XR Framework for Collaborating Remote Heterogeneous Devices

Jongyong Kim* Jonghoon Song* Woong Seo† Insung Ihm† Seung-Hyun Yoon‡ Sanghun Park*

* Dept. of Multimedia, Dongguk University, Korea
† Dept. of Computer Sci. and Eng., Sogang University, Korea
‡ Dept. of Multimedia Eng., Dongguk University, Korea

Abstract

With the advent of high-speed 5G networks, establishing a remote space-sharing XR environment that supports real-time interaction based on the latest VR/AR/MR technology is receiving attention as a promising new research topic. With that aim, we have developed a framework that allows users with different types of devices, in different physical spaces, to effectively build a virtual world where collaborative work can be performed. By using this technology, new types of content can be effectively produced that can interact in real time with various commercial VR/MR head-mounted displays, smart mobile devices, and even beam projectors. In this paper, we demonstrate the effectiveness and potential of this framework through the example of game content development where MR and VR head-mounted display users interact in virtual space.

Index Terms: Human-centered computing—Human computer interaction—Interaction paradigms—Mixed/augmented reality; Human-centered computing—Human computer interaction—Interaction paradigms—Virtual reality

1 Introduction

Research related to extended reality (XR) receive considerable attention due to advances in graphics hardware technology supporting ultra-high-definition real-time rendering, improved performance of head-mounted display (HMD) devices that can display high-resolution images, the development of convenient content-making software, and, most importantly, the commercialization of high-speed 5G networks.

Initial XR studies focused on technology that links multiple disparate devices, rather than running on a single device type. Guggenheimer et al [1] proposed a system that enables interaction between users wearing VR (virtual reality) HMDs and users without HMDs. To improve the immersion of bare-eye users, a beam projector was used to project the space experienced by HMD users. In a similar manner, Zenner et al [3] proposed a VR rock climbing system, which projects virtual rock walls through a beam projector, allowing bare-eye users to experience virtual space indirectly. However, these systems reveal a limitation in increasing the immersion of the users due to their simple projection of virtual space on the floor. Lee et al [2] suggested a method to add a 360 degree camera to HoloLens for real-time streaming of captured images to VR HMD, and to interact with hand tracking information.

2 System Configuration

In this study, we assume situations in which remote users connected by high-speed networks use different devices, and propose an XR framework for effectively producing content that allows them to share virtual space and interact in real time. In addition to supporting the connectivity of typical commercial VR AR (augmented reality) and MR (mixed reality) HMDs, the framework can also work with a specially designed multi-beam projector cooperative solution BtS (beyond the sight) to alleviate the narrow viewing angle problem created by the limitations of MR devices. The overall configuration is shown in Figure 1, consisting largely of the XR framework and BtS solutions. The XR framework provides functions such as sharing coordinate systems among disparate devices connected remotely, and interface integration between heterogeneous devices. The BtS solution supports the linkage of MR devices with projection mapping images made by multiple beam projectors.

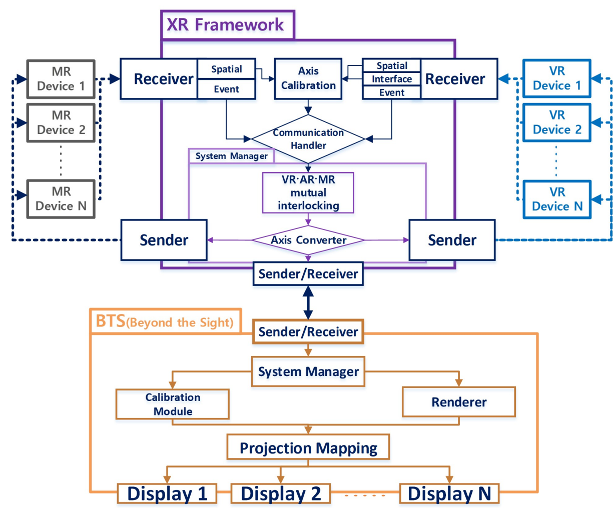

Figure 1: Overall system structure

The XR framework is designed to take full advantage of the positive properties of individual devices. For example, most HoloLens novices feel uncomfortable with the unfamiliar hand gesture interface. However, using the device-to-device calibration technique included in the XR framework, a much more intuitive VIVE controller can be connected to HoloLens.

