# Vision-Sharing System for Android Avatars: Enabling Operator Eye Movement Synchronization and Immersive Presentation of Avatar Sight

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***Abstract*— This study introduces the development of a vision-sharing system for android avatars, aimed at enhancing ease of visual operation while preserving their human-like appearance. The system allows the operator to see from the avatar's perspective, as if they were physically present at its location, by synchronizing the avatar's eye movements with the operator's. This system is anticipated to enhance natural remote communications, allowing eye contact even through avatars.**

## I. Introduction

Technologies that make remote communication as comfortable as face-to-face are expected to facilitate human social activities. Video calls are the most common way to communicate with distant people these days. Still, it is hard to feel as if one is in the same place as the other person while communicating via that, and sometimes it can even cause fatigue. As one of the reasons for this, it has been pointed out that it is impossible to make natural eye contact with others through video calls [1].

Eye contact is one of the crucial methods of nonverbal communication in human interactions. Humans utilize eye contact for various purposes, including information-seeking and establishing social relationships, which are essential for effective communication. Eye contact also possesses both approach and avoidance forces; when we feel some social factor, such as physical distance, is inappropriate for the relationship with the other, we adjust our eye contact to keep proper social distance [2]. However, common remote communication tools today are unable to allow us to make eye contact as naturally as when physically co-present.

Therefore, we propose using androids, robots that closely resemble humans, as avatars to enable eye contact in distant places, enhancing remote communications. In this study, we developed a vision-sharing system that enables avatar operators to control their view similarly to their natural gaze behavior without an avatar, while the system synchronizes the avatar's eye direction with the operator's.

## II. Vision-sharing System

We proposed a concept of a vision-sharing system that allows both eye movement synchronization and sharing the same field of view between operators and avatars. The

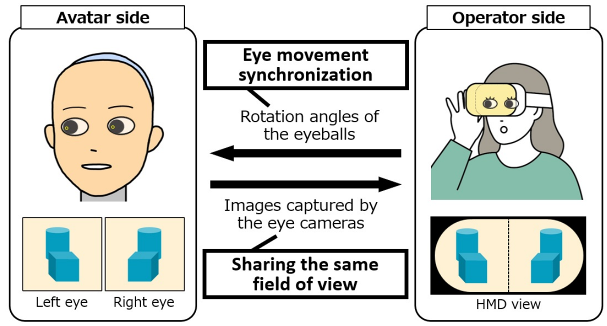


Fig. 1: Concept of the vision-sharing system

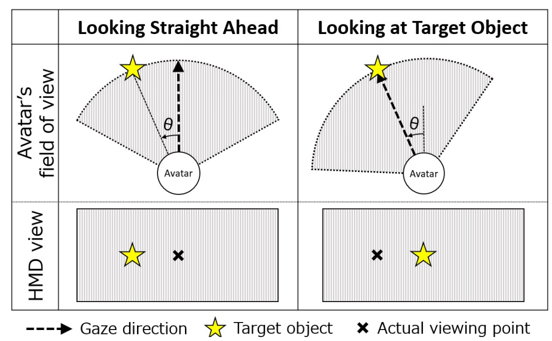


Fig. 2: Problem caused by the eye movement synchronization when the virtual screens are fixed.

overview is shown in Fig. 1. Note that this system requires the avatars to have cameras embedded in both the left and right eyeballs and to be capable of moving these eyeballs up, down, left, and right like humans. To achieve immersive avatar operation, the system was designed for operation with a head-mounted display (HMD). During operation, the avatar's eye movements are synchronized with the operator based on the operator's gaze, as obtained by the HMD. Simultaneously, images captured by the avatar's eye cameras are presented to the operator. The images from the left eye camera of the avatar are displayed on the left side of the HMD, while those from the right eye camera are displayed on the right. Each image is projected onto a hemispherical virtual screen centered on the operator's viewpoint and displayed on the HMD, allowing the operator to view the avatar's environment stereoscopically.

