5-2002

Haptic Interface for Center of Workspace Interaction

Rick Komerska
University of New Hampshire - Manchester

Colin Ware
University of New Hampshire, Durham, colin.ware@unh.edu

Matt D. Plumlee
University of New Hampshire, Durham

Haptic Interface for Center-of-Workspace Interaction

Demonstration Paper

Rick Komerska, Colin Ware and Matthew Plumlee

Data Visualization Research Lab, CCOM, University of New Hampshire

{komerska | colinw | mdp}@ccom.unh.edu

Introduction

In our laboratory, we are involved in creating highly interactive 3D visualizations of various oceanographic data as well as investigating issues related to monitoring and control of remotely operated and autonomous undersea vehicles [1]. For these applications, it is sometimes necessary to examine features at the centimeter scale and to see these in the context of environments covering kilometers. To address this problem, we build upon a new interaction style for 3D interfaces called *center of workspace interaction* [2]. This style of interaction is defined with respect to a central fixed point in 3D space, conceptually within arm's length of the user. This metaphor mimics typical physical workspaces that are commonly constructed, such as an office desk or technician's workbench. Objects in the environment are brought to the center of the workspace, and operated on by contextually appropriate tools.

It has long been recognized that for many user interface problems, adding task-related constraints can improve a user interface. For instance, computer-aided design systems employ sophisticated constraints based on concepts such as snap-dragging [3], forcing objects to line up or rotate about certain fixed axes. A related concept is the notion of "virtual fixtures", which employ force feedback to guide a user in carrying out manual and supervisory control tasks [4, 5]. There are of course many constraints inherent in real world interaction; e.g. physical objects do not in general interpenetrate each other when they come into contact.

An interesting way of combining constraints with a direct manipulation interface is to create haptic widgets [6]. The idea of a widget is to encapsulate both behavior and affordances in a single object. Thus if an object looks like a handle, and behaves like a handle when clicked on with a mouse, learning time will be minimized. Force feedback enables users to feel constraints embodied in a virtual input widget. Thus, for example, if a particular object should only be allowed to rotate about a certain axis, then that constraint can be physically imposed to restrict the range of motion of the input device.

For this demonstration, we will show a haptically enabled fish tank VR that utilizes a set of interaction widgets to support rapid navigation within a large virtual space. Fish tank VR refers to the creation of a small but high quality virtual reality that combines a number of technologies, such as head-tracking and stereo glasses, to their mutual advantage [7].

Haptically Enabled GeoZui3D

The fish tank VR system described is built upon our GeoZui3D geographic visualization system [2], which uses center of workspace interaction as a unifying concept, and incorporates a SensAble Technologies Phantom 1.0 haptic input device. The VR workspace lies within the region of personal space where we normally interact haptically with objects in our environment. Although the working volume of the Phantom device is small, approximately 12 x 17 x 25 cu. cm, this matches well with the size of the VR workspace.

To support haptic interaction, we have evolved the following set of design principles:

- Haptically represent constraints rather than objects
- Display constraints both visually and haptically (constraints are possibilities for movement, limits on motion)
- Visually emphasize potential for interaction (manipulation hot spots)
- On contact, visually reveal additional constraints
- Make state information both haptically and visually accessible

Our widget set, shown partially in Figure 1, is designed to control the viewpoint by bringing a large space (the virtual environment) into the range of a small device (the haptic workspace). It currently encapsulates the behaviors of pitch and yaw rotation, translation and scaling. In general, the user interacts with the widgets by approaching them with the Phantom proxy (visually modeled as a cone). When the proxy falls within 3mm of a widget's hotspot, it is subjected to a force obeying Hooke's Law, with a spring constant of 0.3 N/mm. This action snaps the Phantom proxy to the widget center. Visually, the proxy disappears and the widget changes color to indicate attachment. The user then presses the Phantom stylus switch to enable the widget behavior. Haptic constraints are then imposed which appropriately guide the user during this interaction. Detaching requires the user to release the switch and pull away from the widget, to beyond the 3mm radius, where the attractive force drops

Proceedings of the 10th Symp. On Haptic Interfaces For Virtual Envir. & Teleoperator Systs. (HAPTICS'02)
0-7695-1489-8/02 $17.00 © 2002 **IEEE**

to zero. The widget changes back to its default color and the proxy becomes visible again.

The yaw widget is modeled as a tab on a circular band centered on the vertical axis, and is used to rotate the world about this axis. The widget hotspot is the tab center. Once attached to the tab, the user's motion is constrained along a 11mm radius ring, visually shown as the surface of the band. Major and minor haptic detents are established at 10^{o} and 1^{o} increments, respectively, to indicate position and provide a sense of operating a dial.

