HoloWall: Designing a Finger, Hand, Body, and Object Sensitive Wall

Nobuyuki Matsushita
Department of Computer Science,
Keio University
3-14-1 Hiyoshi, Kohoku-ku,
Yokohama, Kanagawa 223 Japan
matsu@aa.cs.keio.ac.jp

Jun Rekimoto
Sony Computer Science Laboratory Inc.
3-14-13 Higashigotanda, Shinagawa-ku,
Tokyo 141 Japan
rekimoto@csl.sony.co.jp

ABSTRACT
This TechNote reports on our initial results of realizing a computer augmented wall called the *HoloWall*. Using an infrared camera located behind the wall, this system allows a user to interact with this computerized wall using fingers, hands, their body, or even a physical object such as a document folder.

KEYWORDS: Wall interfaces, infrared, augmented reality, ubiquitous computing

INTRODUCTION
We are investigating how the future of architectures will be enhanced by computer technologies. Our project is motivated by Ubiquitous Computing [4], Augmented Interactions [3], and other related research on computer augmented environments [6]. We are particularly interested in the role of *walls* in a physical environment. More than just a partition, walls act as our display medium. We regularly exchange information on walls through calendars, posters, signs, notices, or bulletin boards. Thus it should be worthwhile to research how computer augmented walls will support our daily activities. We consider computerized walls as not just a large display panel. Walls must be aware of the physical environment. Since computer walls could be installed anywhere in a building, unlike whiteboard-sized computers, it is also desirable to allow interaction without the need of any special pointing devices.

HOLOWALL
The HoloWall is a wall-sized computer display that allows users to interact without special pointing devices. The display part consists of a glass wall with rear-projection sheet behind it. A video projector behind the wall displays images on the wall.

Inputs are recognized in an interesting way. This is done with infrared (IR) lights (we use an array of IR light-emitting diodes (LEDs)) and a video camera with an
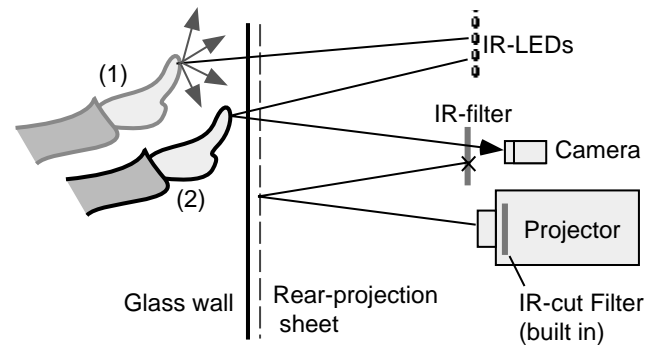

Figure 1: Configuration of the HoloWall

IR filter (an optical filter that blocks light less below 840 nm) installed behind the wall (Figure 1).

The camera captures the images on the back surface of the wall, which is illuminated by the IR lights. Note that the LCD projector (an EPSON ELP-5000) has a built-in IR-cut filter so that the camera is not affected by the projector's light.

Since the rear-projection panel is semi-opaque and diffusive, the user's shape or any other objects in front of the screen are invisible to the camera (Figure 1 (1)). However, when a user moves a finger close enough to the screen (between 0 cm to 30 cm, depending on the threshold value of the recognition software), it reflects IR light and thus becomes visible to the camera (Figure 1 (2)). With a simple image processing technique such as frame subtraction, the finger shape can easily be separated from the background. By controlling the threshold value, it is also possible to detect a human body when he/she approaches the screen. In the same way, any physical objects that reflect IR light are detectable. We tested VCR tapes, paper, and document folders, and all were clearly separated from the background (Figure 2, right). We also attached a 2D-barcode to the surface of an object to make it identifiable. When a user puts an object (such as a document folder) with a 2D-barcode on the wall, the system can detect its ID as well as its position. This feature makes it possible to implement an object-sensitive interface.

Figure 2: HoloWall in action: hands (left), video tape (middle), and a captured image (right)

POTENTIAL APPLICATIONS

The HoloWall can be a simple alternative to touch-sensitive panels, because large (wall-sized) touch panels are very difficult to construct and thus are quite expensive.

However, the potential of the HoloWall is not limited to touch panels. Since the HoloWall can detect two or more hands (or fingers) simultaneously, several multi-hand interfaces should be feasible (Figure 3 left). By measuring the location and the distance of the user's body from the screen, we can design a user interface that is aware of the user's movements. For example, the system might show a world map on the wall and when a user walks toward a specific area of the map, information related to that area would automatically appear on the map. Finally, it should also be possible to implement a wall that is sensitive to physical objects such as document folders (Figure 3 right).

RELATED WORK

Our method has many advantages over traditional touch panels. The HoloWall can detect two or more objects simultaneously, and can also detect human bodies or physical objects other than fingers.

The LiveBoard [1] is a pen sensitive projection display designed as a computerized white board. Unlike the HoloWall, it requires a special IR emitting pen for interaction. LiveBoard tracks only one pen at the same time.

VIDEOPLACE [2] is an artistic installation using a video camera that lets a visitor interact with the environment using his/her body. The visitor manipulates computer objects by means of their own silhouette, so the interaction is indirect as compared to the HoloWall.

All these systems do not allow interactions between physical objects and the computer.

CONCLUSION AND FUTURE WORK

We have proposed a new way to realize a computer augmented wall by using a camera and infrared filters. The prototype system, called the HoloWall, proves the feasibility of our idea and demonstrates its potential. We are now developing complete applications featuring multi-hand and object-aware interactions. We are also developing a table version of the HoloWall called the
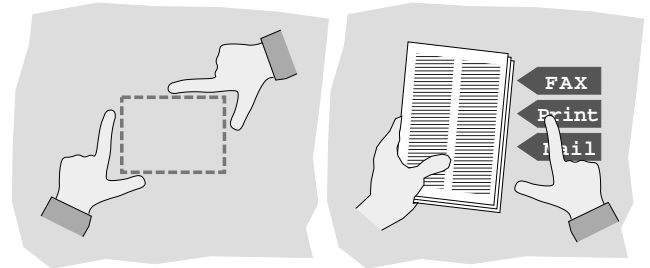

Figure 3: Two possible enhancements of wall interfaces: two-hand manipulation (left) and object sensitive response (right)

HoloTable. The HoloTable's top is sensitive to physical objects as well as fingers, and thus would be an interesting enhancement on computer augmented desks such as the DigitalDesk [5].

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