Enhancing Social Presence in Augmented Reality-Based Telecommunication System

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Abstract. The main contribution of this paper is to examine the new method of augmented reality from a telecommunication point of view. Then, we tried to present the fact that the concept of social presence is an important cue for developing telecommunication system based on augmented reality technology. The evaluation was conducted with 32 participants. According to the questionnaires results, the augmented reality based telecommunication system was better than 2 dimensional based display telecommunication system. To develop our concept, we should closely analyze communication patterns and improve our augmented reality based communication system.

Keywords: Telecommunication, Augmented Reality, Social Presence.

1 Introduction

Between remotely located people, Telecommunication systems have consistently developed from mobile device to a networked virtual environment such as computer-supported cooperative work (CSCW). In this context, augmented reality (AR) systems supplement the real world with virtual objects that appear to coexist in the same space as the real world [1] and create a face-to-face type of environment. However, the situation of optimal communication is the case of face-to-face communication in practice because cues of natural nonverbal communication exist [2][3]. Thus, some researchers presented social presence as one of the key features of the telecommunication that is focused on users' social psychological properties [4-6]. Especially, understanding of social presence's factors is important for supporting the high level of social presence in the telecommunication.

2 Related Work

2.1 Social Presence in Telecommunication

Many researchers studied ways of keeping a social presence with remote person in telecommunication. Hauber and colleagues explored ways to combine the video of a remote person to best emulate face-to-face cooperation with a shared tablet display [7].

R. Shumaker (Ed.): VAMR/HCII 2013, Part I, LNCS 8021, pp. 359–367, 2013.

They compared the values of social presence of a standard non-spatial two-dimensional (2D) interface with four kinds of conditions, not AR. Meanwhile, the system was made for enhancing the social presence of telecommunication [8]. Although researchers proposed an AR approach, their system did not have proper factors of AR but merely expanded the closed 2D display. The TeleHuman three-dimensional (3D) videoconferencing system supports 360-degrees motion parallax as the viewer moves around the cylinder and stereoscopic 3D display of the remote person with a high sense of social presence [9]. However, one-way telecommunication system could not lead to real communication between both of the users. Besides, the motion cannot solidify enough of the factor of a high sense of social presence for effective communication. Through related works, our vision was that we considered not only technology-centered thought, but also user-centered thought. Therefore, we made an effort to identify the factors of maximizing social presence for understanding the full potential of AR to telecommunication experience.

2.2 Augmented Reality

Augmented reality was defined as "a continuum of real-to-virtual environments, in which augmented reality is one part of the general area of mixed reality" [10]. Azuma specified augmented reality as augmenting the real world environment with virtual information by improving people's senses and skills [1]. He also mentioned three common characteristics of augmented reality scenes; combination of the real and virtual, interactive in real time and having the scenes registered in 3D. Although these explanations were greatly obvious, they did not get enough attributes for defining effective communicating tool as AR-based telecommunication. Thus, the concept of augmented reality must be redefined maximizing the effect of social presence effect on telecommunication.

3 The Three Factors of Social Presence

The purpose of this study is to find the proper factors of social presence to the experience of AR-based telecommunication, make a prototype based on found the factors found and conduct empirical evaluation. That is, we make an effort to identify factors that enhance a sense of social presence for understanding the full potential of AR in the telecommunication experience. Therefore, this paper presents the new characteristics of AR considering the concept of social presence based on the three common characteristics of Azuma's study.

3.1 A Sense of Being Together

AR technology supports the combination of the real environment and a virtual environment [1]. Towell and Towell presented an understanding of the contribution to presence through social interaction in other virtual environments [11]. They found an important factor in the user's experience of being with others is a sense of social

presence. In AR-based telecommunication, users can feel a sense of being with another person who is in another virtual environment.

3.2 A Sense of Spatial Co-presence

AR has scenes registered in 3D [1]. When a person and a remote person share an AR's scene, they can feel a spatial co-presence, which is one of the factors associated with a sense of social presence [12]. Meanwhile, conducting work with common interesting thing leads to a feeling of high cohesion [13]. Therefore, AR-based telecommunication needs common interesting things to enhance social presence.

