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Demo

Investigating Perception of Multiple Virtual Hands using Startle Response

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Figure 1: *System overview. The user can move multiple virtual hands with motion synchronization.*

Abstract

Studies have been conducted to examine the human body perception of a whole body when having multiple bodies. In this paper, we investigate how does the sense of body ownership and the sense of agency change when a user synchronously moves multiple body parts in a virtual environment. Participants in a demonstration will perform a reaching task for 150 seconds by physically moving their right hands while visualised as one or nine hands in a virtual reality environment. At the end of the reaching task, a threat stimulus is triggered and participants' electromyography are measured as an objective index of the sense of body ownership. Finally, a short survey will be conducted to query the strength of the subjective sense of body ownership and agency.

CCS Concepts

• ***Human-centered computing*** → ***HCI theory, concepts and models;***

1. Introduction

Humans can feel the sense of body ownership and sense of agency by synchronizing visual information and body movements, even for non-innate virtual bodies [SVSF*10]. In addition, virtual environments can offer benefits that allow us to investigate or study body perception in extreme conditions that are difficult or impossible to achieve in the physical world. For example, a person manipulating or seeing multiple bodies in virtual reality [GLSE20, MKK*21]. In their study, users controlled up to four synchronized virtual bodies and showed that each provided an equivalent sense of body ownership and sense of agency. From these studies, the authors investigated the ownership of the whole body in a situation when a user had multiple bodies. However, the authors did not explore partial ownership of multiple body parts such as hands, which is also essential for studying human body perception. In addition, they have yet to investigate the sense of body ownership and sense of agency for multiple bodies that can view uniformly.

This paper investigates whether it is possible for a user to receive a sense of body ownership and sense of agency when multiple hands are presented. In particular, we aim to investigate whether switching attention is performed for the sense of body ownership of multiple hands. In a demonstration, the participants will perform a reaching task using nine virtual hands, followed by an event of a threat stimulus (knife stab or explosion). During the demonstration, participants wear an electromyography (EMG), a device to track the electrical activity produced by skeletal muscles. Then, we

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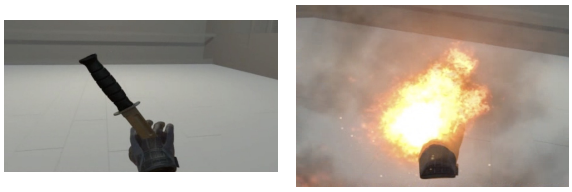
(a) VIVE Tracker (b) EMG Sensor

Figure 2: *Measurement device for hand position and EMG.*



(a) knife (b) explosion

Figure 3: *Examples of stimuli.*

will test whether the EMG for the startle response changes when the target hand (gazing or not) or the timing of the threat stimulus is varied. Finally, we will ask the participants to complete a questionnaire to investigate the body perception when multiple hands are used.

2. System design

Environment:The participant wears a VALVE INDEX for the virtual reality head-mounted display, and immersed in a virtual environment built with Unity. The virtual environment consists of a 10m x 5m x 10m room with a white and red sphere in it. The spheres are always hidden and only appear during the reaching task. The white sphere is used as an origin, and the red sphere is used as a target for the reaching task. A trial involves the participant reaching from the origin to the target position, and returning to the origin using the virtual hand(s). The red sphere can be reached by any hand. However, In the case of nine virtual hands, the position of the center-nearest hand has the exact coordinates as the physical hand. Therefore, the white sphere must be reached by that hand.

Hand tracking:A VIVE Tracker(Fig. 2(a)) is used for tracking and measuring the participants' hand motions. The hand tracker is attached to the dorsal surface of the right hand with a hand strap, allowing hands-free movement throughout the demonstration.

Multiple hands: To examine the body perception of multiple hands, we synchronized the movement of nine virtual hands with the position and rotation data obtained from the hand tracker. Then we added the virtual hands to the center of the room and align them in a 3x3 dotted grid pattern so that all the hands can be seen uniformly. In addition, we calibrate by aligning the position of the center-nearest hand to the participant's physical hand. In this way, participants can synchronously manipulate all hands in a first person perspective as if these were their own hands.

Measurement of EMG: The EMG sensor(Fig. 2(b)) was a Trigno Quattro Sensor from Delsys, which was attached to the right arm around the brachioradialis, extensor carpi ulnaris, biceps brachii, and triceps brachii muscles for tracking the electrical activity at four locations. The EMG sensor data calculate by root mean square (RMS) per 20 samples.

Before the participants perform the reaching task in each condition, the maximum voluntary contraction with muscle force and voluntary contraction with muscle weakness are measured and calibrated.

Stimuli: Two types of threat stimuli are used to examine the startle response. This consists of a knife(Fig. 3(a)) stabbing on the hand and an explosion(Fig. 3(b)) against the hand.

3. User Experience

By wearing the head-mounted display, the participants can experience immersive multiple hand motions through a reaching task. The reaching task is performed by moving nine virtual hands between white and red spheres in a 10m x 5m x 10m room while seated. Participants can manipulate multiple virtual hands by synchronising the movements with their physical hand using the VIVE tracker. This allows the participants to perform the task without holding a controller. Task-wise, a white and red spheres are used as the reaching targets. The white sphere is generated at a fixed position which requires the participants to return their hands to an origin by touching it using the aligned hand (center-nearest). The red sphere is generated randomly within the reachable distance for any of the hands. Overall, the participants perform the task while the system alters between the white and red reaching targets.

4. Conclusion

In this demonstration, we introduced human hand extensions, a prototype that surpasses the human physical characteristic. This system allows people to experience synchronously owning and manipulating multiple hands, which they do not naturally have. We expect our work to engage future research topics towards the sense of body ownership and sense of agency and how it can be changed when multiple hands or human body parts are been manipulated.

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