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E. P. Mertens

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Westinghouse Hanford Company
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VIRTUAL REALITY AND STEREOSCOPIC TELEPRESENCE

E. P. Mertens

NEW APPLICATIONS FOR EXISTING TECHNOLOGY

Virtual reality technology is commonly thought to have few, if any, applications beyond the national research laboratories, the aerospace industry, and the entertainment world. It is dismissed as too expensive, complex, and impractical for other uses. Now, that view is insupportable.

A team at Westinghouse Hanford Company (WHC) is developing applications for virtual reality technology that make it a practical, viable, portable, and cost-effective business and training tool. The technology transfer is particularly applicable to the waste management industry and has become a tool that can serve the entire work force spectrum, from industrial sites to business offices.

For three and a half years, a small team of WHC personnel has been developing an effective and practical method of bringing virtual reality technology to the job site. Through a technique they term stereoscopic telepresence, the technology immerses employees in a simulated environment where those employees will have the ability to--

- Safely, conveniently, repeatedly, and cost-effectively practice simulated work place scenarios in the realistic surroundings of a virtual reality setting.

- Receive the psychological impact of real-time training without having to cope with the consequences of accidents or mistakes.

- Experience the sensation of operating equipment, performing complex tasks, responding to emergencies, or working with hazardous materials.

- Learn more easily by training in familiar and comfortable surroundings and by enjoying the learning experience.

The applications are practical, the results are repeatable, and the equipment costs are within the range of present-day office machines. That combination can evolve into a competitive advantage for commercial business interests. The WHC team has contained system costs by using commercially available equipment and personal computers to create effective virtual reality work stations for less than $20,000.

WHAT ARE VIRTUAL REALITY AND STEREOSCOPIC TELEPRESENCE?

Virtual reality is a technology-mediated illusion that gives the viewer a realistic visual sense of being immersed in a three-dimensional, computer-

generated scene. Virtual world graphic scenes can consist of anything that can be modelled in computer graphics. The viewer can navigate through the scene and manipulate objects that seem to have spatial presence.

Stereoscopic telepresence is the name of an accompanying technology that gives a viewer the sense of interacting with a stereo video image. The technique uses images from a dual-camera stereoscopic video system to allow individuals in one location to sense that they are viewing and performing activities at a remote location with full three-dimensional depth perception. The activities at the remote site can be performed by using a variety of remote mechanical devices outfitted with the appropriate stereo camera system.

WHY USE VIRTUAL REALITY AND STEREOSCOPIC TELEPRESENCE?

The introduction of virtual reality work stations holds a remarkable potential as a business tool. Because each work station is as portable as any personal computer and can be readily transported and used at any work site, it precludes the need to have workers travel to a dedicated training facility. Even a partial list of the application advantages is impressive. For example, the existing technology can provide a system that--

- Is safe, efficient, affordable, portable, effective, easily transferable, and user friendly; it invites participation.
- Produces results that are consistent, predictable, measurable, and reproducible.
- Is applicable to business offices, factories, field sites, classrooms, training facilities, laboratories, and seminars.
- Uses commercially available hardware priced at levels consistent with other electronic office equipment to create suitable visual images.
- Can serve as a technology transfer showcase among businesses, government agencies, and others concerned with waste management.

APPLYING AND TRANSFERRING THE TECHNOLOGY

The waste management industry offers many immediate opportunities to apply virtual reality technology. Not only have those opportunities been particularly apparent in the environmental restoration and remediation effort at the Hanford Site, the accomplishments of the WHC team can be readily and inexpensively used throughout the waste management industry.

Between 1991 and 1993, the WHC team researched and tested the technology for practicality and cost savings within the Hanford Transuranic Waste Characterization and Retrieval Pilot Program. Since July 1993, evolving forms

of virtual reality technology have been available for use on the programs and projects at the Hanford Site.

Over the past year, a number of other organizations at Hanford have identified additional applications for virtual reality and stereoscopic telepresence that could increase efficiency, improve safety, and yield significant cost savings.

