# Optically Hiding of Information with Polarized Complementary Projection

Mariko Miki * Osaka University
Daisuke Iwai † Osaka University
Kosuke Sato ‡ Osaka University

## Abstract

We propose the concept and implementation of a graphical information hiding technique for interactive tabletops where users can view the information by simply casting real shadows. We placed three projectors (one in the rear and two in the front) in such a way that the rear one projects graphical information onto a tabletop surface, and the front ones project a complementary image, so that the combined image displayed on the surface becomes uniformly gray, thus hiding the information from the viewer. Users can view the hidden information by blocking the light from the front projector, revealing the complementary image that is being projected onto the occluder. We use the other front projector and polarization filters to make the complementary image projected onto the occluder also uniformly gray. Because the technique completely relies on optical phenomena, users can interact with the system without suffering from any false recognitions or delays.

**Keywords:** Multi-projection, complementary color, shadow.

## 1 Introduction

When interactive tabletops are installed in our daily environment, it is necessary to take into account the following two issues: (1) tabletops sometimes react to users' unintentional actions or physical objects that are placed on the tabletops, and (2) sensing and recognition processes inherently cause the delays in the systems' reactions some of which are perceived by users. As soon as these occur, users' natural interactions with tabletops are significantly disturbed. We propose an interaction technique in which users interact with tabletop systems by casting shadows on the surfaces (Fig. 1). The basic idea of hiding information with two projectors and revealing it by casting shadows was proposed by Minomo et al. [1]. However, they did not consider that complementary images would be revealed on anything occluding the projection of images. On the other hand, our technique solves the problem of visual disturbance from objects occluding images.

## 2 Optical Design

Figure 2 shows the proposed system's configuration. A beam splitter is used to ensure that the two front projectors share the same perspective. A polarization filter $f_p$ is placed in front of one of the front projectors, while another polarization filter $f_p^{\perp}$, the polarization direction of which is perpendicular to $f_p$, is placed in front of the other front projector. We place another filter $f_t$ on the tabletop surface so that the polarization direction is the same as that of $f_p$. The rear projector $p_r$ projects graphical information $i_r$ on the surface. One of the front projectors $p_f$ (with $f_p$) projects a complementary image $i_f$ on the surface. The other front projector $p_f^{\perp}$ (with $f_p^{\perp}$) projects an image $i_f^{\perp}$ which is complementary to $i_f$. Consequently, the projected images $i_r$ and $i_f$ are overlaid on the surface while $i_f^{\perp}$ does not reach it. The combination of images results in a uniform gray image being displayed on the surface. When an object blocks the front projection images $i_f$ and $i_f^{\perp}$, a uniform gray image appears on the object's surface by the overlay of $i_f$ and $i_f^{\perp}$. At the same time, the information is revealed in the shadow area where only $i_r$ is displayed. To compute the projection image for $p_f$ to display $i_f$, $i_r$ from $p_r$, and $p_f^{\perp}$ to display $i_f^{\perp}$, we used a camera and a color mixing matrix to estimate the appearance of a projected image on the surface. [2].

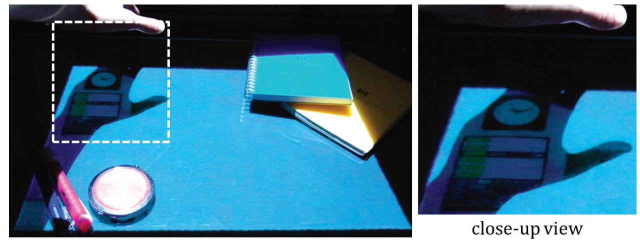


Figure 1: Graphical information is revealed in a real shadow area.

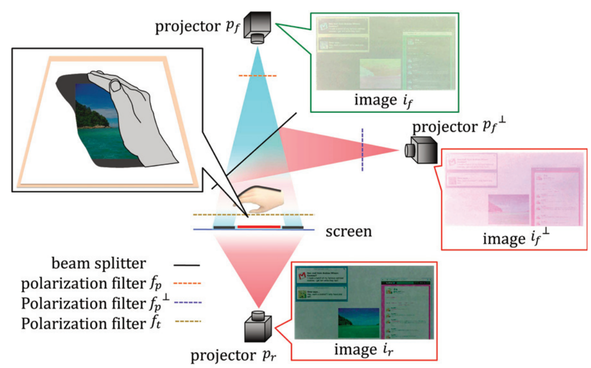


Figure 2: Optical configuration.

## 3 Result and Conclusion

We built a proof-of-concept system consisting of three projectors. And we confirmed that the proposed technique could hide any graphical information projected from the rear projector and the hidden information would be revealed only in shadow areas.

## References

[1] Y. Minomo et al.: Transforming your shadow into colorful visual media: multiprojection of complementary colors, ACM CIE, vol. 4, no. 3, article no. 10, 2006.

[2] T. Yoshida et al.: A virtual color reconstruction system for real heritage with light projection, In Proc. of VSMM, pp. 161-168, 2003.

*e-mail: mariko@sens.sys.es.osaka-u.ac.jp
†e-mail: daisuke.iwai@sys.es.osaka-u.ac.jp
‡e-mail: sato@sys.es.osaka-u.ac.jp

The 21st International Conference on Artificial Reality and Telexistence
November 28-30, 2011, Osaka, Japan
ISSN: 1345-1278 