Effect of Full Body Avatar in Augmented Reality Remote Collaboration

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Abstract

In this paper, we compared three different types of avatar design ("Body", "Hand + Arm", and "Hand only") for the augmented reality remote instruction system in terms of usability. The result showed that the usability of the remote instruction system with full body avatar has a higher usability. In addition, participants felt more easily to track the full body avatar than the avatar with hand only. However, concerning the understandability of the instruction, there was no difference between three designs.

Index Terms: Human-centered computing—Human computer interaction (HCI)—Interaction paradigms—Virtual reality.

1 Introduction

Augmented reality is a trend technology which enables users to experience the real world with virtual objects added. There are plenty of usages of augmented reality, such as education and entertainment. Some studies applied augmented reality to remote collaboration to increase the users' awareness. Among all types of remote collaboration, remote instruction is one of the typical type. Instead of staying in a same location, an instructor who stays far way provides instructions to a worker. To conduct a successful remote instruction, the instructor should correctly understand the worker's environment and effectively transmit his/her instruction. In addition, the worker should correctly understand the instruction.

With a 2d display, such as tablet and PC, the instructor can only transmit the instruction verbally, so it usually resulted in many mistakes during the task. To solve this problem, some researchers developed augmented reality system that can transmit gesture to make the instruction more understandable [3]. Those existing studies mainly focused on small area. Both instructor and worker do not have to move around during the task, and transmitting instructors' hand information and gesture can effectively improve the understandability of the instruction [3]. However, in a wider area, we assumed that providing hand information only cannot fully support the remote instruction. Schegloff suggested that human's body torque represented his/her interest [7]. Thus, during face-to-face interaction, people observed partners' body trunk and anticipate the partner's next step. To enrich the remote instruction, some research proposed showing head and arm avatars to the local workers [4, 5] and other research provided a full body avatar in the remote collaboration system [2, 8]. Based on some studies, they suggested that providing embodied avatar increased the social presence rating [6, 8]. Therefore, we assumed that providing more detailed body information in the wide area can improved the quality of the remote instruction system. However, to the best of our knowledge, there is little research comparing the usability of different avatar designs which could be an important guideline for the designer. Thus, in this paper, we compared the usability of remote instruction systems providing different types of avatar design.

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Figure 1: Different types of avatar shown in the workers' HMD.

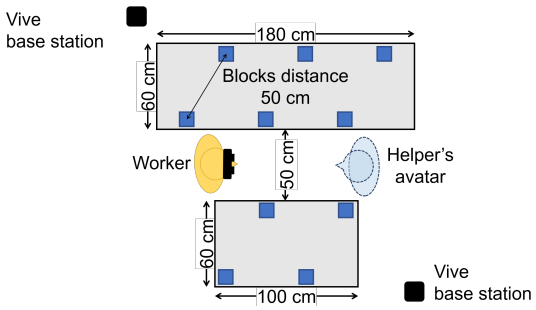

Figure 2: The experiment setting.

2 Experiment

2.1 Hypothesis and Method

On the basis of previous study, we set up a hypothesis: The remote instruction system providing more detailed instructor's body information has a higher usability.

We conducted a within-participant experiment. There are three conditions: "Body [6, 8]", "Hand + Arm [4, 5]", and "Hand only [3,8]" (Fig. 1). To test the hypothesis, we prerecorded five sequences of instruction with the motion capture system "Optitrack S250e". Fig. 2 shows the experimental environment. An actor pointed to the blocks on the table one by one and each block was pointed once. Each sequence consisted of 10 instructions and average time of the sequence was about 33 seconds, the order of instructions were different between the sequences.

2.2 Measure

In this study, we applied the System Usability Scale which was used in carrying out comparisons of usability between systems [1]. The System Usability Scale consisted of 10 items and was measured with a 5-point rating scale. The score of each item ranged from 0 to 4 and was multiplied by 2.5 during the analysis.

