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HaptoCloneAR (Haptic-Optical Clone with Augmented Reality) for Mutual Interactions with Midair 3D Floating Image and Superimposed 2D Display.

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Abstract. In the previous study, a new interactive system called HaptoClone was proposed. In HaptoClone system, a user can interact with optically copied objects from the adjacent workspace with haptic feedback. In this study, we propose an improved version of the HaptoClone system called HaptoCloneAR, which superimposes a virtual 2D screen on the copied objects by using half-mirrors. The system can display 2 different images independently to each workspace. In this paper, we show a basic configuration of the HaptoCloneAR system. We demonstrate a feasibility of the proposed system with our prototype.

Keywords: 3D interaction, Augmented reality (AR), Tactile display, Telexistence

1 Introduction

In the previous study by Makino et al, they proposed HaptoClone (Haptic-Optical Clone) system, which was a mutual interactive system [1]. This system enables two users sitting side by side interact mutually with each other's cloned 3D volumetric image with haptic feedback. Since the 3D image is cloned optically by using a pair of micro-mirror array plates (MMAPs), the refresh rate of the cloned image is as fast as the speed of lights, and users can see it without wearing any glasses [2]. When users or objects touch the cloned image, haptic feedback is also given by using an airborne ultrasound tactile display (AUTD) [3]. AUTD can make converged ultrasound foci to make tactile stimulations in midair by controlling phases of each transducer. The contact positions, where AUTD gives forces, are determined by measuring contact point from depth images by Kinect2 sensors. Since the volumetric image in the HaptoClone system was realized by

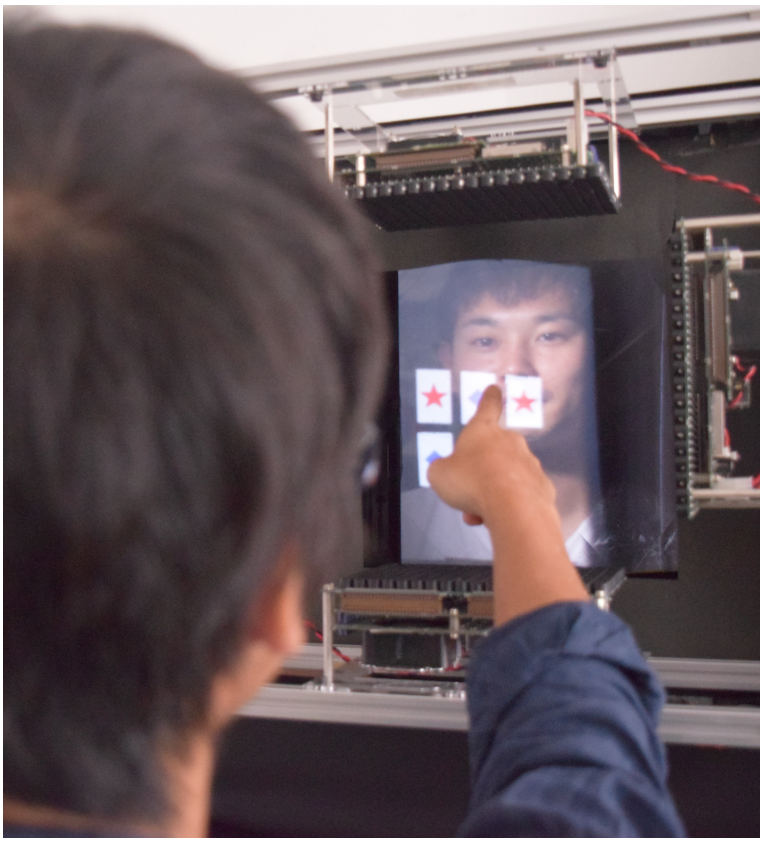

Fig. 1. The Picture of Using HaptoCloneAR

an optical mirror mechanism, it was difficult to display artificial images onto cloned volumetric images.

In this paper, we propose a new system named HaptoCloneAR (Haptic-Optical Clone with Augmented Reality) that superimposes 2D images onto conventional 3D cloned images. Figure 1 shows a picture of HaptoCloneAR. We present a virtual screen onto the cloned floating image to show a lot of information. Haptic feedback is also given to the virtual 2D screen when a user touches it. With this HaptoCloneAR system, users sitting side by side can interact with each other with touchable 2D information. For example, people can play cards in the virtual field seeing an opponent's face.

