Indian Journal of Science and Technology, *Vol 9(24), DOI: 10.17485/ijst/2016/v9i24/96161, June 2016*
ISSN (Print) : 0974-6846
ISSN (Online) : 0974-5645

Realization of Multi-User Tangible Non-Glasses Mixed Reality Space

A-Leum Jung[1*], Min-Geun Kim[1], Woo-Cheol Shin[2] and Kyounghak Lee[3]

[1]Department Virtual Augmented Reality, Namseoul University, Korea;
ddoddi47@naver.com, kumi1219@hanmail.net
[2]Department Mogencelab, Korea; pureraniny@mogencelab.com
[3]IACF, Namseoul University, Korea; khlee@nsu.ac.kr

Abstract

Background/Objectives: Studies on convergent space, where multiple users can participate simultaneously, are lacking despite the spatial characteristic of mixed reality space where several people can coexist. **Methods/Statistical Analysis**: Based on the Unity3D engine, four-sided mapping was done using a multi camera in a CAVE type space. An autostereoscopic 3D image was provided by forming a parallax barrier using binocular disparity, and a space capable of multiple user participation was formed by implementing a multi-tracking system using Kinect. **Findings:** The development of technologies that allow autostereoscopic virtual reality and mixed reality experiences are currently underway, but a technology that can implement a mixed reality space for multiple users to experience virtual reality without special glasses in a real spatial environment is still in the development stage. The present study created an autostereoscopic 3D environment for resolving user discomfort, and implemented a multi-tracking system aimed at multiple user participation. As a result, the study was limited in that the definition of the screen differs depending on the light in accordance with the characteristics of beam projectors and that the restrictions to CAVE space only allows a restricted number of personnel to participate. **Application/Improvements:** Active research must be conducted on contents that are usable in mixed reality space implemented for vitalizing virtual reality space research.

Keywords: Convergence Spaces, Mixed Reality, VR, 3D hologram

1. Introduction

Virtual reality provides an immersive user environment through multi-sensuous experiences, because of its strong attraction power. Therefore, virtual reality has unlimited potential as an optimal media to induce users' immersion at the aspect of the experience. In particular, a mixed reality space means reality augmented with virtual reality. It is a space containing various contents and a service system, which is provided to users, by fusing the ubiquitous technology and the space design. Technologies to implement a multi-user mixed reality space, which is required in the modern society, has a great effect on the virtual reality and related industries[1,2]. However, there is few studies on a mixed reality space allowing multiple users to interact simultaneously without wearing special glasses, despite it has inconveniences such as not supporting multi-interaction or wearing special glasses, Contrarily, a stereoscopic image mainly applied to game consoles and mobile phones does not require special glasses and this method is expected to seize the stereoscopic image market[3]. A stereoscopic image is one of main technologies used to deliver visual contents to users in a mixed reality space based on a reality space effectively. If multiple people can experience contents in the same space without wearing special glasses, users will be able to experience telepresence between users and contents and augmented reality, where users exchange their associations, communication, and experiences. A stereoscopic image is one of main technologies used to deliver visual contents to users in

**Author for correspondence*

a mixed reality space based on a reality space effectively. If multiple people can experience contents in the same space without wearing special glasses, users will be able to experience telepresence between users and contents and augmented reality, where users exchange their associations, communication, and experiences. Multi-user tangible non-glasses mixed reality was to be realized by describing the parallax barrier method utilizing for projecting non-glasses 3D image with using the binocular disparity method and introducing an interaction system responding to user behaviors based on behavior recognition with using Kinect and a user location matching technique.

2. Study Background

This chapter reviewed studies on terminologist and main techniques used to realize a multi-user tangible non-glasses mixed reality space.

2.1 Mixed Reality

Mixed reality means a fusion of a reality space and a virtual space. It is actually impossible to build a perfect virtual world, so an augmented reality space and an augmented virtual space are proposed to graft a virtual world to a reality world. A mixed reality space, which is a mixture of a real space and a virtual object, provides human augmented sense of reality, which is better than actual five senses based environment. Mixed reality is a fusion between reality and a virtual space or a virtual media. It means to realize a new environment, where an actual object and a digital object coexist and interact[4,5] (Figure 1).

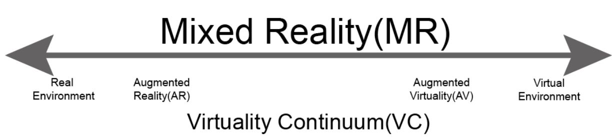

Figure 1. A reality – virtual mixture.

