# Development of a Telepresence System for Sharing 3D Physical Objects
## Sharing real-time point clouds between multi users by using Mixed Reality

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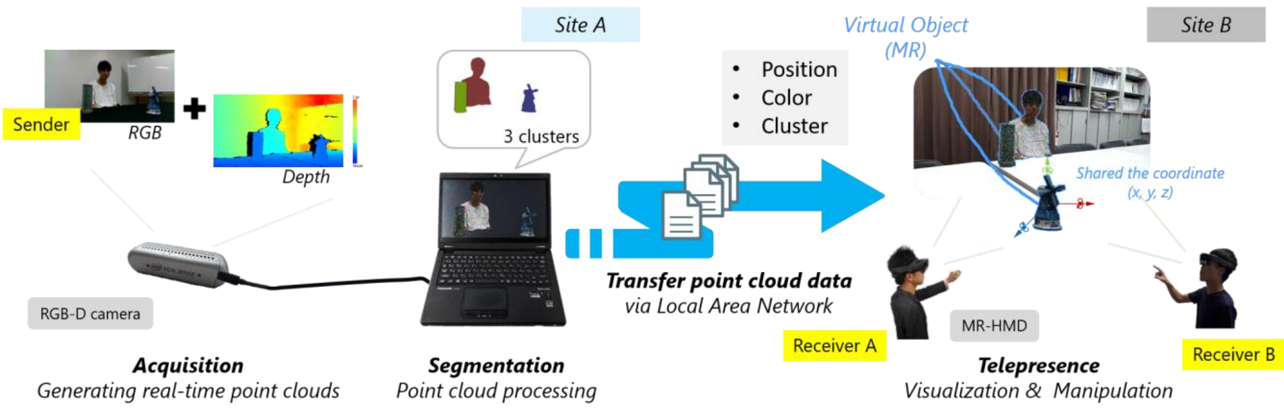


Figure 1. The proposed system configuration

## 1. Introduction

Consensus building between stakeholders is necessary to enhance the quality of the decision-making. Telepresence allows one to feel as though other users in remote areas were presently at the same location[1].

Virtual Reality (VR) and Mixed Reality (MR) can provide immersive experiences with people wearing VR/MR-Head Mounted Display (HMD). Kantonen *et al.* proposed an MR telepresence system, Augmented Collaboration in Mixed Environment (ACME) that can share 3D virtual objects made by Building Information Modeling (BIM) between stakeholders[2]. However, this system requires 3D virtual models to be made in advance, making it difficult to share 3D physical objects whose shapes continuously change in real-time.

Real-time point clouds enable modeling of 3D physical objects in real-time by using an RGB-D camera. In our previous research, Ishikawa *et al.* proposed an immersive telepresence system to improve operability of real-time point clouds in order to share and manipulate the 3D physical objects more easily in remote areas[3]. This system only allows one-to-one communication: a sender and a receiver.

The research presented in this paper aims to develop a telepresence system adapted into multi users communication: a sender and some receivers. This is accomplished by sharing the coordinates of 3D virtual objects between MR-HMDs the receivers wearing.

## 2. System configuration

Figure 1 shows the proposed system configuration. At first, an RGB-D camera simultaneously captures the RGB images and depth data in real-time to generate real-time point clouds. After point cloud processing for point cloud segmentation, real-time point clouds are classified into individual clusters by the Euclidean Cluster Extraction method[4].

Point cloud data with XYZ coordinates, RGB color values, and cluster information of real-time point clouds are transmitted to MR-HMD devices in a remote area connected via the same Local Area Network (LAN). Receivers wearing MR-HMD is able to observe, in the real world, 3D virtual objects generated by point cloud data through MR in real-time. Connecting each MR-HMD with a server PC, the coordinates of 3D virtual objects among MR-HMDs are shared.

