OpaqueLusion: Opaque Mid-air Images using Dynamic Mask for Occlusion Expression

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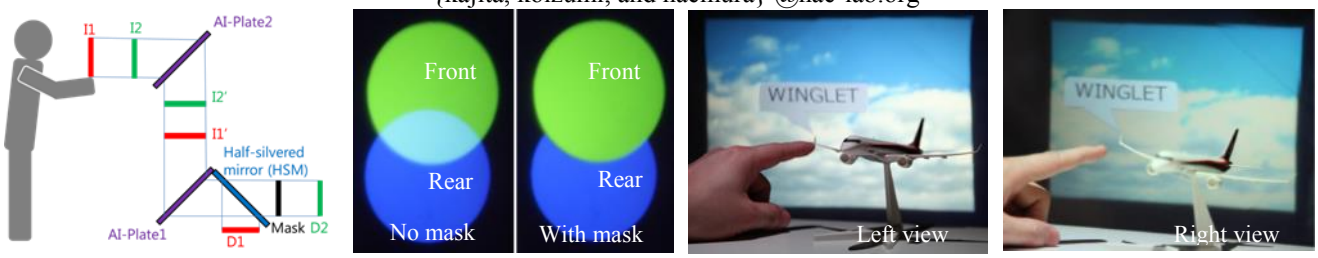

(a) (b) (c) (d)

Figure 1: *(a) Optical system configuration, (b) visibility control with dynamic mask, and direct annotation next to physical object and background image for stage scenery from (c) left view and (d) right view (front: annotation, rear: sky image).*

1 Introduction

Mid-air imaging has the advantage of expression along the depth direction. For example, MARIO [1], a mid-air display, can form an image in the depth range of 30 cm by physically moving the light source display. Multi-layered mid-air images can be displayed at various depths, but such multi-layered images are transparent and experience color mixture due to the addition of light from the light source displays. It is difficult to see the front of transparent images because they have no occlusion expression.

In response to the above, we propose OpaqueLusion, an opaque mid-air imaging method using a dynamic mask for occlusion expression. The novel point is our use of optical design to solve the problems stemming from additive mixture of color in multi-layered images. Specifically, we use a transparent LCD as a dynamic mask to block the light from the rear images.

The proposed method consists of two components: additive mixture and blockage of light. In the first component, a half-silvered mirror mixes light rays from each display but does not represent occlusion. In the second component, a transparent LCD blocks undesirable light. This component has previously been used in ELMO [2], an optical see-through HMD, to prevent the mixing of real and CG light.

2 Design

The design of OpaqueLusion consists of two main processes: overlapping two layers of mid-air images in the front and rear positions and forming a dynamic optical mask by a transparent LCD. Figure 1 (a) shows the optical system configuration of OpaqueLusion. As light sources for mid-air images, we used two displays (D1, D2). To form mid-air images, we used two AI-Plates, which are plate-shaped imaging optical devices that can form a mid-air image at the plane-symmetric position by reflecting incident lights. To overlap the mid-air images, we used a half-silvered mirror (HSM). For a dynamic optical mask (Mask) between mid-air images, we placed a transparent LCD at the position conjugate to D1.

Our main contribution is an optical mask technique for mid-air images. By displaying a black image that is the same shape as the front image, light rays can be blocked from the rear image as if the front image were opaque. Figure 1 (b) shows the resulting image with and without a mask.

Figure 1 (c) and (d) shows that mid-air images can be formed nearby real objects. The front annotation and the user's fingertip are pointing at the same position of the plane model. The positional relationship does not change even if the user's viewpoint changes from left to right. We expect applications of this method in various scenarios such as museum exhibitions or digital signage.

3 Evaluation

We evaluated the difference in visibility of the mid-air images due to the presence or absence of the mask by a text reading experiment. We compared three combinations: no mask, with mask, and without the rear image. We measured the average time it took each of 12 participants to recognize the image. We found that they recognized the front mid-air image with a mask significantly faster than that without a mask.

References

[1] Hanyuool Kim, et al. "MARIO: Mid-air Augmented Reality Interaction with Objects." Entertainment Computing 5.4 233–241 (2014).
[2] Kiyoshi Kiyokawa, et al. "An Occlusion-Capable Optical See-through Head Mount Display for Supporting Co-located Collaboration." Proceedings of the 2nd IEEE/ACM International Symposium on Mixed and Augmented Reality, p. 133 (2003).

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