Two-handed Visualization: Bimanual Interaction Techniques for Exploring Time-Varying 3D Data

Trevor M. O'Brien,* Daniel F. Keefe,† David H. Laidlaw‡

1 Introduction

We use both of our hands to work fluidly and quickly for many tasks as we go through our day: we tie our shoes using both hands; we eat with a knife and fork; we hold a nail in one hand and a hammer in the other. In an effort to more fluidly interact with data visualizations, it makes sense that we might also leverage coordinated efforts from both our hands to manipulate data views on a computer. Interacting with computers using both hands is, of course, not a new idea. Bimanual interaction has a rich history of study in the HCI community, as can be seen, for example, in [1, 4]. We are interested in adapting and refining aspects of this research to resonate with tasks required in interactive scientific visualizations. In this demonstration, we present two-handed interaction techniques designed to handle multiple modes of 3D navigation in a time-varying setting. This work builds on research originally presented in [5], including revisions specifically aimed to facilitate spatio-temporal exploration, collaborative visualization, and to emphasize mode-switches in an effectively perceivable manner.

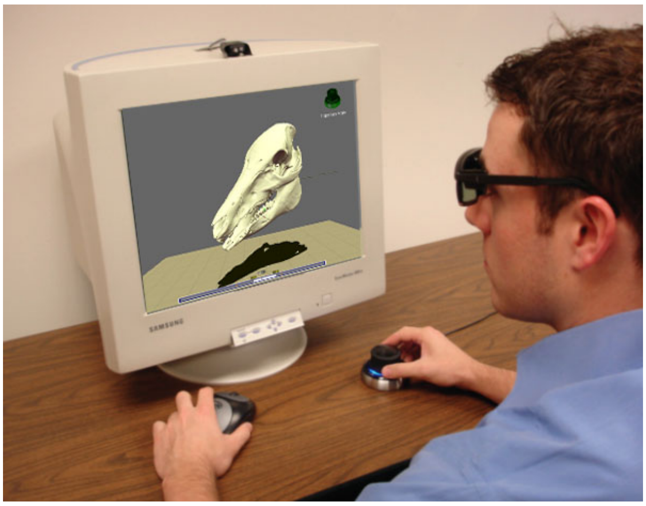

Figure 1: An example of a user navigating a time-varying 3D visualization of animal kinematics with bimanual techniques.

As described in [5] and pictured in Figure 1, the two-handed approach given here relies on two input devices: one, a standard mouse device, and the other a 6-DOF input controller known as a Space Navigator (3D Connexion, Inc.). While direct mappings for 3D navigation are straightforward with a 6-DOF controller, any additional interactions require the device to be overloaded. To extend the device without taxing users' cognitive load, a context-driven approach is used to trigger mode-switches for the input mapping. This is achieved through the simple positioning of the mouse device onscreen. Analogous to the methods of a sculptor, the non-dominant hand, controlling the mouse, is used to loosely orient and prepare for more intricate interactions, performed with the high-DOF device in the preferred hand. While users of this initial system found the context-driven approach to be successful, first-time users sometimes became confused when a mode-switch occurred without them being fully aware of the change. In addition, users expressed the desire to document, or bookmark, particular times and views in their interactive exploration as a means of both reviewing their interaction history and sharing their findings with others. Here, we discuss our approach to these issues.

