The Effect of Synchronized Movement of the Tele-presence Robot on User's Perception

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***Abstract*— Does synchronized movement of a telepresence robot with remote sender's movement improve telepresence communication between a sender and a receiver? For answering this question, we executed a 3 within-participants experiment for a telepresence robot with synchronized movement, a telepresence robot without movement and computer based video chat. The participants observed three different videos showing a remote sender and the perceived presence for each condition was measured in terms of telepresence, co-presence and social presence. The experimental results implied the importance of synchronization between robot and a remote sender in designing telepresence robot. The results showed that the participants felt more presence when interacting with the telepresence robot with synchronized movement than the robot without any movement or the computer-based video chat.**

Keywords— Human-Robot Interaction; Telepresence Robot; Synchronization; Co-presence; Telepresence; Social Presence

I. INTRODUCTION

It is importance to explore interaction design factors of a telepresence robot which has been developed for social communication between people at a distance [1], since a telepresence robot has multimodal communicative faculties that make it effectively deliver the presence of a remote sender to a receiver. Several researchers demonstrated that telepresence robot engages remote senders and receivers in robot mediated emotional interactions between remote senders and receivers. For instance, people experience comfort [2], social presence [3] and emotional empathy [4] in telecommunication through the telepresence robot.

The effectiveness of conveying the presence of a remote sender through the telepresence robot is significantly associated with physical embodiment of robot which other telecommunication devices such as smartphones and personal computers do not possess. The physical embodiment of the telepresence robot provides not only visual and auditory cues but also tactile information and physical motions that enhance presence.

This study focuses on an effect of telepresence robot movement synchronized with remote sender's movement. To do that, an experiment was designed in terms of three dimensions including telepresence, co-presence and social presence. Those have been recognized as major factors to be considered in many telecommunication systems.

In this paper, Section 2 discusses the preceding works on two issues: telepresence robot and synchronization. Section 3 introduces the study design including the hypotheses. In Section 4, the experimental results are shown in detail.

II. RELATED WORK

A. Telepresence Robot

Robots could be classified as a tele-operated robot and an autonomous robot according to the human intervention level [5]. Tele-operated robot is mainly focused on manipulating objects by a human operator in the remote site. Rather, telepresence robot is specialized with the purpose of the social communication between a remote sender and a receiver [6].

There are studies for the consequential effect of the human-robot interaction according to human intervention level by comparing between robot mediated human-human interaction and human-autonomous robot interaction. In simulated earthquake situation, people felt more comfortable toward a tele-operated robot than an autonomous robot [2]. People experienced more embarrassment and social presence when they had an interview through telepresence robots connected to interviewers than with autonomous robots [3]. Moreover, people had more emotional empathy to a tele-operated robot than an autonomous robot [4]. These studies showed that a telepresence robot enables people to emotionally interact with each other and effectively deliver the presence of the remote sender.

In telecommunication, presence is classified as three interrelated concepts, which can be described as 'you are there', 'it is here', and 'we are together'. Telepresence in its meaning 'you are there' characterizes the feeling that you are actually transported to a mediated world, the sense of being there inside the media. Co-presence in its meaning 'it is here' delineates the feeling that a remote sender comes to you while you are remaining, the sense of being connected to a remote sender [7]. Social presence in its meaning 'we are together' describes the feeling that a receiver and a remote sender shares emotion, the sense of being together with a remote sender emotionally [8]. For such concepts of presence, the previous studies in many

application domains such as persuasion [9] and education [10] have proved the effectiveness and usefulness of transmitting the presence of a remote sender by telepresence robot. In spite of that, investigating various interaction design factors is still required to augment the presence of a remote sender to a receiver for richer interactions between them.

B. Synchronization

Regarding presence in telecommunication, most of preceding studies have mainly focused on virtual environment through computers [11]. However, in the case of telepresence robot, it is essential to pay attention to the effect of physical embodiment on presence.

Sirkin and Ju [12] addressed this issue from point of view in synchronized movements between a remote sender and a robot. Their study revealed that synchronization between remote sender's movement and physical movement made by a telepresence robot significantly improved the receiver's interpretation for the remote sender's intention, compared to single-handed remote sender's movement or the physical movement made by a telepresence robot. Moreover, the physical movement positively influenced the perceptions of both the remote sender and the receiver. When the telepresence robot showed the receiver an unsynchronized movement, it led proxy-in-proxy problem that interrupted the receiver's interpretation about the remote sender's message. Ju et al. investigated the impact of synchronization focusing on a receiver's information interpretation in the telecommunication through the telepresence robot. Beside the information exchange, since a remote sender and a receiver are involved in the social interaction, further studies on emotional interactions through telepresence robot were needed.

