The NASA Ames VIEWlab Project—A Brief History

Editors' Note: To celebrate Presence*'s 25th year of publication, we have invited selected members of the journal's original editorial board and authors of several early articles to contribute essays looking back on the field of virtual reality, from its very earliest days to the current time. This essay comes from founding editorial board member Scott Fisher, who explains how a downturn in one industry (computer games) led to opportunities in another at NASA.*

I first visited NASA Ames in early 1984 for a special workshop on human factors issues for the U.S. Space Station program that was just beginning. At the time, I was still working with Alan Kay at Atari Corporate Research, mostly focusing on developing immersive video games and educational environments with the Coin-Op division as well as continuing longer term research on the possible uses of head-mounted displays (HMDs) and first-person technologies for a range of home and entertainment applications. At the Ames conference I was introduced to Dave Nagel, who was Assistant Chief of the Aerospace Human Factors Research Division. Nagel expressed interest in my research and asked me if I would give a presentation sometime on it for their division. Soon after that, Atari collapsed and I was looking around for somewhere to continue the same thread of research and that would specifically support development of an HMD-based program. Nagel expressed interest in having me work there and got a new research position opening announced for which I had to formally apply to become a Civil Servant. I returned to Ames and gave a slide and talk presentation called "Interactive Technologies for Simulation of First-Person Experience," in which I showed our work from MIT and Atari and talked about other new technologies that I had been looking at for use in the Coin-Op division, including some background on head-mounted displays. One of the technologies I showed was the LEEP lens system that Eric Howlett invented to provide very wide field-of-view life-sized stereo images by means of a unique nonlinear lens set and camera system. He had contacted me at the MIT Architecture Machine Group a few years earlier to see if we would be interested in his system. Later, at Atari, I worked on making a consumer version of the LEEP optics for a low-cost 3D arcade game somewhat based on Mort Heilig's groundbreaking Sensorama back in the 1950s and early 1960s.

Steve Ellis and Mike McGreevy were researchers at Ames and both were at my presentation. They later asked specifically about the LEEP optics. At the time, they were working on some interesting graphics to help users (like pilots) make better estimates of spatial relationships on 2D displays. I went back to Ames again and gave them Howlett's contact info and heard nothing further from them. It took almost nine months for NASA HQ to process my employment application and do security checks and I finally started work there in the beginning of 1985. I had heard earlier that year from Ev Palmer, Branch Chief of the Human Machine interface group in Nagel's division, that they would be interested in supporting some HMD development for space station use and was I looking forward to working on this with the team of researchers there. After a few weeks there, I was excited (but a little surprised) to find that McGreevy had in the meantime been working with Jim Humphries, an onsite contractor from Sterling Software, to develop an HMD prototype based around the LEEP optics. Humphries is an extremely talented engineer who did an incredible job of putting it together using displays from

Scott S. Fisher
Associate Dean, Research
Professor, Media Arts + Practice Division
Founding Chair, Interactive Media Division
Director, Mobile & Environmental Media Lab
USC School of Cinematic Arts
Los Angeles, CA 90089-2211
sfisher@cinema.usc.edu

Presence, *Vol. 25, No. 4, Fall 2016,* 339–348
doi:10.1162/PRES_a_00277

a pocket TV. He continued working on subsequent revisions of the HMD with input and feedback from our project team, as well as building the first BOOM, an alternate head-coupled display approach later commercialized by Mark Bolas' company, Fakespace, Inc.

Since all researchers at Ames are essentially "principal investigators," they are expected to develop their own research directions in line with their branch and division's agenda. McGreevy, Ellis, and Beth Wenzel were all in Palmer's branch. I assumed that we would all work together on various aspects of developing the system but soon learned that not everyone was interested in collaborative research. I proceeded anyway with designs to grow the prototype HMD (VIVED) into an interactive, multisensory "system" (VIEW) that could be used as a "generic" user interface for a range of space station applications. (A selection of project documentation slides can be found in the Appendix.) This included designing the specifications for a glove-based input device based on Tom Zimmerman's sensor invention and negotiating the contract with VPL (their first) to build the first "dataglove" for us. I ordered a head-tracker from Polhemus like the one we used at MIT and Atari, started working with Wenzel to add 3D sound and speech I/O to the system, and began looking around for other hackers who could help put this all together. Mark Bolas, Scott Foster, Steve Bryson, and Warren Robinett were some of the stars we eventually got—I also tried to hire Brenda Laurel, but was not successful.

