A DISTRIBUTED MR TRANSPORTER FOR NETWORKED COLLABORATION

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Abstract: There are several transporter is presented in films. This research aims to realize such transporter by using Mixed Reality (MR) technology. In this paper, the authors introduce a framework of “A Distributed MR Transporter” and following two essential technologies to realize it; 1) The coherency control protocol named “Duplication-Selection-Protocol” for comfortable and joyful collaboration in shared MR space, 2) “Ponch-3D” to acquire and reconstruct remote real space as a simplified 3D model. The proposed framework and technologies can be applicable for several practical applications.

Key words: shared virtual reality, shared mixed reality, coherency control, wearable computer, immersive display

1. Introduction

We can find several transporters in films with which people can be transported to remote place immediately and collaborate with people living on other planet. Such transporters are an ultimate goal for communication and collaboration. Virtual Reality (VR) and Mixed Reality (MR) technologies with the Internet can be a powerful tool to realize transportation virtually.

There are several systems to share a space and enables users to collaborate each other [2][3]. However, foregoing systems are insufficient

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for practical collaboration because these systems can handle only computer generated objects in VR space but not real objects in real environment. Thus, these systems cannot reflect the physical environment to collaborative space.

In this paper, the authors introduce “Distributed MR Transporter” and technologies allowing users comfortable and joyful collaboration in distributed MR environment.

2. Distributed MR Transporter

The framework of “Distributed MR Transporter” is shown as *Figure 1*.

Figure 1. A Distributed MR Transporter

The proposed system serves two kinds of users, the user in immersive display system (user-VR) and the user wearing wearable computer system (user-MR). The user-VR can feel the atmosphere of remote places as a Virtual Reality (VR) space displayed on immersive display system where the user-MR is in. The user-MR can feel the same space via a see-through HMD as the Mixed Reality (MR) space. Both users can place the additional virtual objects in the space and handle objects seamlessly.

The framework can be used for several practical applications such as Interior designing of certain room, town planning of certain ward, sharing a experience, remote rehabilitation training and so on. For example, in case of

interior design, if a user want to install new TV in the user's living room, the user can ask the staff of the shop by using "Distributed MR Transporter". The staff of the shop can offer the best proposal for the user and you can try to fit the TV in the room.

This paper points out several problems for producing shared MR space on heterogeneous platform and gives solutions for the problems.

3. Technologies for Distrubuted MR Transporter

In this section, following two problems and technologies to solve them are introduced; 1) coherency control method to solve conflicts about object handling; 2) real workspace measurement to include scenery of real workspace to the remote VR space.

3.1 Coherency Control Protocol

When an object is shared from multiple users, coherency control is one of the most important problems. Roughly, there are two kinds of coherency control protocols; 1) The methods based on exclusion control; 2) The methods based on lazy locking. The methods based on exclusion control is not suitable for real time communication, and the foregoing method based on lazy locking are not suitable for iterative object manipulation such as interior design because the foregoing protocols can support only one solution when the users' operations result in conflicts. If these protocol is used for the application where the users are iteratively handing objects such as interior design, conflicting object might be jumping between the users like a tag-of-war (*Figure 2*) [3].

The authors proposed the coherency control protocol named "Duplication-Selection-Protocol" for comfortable object handling in shared MR environments [4]. The proposed protocol is a kind of methods based on lazy locking. The proposed protocol solves conflicts by duplicating the object and delegating the resolve to users (*Figure 2*). If the users' operations conflict, the object is duplicated, then the users can discuss which is better one and choose better one by deleting another one. Moreover, the proposed protocol enables user-VR to handle remote real object. If the user-VR wants to move a virtual copy of a certain real object in MR space, the operation results conflict because the real object does not move automatically. The proposed protocol solves the conflict by duplicating the object.

Figure 2. Duplication-Selection-Protocol

Figure 3 shows the example of prototype shared MR interior design system using the proposed protocol. The one of the users is User-VR in cylindrical immersive display system. The User-MR is in the remote certain room. The object is duplicated when User-VR and User-MR tried to move the same chair simultaneously. It is confirmed the operation for the object can be performed without interrupted by another user even if the operation conflicts.

Figure 3. The Experiment with the Proposed Protocol.

3.2 Acquiring the real environment on conclusion

To allow the user-VR to feel the atmosphere of the remote real space, the user can collaborate with the remote user by using information that is difficult to exchange such as position, direction and extent of a room. The authors proposed “Ponch-3D” technologies for acquiring and the atmosphere of the real space and reconstructing it as the simplified VR space.

There are several methods to acquire and to reconstruct a real environment as VR space [5][6]. However, foregoing methods acquire the real space as a pure 3D models, thus, these methods requires a large amount of processing time and cannot produce the meanings of the space to be reconstructed such as the region user can walk. Moreover, if the user-VR concerns about region or object in real space, the foregoing methods do not allow the user to specify the region to be reconstructed in detail. Therefore, these foregoing methods are not suitable for real-time collaboration. The “Ponch-3D” aims to acquire and reconstruct the real space as the simplified models that are sufficient for collaboration.

The basic framework of “Ponch-3D” is shown in *Figure 4*.

“Ponch-3D” uses an omni-directional camera for acquiring the real space. When the user-MR starts to share the space and collaboration, the user-MR puts an omni-directional camera near the user. The omni-directional camera acquires the omni-directional image around the user. The objects in the acquired images are translated to simplified 3D models consisting of texture-mapped floor and walls. Moreover, if the user wants to specify the space to reconstruct, the user can specify the region to reconstructing process by walking around the omni-directional camera.

Figure 4. Ponch-3D

To reconstruct the 3D models from the images acquired from an omni-directional camera, the position and height of objects must be determined. In this method, the position of object on floor can be computed from the angle of elevation of the object from the camera. The height of object is computed to assume all objects' side to be vertical. If the user wants to specify the region to be reconstructed, the position of the user's foot on floor is computed similarly. The trajectories of the user's foot will be used for boundary between objects and floor.

The experiment with "Ponch-3D" has been performed to examine whether the real space can be reconstructed naturally. *Figure 5* shows the image of seminar room in information science building acquired from omni-directional camera and the reconstructed 3D model. The omni-directional camera is putted at 162.5cm height in the centre of the room. A wall at this side has been reconstructed as rounded wall because there is no strong edge between the partition and floor.

Figure 5. Reconstructed Seminar Room

Figure 6 shows the experiment performed at elevator hall in information science building. An omni-directional camera is putted at 141cm height and a person walked around the camera along walls shown as white arrow. When the user is near from the camera, reconstructed wall is not straight because the motion of user's foot affects the position of the user.

However, in both case, the feature of real space is reproduced. Moreover, these errors in reconstructing can be reduced by using user's trajectories.

Figure 6. Reconstructed Elevator Hall

4. Conclusion

In this paper, the authors proposed a framework of “Distributed MR Transporter” that enables a user to collaborate with user in remote real space and two essential problems are introduced to realize the comfortable collaboration in shared MR space.

The proposed “Duplication-Selection-Protocol” enables the users to handle the object even if the handling of object results in conflict and it is confirmed by using prototype system. “Ponch-3D” technology realizes the acquiring and reconstructing the feature of real space as a simplified VR space and it is confirmed the reconstructed shape from the trajectories of the users can produce the feature of real space.

It is expected the proposed frameworks and technologies can be used for more comfortable and joyful collaboration in various fields.

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