III. Study Design

In this study, the experiment aims to verify how telepresence robot's synchronized movement can enhance telepresence, co-presence and social presence of a remote sender. The within-participants experiment was designed for telepresence robot with synchronized movement, telepresence robot without movement and a computer-based video chat. All participants were involved in three different conditions. The hypotheses are described as follows.

H1: A robot with synchronized movement of the remote sender will make the participants feel more telepresence than a robot without movement and a computer-based video chat.

H2: A robot with synchronized movement of the remote sender will make the participants feel more co-presence than a robot without movement and a computer-based video chat.

H3: A robot with synchronized movement of the remote sender will make the participants feel more social presence of the remote sender than a robot without movement and a computer-based video chat.

A. Participants

Eighteen participants (Male: 6 and female: 12) who have high technology acceptance were recruited. The participants were ranged in age from 22 to 30. They were educated at the college level on average.

B. Robot

In the experiment, FURo-iHome [13] was used as shown in Fig. 1. FURo-iHome is a cone shaped home service robot which was developed by FutureRobot Co., Ltd. It has a screen on a 1DOF neck which functions a tablet. A user can communicate with fellows via a IP camera, speakers and a microphone using the wireless/wired network.

Fig. 1. FURo-iHome

C. Procedure

We conducted video based experiment [14]. The participants were asked to watch three videos of two types of the telepresence robots and a computer-based video chat. The video stimulus contained video chat between two people through FURo-iHome. The conversation of each video was identical. During the conversation, the remote sender was nodding her head saying yes. In the case of synchronized movement, the robot nodded its screen synchronized of remote sender's nodding. In the other 2 cases did not move. Three videos were shown in a random order for counterbalance. After watching each video, a questionnaire about telepresence, co-presence and social presence was given.

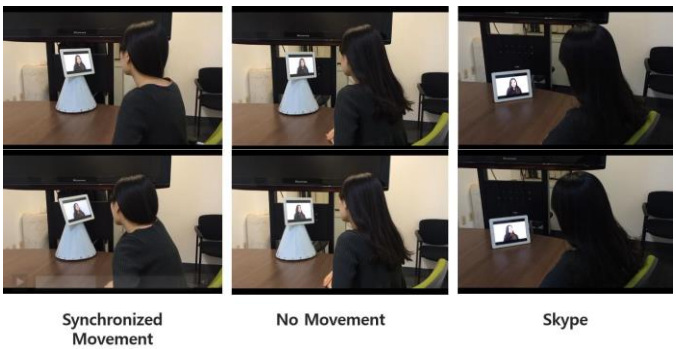

Fig. 2. Video stimulus

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D. Measures

To measure the presence, telepresence, self-reported co-presence, perceived other's co-presence, social presence were used. The participants rated the robot on 29 different Likert-type items, which were drawn from Nowak et al. [15]. The items combined into 4 scales following reliability checks. We can report a Cronbach's Alpha of 0.97 for the telepresence, 0.92 for the self-reported co-presence, 0.97 for the perceived other's co-presence, and 0.96 for the social presence.

IV. RESULTS

A. Telepresence

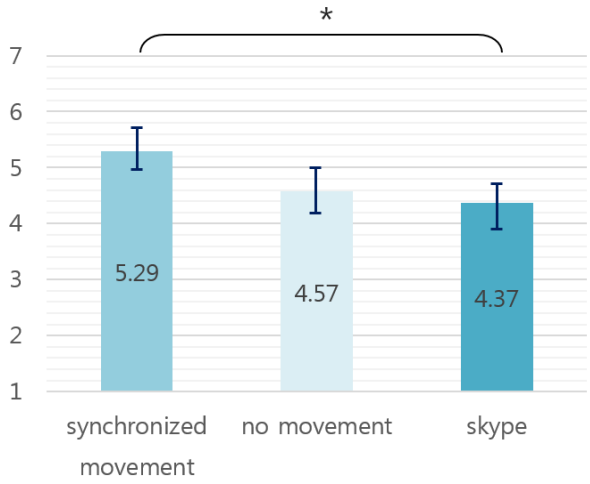

Fig. 3. Telepresence (Note: *, p<0.05)

As predicted by H1, a significant effect of synchronized movement on telepresence was found (F(2,34)=5.803, p<0.05). The robot with the synchronized movement of the remote sender (M=5.29, SD=.88) makes the participants feel more tele presence than the robot without movement (M=4.57, SD=1.01) or the computer-based video chat (M=4.37, SD=1.27).