*Department of Computer Science, Brown University. e-mail: trevor@cs.brown.edu
†Department of Computer Science and Engineering, University of Minnesota. e-mail: keefe@cs.umn.edu
‡Department of Computer Science, Brown University. e-mail: dhl@cs.brown.edu

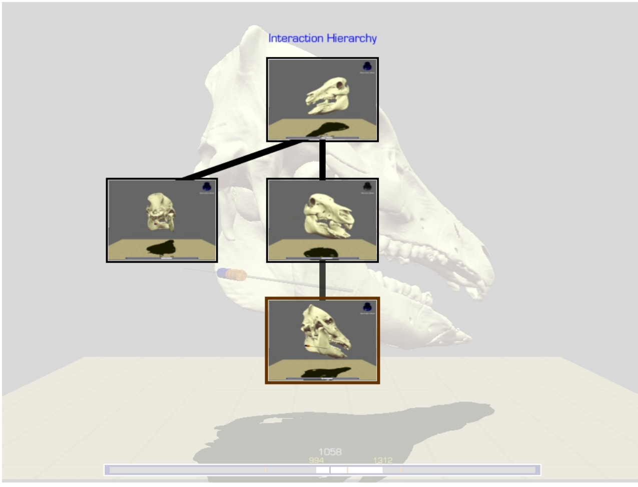

Figure 2: A spatial and temporal interaction tree generated during data exploration.

2 Mode-switching

To make mode-switches more transparent to the user, we make use of some perceptual and cognitive design principles centered on motion detection, similar to those shown effective in [6, 2]. While simple solutions to this mode-switching problem exist, like changing text on-screen when a switch is triggered, initial testing suggested that these techniques often went unnoticed, and would require a complete refocusing of the user's attention to be effective. Since the goal of our interaction scheme is to facilitate scientific exploration without becoming a distraction, these methods were deemed insufficient.

In our demonstration, a set of user interface elements are dedicated to visually depicting any change in the interaction mapping, while also reflecting the current state of that mapping. An example of these graphical elements applied within a pre-existing visualization application can be seen in Figure 2. When a mode-switch occurs, the graphical elements, including an icon of the Space Navigator device itself, are animated in a wiggling fashion for a brief moment. Once the mode has transitioned, the elements also change hue, providing a persistent indication of the interaction mode after the animation has completed. Text is also provided as an additional,

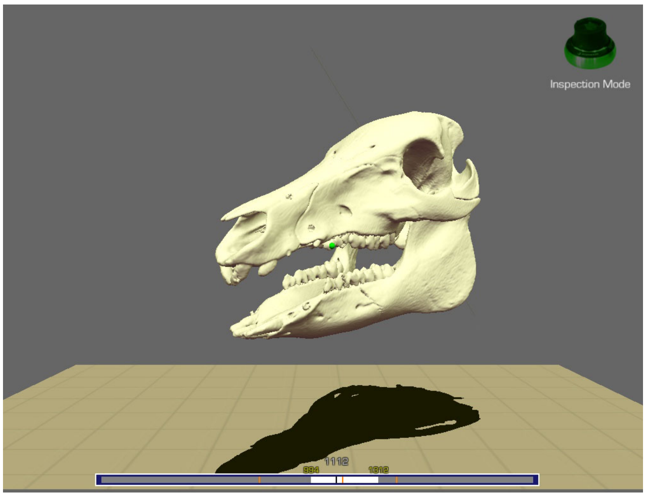

Figure 3: A screenshot from a “two-handed” visualization application. Here, visual cues in the user interface are designed to indicate interaction mode switches.

explicit indication. The goal of these visual cues is to allow users to make use of their peripheral vision to detect mode-switches, without fully swaying their attention from the scientific visualization at hand.

3 Hierarchical Interaction History

To allow users to rewind or retrace their interactive exploration steps, our demonstration gives users the ability to manually generate an interaction hierarchy of both time and 3D space. With a simple click, users are able to bookmark their current 3D view and temporal time step within the data visualization. When a bookmark is created, a thumbnailed view of the given *space-time* is added into a tree-like hierarchy, as can be seen in Figures 1 and 3. This thumbnailed view is similar to work seen in [3], though it differs in that our history includes time, and need not be linear. At any point, a user may go back to a previously created bookmark and begin a new exploratory interaction path, effectively creating a new branch in the tree. When a previous bookmark is selected, an interpolated animation is rendered to give users a sense as to how the previous *space-time* relates to their current time and location.

