Trans-scale Playground: An Immersive Visual Telexistence System for Human Adaptation

Satoshi Hashizume*
University of Tsukuba
Ibaraki, Japan
pota1401@hotmail.co.jp

Akira Ishii*
University of Tsukuba
Ibaraki, Japan
ishii@iplab.cs.tsukuba.ac.jp

Kenta Suzuki
University of Tsukuba
Ibaraki, Japan
Ikuzus.atnek.0626@gmail.com

Kazuki Takazawa
University of Tsukuba
Ibaraki, Japan
kazuki.takazawa@pixiedusttech.com

Yoichi Ochiai
University of Tsukuba
Ibaraki, Japan
wizard@slis.tsukuba.ac.jp

Figure 1. Left: Concept of a small-scale to large-scale trans-scale telexistence system. Middle: Our small-scale telexistence system comprising a controllable robot and omnidirectional cameras. Right: Our large-scale telexistence system comprising a drone.

ABSTRACT
In this paper, we present a novel telexistence system and design methods for telexistence studies to explore spatial-scale deconstruction. There have been studies on the experience of dwarf-sized or giant-sized telepresence have been conducted over a period of many years. In this study, we discuss the scale of movements, image transformation, technical components of telepresence robots, and user experiences of telexistence-based spatial transformations. We implemented two types of telepresence robots with an omnidirectional stereo camera setup for a spatial trans-scale experience, wheeled robots, and quadcopters. These telepresence robots provide users with a trans-scale experience for a distance ranging from 15 cm to 30 m. We conducted user studies for different camera positions on robots and for different image transformation method.

UIST '18 Adjunct October 14–17, 2018, Berlin, Germany

ACM ISBN 978-1-4503-5949-8/18/10.

DOI: https://doi.org/10.1145/3266037.3266103

Author Keywords
Telepresence; telexistence; omnidirectional image; immersive experience; out-of-body.

INTRODUCTION
Recently, numerous studies on telexistence systems using head-mounted displays (HMDs) have been explored. These systems utilize the sense of being highly immersed that is induced by HMDs to produce a sensation of being present in a space and time that the user could not otherwise experience. These telexistence systems are also used for remote communication and remote control. By designing the layout of sensors and the system, it provides users the experience of feeling as if they have taken on the identity of another persons or objects. JackIn Head [1] is an immersive telexistence system that enables a user to experience a 360° spherical image of the surroundings from the perspective of the target person, allowing the user to experience those surroundings from the perspective of that person and enabling the user to understand how the target person sees (e.g., a professional athlete, or a musician).

Furthermore, telexistence systems not only enable experiences of real people but also imaginary existences and objects. In particular, these systems have been used in attempt to expand human physicality to scales different from that of the self and to apply this to the fields of entertainment and

* Hashizume and Ishii contributed equally to the work.

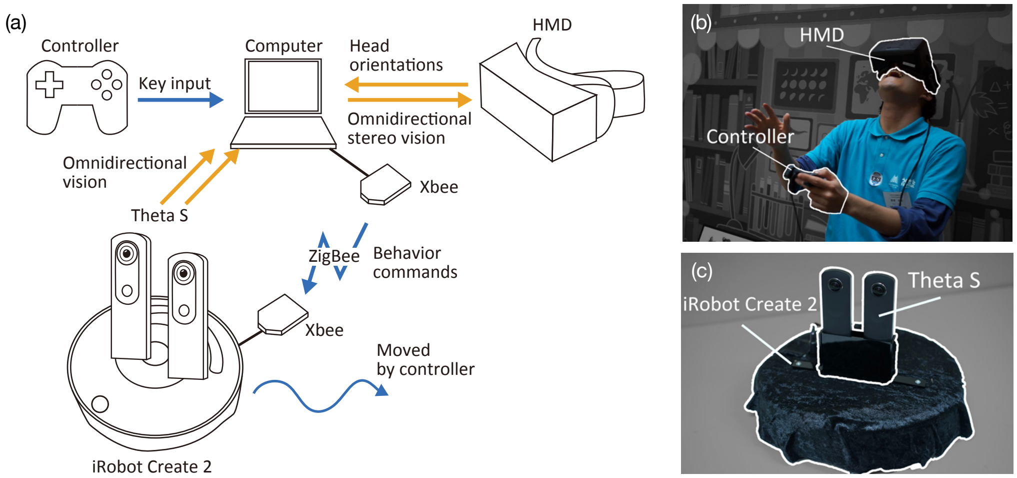

Figure 2. System overview. (a) System components. (b) User-side components. (c) Target-side components.

