360 Robot Hand Interaction for Group Telepresence with MetaPo

Yoshiki Watanabe
Nozomi Hayashida
yoshiki@ucl.nuee.nagoya-u.ac.jp
linda@ucl.nuee.nagoya-u.ac.jp
Nagoya University
Nagoya, Aichi, Japan

Shin Katayama
Kenta Urano
shinsan@ucl.nuee.nagoya-u.ac.jp
vrano@ucl.nuee.nagoya-u.ac.jp
Nagoya University
Nagoya, Aichi, Japan

Takuro Yonezawa
Nobuo Kawaguchi
takuro@nagoya-u.jp
kawaguti@nagoya-u.jp
Nagoya University
Nagoya, Aichi, Japan

ABSTRACT

In this demonstration paper, we present the RHS360, a 360-degree robotic hand system designed to facilitate communication across spatial domains. The RHS360 is capable of providing continuous alignment between the user's position in the cyber space and the robotic hand's position. Furthermore, it allows users in the cyber space to reposition the robotic hand to accommodate their movements within the space. Our system not only enables communication, including gestures, through the use of the robotic hand but also provides essential social cues that are crucial in effective communication.

CCS CONCEPTS

• **Human-centered computing → Interaction devices**.

KEYWORDS

Group Telepresence, Robot Hand System, Virtual Reality

ACM Reference Format:
Yoshiki Watanabe, Nozomi Hayashida, Shin Katayama, Kenta Urano, Takuro Yonezawa, and Nobuo Kawaguchi. 2023. 360 Robot Hand Interaction for Group Telepresence with MetaPo. In *The International Conference on the Internet of Things (IoT 2023), November 7–10, 2023, Nagoya, Japan.* ACM, New York, NY, USA, 3 pages. https://doi.org/10.1145/3627050.3630730

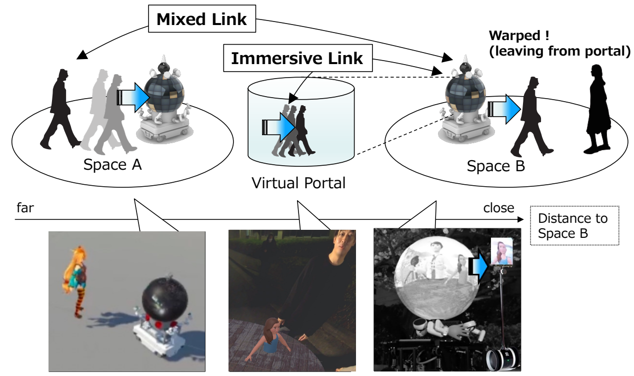

Figure 1: Interspace communication by MetaPo - Mixed Link and Immersed Link[6].

1 INTRODUCTION

Information technology extends our living space to cyber space, i.e., virtual reality or the so-called metaverse. In addition, as the digital counterpart of a physical space, the concept of digital twins[3] attracts many researchers in both academia and industry in the smart city context. Thus, methods to connect or integrate such various spaces are getting more important for enhancing communication and services among these spaces. To tackle the problem, we proposed a new concept called MetaPo[6], a robotic meta portal for interspace linking between physical and cyber spaces. MetaPo can be placed at both physical and cyber spaces, and provide a unified user experience to the users in both spaces by leveraging its 360° I/O, spherical vision and robotic functions. MetaPo provides two levels of linking spaces, called 1) Mixed Link where the users remain in each respective spaces, and 2) Immersive Link where remote users virtually migrate into a local MetaPo instance (see Figure 1). With these functions and services, MetaPo works as a portal to connect distributed physical and cyber spaces and realizes the group telepresence.

In this demonstration, we present flexible robot hand architecture for the group telepresence. By employing a robotic hand in telepresence, we can engage in more direct interactions with remote spaces, expanding beyond just video and audio communication. However, in the 360-degree environment provided by MetaPo, where multiple users can freely move within the space, a fixed robotic hand is not desirable. Therefore, this study aims to construct a mechanism that allows multiple robotic hands to move freely in all 360-degree directions, thereby accommodating the use of multiple users and unrestricted spatial mobility. In this demonstration, we implement MetaPo equipped with three 360-degree robotic hands and conduct a real-world demonstration.

2 RELATED WORK

In existing research, it has been demonstrated that sharing the same physical space between robots and humans during communication has a positive impact on humans. Li et al. showed that the physical presence of a robot has a stronger influence on interactions with humans compared to computer graphics-based agents[2]. Additionally, research has reported on the impact of gestures in communication, with Dargue et al. investigating whether gestures contribute to the understanding of language information[1]. They classified gestures into four categories: iconic gestures, metaphonic gestures, deictic gestures, and beat gestures, and demonstrated the usefulness of all types of gestures.

