The Future of Virtual Reality: Head Mounted Displays Versus Spatially Immersive Displays

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Introduction

Since its inception, the field of virtual reality (VR) has revolved around the head-mounted display (HMD) as the essential visual display device. VR futurists depicted VR as a personal experience wherein the user interacts with a virtual environment (VE) in a manner synonymous with reality: looking, pointing, walking, physics, etc. Early on, some even declared the classic HMD with data glove to be the only true VR. However, our concept of VR continues to broaden.

An emerging alternative to the HMD is the (walk-in) spatially immersive display (SID). These displays physically surround the viewer with a panorama of imagery, typically produced by video projection. The first application of a SID to VR systems is the CAVE, developed at the University of Illinois at Chicago [Cruz-Neira 93]. More advanced SIDs are now in development utilizing domed video projection technology, which could eventually replace the rectilinear CAVE configuration [Bennett 95, McCutchen 91]. Domed SIDs have been used for many years in military flight simulators [Reno 89]. SIDs offer advantages over HMDs, including group viewing and interaction, wide field of view, high resolution, no cumbersome headgear, and low user fatigue. Also, angular viewing is accomplished without head rotation tracking and its associated response time requirements. Stereoscopic displays are also possible using eye-sequential glasses.

A number of technical challenges remain in the development of both HMDs and SIDs. Currently, VR researchers are consumed with refining the HMD. Advances are being made in wide field-of-view, high resolution HMD technology. Very little research is currently underway on SID implementations. This panel compares the ultimate utility of HMDs versus SIDs in emerging VR applications, such as entertainment, education, computer-aided design, simulators, scientific visualization, 3D animation production, biomedicine, and other potential markets. Important issues include cost, size, user mobility, single and multi-user interactivity, stereoscopic viewing, applicability to augmented reality, special hardware/software requirements, physiological concerns, visual quality, and sense of presence.

Steve Bryson
Let the Task Determine the Display

As the field of VR matures, there has appeared an almost bewildering variety of display technologies that support the VR effect. While there are common measures of display quality, such as resolution, field of view, pixel spacing and so forth, there are other considerations that are very difficult to compare from display to display. These other considerations include comfort, mobility, privacy, opacity, and immersiveness. Rather than try to find the unique “best” display in this very high-dimensional space, I feel that one should analyze the task for which the display is being used. Some tasks, such as an architectural walkthrough, require medium resolution wide field immersive displays with a high degree of mobility. Other tasks, such as information or CAD visualization, may require a collaborative, less immersive high-resolution display that several people can see at once. I will propose a task analysis framework which aids in the selection of a display for a particular task.

David Zeltzer
Specifying a Visual Display System

The visual display system is one element of the human/machine interface to any computer system, and the requirements of the display subsystems – visual, auditory and haptic – are strongly dependent on the application for which they are intended.

So-called “immersive” displays are not always the best strategy. For example, we have shown in our lab that well-designed 2D presentations consistently lead to better performance than stereoscopic displays of 3D scenes for certain air traffic control tasks [Jasek 95]. But if “immersion” is important for a particular application, careful task analysis and requirements engineering can help system designers to formulate specifications for the display systems, as well as to understand the engineering tradeoffs and human factors issues involved.

At MIT we have developed a number of VE systems and applications since the late 1980s. Each of these systems has had differing display requirements. Multimodal displays and “immersive” presentations were often called for; but for some VE applications a workstation CRT was sufficient.

We have implemented “immersive” presentations using different techniques, including

- a head-coupled, stereoscopic HDTV system;
- various HMDs; as well as the walk-in
- CAVE system.

In this presentation, I will briefly describe several of these applications and the display systems that were used, and I will discuss the methodology we employ for specifying a display for a given application.

Mark T. Bolas
Alternative Displays

While the head-mounted display serves as a visual icon of VR, alternative immersive technologies have taken root and grown in industries utilizing 3D computer graphics. Having spearheaded alternative immersive peripherals for more than seven years, I will focus my presentation on the lessons learned and the viewpoints formed by working with hundreds of different users and applications. The presentation will concentrate on the following three areas.

The first is to question what constitutes an immersive display to begin with. Is it a strong feeling of immersion? Is it a First Person Point of View? What sparked the original interest in HMDs, and why are we so eager to abandon it? Is this panel simply full of lazy panelists who are shying away from the hard problems of cutting edge immersive displays to move toward the relative utility and security found in projection based and other alternative displays?

The second area concerns mature media and technologies to help make predictions for the media and technologies we are discussing here. Will HMDs follow the same price drop over time as flat panel displays? If the HMD is similar to a pair of audio headphones, are projection systems analogous to audio speakers? How does content development compare?

Finally, a look toward applications and examples is in order. Starting from a clean slate and armed with all the technology SIGGRAPH has to offer, what is the best solution for a small set of example applications? Is there a best flavor of VR? Is there a best flavor of Ice Cream? What does it take to make both the display technology and the content work together to form a seamless immersive experience?

