Virtual Reality: An Overview

By Jorge Franchi

Virtual Reality (VR), a technology which began in Air Force and university laboratories more than 20 years ago, is often called Artificial Reality, Cyberspace, or Synthetic Reality. Virtual Reality is a computer-created sensory experience that completely immerses a participant to believe and barely distinguish a "virtual" experience from a real one. It is the use of computer graphics, sounds and images to reproduce an electronic version of real-life situations.

Cyberspace, a term coined by science fiction writer William Gibson in the seminal 1984 science fiction work, *Neuromancer*, is a vast region that lies just beyond the edge of perceived reality, a realm of three-dimensional graphics that exists only in the silicon-chip brains of computers.

Virtual Reality is not a computer. It is a technology that uses computerized clothing to synthesize reality. It recreates our relationship with the physical world in a new plane. Current VR systems provide little more than visual experiences created by computer-assisted design (CAD) or other graphics/animation systems, but researchers are working on interface devices to add sound and touch to VR experiences. Eventually, VR may be delivered through direct computer-to-brain connections. Although direct brain connections are far off, in the next five to 10 years some other wild predictions for VR applications may come true. An example of this far-fetched concept was presented in the blockbuster movie, *Total Recall*. In the movie, Arnold Schwarzenegger is offered the opportunity to experience life on Mars as a spy through direct inputs to the brain.

Virtual reality breakthrough came with the development of a head-mounted display with two tiny stereoscopic screens just a few inches in front of the eyes. The most popular VR system is made by one of the field's visionaries, Jaron Lanier of VPL Research in Redwood City, California. The system features a head-mounted display called the EyePhone. The user also wears a DataGlove which generates movement and interaction in the virtual environment. Estimated system price: $205,000.

How Does it Work?

Movement in Cyberspace is simulated by shifting the optics in the field of vision in direct response to movement of certain body parts, such as the head or hand. Turn the head and the scene shifts accordingly. The sensation is one of being inside the artificial world the computer has created.

The EyePhone uses a set of wide-angle optics that cover approximately 140 degrees, which is almost the entire horizontal field of view, thus allowing the user to perceive the visual world of Virtual Reality. In addition, the EyePhones have, instead of transparent lenses, visual displays that are rather like small three-dimensional televisions. As the user moves the head to look around, the images seen inside the eyeglasses are shifted in such a way that an illusion of movement is created; the user moves while the virtual world is standing still.

The glasses do one more thing--they have embedded sensors which are capable of sensing facial expressions. This is very important because the user is part of the Virtual Reality and the clothing that is worn has to sense as much as it can about the body. The glasses use that information to control the virtual version of your body, which both the user and other people perceive as being part of the Virtual Reality.

A group at NASA has succeeded in putting together a system of helmet, glove, and a monochrome three-dimensional "stick" reality. The DataGlove reproduces your real hand into a virtual hand by means of flexible fiber-optic cables attached to a lightweight glove you slip your real hand into. When you point, your virtual hand points.

The DataGlove is a key interface device. Using position tracking sensors and fiber-optic strands running down each finger, the glove gives the computer information it then uses to create a replica of the user's hand within the computer. With the DataGlove, a user can manipulate an object that exists only within the simulated environment created by the computer.

Real objects can also be attached to sensors, which allow the objects to become part of the imaginary envi-

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ronment. For instance, a squash racket could be rigged up to sensors so that whenever the user swings the real racket, the computer-generated one follows in tandem.

The DataGlove allows the user to reach out and feel things that aren't really there. The inside of the surface of the glove has tactile stimulators. When the computer (i.e., Home Reality Engine) "senses" that your hand is touching a virtual object (even though there is no object there) the user actually "feels" the virtual object.

Another function of the gloves is to allow the user to interact with objects. The user can pick up an object and do things with it—just like you would with a real object. The DataGlove's most obvious application will be in robotics, particularly in the handling of hazardous materials by robots. Operators can guide the robot's movements by using the glove. It could also be used by astronauts to control robot repairmen from the comfort and safety of a spaceship, from a space station or even from Earth.

