Initial Phase of Communication through Embodied Interaction with Simple-Shape Robot

ABSTRACT

It is difficult to communicate with an unknown robot because we don't know whether it can form a relationship with us or how it will behave without a context or premise for the interaction. We hypothesize that developing a relationship with an unknown robot first requires a notification phase with a robot that has the ability of coordinating behavior and relationships. To model this initial phase of communication, we created an experimental environment to observe the spontaneous interaction between a human and a simple-shaped robot whose movement (moving on the floor) reflected the movement of another human. For comparison our experiment also included an intentional real-time interaction and a non-interactive recorded-motion condition. The results suggest that the interaction pattern differences indicate two types of phase changes for verifying the robots' behavior through interaction or observation. We need to verify the effects of interaction patterns spontaneously performed by humans and investigate what actions and reactions are regarded as signals that enhance interpersonal interaction.

CCS Concepts

•Human-centered computing → Interaction design; User models;

Keywords

Agency Identification; communication relationship

1. INTRODUCTION

In this study, we model the process in which humans spontaneously notice artifacts with which they can form relationships. Humans communicate with each other because they adapt and adjust their behavior and relationships. In human-human interaction, action and reaction inevitably involve aspects of the adjustments of relationships. Therefore one cannot not communicate [3]. On the other hand, it remains unclear whether the motion of such artifacts as robots includes a reference of a relationship with humans, especially at the first meeting. However, we often treat computers as agents [2]. Whether we recognize objects as agents that have a mental state and can regulate their own behavior depends on actual interaction. We assume that some interactions are performed to verify whether the target objects are worth forming a relationship with in the initial communication phase and specify the interaction pattern.

We observed interaction with a simple-shaped robot that only has the ability of changing its positions. Humans manipulate their distances between others based on context or relationship [1]. Since spatial interaction is observed in many animals, it appears to be a primitive and basic interaction. We focus on spacing coordination as a starting point to simplify modeling. In addition, we observed interaction that was not oriented by experimental tasks. Some experiment tasks, such as the Turing test, provide participants with the premise of interaction with objects. We model the process of realization in which participants notice a robot that can create relationships. By modeling this process, such artifacts as a robot begin to adaptively form relationships with humans, estimate their desire for communication, or display a specific pattern of communication notification.

2. EXPERIMENT

2.1 Method

We observed the interaction between a human and a robot that was not previously perceived as having agency. The robot acted as an agent by mirroring a participant's movement. Thus, this interaction was actually a human dyad interaction via the robot between separated rooms (Fig. 1). A three-meter diameter circle constituted the delimited field of the participants' movements. Their positions were measured with a laser rangefinder (URG-04LX, Hokuyo Automatic Co., Ltd.).

We compared the no-instructed and instructed interactions in which one member of a pair knows the robot maps another participant's position before the interaction (Fig. 2). They were also instructed to let their partners notice their existence through interaction. The participants under no-instructed conditions were told that they were under no obligation to do anything with the robot and they could do anything freely in the field. Our experiment was also conducted a non-interactive condition in which the robot just did prerecorded motions from the non-instructed pair's interaction.

2.2 Analysis

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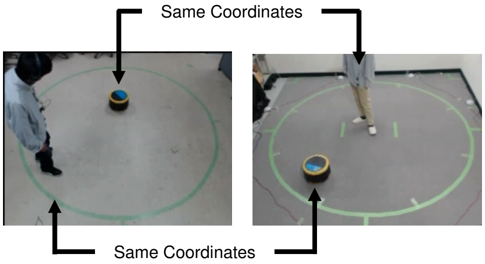

Figure 1: An interaction scene

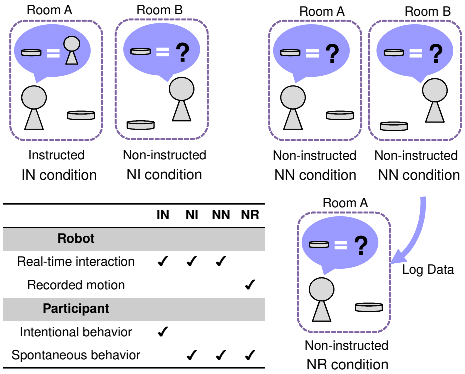

Figure 2: Experimental conditions

As an indicator that specifies the pattern of the participant motions, we calculated their moving direction to the robot's moving direction. H_t and R_t are the participant's position and the robot's position in time t. θ_R is an angle formed by $R_{t-1}R_t$ and $R_{t-1}H_t$, and θ_{H+} is an angle formed by H_tH_{t+1} and H_tR_{t-1}. We calculated the proximity of robot $P_R = \cos\theta_R$ and participants $P_H = \cos\theta_{H+}$ and counted these by dividing it into 5 x 5 bins. The rate of observation is shown as a heat map (Fig. 3).

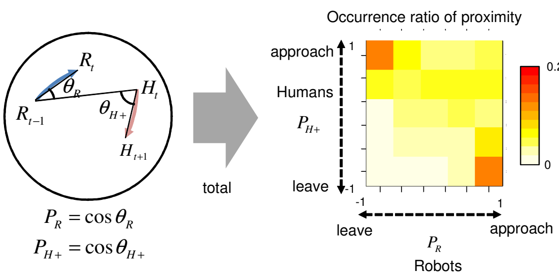

Figure 3: Calculation of proximity

2.3 Results and Discussion

We obtained the following results from this experiment:

(A) The direction of the initial period of spontaneous interaction was vague.

(B) The participants acted with the robot in real-time interaction.

(C) The participants just observed the non-interactive robot behavior.

Figure 4 shows the change of the observation rate of the proximity between the robots and the participants in every condition. In the middle period of the IN, NI, and NN conditions, which were human dyad interaction in real time, the rate of the upper-left region is commonly higher. This indicates a pattern of interaction in which the participants followed the robot when it left them in these conditions, as was frequently observed. On the other hand, the right-middle region was higher in the NR condition in which the robot moved non-interactively. We frequently observed the participants avoiding the approaching robot. The difference in the pattern between these conditions is the result of participants judging whether the robot can respond. These results suggest that the interaction pattern in the initial phase of communication spontaneously shifted two types of phase changes that depend on object responsiveness: the phase of verifying the objects' behavior through interaction and the observation phase.

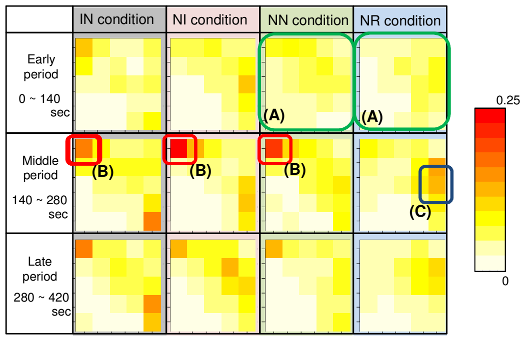

Figure 4: Results of moving direction pattern

3. CONCLUSION

We analyzed the interactions with a simple robot whose positions were mapped by another participant to model the process of the initial communication phase with an unknown robot. Our results suggest that the moving direction differences indicate a change of the communication phase induced by objects' responsiveness. We also investigated other cues. Modeling this interaction process is future work.

4. REFERENCES

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