3.3 A Sense of Psychological Involvement as Mediated Social Presence

AR includes properties of interaction in real time [1]. This interaction means psychological involvement as well as physical communication. Biocca el al. focused on mediated social presence, which means how much users involve themselves psychologically [14]. Psychological involvement is one of the core factors to obtain a feeling of social presence.

4 Implementation

Fig. 2. shows a block diagram of our system, which captures real-space images from an HMD camera, conducts camera pose tracking, and then registers with virtual objects. Specifically, in the offline camera tracking data was obtained via the 3D geometrical structure of a real-world environment. Then, a local reference coordinate was allocated on the planar object (e.g., a picture attached to the wall) in front of a user [15].

In the implementation, the virtual objects are the textured human and some objects in the other space that are augmented based on the local reference coordinate. To do this, the system in the other space detects and segments the foreground objects from the learned environment by using a red-green-blue depth camera (RGB-D camera), and then it transmits the foreground objects to the in-situ user through wired communication.

The hardware used in the implementation included a bi-ocular video see-through HMD [16] with 800 × 600 pixel resolution. A camera attached to the HMD captured 30 images per second with 640 × 480 pixel resolution. A RGB-D camera [17] in front of a user captured 30 RGB images per second with 640 × 480 pixels and 30 gray-scale depth images per second with 320 × 240 pixels for objects within 1.2 to 3.5m. The computer used was equipped with an independent graphics card and a core of the i7 central processing unit (CPU).

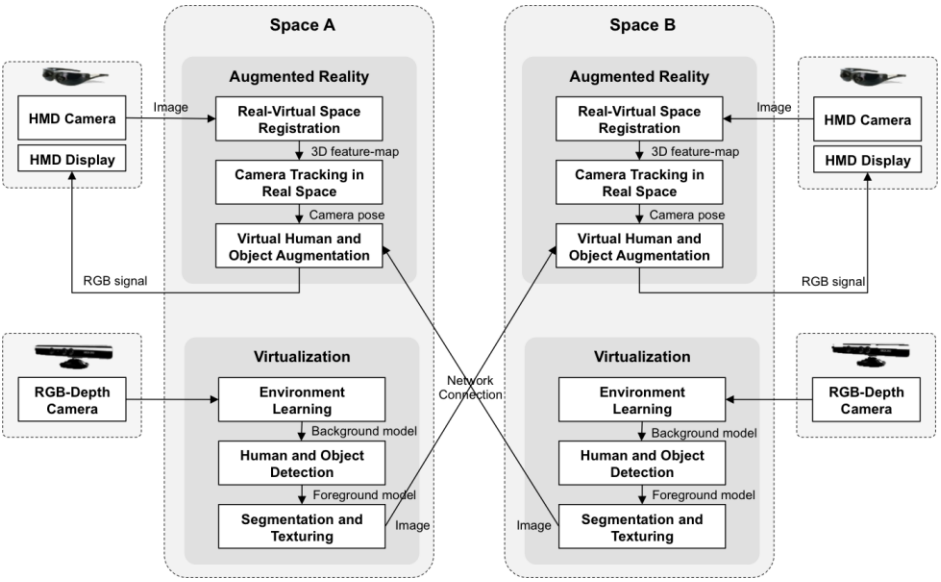

Fig. 1. A block diagram of our AR-based telecommunication system

5 Empirical Evaluation

We designed an experiment to evaluate the suitability of three factors based on the concept of AR and social presence. An experiment focused on how users can feel a sense of social presence when they communicate spontaneously with the common interesting thing. Thus, participants conducted a task-based experiment on a 2D display-based telecommunication system [18] and the AR-based telecommunication system we developed, respectively.

5.1 Participants

The study included 32 participants. The average of age was 24.3 years old, ranging from 19 to 34. Every participant had experienced the telecommunication system at least once. Gender was balanced in the ratio between men and women (i.e., 16 men and 16 women). That is, there is no gender constraint in measuring social presence. Two participants conducted the task as a team.