IoT 2023, November 7–10, 2023, Nagoya, Japan

ACM ISBN 979-8-4007-0854-1/23/11.
https://doi.org/10.1145/3627050.3630730

Furthermore, Shane Saunderson and colleagues conducted research on the psychological impact of human-robot interactions, showing that robots can effectively convey emotions through gestures, enhancing emotional expression[4]. Tanaka et al. examined the effects of discrepancies in the position and size of a user's face and a robot hand when performing a handshake with a remote communication partner[5]. The results of their experiments showed that while there was no significant difference in spatial co-presence and social bonding concerning size discrepancies, ensuring position alignment improved spatial co-presence and social bonding.

Thus, existing studies have shown the effectiveness of using gestures expressed by robots in telepresence communication. However, these studies have primarily focused on fixed robotic hands and have not addressed the issue of user mobility within spaces connected by telepresence, as in the case of MetaPo. The proposed method allows the robotic hand to move in all 360-degree directions while a user in the cyber space operates it for communication. This ensures alignment between the user's position in the cyber space and the robotic hand's position, enabling effective gesture-based communication. Therefore, this research emphasizes the importance of maintaining position alignment.

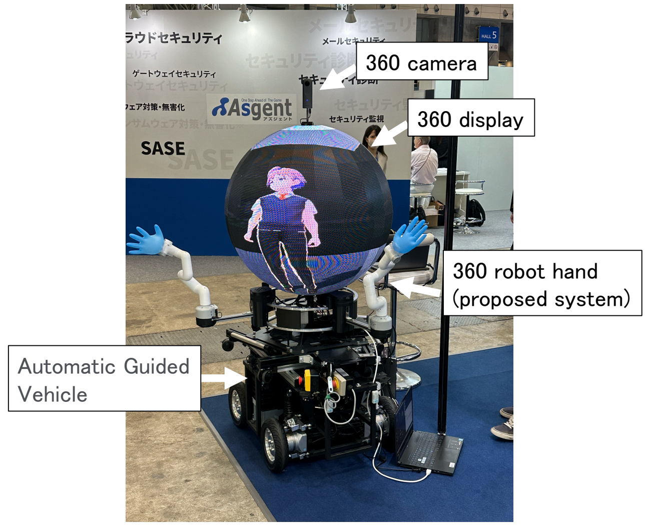

Figure 2: MetaPo with RHS360.

3 360 ROBOT HAND SYSTEM

3.1 Communication Model in MetaPo

In MetaPo, two fundamental inter-space communication modes have been defined(see Figure 1), named the Mixed Link and Immersive Link. Each mode supports traditional communication methods like video calls, but MetaPo has the following unique features.

Mixed Link is a communication mode that connects distant spaces on an equal footing. In this mode, users in their respective spaces can communicate with users in another space while leaving their physical bodies in their own spaces, using panoramic audiovisual media. While Mixed Link supports conventional audio and video calls, MetaPo enhances the experience with 360-degree hardware, providing a wider field of view and improved audio communication.

Immersive Link, on the other hand, offers a more immersive form of connectivity. In this mode, remote users wear VR devices and enter the virtual portal of MetaPo in the cyber space. The virtual portal displays a 360-degree surround video around MetaPo, creating a highly immersive communication environment. Additionally, users in the cyber space can manipulate the robotic hand installed in the MetaPo of the communication partner's space, enabling communication that includes gestures, in addition to video and audio interactions.

3.2 Design and Implementation of RHS360

Figure 2 shows overview of our proposed system for the demonstration. Our proposed 360 robot hand system called RHS360 is integrated to MetaPo.

Figure 3 illustrates the system configuration of RHS360. In RHS360, when a user in the cyber space transitions to the robotic hand control mode, the system automatically assesses and selects an unused robotic hand among others and positions it in a way that maintains alignment with the user's arm. This alignment ensures that gesture-based communication is possible, thus enhancing social bonding and improving the overall communication experience.

Furthermore, when initiating communication, the receiving user sees the robotic hand moving alongside the user in the cyber space, as depicted in Figure 4. The receiving user not only observes the movements of the counterpart's image on the flat surface but also witnesses the scene of a robotic hand in the same space approaching alongside the counterpart. This movement serves as a social cue and aids in understanding which user the robotic hand operator intends to communicate with.

In this manner, the proposed approach addresses two critical issues that arise when communicating between spaces with mobility, such as MetaPo: "alignment maintenance" and "presentation of social cues."

