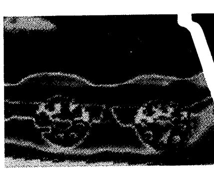
A New Content of Ideas



What happens if an astronaut on a space station of tomorrow needs an emergency appendectomy—and there is no surgeon on board?

Telesurgery is one possibility—surgery performed by a robot whose movements are precisely guided by a surgeon on Earth. He conducts the operation by a combination of computers, television and advanced sensors. The stereoscopic view entirely surrounds the doctor so that he feels he is actually a part of the space station scene, and he is able, through instrumented glove technology, to direct the robot's hand movements to correspond exactly to his own hand movements.

Way out? Not really, according to scientists at Ames Research Center's Aerospace Human Factors Research Division. Telesurgery is not now available, of course, but it is considered feasible for a 21st century time frame, say two to three decades from now. And it is only one of an infinite number of exciting potential applications for a burgeoning new technology called "virtual reality."

The technology is still at the "ground floor" level, still somewhat crude, requiring a great deal of development and refinement. But one of its basic components—3D computer graphics—is already in wide commercial use and expanding explosively. Other components that permit a human operator to "virtually" explore an artificial environment and to interact with it are being demonstrated routinely at Ames and elsewhere. Some of them, in fact, are already commercially available, albeit expensively, and the technology developed for one of Ames' artificial reality research tools—the instrumented glove—has even found its way into a video game.

Virtual reality (VR) might be defined as an environment capable of being virtually entered—telepresence, it is called—or interacted with by a human. One reason for NASA's interest is an anticipated need for large scale remote control of robotic space systems. Robots are becoming more and more sophisticated, more and more dextrous, and there is need for corollary development of devices, displays, skills and techniques that will allow telepresence and effective telerobotic control.

Since the mid-1980s, Ames' Aerospace Human Factors Research Division has been developing experimental systems that permit human/computer interaction. For example, the VIEW system. VIEW stands for Virtual Interface Environment Workstation. It is a head-mounted stereoscopic display system in which the display may

Photo by Wade Sisler

Above, a NASA scientist is conducting a test of Ames Research Center's "virtual reality" headset. She sees a computer-generated 3D scene or a real environment remotely relayed by video cameras; the stereo imagery suggests that she is actually part of the scene.

Topping a selection of spinoffs in computer technology are hardware/software systems for advancing the exciting concept of virtual reality

be an artificial computer-generated environment or a real environment relayed from remote video cameras. The operator can—virtually at least—"step into" this environment and interact with it.

He wears a headset whose centerpiece is a display box containing two small (3.9-inch) television screens, one for each eye so that the TV image appears three dimensional. The scene is accompanied by appropriate sound effects delivered to the headset. The headset bars view of anything but the imagery, thus helps create the illusion that the user is part of the scene pictured. One example of an important practical application: a design engineer can virtually become part of the fuel flow of a rocket engine and travel with the flow, noting places where it slows, speeds up or becomes turbulent; he can learn a great deal about system design that he could not in 2D simulation.

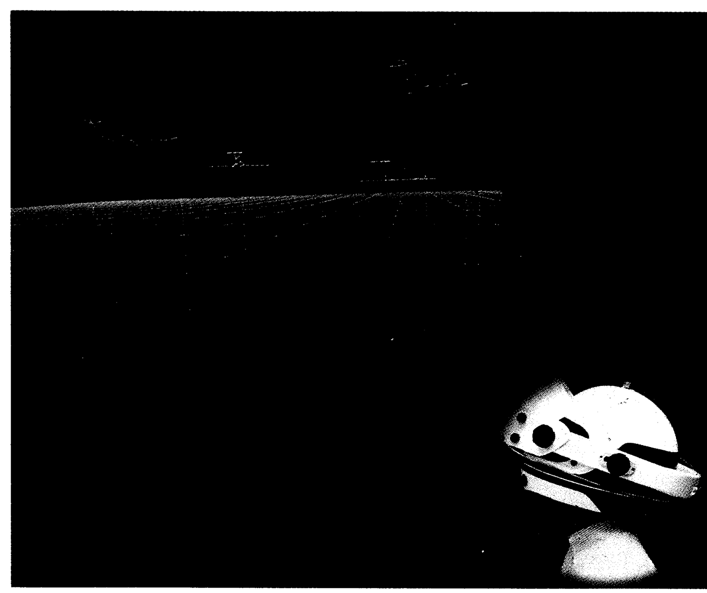
The scene might be a room. If the operator turns his head, the scene shifts just as it would in the real world; a headset-mounted sensor tracks the position of the user's head and communicates this knowledge to the computer. By pointing in a given direction, the operator virtually moves in that direction so he can explore any part of the room. Ames is developing a library of software for various scenes and the operator can select a menu option by a word or gesture, because the system is trained to recognize voice and gesture commands.