5.2 Task

A pair of participants were assigned the roles of manipulator and facilitator. When they decided on their role, the manipulator sat in a chair with a puzzle plate that could accommodate the puzzle pieces. The facilitator sat in the chair with an image of the completed puzzle. These participants stayed separated in different locations. The pair

of participants put the puzzle together with free verbal and nonverbal communication. In the process of putting the puzzle together, the facilitator could help the manipulator because the facilitator had more information about the completed image. The manipulator could not look at the facilitator's completed image. The participants experienced two kinds of telecommunication (i.e. AR and 2D video). For each team, the test schedules were separated by more than two weeks to prevent any learning effects.

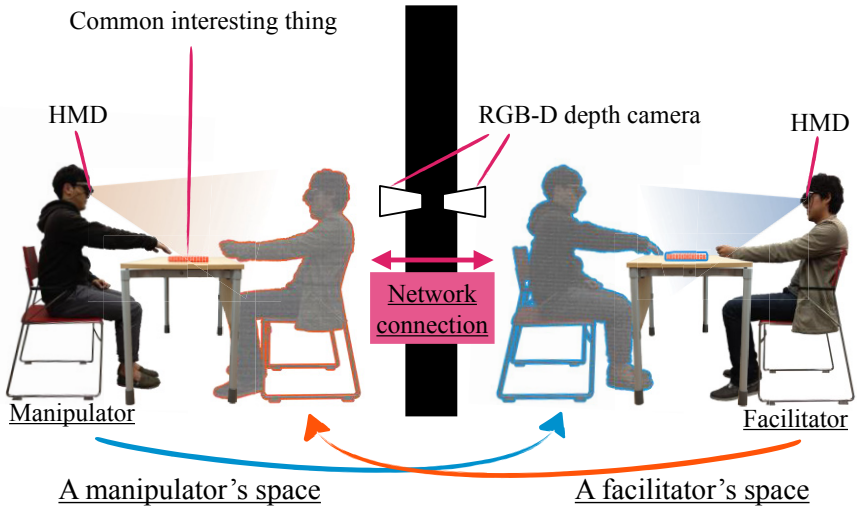

Fig. 2. The teleconferencing environment

5.3 Experiment Design

A within-subjects' design was used. At first, the participants were given an explanation of our task-based experiment. They were given time to practice the systems (i.e. the 2D display-based telecommunication system and the AR-based telecommunication system) for completing a puzzle (i.e. the common interesting thing). Then, the participants answered questionnaires after experiencing the system, respectively. The degree of social presence was measured according to the results of a comparative analysis.

5.4 Questionnaire Construction

To evaluate the degree of social presence, the participants answered seven-point Likert scale questionnaires after each task. In the questionnaire, 1 means "strongly disagree" and 7 means "strongly agree". Three kinds of social presence factors are addressed in a total of 12 items; a sense of being together is related to one item [11], a sense of spatial co-presence is related to one item [12] and a sense of psychological involvement is related to 10 items [14].

