Large High-Resolution Displays for Collaboration

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Abstract
We present a proposal and initial work towards a large tabletop display with natural input that allows co-located and remote participants to collaborate over virtual paper documents with dense text.

Keywords
Mixed presence, remote collaboration, large displays, virtual paper

ACM Classification Keywords
H.5.2 User Interfaces and H.5.3 Group and Organization Interfaces

Introduction
The benefits of large displays are self-evident. For co-located collaboration, large tabletop displays allow participants to work together while adhering to social protocols of personal space and without formal turn-taking. For remote collaboration, large displays provide a shared view of the task in which participants can see each other's gestures and actions. In both cases, each participant is aware of the actions of others through their peripheral vision.

It is therefore not surprising that the literature abounds with large tabletop display projects for a diverse range of applications ranging from planning room layouts to sorting photos. Yet few, if any, of these projects have

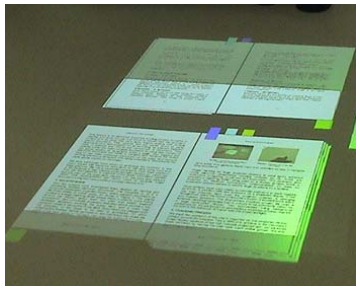

figure 1. Virtual paper documents on a large display.

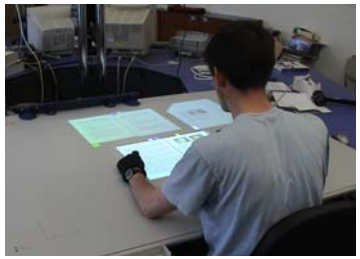

figure 2. A user interacts with virtual paper documents on the large display.

addressed the applications for which most people use their desktop computers and, indeed, their desks and meeting rooms. One of the most important of these applications is finding, reading, discussing and organising documents containing dense text.

This shortcoming in current research is not an oversight but, as we shall explain, is due to the difficulties of creating large displays suitable for presenting documents with dense text. Using recent image-processing techniques, we aim to create a large tabletop display for collaboration around such documents.

In this position paper we outline the shortcomings of both electronic documents on conventional monitor displays, and paper documents. We then present our designs and initial work towards a large tabletop display to support both co-located and remote collaboration around documents containing text.

Paper and Electronic Documents

Our work is partly motivated by the problems of collaborating over electronic or paper documents, and the prospect of large displays as a solution.

Two studies [4, 5] compare reading from paper and from a conventional computer screen. Subjects who read from paper used bimanual actions to navigate and organise documents effectively, while subjects who read from the screen had difficulty determining their location in the document, found the scrolling and annotating processes disruptive to reading, and could not use both hands to interact with the document. Furthermore, many tasks require reading from multiple source documents. The authors observe that paper documents on a table support this by permitting, for example, frequent shifts of attention and side-by-side comparison of documents, while electronic documents on a screen do not.

At first glance then, it appears that paper is the superior medium, and yet electronic documents offer their own benefits. In particular, they can provide a shared workspace for geographically-separated participants to collaboratively view or edit the same document, for example, in a remote tutorial or design meeting. Furthermore, they support up-to-date interactive content; they allow more complex interaction such as hypertext, alternative visualizations, and keyword searching; and they are easy to store, access and distribute securely and quickly.

Virtual Paper on a Large Tabletop Display

We aim to combine the benefits of paper with those of electronic documents to create a large tabletop display that allows co-located and remote participants to collaborate over documents with dense text. The design we describe here is motivated by findings from our preliminary work.

Electronic documents will be projected on the display as normal-sized virtual books that show two pages at once, like a real book (Figures 1, 2 and 3). As with real paper documents, participants will use bimanual hand gestures to flick through pages one at a time, to move documents around the table surface for side-by-side comparison, to group documents into piles for organisation, and to add bookmarks. Users will add freeform electronic annotations using a stylus.

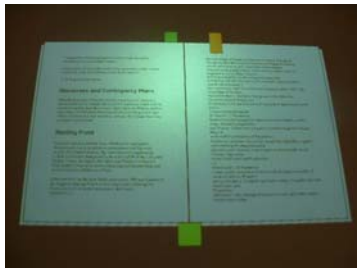

figure 3. Virtual book shows two pages and bookmarks.

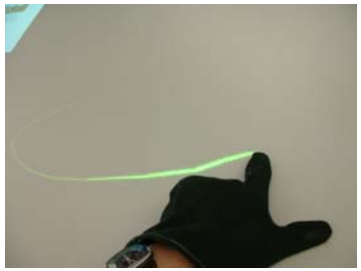

figure 4. A telepointer trace follows hand gestures.