VENDORS AND SUPPLIERS OF VIRTUAL REALITY PRODUCTS

Advanced Gravis Computer Technology

Advanced Gravis manufactures the Ultrasound 3D Holographic 16 Bit, 32 Voice, CD-Quality Sound Card for the PC. Ultrasound is fast becoming the industry standard in the VR world. Ultrasound takes full advantage of Focal Point Technology.

Advanced Gravis Computer Technology
101-3750 North Fraser Way
Burnaby, BC V5J 5B6 CANADA
(604) 431-5020 (604) 431-5155 (fax)

(ART)^n Laboratory

(ART)^n Laboratory is the inventor of PHSColograms—the photography of Virtual Reality. PHSColograms are digital, full color, 3D images. (ART)^n is commercializing PHS Colograms for advertising and entertainment.

(ART)^n Laboratory
319 Wishnick Hall
3255 S. Dearborn Avenue
Chicago, IL 60616
(312) 567-3762 (312) 567-6908 (fax)

Ascension

Ascension's motion-capture product—Flock of Birds—is used for virtual and character animation applications.

Ascension
PO Box 527
Burlington, VT 05402
(802) 860-6440 (802) 860-6439 (fax)

Autodesk, Inc.

Autodesk, Inc. is the leader in design automation software for personal computers. Autodesk's family of products include AutoCAD, 3D Studio and Cyberspace Developer Kit (CDK).

AudoDesk, Inc.
2320 Marinship Way
Sausalito; CA 94965
(415) 332-2344 (415) 491-8308 (fax)

Avatar Partners

Avatar Partners is a virtual reality system developer and systems integrator specializing in the development of complex virtual reality systems for government and industry.

Avatar Partners
13090 Centra Avenue, Suite 3
Boulder Creek, CA 95006
(408) 338-6460 (408) 338-6462 (fax)

Convolvotron 3D Audio System

The Convolvotron is a digital audio signal processing system that reinforces the virtual environment by enabling complementary audio simulation. The PC-compatible system uses headphones to feed sound to users.

Crystal River Engineering, Inc.
12350 Wards Ferry Road
Groveland, CA 95321
(209) 962-6382

CrystalEyes

CrystalEyes eye wear enables users to view computer images with three-dimensional perception. CrystalEyes provides stereoscopic imaging by using infrared signals to synchronize left and right images with liquid crystal shuttered lenses.

StereoGraphics Corporation
2171-H East Francisco Boulevard
San Rafael, CA 94901
(415) 459-4500

CyberEdge Journal

CyberEdge Journal is a bi-monthly newsletter that focuses on technological issues and development related to virtual reality and human/computer interaction.

CyberEdge Journal
1 Gate Six Road, Suite G
Sausalito, CA 94965
(415) 331-EDGE (415) 331-3643 (fax)

Digital Image Design, Inc.

Digital Image Design, Inc. presents Desktop Virtual Reality. InScape and InScape/AVS transform your monitor into a virtual space for 3D visualization.

Digital Image Design
170 Claremont Ave., Suite 6
New York, NY 10027
(212) 222-5236 (212) 864-1189 (fax)

Dimensional International Ltd.

Superscape Virtual Reality Software. Interactive 3D visualization and virtual world building via graphical user interfaces. Superscape VRT3 is an integrated development system used by artists and designers in over 30 different application areas.

Dimension International Ltd.
Zephyr One Calleva Park
Aldermaston, Berkshire, R1G 4QZ
Intl Fax: 44 734 816940

Domark

Domark is the developer and publisher of MIG29, the flying simulation game of Virtual Reality Studio, the world builder product that was used to create "Lemme Out of Here!" Domark's products are distributed in North America by Accolade.

Accolade, Inc.
550 South Winchester Blvd.
San Jose, CA 95128
(408) 246-6607

Evans & Sutherland

Leaders in computer graphics and simulation for 25 years, Evans & Sutherland manufactures high performance real-time graphics hardware for cost-effective virtual reality applications. Software includes off-the-shelf 3D VR environments and custom environment development.