Around mid-1985, Nagel gave McGreevy the opportunity to go to Washington as Ames' representative at NASA HQ. McGreevy accepted and left soon after. Over the rest of the year, we managed to get a couple of real-time head-tracked wireframe demos running in the helmet with only 100 x 100 resolution but were completely awed by the incredible effect of being surrounded with 3D graphics even at low resolution. At the end of 1985, we prepared a press release and Humphries and I made plans to go to the Las Vegas CES show in January 1986 to release it. We were joined there by McGreevy from DC and showed the first project demo tape[1] that I put together over Christmas illustrating the space station applications. We received much media attention and interest from both researchers and industry around the country.

1. https://www.youtube.com/watch?v=cUDAObviWEo

Figure 1. *VIEWlab Software team, 1987. From left to right: Scott Fisher, Steve Bryson, Rick Jacoby, Ian McDowall, Mark Bolas, Phil Stone. Photo credit: NASA/S.S. Fisher.*

Figure 2. *VIEWlab laboratory (real), 1989. Photo credit: NASA/S.S. Fisher.*

Around this time, Nagel, now Division Chief, declared that he was making our work a formal "project" with goals, milestones, project managers, etc. I was appointed the Project Director and proceeded to make detailed plans and schedules to refine the previous HMD display with the goal of making it publicly available along with our system and software documentation at the end of the project (see Figures 1 and 2).

Figure 3. *The Virtual Interface Environment Workstation (VIEW), 1990. Photo credit: NASA/S.S. Fisher, 1989.*

Figure 4. *VIEWlab Documentation project, 1988. Photo credit: NASA/S.S. Fisher, W. Sisler, 1988.*

Over the next four years, we did two more revs of the HMD, had a real-time graphics system custom made for us to generate filled polygons, built the first interactive 3D sound processor (the Convolvotron, later commercialized by Scott Foster's company, Crystal River Engineering), and contracted Ascension (their second contract) to make a very high-powered tracker so that we could move around larger virtual environments in our lab while also tracking two hands. The final VIEW system[2] (see Figures 3 and 4) was widely published in professional journals and covered in the popular media, including a cover story in *Scientific American* in October 1987.

I left Ames in the beginning of 1990 to start Telepresence Research, Inc. with Laurel to continue research on first-person media, and to develop virtual environment and remote presence experiences, systems, and applications—mostly for theme parks and museums. One of our projects was "Menagerie,"[3] the first immersive VR installation in an art museum (Pompidou Centre, Paris 1992), which presented an environment that allowed visitors to interact with virtual characters. Another was the first permanent VR installation in a public museum, the "Virtual Brewery Adventure"[4] (Sapporo Beer Museum, Tokyo 1994). After that, I collaborated on the "Virtual Explorer"[5] project with a team of undergraduate students at UCSD who developed a software framework for teaching basic science concepts in an entertaining format using immersive VR environments with videogame-like interaction. This system's first content module on immunology was installed at San Jose's Tech Museum of Innovation and at the Heinz Nixdorf Computer Museum in Germany.

In 1999, I moved to Tokyo to work at Keio University where we developed an early Augmented Reality (AR) system called "Wearable Environmental Media."[6] This work was funded by NTT Docomo and was designed to link virtual environments to the physical world through integration of capabilities and technology components from the fields of virtual reality, mixed reality, mobile multimedia, and wearable computing. In 2002, I moved back to the U.S. to start a new Interactive Media Division at USC's School of Cinematic Arts. One of the first

2. https://www.youtube.com/watch?v=3L0N7CKvOBA&index=8&list=PLZYUaP_cPHpa9Cad1GxrnvW4Ky3xlPMHg
3. https://www.youtube.com/watch?v=ZKETFeraZFk&index=6&list=PLZYUaP_cPHpa9Cad1GxrnvW4Ky3xlPMHg
4. https://www.youtube.com/watch?v=PyQxQI9agtQ&index=5&list=PLZYUaP_cPHpa9Cad1GxrnvW4Ky3xlPMHg
5. https://www.youtube.com/watch?v=cUyTuKqYTWc
6. https://www.youtube.com/watch?v=SMujvLQdKaE&index=2&list=PLZYUaP_cPHpa9Cad1GxrnvW4Ky3xlPMHg

faculty members I hired there was Mark Bolas, who had played a major role on the original NASA Ames team. At USC, Bolas and other researchers in our labs have continued to develop foundational VR, AR, and Mixed Reality technologies that have enabled many of the commercial systems on the market today (see Figure 5).