In addition, since we want to know if the effect of avatar design influences between the instructions or during the instructions, we

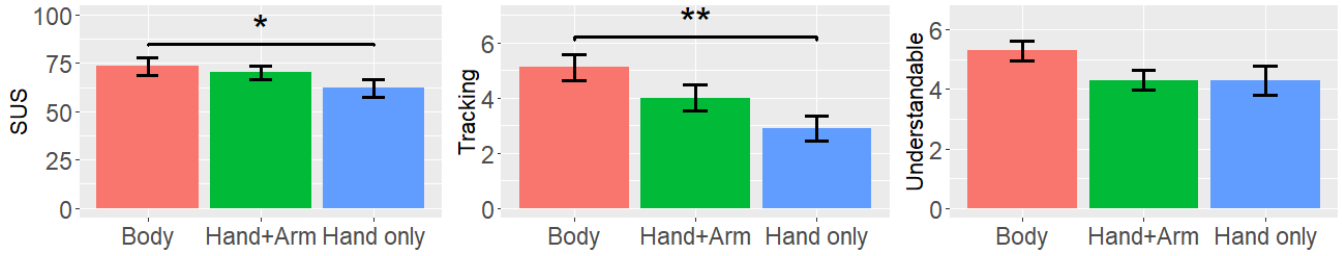

Figure 3: Result of the experiment. The left graph showed the result of the SUS score. The middle graph showed the result of Q1 (reversed). The right graph showed the result of Q2.

asked participants to answer two subjective questions (with a 7-point rating scale):

- Q1. Did you feel difficulty in tracking the avatar during the experiment?
- Q2. Did you feel that it was easy to understand the instruction given by the avatar?

2.3 Procedure

In each experiment, we asked a participant to follow instructions given from three different types of avatar (Fig. 1). In each condition, there were a practice task and main task. We asked the participant to wear the HTC VIVE head mounted display (HMD). Through the HMD, the participant could see the real-world scene captured by stereo camera (ovrVision) and see an avatar standing between two tables (Fig. 2). Later, the participant was asked to stand at the initial point and wait until the avatar start giving instruction. The participant was informed that the instructions would be given continuously, and he/she was requested to touch the corresponding block as soon as possible.

Regarding the instruction sequences, one of the prerecorded sequence was given to all participants in all practice tasks. For the main task, we randomly selected three sequences from the rest four prerecorded sequences, and the order of conditions were also randomized. After the practice task and the main task, the participant was asked to answer the questionnaire (described in Measure section).

2.4 Participant

10 participants (9 males and 1 female) from University of Tsukuba were recruited as our participants. The average age of the participants was 23.6 and the standard deviation was 1.26.

3 Result

Concerning the System Usability Scale, the mean score of the "Body" condition was 73.5, the mean score of the "Hand + Arm" condition was 70.25 and the mean score of the "Hand only" condition was 62.25 (Fig. 3 left). Then, we used a linear mixed model regression to test the significance between conditions. The condition was the fixed factor and the participant factor was the random factor. The result showed a marginal significance between conditions ($F(2,18)=3.47$, $p=0.053$). The score of "Body" condition was significantly higher than the score of "Hand only" condition in the post hoc test with a bonferroni correction ($p=0.031$). Thus, our hypothesis was supported.

Concerning the Q1, we also used a linear mixed model regression to test the significance between conditions (Fig. 3 middle). We found that there was a significance between conditions ($F(2,18)=5.47$, $p=0.014$). The score of "Body" condition was significantly higher than the score of "Hand only" condition in the post hoc test with a bonferroni correction ($p=0.003$). However, there was no significance between conditions in Q2, and neither was the post hoc test (Fig. 3 right). The difficulty of the task and instruction might be the reason why there was no difference between two conditions, and similar tasks with more difficult instructions (moving, turning, etc.) should be conducted in the future.

4 Conclusion

We investigated the importance of providing instructor's full body information during the remote instruction. The result showed the remote instruction system providing instructors' full body information had higher usability than the system providing hand information only, and participants felt easier for tracking the full body avatar comparing with "hand only" avatar.

However, since the instructions could be much more complicate in the real world, as for the future work, we would further examine the effect of full body avatar with more complicate jobs, such as assembly tasks.

Acknowledgments

This work was supported by JSPS KAKENHI Grant Number JP16K16097.

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