An important addition to the Ames system is the DataGlove™, an experiment in telepresence control of advanced robotic hands or fingers. Developed for Ames by VPL Research, Inc., Redwood City, California, the glove has a series of fiber optic cables and sensors that detect any movement of the wearer's fingers and transmit the information to a host computer; a computer-generated image of the hand will move exactly as the operator is moving his gloved hand. With appropriate software, the operator can use the glove to interact with the computer scene by grasping an object, for example, moving a virtual chair within the simulated room; the computer will dutifully move the chair in the TV display. Not only that, the operator can "feel" the virtual chair through tiny vibrators in the fingertips of the DataGlove.

It is possible, Ames and other VR researchers feel, to replicate almost any environment or activity, so VR has immense potential, both as a research tool and an operational system for telepresence/telerobotics.

The possibilities for practical applications of VR in everyday life are even broader, thinks Jaron Z. Lanier. Lanier is chief executive officer of VPL Research, developer of the DataGlove and other systems for creating virtual reality, which he describes as "a new continent of ideas."

(Continued)



A possible future application of virtual reality: an air traffic controller wearing a helmeted version of the headset monitors aircraft from a virtual viewpoint in the airspace.

™ DataGlove is a trademark of VPL Research, Inc.

A New Continent of Ideas

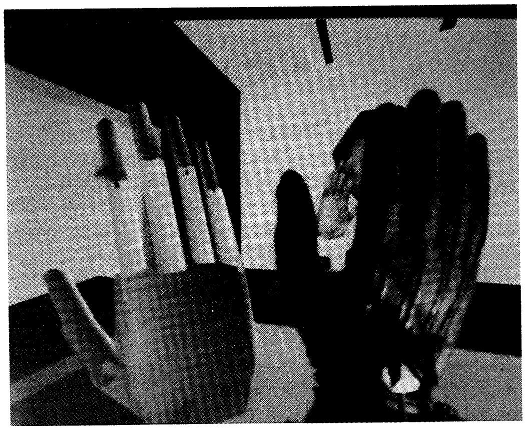
(Continued)

Jaron Lanier, 29, originally planned to be a professional musician, got sidetracked into computers and software, then into designing video games. In 1984, he met Tom Zimmerman, who was developing a wired glove with which to play an imaginary "air guitar." Lanier recognized the virtual reality potential of Zimmerman's concept, persuaded Zimmerman to join him and founded VPL Research to pursue the glove idea and related VR systems.

In April 1986, VPL won a contract for its first product, the NASA DataGlove. Made of thin Lycra, the gloves have sensors at 15 points that monitor flexion and extension of the fingers, the position and orientation of the hand and thus permit hand/computer interaction. The first glove was delivered to NASA in May 1986.

During the NASA contract, Lanier and VPL scientists worked closely with NASA virtual reality principal investigator Scott S. Fisher and his telepresence/telerobotics researchers at Ames' Aerospace Human Factors Research Division. It was a mutually beneficial arrangement; NASA gained an important research capability with development of the DataGlove and VPL learned from extensive use of the technology incorporated in Ames' VIEW system.

