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Virtual Reality: A Short Introduction

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Terminology

The term 'Virtual Reality' (VR) was initially coined by Jaron Lanier, founder of VPL Research (1989). Other related terms include 'Artificial Reality' (Myron Krueger, 1970s), 'Cyberspace' (William Gibson, 1984), and, more recently, 'Virtual Worlds' and 'Virtual Environments' (1990s).

Today, 'Virtual Reality' is used in a variety of ways and often in a confusing and misleading manner. Originally, the term referred to 'Immersive Virtual Reality.' In immersive VR, the user becomes fully immersed in an artificial, three-dimensional world that is completely generated by a computer.

Head-Mounted Display (HMD)

The head-mounted display (HMD) was the first device providing its wearer with an immersive experience. Evans and Sutherland demonstrated a head-mounted stereo display already in 1965. It took more then 20 years before VPL Research introduced a commercially available HMD, the famous "EyePhone" system (1989).

A head-mounted display (HMD):

Web size (83 K)

A typical HMD houses two miniature display screens and an optical system that channels the images from the screens to the eyes, thereby, presenting a stereo view of a virtual world. A motion tracker continuously measures the position and orientation of the user's head and allows the image generating computer to adjust the scene representation to the current view. As a result, the viewer can look around and walk through the surrounding virtual environment.

To overcome the often uncomfortable intrusiveness of a head-mounted display, alternative concepts (e.g., BOOM and CAVE) for immersive viewing of virtual environments were developed.

BOOM

The BOOM (Binocular Omni-Orientation Monitor) from Fakespace is a head-coupled stereoscopic display device. Screens and optical system are housed in a box that is attached to a multi-link arm. The user looks into the box through two holes, sees the virtual world, and can guide the box to any position within the operational volume of the device. Head tracking is accomplished via sensors in the links of the arm that holds the box.

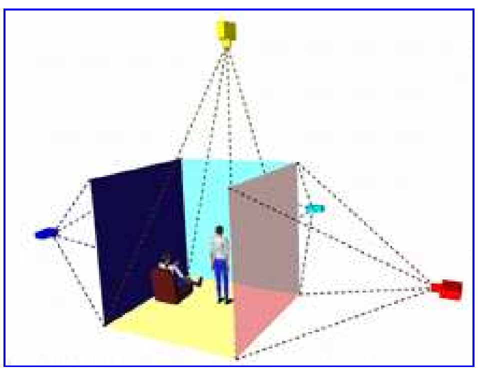
The BOOM, a head-coupled display device:

Screen size (170K) - Max size (100K)

CAVE

The CAVE (Cave Automatic Virtual Environment) was developed at the University of Illinois at Chicago and provides the illusion of immersion by projecting stereo images on the walls and floor of a room-sized cube. Several persons wearing lightweight stereo glasses can enter and walk freely inside the CAVE. A head tracking system continuously adjust the stereo projection to the current position of the leading viewer.

CAVE system (schematic principle):



Web size (29K)

Input Devices and other Sensual Technologies

A variety of input devices like data gloves, joysticks, and hand-held wands allow the user to navigate through a virtual environment and to interact with virtual objects. Directional sound, tactile and force feedback devices, voice recognition and other technologies are being employed to enrich the immersive experience and to create more "sensualized" interfaces.

A data glove allows for interactions with the virtual world:

Moving the steering wheel
Web (120K) - Screen (307K) - Max (428K)

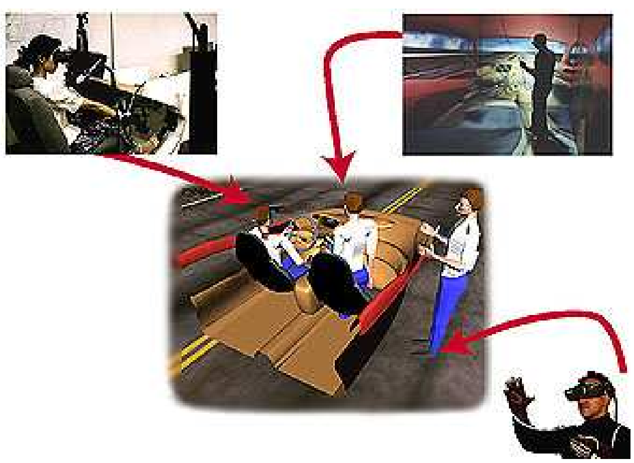
Characteristics of Immersive VR

The unique characteristics of immersive virtual reality can be summarized as follows:

- Head-referenced viewing provides a natural interface for the navigation in three-dimensional space and allows for look-around, walk-around, and fly-through capabilities in virtual environments.
- Stereoscopic viewing enhances the perception of depth and the sense of space.
- The virtual world is presented in full scale and relates properly to the human size.
- Realistic interactions with virtual objects via data glove and similar devices allow for manipulation, operation, and control of virtual worlds.
- The convincing illusion of being fully immersed in an artificial world can be enhanced by auditory, haptic, and other non-visual technologies.
- Networked applications allow for shared virtual environments (see below).