Bertrand de La Chapelle
Considering the Manufacturing and Engineering End-User

VIRTOOLS is pioneering the implementation of Shared Virtual Workspaces for concurrent engineering, collaborative design, and scene layout for the aerospace, automotive, and nuclear power industries. Based on the experience gathered at VIRTOOLS with manufacturing and engineering clients and on extensive contacts with other potential end-users, we strongly believe in the potential of SIDs for such professional applications. Two aspects will be put forward.

1) HMDs are globally ill-adapted for day-to-day professional applications. A key founding component of the VR concept, HMDs have surely become less cumbersome, less expensive and have increased performance. But:

- even if high resolutions and wide field of view (required for professional applications) ultimately appear, price/performance ratio is mostly driven by games; therefore, price will decrease faster than performance improves.
- weight, eye, and neck fatigue prevent use over several hours; this is not likely to change even with greatly improved performances.
- psychological factors are an important limitation: engineers and decision-makers are very reluctant to use such apparatus, considered game gear.
- HMDs isolate users from one another; collaborative work in the same room requires the creation of sophisticated clones, and people can bump into one another.

The main obstacle for HMDs will not be performance, but seclusion. Therefore, they will prosper in applications where people work in isolation for short periods of time and really need to look around them as if they were in a static real environment. Apart from games, the best applications include training and some maintenance assessment. In most other individual uses, devices like the BOOM™ or the Push™ from Fakespace seem more appropriate, offering high resolution, wide field of view, and less fatigue.

2) SIDs offer the best potential for collaborative applications. They still suffer major drawbacks: underdeveloped, very expensive, requiring much more space and hardware (three channels for the CAVE), they are not yet fully industrialized or standardized. But:

- they provide a better sense of presence through a very large field of view (up to 180x for the ARC Dome) and a high resolution (2000 x 2000 and up).
- they allow prolonged work through reduced fatigue, including in stereoscopy.
- they allow the presence of multiple users in the same environment, who can communicate naturally together.
- large models can be displayed (cars, plane segments, plant sections) at once, whereas you need to turn your head around with an HMD.
- they are very well adapted for applications in which the user interacts strongly with the environment through Virtual Tools (3D widgets) and a 3D interface.

As VR applications evolve from simple walkthroughs towards virtual working environments, SIDs might become the new paradigm for professional use. Key developments in graphics hardware (new generation SGIs) and projection devices (mono-lens high power light valve or future micromirrors) will create a range of standard systems, from individual large screen displays to full-fledged multi-participant domed environments. Present prices will go down, thanks to entertainment applications (including immersive prerecorded rides), and such environments are the key to implementation of full concurrent engineering in manufacturing.

David Bennett
Dome and Shared Spaces

We are on the threshold of new methodologies in visualizing and interacting with information. The emphasis here is on why spatial immersion and, in particular, dome projection provides a better solution than other alternatives for groups of people. The primary focus is on teams of people experiencing 3D information space, and experiencing both immersion and interaction as groups rather than as individuals. The focus is also changing from what is acceptable to a “techie” to what is required by mainstream users. Business people, scientists, moms and dads – all need to feel that VE’s are not complex and unusable, but rather as simple to interact with as television.

There is a unique characteristic of domes that makes it ideal for groups, particularly for training and education. Within reasonable constraints, the viewpoint or perspective is the same for everyone. This means that an instructor can be assured that the student is seeing exactly what the instructor sees. Equally important is the sense of presence created with a 180-degree field of view onto a hemisphere, and in a way that is both comfortable and consistent with a real-world experience. The downside of domes is the computational expense of doing distortion correction, limited individual tracking ability, and the space requirements for setting up a dome at your facility. There is as yet no perceived cybersickness; however, motion sickness is still present, just as in any other environment, including the real world.

As we move these technologies forward into everyday life, it is important to focus on simplicity, affordability, portability, and comfort. We have found that acceptance of domes for VR is greater than for HMD’s, since it does not require wearing any restrictive devices and “feels” more like what is expected of VR.

References

[Bennett 95] David Bennett, “Providing Solutions Using Virtual Reality,” Press Release, Alternate Realities Corp., Research Triangle Park, NC, e-mail `davidb@arc.tda.com`, `http://www.arc.com/ARC.html`

[Cruz-Neira 93] Carolina Cruz-Neira, Daniel J. Sandin, and Thomas A. DeFanti, “Surround-Screen Projection-Based Virtual Reality: The Design and Implementation of the CAVE,” Computer Graphics, Annual Conference Proceedings Series, 1993.

[Jasek 95] Jasek, M., N. Pioch and D. Zeltzer, “Effects of Enhanced Visual Displays on Collision Prediction for Air Traffic Control,” Proc. 6th IFAC/IFIP/IFORS/IEA Symposium on Analysis, Design and Evaluation of Man-Machine Systems, Cambridge MA. (1995).

[McCutchen 91] David McCutchen, Method and Apparatus for Dodecahedral Imaging System, U.S. Patent #5,023,725, June 11, 1991.

[Reno 89] Capt. Brian A. Reno, “Full Field of View Dome Display System,” Proceedings of AIAA/FSTC, pp. 390-394, 1989.