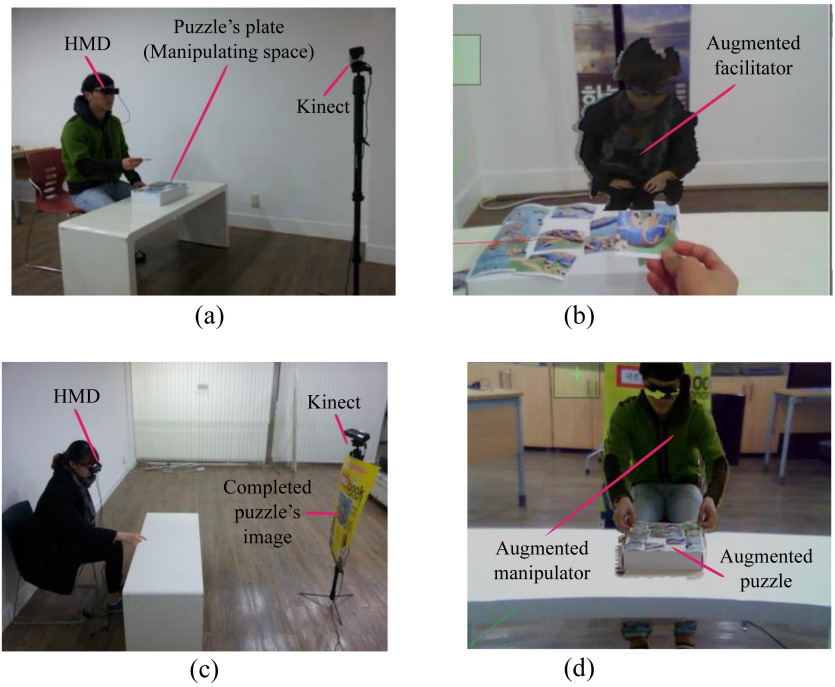

Fig. 3. The actual experimental environment of the AR-based telecommunication: Each user can see his or her virtual remote partner through the video see-through HMD and thus communicate. (a) Manipulator stay with puzzle's plate, (b) Manipulator's view through HMD, (c) Facilitator stay with complete puzzle's image, (d) Facilitator's view through HMD.

5.5 Results

In dealing with the questionnaire results, this paper took a survey of 32 participants (i.e., 16 pairs) and analyzed each survey item's reliability. For the comparative analysis, the questionnaire results were analyzed using a within-subjects analysis of variance (i.e., paired samples t-test), evaluated at an alpha level of .05.

These results indicated that the participants felt a significantly greater sense of being together ($p<0.05$) and spatial co-presence ($p<0.05$) with AR-based telecommunication. However, there was no significant difference in a total of 10 questions related to a sense of psychological involvement as mediated social presence ($p=0.113$).

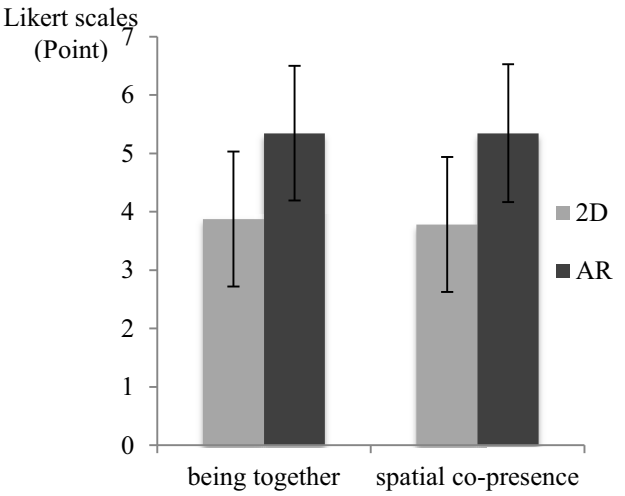

Fig. 4. The graph of questionnaire results about a sense of being together and spatial co-presence

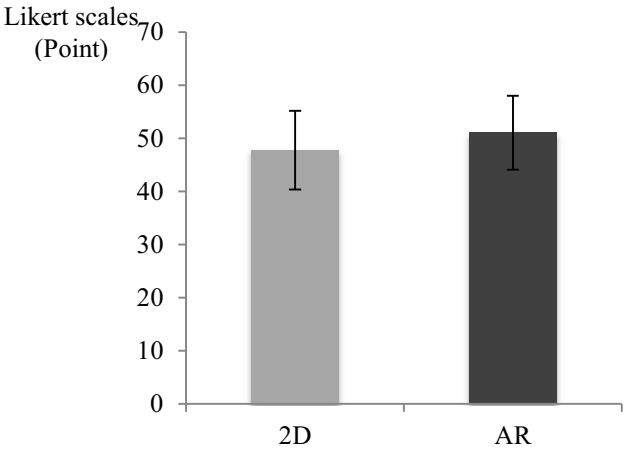

Fig. 5. The graph of questionnaire results about a sense of psychological involvement as mediated social presence

5.6 Discussion

According to the questionnaire result, an AR-based telecommunication system could enable participants to feel a sense of being together and spatial co-presence. That is, the telecommunication with AR technology with HMD is a better way to communicate together like face-to-face than telecommunication with a 2D display. However we cannot sure that the suggested factors are the best way to conduct AR-based telecommunication. For a better telecommunicating experience, we would clarify which of our factors are essential.

In the case of the factor of psychological involvement, we should analyze more detailed information in our experimental environment. The participant actually communicated together with each other in verbal and non-verbal ways. Therefore, we can explain the results precisely when we analyze the participants' communication patterns.