In addition, paths may be chosen within the interaction hierarchy, as indicated by the blue connecting lines in Figure 3, and animated, allowing for an abridged *replay* of exploration. While this system gives users the ability to revisit their interaction steps and keep a detailed history of their explorations, it also serves as a tool for collaborative visualization.

Once generated, an interaction hierarchy may be stored out and loaded by another user, who then has the ability to review that interaction hierarchy, add to it, or perhaps revise it. In this sense, the interaction itself becomes a persistent addition to the data, and is not necessarily something transient that may never be recovered.

4 HCI Impact in the Visualization Community

While the majority of this work is heavily interaction based, we believe it has the potential for significant impact within the visualization community. As discussed in Jian Chen’s 2007 Vis Panel *Getting Human-Centered Computing and Scientific Visualization Married: the Myth and Critical Issues*, the intersection of the HCI and visualization fields is an exciting area with challenging design problems, the results of which may have far-reaching implications. With innovative interactive devices like the Nintendo Wiimote and

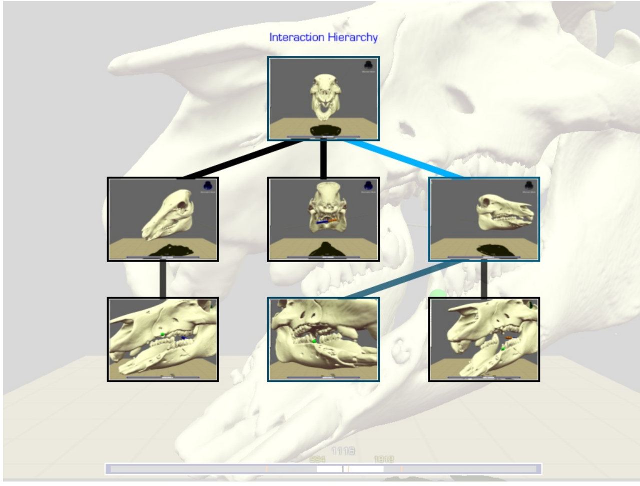

Figure 4: In this interaction hierarchy, a path has been selected which may be used to replay exploration or share in a collaborative setting.

the iPhone enhancing the way users make use of their data on a day-to-day basis, it would appear there is still a wealth of possibilities to be uncovered when discussing interaction design in the visualization community. We hope the ideas and design principles presented in this demonstration will provoke further discussion on this topic during VisWeek 2008.

References

[1] W. Buxton and B. Myers. A study in two-handed input. *SIGCHI Bull.*, 17(4):321–326, 1986.

[2] B.-W. Chang and D. Ungar. Animation: from cartoons to the user interface. In *UIST ’93: Proceedings of the 6th annual ACM symposium on User interface software and technology*, pages 45–55, New York, NY, USA, 1993. ACM.

[3] G. Fitzmaurice, J. Matejka, I. Mordatch, A. Khan, and G. Kurtenbach. Safe 3d navigation. In *SI3D ’08: Proceedings of the 2008 symposium on Interactive 3D graphics and games*, pages 7–15, New York, NY, USA, 2008. ACM.

[4] K. Hinckley, R. Pausch, D. Proffitt, J. Patten, and N. Kassell. Cooperative bimanual action. In *CHI ’97: Proceedings of the SIGCHI conference on Human factors in computing systems*, pages 27–34, New York, NY, USA, 1997. ACM.

[5] T. M. O’Brien, D. F. Keefe, and D. H. Laidlaw. A case study in using gestures and bimanual interaction to extend a high-dof input device. In *SI3D ’08: Proceedings of the 2008 symposium on Interactive 3D graphics and games*, pages 1–1, New York, NY, USA, 2008. ACM.

[6] C. Ware and G. Franck. Evaluating stereo and motion cues for visualizing information nets in three dimensions. *ACM Trans. Graph.*, 15(2):121–140, 1996.