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HaptoCloneAR: Mutual Haptic-Optic Interactive System with 2D Image Superimpose

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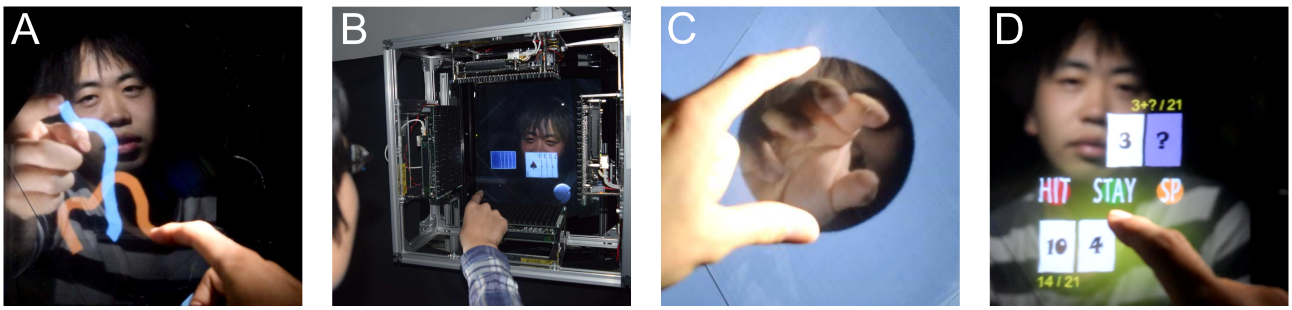

Figure 1: A) Mutual drawing. B) Playing cards. C) Wall and hole. D) Interactive game.

ABSTRACT

In our previous study called HaptoClone, a user can interact with optically copied objects from the adjacent workspace with haptic feedback. In this study, we added two displays and two half mirrors in the system, so that users can see and touch not only cloned real objects but also 2D superimposed virtual screens. This system enables users to experience more various contents such as a videophone, fighting games, and other entertainments so called AR (Augmented Reality) or MR (Mixed Reality) with haptic feedback.

CCS CONCEPTS

• **Hardware** → *Emerging optical and photonic technologies*;

KEYWORDS

3D interaction; augmented reality; tactile display

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1 INTRODUCTION

In the previous study, HaptoClone (Haptic-Optical Clone) system was proposed [Makino et al. 2016]. The system enabled two users sitting side by side to interact mutually with haptic feedback. Two users' 3D volumetric images were optically cloned by using a pair of micro-mirror array plates (MMAPs) [Asukanet Co. Ltd Asukanet Co. Ltd]. Haptic feedback was also presented when their cloned images contacted. We used airborne ultrasound tactile displays (AUTDs) to create haptic feedback at an exact position of the optical contacts [Hoshi et al. 2010]. Therefore, it had a great benefit in that users did not have to wear any equipment such as glasses and gloves. However, its interactions were limited in real objects because it simply used only reflects of some real objects by MMAPs.

In this paper, we propose a new version of the system named HaptoCloneAR (Haptic-Optical Clone with Augmented Reality), which is added a function to display artificial images onto real images. We realize the superimposition by newly installing two 2D displays and two half mirrors in the system. The proposed system enables users to let a virtual screen appear and disappear freely while interacting with each other. Moreover, our system has two displays independently shown for each user, so it can be applied to games, modelings, and many other contents so called Augmented Reality (AR) as shown in Figure 1.

2 PRINCIPLE

Figure 2 shows the entire configuration (top view) of HaptoCloneAR. Two half mirrors and displays, which are newly installed in the system, are painted in red. This configuration reconstructs an image of display A to A′ by reflection of a half mirror. Then next, the reconstructed image at A′ is re-reconstructed to A′′ by a MMAP1.

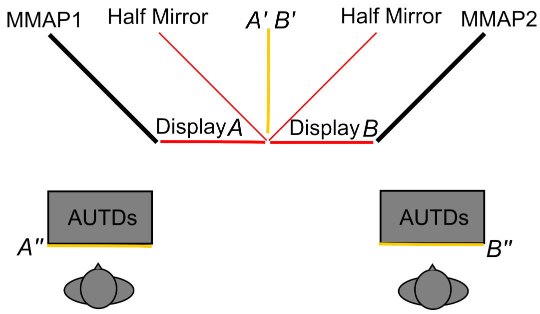

Figure 2: Configuration of the system (top view): displays and half mirrors are painted in red, and the reconstructed images are painted in orange.

