Designing Effective Interaction with Large High-Resolution Displays

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INTRODUCTION

With recent advances in technology, large high-resolution displays are becoming prevalent in *scientific visualization* [13], *automotive design* [5], *creativity and innovation* [15], and *collaborative work* [8, 9, 10]. A common configuration is to couple many commercially available projectors and PCs in a *projector array* to produce a tiled seamless high quality display landscape.

Large high-resolution displays do not restrict designs to traditional desktop displays, creating new opportunities for various research communities. However, we cannot fully exploit the benefits of large high-resolution displays by merely presenting a huge amount of information. Rather, we should develop usable and useful input devices and interaction techniques that accommodate distinct characteristics afforded by such emerging technologies. Large high-resolution displays presents a number of interaction challenges not well addressed by traditional input devices (represented by keyboard and mouse) and graphical user interface metaphors (represented by WIMP).

Remote target acquisition

As screen size significantly increases, accessing icons, windows, and rendered objects across large distance is increasingly difficult and time consuming [14]. It is particularly frustrating if users stand relatively close to a wall-sized display, demanding much effort to physically move from side to side. With traditional pointing devices, accessing information requires moving a cursor in a long distance, which takes time and introduces difficulty with cursor tracking.

Cursor tracking

Traditional cursor without modification are not appropriately applicable for interacting with large high-resolution displays since users are likely to lose track of it by moving the mouse faster or selecting higher acceleration. Once it occurs, users tend to rescan the whole screen to retrieve the cursor. In addition, it becomes even more difficult to locate a stationary cursor with increased size of display [14].

Limitations of traditional input devices

Traditional keyboard and mouse are not always desirable input devices for interacting with large high-resolution displays. One of obvious drawbacks is that both of them require a stable surface to operate. But when users work up close to a large display and step back and forth, it is not practical to hold a keyboard or a mouse while effectively manipulate the contents on the display space.

RELATED WORK

Prior efforts on large high-resolution displays have been along several threads, including hardware architecture for constructing tiled display walls, software architecture for cluster rendering, applications of large displays, collaborative, visual perception, user interfaces and interaction. Since we focus on designing effective interaction techniques for large high-resolution displays, we summarize related representative works published in various conferences.

Guimbretiere et al described new interaction techniques for direct pen-based interaction on the Interactive Mural, a large high-resolution display constructed at Stanford University [9]. They supported free hand

sketching, high-resolution materials presenting, and fluid interaction by FlowMenu. The techniques were designed for digital brainstorming.

VisionWand, a passive wand tracked in 3D, was explored as a new input device for interacting with large displays [6]. A set of postures and gestures were developed to track wand state and enable command input through a pie menu. The concept was interesting since a wand tracked in 3D with computer vision techniques enabled higher *degrees of freedom* (DOF), hence richer interaction styles.

There have been works addressing the problem of losing the cursor on large high-resolution displays. A nature solution is to modify existing cursors such that they are usable in the new context. For example, high-density cursor used temporal supersampling to fill the space between the cursor's current and previous position with additional cursor images. Another solution is to create new metaphors, which act as substitutes of tradition cursors. Khan et al proposed *spotlight* for directing users' visual attention on large wall-sized displays, and reported the significant advantages of the spotlight over the cursor by an experiment [11].

Drag-and-pop and drag-and-pick were demonstrated by Baudisch et al, which facilitated accessing remote screen content on touch- and pen-operated screens [2]. An improvement to drag-and-drop, called push-and-pop, was also described very recently [7]. In addition, new widgets such as *Frisbee* [12] and *Vacuum* [3] were created to alleviate the difficulties with accessing the entire display landscape.

OUR VISION AND APPROACH

An emerging interest in designing interaction techniques for large high-resolution displays by observing recent publications in HCI-related conference proceedings, including CHI, UIST, and GI. There was also a special issue of *IEEE Computer Graphics and Applications* on applications of large displays, which is published in August.

Large high-resolution displays have opened – and will open – numerous research opportunities to explore. We have experienced with 3D user interfaces design and evaluation for many years, and theoretical foundations and practical researches in 3D UI have been systematically organized and presented in the book *3D User Interfaces: Theory and Practice* by Bowman et al [4]. We envision that technological changes will stimulate additional 3D UI research. Although the majority of 3D UI research has targeted the desktop, immersive virtual environments, or augmented reality, emerging technology such as large high-resolution displays will provide wide space for further 3D UI research. 3D UI design and evaluation methodologies could be well applicable to UI design for large high-resolution displays, and existing 3D interaction devices and metaphors could be adopted and modified to create original effective techniques in the new context. For example, there has been an interesting work published in CHI 2005, where Ashdown et al combined head tracking and mouse input to facilitate mouse switching between monitors [1]. However, we have not seen much effort on applying 3D UI technologies in large high-resolution displays, though it is promising to further explore.

