The Virtual Tricorder: A Uniform Interface for Virtual Reality

Matthias M. Wloka and Eliot Greenfield**
Science and Technology Center for Computer Graphics and Scientific Visualization,
Brown University Site
Department of Computer Science, Box 1910
Providence, RI 02912, USA
+1-401-863-7600
{mmw|esg}@cs.brown.edu

ABSTRACT
We describe a new user-interface metaphor for immersive virtual reality — the virtual tricorder. The virtual tricorder visually duplicates a six-degrees-of-freedom input device in the virtual environment. Since we map the input device to the tricorder one-to-one at all times, the user identifies the two. Thus, the resulting interface is visual as well as tactile, multipurpose, and based on a tool metaphor. It unifies many existing interaction techniques for immersive virtual reality.

KEYWORDS: immersive virtual reality, user-interface metaphor, 3D user interface, tactile feedback

INTRODUCTION

The functionality of the Star Trek [4] tricorder encompasses chemical and structural analysis, locating life-forms, and recording data in general. It is an amazing and truly useful multipurpose tool.

Using immersive virtual reality (VR), we create a similar device, the *virtual tricorder* (a term first coined by H. Sowizral [1]). Its implementation maps a six-degrees-of-freedom input device (e.g. Logitech Flymouse) to a visual model of that input device. An immersive display relays the visual feedback to the user. The virtual device moves in the virtual world like the real device in the real world, since the input device's translations and rotations are tracked.

In contrast to other work [2], our virtual device always maintains its resemblance and its one-to-one mapping to the real input device. Thus, it presents the user with a single multipurpose tool (like the Star Trek tricorder). This uniformity results in several advantages described below.

TACTILE FEEDBACK

Because the user touches the actual user-input device while only seeing the virtual tricorder (whose shape matches the real device), the user identifies the tactile sensation received from the real device with the virtual device. Inertial effects intensify this tactile sensation. The virtual tricorder therefore feels "real."

This tactile feedback reinforces the user's sense of presence within the virtual environment. (The primary reason for the sense of presence, though, stems from the visual presentation.) The feeling of presence in turn allows users to make their bodies the spatial reference to which all actions are relative, which is desirable [3].

THE TOOL METAPHOR

Glove interfaces are popular in VR because they mimic direct human-object interaction in the real world. Humans, however, typically work with tools. Accordingly, a tool metaphor, while less direct, is equally valid. Instead of hiding a tool's inherent indirectness [2], we emphasize it via the uniform presentation of the tricorder. The user thus perceives the tricorder as a distinct object — a multipurpose tool.

A tool metaphor may also be preferable because a tool's shape and labels indicate its use. With traditional glove interfaces, the user must either remember how to manipulate an object, or use an object-specific tool (i.e., a 3D widget that also introduces indirection) that possibly obscures the object. The tricorder is less prone to obscure objects it operates on, since a tool is not inherently linked to the object. Thus, we can often use it from an angle without obscuring the object.

Clutching [3] is crucial for avoiding uncomfortable hand positions. However, a dedicated clutching mechanism, e.g., a hard-wired button that temporarily disconnects the tracked input device from the virtual representation, destroys the user's identification of virtual with real devices. Tools obviate the need for such a hard-wired clutch, since they incorporate two conceptual clutches without suspending the real-to-virtual mapping. The first clutch is between the user's hands and the tool: while the non-active hand temporarily holds the tool, the other hand adjusts its grab on the tool to a comfortable position. The second clutch is between the tool and the manipulated object: the user applies and disengages the tool at will. Neither clutch destroys the virtual tricorder metaphor.

MULTIPURPOSE FUNCTIONALITY

The tricorder's uniform interface does not impair its functionality. We implement a variety of previously published,

*This work was sponsored in part by the NSF/ARPA Science and Technology Center for Computer Graphics and Scientific Visualization, Sun Microsystems, Autodesk, Taco Inc., Microsoft, NASA, Hewlett Packard, and Apple.

disparate interaction techniques, e.g., for navigation, object selection/manipulation, and information visualization (Figures 2, 3, and 4). These tools maintain the real input device's base-shape, but nonetheless vary in appearance to communicate and enhance function.

A 2D tricorder-anchored menu lets us select among these different tools. While other VR menus often suffer from poor readability, the tricorder-anchored menu improves it because users automatically pull the tricorder (and thus the menu) to their eyes if they cannot read the text.

RELATED WORK

Other work [1] inspired the virtual tricorder. While also displaying a visual model of a six-degrees-of-freedom user input device in VR, that work only allows interaction with 2D data displayed on a virtual screen protruding from the device. Thus, it does not take advantage of the full potential of a programmable 3D tool for a 3D world.

Some researchers like to create for every new task a new hardware input device tailored to the task-specific requirements [3]. In a sense, our virtual tricorder is a software implementation of this device-per-task philosophy. While the tricorder metaphor maintains the advantages of tactile feedback and physical tool manipulation, due to its generality, it cannot, however, outperform such specialized, single-purpose input devices.

Finally, while glove interfaces are attractive in principle, they are problematic in practice. For example, calibration inaccuracies make it hard to perform a gesture/posture so that the computer recognizes it. (We avoid such problems by relying on button presses.) In addition, many actions in the virtual world, e.g. flying or scaling, are unnatural, so that no intuitive or natural interface exists for them — an indirect and abstract tool interface avoids this problem.

IMPLICATIONS

Using a single multipurpose tool literally creates a uniform look and feel for previously disparate collections of interaction techniques. If we imagine a more complex input device featuring not only buttons but also a trackball, it is possible to transport two decades of research in 2D user-interface design into VR. Nonetheless, the virtual tricorder coexists with rather than replaces other immersive user-interface metaphors.

REFERENCES

1. Angus, I.G. and Sowizral, H.A. Embedding the 2D interaction metaphor in a real 3D virtual environment. Technical report, Boeing Computer Services, 1994.

2. Butterworth, J., Davidson, A., Hench, S., and Olano, T.M. 3DM: A three dimensional modeler using a head-mounted display. *Computer Graphics (1992 Symposium on Interactive 3D Graphics)*, 25(2):135–138, March 1992.

3. Hinckley, K., Pausch, R., Goble, J.C., and Kassel, N.F. A survey of design issues in spatial input. In *Proceedings of UIST'94*, ACM, NY, 1994, pp. 213–222.

4. Roddenberry, G. Star Trek. Paramount TV Series, 1966.

Figure 1: Our setup uses a Logitech Flymouse and a FakeSpace Boom 2C-M connected to an SGI Onyx with a RealityEngine2. Mounting the base triangle on the Boom ensures that if the Flymouse leaves its tracking range, its visual representation is then also outside the user's view volume.

Figure 2: Users navigate their environment with a virtual grappling iron. Affixing the grappling iron to an arbitrary point in space, they pull, push, or throw themselves towards or away from that point. A built-in jet-thruster lets them alter direction and magnitude of their resulting motion. This technique seamlessly combines a translation-only "scene in hand" and the "flying vehicle control" metaphors (respectively good for precise short-range and fast long-range navigation).

Figure 3: The cone projecting from the front of the tricorder literally highlights the object to be selected (left). The cone's width interactively adjusts to ease selection. Users either rotate or translate a selected object by rotating or translating the virtual tricorder (right). Users amplify or de-amplify (for rough or precise positioning) their movements by interactively modifying how the tricorder's movements map to the object.

Figure 4: The user examines details with a magnifying magic lens attached to the tricorder (the magnification factor is selected on the fly). Moving the lens closer to one's eyes automatically changes how much of the view is seen through the lens.