2.2 Projection Mapping

Projection mapping is a composite word. Projection means 'illuminate light' or 'throw light', while mapping is a computer graphic terminology giving factuality by overlaying a 2D image on an object. It is a method to deliver visual stimuli by aligning 3D image projected by a beam projector on an outer wall of a physical 3D space or surface of an object. Project mapping is to overlap another virtual space on a real space by projecting an image on the surface of an existing object. As the terminology mapping means, it acts as a virtual skin of objects. By adding illusion effects, it realizes augmented reality, which makes 2D look like 3D and 3D look like 2D[6] (Figure 2).

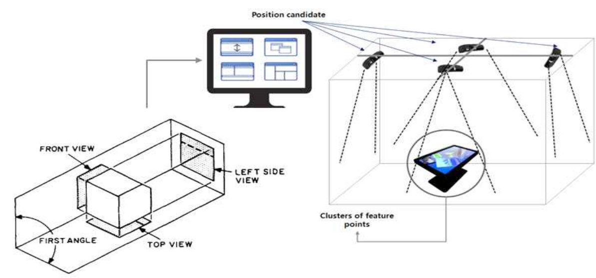

Figure 2. A projector mapping.

2.3 3D Hologram

The 3D hologram is a technology realizing a stereoscopic image, which can be viewed from all directions. An image generated by a 3D hologram technology provides users a cubic effect, as if it is real, so it has strengths of increase the sense of reality and immersion. Hologram means to see the whole image of an object. It reproduces a 360-degree 3D image by using a holography theory. A 3D image produced by a hologram provides people a cubic effect, as if it is real, and it has a better sense of reality than the stereoscopic method. Moreover, anyone can enjoy a hologram image at any angle conveniently[7].

3. Realizing a multi-user tangible non-glasses mixed reality space

This chapter explains a method to realize 'a mixed reality space', which allows multiple users to experience a 3D special image in a 4 faces cube shape real 'space' without wearing special glasses.

3.1 Design Tangible 4 Faces Mixed Reality Space based on 3D

The projection mapping technology and the hologram technology, previously described, were utilized to build a 4 faces cube-shape mixed reality space. First, an extreme immersive space was manufactured by attaching specially made hologram film on the 4 faces of a cube-shape space and projecting images with a beam projector on each face (i.e., front, bottom, left, and right). The binocular disparity type parallax barrier method and the lenticular lens technique were applied to project non-glasses 3D image. Left and right eyeballs of users see different corresponding pixels and a user feel the cubic effect because two eyeballs see different images. The same effect can be acquired when a screen with vertically arranged screen cylindrical lenses is used instead of the parallax barrier[8,9]. Moreover, resolution decrease due to the interference caused by external light (e.g., sunlight and fluorescent light) prohibited by using a proximity projector. The proposed mixed reality space was design model is the same as the following picture (Figure 3), (Figure 4).

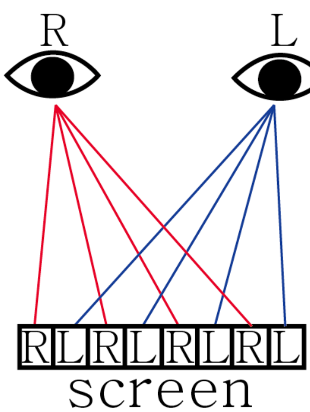

Figure 3. Parallax barrier method.

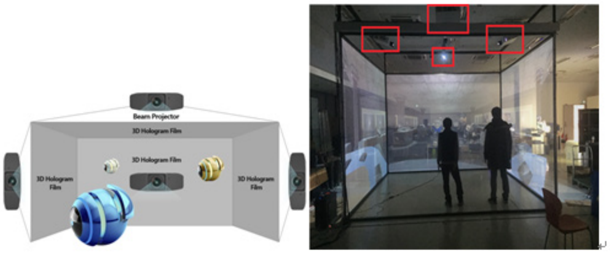

Figure 4. A proximity projector design model.

3.2 Visualization of 4 Faces Mixed Reality Space Image

Designing a virtual space is important to project 3D images to the 4 faces cube-shape space for the visualization of a mixed reality space image, which makes images projected on each face look connected. This study arranges a virtual space, which has identical space size with the 4 faces, and front, left, right, and bottom to a cube shape in the Unity engine by utilizing the Unity engine. To reflect an image on each face, it was set up for each camera object to render texture on each face by creating 4 camera objects. It is a method to render one image to 4 cameras discretely. The following picture explains the theory of 4 faces projecting rendering with utilizing the Unity engine (Figure 5).