Appendix: Project Documentation Slides Projects@NASA Ames Research Center

Concept and Program Slides

TELEPRESENCE. One application of the VIEW system was to interact with a simulated telerobotic task environment. The system operator could call up multiple images of the remote task environment that represent viewpoints from free-flying or telerobot-mounted camera platforms. Three-dimensional sound cues give distance and direction information for proximate objects and events. Switching to telepresence control mode, the operator's wide-angle, stereoscopic display is directly linked to the telerobot 3D camera system for precise viewpoint control. Using the tactile input glove technology and speech commands, the operator directly controls the robot arm and dexterous end effector that appears to be spatially correspondent with his own arm (see Figures A1 and A2).

DATASPACE. Advanced data display and manipulation concepts for information management were also developed with the VIEW system technology. Efforts included use of the system to create a display environment in which data manipulation and system monitoring tasks are organized in virtual display space around the operator. Through speech and gesture interaction with the virtual display, the operator could rapidly call up or delete information windows and reposition them in 3D space. Three-dimensional sound cues and speech-synthesis technologies were used to enhance the operator's overall situational awareness of the virtual data environment. The system also has the capability to display reconfigurable, virtual control panels that respond to glove-like tactile input devices worn by the operator (see Figure A3).

Hardware Slides

In the Aerospace Human Factors Research Division of NASA's Ames Research Center, an interactive Virtual Interface Environment Workstation (VIEW) was developed as a new kind of media-based display and control environment that is closely matched to human sensory and cognitive capabilities. The VIEW system provided a virtual auditory and stereoscopic image surround that is responsive to inputs from the operator's position, voice, and gestures. As a low-cost, multipurpose simulation device, this variable interface configuration allows an operator to virtually explore a 360-degree synthesized or remotely sensed environment and viscerally interact with its components. The Virtual Interface Environment Workstation system consists of a wide-angle stereoscopic display unit, glove-like devices for multiple degree-of-freedom tactile input, connected speech recognition technology, gesture tracking devices, 3D auditory display and speech-synthesis technology, and computer graphic and video image generation equipment (see Figures A4, A5, A6, and A7).

When combined with magnetic head and limb position tracking technology, the head-coupled display presents visual and auditory imagery that appears to completely surround the user in 3D space. The gloves provide interactive manipulation of virtual objects in virtual environments that are either synthesized with 3D computer-generated imagery, or that are remotely sensed by user-controlled, stereoscopic video camera configurations. The computer image system enables a high-performance real-time 3D graphics presentation that is generated at rates up to 30 frames per second as required, updating image viewpoints in coordination with head and limb motion. Dual independent synchronized display channels are implemented to present disparate imagery to each eye of the viewer for true stereoscopic depth cues. For real-time video input of remote environments, two miniature CCD video cameras are used to provide stereoscopic imagery. Development and evaluation of several head-coupled, remote camera platform and gimbal prototypes were also carried out to determine optimal hardware and control configurations for remotely controlled camera systems (see Figures A8, A9, and A10).

Figure 5. *The origins of VR from seminal early work in the field by USC/SCA faculty through the ongoing development of unique immersive content and design tools by SCA and ICT researchers. Illustration compiled by Mark Bolas, David Nelson, Scott Fisher, and Roberto Gomez.*

