Interaction to Unknown Entity in Virtual Embodied Interaction

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Abstract: In order to encourage communication relationships between people and artifacts, the artifact's behavioral design must be considered. We examined how people act towards an unknown entity that has no physical appearance and, thus, is without predisposed prejudice. In our experimental environment, the unknown entity is expressed as a shadow circle and the participants interacted with these shadow circles based on physical position. The participants began the experimental task by standing at a position marked by an x and we analyzed the participants'movement as they walked from one x mark to the next. When the shadows carried out an intricate movement based on the participant's position, the participants more frequently avoided or pursued the shadows. Therefore, human primary action toward a social entity responds to the movement of the target entity.

1 Introduction

It is expected that artifacts, such as robots, will increasingly be developed to cooperate with us and assume social roles in human society. In order to encourage human interaction and communication with an artifact, the design of the artifact's physical appearance and behavior should be considered. Design of the artifact's physical appearance can promote communication relationships between humans and the artifact if derived from previous human interactions. As such, robots have been developed with more human-like bodies in order to facilitate human/robot relationships. However, not all robots need to be humanoid in shape. Engineering a robot's body shape to resemble that of the human body can be very costly. Moreover, when human action is induced from previous knowledge, it is possible that the adaptation gap [1] may negatively influence continued interaction. Therefore, we focus on the artifact's behavior rather than its physical appearance. We examine how an interaction partner is viewed as a "social actor" only from their actual behavior during the interaction. In this paper, we define the "social actor" as an entity that possesses the intellectual ability to form a relationship with a human [2]. We particularly focus on the primary stage in communication between the human and the "other." When an object's identity is unknown and provides no visual cues to its appearance, how do people interact with it? If they regard the object as an interaction partner, how do people react to or act towards it? In order to answer these questions, we conducted an experiment in which participants interact with an unknown entity.

2 Interaction with Unknown Entity

In this paper, the unknown entity is an entity about which no information is given beforehand and of which no cues to its appearance are provided. The only way to identify/interpret the unknown entity is to observe its movement. The minimum information for embodied interaction is physical position. We used a circle to represent the unknown entity. Humans can perceive the properties of an object or agent, such as its animacy and intention, by observing a moving geometric figure [3]. Moreover, several studies have been conducted on the perception of these properties through interaction with an abstract-shaped object. Fukuda and Ueda showed that actual interaction with an object influences our perception of the moving object's animacy [4]. Yet there have been few studies attempting to observe undirected interaction with others. We therefore focus on a primary stage of communication and attempt to solve the following issues: What interaction will occur between a human and an unknown entity and can the human regard the unknown entity as a"social actor?"

In this study, we created an unknown entity that is displayed on a floor. Interaction is carried out based on position. Until recently, many studies of interaction have used upper limb motion. Entire body movements, such as gait, differ from upper limb action [5]. While walking, humans unconsciously adjust direction and automatically avoid obstacles underfoot. By displaying interaction partners underfoot, we can observe lower-limb-driven interaction. Therefore, unconscious motions occur at a high frequency in comparison with interaction using only the upper limbs. This unconscious movement is affected by perception of the agency to an interaction partner. Thus, we have chosen to display the unknown entity on the floor in our experiment.

3 Experiment

3.1 Purpose

In this section, we provide the details of our experiment for observing how people interact with an unknown entity. The unknown entity is represented as a shadow circle and the entity's design motion is based on a simple model. We observed the interaction between the participants and the shadow circle to investigate differences in the participants' action with respect to the shadow's movement, whether the shadows interacted with the participant or not.

3.2 Method

3.2.1 Apparatus

A 2.2-m white square projected on the floor by two LCD projectors was used as the interaction field between the participants and the unknown entities (Fig. 1). We used a 20-cm-diameter circle-shaped shadow as the unknown entity. Two shadow circles were projected onto the square interaction field. The range of the participants' and the shadows' movement was restricted within the square during the experiment. The participant's position was measured with a Kinect sensor. The position of the shadow circles was calculated according to specific conditions, as described in Section 3.2.3 below.

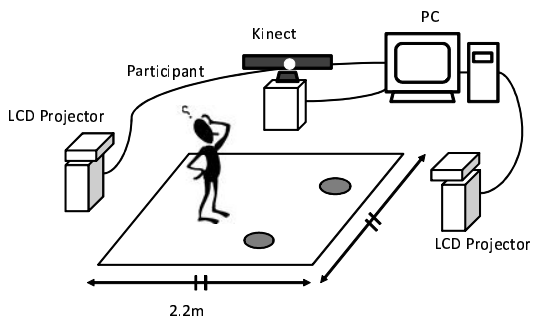

Figure 1: Setting of the experiment

3.2.2 Participants and Task

We assigned 20 university students equally to each condition. The participants were instructed to stand on an x mark when it appears and to move freely within the interaction field when the mark is not shown (Fig. 2). The participants were not told about the shadow circles. During the first 30 seconds of each trial, the x mark was not displayed and the participants freely interacted with the moving shadow. During the next 15 seconds, the x mark was displayed at a specific position. During the second 15-second interval, the x mark was displayed at a different position from the first position. As each one-minute trial ended, a new trial immediately started. Each experiment consisted of five trials, after which the participants answered questionnaires.

