Remote Collaboration Demanding Multiple Field Workers Using Real-world Projection Interface

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1. Introduction

Earlier studies of wearable collaborative systems[1][2] focus on supporting a single field worker and a single remote expert. However, we assume that, in a situation of that under a remote collaboration demanding multiple field workers, only the one field worker allows to wear an interface of remote collaborative system. And then, as shown in left side of figure 1, using a display device for a single user such like HMD (Head Mounted Display), the remote collaborative system can not support that the remote expert sends the instructions to the non-interface-worker directly. This is caused by that HMD, which has been main information display for a single user in those wearable collaborative systems[1], can be watched by only the wearer. There might be discrepancies, such like a telephone game, in the transmission of the instruction information among the field workers and a remote expert. Finally the remote collaboration can not be carried out smoothly.

Therefore, to support smooth remote collaboration demanding multiple field workers in a situation of that only one interface allows to exist in the field, we propose and evaluate a suitable wearable interface. We equip one field worker with a projection device as suitable wearable interface of the remote collaboration. As shown in right side of Figure 1, the real-world projection device such like a projector has the one big feature that the projected information can be watched by not only the just one person, but also the people around the projection device. Therefore, applying the feature to a remote collaboration system, we can compensate the discrepancies. In this paper, we proposed that WACL[3][4], which is one of the simplest real-world projection device, is suitable wearable device for preventing the discrepancies in the transmission of the instruction information among the field workers and a remote expert.

2. Burdens of worker

As the figure 2 shows, 13 blocks and the paper with squares patterns(5x5cm) were placed on the table, and interface-wearer and non-interface-worker sat in front of a table. One work was that the remote expert indicated one block from 13 blocks to a worker on the table, and the remote expert indicated a position to the worker on the paper. As one task, first, the remote expert instructed the work to interface-wearer three times. Second, the remote expert instructed the work to non-interface-worker three times. Finally both the workers take required blocks and put those blocks to the required positions. We hypothesized that HMD interface-wearer tends to take a wrong block or puts on a wrong position because the interface-wearer with HMD keeps remembering required blocks and positions even while the interface-wearer forwards remote expert's instructions displayed on the HMD to a non-interface-worker.

As shown in Figure 3, with HMD condition, the average number of error is 7.5 times per person in all 15 works. On the other hand, with WACL condition, it is 2 times per person in all 15 works. Using the
Wilcoxon signed rank test, we found significant difference between WACL condition and HMD condition (p=0.011).

As shown in Figure 4, with HMD condition, the average of number of error is 2 times per person in all 15 works. On the other hand, with WACL condition, it is 1.5 times per person in all 15 works. Using the Wilcoxon signed rank test, we found no significant difference between WACL condition and HMD condition (p=0.011).

3. Conclusion

A display for single-user such as HMD imposes more burdens on interface-wearer when forwarding the instructions to non-interface-worker. On the other hands, a real world projection interface can reduce the burdens. Also, we found that direct instructions with a laser spot of WACL and sidelong instructions by the interface-wearer's hand via HMD has a same task performance in a simple pick-up-and-put task.

In this study, in simple pick-up-and-put task we set, we can not observe the difference of instruction quality between direct instructions with a laser spot of WACL and sidelong instructions by the interface-wearer's hand via HMD. On the other hand, in this study, we aimed only at the transmission of instructions. We plan to conduct studies on the share of instructions. However, we suppose that there is no difference of instruction quality on the share of instructions in the simple tasks. For the future, it is necessary to set complex fabrication task. However, Kurata et al. reported[3] WACL imposed more burdens on the experts when sending detailed instructions. In addition to, in this study, we found the problem that the laser spot was unstable with WACL condition when the remote expert instructed the non-interface-worker while the interface-wearer was working. Consequently, to conduct complex remote collaboration, we have to develop a wearable richly expressive projection interface, for example, wearable projector-camera system, which can render a video and image, and implement high precision stabilize function.

4. References