In addition to the many possible applications at Hanford, the technology transfer opportunities beyond Hanford are growing at a rapid pace. An assessment of potential technology transfer was developed from feedback received after two on-site demonstrations were organized with the participation of local and out-of-state private sector businesses. Two non-Hanford companies--one from California and one from Washington--that are experienced in hazardous waste management projects viewed the demonstration. The enthusiasm shown by personnel from both companies affirmed that the use of the technology to visualize and plan effective waste management practices is of interest to companies outside the Hanford community.

Personnel from a mechanical/electrical construction and contracting company viewed a demonstration. They said the technology would give them the ability to create engineering designs and test conceptual layouts before they were committed to detailed designs and construction.

Members of a law firm noted that the technology could be used to model accident scenarios. The scenarios could be tested from different points of view and, perhaps, be used in court to illustrate a client's viewpoint. People in the courtroom could "experience" the circumstances surrounding an accident as if they were present when the accident happened.

Representatives of a real estate and property management firm said that new house designs could be presented to potential buyers before a developer invested in a housing development. Also, many hours of house-hunting time could be saved by making stereoscopic-video tapes of houses that have been listed with the real estate firm. Prospective home buyers could gain a sense of walking through the houses without leaving the broker's office and thereby reduce the time spent in travelling to the homesite only to decide they did not care for the house.

Industrial firms could use the technology to test plant designs and alternative equipment layout patterns with members of the work force.

GROWTH PROJECTIONS AND EXTENDED APPLICATIONS

The October 1993 issue of *Washington CEO* magazine focused on virtual reality technology and described its business potential, growth projections, and extended applications. A number of people recognized for their understanding of the technology are quoted and discuss the near-term possibilities. For example, they concur in the belief that the U.S. is now

the world leader in developing virtual reality technology and will likely remain so for at least two or three more years. They consider the State of Washington to be the technological epicenter for virtual reality development.

The magazine mentions some of the possibilities, but it leaves the reader with the knowledge that there are enormous immediate application opportunities. Virtual reality applications already exist in manufacturing, medicine, education, engineering, aviation, architecture, construction, transportation, mining, agriculture, and housing. Business offices offer excellent opportunities with personnel who are concerned with marketing, sales, accounting, human resources, interviewing, documentation, management practices, skill development, presentations, trade shows, and conferences.

WORKER ACCEPTANCE AND OPERATIONAL VALIDATION

Once the prototype work station was assembled, the WHC team took it to several Hanford project sites to test work force acceptance and gather data. The workers were attracted to the novelty of the concept and volunteered to participate in the test. The team observed that after an average of less than five minutes of adjusting to the virtual environment, more than 97% of the workers tested were able to perform the test with ease.

Next, the team introduced stereoscopic telepresence as a complementary addition to the virtual reality system. The addition was tested at the Fast Flux Test Facility in an IM test cell by simulating activities an operator would perform from a remote location under hot-cell conditions.

The results exceeded all expectations. Both the operator who performed in the simulation and his manager said that by using the technique, the time needed to train new operators, which now takes five and a half to eight years, could easily be reduced by half.

TYPICAL APPLICATIONS AT HANFORD

Since July 1993, several virtual reality and stereoscopic telepresence demonstrations have been given to various organizations at the Hanford Site to acquaint them with the technology and to solicit ideas for new applications.

All of the viewers quickly saw how the technology might be adapted to their programmatic and operational needs. Among those who viewed the demonstrations were personnel from the Transition Projects; Engineering; Tank Farms; Waste, Analytical, and Environmental Services; Security; Training Services; and Communications. Viewers from the Communications organization said they could readily use the technology as an additional means of delivering their public awareness messages. Each of the other organizations saw similar opportunities and suggested ways in which the technology could be used. The following examples are typical responses.