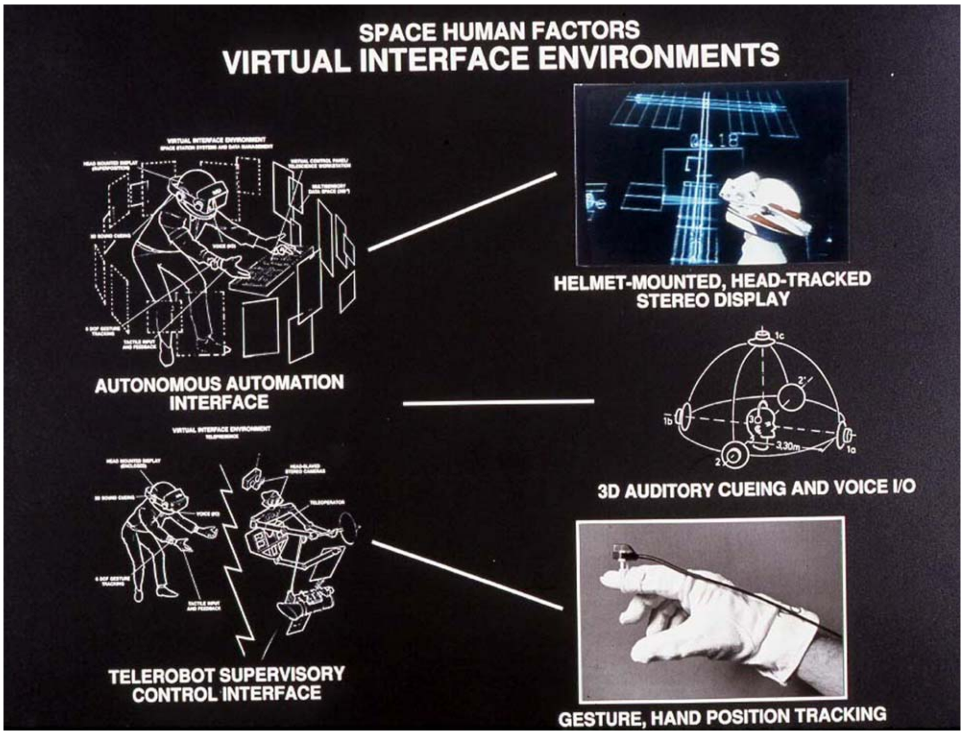

Figure A1. *VIEWlab: Project overview, 1986. Photo credit: NASA/S.S. Fisher, 1986.*

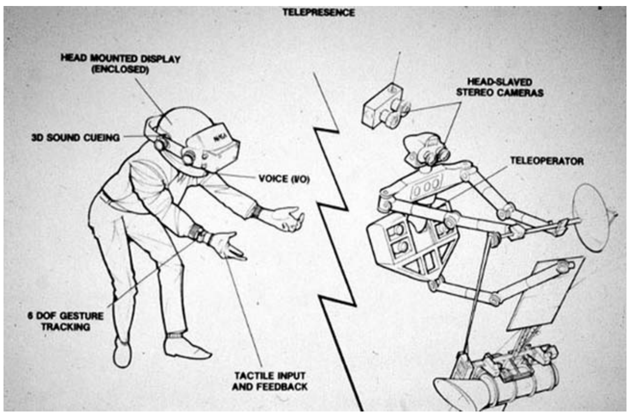

Figure A2. *VIEWlab: Telepresence project concept, 1986, Photo credit: NASA/S.S. Fisher, 1986.*

Figure A3. *VIEWlab: Dataspace project concept, 1986. Photo credit: NASA/S.S. Fisher, 1986.*

A few years ago, the only way of creating convincing three-dimensional sound was to place a large number of loudspeakers around the user, each speaker emitting appropriate cues to manipulate the position of the virtual sound source. Such systems were too cumbersome to be used other than in laboratory conditions, and lighter, more flexible solutions were sought. By combining research on how humans localize sound in space with new computer systems to process sound digitally, a solution was developed that allowed for sound cues to

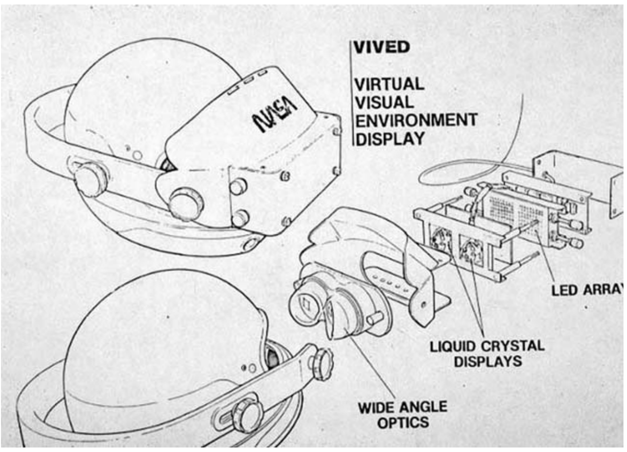

Figure A4. *VIEWlab prototype HMD diagram, 1985. Photo credit: NASA Ames Research Center, 1985.*

Figure A5. *VIEWlab System Prototype 1, 1985, Photo credit: NASA/S.S. Fisher, W. Sisler, 1985.*

Figure A6. *VIEWlab System Prototype 2, 1986. Photo credit: NASA/S.S. Fisher, W. Sisler, 1986.*

Figure A7. *VIEWlab System Prototype 3, 1988. Photo credit: NASA/S.S. Fisher, W. Sisler, 1988.*

be associated with different objects or points within the virtual space, clearly identifiable by the user when moving his or her head. This research gave rise to the Convolvotron, first developed at NASA by Scott Foster and Elizabeth Wenzel. The Crystal River Engineering Company, now part of Aureal Semiconductor, marketed this system.

