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Tangible Interaction for 3D Widget Manipulation in Virtual Environments

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Abstract

In this paper we explore the usage of tangible controllers for the manipulation of 3D widgets in scientific visualization applications. Tangible controllers can be more efficient than unrestricted 6-DOF devices, since many 3D widgets impose some restrictions on how they can be manipulated. In particular for tasks that are in essence two-dimensional, such as drawing a contour on a surface, tangible controllers have advantages over 6-DOF devices. We have conducted a user study in which subjects draw a contour on a three-dimensional curved surface using a 3D contour drawing widget. We compared four different input methods for controlling the contour drawing widget and the viewpoint of the surface: using one 2D mouse for drawing and viewpoint selection, using a 6-DOF pen for drawing and a 6-DOF cube device for viewpoint selection, using a 6-DOF pen for drawing on a tangible 6-DOF cube which implements a Magic Lens style visualization technique, and using a 2D mouse for drawing and a 6-DOF cube for viewpoint selection. We show that while the mouse outperforms 6-DOF input methods, the tangible controller is superior to unrestricted 6-DOF input.

Categories and Subject Descriptors (according to ACM CCS): I.3.6 [Computer Graphics]: Methodology and Techniques – Interaction Techniques H.5.2 [Information Interfaces and Presentation]: User Interfaces

1. Introduction

Interaction with visualizations of three-dimensional data often involves 3D user interface widgets. A widget is a combination of geometry with certain behavior which is used to control the visualized data, or to query information about that data. The widget is placed in the 3D scene and can then be manipulated. Examples of 3D widgets are widgets for probing data values inside a data set, placement of seed points for creating streamlines in a vector field, placement and orientation of slicing planes, drawing and manipulation of selection contours, manipulation of bounding boxes for extracting part of a data set, or scaling, orienting and placing a geometric structure.

While widgets are interaction techniques for manipulating data, the widgets themselves are manipulated using an input controller. These controllers vary in the number of degrees of freedom (DOF) they have. For example a desktop mouse has two degrees of freedom, while a sensor which reports position and orientation in space has six degrees of freedom, thus offering a very natural and direct way of interaction with three-dimensional objects. However, 3D widgets often place restrictions on the way in which they can be manipulated, and often not all degrees of freedom are necessary to use such a widget, while sometimes the additional freedom of movement makes widget manipulation more difficult.

Tangible 3D input controllers restrict the number of degrees of freedom, and thus can provide a method of interaction which corresponds better to the way in which a widget allows itself to be manipulated. This can especially be the case for manipulations that are in essence restricted to two dimensions, such as placing points on a plane or drawing on a surface. In addition the use of tangible controllers can give the user a better perception of where the manipulation is taking place than manipulation using an unrestricted 6-DOF controller.

We have conducted a user study to determine the advantage of using a tangible controller to restrict the number of degrees of freedom of an input device when manipulating certain 3D widgets in a 3D environment. We