Volume Manager: A High-Level VR Tool

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1. Introduction

At the Computer Graphics lab at the University of Alberta, we have been experimenting with Virtual Reality User Interface Tools (VRUIT), using Headmounts, Isotraks, Gloves, and so on. We have built a number of simple demonstration programs [Green90] that illustrate the use of these devices.

The demonstration programs are as follows:

1) A simple mesh viewer uses an Isotrak to manipulate the position and orientation of polygonal meshes.

2) Schools of fish in a pond are behaviourally simulated. The fish school together, avoiding the Data-Glove. The user sees the simulation in the head-mounted display, and tries to grab fish with the Data-Glove.

3) A simple architectural simulation uses the head-mounted display to view a static model of some rooms.

4) A fluid dynamics simulation uses the head-mounted display to view the surface of the fluid, and the DataGlove to input force boundary conditions on the surface.

Our group has been building general-purpose tools that provide the system-level functionality required by most VR systems [Shaw92]. The programmer need only provide the simulation and geometric component for his or her VR application, and the tools handle the remaining low-level tasks. While this work is in progress, it is now time to start thinking about high-level tools that will make VRUIT useful to people.

By contrast, almost all other current VR demonstrations are simply viewers of static polygonal data-bases [Blanchard90]. They are the 3D equivalent of raster picture viewers, which are quite uninteresting. In particular, the simulation component of the average VR demo is somewhat lacking. If VR technology is going to get anywhere, it must provide a computational service not otherwise available. It should also make this service easy to use. Certainly, most VR demonstrations give you a natural means to view a particular polygonal database, but as soon as you want to switch databases, you must get into command-line mode, and invoke the VR demonstration on another file. Current VR systems are single-task applications with no operating system and no file system.

If VR systems are to move out of the 1950's, we need a set of tools that allow the user to manage multiple VR contexts, multiple tasks, and the easy hierarchical management of 3D data. This paper proposes a high-level tool that will build on the foundation reported in [Shaw92]. This paper also suggests a metaphor for organizing VR data that takes advantage of such a tool in a wider context.

2. The Volume Manager

This VR tool is the Volume Manager, which is the 3D equivalent of the 2D window manager. The first purpose for such a tool is to manage the allocation of the small real 3D space that the user resides in. If some of the real space causes problems with tracker device noise, the Volume Manager can arrange that while the tracker is in that volume, special data filtering is to take place. Other areas of the real space may be out of bounds because there is furniture in the way, or because a tracker is out of its effective range. Similarly, if the user is wearing an opaque head-mounted display, the volume manager should tell the user when he or she is getting too close to a wall, and so on.

This tool can also assign a context for interpreting device input based upon where the devices are. So, for example, if a user wearing the DataGlove is about to use the mouse, the Volume Manager can decide to ignore all DataGlove activity while the DataGlove is in the volume enclosing the mouse and mouse pad

[Feiner90]. Specialized contexts of this nature can solve problems like accidental gesture recognition, since the manager can assign the same gesture to different actions depending upon the context in which the gesture is made.

3. Model Space Management

A wider application of the Volume Manager tool is the organization and management of the *virtual* space that the user is working in. Thus, while the user is running multiple applications simultaneously, the Volume Manager can direct user-generated data to the application upon which the user is currently focusing. Current focus will usually be in the volume in which the user's devices currently reside.

If the user is running a CAD application, for example, he or she may need a scratch area for half-designed parts, or the user may want a special area from which to grab things out of a library. Another part of the virtual space may be allocated to such things as clocks, mailboxes, etc.

The Volume Manager should provide facilities for the user to arrange the workspace in a way the user sees fit. If the user wants to work on only one application at one time, then the Volume Manager should facilitate this desire, and the user gets the benefit of devoting all of the available volumetric real estate to the single application. However, if the user wishes to allocate some space to the main task, but needs to refer to other data sets, the Volume Manager must allow the user to easily switch context in order to view or manipulate these other aspects of the task at hand.

If the user is in none of the application contexts, user requests can be interpreted as organizational commands. In this way, the Volume Manager can provide an opportunity for user requests that are not tied to any particular application, but are instead requests to the Volume Manager or to the Operating System.

Another aspect of virtual space management is navigation through simulated 3D spaces that are much larger or much smaller than the real space that the user occupies. For example, in an architectural viewing application, the user wants to be able to move from room to room in the model without exceeding the physical range of the harness of the head-mounted display. In fact, the architectural viewing example can be transformed into an organizational metaphor, since putting up walls within a building is a means of allocating and claiming space.

4. A Virtual Building Metaphor

The virtual world is a building is a metaphor perhaps first explored by Henderson & Card [Henderson86]. Card and Mackinlay have recently extended their rooms system to 3D. This metaphor has numerous advantages. First, everyone knows what buildings are and how they work. People are also used to the idea of navigating through buildings, and most people are used to the idea that buildings have a hierarchical structure. If a user wants to hierarchically divide the workspace, the user may simply divide his or her virtual building into a number of floors, each of which has a number of rooms containing special contexts, much in the same way that real rooms contain real contexts, such as "kitchen", "dining room", "main office" and so on. Thus, in a 3D user interface, one may have a floor devoted to one's scientific visualization activity, while on the party floor above there's a game of 3D "rogue" in progress.

Fortunately, these metaphorical buildings are not constrained by physical laws, so they can be of any size and shape, and rooms may themselves contain whole campuses devoted to some very specialized context. Of course, rearranging the furniture is simple, as is rearranging the structure of a room, its hallway, its floor, and its building.

The role of the Volume Manager is to provide the techniques for creation, rearrangement, copying and deletion of rooms and hallways. The Volume Manager also provides the navigation and the manipulation facilities both in the large, at the room-to-room level, and at the organize-your-desk level within one room. The obvious analogue to current Operating System practice is the presence of utilities to move files, directories, and so forth.

The purpose of the seemingly elaborate metaphor is twofold: It first provides a mental model of organization that the user doesn't need to consciously think about. The user can simply act according to the practices he or she has developed in the real world. Secondly, it provides all the traditional computational tools of command-lines, file systems and window managers in a form that fits the 3D nature of the Virtual

Reality user interface style.

Another advantage of the metaphor is that it can take advantage of people's abilities to remember things according to spatial context. Historical accounts of human memory skills sometimes refer to the medieval Christian monks, who were able to memorize large chunks of text through the use of spatial visual cues. Saint Thomas Aquinas is said to have imagined his memory as a mind-castle, in which each room contained some of his knowledge. To remember the knowledge, Aquinas pictured himself in the room, which gave him the spatial visual cue needed to remember the memorized text. Of course, the monks needed this memory skill because they had to make their books by hand, but the same kind of memory jogs will be needed once Virtual World applications become complex and heterogenous enough to require the adoption of an organizational structure.

5. Conclusion

If Virtual Reality is to be a successful user interface style, it must provide the organizational tools usually available in more prosaic computer environments. Volume management is the means by which such organization should be effected. However, volume management of the real space in which the user is interacting is not enough. The management of virtual space is vital, since the fundamental resource for 3D user interfaces is volume. A real-world means of allocating and claiming volume will serve as an effective metaphor for allocating virtual space, and this paper presents the Building Metaphor as a user model of space allocation.

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