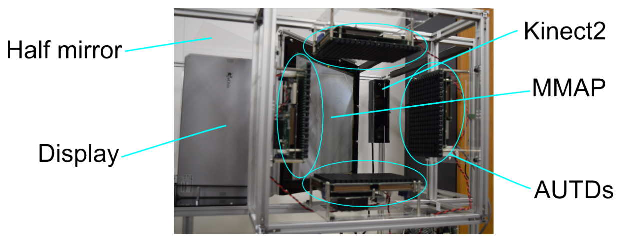

Figure 3: Implementation of one side.

Therefore, the image of the display A is seen floating at A′′ in front of a user on the left side. In the same way, the image of the display B is presented at B′′ through a half mirror and a MMAP2.

One important characteristic of the configuration is that two images of the display A and B are reconstructed independently to each side. Thanks to that, users can be presented different images between two sides. It allows its contents to include something which should presents different information to each user such as playing cards or showing opponents' information on the screen.

A user's hand or any other objects in the environment is measured by a depth sensor. After 3D point clouds are measured by the sensor, those point clouds are sent mutually by UDP transportation. When collision occurs between point clouds from own side and the other side, 3D positions of the collision are sent to present tactile sensations. In addition to that, when point clouds from own side contact the virtual screen, its operation is sent to the screen and Rupdate it with haptic feedback, if necessary. By synchronizing two screens, two users can also interact through the virtual display.

3 IMPLEMENTATION

The implementation of one side is shown in Figure 3, and it shows a half mirror and a display are installed at the positions explained in the previous section. In this system, we used normal transparent acrylic plates whose thickness was 1 mm as half mirrors, because they had to keep its permeability considerably high in order to clarify the vision of cloned 3D images, even at the cost of weak reflectance. To cover their weak reflectance, we used high brightness displays (Durapixel 1568-E (1600cd/m^2)) as displays which would be superimposed onto the 3D images. A depth sensor (Kinect v2) and four AUTDs are attached on one side as shown in Figure 3.

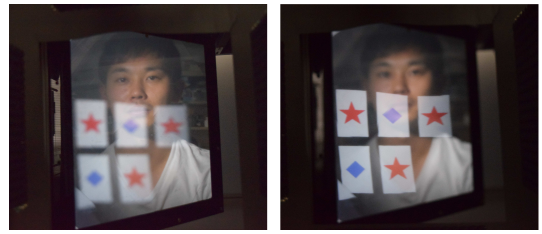

Figure 4: Left: focused on the opposite user. Right: focused on the superimposed screen.

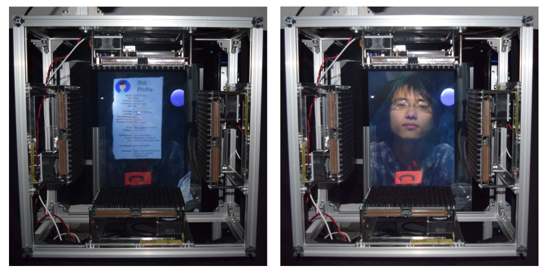

Figure 5: Left: interface screen is superimposed onto the opposite user's face. Right: a main part of screen's brightness is at its lowest level.

Then, Figure 4 shows the image from user's point of view when five cards are displayed in the screen. The user can see not only adjacent 3D environments but also the superimposed 2D screen. In addition, the image keeps its depth information by using a MMAP (Aerial Imaging Plate, product of Asukanet), so the user can focus on both the opposite environments and the virtual screen floating in front.

When the display presents images with high brightness, the opposite environments become hard to be seen. Figure 5 shows the user's vision when superimposed an interface onto the opposite user's face. This characteristic can extend the range of applications, since we can not only add 2D images onto 3D objects but also hide real objects.

4 PROSPECT

Superimposing a display significantly enlarges the contents of the system as an application. We implemented some applications shown in Figure 1, but it has more possibilities to be added. For example, we can add some image effects to the tactile stimulations to enrich haptic experiences.

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