The earliest device for interactivity in a virtual environment and with virtual objects was the dataglove, developed at NASA Ames. Based on an invention developed by Tom Zimmerman while he was at Atari Research for measuring motion of a single finger, the gloves were cus-

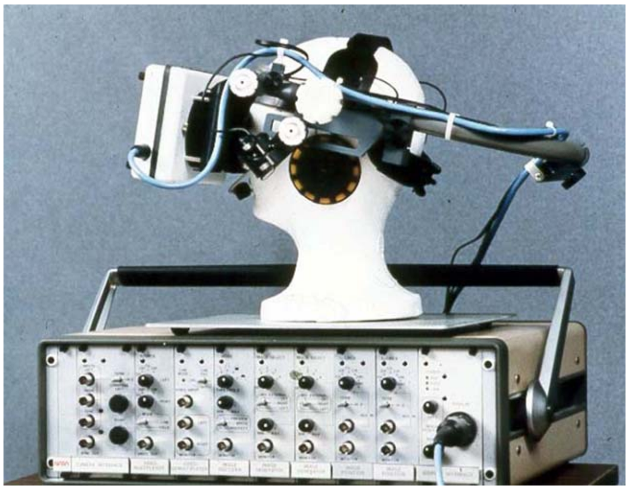

Figure A8. *VIEWlab HMD electronics system, 1988. Photo credit: NASA/S.S. Fisher, 1988.*

Figure A9. *VIEWlab counterbalanced CRT-based stereoscopic viewer (CCSV). Photo credit: NASA/S.S. Fisher, 1988.*

Figure A10. *VIEWlab remote controlled stereoscopic telepresence camera system. Photo credit: NASA/S.S. Fisher, 1988.*

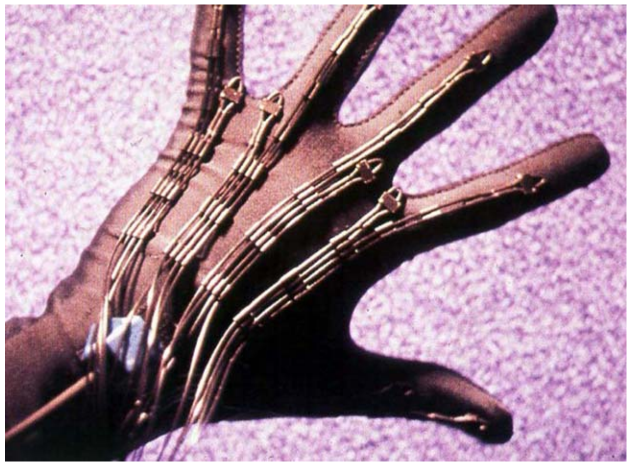

Figure A11. *VIEWlab fiberoptic dataglove prototype, 1987. Photo credit: NASA Ames Research Center, 1987.*

tom built for NASA by Zimmerman at VPL Research and later marketed by VPL as a commercial product. These gloves were fitted with special sensors to measure the bend of the fingers and equipped with a magnetic tracking system that allowed for the glove, and the hand inside it, to be followed in 3D space and the ability to handle virtual objects freely. Special software was also developed in the VIEWlab to allow different gestures for specific actions and system commands such as “flying” through the virtual environment, interacting with virtual menus, or easily scaling models of virtual objects (see Figure A11).

