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

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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.

Figure 1: The HIPerSpace wall display at CalIT2

HIPERSPACE WALL DISPLAY

The CalIT2 Highly Interactive Parallelized Display Space (HIPerSpace[1]) 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 CGLX[2] (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.

The HIPerPaper interface is based on Anoto technology[3] 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

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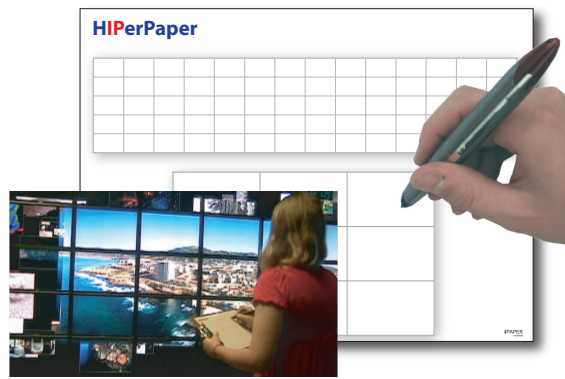[2]http://vis.ucsd.edu/ cglx/
[3]http://www.anoto.com

Figure 2: HIPerPaper Interface

printed on paper. Multiple users can interact with the wall using multiple paper-based interfaces and digital pens provided with traditional or non-marking pen tips. Different from existing systems based on interactive paper and wall displays, such as [6], our design goal is to encourage the main focus of attention to be on the high-resolution wall display. To give users simple locational references, the paper interface includes a scaled outline representation of the tiled displays.

Movements of the pen in the upper region of the main paper interface support coarse navigation of the wall display. The lower region provides multiscale focused access to a particular part of the whole display (i.e., the specific area the user is interacting with on the large overview). After roughly positioning their cursor on the display through the main interface, users can switch to the focused interface for fine positioning.

The digital pen is connected over Bluetooth to the HIPerSpace wall and continuously transmits timestamped (x,y) coordinates to the underlying HIPerPaper software. Besides a direct mapping to the coordinate space of the wall display, this allows exploiting derived information, e.g., speed and acceleration, as a basis for new forms of interaction. Moreover, the pen also records the pressure that the user applies when interacting with the paper interface, the rotation of the pen, and its tilt with respect to a vertical position.

We have explored pen and paper techniques for selecting, moving, scaling, and rotating objects as well as gestures for panning and zooming and for issuing commands to the applications running on the HIPerSpace wall. We use basic (x,y) position tracking of the pen to move a pointer on the display in the default *navigation* mode. In order to select a specific object and move it around, scale it, rotate it, as well as to release it, we introduced a mechanism for mode switching relying on pen pressure: users touch the paper interface lightly to receive visual feedback regarding their location on the wall, while a firm touch with the pen tip triggers the activation of particular modes on the interface (such as 'select'), which will be deactivated on the next pen-up event. Despite the low sensitivity of the pressure sensor, it can successfully be used for detecting such an *instantaneous* change in pressure. Preliminary user testing indicates this is a feasible mechanism for mode switching.

In addition to the main paper interface, the current system incorporates a set of paper-based buttons and widgets. Touching or moving the pen tip on these widgets issues commands to the application running on the wall. The paper buttons and widgets can be printed directly on the main paper interface,

printed on separate papers sheets, or deployed in the form of removable stickers to be placed in convenient locations such as on a clipboard, a table, or even on the face of a watch or other body location. These widgets are easily customizable to suit any given application.

Since scaling is one of the most valuable functions on high-resolution wall displays, we introduced a general paper-based scaling interface based on circular interactions with a widget [7]. Similar to scrolling through music on an Apple iPod, users can scale an object on the HIPerSpace wall by first selecting it and then moving circularly, adjusting their path and speed of movement for fine or coarse scaling.

CONCLUSION AND FUTURE WORK

HIPerPaper opens up a range of opportunities for studying a richer and more natural ecology of interactions with wall-sized 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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