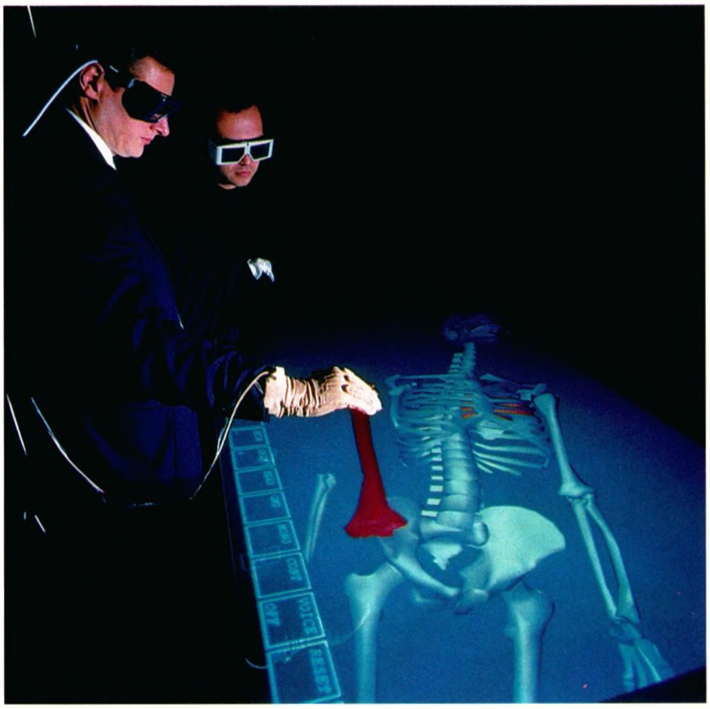

The Responsive Workbench: A Virtual Working Environment for Architects, Designers, Physicians, and Scientists

The standard metaphor for human-computer interaction has been based on the daily experience of a white-collar office worker. For the last 20 years, more and more enhanced desktop systems have been developed to provide the user with tools such as line and raster graphics, window-icon-mouse-pointer graphical user interfaces, and advanced multimedia extensions. With the advent of immersive virtual environments, the user finally arrived in a 3D space. Walk-through experiences, manipulation of virtual objects, and meetings with synthesized collaborators have been proposed as the special human-computer interfaces for the scientific visualization process.

There is another approach to the design problem for future human-computer interfaces. Based on the early ideas of Myron Krueger, non-immersive interactive multimedia environments have been developed. Basically, they are centered rigorously on the user's point of view. Application-oriented visualization environments have been proposed and built to support specific problem-solving processes. In these systems, the computer acts as an intelligent server in the background, providing information across multi-sensory interaction channels.

The Responsive Workbench has been developed as an alternative model to the multimedia and virtual reality systems of the past decade. Analyzing the daily working situations of such different computer users as scientists, architects, pilots, physicians, and service people in travel agencies and at ticket counters, the developers recognized that almost nobody wants to live with simulations of their working worlds in a desktop environment.

Generally, computer users want to focus on their tasks rather than on operating the computer. The future computer system should use and adapt to the rich human living and working environments. It should be designed to work as a part of a responsive environment. From the beginning, the Responsive Workbench has been designed by an interdisciplinary group that includes a designer, an architect, and physicians.

The architect's point of view: The ultimate design environment is and will be the designer's desk: "The tableau is the place where objects come together" (J. Beaudrillard). Design is a process which is based on a dynamic, free-floating interaction between brain, eyes, hands, and the environment: "The hand is the exterior brain of the human" (I. Kant).

Comments of physicians: The center of interest is the patient or the education process, not the operation of computer equipment. The typical working situations are cooperative tasks amongst specialists around a table, on which the patient is positioned for surgery, radiation treatment, medical education, and other procedures.

Scenario

Virtual objects and control tools are located on a real "workbench." The objects, displayed as computer-generated stereo images, are projected onto the surface of the workbench. This setting corresponds to the actual work situation in an architect's office or an operating room. A guide uses the virtual working environment as several observers watch events through stereo shutter glasses. Participants operate within a non-immersive virtual environment. Depending on the application, various input and output modules can be integrated, such as motion, gesture, and voice-recognition systems, which characterize the general trend away from the classical human-machine interface. Several guides can work together in similar environments either locally or by using broadband communication networks. A responsive environment, consisting of powerful graphic workstations, tracking systems, cameras, projectors, and microphones, replaces the traditional multimedia desktop workstation.

Two scenarios have been realized so far:

• The design and discussion process in architecture, landscape architecture, and environmental planning. An architectural model is shown on the workbench. In front of the table, two architects discuss the model, moving buildings or other objects such as trees around in the virtual world. Light sources can be set by the data glove to simulate different times of day. For this environment, the concept of active objects appears to be essential; e.g., cars driving around or pedestrians walking along the street. Objects such as trees can be added and relocated. The problem of generating an animation path for each object is easily solved by an additional Polhemus, which can be moved around in the virtual world like an object to be animated. The Polhemus generates the position, orientation, and velocity data for the animation path.

• Surgery planning and non-sequential medical training. This application shows a resizeable model of a patient, called the transparent woman, in a teacher-student scenario. The patient's skin can become transparent, and the arrangement of the bones becomes visible. Then it is possible to pick up a bone with the data glove and examine the joints to which it connects or take a close look at the bone itself. A different scenario is surgery planning with virtual bodies that originate from real datasets derived from CT or MRI measurements.

Future applications and systems extensions

During discussion of the Responsive Workbench concept, the setup of the whole system, and realization of the first application scenarios, the developers came up with the following ideas for improvements and extensions:

• Enhancement of the system's I/O and rendering tools.

• Inclusion of other applications, suited to this specific environment.

• Design of appropriate responsive environments for other classes of users.

The Responsive Workshop is designed to demonstrate the ideas and power of future cooperative-responsive environments. Further applications for this virtual workbench will be an adapted "virtual wind tunnel" for car design, simulation of air and ground traffic at airports, a training environment for complicated mechanical tasks (e.g., taking apart a machine for repair, landscape design, and environmental studies via terrain modeling), and modeling of virtual objects ("virtual clay"). These applications also rely on the workbench metaphor, but require specific interaction and I/O tools.

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