Total Recall: In-place Viewing of Captured Whiteboard Annotations

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ABSTRACT
Total Recall introduces a new way to view captured whiteboard annotations. To digitize drawings we used a modified commercial system. However, instead of displaying the annotations on a separate computer screen, Total Recall shows the annotations at the place on the board where they were actually made. The user holds a hand-held computer to the board and moves it to reveal the desirable portion of the captured annotations. By using ultra-sonic positioning and optimized graphics, we achieve a high frame-rate (30 fps), allowing for very smooth panning and interaction. We argue that this way of viewing captured whiteboard annotations is more natural and intuitive than current desktop-based systems.

Keywords
Whiteboard capture systems, ubiquitous computing

INTRODUCTION
Interactive whiteboards have been a staple of HCI research for many years. In the ubiquitous computing project at Xerox PARC, the *LiveBoard* allowed for annotations to be made on an interactive canvas displayed on a very large touch-sensitive computer screen [4]. This was later developed into commercial products such as the *SmartBoard* (www.smarttech.com). But this type of interactive whiteboard is quite expensive, and can be difficult to install because of its size. An additional disadvantage is that if someone accidentally uses a *real* whiteboard pen, the screen can be permanently damaged!

An alternative approach uses a real whiteboard and some kind of capture system. An example is Mimio from Virtual Ink (www.mimio.com). This system uses ordinary whiteboard pens, which are enclosed in a shell that emits an ultra-sonic signal when the pen is pressed to the whiteboard. A sensor attached to the edge of the whiteboard determines the pen's position and sends data to a computer, where the annotations can be viewed and edited. But while this approach has the advantage of using ordinary whiteboards and pens, it requires the use of a separate computer to display the annotations. This decouples the "real" annotations on the board from the "virtual" annotations that are stored on the computer.

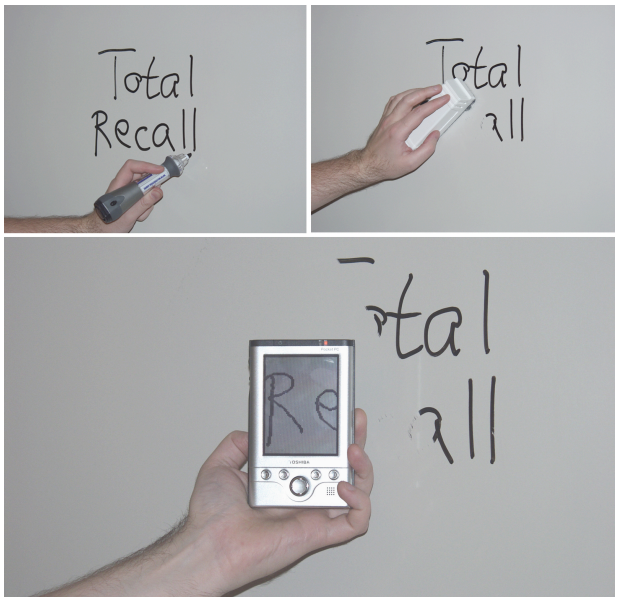

Figure 1. An annotation is created; partly wiped out; and recalled in the original location

To address this, we have developed a system that allows viewing of captured whiteboard annotations *on the place of the whiteboard where the annotation was made* – without the need for installing a large screen or dedicated projector.

TOTAL RECALL
The Total Recall system is based on the Mimio whiteboard capture hardware. A hand-held computer with wireless networking functions as the display, and a stationary PC is used to process positioning information, for both pens and display. The whiteboard has been fitted with a Mimio ultra-sonic sensor. When the user is making annotations, she uses ordinary whiteboard pens enclosed in the Mimio-supplied shell. When she wants to recall an annotation, she holds a hand-held computer to the whiteboard. The stored annotations are displayed on the screen of the hand-held device – in a position matching the place on the whiteboard where they were originally made (see **Figure 1**). An ultra-sonic emitter is fitted on the back of the display to

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determine its position. The display updates at a rate of 30 fps, allowing for very smooth panning of the image.

Our system does not supplant the functionality of whiteboard capture systems; all traditional functions such as storing, editing, sharing of images via networks, etc. can still be used. However, it introduces the important additional benefit of *in-place viewing* of annotations. This can be particularly useful when accessing layered annotations. A whiteboard is typically a space that evolves over time – annotations are added, changed, erased, re-created, and so on, reflecting the flow of a meeting or intellectual discussion. In systems that only store the final product, this dynamic is lost. Even when some kind of "replay" is available, it is not possible to access annotations from different points in time simultaneously. In the current Total Recall system, it is already possible to juxtapose past annotations with what is currently on the board. With the planned additions of a means to navigate through time and the possibility to use several screens at the same time, it will be possible to directly juxtapose and compare annotations from different positions and points in time.

IMPLEMENTATION

We used the Mimio sensor and pen shells to get positioning information, both for pens and the hand-held display. When the user makes annotations, XY-coordinates are sent to the stationary PC. The PC then sends annotation information via the wireless network to the hand-held computer. To save bandwidth, they are sent as drawing operations rather than graphical images. An application on the hand-held computer continuously updates an internal image to reflect the annotations. To get positioning information for the display, we extracted the interior of a Mimio pen shell, and attached it to the back of the hand-held computer (see **Figure 2**). When the user moves the device over the whiteboard, the PC receives the XY-coordinates via the Mimio sensor and sends them to the hand-held device via the wireless network. The hand-held computer can then pan the internally stored image to show the annotations on the correct position. A calibration feature is provided to align the size and position of the computer graphics with the real whiteboard annotations before use.

Figure 2. Positioning hardware; the ultra-sonic transmitter is visible at right.

INFORMAL EVALUATION

We let a few people try the system informally. They made annotations on a board, wiped them out and recalled them by using the PDA. The application seemed straightforward to use and people picked it up easily, although there were some problems with the positioning hardware. We also got some valuable suggestions. For instance, one user suggested that we distribute the captured annotations to the handheld computers of all the participants in a meeting, so that participants could find suitable annotations themselves (perhaps through some kind of replay mechanism) and then come up to the whiteboard to display them.

RELATED WORK

Total Recall can be seen as a physical instantiation of a *Magic Lens*, an operator that is positioned over an on-screen area to change the view of objects in that region [1]. A spatially aware display that functioned as a "window" on a large image was presented in [3]. *Peephole Displays* expanded on this and tracked movements in 2 dimensions, by attaching the display to a system of thin wires that affected the rollers in a mechanical mouse [5]; while giving accurate results, this tethered arrangement seems to limit that system's potential. The *Interaction Lens* captured and displayed notebook annotations by using a WACOM tablet and a 4D mouse [2]; however, the interaction area was small (a notebook) and the frame-rate very low (2-3 fps).

DISCUSSION AND FUTURE WORK

Matching up the position of the real annotations with the display is still an issue; at present, the system has to be manually calibrated at startup. However, we found that in use, it is not really necessary that the images match up perfectly, since the user will perform a sort of "calibration" by simply moving the device to display the desired portion.

We have not yet implemented a way to navigate through time-based annotations. Ideally, this should be some kind of tangible interface separate from the server computer. With this, it would become possible to "wind" forward and backward through time to view annotations made at different times. When we add more hand-held displays, allowing individual control of both the position and the point in time that is displayed, we believe the system will provide users with an even more rich and compelling way to recall whiteboard annotations.

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