MixPad: Augmenting Interactive Paper with Mice & Keyboards for Fine-grained Cross-media Interaction with Documents

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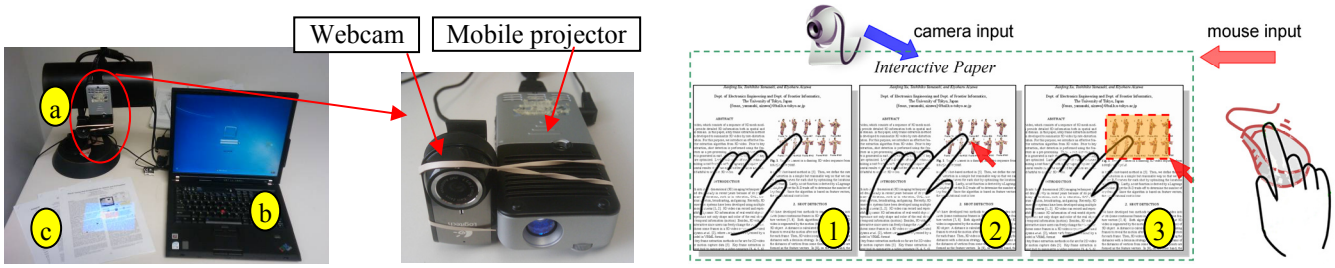

Figure 1. (left) The MixPad interface components: (a) camera-projector unit, (b) laptop and (c) printout. (middle) Close-up of the camera-projector unit. (right) The steps to select an image region on paper: (1) roughly pointing a finger to the region, (2) mouse cursor being projected around the finger tip, and (3) moving the mouse cursor to select the desired region at fine granularity.

ABSTRACT
This demo shows an interactive paper system called MixPad, which features using mice and keyboards to enhance the conventional pen-finger-gesture based interaction with paper documents. Similar to many interactive paper systems, MixPad adopts a mobile camera-projector unit to recognize paper documents, detect pen and finger gestures and provide visual feedback. Unlike these systems, MixPad allows using mice and keyboards to help users interact with fine-grained document content on paper (e.g. individual words and user-defined arbitrary regions), and to facilitate cross-media operations. For instance, to copy a document segment from paper to a laptop, one first points a finger of her non-dominant hand to the segment roughly, and then uses a mouse in her dominant hand to refine the selection and drag it to the laptop; she can also type text as a detailed comment on a paper document. This novel interaction paradigm combines the advantages of mice, keyboards, pens and fingers, and therefore enables rich digital functions on paper.

Author Keywords
interactive paper, keyboard, mouse, cross-media, document

ACM Classification Keywords
H.5.2 User Interfaces (D.2.2,H.1.2, I.3.6): Interaction Styles

General Terms
Human Factors, Design

INTRODUCTION
Most existing interactive paper systems [3, 4] rely on fingers or pens as the input devices. Although fingers and pens are natural for free-style marking and gesturing, they lack high precision, high performance and capability to interact with distant objects. This limitation makes it hard to support many useful digital functions on paper such as precisely selecting a small region on a printout or efficiently annotating a printed figure with detailed text.

Moreover the pen-finger-only input on paper may harm user experience of cross-media interaction: When a user switches between paper and a laptop, she needs to change the input devices (e.g. pen vs. mouse) in her dominant hand and sometime adjust body pose to reach the distant document. Such device switching not only causes overhead, but also breaks the user perception of the continuum of a document workspace spanning paper and screens.

In this demo, we show a system called MixPad, which adopts mice and keyboards to augment interaction with paper. Based on the FACT system [4], MixPad consists of a camera-projector unit, which is connected to a laptop, and ordinary paper documents without any special markers (Figure 1). Using the camera-projector unit, the system can recognize the paper documents and detect pen and finger gestures for users to interact with the documents.

Distinguished from FACT and other systems [1, 3, 6], MixPad incorporates mice and keyboards into paper interaction for better user experience. For instance, while editing PowerPoint slides on the laptop, a user wants to insert a portion of a printed figure. As illustrated in Figure 1, without dropping the mouse in her right hand, she simply points her left index finger to the figure. In response, the system projects the mouse cursor around the finger. The user then moves the cursor to refine the selection. Upon the selection is done, the user easily drags the region with the mouse and drops it into PowerPoint on the laptop.

We were inspired by Hartmann's work [2], which uses mice and keyboards to augment multi-touch interactive tables. Differently, MixPad augments interaction with paper. We

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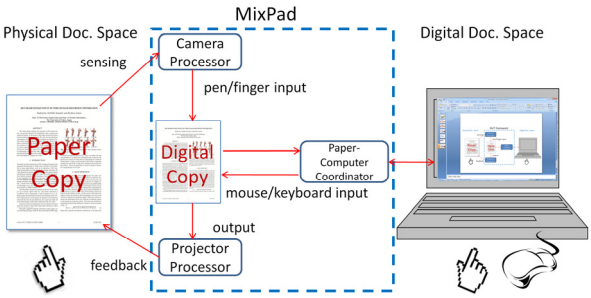

Figure 2. Architecture of MixPad

also borrowed the concept of "continuous space" from Augmented Surfaces [5], which does not support mouse and keyboard interaction on ordinary paper documents.

