# Mapping Gaze and Head Movement via Salience Modulation and Hanger Reflex


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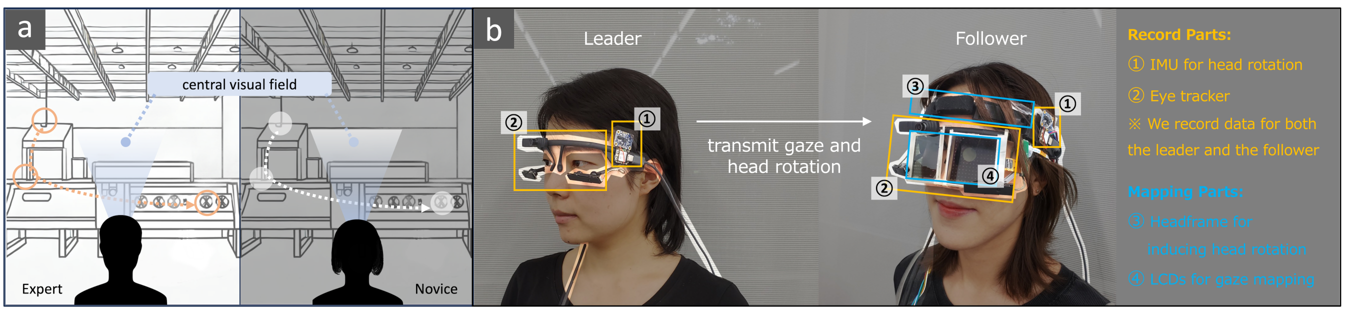


**Figure 1: (a) Some industries require skilled workers to have years of visual confirmation experience. We propose a system that can directly replicate the visual trajectory of experts to reproduce to novices. (b) The *leader*'s head rotation and gaze are recorded using an IMU and eye tracker. The *follower* replicates the *leader*'s head rotation and gaze using a head rotation induction device and LCDs.**


## ABSTRACT

Vision is crucial for daily input and plays a significant role in remote collaboration. Sharing gaze has been explored to enhance communication, but sharing gaze alone is not natural due to limited central vision (30 degrees). We propose a novel approach to map gaze and head movements simultaneously, enabling replicating natural observation across individuals. In this paper, we evaluate the effectiveness of replication head movements and gaze on another person by a pilot study. In the future, we will also explore the possibility of improving novices' efficiency in imitating experts by replicating the gaze trajectories of experts.



## CCS CONCEPTS

• **Human-centered computing** → *Collaborative and social computing devices.*




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## KEYWORDS

Remote Communication, Gaze Mapping, Head Rotation Transfer

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## 1 INTRODUCTION

Gaze functions as a powerful, non-verbal conduit for conveying users' intentions. We adopt a second-person perspective when decoding the intentions behind someone's gaze. Qvarfordt and Zhai [2] explored using gaze direction to enhance communication within virtual environments. However, the second-person perspective confines us to observe another person's gaze without directly experiencing it. Experiencing another individual's gaze from a first-person perspective can deepen our understanding of communication. This is exemplified when experts impart their experience to novices, creating a richer exchange. (Figure 1(a))

Numerous studies have investigated the transmission of eye gaze. For instance, *GazeSync* used monochrome Liquid Crystal Displays (LCDs) with different transparency levels to synchronize the eye movements of two individuals [6]. However, in natural viewing conditions, individuals often turn their heads while shifting their gaze to maintain a comfortable experience. Therefore, this pilot study aims to explore direct gaze and head rotation simultaneously. To direct gaze, we dynamically adjust visual salience using a punched pattern on transparent LCDs. To induce head rotation, we utilize a method called the Hanger Reflex, initially demonstrated in *Sato*'s research by applying varying lever pressures to the forehead [3]. We present a system, as shown in Figure 1, that allows for the natural recording of observations from a first-person perspective and allows another individual to experience it intuitively.

## 2 PROTOTYPES OF MAPPING HEAD AND GAZE MOVEMENT

We developed devices combining eye gaze and head rotation for shared observation in remote communication. They are divided into *Leader's Device* and *Follower's Device*. The *Leader* wears an eye tracker attached to an IMU (inertial measurement unit) sensor to record both gaze movement and head rotation, while the *Follower* wears a device that replicates the GazeSync [6] device and further added a prototype equipped with pneumatic actuators to trigger head rotation. They are detailed in the following paragraphs.

