Effect of Synchronized Remote Sender’s and Robot’s Motion Cues on Presence in Telerobotics

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Abstract. As a telepresence robot is a robot intended for use in telecommunications, conveying the presence of a remote sender is an important issue. Even though certain characteristics of robots such as motion cues could be effective at generating a sense of remote sender presence, motion cues also have risks yielding a distortion of the remote sender presence when these are used in an inappropriate way. Thus, in order to find effective ways to increase the remote sender presence, we executed an experiment comparing a telepresence robot with synchronized motion cues which provides synchronized motion with remote sender’s motion and a robot with unsynchronized motion cues which provides independent motion and unsynchronized with remote sender’s motion (N=48). Participants engaged in a video call with a remote sender through a telepresence robot having synchronized motion cues or unsynchronized motion cues. The results showed that participants felt more co-presence and social presence of a remote sender when interacting with a telepresence robot with synchronized motion cues than they did with the one with unsynchronized motion cues. The implications for the design of telepresence robots in terms of increasing presence are discussed in detail.

Keywords: Synchrony, Motion cues, Telepresence robots, Telerobotics

1 Introduction

Marvin Minsky [1] drew a picture of people suiting up in sensor-motor jackets to work at their jobs thousand miles away in 1980. He called the remote control tools telepresences, which emphasized the idea of remotely ‘being there’ in a high fidelity.
manner that it would seem as the experience was made in person. Current telepresence systems are quite mature in visual and auditory aspects of communication and close to what Minsky projected, but feeling expression means are limited to emoticons and words in chat and text messaging; audio in voice calls; or audio and facial expressions in video call systems [2]. Although wealth of emotional content can be perceived from these channels, their delivery on the cold, sterile screens of smart phones and laptops are still far away from golden standard of face to face interaction. Saadatian et al. [2] suggested that one reason might be the lack of physical body, embodiment in the conventional communication mediums. Using bodily signals, such as gestures, is essential in usual communications. These are reasons that support the significance of embodied telepresence on communication [3].

Telerobotics is a newer variant of embodied telepresence. This system is done by embodying the user in a way that facilitates them with acceptable likeness in the remote site, so that they can be immersed in the context and be felt by their interaction parties as being similarly present [4].

Although it may appear that telepresence robots can be effectively applied in situations requiring telepresence systems, combining a video display of a remote sender on an articulating base could create a confusion to a receiver, which is called proxy-in-proxy problem [5]. The remote sender has two representations in the remote place: that of the audiovisual feed on the screen, and that of the physical motion feed on the articulating base. These two distinct features are likely to portray inconsistent non-verbal motion cues. In face-to-face interactions, inconsistencies in verbal and non-verbal cues are often interpreted as a sign of a deceit and mistrust, and cause increased cognitive load.

We are interested in investigating how synchronized motion cues provided by a telepresence robot can enhance the perceived remote sender presence in telecommunication. Thus, in this study, we conduct a within-participants experiment with synchronized motion cues as the independent variable, which has two levels: telepresence robot with synchronized motion cues and with unsynchronized motion cues. Hence, we examined the effect of the synchronized motion cues on the perceived remote sender presence. The implications of the results for the ongoing development of telepresence robots are then considered.

2 Synchronized Motion Cues

As a robot has physical embodiment, it is able to enrich telecommunication by conveying non-verbal cues. Non-verbal cues made by a robot make people read intentions of a robot. According to Argyle’s study, non-verbal communication such as gestures, body movements, posture, and orientation is effective on expressing emotions, conveying attitudes, and encouraging turn-taking [6], and several studies suggested that people prefer that our technological counterparts, an agent or a robot, follow suit. For example, Isbister and Nass [7] demonstrated that people respond positively towards agents that display synchronization in verbal and non-verbal cues compared to those with unsynchronized cues. Although several studies showed the effect of synchronization in cues provided by agents in computer-mediated environments, as one cue sup-
porting another, limited work has been done on synchronization in an agent and a remote sender motion cues in robot-mediated environments.

Since a telepresence robot is a medium intended to be used in interpersonal communication, conveying the presence of a remote sender is an important issue. In robot-mediated environment, there are two types of actions. One is the remote sender’s on-screen action and the other is the robot’s physical action. These two motion cues could represent either with synchronized motions of a remote sender or unsynchronized motions, which are independently made by a robot itself. We therefore investigate how those motion cue types contribute to positive interactions. In a telepresence robot with synchronized motion cues, a telepresence robot shows the same physical movement of remote sender’s on-screen movement while in a telepresence robot with unsynchronized motion cues, a telepresence robot shows the different physical movement from that of a remote sender. According to the previous studies [5,7], we assumed that synchronization in a robot’s and a remote sender’s motion could help interpersonal communication between a receiver and a remote sender enhancing the presence of a remote sender. However, when the movement of a robot and a remote sender is not synchronized with each other, people would be distracted and have less presence toward a remote sender. This analysis led to the following hypothesis:

H1. A telepresence robot with synchronized motion cues would yield increased co-presence of a remote sender compared to a robot with unsynchronized motion cues.

