MetaPo: A Robotic Meta Portal for Interspace Communication

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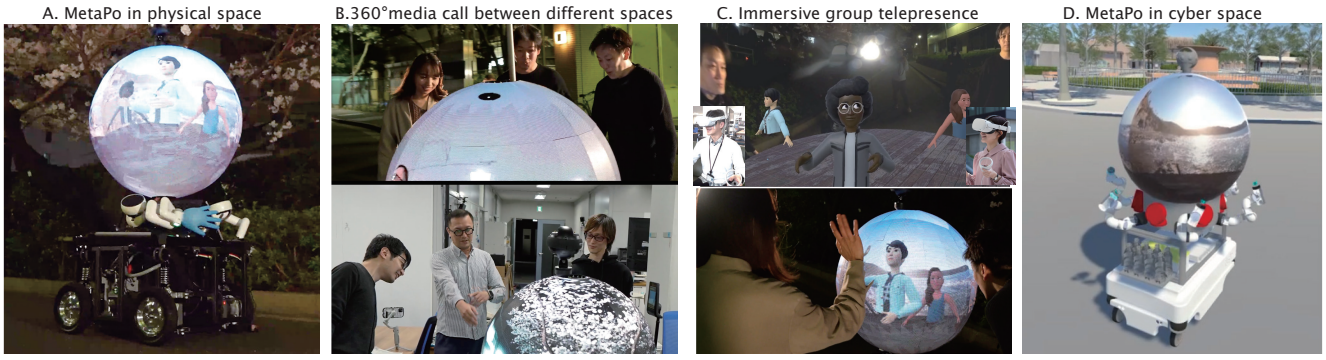

Figure 1: Interspace communication with MetaPo, unifying communication among different spaces with 360° telecommunication and immersive group telepresence.

ABSTRACT

We introduce MetaPo, a mobile robot with spheric display, 360° media I/O and robotic hands for creating a unified model of interspace communication. MetaPo works as a portal between pairs of physical-physical, cyber-cyber and cyber-physical spaces to provide 1) panoramic communication for multiple remote users, and 2) immersive interspace migration with mobility functionality. The paper overviews our concept and first prototype of MetaPo with its hardware and software implementation.

CCS CONCEPTS

• **Human-centered computing** → **Virtual reality**; **Collaborative and social computing**.

KEYWORDS

virtual reality, cyber-physical system, interspace communication

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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[Saracco 2019] 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. Many methods have been proposed to bridge physical and cyber worlds, however, there still remains an unsolved key challenge - "what is the unified way to connect distributed physical and cyber spaces?".

We introduce a new concept called MetaPo, a robotic meta portal for interspace linking between physical and cyber spaces. MetaPo can be placed at both physical and cyber spaces (A. and D. in Fig.1), 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 (B. in Fig.1), and 2) Immersive Link where remote users virtually migrate into a local MetaPo instance (C. in Fig.1). With these functions and services, MetaPo works as a portal to connect distributed physical and cyber spaces. Moreover, it envisions the future social network where physical and cyber boundaries are fading seamlessly.

2 METAPO

2.1 Design

MetaPo is designed to work as a portal that connects distributed physical and cyber spaces. Fig.2 shows the concept design of MetaPo. MetaPo is a four-wheeled robot which equips several I/O components such as 360° camera and microphone, directional speakers,

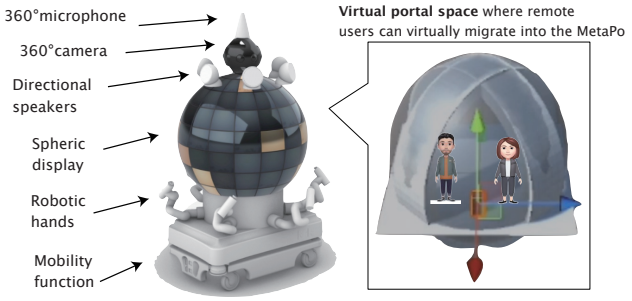

Figure 2: Design of MetaPo with virtual portal.