design. CHILDHOOD [2] is another immersive telexistence system that enables a user to experience the world from a child's perspective. By experiencing and understanding the child's viewpoint, which is lower than an adult's viewpoint, the information obtained can be used for universal design and applied to products or architectures. The concept of our system, Trans-scale Playground is shown in Figure 1. Telexistence greatly expands the user's physicality and can be expected to significantly contribute to various fields. However, existing research does not explore in depth the contribution of design elements of telexistence (e.g., viewpoints and distance between pupils) on the user's experience across different scales. In this research, we developed a trans-scale existence system that allows users to move on different scales.

This system provides an extracorporeal experience of a user's surroundings due to the presence of viewpoints on different scales. We focus on extracting and evaluating the design factors of the telexistence system that differ from those of the user's scale. Evaluating the sensation that the user undergoes during a change in the scale contributes to the research in the field of telexistence. In particular, it facilitates developments to enhance the sense of immersion into objects other than imaginary objects and human beings, and to further expand human physicality.

IMPLEMENTATION

An overview of our system is shown in Figure 2. Our telexistence system comprises a remote controlled robot[1] that moves around freely, a controller to manipulate the robot, two omnidirectional cameras[2] to provide a 360° image source, an HMD to display spherical images, wireless modules to control the robot, and a laptop.

The robot wirelessly connected to the laptop, receives the user's inputs upon controller operation, and moves depending on the user's inputs. In this research, we adopted two types of robots. A drone flying in the air is used for experiences larger than the user's scale, and a cleaning robot moving on land is used for experiences smaller than the user's scale. Both robots move based on hot the user operates the controller.

We adopted an omnidirectional camera as the camera on the target's side to capture image from the robot's viewpoint. Changing the viewpoint in response to the user's head movement is necessary for a building virtual body image. This system can provide free-viewpoint accordance with the movement of the user's head without any special mechanism because the omnidirectional cameras can capture 360° images around the slave.

This method enable faster and smoother changes in viewpoint compared to alternative methods that use a wide-angle camera attached to the front of the robot. Using omnidirectional cameras together with image processing can facilitate a faster change in viewpoint compare with systems using a forward-facing wide-angle camera on the robot that changes the viewpoint via robot movement. Therefore, in this study, two omnidirectional cameras were used to achieve binocular vision.

The omnidirectional cameras are attached to the top of the robot, which is connected to the laptop via a wireless HMD transmitter. The computer converts 360° images into spherical images on Unity and sends the images to the an HMD via HDMI cable. The HMD displays the spherical images corresponding to the movement of the user's head.

DEMONSTRATION

We demonstrated a prototype of our system at an exhibition at the Umekita Festival 2016, held at the Grand Front Osaka in Osaka, Japan, from March 30, 2016, to April 2, 2016. More than one hundred visitors experienced our system (a dwarf version). We obtained various feedback: *"I found this installation enjoyable" "This is a unique experience that has never been accomplished before"* and *"I felt as I was literally a dwarf, and the feeling of oppression due to the taller people generated by the viewpoint of this system was scary."*

[1]https://www.irobot.com/About-iRobot/STEM/Create-2.aspx, (last accessed August 15, 2018).

[2]https://theta360.com/en/about/theta/s.html, (last accessed August 15, 2018).

REFERENCES

1. Shunichi Kasahara and Jun Rekimoto. 2015. JackIn Head: Immersive Visual Telepresence System with Omnidirectional Wearable Camera for Remote Collaboration. In *Proceedings of the 21st ACM Symposium on Virtual Reality Software and Technology (VRST '15)*. ACM, New York, NY, USA, 217–225. DOI: http://dx.doi.org/10.1145/2821592.2821608
2. Jun Nishida, Hikaru Takatori, Kosuke Sato, and Kenji Suzuki. 2015. CHILDHOOD: Wearable Suit for Augmented Child Experience. In *ACM SIGGRAPH 2015 Emerging Technologies (SIGGRAPH '15)*. ACM, New York, NY, USA, Article 7, 1 pages. DOI: http://dx.doi.org/10.1145/2782782.2792501