In 3D UI research, we start with identifying a set of fundamental 3D interaction tasks, such as selection, manipulation, navigation, system control, and symbolic input. We then decomposed tasks into canonical subtasks, which are building blocks of more complex interaction efforts. A classification, or taxonomy, of an interaction technique is established, exposing a design space in whole. At the generic level, interaction techniques are designed and implemented according to tasks. We also develop approaches and tools to evaluate 3D user interfaces, which in turn provide insights into usability of our designs and leads to refining and redesigning techniques. Such an iterative approach could be generalized to UI design and evaluation for large high-resolution displays.

Recently, we started our effort with identifying a fundamental but not well-addressed research question: How users benefit from large high-resolution displays. We designed a controlled experiment to evaluate the effects of display size and resolution on task performance in an *Information-Rich Virtual Environment* (IRVE). An IRVE testbed embodied spatial, perceptual and abstract information to support navigation and comprehension of data types in various dimensions. We were the first to isolate display size and resolution as independent variables, and to investigate how large high-resolution displays affect task performance in an integrated 2D and 3D information space. Furthermore, our work proposed an original experiment design, establishing a reusable and generalizable methodology for future evaluation work relevant to large high-resolution displays.

Our future endeavors will include designing effective user interfaces and interaction techniques for large high-resolution displays, which are important to developing usable information visualization applications, even though they deal with 2D data. It is worth emphasizing that the interaction techniques include both hardware and software components. While we design *control-display mappings*, which are the software components of interaction techniques, we cannot overlook the role of input devices.

MOTIVATION

The Visualization 2005 workshop on using large high-resolution displays for information visualization is interesting to me, since it presents an ideal venue to meet experts from other institutes who share similar research interests with us, and to identify future research challenges and directions.

REREFERENCES

1. Ashdown, M., Oka, K., Sato, Y. (2005). "Combining Head Tracking and Mouse Input for a GUI on Multiple Monitors. *Proceedings of CHI 2005,* April 2-7, 2005, Portland, Oregon, USA.
2. Baudisch, P., Cutrell, E., Robbins, D., Czerwinski, M., Tandler, P. Bederson, B., and Zierlinger, A. (2003). "Drag-and-Pop and Drag-and-Pick: Techniques for Accessing Remote Screen Content on Touch- and Pen-operated Systems". *Proceedings of Interact 2003,* August 2003, Zurich, Switzerland.
3. Bezerianos, A., Balakrishnan, R. (2005). "The Vacuum: Facilitating the Manipulation of Distant Objects". *Proceedings of CHI 2005,* April 2-7, 2005, Portland, Oregon, USA.
4. Bowman, D.A., Kruijff, E., LaViola, J.J., Poupyrev, I. (2004). "3D User Interfaces: Theory and Practice." Addison-Wesley, Boston.
5. Buxton, W., Fitzmaurice, G., Balakrishnan, R., and Kurtenbach, G. (2000). "Large Displays in Automotive Design". *IEEE Computer Graphics and Applications,* 20(4), 2000.
6. Cao, X., Balakrishnan, R. (2003). "VisionWand: Interaction Techniques for Large Displays Using a Passive Wand Tracked in 3D". *Proceedings of UIST 2003*.
7. Collomb, M., Hascoet, M., Baudisch, P., and Lee, B. (2005). "Improving drag-and-drop on wall-size displays". *Proceedings of Graphics Interface 2005,* May 2005, Victoria, BC, Canada.
8. Elrod, S., Bruce, R., Gold, R., Goldberg, D., Halasz, F., Janssen, W., Lee, D., McCall, K., Pederson, E., Pier, K., Tang, J., and Welch, B. (1992). "Liveboard: A large interactive display supporting group meetings, presentations and remote collaboration". *Proceedings of CHI 1992*, 599-607, June 1992.
9. Guimbretiere, F., Stone, M., Winograd, T. (2001). "Fluid Interaction with High-resolution Wall-size Displays". *Proceedings of UIST 2001*, November 2001, Orlando, Florida, USA.
10. Izadi, S., Brignull, H., Rodden, T., Rogers, Y., and Underwood, M. (2003). "Dynamo: A Public Interactive Surface Supporting the Cooperative Sharing and Exchange of Media". *Proceedings of UIST,* 159-168, November 2003.
11. Khan, A., Fitzmaurice, G., Kurtenbach, G. (2005). "Spotlight: Directing Users' Attention on Large Displays". *Proceedings of CHI 2005*, April 2-7, 2005 Portland, Oregon, USA.
12. Khan, A., Fitzmaurice, G., Almeida, D., Burtnyk, N., Kurtenbach, G. (2004). "A Remote Control Interface for Large Displays". *Proceedings of UIST 2004,*
13. PowerWall, University of Minnesota. http://www.lcse.umn.edu/research/powerwall/powerwall.html.
14. Robertson, G., Czerwinski, M., Baudisch, P., Meyers, B., Robbins, D., Smith, G., Tan, D. (2005). "The Large-Display User Experience". *IEEE Computer Graphics and Applications,* July/August 2005.
15. Streitz, N.A., Geißler, J., Holmer, T., Konomi, S., Müller-Tomfelde, C., Reischl, W., Rexroth, P., Seitz, P., and Steinmetz, R. (1999). "I-LAND: An Interactive Landscape for Creativity and Innovation". *Proceedings of CHI 1999,* 120-127, May 1999.