Co-located Sharing Experience for Augmented Reality between HMD and Non-HMD Users

Shihui Xu, Jiro Tanaka
(Graduate School of Information, Production and Systems, Waseda University)

1 Introduction

See-through type head-mounted augmented reality (AR) devices allow for immersive experience where virtual environment is embedded in real physical world[1, 2]. Currently, however, most AR systems of head-mounted display (HMD) are designed for the single user who is wearing the HMD (HMD user), isolating the bystanders without an HMD (non-HMD users) from the AR experience[3]. Previous work shows excluding bystanders can further worsen the experience of HMD user[4]. Therefore, an approach to share the AR experience between HMD and non-HMD users in co-located situation is needed.

Our research focuses on enhancing the co-located sharing experience between HMD user and non-HMD user in AR and enabling non-HMD user also to participate in HMD user's experience. We propose to share the AR objects and their transform between HMD and non-HMD user by sharing AR world to smartphone, also, to enable non-HMD user to interact with the virtual objects by manipulating smartphone.

2 System Design

Figure 1 shows an overview of our system. There are two kinds of users: HMD user using see-through type HMD (HoloLens) and non-HMD user using smartphone (iPhone X). Both users share the AR objects and their transform, and they have independent views so that they could see the AR objects from different point of view. Furthermore, our system enables one HMD user and several non-HMD users to share AR experience together. HMD user can interact with AR system by hand gestures, while non-HMD users can interact by touching the screen of smartphone.

2.1 Shared AR Objects

We propose to share AR objects and their transform to support multiple views from different point for users, including AR environment sharing and transform synchronization. In this case, users can see the AR objects independently.

The AR environment sharing synchronizes AR environments in different devices, therefore enabling users to see the AR objects superimposed on real environment in same coordinate. The procedure is that non-HMD user first scan physical world floor by smartphone to build AR environment on smartphone. When successful to scan, a QR code will arise on smartphone. Non-HMD user need to show the QR code to HMD so that the position of smartphone will be calculated. Then the AR environments in HMD and smartphone will be spatial synchronized.

Transform information of AR objects, including movement, rotation, scale and color, are synchronized for different users. Transform synchronization is client-server structure, HMD as server and smartphone as client. When the transform information changes in HMD, the changes will synchronize directly from server to client by synchronous variables which are provided by Unity

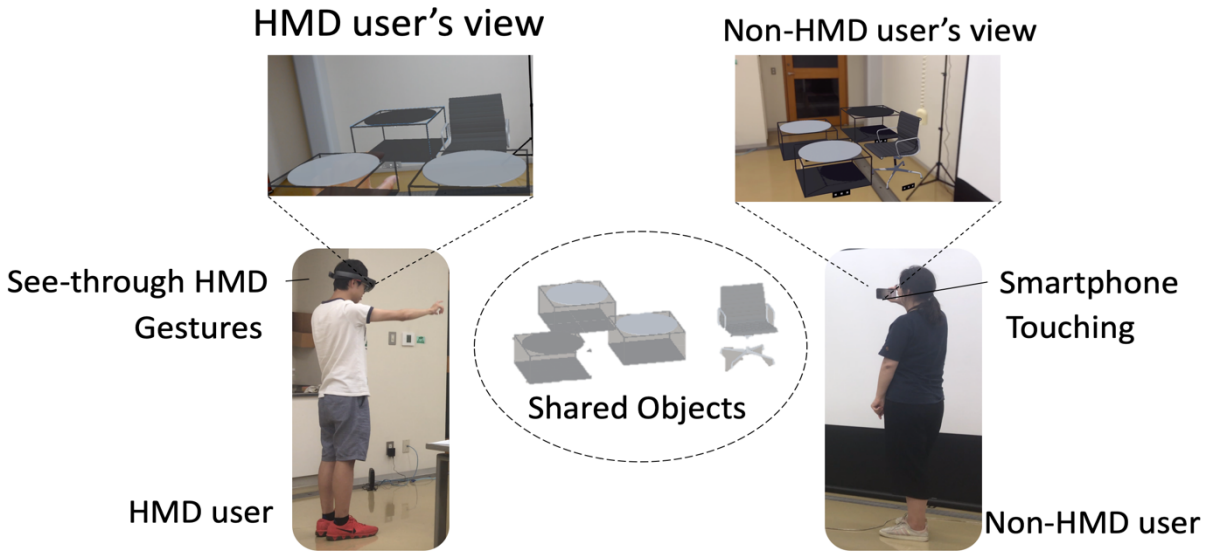

Figure 1 Overview

Network API. When the transform information changes in smartphone, the changes will first synchronize to server by User Datagram Protocol, then the server will synchronize changed transform information to all clients.

2.2 Interaction Methods

Interaction methods are designed for different kinds of users, enabling users to interact with AR objects on their own devices. Non-HMD user interact mainly by touching screen of smartphone. While HMD user interacts by hand gestures. Table 1 shows the comparison of interaction methods for two kinds of users. To move an AR object, non-HMD user can slide the screen with one finger and HMD user can tap to place AR objects on surface of physical world. To rotate an AR object, non-HMD user can use two fingers to twist the screen of smartphone and HMD user can use two hands to rotate a degree. To scale an AR object, non-HMD user can zoom in and zoom out by pinching the screen and HMD user can use two hands to move close and away.

	Non-HMD User	HMD User
Move	Sliding the screen of smartphone with one finger	Tapping to place on surface of physical world.
Rotate	Twisting the screen of smartphone using two fingers	Using two hands to rotate a degree
Scale	Pinching screen of smartphone to zoom in and zoom out	Using two hands to move close and away

Table 1 Interaction methods

3 Evaluation

To explore the effectiveness of our system, we conducted a preliminary evaluation to evaluate our system in terms of willingness to share, enjoyment, share ability, engagement, interaction methods and communication.

We recruited 10 participants as non-HMD users (2 females and 8 males), aged between 20 and 25, and one HMD user aged 20 for the evaluation. The evaluation was conducted in a prepared working space. After using our system, non-HMD participants were asked to evaluate our system using 5-point Likert scale.

Figure 2 shows the average scores of our system. Non-HMD user participants gave very positive feedback. Our system is effective for sharing experience between HMD and non-HMD users.

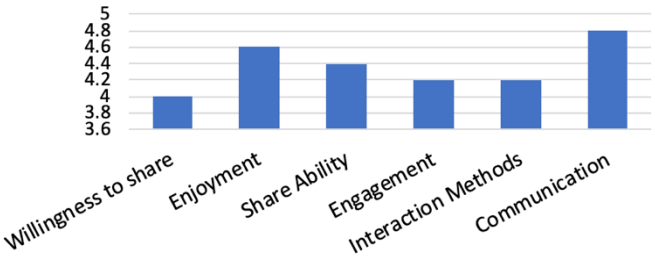

Figure 2 Average scores of evaluation results from non-HMD users

4 Conclusion and Future Work

In this work we design a co-located sharing AR system which enables non-HMD users to share the AR objects and their transform and to interact with AR objects. A prototype with one HMD user and several non-HMD users was made to illustrate our proposal. Further investigation with applying the proposed system to various co-located sharing scenario will help to develop future co-located sharing interfaces.

References

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