HIPerPaper: Introducing Pen and Paper Interfaces for Ultra-Scale Wall Displays

Nadir Weibel, Anne Marie Piper, James D. Hollan
Distributed Cognition and Human Computer Interaction Lab
Department of Cognitive Science, University of California, San Diego
9500 Gilman Dr., La Jolla, CA 92093-0515, USA
{weibel, apiper, hollan}@ucsd.edu

ABSTRACT
While recent advances in graphics, display, and computer hardware support ultra-scale visualizations of a tremendous amount of data sets, mechanisms for interacting with this information on large high-resolution wall displays are still under investigation. Different issues in terms of user interface, ergonomics, multi-user interaction, and system flexibility arise while facing ultra-scale wall displays and none of the introduced approaches fully address them. We introduce HIPerPaper, a novel digital pen and paper interface that enables natural interaction with the HIPerSpace wall, a 31.8 by 7.5 foot tiled wall display of 268,720,000 pixels. HIPerPaper provides a flexible, portable, and inexpensive medium for interacting with large high-resolution wall displays.

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INTRODUCTION
The decreasing cost of displays and growing power of graphics processing units (GPUs) are enabling visualization and analysis of increasingly large multidimensional data sets on tiled wall displays. The scale of these data sets means they cannot be viewed or easily manipulated on desktop or simple projection displays. High-resolution wall displays promise to be particularly useful for information visualization, allowing visual detection of patterns in data that would otherwise be impossible to see on current desktop displays.

While a range of interaction techniques for large wall displays have been explored, for example in the setting of cell phone interaction [2], gestures or physical movement [1], speech-based input [10], and in combination with hand-held devices [9, 4], there are still several systemic challenges that have not yet been fully addressed. One pervasive challenge is how to help users interact with content in distant regions of the display [5]. Others involve supporting interactions for multiple users working in collaboration [11] and identifying ideal use cases for large displays [3]. Interacting with very large high-resolution wall displays introduces additional challenges in terms of selecting, moving, scaling, and rotating objects. Novel interaction techniques and architectures are needed to meet these requirements.

We introduce HIPerPaper, a novel interface that exploits pen and paper as the main interface for controlling HIPerSpace, an experimental tiled high-resolution wall composed of seventy 30” displays. The feature that distinguishes HIPerSpace from other wall display systems is its high resolution, which supports data analysis and exploration in a unique way. Pen and paper interfaces also support high resolution, allowing users to exploit both very precise, fine interactions as well as coarse, higher-level interactions.

HIPERSPACE WALL DISPLAY
The CalIT2 Highly Interactive Parallelized Display Space (HIPerSpace1) is a 31.8 foot wide by 7.5 foot tall wall display. Seventy tiled 30” Dell LCD displays provide a resolution of 286,720,000 pixels. The wall is powered by 18 Dell XPS 710/720 computers with Intel quad-core central processing units and dual nVIDIA FX5600 GPUs for a total of 100 processor cores and 38 GPUs. The system is powered by CGLX2 (Cross-Platform Cluster Graphic Library), a flexible, high-performance OpenGL-based graphics framework.

HIPERPAPER
HIPerPaper is a new interface that provides pen and paper interaction with a large wall display. This kind of interaction is promising for several reasons. Paper is lightweight and flexible. Printing on it allows for myriad types of interfaces, from simple commands and menus to demarcation of regions to provide special functions such as zooming or panning. Paper can be customized easily to suit various tasks and interaction needs, then discarded after use. Paper is mobile, meaning that users can freely navigate in the space in front of the display without being constrained by the means of interaction.

HIPerPaper is based on Anoto technology3 and the iPaper framework [8]. It exploits a novel architecture for handling multi-user, multi-device, multi-channel and multi-modal interactions. The main interface, depicted in Fig. 2, is represented by a scaled version of the HIPerSpace wall.

1http://vis.ucsd.edu/projects/hiperspace/
2http://vis.ucsd.edu/cglx/
3http://www.anoto.com

Figure 1: The HIPerSpace wall display at CalIT2

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HIPerPaper opens up a range of opportunities for studying a richer and more natural ecology of interactions with wallsized displays. Although we have begun to explore a range of novel pen- and paper-based interaction techniques, our longer term research challenge is to identify those that are effective and natural for specific contexts, and design an infrastructure that enables their implementation, composition, and exploration. A key feature of HIPerPaper in this context is that it supports rapid development, deployment, and evaluation of new prototype interactions.

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