SYSTEM INFRASTRUCTURE

Based on the FACT system [4], MixPad consists of three components (Figure 2), namely camera processor, paper-computer coordinator and projector processor. The camera processor uses the camera to recognize a paper document and to detect users' finger or pen tip. It finds the digital version of the document using a natural visual feature based document recognition algorithm [4], and establishes precise coordinate transforms between camera images, the digital version and projector images using feature correspondences [4]. With the transforms, the finger and pen tip operations are interpreted as corresponding pointer manipulations on the digital version. These operations can be enhanced by mouse and keyboard interaction forward by the paper-computer coordinator. The resulting visual output for the paper document is generated by the projector processor and projected on paper for direct visual feedback.

INTERACTION TECHNIQUES

Progressive Fine-grained Paper Interaction Using Mice

The camera-based finger and pen input of MixPad, although natural for paper interaction, is usually less robust and has lower input sampling rate than mice and keyboards. This causes inferior user experience for fine-grained interaction. It could be worse when there is only one hand available for paper interaction, because, without being hold by the other hand, paper may undesiredly move due to finger-paper friction.

MixPad combines finger and mouse interaction into a two-stage progressive fine-grained interaction. As exemplified in Figure 1, users can use a finger to first select a target document segment at coarse granularity and then refine it with stable and precise mouse operations. The similar idea can be extended to selection of any document content on paper (e.g. text, icons, graphic and arbitrary regions) with the granularity at individual word or pixel level. In principle, the finger and mouse interaction could be separately performed by two users for remote collaboration.

Context menus also work with mice on paper. By detecting the distribution of visual features in the camera images, MixPad locates a blank area around the selected segment to project a context menu, from which the user can choose with mice a command to be applied to the selection. As the result, the user-familiar mouse operations can be readily migrated to paper documents, putting paper and computers on more equal footing.

Smooth Cross-media Interaction Using Mice

Enabling mouse operations on paper can effectively facilitate cross-media document interaction, as users do not have to switch input devices in their dominant hand. This results in a smooth experience of a continuous document space. For example one can continuously select, drag and drop a document segment from paper to a laptop, without switching devices. Similarly, one can use a mouse to drag a video clip from the laptop to paper to create a multimedia annotation. The annotation is rendered as an icon projected on paper, and can be played later with a finger/mouse click.

Augmenting Paper Interaction Using Keyboards

A keyboard can be used to add high fidelity text information to paper documents. For example, one can select a document segment on paper and then type detailed text annotation for it. Compared to hand-written annotation, our method is faster for long text and the result is easier to be indexed by computers and shared with other people. Moreover, the annotation can be rendered in a more compact form than handwriting to save space. Short-cut keys are also possible: one can press ctrl-c to copy a selected paragraph on paper, and ctrl-v to paste it into a WORD document on the laptop.

CONCLUSION

We present a novel interactive paper system called MixPad, which incorporates mouse and keyboard input into the finger-pen based paper interaction. This new interaction paradigm enables precise and high fidelity input on paper, avoids frequent input device switching for cross-media interaction, and therefore effectively bridges the paper and digital documents for a continuous document space.

REFERENCES

1. Do-Lenh, S., F. Kaplan, A. Sharma, and P. Dillenbourg. Multi-finger interactions with papers on augmented tabletops. *Proceedings of TEI'09*, pp. 267-274.

2. Hartmann, B., M.R. Morris, H. Benko, and A.D. Wilson. Augmenting interactive tables with mice & keyboards. *Proceedings of UIST'09*, pp. 149-152.

3. Kane, S.K., D. Avrahami, J.O. Wobbrock, B. Harrison, A.D. Rea, M. Philipose, and A. LaMarca. Bonfire: a nomadic system for hybrid laptop-tabletop interaction. *Proceedings of UIST'09*, pp. 129-138.

4. Liao, C., H. Tang, Q. Liu, P. Chiu, and F. Chen. FACT: fine-grained cross-media interaction with documents via a portable hybrid paper-laptop interface. *Proceedings of MM'10*, pp. 361-370.

5. Rekimoto, J. and M. Saitoh. Augmented surfaces: a spatially continuous work space for hybrid computing environments. *Proceedings of CHI'99*, pp. 378 - 385.

6. Wellner, P., Interacting with paper on the DigitalDesk. Communications of the ACM, 1993. **36**(7): p. 87 - 96.