Figure 2: Interaction with the shadow.

3.2.3 Conditions

The experiment was conducted under the four following conditions (Fig. 3):

C1: The shadow circle is attracted and repulsed by an invisible circle.

C2: The shadow circle is attracted and repulsed by the invisible circle and another shadow circle.

C3: The shadow circle is attracted and repulsed by the participant.

C4: The shadow circle is attracted and repulsed by the participant and another shadow circle.

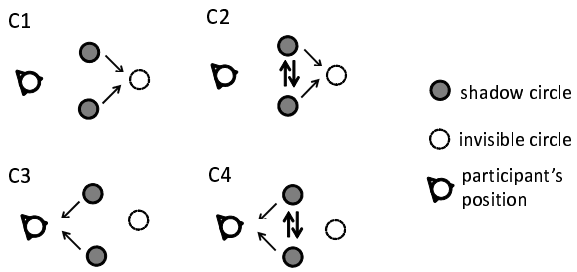

Figure 3: Experimental conditions.

3.2.4 Shadow Circle Motion

The motion of the shadow circle is governed by simple and typical motion. The shadow circle's action on a target consists simply of approaching and separating. Accordingly, we designed the shadow's motion based on an attraction and repulsion model (Fig. 4). The shadow circle approaches a target when the distance between them is further than the threshold; otherwise, it moves away from the target. The motion of

the shadow becomes more intricate when influenced by more than one target. We draw attention to the similarity between this model and theories of personal space.

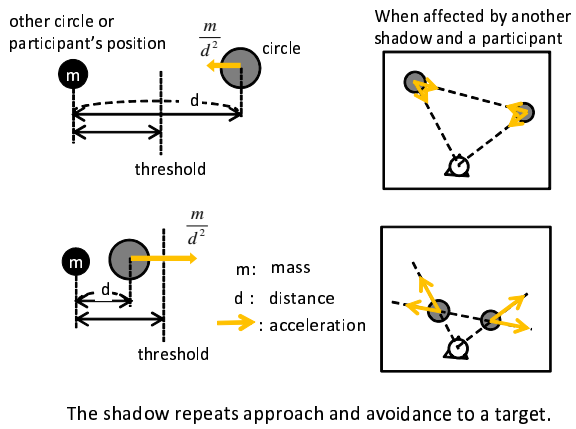

Figure 4: Attraction and Repulsion Model.

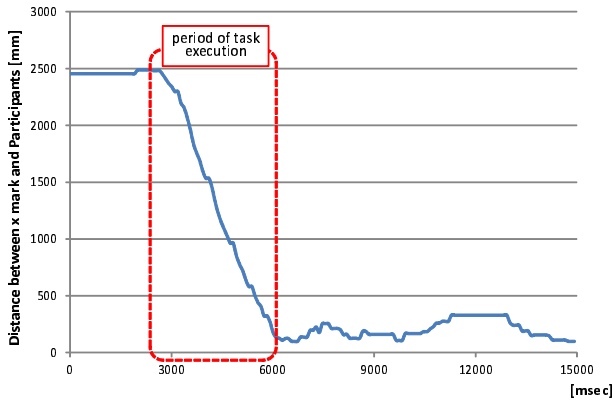

Figure 5: Example data of distance between x mark and participants.

3.3 Observed Data

We observed and analyzed the following data:

- Behavioral data
  - Log data of participant position (every 100 ms)
  - Log data of shadow circle position (every 100 ms)
  - Interaction video
- Questionnaires
  - Participant impression of the shadow circle (animacy/intentionality)

3.4 Results

When a participant moved from one x mark position to another, the participant's movement was not always straight. Participants were observed dodging or following the shadows. The time period in which participants aimed towards an x mark was deduced from the position data (Fig. 5). We then calculated the participants' movement in the task execution period. Figure 6 shows the results of the perpendicular component of the movement. The C4 movement is increased in comparison with the other conditions.

The participants often kicked and stepped on the shadow circles. Even when an x mark was displayed, some participants kicked the shadow circles. Others went to step on the shadow circles after reaching the x mark. In order to compare the frequency of such actions, we calculated the participants'movement minus the task execution period (Fig. 7).

