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Keio University

Verifying behavior and body cognition when simultaneously synchronizing with multiple avatars

As part of a study to verify the behaviors and body cognitions involved under conditions where people adopt avatar bodies and go beyond just their natural body, a research team comprising Professor Maki Sugimoto of the Keio University Faculty of Science and Technology, Reiji Miura (master's student at the Graduate School of Science and Technology), collaborated with Shunichi Kasahara (researcher) of the Sony Computer Science Laboratories, Inc. / the Research Center for Advanced Science and Technology of the University of Tokyo, Professor Michiteru Kitazaki of Toyohashi University of Technology Graduate School of Engineering, and Professor Masahiko Inami and Adrien Verhulst (researcher) at the Research Center for Advanced Science and Technology of the University of Tokyo; specifically, the group tested behavior and body cognition under conditions in which the bodies, movement, and vision of multiple (2 or 4 bodies) avatars (*1) in a virtual environment were synchronized as representations of the physical bodies of the experiment participants. It was shown that under conditions where multiple avatar bodies had been synchronized (4 bodies), a certain degree of sense of agency and body ownership could be obtained simultaneously for the multiple avatars representing the physical body.

The outcomes of this research were presented at the international conference Augmented Humans 2021 (AHs2021), which was held between February 22 and 24, and won the Best Paper Award. The papers of AHs were published on ACM Digital Library recently.

1. Main Points of Research

- By using a virtual environment, a system was built that simultaneously synchronizes the movements and sensations of between the physical body and multiple avatars.
- When compared to conditions for a single avatar body, it was confirmed that in cases where multiple avatar bodies are used, the movement to reach a randomly appearing object could be completed in a shorter travel distance.
- Through the subjective evaluations of the experiment participants, it was verified that a certain degree of sense of agency and body ownership simultaneously arose for multiple avatars representing their physical selves.

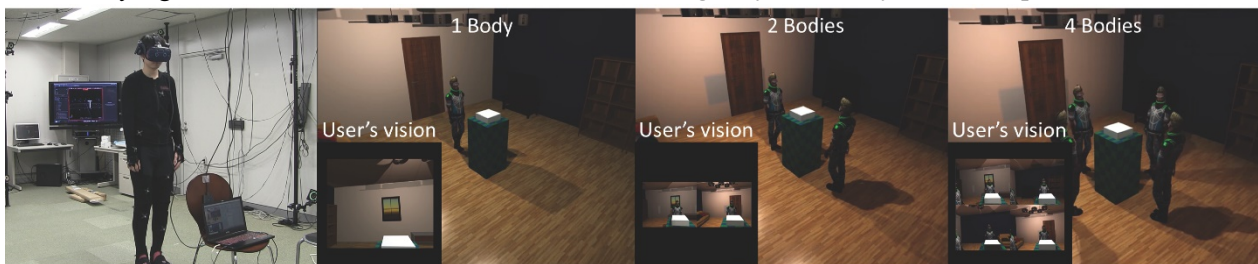
2. Background of Research

We humans use our natural bodies to move around on a daily basis; however, it is possible for these natural bodies to be expanded in various ways through technologies such as wearable robotics and virtual reality. Investigating how people can freely manipulate and recognize these expanded bodies is regarded to be a significant area of research in exploring what the limits are for expanding human potential.

3. Content of Research and Results

In order to synchronize multiple bodies, movements, and sensations, in this study, the movements of the

experiment participants were measured using a motion capturing system (*2) and reflected in all of the avatar bodies, while the visual information from each avatar was simultaneously presented with binocular disparity corresponding to the viewpoints of the left and right eyes by dividing the visual fields of the experiment participants. In the experiment, the tasks of touching randomly generated balls in space using multiple avatar bodies and touching balls that flew to each body were set, and behavior was evaluated using objective indicators while sense of agency and body ownership were verified through subjective indicators. When compared with conditions in which a single avatar body was being manipulated, it was confirmed that tasks could be completed with less travel distance for conditions in which multiple avatars were being manipulated simultaneously. On the other hand, when compared with conditions for a single avatar body, the time to complete tasks did not reduce when the number of avatar bodies increased, suggesting that the surge in cognitive load due to the increased sensory information resulting from a larger number of bodies had had an effect. From the subjective evaluation, it was verified that a certain degree of sense of agency and body ownership could be obtained simultaneously for multiple avatars representing the physical body. When conditions in which multiple avatar bodies (4 bodies) were being manipulated was compared with the conditions for a single body, there were multiple items for which no statistically significant differences were found for sense of agency and body ownership.



*Reference video: <https://www.youtube.com/watch?v=IsjvYpgCIPE>

4. Future Developments

If a variety of expanded bodies can be manipulated at will, there are expectations that multiple avatar bodies can be utilized simultaneously to explore space side by side, and it may become possible for an operator to work together with representations of his/her physical self. In the future, there are plans to continue exploring the possibilities of freeing various body manipulations and expanding human potential based on people's body cognition and behavior.

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< Details of original paper >

Reiji Miura, Shunichi Kasahara, Michiteru Kitazaki, Adrien Verhulst, Masahiko Inami, and Maki Sugimoto. 2021. MultiSoma: Distributed Embodiment with Synchronized Behavior and Perception. In Augmented Humans International Conference 2021 (AHs2021), February 22–24, 2021, Rovaniemi, Finland. ACM, New York, NY, USA, 9 pages. <https://doi.org/10.1145/3458709.3458878> 【Augmented Humans 2021 Best Paper Award】

< Glossary >

*1 The body (figure) that acts as the representation of the operator.

*2 Technology for measuring motion using measurement devices such as cameras and inertial sensors.

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