2 Principle

Figure 2 shows the configuration of HaptoCloneAR. In our proposed system, two half mirrors and two displays, shown in red, are added to the HaptoClone (the previous system). This configuration reconstructs the image of display A to A' by

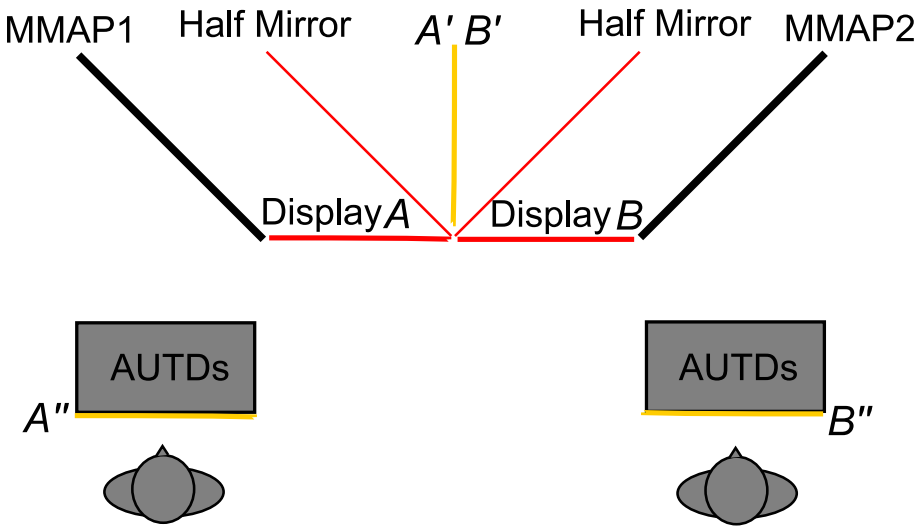

Fig. 2. Configuration of the System: added displays and half mirrors are painted in red, and the reconstructed images are painted in orange.

reflection of the half mirror. The reconstructed image at A' is re-reconstructed at A'' by the MMAP1. Therefore, a user sees the reconstructed image of the display A at A''. In the same way, the image of display B is seen at B'' through half mirror, and MMAP2.

One important characteristic of this configuration is that, two images of the display A and B are reconstructed independently to each workspace. As a result, the system can present different images to each user. This characteristic is suitable for presenting information that should be given to each user independently, such as playing cards.

3 Prototype System

Figure 3 shows the picture of the proposed prototype system. As shown in Fig. 3, half mirrors and displays are installed at the positions explained in Fig. 2. Then, the image from the user's point of view is shown in Fig. 4 (in adjusted light environments). A user can see not only adjacent 3D environments but also superimposed 2D display information. By using measured finger position with Kinect2 sensors, users can touch floating image, as well as the cloned 3D image, by using AUTDs, which is set in front of the users.

4 Conclusion

In this study, we proposed a new interactive system named HaptoCloneAR, which is an improved version of the previous system HaptoClone. In the previous HaptoClone system, users could touch copied objects from the adjacent

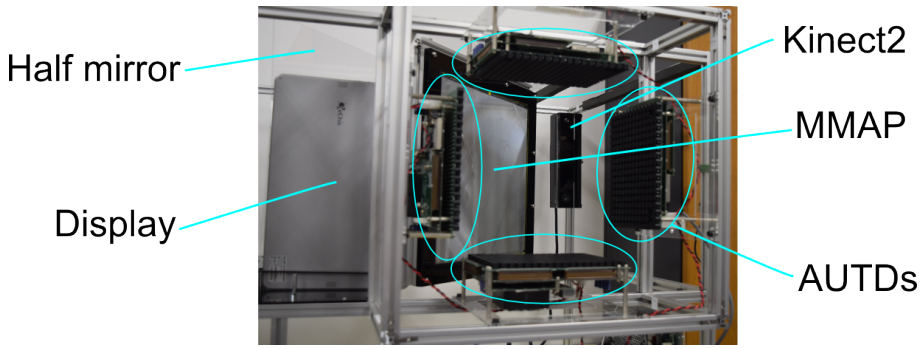

Fig. 3. Whole System of HaptoCloneAR

[1] Focused on the opposite user. [2] Focused on the superimposed screen.

Fig. 4. User's Vision: an image of cards is superimposed onto the opposite user's face.

workspace. In our proposed HaptoCloneAR system, we added 2D displays to superimpose 2D image on 3D floating image. Users can see and touch both of them. This 2D image can be presented independently to each side, which enables the system to show different information for each user. This is very effective when we assume applications that require one-way information such as playing cards. In this paper, we showed the principle of the HaptoCloneAR system and our prototype.

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