Virtual Simulations Through High Performance Computing

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Don Stredney - Virtual Simulations Through High Performance Computing

Overview

At the Ohio Supercomputer Center, and the College of Medicine and the Advanced Computing Center for the Arts and Design at The Ohio State University, We are developing a a system to provide an intuitive interface for manipulating and experiencing virtual data sets, specifically volume reconstructions of multi-modal medical data. This design requires a minimum of setup time and user calibration. Initial user settings are stored on line, and can be readily modified to accommodate user differences.

Our system provides a cost efficient, unencumbered experience with virtual information. We are not attempting to provide a "full immersion into a virtual reality." We do not feel that the technology is fully developed at this time. Our goal is not to convince users that they are somewhere else or actually working on the "real patient." The objective is to provide an improved experience with a reconstructed model to gain new understanding of patient anatomy and the intricacies of medical procedures. Our intent is to provide meaningful cues in the simulator to facilitate rapid association, allowing users to readily assimilate the information and transfer the gained knowledge to actual practice. In addition, the interface minimizes the amount of interactive modifications required by the users, thereby allowing for more user flexibility.

Description

Our system interface integrates the following interface modalities:
Visual - Stereo Viewing/Head Tracking
Vocal - Speech Recognition
Haptic - Instrumented Gloved Interface

Stereo Viewing/Head Tracking

Stereo presentation of imagery is essential for precise spatial discrimination tasks. Most imaging systems have a 2-D projection of a 3-D scene. By capitalizing on human stereopsis, we can improve the dimensional quality of images that employ only monocular depth cues such as occlusion, texture gradients, and shadows. Our stereo viewing is accomplished using a stereo monitor with an alternating field approach and a set of CrystalEyes™ stereo viewing glasses. The stereo glasses are lightweight, are easy to don and remove, and provide an unencumbered method for stereo viewing without obtrusive equipment and tethers.

The glasses contain liquid crystal shutters. The lenses are either transparent or opaque and are synchronized with the viewing monitor through the emission of an infrared emitter located atop the monitor. The user's brain is presented with alternating left and right images, and thus perceives a stereo presentation with augmented depth cues. This alternating presentation minimizes depth ambiguities often found in non-stereo imaging.

Head tracking is accomplished using line-of-sight technology. This technology employs a small metallic reflector on the glasses that is tracked by a sensor sitting atop the monitor. As the user's head moves, the sensor tracks the movement and sends the information back to the renderer, which adjusts the viewing angle of the data set.

Although stereo viewing and head tracking can impose a slight overhead in image rendering time, we feel that this is nominal and easily mitigated by the improved speed of available workstations. Stereo and head tracking can be optionally selected by the user.

Current workstations include the Silicon Graphics Indigo, Crimson, and Onyx. Additional computational power is provided by a CRAY T3D, CRAY YMP 8/864, a CRAY Y-MP2E/232, and a CRAY YMP-EL/332.

Speech Recognition

The implication of speech recognition as a selective command modality in relationship to instrumented gloved interfaces needs mentioning. The instrumented gloved interface is a key to the user interface. The use of the glove as a 3-D selection device in conjunction with a mouse and keyboard relates it to the level of a glorified 3-D mouse. We use the glove to provide a more natural hand interaction with the simulation. For this reason speech recognition becomes useful, as it frees the hands for more meaningful use. Through voice, the user can enter specified commands to the system without having to call up menus and traverse menu trees. The Ohio Supercomputer Center and the Advanced Computing Center for the Arts and Design are beta test sites for Silicon Graphics' discrete phrase recognition software.

Instrumented Gloved Interface

As medical procedures such as surgery are extremely dexterous enterprises, it is necessary to employ a gloved interface in the system design. We have chosen the CybergloveTM, manufactured by Virtual Technologies. The Cyberglove™ allows free movement of the hand with no recognizable inertia to overcome. This light design is essential in trying to represent fine dexterous movements of the fingers and hands, as encountered in surgery.

The Cyberglove™, with a precision of 8 bit resolution per joint, measures the following movement with a 0.5 degree accuracy depending on the gain setting:
- Flexion and Extension of the wrist, fingers, and thumb.
- Abduction and Adduction of the wrist, fingers, and thumb.
- and Opposition of the fingers and thumb.

To facilitate user interaction with volumetric data sets, we are developing a human-like virtual hand with real-time response. Input from the CyberGlove is analyzed for current finger and hand positions, and passed on to a display module. Several methods of modelling are being tested, to determine which is most effective while maintaining a high screen update rate; these range from the application of simple free-form deformations (FFDs) to a tessellated hand model, through the construction of a set of non-uniform rational B-spline (NURBS) surfaces which mimic the gloved contours of a surgeon's hand. Ultimately the user will use the on-screen hand as an agent within the virtual world, manipulating data with a greater sense of physical presence than that provided by simple cursors and typed commands.

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