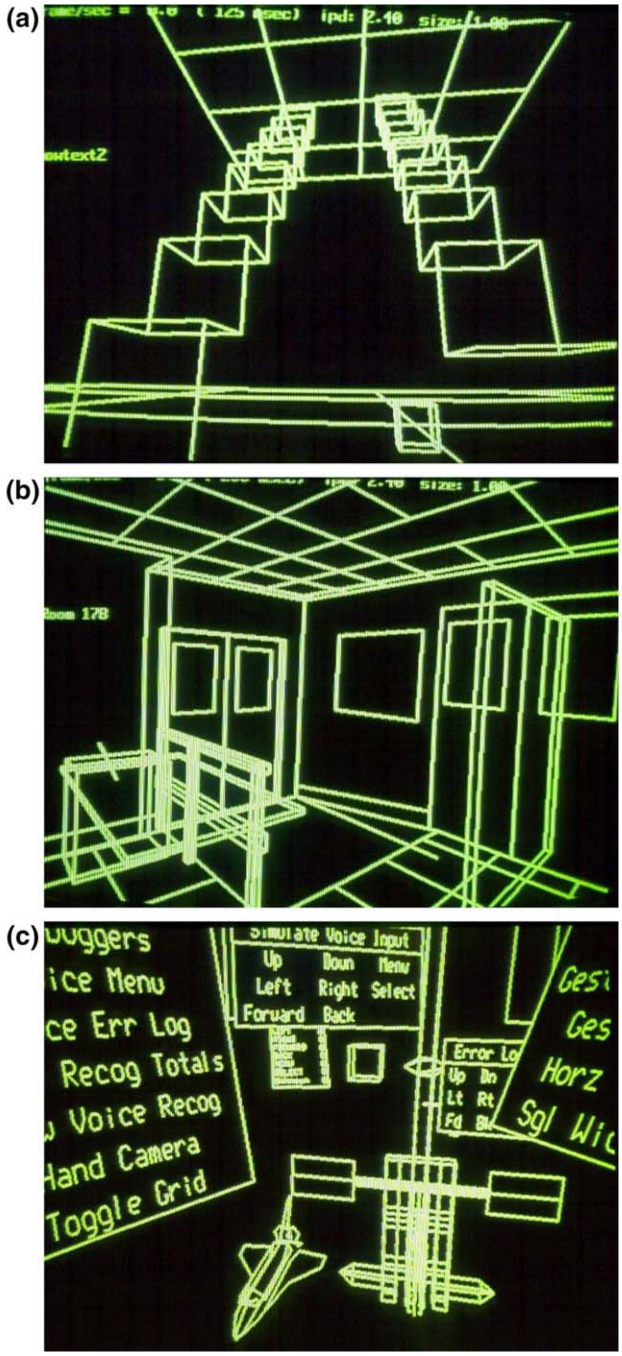

Figure A12. *(a) VIEWlab: Virtual escalator, 1986; (b) VIEWlab: Virtual lab model, 1986; (c) VIEWlab: Menus in virtual dataspace, 1986.*

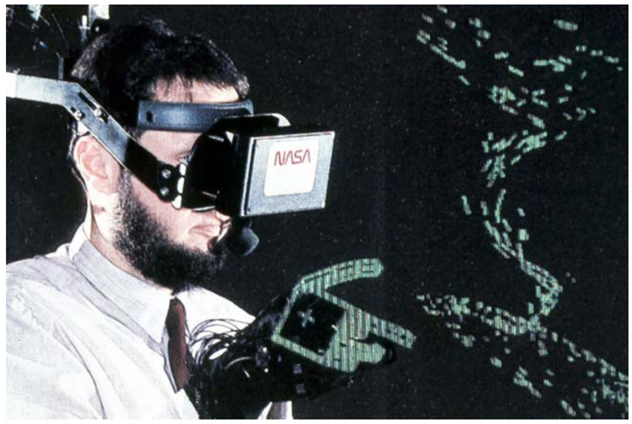

Figure A13. *VIEWlab: Fluid flow visualization, 1986. Photo credit: NASA/S.S. Fisher, 1986.*

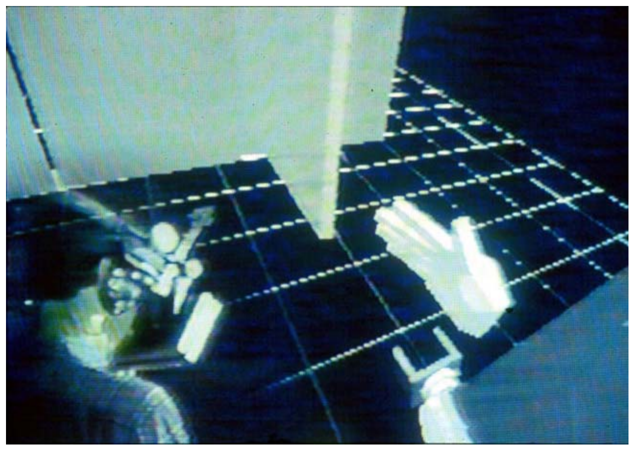

Figure A14. *VIEWlab: Prototype telerobot control system interface, 1988. Photo credit: NASA/S.S. Fisher, 1988.*

