ASSESSING USER PROFICIENCY THROUGH VIRTUAL SIMULATIONS

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ABSTRACT

This paper describes a virtual simulation environment used for the following: 1) evaluating architectural designs, prior to construction, for ADA compliance, 2) as a simulation environment to provide users with appropriate training for power chair upgrades, and 3) as an environment for assessing the proficiency of users for using power chair equipment. We describe the configuration of the system, its hardware and software components, and our methods to improve the users' sense of immersion. Finally, we present our current focus on system improvements used for assessing user proficiency.

BACKGROUND

Trial and error has traditionally determined whether following construction guidelines provides adequate accessibility for handicapped people. We have developed a system that integrates computer visualization with innovative interface technology to create a virtual environment that simulates the movement of a power wheelchair through synthesized architectural environments. The objectives of this project are to investigate simulation technology for accessing architectural data sets, to provide an environment for user training, and to provide a vehicle for health-care providers to assess the proficiency of users for using power wheelchairs. In previous publications, we have presented work on developing a virtual platform for the virtual simulation of navigating through pre-visualized architectural data sets for assessing compliance with ADA standards (Carlson et al. 1994, Swan et al. 1994, Stredney et al. 1995). In this paper, we focus on methods to increase the users' sense of immersion and the integration of the simulation environment for assessing user proficiency.

RESEARCH QUESTION(S)

The overall objective of this effort was to create a robust simulation environment that provides a tool for three groups of people:

1) for architects and designers, it provides structure previsualization and analysis that can both improve the handicapped accessibility of building designs and test structures for compliance with the Americans with Disabilities Act of 1990

2) for wheelchair users, it provides a robust simulation environment for assessing more appropriate device fitting and training with wheelchair control systems

3) for health care professionals, it provides a system for assessing user performance and for determining the best power chair control mechanism for a particular patient.

In addition, our charge was to explore the development of new software and integration of interface equipment to increase the realism and accuracy of the simulation for both the user and the evaluator.

METHODS/RESULTS

The simulation environment includes a high-end graphics workstation capable of providing stereo images. We have chosen a Silicon Graphics IRIS Crimson VGXT™, with a 150 MHz R4400 CPU and 16MB of RAM running IRIX 5.3™. The monitor provides stereovision through a pair of CrystalEyes™ polarized viewing glasses manufactured by StereoGraphics.

Our system uses SGI's Performer™ libraries, which are optimized for efficient rendering on Silicon Graphics computers and therefore facilitate real-time frame rates for visual data bases. We have implemented a more efficient visibility preprocessing algorithm, in addition to the use of Performer, to handle architectural models.

Our software has been ported from its original Performer 1.2 implementation to Performer 2.0 in the past summer. In our previous implementation (Performer 1.2,) we've seen about 30-50% performance increase over the non-VP version in a small test model. We expect to see improved rendering speeds with more complicated models. We are modifying the scene data base format to facilitate integration with Performer 2.0. We will then compare this using a large model or replicating the current model .

There are two advantage of incorporating visibility preprocessing. 1) We gain increased performance for a given model, and 2) it allows us to use much more complex environments, thereby increasing the sense of immersion for the user. This increase facilitates our objective of evaluating architectures for ADA-compliant design. In architectural models, many detail features such as chairs, desks, and interior decorations are scattered in different rooms. The preprocessing uses space subdivision and cell-based visibility algorithm to cull model details that are not visible from a "cell" (a subdivided space region). We take advantage of the occlusion caused by wall connections to decide the cell visibility.

The system's user interface is simple. The wheelchair is connected to the workstation with a standard RS232 serial cable. The user sits in an Invacare Action wheelchair utilizing a standard joystick interface. The user dons the CrystalEyes glasses, and through the joystick control, navigates through a computer-synthesized environment. The system depicts the dynamics of the wheelchair in the particular environment. The virtual chair moves with the same speed and turning radius as a chair in the physical world. The system easily supports chairs with different control mechanisms. Invacare's power chairs are fitted with a variety of controls in addition to the joystick, including a chest muscle actuator, a halo device, which detects the tilt of the user's head, and a sip&puff device, which the user controls with their breathing. Wheelchairs with any of these control mechanisms can be instrumented with a serial computer interface. When the chair is connected to a computer, we disengage the motors so the chair does not move while connected to the simulator. The speed and direction of rotation of each of the wheelchair's wheels are sampled through the serial interface.

In addition. we have integrated a 2 degree of freedom force reflecting (haptic) joystick developed by Immersion Corporation This joystick allows both passive feedback (braking) and active feedback (applying a 2D force to the joystick). Both methods are used in our simulation. In passive mode, the joystick will discourage the user from going towards obstacles by making it harder to push the joystick in that direction. For example, if the simulation is facing down a narrow corridor, the joystick will allow only travel forwards or backwards and restricts the user from steering into a wall. The strength of the response of the joystick is proportional to the proximity of obstacles.

In active mode, the joystick exerts a force that will guide the user towards a less-congested direction. As the user steers towards an obstacle, the joystick will provide a moderate force to guide the user away from the obstruction. The correcting force becomes proportionally stronger based upon both the velocity of the chair and proximity of the obstacle. Descriptions of trials that investigated integration of a haptic joystick can be found on the Web (WEB96).

Our colleagues who evaluate individuals for upgrade to power chairs are interested in reaction times and cognitive disorders, such as side neglect. In response, we have implemented a graphical user interface for the healthcare evaluator to interact, albeit surreptitiously, with the user and the environment. This interaction can take place on a remote workstation, provided it is capable of running the same software. The evaluator sees both a subjective camera from the viewer's perspective, as well as a "god's eye" view of the environment and the location and movements of the user. The evaluator can trigger a movable object (e.g., a representation of another human) to move toward the wheelchair user in a certain speed and trajectory. While watching the patient remotely, the evaluator can observe the reaction of the patient to that obstacle. This observation includes simple tracking, such as the number of collisions the user undergoes, which location (left, right, front or back), as well as the reaction response to the moving object. We are integrating a head mounted display with the system. Our goal is to provide the precise location of objects in the user's field of view at the time of reaction. All of this information is automatically filed for the evaluator, providing a comprehensive analysis of the user's performance.

DISCUSSION

To date, we have developed a robust system that provides previsualization of architectural data sets and assists in assessment for ADA compliance. In addition, the system provides an immersive environment for users to train themselves in the use of a powerchair, therefore limiting the application of unsuitable technology that may never be fully, or even partially, utilized.

In addition, we are completing an evaluator's environment for trials to evaluate individuals in power chair proficiency. The system provides a wide range of interface devices for both simulation of chair interfaces as well as simulation interfaces for creating an immersive simulation.

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WEB: www.osc.edu/Biomed/wc.html

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