Evans & Sutherland
600 Komas Drive
Salt Lake City, UT 84108
(801) 582-5847 (801) 582-5848 (fax)

Flogiston Chair

The Flogiston Chair, based on principles of posture, balance, equilibrium, and energy enables users to focus their senses on the virtual environment.

Flogiston Corporation
462 Capehill
Webster, TX 77598
(713) 280-8554

Focal Point

Focal Point digital audio processing card uses audio stimulus to enhance virtual reality. Boasting a Midi3D controller, the product manages synthesizer, sampler, and disc file sound within the 3D environment.

Focal Point 3-D Audio
1402 Pine Avenue, Suite 127
Niagara Falls, NY 14301
(416) 963-9188

Immersion Corporation

Immersion Corporation has available three innovative products for natural human interfacing to virtual environments: the Immersion Probe™, the Immersion Interface Box™, and the Immersion Vector Stick™.

Immersion Corporation
PO Box 8669

Virtual Worlds

As a fluid, interactive medium, VR goes far beyond 3-D arcade applications. With products such as VPL's Swivel 3-D and Sense8 Corp.'s World Tool Kit, virtual worlds are just waiting to be created, explored, and even inhabited. As more and more people create, share, and interact in the same virtual environments, it is logical that some form of virtual societies will begin to emerge.

Naturally, the ability to create one's own "place" in Cyberspace has led to much speculation about fantasies running rampant. So pervasive is the idea of sexual escapades in VR that there is a name for it—teledildonics—even though it will be quite some time before the technology has advanced enough to provide the requisite tactile sensations. The idea of teledildonics was exposed in the movie, *Brainstorm*, where Christopher Walken invents a headpiece that sorts off videotapes and lays back past and new experiences.

VENDORS AND SUPPLIERS OF VIRTUAL REALITY PRODUCTS

Palo Alto, CA 94309
(415) 960-6882 (415) 960-6977 (fax)

MacroMind/Paracomp

MacroMind/Paracomp publishes 3-D modeling, animation, and rendering software including MacroMind Director, MacroMind Three-D and Swivel 30.

MacroMind/Paracomp
600 Townsend, Suite 310
San Francisco, CA 94102
(415) 252-2000

MANDALA

MANDALA Virtual Reality Authoring Software is a multimedia interface package that lets users interact within virtual environment. Through audio/visual processing, the virtual environment is able to react instantly to the gestures the user's imported video image.

The Vivid Group
317 Adelaide Street W., #302
Toronto, ON M5V 1P9 Canada
(416) 340-9290

Meckler

Meckler organizes virtual reality conferences and exihibitions each year: San Jose, California—May 11–13, 1994; Paris, France—November 2–4, 1994; and New York City, New York—November 29–December 2, 1994.

Meckler
11 Ferry Lane West
Westport, CT 06880
(203) 226-6967 (203) 454-5840 (fax)

Micro Synetic, Inc.

Micro Synetic is the developer of Stare-EO, the random-dot stereogram paint program. Stare-EO is published by NE Thing.

Micro Synetic, Inc.
Plaza of the Americas Suite 318 LB 385
700 N. Pearl Dallas, TX 75201
(214) 606-3000

NE Thing Enterprises

NE Thing publishes Stare-EO, the random-dot stereogram paint program. NE Thing is currently developing a line of products based on the random-dot 3-D concept including posters and calendars.

NE Thing Enterprises
19A Crosby Drive
Bedford, MA 01730
(617) 275-6960

PhotoVR

PhotoVR is a virtual reality package for desktop systems that loads graphic images quickly into a virtual environment, then updates the motion and orientation of the graphic image in near real-time. Straylight is featuring Cyberton, an immersive, motion platform-based arcade system.

Straylight Corporation
150 Mount Bethel Road
Warren, NJ 07059
(908) 580-0086 (908) 580-0092 (fax)

Sense8

Sense8 develops the high-end virtual reality package World Tool Kit, consisting of both hardware and software.

