A Case Study in Using Gestures and Bimanual Interaction to Extend a High-DOF Input Device

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1 Introduction

Interactive 3D visualizations typically require complex, high-dimensional input. As a result, generating simple, efficient input mappings from device controllers to desired interactions is often a non-trivial design problem. While natural solutions include increasing the number of input controllers and overloading devices via key mappings, these methods add a level of complexity to the interaction that may ultimately detract from the utility of the visualization.

In this work, we explore two alternatives to these approaches. First, we present a cooperative bimanual technique for overloading a six degree-of-freedom (DOF) Space Navigator (3D Connexion, Inc.) via context sensitivity. We then present a manually triggered, gesture-based technique for extending the Space Navigator's control. While neither context-driven nor gesture-based interactions are entirely novel, combining these approaches within a complex visualization application creates challenging, driving design problems. Here, we present a case study of the design and application of these techniques within a real 3D scientific visualization application.

Analysis of the design principles explored in this work has far-reaching implications. In the case of scientific visualizations, creating effective, inconspicuous interaction schemes will allow science to remain the preeminent focus of the application, and, in turn, facilitate research and lead to greater productivity. It should also be noted that while these techniques were designed to aid in scientific research, they also address the more general problem of overloading input controllers in a clear, seamless manner.

2 Related Work in Bimanual Interaction

It has been shown that the success of bimanual interaction techniques relies heavily on the degrees of parallelism and symmetry between the tasks assigned to each hand [Buxton and Myers 1986]. Parallel tasks are those in which both hands work simultaneously, while symmetric tasks are those in which each hand is assigned an identical task. Past studies suggest that a parallel, asymmetric approach is often more successful than other alternatives, though a well-defined solution does not yet exist [Hinckley et al. 1997].

Using these results as basic design principles, our technique aims to exploit parallel cooperation while assigning each hand fully asymmetric roles. The dominant hand controls the 6-DOF Space Navigator, the utility of which is reserved for tasks that require fine, precision interactions. The non-dominant hand is assigned the mouse and is responsible for providing context for the precision interaction. This is analogous to the methods of a sculptor, where the non-preferred hand is used to orient the medium while the dominant hand performs all intricate interactions.

3 Methods

Our context-sensitive and gesture-triggered interaction techniques are applied within a preexisting scientific visualization involving the study of skeletal kinematics. In this application, scientists examine animated 3D skeletal models driven by real, high-speed motion data.

3.1 Context Sensitivity

Controlled by the non-preferred hand, the mouse is used to establish context within our interaction scheme. When the mouse is hovering over open space in our application, the Space Navigator is determined to be in *observation mode*. Here the 6-DOF device provides control as though the user were holding the 3D models in space. When lifted up, pressed down, or shifted any which way, the model translates accordingly in three-space. The same is true for rotations, as the models rotate about their centers in accordance with the rotations induced on the Space Navigator.

For closer inspection, when the mouse is placed over one of the skeletal models, a ray is cast from the camera to the model and determines a point of interest. In this context, the Space Navigator enters *inspection mode*. Here, all rotations occur about the point of interest indicated by the non-dominant hand. Further, by holding the left mouse button while in this mode, the Space Navigator takes on the role of zoom control. Lifting up results in a zooming in on the point of interest, and pressing down a zooming out. This mode was found to be particularly useful in our visualization application, as it allows for close inspection of joint interactions, tooth occlusion, and other kinematic subtleties.

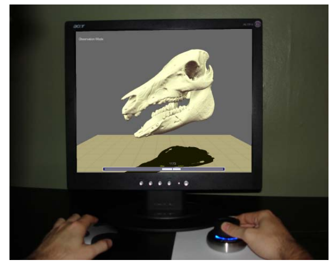

Figure 1: *Bimanual interaction techniques applied within the skeletal kinematics visualization application.*

A third mode exists to provide control of the animation playback. When the mouse is positioned below the skeletal models onscreen, the Space Navigator assumes control of the playback timeline. A clockwise rotation about the z-axis progresses the animation in a forward direction, while a counterclockwise rotation moves backward.

3.2 Gestures

In certain instances, where modes of interaction are nested, context-sensitivity fails to determine necessary transitions. In these cases, we opt to use simple gestures with the Space Navigator to manually trigger a transition. Two gestures were implemented in this study: a downward pump of the device, and a double twist in either the clockwise or counterclockwise direction.

Within zoom mode, the downward pump gesture performs an "undo" operation, restoring the visualization setting to its state prior to zooming. In playback mode, the downward pump gives the Space Navigator control of the playback's velocity, where a clockwise twist results in a "fast forward", and a counterclockwise twist acts as "rewind". Also within playback mode, a double twist gesture in either direction snaps to the next designated "frame of interest" along the timeline in the appropriate direction.

4 Conclusions and Future Work

We believe the techniques for overloading a high-DOF input device presented in this work are promising, built atop solid design principles. Based on preliminary feedback, we believe these techniques may help facilitate scientific research. We intend to expand this work by more rigorously examining the trade-offs of having the non-dominant hand control key mappings as opposed to the mouse. While key modifiers may allow for faster transitions, drawbacks include the increased complexity of the input mapping, as well as a potential loss of features such as point-of-interest selection.

References

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