Further Development of the Responsive Workbench

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Abstract. The Responsive Workbench [8] is designed to support end users as scientists, engineers, physicians, and architects working on desks, workbenches, and tables with an adequate human-machine interface. Virtual objects are located on a real "workbench". The objects, displayed as computer generated stereoscopic images are projected onto the surface of a table. The participants operate within a non-immersive virtual environment. A "guide" uses the virtual environment while several observers can watch events by using shutter glasses. Depending on the application, various input and output modules have been integrated, such as motion, gesture and voice recognition systems which characterize the general trend away from the classical multimedia desktop interface.
The system is explained and evaluated in several applications: A virtual patient serves as an example for non-sequential medical training. The car industry benefits from areas like rapid prototyping for exterior design and interactive visualization and examination of flow field simulations (virtual windtunnel, mixing processes). Visualization and verification of experiments with mobile instrument deployment devices in outer space missions are another fascinating application. Architecture and landscape design are another discipline well suited for the workbench environment.

1 Motivation

The standard metaphor for human-computer interaction arose from the daily experience of a white-collar office worker. For the last 20 years desktop systems have been enhanced more and more, providing tools such as line and raster graphics, WIMP(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. Walkthrough experiences, manipulation of virtual objects, and meetings with synthesized collaborators have been proposed as special human-computer interfaces for the scientific visualization process. Specific interfaces, originally developed for pilots and telepresence tasks, became available to the ordinary user (see [7], for example).

The dream of the ultimate medium, which uses all channels of human perception, has guided the efforts of user interface design towards these virtual reality

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systems. Unfortunately, head-mounted displays, body-tracking suits, and force-feedback exoskeletons are obstrusive. These systems separate the users from each other. Especially in scientific visualization applications, comprehensive attempts have been made to overcome these drawbacks. The BOOM systems allow for easy-to-use walkthrough and object manipulation experiences [3]. The surround-screen projection-based virtual environment CAVE [2] was designed for several users to become immersed with their whole body in a virtual space.

All these approaches to future user interface systems have one point in common: design of an (almost) universal interface based on the most advanced computer and display technology available.

Another approach to the design problem for future human-computer interfaces is rigorously centered on the users's point of view. Myron Krueger pioneered this attempt with his work on non-immersive responsive environments [7]. Application-oriented visualization environments have been proposed and built to support a specific problem-solving process. The computer acts as an intelligent server in the background providing necessary information across multi-sensory interaction channels (see [4], [10], for example).

We developed the Responsive Workbench concept, first described in [8], as an alternative model to the multimedia and virtual reality systems of the past decade. Analyzing the daily working situation of such different computer users as scientists, architects, pilots, physicians, and professional people in travel agencies and at ticket counters, we recognized that there is only small acceptance of a simulation of working worlds in a desktop environment. Generally, users want to focus on their tasks rather than on operating the computer. Future computer systems should use and adapt to the rich human living and working environments, becoming part of a responsive environment.

2 System description

During the analysis of the working environment and of the behaviour of the specialists, we recognized that the (cooperative) tasks of this class of users relies on a "workbench" scenario. The future impact of desk-like user interfaces in general has been discussed in [9]. Using a beamer, a large mirror and a special glass plate as table top, we built an appropriate virtual environment.

Virtual objects and control tools are located on a real "workbench" (see Figure 1). The objects, displayed as computer generated stereoscopic images, are projected onto the surface of the workbench. The projection parameters are tuned such that the virtual objects appear above the table. Depending on the application, various input and output modules can be integrated, such as motion, gesture and speech recognition systems. A responsive environment, consisting of powerful graphics workstations, tracking systems, cameras, projectors and microphones, replaces the traditional multimedia desktop workstation.

The most important and natural manipulation tool for virtual environments is the user's hand. Our environment depends on the real hand, not a computer-generated representation. The user wears a data glove with a Polhemus sensor