Software and World Slides

For a long time, the images seen by visitors to virtual space—such as the images produced by NASA in the 1980s—were very simple. Until recently it was very difficult and expensive to generate complex images fast enough—20 or 30 images a second—for users to have the impression of real immersion in a virtual environment, with instantaneous changes in what they saw corresponding to movements of their head and eyes. Today this technology has made considerable progress and there are now high-performance computer cards that can create detailed stereoscopic images at very high frame rates. Similar devices are also becoming available for use with ordinary personal computers (see Figures A12, A13, A14, and A15).

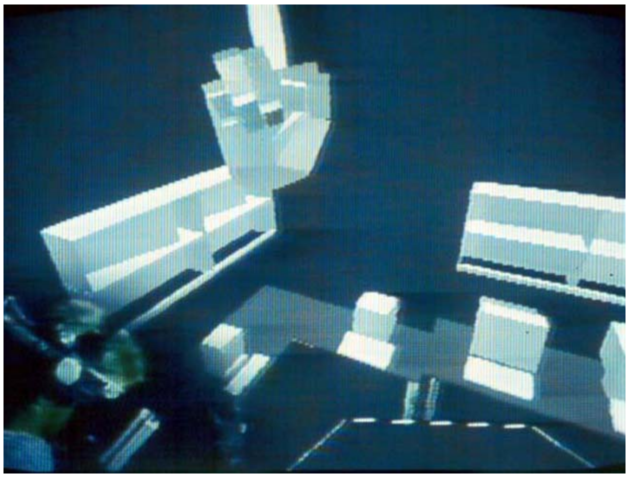

Figure A15. *VIEWlab: Virtual lab model 2, 1988. Photo credit: NASA/S.S. Fisher, 1988.*

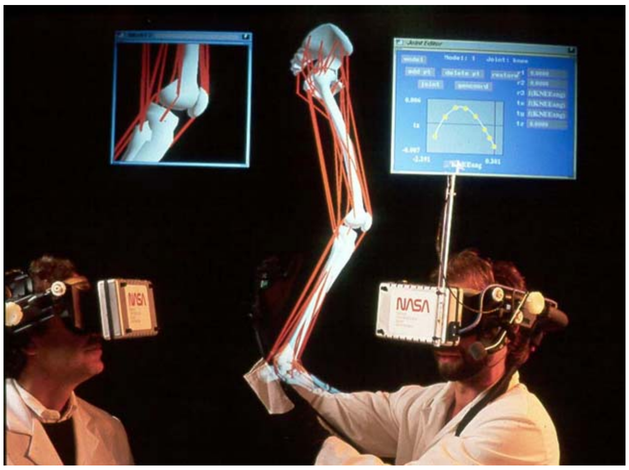

Figure A16. *VIEWlab: Surgical simulation project, 1989. Photo credit: NASA/S.S. Fisher, 1989.*

A VIEWlab Virtual World Database for Use in Surgical Planning and Education

A VIEWlab Virtual World database was developed for use in surgical planning and education in collaboration with MIT Media Lab and Stanford Medical School. The medical applications of telepresence have made rapid progress over the past few years. One notable development is a virtual cadaver on which surgeons can test new operating techniques and which can also be used for training medical students. NASA, Stanford University, and MIT have designed a virtual skeleton with the tendons and muscles attached to the bones and which the user may manipulate as though in plastic surgery. Joseph Rosen, Scott Delp, and Steve Pieper were the main creators of this system. NASA has also experimented with remote surgical operations to be carried out on astronauts by robots. These tests were abandoned, however, since the delay in transmitting the information represented too great a risk factor. This research was directed then toward the idea of remote medical assistance, with experts using telepresence to give advice to medical staff onboard a spaceship (see Figure A16).

Figure A17. *Telepresence mobile robot, 1991. Photo credit: ©S.S. Fisher, 1991.*

Remote Presence Technologies

A Remote Presence system was developed by Telepresence Research and Fake Space Labs based on earlier work at NASA Ames Research Center. The system includes a head-coupled stereoscopic camera unit and computer-controlled platform that moves in correspondence with the BOOM viewer motion. The camera system is mounted on a mobile robot platform that enables overall positional changes with joystick or speech commands (see Figure A17).