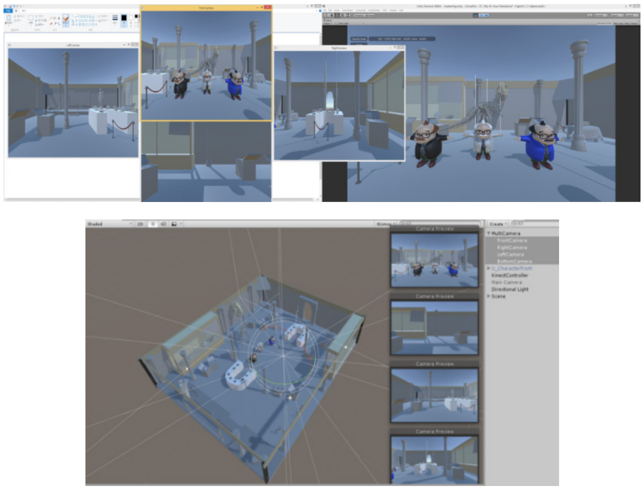

Figure 5. 4 faces multi-camera output through unity open GL.

3.3 Multi-User Tangible Interaction

Moreover, Two methods were proposed to provide tangible interaction to multi-users in a mixed reality space. The first is to develop multi-user interaction technology for a stable recognition when multi-users interact simultaneously. Develop a technology, which allows the tracking of users' movements and gestures by recognizing the behaviors of multi-users and by analyzing human interaction information acquired from a camera exclusively for recognizing interactions. The second is to develop a technology interworking the actual coordinate system and the virtual coordinate system. It interworks the actual coordinate system and the virtual coordinate system, while users use the content, to provide users experience environment similar to an actual environment based on the users' interaction in a virtual reality space to real-time track multi-users simultaneously. To provide these two technologies stably, it was made possible to recognize behaviors using Kinect and precisely match user location coordinates. Figure 6 shows tracking multi-users in real time.

Kinect senses users' movement or condition and displays them consistently according to a condition. Moreover, IT provides an experience, which is the same as the actual experience environment.

Figure 6. Mult-user tracking with using Kinect.

3.4 Realization Results

Owing to the previously built 3D based 4 faces space, the realized mixed reality space for multi-users allowed users to watch 3D images when 3D special images were projected without wearing special glasses such as the 3D stereoscopic method, which shows binocular focuses with using 2 special lenses (or special glasses). Moreover, the multi-user tangible interaction was provided to make multi-users recognize that they are in 'a mixed reality space'. The mixed reality space proposed in this study showed that it was possible to experience 3D special images and tangible interaction on non-glasses base. Realization also reveals that followings should be improved or modified. First, although a proximity projector was used to prevent resolution decrease, the environment should be dark overall due to the nature of a beam projector. To solve this issue fundamentally, an alternative technology is required to replace the projection mapping technology from the designing stage. Moreover, both the resolution of an image and brightness of a beam projector should be high to provide high resolution. Secondly, there was a limit in space and a maximum number of users due to the technological limitation in multi-user tracking. This can be supplemented by continuous technological development in the future. Lastly, 'viewpoint', which multi-users recognize a space, should be studied persistently. Because it is a multi-user based space, multi-users should be able to recognize the viewpoint jointly but the mixed reality space proposed by this study had a first person viewpoint image. Figure 7 showed its realized figure.

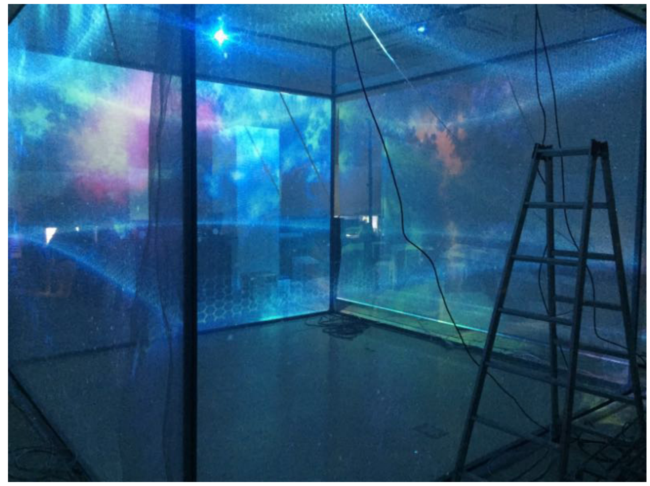

Figure 7. The realization of multi-user tangible non-glasses mixed reality space.