***Leader's Device: record observational pattern in gaze and head movement.*** To capture the gaze patterns of both the "leader" and the "follower", we employed the Pupil Core eye tracker, which has been widely used in numerous related studies [4–6] due to its reliable performance and modular design. To monitor associated head movements during the mapping of the leader's gaze and head movement, an IMU was attached to the right leg of the eyeglasses, as shown in Figure 1(b)(left). This IMU was wired with a microcontroller.

***Follower's Device: mapping gaze and head movements.*** The gaze direction mapping apparatus, depicted in Figure 1 (b) (right), employs two transparent monochrome LCDs as see-through lenses to guide the gaze. To transmit the leader's gaze onto another, the LCDs show transparent moving circles to indicate the gaze point. Meanwhile, the central transparent pattern enhances the visual salience of the transparent region by occluding other areas. The head movement transmission apparatus leverages the Hanger Reflex [3], which triggers involuntary head rotation to counteract uneven diagonal pressure applied to the forehead. This Hanger Reflex triggering device was replicated and adapted from the model by Li et al. [1], which features four airbags within a 3D printed headband to exert pressure on the head instead of an actual hanger.

## 3 INITIAL EXPLORATION

Since head rotation and gaze operate in different coordinate systems during observation, many issues remain to be addressed for replication of continuous observation. Therefore, we first performed a short-distance observation experiment to confirm the feasibility of simultaneously mapping gaze and head movement. First, we set up the experimental scene as shown in Figure 2(Left). Nine markers were attached to the wall, including a center position marker "+" and eight alphabet letters as target markers. The eight tasks involve moving from the center position marker "+" to each target marker.

We enrolled 6 individuals (ages 23 to 31 years, with 1 male and 5 females). One person served as the leader, equipped the leader's device, and executed the eight tasks to capture gaze and head movement data for mapping. The remaining participants wore the follower's device and encountered the leader's gaze movement data replayed in a random sequence. They verbally communicated to the experimenter which letter was directed to them.

## 4 RESULT & INTERPRETATION

Each target marker was replayed randomly once per round from the followers' viewpoint, with each participant completing five rounds. This led to 25 tests per marker (5 participants * 5 rounds). The outcomes are displayed in Figure 2(right). To interpret the result, markers A to D are located near the central visual field, and directing the gaze towards them may not necessitate head rotation, resulting in accuracy levels exceeding 88%. Conversely, markers E to H are situated far from the central visual field, and current gaze guidance methods without head movements might fail with these larger gaze sweeps. Despite the lower accuracy for markers E to H compared to markers A to D, we believe this outcome indicates that our combined gaze and head guidance approach has the potential to provide intuitive observational pattern mapping in the following refined attempts.

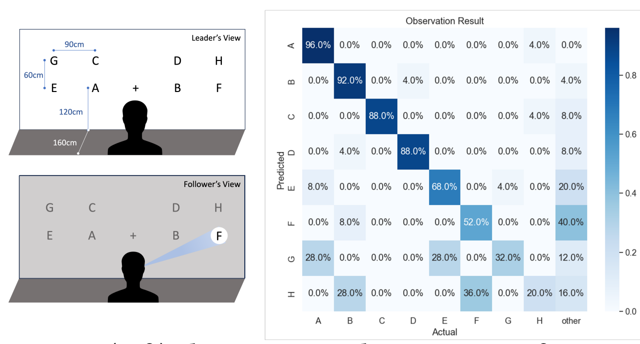


**Figure 2: (Left) The experimental environment of mapping gaze and head rotation from one to another. (Right) The results regarding mapped directions of eight target markers.**

## 5 CONCLUSION AND FUTURE WORK

The pilot study results suggest that our method can effectively guide an individual's gaze to areas not only near central vision but also towards more peripheral vision in most cases. However, we observed that when aligning head movements and gaze with another individual, it is essential to consider the pitch direction for mappings that include upward and downward gaze movements. Furthermore, in future research, we will investigate how gaze and head movement are coordinated in more intricate observational behaviors and test the practicality of our approach in real-world settings.

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