4 CONCLUSION

In this study, we propose the RHS360, a high-degree-of-freedom robotic hand system integrated with MetaPo, designed for telepresence environments involving multiple users. In this live demonstration, we utilize the actual hardware to achieve real-time group telepresence. Furthermore, participants will have the opportunity to experience the RHS360 in action, witnessing its ability to follow the positions of users within the virtual space and providing them with control.

Through this demonstration, we aim to elucidate the advantages and constraints of our concept. Additionally, we intend to engage in discussions with participants about innovative applications of IoT facilitated by our approach.

ACKNOWLEDGMENTS

This research is supported by JST CREST JPMJCR22M4.

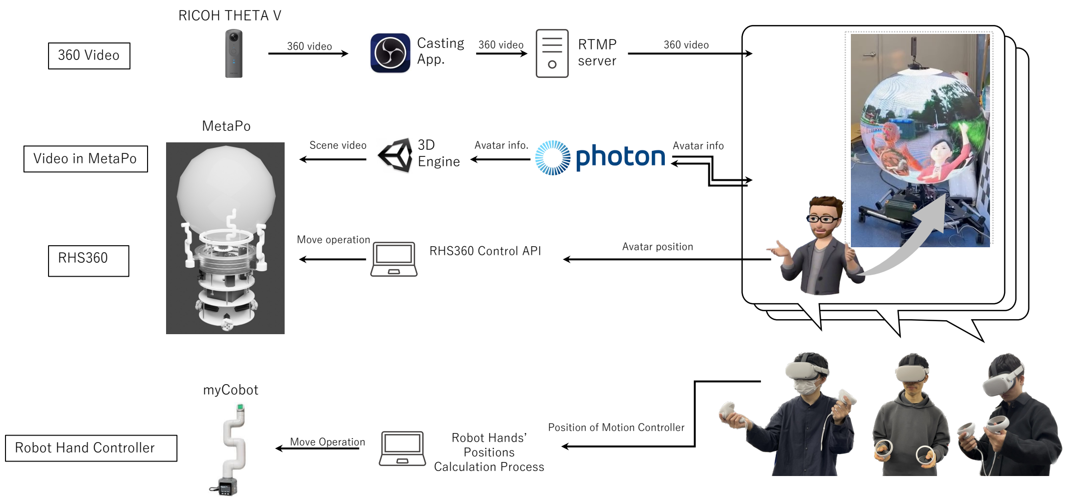

Figure 3: System overview of MetaPo including RHS360.

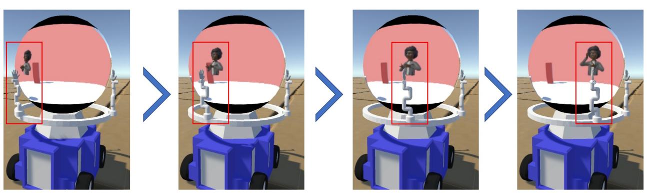

Figure 4: Social cue provided by RHS360.

REFERENCES

[1] Nicole Dargue, Naomi Sweller, and Michael P Jones. 2019. When our hands help us understand: A meta-analysis into the effects of gesture on comprehension. *Psychological Bulletin* 145, 8 (2019), 765.

[2] Jamy Li. 2015. The benefit of being physically present: A survey of experimental works comparing copresent robots, telepresent robots and virtual agents. *International Journal of Human-Computer Studies* 77 (2015), 23–37.

[3] Roberto Saracco. 2019. Digital Twins: Bridging Physical Space and Cyberspace. *Computer* 52, 12 (2019), 58–64. https://doi.org/10.1109/MC.2019.2942803

[4] Shane Saunderson and Goldie Nejat. 2019. How robots influence humans: A survey of nonverbal communication in social human–robot interaction. *International Journal of Social Robotics* 11, 4 (2019), 575–608.

[5] Kazuaki Tanaka, Reo Mayuzumi, Tomomi Takahashi, Sho Takaki, and Natsuki Oka. 2021. Robot Mediated Handholding Combined with a Mobile Video Call Makes the Users Feel Nearer and Closer. In *Proceedings of the 9th International Conference on Human-Agent Interaction*. 3–12.

[6] Takuro Yonezawa, Nozomi Hayashida, Kenta Urano, Johannes Przybilla, Yutaro Kyono, and Nobuo Kawaguchi. 2022. MetaPo: A Robotic Meta Portal for Interspace Communication. In *ACM SIGGRAPH 2022 Posters* (Vancouver, BC, Canada) *(SIGGRAPH '22)*. Association for Computing Machinery, New York, NY, USA, Article 28, 2 pages. https://doi.org/10.1145/3532719.3543255