Interaction System with Mid-Air CG Character that Has Own Eyes

Kei Tsuchiya
The University of Electro-Communications
tsuchiya@media.lab.uec.ac.jp

Ayaka Sano
The University of Electro-Communications
sano@media.lab.uec.ac.jp

Naoya Koizumi
The University of Electro-Communications
JST PREST
koizumi.naoya@uec.ac.jp

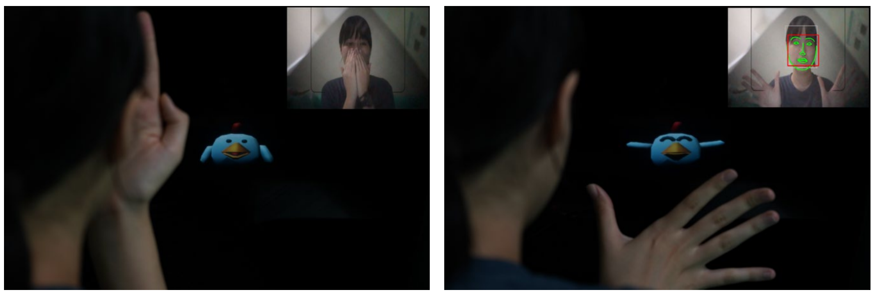

Figure 1: Mid-air image and capturing a user

ABSTRACT

This paper proposes an optical system that can capture a user from the viewpoint of a mid-air CG character. The mid-air imaging system enables us to display a CG character in real space. In order for users to interact with this character, we must observe their behavior from the character's viewpoint. Therefore, we propose a method of capturing from the mid-air image position by arranging a light source display and a camera at a conjugate position using a half mirror, optically transferring them with micro-mirror array plates. The contribution of this system is capturing the full face of a user from the position of the mid-air image.

CCS CONCEPTS

• **Human-centered computing → Display and imagers**

KEYWORDS

mid-air image, virtual camera, interaction

ACM Reference format:

Kei Tsuchiya, Ayaka Sano, and Naoya Koizumi. 2018. Interaction System with Mid-Air CG Character that Has Own Eyes. In *Proceedings of SA '18 Posters, December 04-07, 2018, Tokyo, Japan*, 2 pages. https://doi.org/10.1145/3283289.3283318

SA '18 Posters, December 04-07, 2018, Tokyo, Japan

1 INTRODUCTION

This study allows users to interact with a mid-air CG character by displaying mid-air images and capturing from that viewpoint. A mid-air image refers to a real image formed in the air by the reflection and refraction of light. The mid-air imaging system enables us to display the CG character away from the light source display.

We must observe users' behavior in order to enable interaction with the mid-air CG character in real space. The optical system that we propose can do this by capture from the mid-air image position. By combining the mid-air imaging display and the optical transfer of the camera viewpoint, we can capture from the mid-air image position while displaying it. The design uses micro-mirror array plates (MMAPs) and a half mirror. The light source display and the camera are arranged at a conjugate position with a half mirror, and they are optically transferred with MMAPs.

2 SYSTEM DESIGN

Our system is a combination of the design of GoThro [Naemura Lab et al. 2017, Niwa et al. 2017] and the mid-air imaging design. Figure 2 shows our proposed optical design and system flow. The system consists of a display, a DSLR camera, a concave lens, a half mirror, and MMAPs [Otsubo. 2014]. Light from the display is reflected by the half mirror and forms D'. MMAPs form a mid-air image with light from D' and transfer the camera viewpoint to the mid-air image position. Thus, we can display the mid-air image and capture from that viewpoint. The concave lens is mounted on the camera lens to regulate the depth of field of the mid-air camera. The

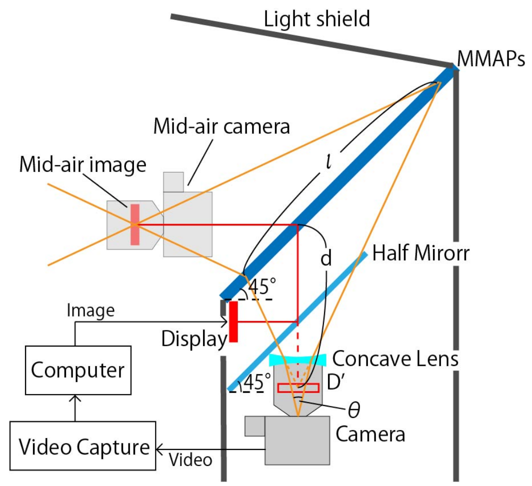

Figure 2: Optical design & System flow

slopes of MMAPs and the half mirror are both 45°. The video taken with the camera is captured onto a computer via the video capture. We operate the CG character on the display based on the face detection processing on the computer. In order to prevent undesirable light, we shielded the MMAPs other than in the imaging direction of the mid-air image with light shielding material.