Safety Training

Personnel from the safety training organizations suggested many possible applications. After viewing the demonstration, they stated that the use of virtual reality and stereoscopic telepresence training technology at Hanford can yield significant time and cost savings and can help improve safety for site operations through enhanced training programs. The Training Services organization already is working to implement some initial virtual reality and stereoscopic telepresence training.

The technique could be especially valuable in training workers to respond in the most appropriate manner to emergencies that involve hazardous and radiological issues. Workers could experience the immediacy of an emergency and not have to cope with the consequences of accidents or mistakes.

Labor intensive training activities could be minimized by using virtual worlds. Support activities could be simulated and the training steps could be practiced independent of uncontrollable factors such as inclement weather conditions and equipment failures.

Engineering and Design

New engineering concepts and designs could be tested and validated in a virtual world long before the designs were fabricated and installed.

Hazardous Waste Treatment

Waste sites and facilities could be modelled. By using a virtual reality model, operating personnel could move around freely in the realistic model and could gain a sense of being immersed in the operational activities. The personnel could manipulate controls, move objects, follow the steps of a specific procedure, and evaluate the risks associated with performing a particular task. In the model, the components could take on any given set of characteristics. For example, the model might include hazardous materials, volatile liquids, or high-activity waste. The workers could test their reactions, validate procedures, or practice difficult tasks. They could repeat the actions and refine their skills before performing the actual tasks.

Accident Scenarios

Accident scenarios could be thoroughly tested without danger. The technology could be used to help develop consensus agreement regarding the best response to any given accident. A project team could use the technology to visualize a wide range of specific operations and introduce all of the alternative accident scenarios before committing the resources to create Safety Analysis Reports and similar documents.

DEVELOPMENTS AT THE IDAHO NATIONAL ENGINEERING LABORATORY

Researchers at the Idaho National Engineering Laboratory (INEL) have also been investigating virtual reality and stereoscopic telepresence technology as one means of improving waste management operations.

As part of the INEL Buried Waste Integrated Demonstration project (BWID), a portion of the FY 1994 BWID funding was devoted to developing a virtual reality feature entitled "Virtual Environment Generation of Buried Waste." The purpose was to investigate the issues, requirements, and feasibility of developing a computer generated virtual environment for buried waste sites. The model will be designed from site characterization field data collected by electromagnetic sensors passed over the burial site. The results are to be represented on a database grid and built into a three-dimensional burial site model.

The goal at INEL is to construct a full-featured, simulation-based, planning and design (SBPD) system to be used in site characterization analyses and in the design of actual remediation efforts. They envision that an SBPD system will also support worker training techniques associated with hazardous material handling.

In August 1994, the WHC team from Hanford went to INEL and presented a demonstration of their research to the BWID project team. After viewing the demonstration, the BWID personnel stated that the WHC virtual reality accomplishments are "far ahead" of the development work at INEL. They stated that they want to learn more about the Hanford applications and how the INEL can benefit from the work WHC has accomplished.

PROTOTYPE WORK STATION COST BREAKDOWN

The following cost breakdown applies to the prototype work station the WHC team has used in its demonstrations.

A.	Personal Computer (486DX2-66, or better)	$ 4,000.00
B.	Customized VR Development Kit	3,500.00
C.	Modelling 3-D Program	3,000.00
D.	C++ Compiler	2,000.00
E.	Monitor (20", 120 Hz vertical refresh rate)	1,700.00
F.	Navigation Tool	1,500.00
G.	High Speed Video Board	1,500.00
H.	Stereo Gear (1 pair glasses and emitter)	1,000.00
I.	DOS Extender	800.00
Total		$ 19,000.00

All of the listed items are commercially available, and the prices of most of them have already decreased since the system was assembled. Market competition will tend to drive the costs even lower.

WHERE FROM HERE?

Westinghouse Hanford Company is poised to begin additional real world applications of its newly developed virtual reality and stereoscopic telepresence systems. These will include virtual reality based training programs for hazardous and radiological workers as well as many other business based applications that will take the company into the future... today!