Our previous study [3] partially verified the effect of eye movement synchronization. However, by synchronizing eye movements, when the operator shifts the viewing point of the image displayed on the HMD to a desired position, the

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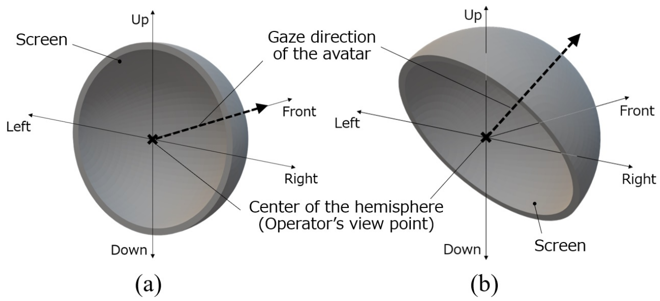


Fig. 3: Rotation of the hemispherical screen: (a) Avatar looking straight ahead; (b) looking toward the upper right.

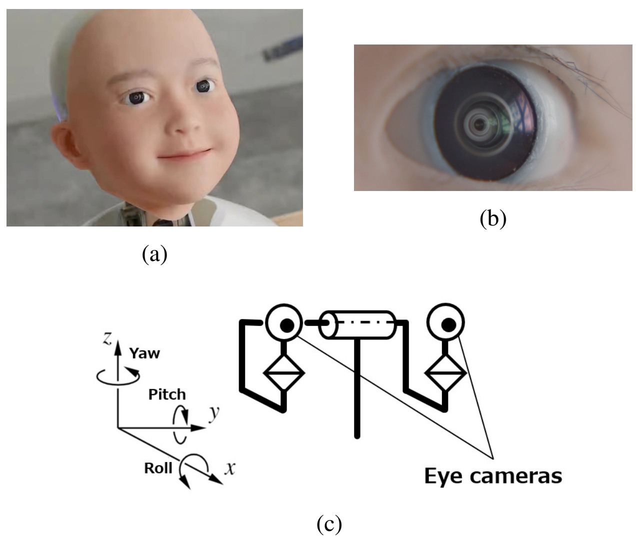


Fig. 4: Android avatar Yui: (a) Front view; (b) Close-up view of the eyeball; (c) Schematic diagram around the eyeballs.

camera's capture area also shifts, causing a problem that what the operator wants to see would not be displayed at the viewing point (see Fig. 2). This synchronization issue prevents making eye contact with the interlocutor. Therefore, the system was designed to rotate the hemispherical screens rotated according to the avatar's gaze direction (see Fig. 3). The system allows the operator to see a stable, shift-free view regardless of gaze shifts while ensuring the direction of the avatar's gaze is synchronized with that of the operator.

## III. Implementation for an android avatar

We implemented our proposed vision-sharing system on a humanoid cybernetic avatar Yui, serving as an android avatar [4] shown in Fig. 4(a). Its eyeball, shown in Fig. 4(b), is equipped with a camera module featuring a 200° wide-angle lens, allowing it to capture an image nearly as wide as the human field of view. Despite the integration of the camera, it maintains the realistic appearance of a human eye. Fig. 4(c) shows the mechanism surrounding the eyeballs. Three motors enable the yaw axis rotation for each eyeball and the pitch axis rotation for both eyeballs.

We use an HMD (Meta Quest Pro, Meta), capable of eye tracking, and Unity to simultaneously acquire the operator's

Fig. 5: Captured images displayed on the screens

eye movements and present video from the avatar's point of view. Robot Operating System 2 (ROS2) is used for constructing the system and for data transmission between the avatar and the operator. The yaw and pitch angles of the operator's eyes are captured using the eye tracker of HMD. Subsequently, these angles are input as target values to the motors controlling the avatar's eyeballs. For the vertical movement, the average pitch angle of the left and right operator's eye is used as the target value.

Of the 200° range image acquired by the eye camera, the 180° range image is projected onto the hemispherical screen, allowing the operator to view the avatar's environment on a scale equivalent to the real environment. Fig. 5 shows the actual display of the image.

During operation, camera images and the actual rotation angles of each avatar's eyeballs are captured with timestamps. The direction of the avatar's gaze at the time the images were captured is calculated using linear interpolation based on the timestamps, and the system rotates the screens that project the images. Each image is displayed on a screen, which is rotated so that the normal vector of the cross-section through the center of the screen hemisphere corresponds to the avatar's gaze vector. When the operator looks at a target around the avatar using this system, the avatar's eyeballs rotate by almost the same amount as they would if the operator were physically present at the avatar's location.

## IV. Conclusion

In this study, we proposed a vision-sharing system for android avatars and implemented it for an android avatar. This system enhances both the appearance and the operator's sensation during gaze shifts, closely mimicking natural human eye behavior. The system is expected to enable interactions with eye contact between people in distant places, facilitating comfortable remote communication.

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