The BtS solution includes not only inter-projector calibration to create a space surrounded by large wide images created by N multiple beam projectors but also the ability to calibrate between MR devices and projectors (see Figure 2). In addition, using the real-time interlocking property of projectors and MR HMDs, it is possible to create dynamic scenes in which 3D graphic objects move freely on 2D projected screens and in 3D MR space. Figures 3(a) and 3(b) show car images with the front clipping made by the beam projector, and rear clipping images rendered in the MR HMD, respectively. The final result of combining images of these two independent devices is shown in Figure 3(c). To establish a common coordinate system between devices, a beam projector projects a marker on the screen, and each MR HMD recognizes it and then sets the corresponding position as the origin of the world coordinates.

*e-mail: {khj8499,whdrktsk1218,mshpark}@dongguk.edu
†e-mail: {wng0620,ihm}@sogang.ac.kr
‡e-mail: shyun@dongguk.edu

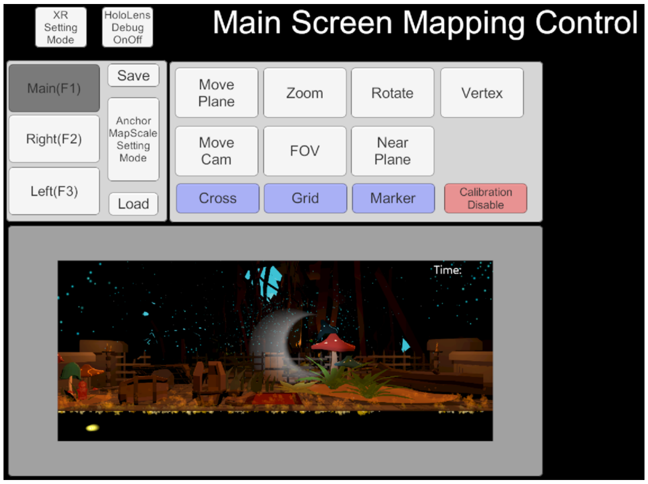

Figure 2: GUI for calibration between heterogeneous devices

(a) Display device view

(b) MR device view

(c) Composite result

Figure 3: Final result combining clipping images rendered by individual devices

3 Demonstration Content

Bright Space content has been created to demonstrate the potential for effective use of this system (see Figure 4). This is a game content in which players achieve their goal through real-time interaction in situations where multiple HoloLens and VIVE users share virtual space by connecting to the server from physically separate environments. MR users playing in the projection space created by the BtS solution will play the role of golem protecting the treasures of dungeon, as shown in Figure 4(a), while VR users will participate in the game as an adventurer who steals treasures, as shown in Figure 4(b). MR users attack the adventurers hiding in the dungeon using a flashlight, which is a VIVE tracker with an attached custom interface. On the contrary, VR users have to go around the game space to gather hidden keys, open boxes and steal treasures without being caught by golem.

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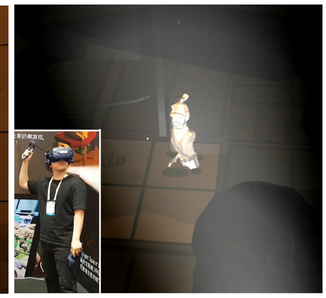
(a) MR user in golem role



(b) VR user in adventurer role

(c) Game scene from the third-person point of view

Figure 4: Bright Space built on development system

4 Conclusion

The system demonstrates new forms of XR content that can connect remote users using heterogeneous devices in real time and work with projection mapping technology. We have demonstrated the superior performance of our developed XR technology and presented its potential for future expansion.

Acknowledgments

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