3 DESIGN OF INTERACTION AREA

We designed the interaction area of this system based on the relation between the angle of view (θ [degree]), the length of MMAPs (l [mm]), and the distance from the camera viewpoint to MMAPs (d [mm]). The aim was to reproduce the original angle of view when the camera viewpoint is transferred. Discounting the concave lens, we regard the principal point of the camera lens as the camera viewpoint. The relation between θ, l, and d is given by the following formula.

$$l = \sqrt{2}d \tan \theta \tag{1}$$

We designed an interaction area according to the parameters of the affordable materials. We assume the use of three types of lenses: a wide-angle lens ($\theta = 70^\circ$, $x = 280$ mm, f = 16 mm), a normal lens ($\theta = 54^\circ$, $x = 380$ mm, f = 24 mm) and a telephoto lens ($\theta = 20^\circ$, $x = 900$ mm, f = 70 mm). x is the minimum focusing distance and f is and the focal length. Figure 3 shows the relation between l and d in this case. The length of MMAPs in this system is 488 mm. Figure 4 shows the interaction area of the normal lens. According to Figure 3, the maximum of d is about 250 mm. If we prevent the user from seeing the camera through MMAPs, the minimum of d is about 85 mm. Therefore, the mid-air image and the camera viewpoint are transferred to the point where the distance from MMAPs is 85 mm to 250 mm. We obtained the distance from the camera viewpoint to the front of the capture range by subtracting the focal length of the camera lens from the minimum focusing distance. It was 356 mm.

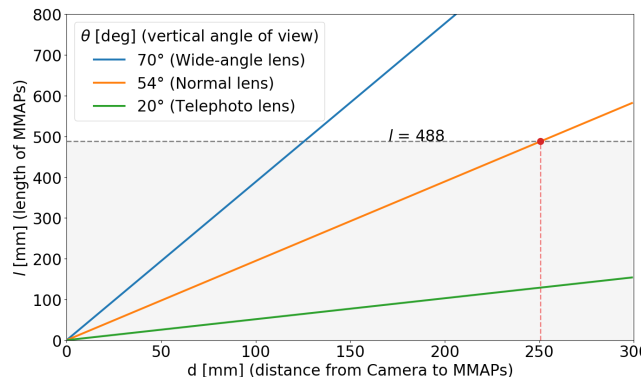

Figure 3: Relation between *l* and d

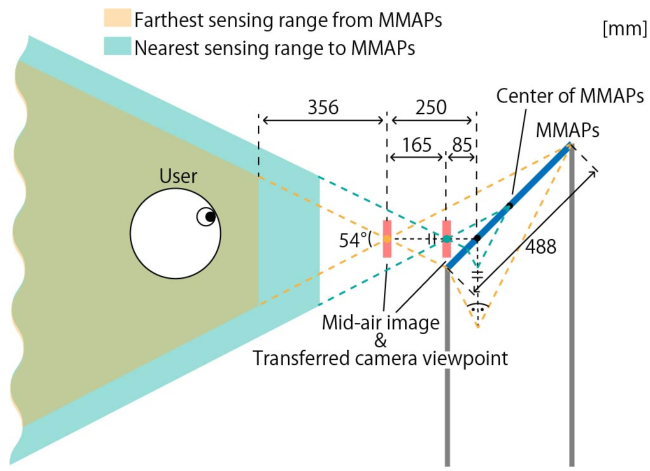

Figure 4: Interaction area of normal lens

This system enables an interaction in which the user and the mid-air CG character stare each other. Approaching the mid-air image, the mid-air camera recognizes the user. Since the mid-air CG character can move about 16 cm back and forth, it is possible to express the mid-air image walking around on the user's palm. We implemented an interaction system with the face detection. In this interaction, the behavior of the CG character changes in response to the user hiding their face. In other words, the user can play peek-a-boo with the character (Figure 1). Furthermore, this system can be applied to a mid-air agent that can observe the user like in a sci-fi movie.

ACKNOWLEDGMENTS

This research was supported by PREST, JST (JPMJPR16D5).

REFERENCES

Naemura Laboratory, Koizumi Laboratory. 2017. GoThro – DCEXPO2017. https://www.dcexpo.jp/archives/2017/en/16284.html.

Y. Niwa, H. Kajita, N, Koizumi, T. Naemura. 2017, GoThro: Camera that optically passes through the barrier. Proceedings of the 22nd Annual Conference of the Virtual Reality Society of Japan, 1B3-05.

M. Otsubo. 2014. U.S. Patent No. 8,702,252. Filed January 30, 2012, issued April 22.