A Demonstration of TouchLight, an Imaging Touch Screen and Display for Gesture-Based Interaction

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ABSTRACT

A novel touch screen technology is presented. TouchLight uses simple image processing techniques to combine the output of two video cameras placed behind a semi-transparent plane in front of the user. The resulting image shows objects that are on the plane. This technique is well suited for application with a commercially available projection screen material (DNP HoloScreen) which permits projection onto a transparent sheet of acrylic plastic in normal indoor lighting conditions. The resulting touch screen display system transforms an otherwise normal sheet of acrylic plastic into a high bandwidth input/output surface suitable for gesture-based interaction.

KEYWORDS: Computer vision, gesture recognition, displays, computer human interaction

INTRODUCTION

The TouchLight system uses simple computer vision techniques to compute an image of objects situated on a plane between a pair of cameras and the user (see Figures 1 and 2). We demonstrate these techniques in combination with a projection display material which permits the projection of an image onto a transparent sheet of acrylic plastic (DNP HoloScreen), and the simultaneous
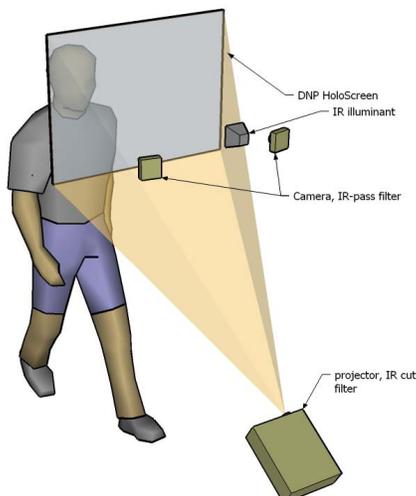

Figure 1 TouchLight physical configuration: DNP HoloScreen with two IR cameras and IR illuminant behind screen.

operation of the computer vision processes. TouchLight is presented in more detail in [1].

TouchLight goes beyond previous camera-based touch screen systems; by not using a diffusing projection surface, it permits a high resolution image of objects placed on the display. For example, a high resolution image of a paper document may be captured using a high-resolution still camera, or one of the newer high resolution CMOS video cameras.

The absence of a diffuser also permits the cameras to see beyond the display surface, just as they would if placed behind a sheet of glass. This allows a variety of interesting capabilities such as using face recognition techniques to identify the current user, eye-to-eye video conferencing, and other processes which are typically the domain of vision-based perceptual user interfaces.

IMAGE PROCESSING

The goal of TouchLight image processing is to compute an image of the objects touching the surface of the display, such as the user's hand. Due to the transparency of the display, each camera view shows the objects on the display and objects beyond the surface of the display, including the background and the rest of the user. With two cameras, the system can determine if a given object is on the display surface or above it. TouchLight image processing acts as a filter to remove objects not on the display surface, producing a *touch image* which shows objects that are on
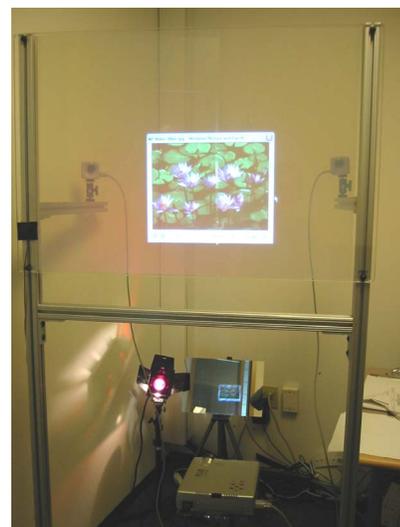

Figure 2 TouchLight prototype. Note two cameras clearly visible behind transparent projection display.

the display surface and is blank everywhere else. Figure 3 illustrates the image processing steps. A sample output image is illustrated in Figure 3d.

Figure 4 shows three different visualizations of the touch image as it is projected back to the user. Figure 4a shows the user's hand on the surface, which displays both left and right undistorted views composited together (not a simple reflection of two people in front of the display). This shows how an object fuses as it gets closer to the display. Figure 4b shows a hand on the surface, which displays the computed touch image. Note that because of the computed homography, the image of the hand indicated by

(a) Raw input

(b) Lens distortion correction

(c) Perspective correction

(d) Image product

Figure 3 TouchLight image processing steps illustrated. Images are captured in an office with normal indoor lighting: (a) raw input from both cameras, (b) input after lens distortion correction, showing display geometry during calibration, (c) input after perspective correction to rectify both views to display, and (d) image product shows only the objects that are very near the display. Hand on the left is placed flat on the display, hand on the right is slightly cupped, with tips of fingers on the display, and surface of palm above the display.

bright regions is physically aligned with the hand on the screen.

Presently we have only begun exploring the possibilities in interpreting the touch image. Figure 4c shows an interactive drawing program that adds strokes derived from the touch image to a drawing image while using a cycling colormap.

APPLICATIONS

TouchLight applications include multi-touch touchscreen-based interaction scenarios, gesture-based interactions, visible light surface scanning, eye-to-eye videoconferencing, augmented reality, spatial displays, and displays based on mirror or window metaphors.

REFERENCES

1. Wilson, A. TouchLight: An Imaging Touch Screen and Display for Gesture-Based Interaction. in *Proceedings of the International Conference on Multimodal Interfaces,* (2004)
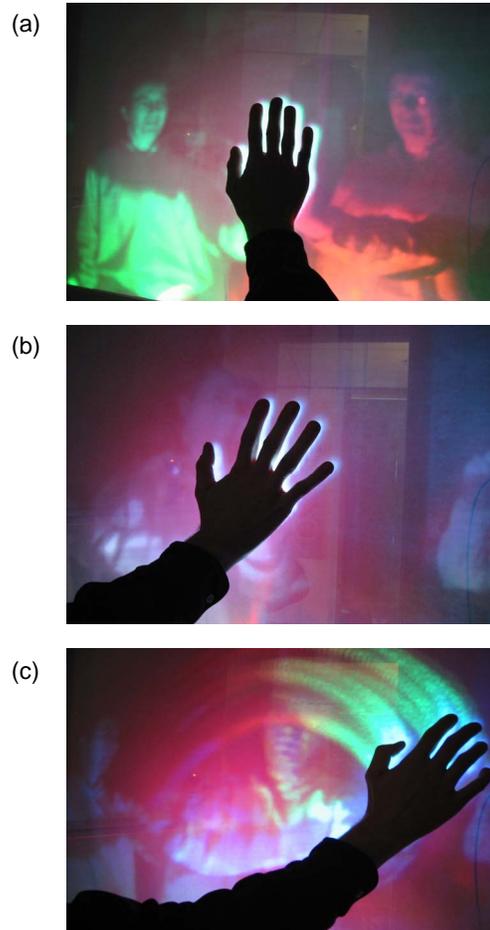
(a)

(b)

(c)

Figure 4 Three different projected visualizations of TouchLight touch image: (a) left undistorted image in the green channel, right undistorted image in red channel. (b) projection of touch image illustrates alignment of touch image with physical display. (c) an interactive drawing application with decaying strokes and cycling colors.