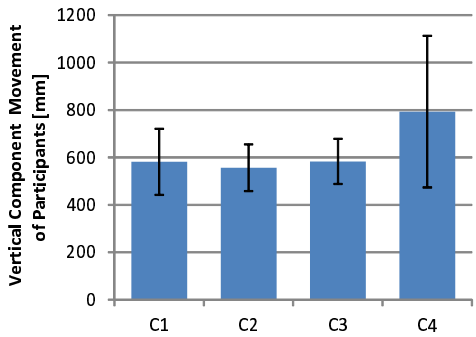

Figure 6: Result of behavioral data during task execution.

The value of the C3 movement was the highest. C1 and C2 had low values compared with C3 and C4. Figure 8 shows the results of our questionnaires about participant impressions regarding animacy and intentionality after the interaction.

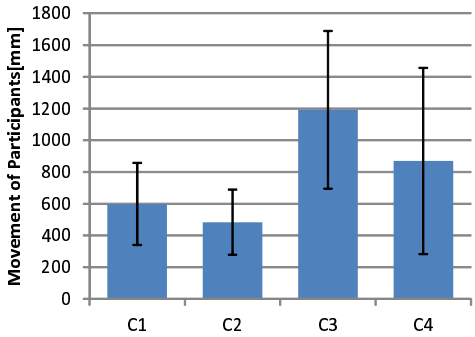

Figure 7: Result of behavioral data except task execution.

Both the animacy rating and intentionality rating ranked in the order of high to low as C4, C3, C2, and C1.

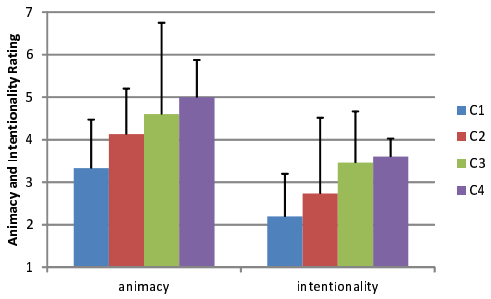

Figure 8: Result of questionnaires data.

3.5 Considerations

When the participants moved from one position to another position, the shadows'movement influenced the participants' path. The shadows' motion in C4 is related to the position of the participants and is a complicated movement. It appears that this motion influenced the participants'actions, such as approaching or avoiding the shadows. These are social actions. Thus, it seems that the participants felt that the shadow circles possessed sociality by interacting with them. People therefore can accept that an entity without physical appearance possesses sociality by carrying out an interaction without previous knowledge.

The participants took actions such as kicking or stepping on a shadow circle when instructed to stand on the x mark. These are positive actions made in an attempt to understand the motion of the shadow circles. The motion of the shadow circles in C4 is more complicated than that of C3. However, the relativity of the motion in C4 is lower. Therefore, it can be said that an action towards an unknown entity is induced by the response of the entity's motion rather than the complexity of the motion.

In this experiment, we gave the participants an experimental task that was unrelated to any interaction with the shadow circles, thus allowing us to analyze the impressions of the interaction partner from behavioral data. However, the process of forming the impression of sociality must be analyzed further. It will be necessary to analyze the behavioral data when the x mark is not displayed.

4 Conclusion

In this study, we examined how people can regard an unknown entity as an interaction partner possessing sociality only from actual behavior during interaction. We observed the interaction between the participants and shadow circles. In this interaction, the participants had no prior knowledge of the shadow circles. As a result, when the motion of the shadows was related to the participant's position, the actions of the participants, such as kicking or avoiding the shadow circles, was promoted. This result indicates that people can recognize the sociality of an unknown entity through an interaction determined by only physical position.

References

[1] Komatsu, T., Yamada, S.: Adaptation gap hypothesis: How differences between users' expected and perceived agent functions affect their subjective impression *Journal of Systemics, Cybernetics and Informatics*, Vol. 9, No. 1, pp. 67–74 (2011)

[2] Fogg, B. J.: Using Computers to Change What We Think and Do, *Morgan Kaufmann Publishers* (2003)

[3] Heider, F., Simmel, M.: An Experimental Study of Apparent Behavior, *American Journal of Psychology*,Vol. 57, pp. 67–70 (1944)

[4] Fukuda, H., Ueda, K.: Interaction with a Moving Object Affects One 's Perception of Its Animacy, *International Journal of Social Robotics*, Vol. 2, pp. 187–193 (2010)

[5] Kannape, O., Blanke, O.: Agency, gait and self-consciousness, *International Journal of Psychophysiology*, Vol. 83, pp. 191–199 (2012)