

Non-Immersive Virtual Reality
G. G. Robertson, S. K. Card and J. D. Mackinlay

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Nonimmersive virtual reality

George G. Robertson, Stuart K. Card, and Jock D. Mackinlay, Xerox PARC

The goal of virtual reality systems is to place the user in a three-dimensional environment that can be directly manipulated.¹ Ideally, users cease to think of themselves as interacting with a computer and interact instead with the 3D environment. The usual definition of VR involves full immersion. That is, users wear head-mounted stereo displays to provide full visual immersion and special gloves that allow six-degree-of-freedom input for directly manipulating the environment.

An alternative form of VR is being explored in a number of research labs. Nonimmersive VR also places the user in a 3D environment that can be directly manipulated, but it does so with a conventional graphics workstation using a monitor, a keyboard, and a mouse. The scene is displayed with the same 3D depth cues used in immersive VR: perspective view, hidden-surface elimination, color, texture, lighting, shading, and shadows. As in immersive VR, animation and simulation are interactively controlled in response to the user's direct manipulation. Much of the technology used to support immersive and nonimmersive VR is the same. They use the

same 3D modeling and rendering and many of the same interaction techniques.

Immersive vs. nonimmersive VR.

Full immersion is often seen as a major advantage. But our experience and the experiences of others suggest that, for many applications, the same effect is possible with proper 3D cues and interactive animation. As the user controls the animation and focuses on it, he or she is drawn into the 3D world. Mental and emotional immersion takes place, in spite of the lack of visual or perceptual immersion. Anyone who has recently played a good video arcade game, many of which are examples of nonimmersive VR, knows the truth of this. In addition, current immersive VR techniques cause display jitter and have a lag between the user's head or hand movement and the resulting environmental change. These effects, which tend to inhibit the illusion of immersion, are not a problem in nonimmersive VR systems.

Similarly, it is often assumed that six-degree-of-freedom input devices give the user more direct control. At Xerox PARC, we have developed

simple mouse/keyboard-controlled interaction techniques for viewpoint and object movement. They are easy to learn and use and are often faster than Dataglove interaction techniques, although our technique could be adapted to a glove. Andy van Dam's group at Brown University has developed a series of direct-manipulation interaction techniques for creating and manipulating objects using conventional input devices. Also, SGI Inventor,² a recently introduced high-level 3D toolkit, provides a set of direct-manipulation interaction techniques for creating and manipulating objects using conventional input devices.

Spatialized 3D audio is possible in both types of VR, but immersive VR does have an advantage. Since the head orientation is known in immersive systems, the system can allow the user to localize sound — that is, “home in” on it by turning the head, as one does in the real world.

Advantages of nonimmersive VR systems. Nonimmersive VR systems have three advantages over immersive VR systems: evolutionary advantages caused by the current state of the computer industry, advantages in overcoming current technical limits or problems with immersive techniques,

(Continued on p. 83)

Nonimmersive VR (cont'd from p. 81)

and advantages in the way the techniques are used.

Evolutionary. The evolutionary advantages of nonimmersive VR are its use of familiar tools — display, keyboard, and mouse — and lower start-up costs. Many office workers already have the basic tools on their desks, and graphics workstations are commonplace and inexpensive compared to head-mounted displays and six-degree-of-freedom input devices. Until recently, supporting 3D smooth interactive animation required advanced graphics accelerator hardware. Because of rapid progress in processor technology, we are at the threshold of a period when fast processors can accomplish the same task. These factors suggest that there will be a large initial installed base into which nonimmersive VR technology can be introduced.

Technical limits. The second advantage of nonimmersive VR has to do with limits or problems in current immersive VR technology. Immersive VR researchers and users spend much time worrying about the lag in six-degree-of-freedom input devices, display jitter, and synchronizing machines for stereo generation without loss of performance. Researchers often become slaves to the devices rather than focusing on applications or interaction techniques.

The lag from head and hand tracking to scene change is caused by scene rendering time and the handling of immersive input devices. There is noticeably less lag in nonimmersive VR because it eliminates tracking devices. Display jitter in immersive VR is caused by noise in the data coming from the head tracker and by the neck muscles moving the tracker. Both causes are eliminated in nonimmersive VR. Much of current immersive VR uses lower resolution display technology to get the display onto the head; thus, by default, nonimmersive VR has higher resolution displays. Likewise, producing and synchronizing stereo images is not an issue in nonimmersive VR, which does not require stereo vision. There is some evidence that, for some applications, animation is a more effective communicator than stereo; hence, the ability to run without stereo can be a real advantage.