Finally, our AR-based telecommunication system requires adjustments to address technical issues. In conducting the usability test, we found some technical problems such as turning off and being suddenly unable to look at augmented people.

6 Conclusion

The purpose of the current study was to identify the proper factors of social presence in experiencing AR-based telecommunication and to confirm the effectiveness by conducting an empirical evaluation. We proposed three AR-based telecommunication factors based on previous concepts of social presence. The evaluation was conducted with 32 participants. According to the questionnaires results, the AR-based telecommunication system was better than 2D display-based telecommunication system in terms of feeling a sense of being together and spatial co-presence. However, there was no significant difference in the result for psychological involvement.

To develop our concept, future research should closely analyze communication patterns. Furthermore, we should improve our AR-based telecommunication system to address technical and visual issues.

The present study examined a new method of augmented reality from a telecommunication point of view. Then, we tried to present the fact that the concept of social presence is an important cue for developing telecommunication system based on AR technology. Additionally, conducting a well-ordered empirical evaluation would be helpful in designing future telecommunication system.

References

1. Azuma, R.T.: A Survey of Augmented Reality, Presence: Teleoperators and Virtual Environments, pp. 355–385 (August 1997)
2. Walther, J.B., Burgoon, J.K.: Relational Communication in Computer-mediated Interaction. Human Communication Research 19(1), 50–88 (1992)
3. Walther, J.B.: Computer-mediated Communication: Impersonal, Interpersonal, and Hyperpersonal Interaction. Communication Research 23(1), 3–43 (1996)
4. Short, J.A., Williams, E., Christie, B.: The Social Psychology of Telecommunication. John Wiley & Sons, Ltd., London (1976)
5. Tu, C.-H.: The Measurement of Social Presence in an Online Learning Environment. International Journal on E-learning 1(2), 34–45 (1992)
6. Lee, M.N., Nass, C.: Designing Social Presence of Social Actors in Human Computer Interaction. In: Proceedings of the the SIGCHI Conference on Human Factors in Computing System, pp. 289–296 (April 2003)

7. Hauber, J., Regenbrecht, H., Billinghust, M., Cockburn, A.: Spatiality in Videoconferencing: Trade-offs between Efficiency and Social Presence. In: Proceedings of the 2006 20th Anniversary Conference on Computer Supported Cooperative Work, pp. 413–422 (November 2006)
8. Almeida, I.S., Oikawa, M.A., Carres, J.P., Miyajaki, J., Kato, H., Billinghurst, M.: AR-based Video Mediated Communication: A Social Presence Enhancing Experience. In: Virtual and Augmented Reality, pp. 125–130 (May 2012)
9. Kim, K., Bolton, J., Girouard, A., Cooperstock, J., Vertegaal, R.: TeleHuman: Effects of 3d Perspective on Gaze and Pose Estimation with a Life-size Cylindrical Telepresence Pod. In: Proceedings of the SIGCHI Conference on Human Factors in Computing Systems, pp. 2541–2540 (May 2012)
10. Milgram, P., Takemura, H., Utsumi, A., Kishino, F.: Augmented Reality: A Class of Displays on the Reality-virtuality Continuum. In: Telemanipulator and Telepresence Technologies, pp. 282–292 (November 1994)
11. Towell, J.F., Towell, E.: Presence in Text-Based Networked Virtual Environments of MUDS, pp. 590–595. MIT Press (September 1997)
12. Mason, R.: Using Communications Media in Open and Flexible Learning. Kogan Page, London (1994)
13. Wenger, E.: Communities of Practice. Cambridge University Press (1998)
14. Biocca, F., Harms, C., Gregg, J.: The Networked Minds Measure of Social Presence: Pilot Test of the Factor Structure and Concurrent Validity. Paper presented at the Presence 2001 Conference (2001)
15. Kim, K., Lepetitb, V., Woo, W.: Real-Time Interactive Modeling and Scalable Multiple Object Tracking for AR. Computers and Graphics 36(8), 945–954 (2012)
16. Wrap™ 920AR, `http://www.vuzix.com`
17. MS Kinect sensor, `http://www.microsoft.com/en-us/kinectforwindows/`
18. Skype, `http://www.skype.com`