In a remarkably short span, VPL has expanded its research and product line. A natural follow-on to the DataGlove was the DataSuit™, a sensor equipped full body garment that greatly increases the sphere of performance for virtual reality simulations by reporting to the computer the motions, bends, gestures and spatial orientation of the wearer—in other words, it makes possible full body interaction with the computer generated virtual world. The absolute position sensors for the DataGlove and DataSuit—and also for the head tracker in Ames' VIEW system—are provided by Polhemus Inc., Colchester, Vermont. The DataSuit has already found a commercial application, an unusual one: it is worn by film actors to give fluid, realistic motion to animated characters in computer-generated movie special effects.



At top is the DataGlove developed for NASA by VPL Research, a computer input device for manipulating 3D environments. In the lower photo the movements of the gloved hand are duplicated on the screen by a computer-generated graphic hand.

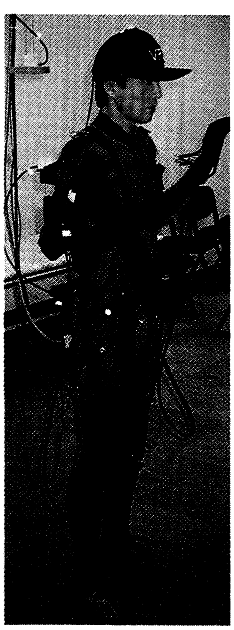
The VPL Research EyePhone is a headset in which the viewer can't see the physical world, instead sees a computer generated VR world in color and 3D. With the DataGlove, the goggled VPL engineer shown can virtually grasp and pick up objects in the VR world as if they were real.

After DataSuit, VPL created its own version of the eye display in NASA's helmet system, the EyePhone™, a head-mounted stereo display. VPL has developed a line of software for virtual reality applications. The company offers a complete package, the RB2 Virtual Environment, that includes one DataGlove, the EyePhone, a design control workstation with processor and associated software, cables, transceivers and connections, for $45,000. With the computers, which are made by Silicon Graphics, Mountain View, California, the whole system goes for $200,000 for a single user, $400,000 for two users.

That's costly, to be sure, but VR enthusiasts are counting on continuance of the dramatic drop in computer costs that made personal computers available to all and may similarly broaden VR applications.

The DataGlove alone sells for about $9,000. Among immediate applications are Computer-Aided Design and Manufacturing (CAD-CAM), wherein the glove serves as an input device for manipulating 3D environments; the user can grasp objects on the screen to change an environment without lengthy keyboard stroking. In robotics, robot arms and grippers can be manipulated in real time by the gloved hand, for training or telemanipulation. In animation, computer-generated characters can be puppeted by mapping DataGlove sensor values to the characters' limbs or actions.

The glove has medical applications, too, for example, it can be used for sign language research or as a tool for assessing hand function and performance; these applications are being developed by Greenleaf Medical Systems, Palo Alto, California. And, of course, it can be used to interact with simulated environments for a variety of purposes; already on the market is Mattel Toys' simplified version of the glove for use in Nintendo video games.



Wearing sensor-equipped DataGloves and a full-body DataSuit, a technician can virtually become part of a computer-generated environment. Sensor signals are picked up by the computer and the suit-wearer's motions, bends and gestures are replicated in the artificial environment.

With improvements contemplated for the next few years, VPL sees such additional uses for the RB2 system as allowing an architect's clients to inspect and perhaps alter a building design before the structure is built by virtually walking through a graphic replication of it; similarly, the system makes it possible to walk through dynamic models of communication networks, large databases and traffic control systems. VR offers three-dimensional scientific visualization, particularly useful in chemistry, geology and aerodynamics. In medicine, it offers an additional increment of information-gathering capability when used as an image enhancement tool in diagnostic body imaging.

VR has broad potential for training in a number of fields. As for education, it permits virtual travel in time; a student can virtually *be* a pharaoh in ancient Egypt, a tyrannosaurus hobnobbing with other dinosaurs or a comet soaring past planets and moons and asteroids at a million miles an hour. And entertainment? Says VPL: "We leave that to your imagination. . ."

"VR is shared and objectively present like the physical world," company literature states, "composable as a work of art and as unlimited and harmless as a dream. When VR becomes widely available, it will not be seen as a medium used within a physical reality, but rather as an additional reality. VR opens up a new continent of ideas and possibilities."

™ DataSuit and EyePhone are trademarks of VPL Research, Inc.