A Distributed Display System for Interactive Sketching

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INTRODUCTION

When using physical tools, designers can sketch artifacts and spread them about the walls of a room to explore, communicate, and juxtapose design ideas. However, when using *electronic* sketching tools, designers are typically confined to the use of a physically smaller (desktop-size) workspace, which inhibits creativity and collaboration.

To be effective for sketching, a larger workspace must enable designers to sketch on a high-resolution screen in an ergonomic manner, quickly navigate to different parts of a design, sketch details in context of the broader design, instantaneously switch between details and context, and support groups of designers. Such workspaces are needed in mechanical, industrial, graphics, and interactive design [3].

To provide a workspace satisfying these requirements, we are developing a distributed display system that electronically tethers smaller focus screens to a larger context screen. Integrating sketching tools with our display system can make them more effective. For example, it could enhance tools that enable designers to sketch early designs, annotate large-scale graphs, or shade curves and surfaces.

EXISTING APPROACHES

A zooming canvas can provide a virtually larger workspace [2], but does not enable designers to sketch details in context of the broader design. Distortion-based views [8, 9, 10] are effective for visualizing large data sets, but the inherent spatial distortion is inappropriate for sketching.

To provide a physically larger workspace, we could use a large digital desk. However, it does not allow the focus to be controlled independent of the context and offers poor ergonomics [5]. The use of a single large vertical display requires that a designer stand, reach, and physically move about, which is unacceptable for many hours of design.

A high-resolution screen could be surrounded by a lower-resolution large screen [1]. However, since the screens lie in the same vertical plane, a designer must sit very close to sketch, overly limiting the view of surrounding context. Previous systems which tied smaller displays to a large display, e.g., [13, 14], did not support sketching. Photoshop provides a radar view in a separate window, but this overly competes for screen space, a precious commodity.

A DISTRIBUTED DISPLAY SYSTEM FOR SKETCHING

We are developing a distributed display system effective for sketching solutions to large-scale design problems. Our first implementation tethered a high-resolution tablet (focus) to a lower-resolution large screen (context) [6]. A designer can sketch details on the tablet and instantaneously view context on the large screen. The focus screen provides a magnified view of that part of a design lying in the frame of reference.

Multiple Displays and Two-Handed Interaction

We physically separate the screens to enable the views to be controlled *independently*, i.e., the focus view can be panned or zoomed without affecting the context view. The large screen is positioned just above the focus screen to ensure that it does not block the context view and just far enough away to make it more 'public' - enabling others to view the design without awkwardly leaning over the designer. This would occur if the context screen was placed adjacent to the focus screen in a designer's private workspace.

A graphics display tablet is used as a focus screen since it offers a high-resolution surface for sketching as well as the freedom to move, pivot, and reposition the display itself. For the context screen, a large screen is projected on the wall, but any large display could be used. The displays are driven from a single machine with a multi-head video card.

Consistent with bimanual theory [7], a designer controls the views with a 6DOF input device in her non-dominant hand while sketching with her dominant hand, facilitating better performance and more naturalistic interaction [4].

Support for Collaboration

Design is often collaborative, e.g., designers exploring early ideas together or communicating ideas to others. To better support collaboration, we are extending our implementation to allow any number of tablets to connect to a machine driving a large display. For maximum flexibility, a client / server architecture is being used to integrate the systems.

Once a design is loaded, it is shown on the context screen while each focus screen shows a different part of the design, as controlled by a designer. To enable more detail to be shown on the context screen, we are now using a high-resolution large display as the context screen, though our implementation still allows any large display to be used.

The interaction design of the system is being guided by theory and practice related to collaboration and creativity. For example, field studies of collaborative work show that people often shift between public and private work modes [11] and theories of creativity argue that juxtaposing alternative ideas facilitates creative thinking [12]. We are currently exploring how to best support these and other tasks through a series of low-fidelity prototypes.

EXPERIENCES USING DISTRIBUTED DISPLAYS

We discuss how our experiences with distributed display environments (DDE) can contribute to the workshop goals.

Promising Areas for Interaction Research

Interacting with content on a large display changes the ergonomics of the user experience, as users must now stand, reach, and physically move about the display. While many techniques have been developed to reduce physical movement, they often require that users be near the screen. By mediating interaction through smaller, portable devices, the use of DDEs offers a new approach for interacting with remote content. Investigating how smaller devices can be most effectively used to interact with remote content on large displays offers exciting areas for interaction research.

However, interaction research in DDEs must be grounded in theory and practice. This will serve to guide design decisions and provide a basis for later evaluation.

Incorporating Passive Information Display

Passive information display is a central part of our system - designers use it to maintain awareness of design context, alternative design ideas, and ongoing activity of other designers. All of this information is shown on the context screen. One challenge is to understand how often designers use this information and how it affects the design process.

Another challenge is determine an effective level of detail for conveying design activity in collaborative settings. For example, should the visualization show each stroke in real-time or groups of strokes made during periodic intervals? Because there is more screen space in a DDE, it will also be important to understand when, where, and how often users allocate their visual attention to this information.

Since no single visualization will likely satisfy the needs of all DDE research, we should focus on developing toolkits that enable rapid exploration of alternative visualizations and developing guidelines for determining an appropriate level of detail to show given the task environment.

Evaluation of DDEs

Evaluation should focus on how well a user can perform relevant tasks using a DDE *and* how the use of the DDE affects the tasks performed. For our system, for example, we want to evaluate not only how effectively designers can utilize the system to sketch design ideas, but also how the use of the system affects the ideas that are sketched - design shapes the designer as much as the designer shapes the design. Grounding interaction designs for DDEs in theory and practice will facilitate more effective evaluation. For example, this will help in selecting appropriate metrics as well as predicting and explaining the experimental results.

Broader Implications of DDEs to HCI Research

While we are investigating how the use of a distributed display system impacts interactive systems design, similar systems could be developed and evaluated for industrial, mechanical, architectural, and graphic design. Our system is just one example of how small and large displays can be integrated to form a workspace more effective than its parts.

To enable broader research on DDEs, software toolkits are needed that will allow users to immediately form integrated workspaces from a collection of small and large displays. Developing toolkits is a hallmark of the CHI community.

Another implication is to understand how the use of DDEs can enhance, or even amplify, creativity in design, e.g., by enabling more effective exploration, communication, and juxtaposition of ideas. How technology shapes creativity is an emerging research topic in the CHI community.

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