Sense8
1001 Bridgeway, #477
Sausalito, CA 94965
(415) 331-6318

SIG-Advanced Applications, Inc.

SIG-Advanced Applications, Inc. publishes *Virtual Reality Systems* magazine and produces VR conference and exhibitions. The firm also publishes conference proceedings from its many events.

Sig-Advanced Applications, Inc.
1582 First Avenue, Suite 286
New York, New York 10028
(212) 717-7318 (212) 861-0588 (fax).

Spectrum HoloByte

Spectrum HoloByte is the developer of the software that runs the Virtuality machines, and the publisher of numerous computer games for various platforms.

Spectrum HoloByte
2061 Challenger Drive
Alameda, CA 94501
(510) 522-3584

SpaceBall 2003

SpaceBall 2003 provides an intuitive 3D interface that allows the user to manipulate virtual environments through hand movements. Spaceware, an available set of drivers, ensures the product's compatibility with numerous commercial applications.

SpaceBall Technologies, Inc.
600 Suffolk Street
Lowell, MA 01854
(508) 970-0330

StereoGraphics Corp.

StereoGraphics manufactures CrystalEyes, the LCD shutter glasses that produce flicker-free 3-D images on PC computers and closed-circuit television systems.

StereoGraphics Corp.
2171-H East Francisco Blvd.
San Rafael, CA 94901
(415) 459-4500 (415) 459-3020 (fax)

Virtual Reality Development System

Virtual Reality Development System is a complete package that enables PC users to create and interact with 3D virtual environments in real time. This system is compatible with standard PC hardware and supports specialized hardware for increased interactivity.

VREAM, Inc.
2568 N. Clark Street, #250
Chicago, IL 60614
(312) 477-0425

VPL Research, Inc.

VPL Research, Inc. manufactures and markets a Macintosh-based virtual reality system known as MicroCosm. The system, which is based on a Macintosh Quadra 9000 and which includes a headmounted display and data gloves, retails for $58,000.

VPL Research, Inc.
656 Bair Island Road, Third Floor
Redwood City, CA 94063
(415) 306-1150 (415) 361-1845 (fax)

VRASP

VRASP, the Virtual Reality Alliance of Students and Professionals, disseminates information through *PIXElation* magazine.

VRASP
PO Box 4139
Highland Park, NJ 08964
(908) 463-VRVR (908) 580-0092 (fax)

Xtensory, Inc.

Xtensory manufactures tactile devices for use with data gloves.

Xtensory, Inc.
140 Sunridge Drive
Scotts Valley, CA 95066
(408) 439-0600

Potential Applications

There are many potential applications for VR. Surgeons and doctors will use VR applications to visualize in three dimensions the innards of their patients, even "walk" through the brain or rehearse a surgical procedure on a virtual patient before cutting into the real thing.

Virtual Reality has applications for archaeology, too. Right now archaeologists are measuring the Pyramids and "inputting" the data on CAD laptops. The list of possible applications seems endless. Someday scientists expect to explore celestial bodies and study lakes beneath the Antarctic ice pack using VR applications like telerobotics. Disabled persons, through prosthetic interfaces, one day may use telerobotics to perform tasks that are now only a dream. At theme parks such as Universal Studios Florida in Orlando, computer-simulated rides reproduce the feeling of an adventure without visitors leaving the confines of their seats.

The world of VR is not simply visual. Air traffic controllers will hear the voices of pilots coming from the actual direction of the plane approaching the airport. What 3-D may one day mean for the blind can only be hinted at.

Drawbacks of VR

Despite such practical applications, VR has a few drawbacks. It is enormously expensive, and the graphics are still cartoonish because of the additional computational power required to generate more lifelike images. In addition, there is a slight but perceptible time lag between the user's body movements and their eventual translation in Cyberspace.

Head-mounted displays are bulky and perhaps just a bit too avant-garde in appearance for easy acceptance in the workplace. Also, the resolution is very slow.