The two types of VR systems have many interaction techniques and issues in common. Because of the technology limits, it seems clear that it will

be easier to explore these common interaction techniques with nonimmersive VR.

Use. Typical office workers will probably be unwilling to put on special equipment to do their work, especially if it obscures their surroundings. Nonimmersive VR does not prevent users from seeing what is around them and does not require wearing any special equipment. The use of immersive VR for extended time periods is likely to cause psychological and physical stress that most users will not tolerate. Nonimmersive VR stress factors are the same as those for general computer use and are likely to be much less than for immersive techniques.

Hybrid possibilities. Of course, there are a number of hybrid possibilities between these two kinds of VR. Six-degree-of-freedom input devices, like the VPL Dataglove, can be introduced into nonimmersive VR. Stereo video can be added without using head-mounted displays — for example, by using shuttered glasses synchronized with the display. Also, head tracking that produces parallax effects can be added without using head-mounted displays or stereo vision. Parallax effects — side-to-side head movements to see slight side-to-side scene shifts — would let the user look around an object.

Applications of nonimmersive VR. A number of places are researching and developing nonimmersive VR techniques and applications. The Information Visualizer³ is a nonimmersive system for visualizing and browsing information structures with content-based information access. It exploits the human perceptual system, using 3D and interactive animation, to help the user visualize information structures found in typical office or business situations (for example, time-ordered sets of documents or hierarchies like organization charts). Like many of these systems, it uses smooth animation for transitions from one state to another, rather than having the display simply blink to the new state. The user does not have to re-assimilate relationships between objects; instead, the perceptual system tracks the relationships during the animation.

At Bellcore, Jim Hollan and his group are exploring nonimmersive VR business applications, including visualization of a telephone switching network. Steve Feiner's group at Columbia University is also exploring business applications. Their n-Vision

system exploits 3D to visualize n -dimensional business data. Multivariate functions are displayed in nested coordinate systems, using a metaphor called worlds-within-worlds. Although n-Vision uses hybrid immersive VR techniques, it could easily be implemented in nonimmersive VR. At Brown University, Andy van Dam and his group are developing 3D Widgets and direct-manipulation techniques for nonimmersive VR. Silicon Graphics' Inventor, a high-level 3D toolkit,² also provides a number of nonimmersive direct-manipulation techniques and is an important step toward a common software platform for building 3D and VR systems.

In the near term, we believe nonimmersive VR will dominate business applications and research and development of VR interaction techniques. Immersive VR will dominate in entertainment and in applications where users already need to wear special equipment (for example, space applications, medical applications, and support for handicapped users). Ultimately, new display and input device technology may lead to immersive technology that is not awkward or intrusive (for example, displays embedded in eyeglasses). When and if that happens, immersive technology may become acceptable for mass use and dominate all VR applications.

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George G. Robertson is a principal scientist at Xerox PARC, 3333 Coyote Hill Rd., Palo Alto, CA 94304. His e-mail address is robertson@parc.xerox.com.

Stuart K. Card is a research fellow and manager of the User Interface Research Group at Xerox PARC. His e-mail address is card@parc.xerox.com.

Jock D. Mackinlay is a member of the research staff at Xerox PARC. His e-mail address is mackinlay@parc.xerox.com.

COMPUTER

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ARTICLES

8 Distributed Computing with High-Speed Optical Networks

Ronald J. Vetter and David H.C. Du

The authors describe an environment that uses wavelength-division multiplexing techniques and optical switching and processing to provide large bandwidths, short delays, and multiple data streams for distributed processing.

22 Processor- and Memory-Based Checkpoint and Rollback Recovery

Nicholas S. Bowen and Dhiraj K. Pradhan

Checkpoint and rollback recovery enables a system to tolerate failures by periodically saving the entire state and rolling back to the saved state if an error is detected.

34 A Cataloging Framework for Software Development Methods

Gerald M. Karam and Ronald S. Casselman

This framework provides a basis for comparing and evaluating software development methods. With it, practitioners and methodologists can describe and rate an SDM's support for 21 properties.

48 Object-Oriented Database Management Systems: Evolution and Performance Issues

A.R. Hurson, Simin H. Pakzad, and Jia-bing Cheng

Applications that involve complex data and operations are not served well by conventional data models and DBMSs. This article surveys current research and development in object-oriented DBMSs.

62 A Survey of Wormhole Routing Techniques in Direct Networks

Lionel M. Ni and Philip K. McKinley

Efficient routing of messages is critical to the performance of direct network systems. The popular wormhole routing technique faces several challenges—particularly flow control and deadlock avoidance.

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