In order to support co-located collaboration around a single display, the system will allow each participant will have their own stylus and to make hand gestures and annotations independently of others.

Remote or mixed-presence collaboration will be possible between two geographically-separated groups. An audio channel connecting the two sites will allow the participants to hear each other. Each group will collaborate around its own display, while telepointer traces or some other form of embodiment will follow each participant's hand and pen gestures (Figure 4). The two displays will be linked so that both show the same shared view of the task, and thus each participant will see all other participants' gesture embodiments and annotations. So, for example, users will be able to gesture to remote participants by pointing whilst saying "that paragraph there", and to sketch out ideas to remote users by annotating with a stylus.

We believe the key issues for remote collaboration will be in resolving the disparity in information orientation and display form-factor between the two sites and in choosing an embodiment to convey presence.

We aim to investigate the usability of the display for remote collaboration by examining its effectiveness, efficiency and user satisfaction. The task will be a small tutorial session in which lecture notes, assignments and exam questions are discussed between a tutor and students, some of whom are remote. Such a task would normally involve many paper documents and a co-located group, and is similar in nature to a design meeting in which participants present and discuss their designs.

As preliminary work, we have implemented a system based on the Escritoire project [1] to support virtual books and hand input for remote but not co-located collaboration (Figures 1 to 4). Our early observations indicate that participants are comfortable using hands and a stylus to gesture to remote participants via telepointer traces, and that hand gestures are likely to be an effective way to navigate long documents if the gesture recognition system is reliable.

We are now implementing the full system proposed here.

Related Work

The Escritoire [1] presents virtual sheets of paper on a tabletop display for remote collaboration, though it provides no way to navigate long documents or to discuss several documents simultaneously, and provides no support for co-located collaboration. Many other projects augment paper documents on a desk with projected graphics to support interactive content [3,7] or for remote collaboration [6,8].

However, none of these projects have the capability to present pages of dense text and annotations on a large display as we propose. Many use only a single commodity projector over an entire tabletop and thus the display resolution is too poor. Other projects use multiple overlapping projectors in a tiled array. In this case, image warping techniques are normally applied to the individual projector outputs to create a single contiguous display [2], but unfortunately these techniques severely disrupt high-contrast features such as dense text and thus are not suitable for our display. The Escritoire suffered from this problem.

Hereld and Stevens [2] describe a technique to perform warping for multi-projector displays without disrupting dense high-resolution text. Essentially, individual words are automatically identified before warping and are later "pasted" back into the warped image in their unwarped form. Thus the image is warped suitable for the multiprojector display, but the individual words are legible. Using this technique we aim to use multiple overlapping projectors to create the proposed large display capable of displaying dense text at high resolution.

About the Authors

Philip Tuddenham is a PhD student working under the supervision of Professor Peter Robinson at the University of Cambridge.

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References

[1] Ashdown, M. and Robinson, P. Escritoire: A Personal Projected Display. *IEEE Multimedia Magazine*, 12 (1) (2005), 34–42.

[2] Hereld, M. and Stevens, R. L. Pixel-Aligned Warping for Multiprojector Tiled Displays. *Proc. PROCAMS 2005*, IEEE (2005)

[3] Koike, H., Sato, Y. and Kobayashi, Y. Integrating paper and digital information on EnhancedDesk: a method for realtime finger tracking on an augmented desk system. *ACM TOCHI* 8 (4) (2001), 307–322

[4] O'Hara, K. P. and Sellen, A. J. A comparison of reading paper and on-line documents. *Proc. CHI 1997*, ACM Press (1997), 335–342

[5] O'Hara, K. P., Taylor, A., Newman, W., and Sellen, A. J. Understanding the materiality of writing from multiple sources. International Journal of Human-Computer Studies, 56 (3) (2002), 269–305

[6] Takao, N., Shi, J. and Baker, S. Tele-Graffiti: A Camera-Projector Based Remote Sketching System with Hand-Based User Interface and Automatic Session Summarization. *Int. J. Comput. Vision* 53 (2003), 115-133

[7] Wellner, P. Interacting with paper on the DigitalDesk. *Commun. ACM*, 36 (1993), 87-96

[8] Wellner, P. and Freeman, S. *The DoubleDigitalDesk: Shared Editing of Paper Documents*. Technical report EPC-93-108, Xerox Research Centre, Cambridge (1993)