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EVALUATING HUMAN GOAL-DIRECTED ACTIVITIES IN VIRTUAL AND AUGMENTED ENVIRONMENTS

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Introduction and Objectives

Virtual and augmented environments have been applied primarily to visualization and entertainment in the past. They are now being explored for goal-directed human activities like surgery, training and collaborative work. For these applications, we are pursuing augmented environments where there are both physical ("real world") objects, and virtual (computer-generated) objects. These environments may be rendered through graphics, haptics, audio or even olfactory displays.

The objectives of our 5-year team project are:

1) to design and implement an Enhanced Virtual Hand Laboratory, incorporating integrated displays and controls that exploit natural human perception and movement. This will provide a high degree of presence, and rich data acquisition/analysis of goal-directed human behavior.
2) to ask basic research questions about the processes underlying successful human manipulation in goal-directed activities in natural, augmented and remote environments.
3) to examine human-computer interaction (HCI) in the performance of selected tasks in the domains of surgery, design, remote manipulation and training.

We use a triangle framework of user-task-tool, studying actions of humans using a particular tool in the task-specific context of a computer-augmented environment.

Virtual Hand Laboratory

Our current Virtual Hand Laboratory (VHL) provides stereoscopic, head-coupled graphical displays as users interact with physical, virtual or augmented objects. The hardware consists of an opto-electric 3-D motion analysis system (OPTOTRAK, Northern Digital Inc.) with infrared emitting markers, a graphics workstation (Onyx2, Silicon Graphics Inc.), and stereoscopic glasses (CrystalEYES, StereoGraphics Corp.). An SGI monitor is placed upside-down on a cart, above and parallel to a table surface. The graphics image is reflected in a half-silvered mirror parallel to the tabletop so that virtual objects appear to the subject to be in the workspace below. We have calibrated this small desktop workspace. Position co-ordinates are used to drive the graphics in real-time (60 Hz with one frame lag), as the subject engages in goal-directed movement.

Position data from the OPTOTRAK are used also for extensive analyses of human movement behavior. To date we have conducted experiments on pointing, object manipulation and remote manipulation. We analyze these kinematic data to make inferences about planning, organization and human performance in natural, virtual and augmented environments.

Decomposition of goal-directed activity

Our vision is to extend computer-augmented environments from simple manipulation tasks to complex goal-directed activities. Task analyses and hierarchical decompositions of goal-directed activities are being carried out in the domains of surgery, training, design, and collaborative work. For example, in surgery, based on fieldwork and extensive video annotation, we have hierarchically decomposed selected laparoscopic procedures. These have been abstracted to surgical steps, sub-steps and tasks. In turn, these surgical tasks have been further broken down to the subtasks and motions, detectable by 3-D motion analysis systems. In parallel, we are analyzing what information is used by the surgeon, and exploring ways of presenting this information to the surgeon through computer graphics, in augmented reality systems. In this way, we can make recommendations for the design of usable, efficient, human-centered tools that enable humans to perform their tasks in augmented environments with a high degree of ease and presence.

Enhanced Virtual Hand Laboratory

In the Enhanced Virtual Hand Lab, we are adding other modalities to the visual modality. Computer-generated haptic and audio rendering of objects will complement the computer graphics in the current system for multimodal augmented environments. We highlight technical, theoretical and empirical challenges, our system status, and future directions.

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