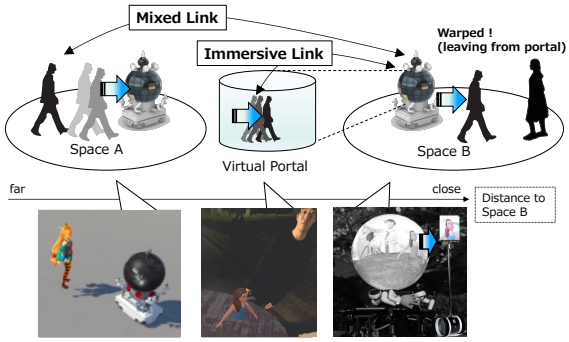

Figure 3: Interspace communication by MetaPo - Mixed Link and Immersed Link.

spheric display, and robot hands for physical interaction. In addition, each MetaPo has its corresponding virtual portal space where remote users can virtually migrate into the MetaPo. This enables immersive group telepresence via VR devices, allowing various kinds of applications within the MetaPo platform. We assume that one-to-many remote communication creates a psychological load to both sides due to its asymmetric relationship. It would mean, that applications that connect remote spaces should provide multi-user capability for any service. Therefore, MetaPo supports panoramic I/O function and multiple robot hands for multi-users experiences, as well as conventional one-to many communication.

2.2 Interspace Communication

MetaPo defines two basic communication modes between different spaces, named Mixed Link and Immersive Link. Conventional communication methods are supported in each mode, but we focus on the differences below.

Mixed Link is a communication mode that connects remote spaces by treating them as equal. Users in each space can communicate with users in another space using the panoramic audiovisual media, while keeping their own bodies in their respective spaces. Conventional voice/video calls can be placed in the Mixed Link scenario, but additionally MetaPo provides a broader view and voice communication by using it's 360° hardware. Furthermore, MetaPo can be moved freely by using its mobility function. These features provide flexible communication from any direction, instead of conventional fixed and limited directional communication.

Immersive Link is a communication mode that connects users to remote spaces in a more immersive way. In this mode, remote users enter MetaPo's virtual portal, which is located in a different space, by wearing VR devices. The virtual portal projects a 360° surround image of the MetaPo's surroundings, enabling highly immersive communication. Single user VR telepresence is supported in the Immersive Link mode, but MetaPo provides group telepresence with panorama and mobility capability.

Fig.3 shows the relationship of Mixed Link and Immersive Link - starting from Mixed Link, users in space A can get closer to space B through a transition to Immersive Link. MetaPo also plans to support conventional single-user telepresence devices. This implies that the MetaPo platform provides additional "warp" mode that allows the users to leave MetaPo's shared virtual portal, and move freely through a remote space individually. This will also allow us to compare our many-to-many scenarios with traditional one-to-many scenarios in future work. Existing work has introduced similar conceptual methods for multi-user communication in different ways, such as panoramic communication with a spherical display [Li et al. 2020] or immersive group telepresence[Beck et al. 2013]. MetaPo provides a seamless integration of those communication modes through its hardware and software combination and adds several actuating and mobility functions.

2.3 Prototype

For the hardware implementation, we combine Insta360, H3-VR microphone, LED spherical display SP2.5, myCobot 280 M5, AIO-2GEN speakers, and HAKOBOT. The current prototype has a height of 120 cm and weighs 160 kg. For the software implementation, we use the RTMP protocol for media streaming in both Mixed Link and Immersive Link scenarios. For the implementation of the virtual portal, we leverage the Unity engine with the Oculus Integration SDK. The spheric display shows two types of panoramic views - one from the physical 360° camera (Mixed Link) and the other from the surrounding view of the virtual portal space (Immersive Link). The surrounding view is composed by stitching multiple perspectives from virtual cameras placed around the virtual portal space.

3 CONCLUSION

We proposed MetaPo, a robotic meta portal for interspace communication. MetaPo introduces a new linking model of spaces, that handles both physical and cyber spaces equivalently, enabling a unified and seamless communication between them.

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REFERENCES

Stephan Beck, André Kunert, Alexander Kulik, and Bernd Froehlich. 2013. Immersive Group-to-Group Telepresence. *IEEE Transactions on Visualization and Computer Graphics* 19, 4 (2013), 616–625. https://doi.org/10.1109/TVCG.2013.33

Zhengqing Li, Theophilus Teo, Liwei Chan, Gun Lee, Matt Adcock, Mark Billinghurst, and Hideki Koike. 2020. *OmniGlobeVR: A Collaborative 360-Degree Communication System for VR.* Association for Computing Machinery, New York, NY, USA, 615–625. https://doi.org/10.1145/3357236.3395429

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