B. Co-presence

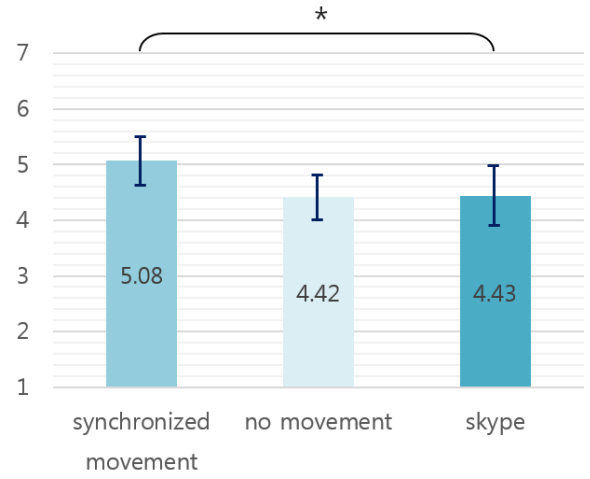

Fig. 4. Self-reported Co-presence (Note: *, p<0.05)

H2 was supported. A significant effect of synchronized movement on self-reported co-presence was found (F(2,34)=4.351, p<0.05). The robot with synchronized movement of the remote sender (M=5.08, SD=1.07) makes the participants feel more self-reported co-presence than the robot without movement (M=4.42, SD=.87) or the computer-based video chat (M=4.43, SD=1.31).

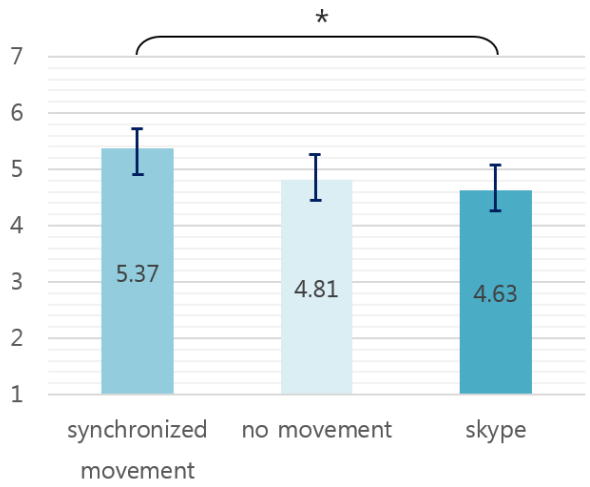

Fig. 5. Perceived Other's Co-presence (Note: *, p<0.05)

A significant effect of synchronized movement on perceived other's co-presence was found (F(2,34)=4.351, p<0.05). The robot with synchronized movement of the remote sender (M=5.37, SD=1.00) makes the participants feel more perceived other's co-presence than the robot without movement (M=4.81, SD=1.09) or the computer-based video chat (M=4.63, SD=1.11).

C. Social presence

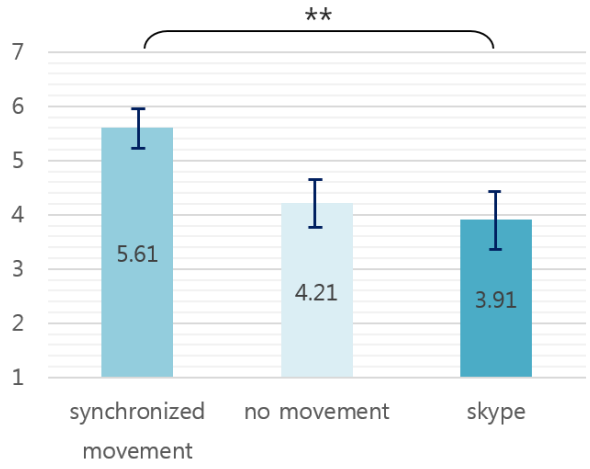

Fig. 6. Social presence (Note: **, p<0.01)

H3 was also supported. A significant effect of synchronized movement on social presence was found (F(2,34)=8.667, p<0.01). The robot with synchronized movement of the remote

sender (*M*=5.61, *SD*=.87) makes the participants feel more social presence than the robot without movement (*M*=4.21, *SD*=1.07) or the computer-based video chat (*M*=3.91, *SD*=1.25).

V. CONCLUSION

In this study, the effect of the telepresence robot with synchronized movement of a remote sender was examined. The participants felt more presence toward the telepresence robot with synchronization of a remote sender's movement than the telepresence robot without movement or the computer-based video chat. Through a remote sender's movement delivery, even a robot could impress people being in the same space. Although there are some limitations in this study, the results suggest that robot designers and engineers use the synchronized movement of a telepresence robot to effectively raise realism of the sender at a remote place. As this study was limited to the video-based short term study, follow-up experiments could be conducted in the live-based long term study. In addition, various range of ages and different cultural backgrounds will be involved in the follow-up study.

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