Shared Virtual Environments

In the example illustrated below, three networked users at different locations (anywhere in the world) meet in the same virtual world by using a BOOM device, a CAVE system, and a Head-Mounted Display, respectively. All users see the same virtual environment from their respective points of view. Each user is presented as a virtual human (avatar) to the other participants. The users can see each other, communicated with each other, and interact with the virtual world as a team.



Web size (49K) - Screen size (185K) - Max size (166K)

Non-immersive VR

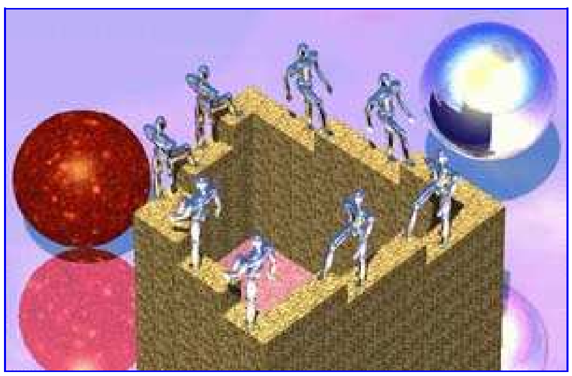
Today, the term 'Virtual Reality' is also used for applications that are not fully immersive. The boundaries are becoming blurred, but all variations of VR will be important in the future. This includes mouse-controlled navigation through a three-dimensional environment on a graphics monitor, stereo viewing from the monitor via stereo glasses, stereo projection systems, and others. Apple's QuickTime VR, for example, uses photographs for the modeling of three-dimensional worlds and provides pseudo look-around and walk-trough capabilities on a graphics monitor.

VRML

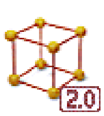
Most exciting is the ongoing development of VRML (Virtual Reality Modeling Language) on the World Wide Web. In addition to HTML (HyperText Markup Language), that has become a standard authoring tool for the creation of home pages, VRML provides three-dimensional worlds with integrated hyperlinks on the Web. Home pages become home spaces. The viewing of VRML models via a VRML plug-in for Web browsers is usually done on a graphics monitor under mouse-control and, therefore, not fully immersive. However, the syntax and data structure of VRML provide an excellent tool for the modeling of three-dimensional worlds that are functional and interactive and that can, ultimately, be transferred into fully immersive viewing systems. The current version VRML 2.0 has become an international ISO/IEC standard under the name VRML97.

To view and interact with the following VRML example (Escher's Penrose Staircase), we recommend to install the CosmoPlayer plug-in for Netscape or Explorer Web browsers.

Rendering of Escher's Penrose Staircase (modeled by Diganta Saha):



Web size (97K) - Screen size (427K) - Max size (688K)



Load the 3D VRML 2.0 model (3K) and reveal the mystery of the Penrose Staircase.
The model is animated (click on the ball) and comes with sound. (No time to install the VRML plug-in? Click solution.)

VR-related Technologies

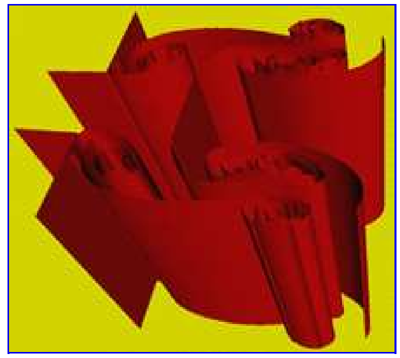
Other VR-related technologies combine virtual and real environments. Motion trackers are employed to monitor the movements of dancers or athletes for subsequent studies in immersive VR. The technologies of 'Augmented Reality' allow for the viewing of real environments with superimposed virtual objects. Telepresence systems (e.g., telemedicine, telerobotics) immerse a viewer in a real world that is captured by video cameras at a distant location and allow for the remote manipulation of real objects via robot arms and manipulators.

Applications

As the technologies of virtual reality evolve, the applications of VR become literally unlimited. It is assumed that VR will reshape the interface between people and information technology by offering new ways for the communication of information, the visualization of processes, and the creative expression of ideas.

Note that a virtual environment can represent any three-dimensional world that is either real or abstract. This includes real systems like buildings, landscapes, underwater shipwrecks, spacecrafts, archaeological excavation sites, human anatomy, sculptures, crime scene reconstructions, solar systems, and so on. Of special interest is the visual and sensual representation of abstract systems like magnetic fields, turbulent flow structures, molecular models, mathematical systems, auditorium acoustics, stock market behavior, population densities, information flows, and any other conceivable system including artistic and creative work of abstract nature. These virtual worlds can be animated, interactive, shared, and can expose behavior and functionality.

Real and abstract virtual worlds (Michigan Stadium, Flow Structure):



Web (137K) - Screen (455K) - Max size (633K) Web (32K) - Screen (99K) - Max size (146K)

Useful applications of VR include training in a variety of areas (military, medical, equipment operation, etc.), education, design evaluation (virtual prototyping), architectural walk-through, human factors and ergonomic studies, simulation of assembly sequences and maintenance tasks, assistance for the handicapped, study and treatment of phobias (e.g., fear of height), entertainment, and much more.

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