT systems are open to the public on a permanent and regular basis: the Ars Electronica Center in Austria, the first museum to install a CAVE™, the Intercommunication Center in Tokyo, where a CAVE is used as an artist's exhibition platform, and recently the Foundation of the Hellenic World's cultural heritage museum which, in addition to the ImmersaDesk, is in the process of installing a CAVE for the sole purpose of presenting educational and cultural content. Additionally, a number of other museums are currently installing or have installed dome-shaped theaters displaying computer-generated content. Experience drawn from observing users at these institutions and at large conferences and events has shown that immersive VR can afford unique educational and recreational opportunities but suffers from a number of drawbacks in terms of usability and content development. Moreover, through the study of multiple children that have participated in research-based VR learning environments in projection-based systems, a number of interesting usability and performance issues have been observed [9].

Usability and Interface Issues

Projection-based systems overcome some of the limitations imposed by head-mounted displays: 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 [1]. 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 utilizing 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 [4]. 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.

Clearly, an 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 an IPT site each day, more so if the site is set up to welcome visitor interaction. 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 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 (Fig. 2b).

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.

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. An issue that has been observed through extensive use of tracked IPT systems with the public is that people do not understand the concept of head tracking. In most cases people standing far from the tracked head can be viewing largely incorrect perspective, yet accept this as part of the given setup. Disabling head tracking requires establishing a set point of view that can be appropriate to all visitors at the same time, taking into account that visitors differ in shapes and sizes.

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 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.

Figure 2. (a) An unusual site: IPT in a traditional classroom.
(b) The tools of IPT not designed with novice users in mind.

The Roundearth project - Courtesy EVL/ICE, University of Illinois at Chicago

Many of these issues become more apparent when the technology must be applied to unique setups. The Foundation of the Hellenic World, for instance, is a non-profit museum and cultural research center with a mission is to preserve and disseminate Hellenic culture, historical memory and tradition. High-end virtual reality technology as used at the Foundation's cultural center functions in two basic ways: as an educational/entertainment tool and as an instrument of historic research, simulation, and reconstruction. Examples of applications include an educational environment related to traditional Greek costume throughout time and the reconstruction and journey through the ancient city of Miletus by the coast of Asia Minor, as it was in antiquity. Guided by a virtual "time-machine", travelers are able to 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. To present such projects, the Foundation has placed a roving immersive projection table, the ImmersaDesk™, in a public area of the museum. This virtual reality environment "on wheels" has the ability to move about the museum campus. It thus enables the creation of a truly flexible virtual reality setting for the museum and allows for customization of the virtual reality exhibit to any current exhibition or program.

While this type of setup can afford unique educational and recreational opportunities, equipment of this kind is inevitably in an experimental stage and suffers from a number of drawbacks in terms of usability -- essentially many of the practical problems mentioned above: the roving nature of the particular virtual reality system is a relative advantage as the equipment is fragile and requires special handling; once installed, the virtual reality equipment requires a specially designed place where metal structures are not present; the display system must be designed to withstand breakage, short attention spans, greasy fingers, and large numbers of visitors; the active stereo glasses are expensive and can break easily as their sizes are not made to fit everyone's head; equipment must be placed out of reach, yet still be accessible to the technical staff; the projection table must always be moved in areas where light is controlled or eliminated; finally, experienced guides who have both the technical skills and the museum education background are always required.

In brief, museums that deal with the public are concerned with issues pertaining to both form and function of their exhibits and displays. Immersive projection technology accessible to the public must thus be characterized by:

- Rugged engineering
- Accessibility
- Practical to maintain
- Attractive design

User Experience

Immersive displays for entertainment and informal education applications must place emphasis on the overall quality of visitor experience [4]. There is strong belief amongst researchers that immersive VR environments can provide rewarding aesthetic and learning experiences that are otherwise difficult to obtain [6]. Unfortunately, this kind of technological innovation often creates the suspicion of high cost and low content and current applications seem unable to step out of paradigms created by "older" media for the newer media [10]. The format of a typical museum experience involving technology is inevitably controlled, structured, and brief. As a result, most educated audiences, such as teachers, architects, historians or artists are skeptical regarding the added value and appropriateness of virtual reality in the public domain. The expense, inaccessibility, and fragility of immersive virtual reality displays as mentioned above invite skepticism with good reason over their value as instructional media. With IPT systems, it may very well be the case that novelty of the display environment overshadows content. In the museum context, technological developments may often be associated with disappointing gains for users whereas compelling content will most likely engage the visitor regardless what the form of presentation may be. Therefore, the applications implemented for display in an IPT system must be a priori arguably enhanced by VR technologies.

As is the case with many technologies in their infancy, virtual reality software development is highly proprietary to the field to which it is applied. Every research or industry laboratory develops its own tools and applications. Even the more commercially developed areas, such as vehicle simulation and training, neither use nor produce tools other than the ones directly applicable to their specific domain.

Although museums and schools are the creators of content, these institutions are not research labs. They have neither the means nor the appropriate know-how for the development of high-end virtual reality applications. Efforts are being made by researchers to develop software with which non-scientists will be able to author effective applications without having to know all the intricate details of computer programming and the correct technical apparatus [7]. Also just recently, a couple companies are porting their software to support immersive tracked systems. Meanwhile, museums or schools must rely on others to develop applications or make considerable investment to acquire the appropriate staff. Even so, it is necessary for those without the technological expertise to become involved with the design of the virtual reality experience.

Figure 3. A young child interacting with a VR learning environment in the CAVE.

The NICE project - Courtesy EVL/ICE, University of Illinois at Chicago

As virtual reality systems are becoming more accessible to the public, emphasis should be given on the development of immersive educational and general-purpose environments which, coupled with research and evidence of their usability and value, can become essential test cases for the future of projection-based systems.

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