H2. A telepresence robot with synchronized motion cues would yield increased social presence of a remote sender compared to a robot with unsynchronized motion cues.

3 Study Design

We used a two within-participants experiment design, comparing a telepresence robot having synchronized or unsynchronized motion cues with remote sender’s motion. As this was a within-participants study, study participants experienced both of the two communication setups.

3.1 Participants

Forty eight university students (24 male and 24 female) with high technology acceptance participated in the study. Participants’ ages ranged from 20 to 35. They were fairly well educated, on average, with the college level.

3.2 Materials

We used a home-service robot FURo-i Home [8] for this study. The robot enables telecommunicate with video and audio streaming and live chat. We developed two types of telepresence robots: one with synchronized, and one with unsynchronized motion cues with a remote sender. The telepresence robot with synchronized motion
cues generates a forward movement which was synchronized with remote sender’s moving forward action towards the receiver for sending a kiss. The robot with unsynchronized motion cues generates a forward movement which was unsynchronized with remote sender’s hand waving action to the receiver for saying hello.

3.3 Procedure

Participants were welcomed to the lab by a researcher and experienced the two interaction conditions described above in a random order. After the participants had completed each stage of the experiment, a questionnaire for each stimulus was administered. Then, they evaluated the co-presence and social presence of the remote sender.

3.4 Measures

In the post-experimental survey, the participants evaluated their experiences based on 23 different Likert-type items combined into three scales: self-reported co-presence, co-presence by others, and social presence.

Co-presence Measures

Co-presence is related to the sense of connection between two people. Given the dual-ecology of the setup, each participant’s sense of co-presence was measured using two separate scales: self-reported co-presence (Cronbach’s $\alpha=0.71$), and co-presence perceived by others (Cronbach’s $\alpha=0.83$). Self-reported co-presence refers to the participant’s self-report of their own involvement in the interaction, whereas the co-presence perceived by others refers to the participants’ perception of the remote sender’s involvement in the interaction. The scale for self-reported co-presence included the same six items used to assess co-presence perceived by others, but revised such that they asked the participants to report on their own level of involvement in the interaction. The scale for co-presence perceived by others is comprised of 11 items. All items were drawn from the study by Nowak and Biocca [9].

Social Presence Measures

Social presence refers to the perceived ability of the medium to connect people. Our evaluation of social presence is comprised of six items (Cronbach’s $\alpha=0.73$). All items were drawn from the reports by Short et al. [10] and Nowak and Biocca [9].

4 Results

We investigated the effect of the synchronized motion cues on perceived presence of a remote sender. Statistical analysis was conducted using the paired $t$-test.

As predicted by H1, a significant effect was observed based on the synchronized motion cues in terms of self-reported co-presence ($t=6.585$, df=47, $p=0.00025$, one-tailed). Participants felt that they were more involved in the interaction when com-
Communicating with a remote sender through a telepresence robot with synchronized motion cues ($M=4.76$, $SD=0.58$) than one with unsynchronized motion cues ($M=4.04$, $SD=0.46$). The same results were revealed regarding the co-presence perceived by others ($t=6.634$, df=47, $p=0.00025$, one-tailed). Participants perceived the remote sender’s involvement as higher when communicating with the remote sender through a telepresence robot with synchronized motion cues ($M=4.80$, $SD=0.58$) than one with unsynchronized motion cues ($M=4.20$, $SD=0.55$).

As predicted by H2, a significant effect was observed based on the synchronized motion cues in terms of the social presence ($t=5.043$, df=47, $p=0.00025$, one-tailed). Participants felt more social presence of a remote sender when interacting with a telepresence robot with synchronized motion cues ($M=4.65$, $SD=0.72$) than one with unsynchronized motion cues ($M=4.12$, $SD=0.40$).

5 Discussion

H1 predicted that a telepresence robot with synchronized motion cues could increase the presence of a remote sender compared to that with unsynchronized motion cues. The results of this study supported H1. This could be interpreted as a telepresence robot with synchronized motion cues make the user feel more involved when interacting with a remote sender, and that the interaction partner was likewise more involved in the interaction with the user. This implies that synchronized motion cues of a telepresence robot can make the user feel as if the interaction partners are closely connected during the interaction.

In addition, we also predicted that a telepresence robot with synchronized motion cues could increase the social presence of a remote sender more than one with unsynchronized motion cues. The results of this study also supported H2. This indicates that a telepresence robot with synchronized motion cues allows the user to access the interaction partners’ thoughts, emotions, and physicality. However, when a telepresence robot provides independent, unsynchronized motion cues, a telepresence robot could increase distraction for the user to access interaction partners’ thoughts, emotions, and presence.

6 Conclusions

The objective of this study was to investigate the effects of synchronized motion cues on presence in robot-mediated communication. People perceived a telepresence robot with synchronized motion cues as more effective on presence of a remote sender than that with unsynchronized motion. These results suggest that synchronized motion cues could be used as an effective way to convey presence of a remote sender in robot-mediated communication.
References