4. Conclusions and Future Study Directions

This study started from human technological to provide 'users', who use a space, 'virtual reality' or 'mixed reality' 'conveniently' at highly advancing user environment. Although non-glasses type technologies are being developed to experience virtual reality and mixed reality, a technique to realize a mixed reality space, where multi-users can experience virtual reality without wearing special glasses, is still in its early stage. It is because it should be studied with highly advanced technologies such as computer graphics, artificial intelligence, computer vision, sensor engineering, and HCI and minimizing the unnaturalness when fusing a virtual object with a real object still remains as the most difficult problem[9]. Therefore, this study proposed a tangible non-glasses mixed reality space based on multi-user. Studies on mixed reality, projection mapping, and hologram were preceded and they were reflected in the actual realization technology. The following results were withdrawn from the realization of a mixed reality space.

First, the proposed method provided users an opportunity to watch 3D images without wearing special glasses and multi-user based tangible interaction. Secondly, the environment of the space should be dark overall and the resolution of an image and brightness of a beam projector should be high to provide a high resolution. Thirdly, there was a limit in space and a maximum number of users due to the technological limitation in multi-user tracking.

Lastly, the mixed reality space proposed by this study is to share a viewpoint of one user with all multi-users, so it is necessary to persistently study the 'viewpoint' for all multi-users to recognize a space simultaneously.

Future study directions are to manufacture suitable contents by establishing a concrete application plan based on the realized mixed reality space and to amend and improve the current project based on the usability test for establishing a high-quality mixed reality space.

5. Acknowledgment

This work was supported by Institute for Information and Communications Technology Promotion (IITP) grant funded by the Korea Government (MSIP) (No. R0126-15-1039, Technology development of tangible creative functional contents education service based on virtualization).

6. References

1. Choi JS, Choi JD, Park CY, Kim DH, The design of viual space for multi-user using viutual reality. The Korea Society for Simulation; 1997.
2. Park S. Technology analysis about realization of multi-feeling virtual reality. KMIS. 2009; 2009(2):632–7.
3. Keun OH, Seok OE. A study on interaxial distance optimization for autostereoscopy with the 8-P.O.V camera. Journal of Digital Design. 2012; 12(2):1–10.
4. Milgram P, Keshion F. A taxonomy of mixed reality visual display. IEICE Transactions on Information and Systems. 1994; E77-D:1321–9.
5. Yongsoo L. Problem of definition on mixed reality and its alternative, and relationship of virtual/augmented reality. Korea Design Knowledge Journeal. 2015; 34:193–202.
6. Joon C-J, Young LH, Hyung LW. A study on the expression method of illusionism and expandability of space using projection mapping. Korea Design Knowledge Journal. 2013; 26(6):125–33.
7. Kim MS, Yong YB, Sung YC. A study on the relationships among flow of holograms 3D contents and learning satisfaction for e-learning. Korea Digital Design Council. 2016; 4:247–50.
8. Geun LS, Cheon LD. Geospatial data display technique for non-glasses stereoscopic monitor. The Journal of the Korean Society of Surveying, Geodesy, Photogrammetry and Cartography. 2008; 26(6):5–60.
9. Kim H-J. Realization technologies of the augmented reality continuum. Communications of the Korea Information Science Society. 2012; 30(5):70–80.
10. Kim S, Kang C, Jeong Y. An eye tracking method for glasses-free autostereoscopic 3D monitors. Proceedings of Symposium of the Korean Institute of communications and Information Sciences. 2011; 2:66–7.
11. Jin BH, Young LY. Mied reality continuum using augmented reality design - ocusing on the analysis of theory and technical background. Journal of Digital Design. 2012; 12(2):44–457.
12. Hye KJ, Mi KY, Geun KM, Jee SE. Kidult contents development using mobile augmented reality. Indian Journal of Science and Technology. 2015 May; 8(S9):518–25.
13. Vasudevan SK, Vivek C, Srivathsan S. An intelligent boxing application through augmented reality for two users – human computer interaction attempt, Indian Journal of Science and Technology. 2015 Dec; 8(34).