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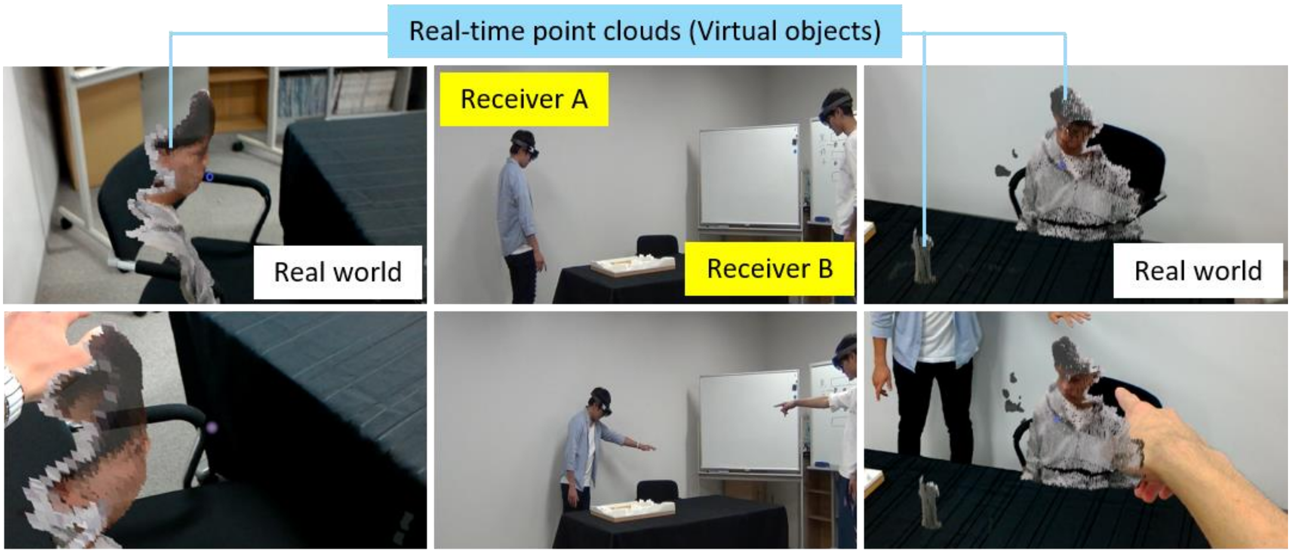


(a) The receiver A's view through HoloLens  (b) The state of receiver A and the receiver B  (c) The receiver B's view through HoloLens

Figure 2. Sharing the coordinates of 3D virtual objects

**3. Experiment and Result**

In this experiment, two receivers in the same room realized for sharing the coordinate of 3D virtual objects generated using real-time point cloud data acquired from a remote area.

In Figure 6a and 6c, while the receiver A touched 3D virtual objects, the receiver B could observe this situation. From this result, we confirmed that the coordinates of 3D virtual objects were synchronized between the receiver A and the receiver B

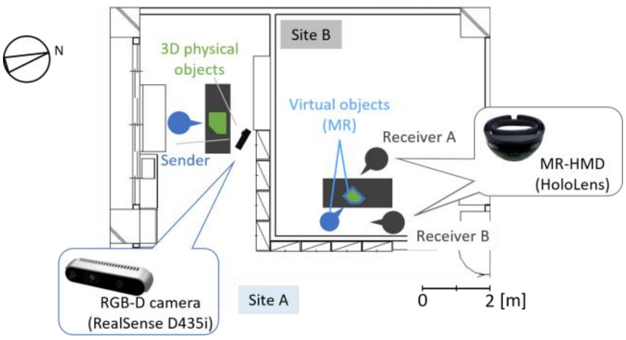


Figure 3. Floor plan showing two sites


(a) Around sender  (b) The view of RealSense D435i

Figure 3. The state of the sender

**4. Limitations**

In the proposed system, some limitations still exist.

The first is the usage environment. In order to use the system, an RGB camera and MR-HMDs are necessary under the same LAN environment.

The second is the light environment. An RGB-D camera is weak to light reflection due to using laser to capture depth data. To run this system better, we prepare a room not too bright.

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