A Laser-Based System for Through-the-Screen Collaboration

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Figure 1: *(a) Prototype system with part of enclosure removed, (b) captured image showing interference from backscattered projected image, (c) system in use with notch filter on camera (inset shows captured image, mirrored, sent to remote user)*

1 Introduction

We describe a novel system for supporting remote collaboration over shared media. The system is based on the "ClearBoard" idea of [Ishii and Kobayashi 1992] where the shared media is presented as though on a sheet of glass between local and remote participants.

Conventional videoconferencing solutions do not lend themselves well to supporting natural collaboration experiences. For communication to be effective in these situations we have to go beyond doing a reasonable job with eye contact, to accurately conveying gestures and gaze direction with respect to the shared media: the same non-verbal cues that enhance communication in a co-located situation.

An ideal way to capture this information, along with a frontal view of the user, is by capturing images through the display. The ClearBoard system used 45° half-silvered mirrors and polarizing filters to achieve this. Recent work, e.g. HoloPort [Kuechler and Kunz 2006] and ConnectBoard [Tan et al. 2009], has focused on using holographic diffusing screens developed for electronic signage applications. These screens are naturally transparent except to light from a particular point, at which the projector is placed, where the holographic film's encoded optical elements steer the projected light out through a designed viewing angle. However, some fraction of the projected image is scattered off the back of the screen and is visible to the camera, interfering with the desired light coming from the scene beyond the screen. In order to prevent the camera picking up this portion of the projected image, various multiplexing schemes have been implemented: temporal in the HoloPort, wavelength division in the ConnectBoard. However, all of these methods, including Ishii's original polarization scheme, suffer from the usual multiplexing inefficiencies whereby significantly less than half the light available makes it to the screen and into the camera lens.

2 Our Approach

Our approach is to exploit wavelength multiplexing in conjunction with a laser-based projection display to avoid these issues. The only filter used in the system is a notch filter just before the camera, which is used to remove the three laser frequencies (red, green and blue). As these notches can be very narrow, roughly 80% or more of the visible spectrum is available to the camera. No filters are used with the projector so 100% or its output is used.

To test this approach we used a Mitsubishi LaserVue L65-A90 as a convenient source of an off-the-shelf laser rear-projection system that happened to roughly correspond to the acceptance angles of an available holographic diffusing screen (a 55deg HOPS Glass screen from Sax3D). The TV was dismantled, it's screen removed and replaced with the holographic screen, and its electronics relocated to allow a camera a clear line of sight through the screen from behind. An off-the-shelf triple notch filter was attached to the camera to block the laser wavelengths. The resulting system was enclosed to prevent stray light from entering the reconfigured rear-projection system.

3 Results

The images above show the camera output before and after the notch filters are placed in front of the camera. Note that the backscattered light is no longer visible in the second image. The blue-ish disc in the filtered image is an artifact due to the off-the-shelf filter's blue notch not being ideally matched with the blue laser wavelength over the range of incidence angles at the camera.

References

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SIGGRAPH 2010, Los Angeles, California, July 25 – 29, 2010.
ISBN 978-1-4503-0210-4/10/0007