VR Research Facilities

At the Human Interface Technology Laboratory at the University of Washington in Seattle, researchers are attempting to replace the head-mounted display with lightweight glasses that would scan the computer-generated images directly onto the retinas via low-power lasers. Companies like Sense8 through its Stereo-CAD product, hope to elude head-mounted displays with lightweight stereoscopic glasses that render in 3-D the images on a conventional desktop monitor. At this early phase, no one knows what long-term effects of using headmounted displays might be on human eyes, or the possible psychological fallout of spending excessive amounts of time in Cyberspace.

Another aspect of VR systems that will need improvement if they are to be used in technical training is that of tactile feedback. The DataGlove has tiny metallic vibrators in the fingertips that create a tingling sensation that approximates the sense of touch. But objects in VR environments give no resistance, have no weight and no heft. Many VR researchers are working to create new interface devices to provide this dimension.

Although the graphics/animation technology behind Virtual Reality is still in its infancy, VR promises trainers the ultimate method of stimulation. The Visual Systems Laboratory (VSL) at the University of Central Florida (UCF) Institute for Simulation and Training (IST) is currently exploring visual database issues related to real-time image generation. Research into different areas has lead the VSL to investigate the applicability of Virtual Environments (VEs) in training situations. The development of the Virtual Environment Real-Time Network (VERN) protocol has provided a generic platform for the development of mass-participation distributed simulations. VERN is based on a dead-reckoning paradigm that was introduced in SIMNET, the first large-scale networked training simulator.

The VSL is in the process of developing resources to set-up a Virtual Environment Test Bed (VETB). The VETB will be a multi-site distributed laboratory for the development and evaluation of new VE technology with respect to training. Participants in this unique project include UCF's Computer Science Department and IST/VSL, MIT's Media Lab, Georgia Tech's College of Computing and Visualization Graphics and Usability Lab, and the University of Iowa's Computer Science Department and Center for Simulation and Design Optimization.

The Future of VR

Customers for Virtual Reality systems can be found in widely diverse markets, each having its own set of dynamics that contrast with the defense market. The Electronic Industries Association, a Washington, D.C.-based trade group which represents hundreds of defense contractors nationwide, conducted a study and presented its findings at their annual 10-year Forecast Conference. The study projects annual sales of virtual reality technology, both in defense and non-defense areas, to explode from about $100 billion in 1994 to $280 billion in 2003.

Ten years ago VR was a science-fiction fantasy. Today it is a developing technology seen primarily in research labs and at trade shows. Tomorrow it may be as common as television. Lanier likes to say that "VR is a medium whose only limiting factor is the imagination of the user."

Bibliography

An interview with Jaron Lanier. (1989, Fall). *Whole Earth Review*, pp. 108–119.

Ditlea, S. (1989, November). Inside Artificial Reality. *PC Computing*, pp. 91–102.

Emery, G. (1990, December). Close Encounter of the Visual Kind. *Insight*, pp. 30–31.

Foley, J.D. (1987). Interfaces for Advanced Computing. *Trends in Computing*, pp. 62–67.

Fritz, M. (1990, June). Eyephones, DataSuits, and Cyberspace. *CBT Directions*, pp. 11–17.

Fritz, M. (1991, February). The World of Virtual Reality. *Training*, pp. 45–50.

Furness, T.A. (1988). Harnessing Virtual Space. *SID International Symposium*. Playa del Rey, CA: Society for Information Display.

Helsel, S.K. (Ed). (1991, January/February). *Virtual Reality Report*, 1(1).

Lovece, F. (1989). An Interview with Howard Rheinglod. *Audio/Video Interiors*, pp. 106–110.

Weimer, D. & Ganapathy, S.K. (1989, May). *A Synthetic Visual Environment with Hand Gesturing and Voice Input*. Holmdel, NJ: AT&T Bell Laboratories.

Zimmerman, T.G., Lanier, J., Blanchard, C., Bryson, S. & Harvill, Y. (1987). *A Hand Gesture Interface Device*. Redwood City, CA; VPL Research, Inc. ■