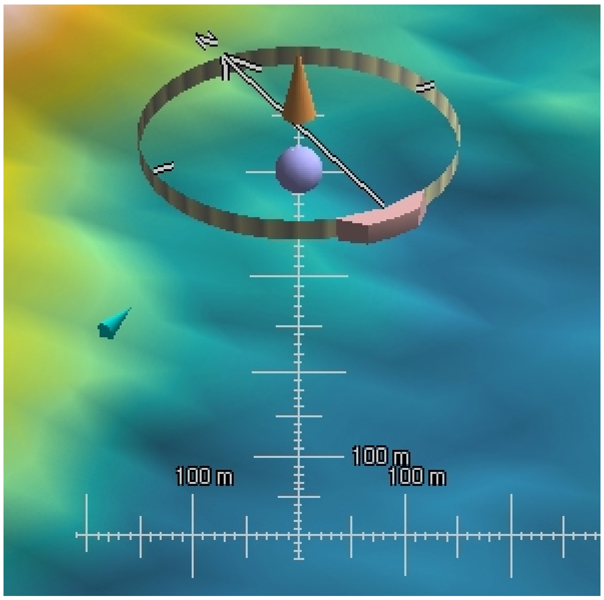

Figure 1. Haptic widget set in GeoZui3D (shown with 30^{o} Yaw, 45^{o} Pitch).

The pitch widget allows the user to rotate the world about the horizontal axis and is modeled as a lever arm, whose handle is shown as a sphere near the top of the vertical axis. Once attached to this handle, the user's motion is constrained along a 35mm radius circle. This circle has its origin at the crosshairs and lies in the plane parallel to the vertical axis and perpendicular to the horizontal axis. Haptic stops are imposed at $+90^{o}$ (toward the user) and -40^{o} to help prevent the environment surface from hiding the widgets. Major and minor haptic detents are established at 15^{o} and 0.5^{o} increments, respectively. As the pitch changes, the orientation of the vertical axis, along with the location and orientation of the yaw, pitch and scale widgets, also changes.

Uniform scaling about the center of the workspace is implemented through use of the scale widget, shown visually as a cone atop the vertical axis. Once attached to the cone, the user pulls up or pushes down *along* the axis direction to zoom in or out, respectively. Haptically, this is modeled as a stiff spring and controls the magnitude of the magnification and minification rate.

Re-centering within the environment is handled somewhat differently. The user, while not attached to any of the other widgets, simply presses the Phantom switch and drags the point of interest to the crosshairs. Visually, the Phantom proxy changes to a spherical shape, which then remains fixed with respect to the dragged world. The frame of reference is the fixed haptic frame, which provides an intuitive frame for direct manipulation. A small amount of inertia is imposed while dragging to give the world a sense of "weight". If the location of interest lies outside of the reachable haptic workspace, the user can employ the scaling widget to zoom out such that the location is reachable, then drag the location of interest to the workspace center. Scaling in on this new center permits more detailed study and manipulation.

In addition to the viewpoint control widgets, we are currently developing a set of application specific haptic widgets to aid in the monitoring and control of undersea vehicles. One goal is to help mission planners to define optimal transit paths for vehicles. Transit path selection constraints may include maintaining constant transponder line-of-sight and sensor coverage while accounting for depth uncertainties and vehicle energy and time budgets. These widgets leverage both the center of workspace metaphor and design guidelines previously discussed to aid the planner in these particular tasks.

References

[1] M. Plumlee, R. Komerska, R. Arsenault, C. Ware, L. Mayer, and S. G. Chappell, "Visualization Techniques to Support Monitoring and Control of Autonomous Platforms," *Proceedings 12th International Symposium on Unmanned Untethered Submersible Technology*, Durham, NH, 2001.

[2] C. Ware, M. Plumlee, R. Arsenault, L. A. Mayer, S. Smith, and D. House, "GeoZui3D: Data Fusion for Interpreting Oceanographic Data," *Proceedings Oceans 2001*, 2001.

[3] E. A. Bier, "Snap-Dragging in Three Dimensions," *Proceedings Symposium on Interactive 3D Graphics*, Snowbird, UT, 1990, pp. 193-204.

[4] Z. Stanisic, E. Jackson, and S. Payandeh, "Virtual Fixtures as an Aid for Teleoperation," *Proceedings 9th Canadian Aeronautic and Space Institute Conference*, 1996.

[5] C. P. Sayers and R. P. Paul, "An Operator Interface for Teleprogramming Employing Synthetic Fixtures," *Presence*, vol. 3, pp. 309-320, 1994.

[6] T. Miller and R. Zeleznik, "The Design of 3D Haptic Widgets," *Proceedings Symposium on Interactive 3D Graphics*, Atlanta, GA, 1999, pp. 97-102.

[7] C. Ware, K. Arthur, and K. S. Booth, "Fish Tank Virtual Reality," *Proceedings INTERCHI '93 Conference on Human Factors in Computing Systems*, Amsterdam, The Netherlands, 1993, pp. 37-42.

0-7695-1489-8/02 $17.00 © 2002 **IEEE**