Mako-no-te: Investigating Intersubjectivity with Side-by-Side Walking Robot

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ABSTRACT

How do we interact with mechanical systems such as PC, smartphone and so on? Users command something to the system, and the system always accepts and reacts it. That kind of relationship can be named "leader-follower" relationship. On the other hand, thinking about a scene that you have a walk in a park with your partner, there are neither a definite leader nor a follower. You and your partner co-adjust the walking direction and pace by considering each other's intention and feeling from implicit cues. Such relationship has "intersubjectivity" that people share their feeling and intention with others. This study is motivated to build "intersubjective relationship" between human and robot. In this paper, we propose the concept of a side-by-side walking robot "Mako-no-te".

CCS CONCEPTS

• **Human-centered computing → Interaction design theory, concepts and paradigms**

KEYWORDS

Intersubjectivity, Side-by-side communication, Hand-in-hand walking

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1 Introduction

Think about a scene that two people are having a walk side-by-side in a park. Even though they don't speak to each other, they can adopt walking direction, pace, and distance. They can walk together without any trouble. In this scene, they infer each other's intention and feeling from implicit cues such as walking pace, pulling hand, and subtle behaviors. Such a relationship seems to have "intersubjectivity" that people share their feeling and intention with others.

While thinking about a general relationship between humans and mechanical systems such as PC and smartphone, a user asks a smartphone today's weather, then the smartphone always accepts and replies. In this relationship, the user is always the role of "leader" and the system is "follower". Therefore, this relationship is "leader-follower" relationship. Considering the future society that humans and robots live together, it is crucial to build "intersubjective relationship" between human and robot as well as between human and human. In this paper, we propose a robot "Mako-no-te" (shown in Fig. 1) that walks with human side-by-side and hand-in-hand toward investigating intersubjectivity of robot and human.

Figure 1: "Mako-no-te" having a walk with human

2 Background

2.1 Intersubjectivity

When two individuals interact, they sometimes feel each other's feeling and intention as if it is their own by inferring each other unconsciously. Such a phenomenon is called "intersubjectivity". Kujiraoka have investigated intersubjectivity between child and parent [1]. According to the investigation, it does not go well that the parent tries to make his/her child to do something without considering the child's feeling ant intention. It is crucial

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for the parent and the child that the parent accepts the child's feeling and the child do as well.

One of the key parts to build intersubjective relationship is triadic interaction. Triadic interaction is a state that two individuals share the focus on an object, which is also known as joint attention [2]. To infer the feeling and intention of others, sharing what they focus on is important.

2.2 Robots walk with humans

Almost relationship between existing robot and human is based on "leader-follower" relationship. There are some researches on robots that walk with humans. The researches can be classified into three types. The first type is that the robot walks ahead and lead the human. A guide robot in a museum lead humans and introduces exhibitions [3]. The second type is that the robot follows the human. Tasks of these robots are following a specific person goes through a crowd and transport baggage [4]. The third one is the robot walk with human side-by-side. A wheelchair-shaped robot moves along with the human [5].

The first and second type are definitely "leader-follower" relationship even though there is a difference of role that the robot is a leader in the first one, and is a follower in the second one. About the third one, its physical arrangement is side-by-side. However, the wheelchair robot always adopts the moving speed and direction to the human one-sidedly. Therefore, the third one is also counted as "leader-follower".

3 Mako-no-Te

3.1 Concept

The relationship between human and human is not only "leader-follower" relationship, but also "intersubjective relationship" that people infer each other's feeling and intention, and there are neither a definite leader nor a follower. We have focused on a scene that robot and human have a walk side-by-side and hand-in-hand, we have developed a robot "Mako-no-te" toward building "intersubjective relationship" between human and robot (Fig. 2).

"Mako-no-te" is a robot has a walk with human side-by-side and hand-in-hand. "Mako-no-te" is able to express implicit cues such as adjusting moving direction and speed by its locomotion device, and pulling hand by its arm. "Mako-no-te" is also able to detect surrounding objects in the walking environment. The three existence, human, "Mako-no-te", and objects in the walking environment, make triadic interaction while walking. Then, we aim to build "intersubjective relationship" between human and robot.

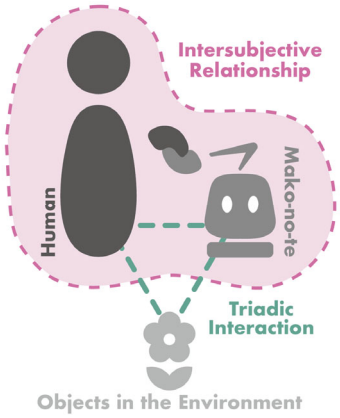

Figure 2: Concept of "Mako-no-te"

3.2 Implementation

The hardware architecture of "Mako-no-te" mainly consists of iRobot create as a mobile robot, a small PC, 4 servomotors in its arm, and a laser range sensor (Fig. 3). Each servomotor that makes up the arm is also used as a sensor for detecting the position of its hand-holding human's hand as well as an actuator to move the arm. The laser range sensor measures the distance between human and "Mako-no-te" and is also used for detecting surrounding objects. The hardware explained above is controlled by the software developed with ROS (Robotic Operating System).

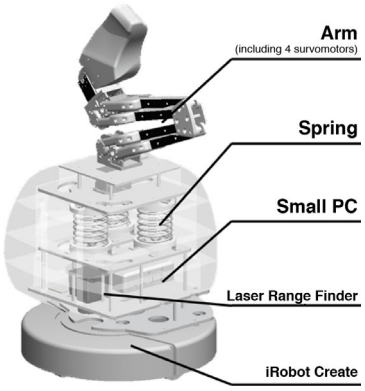

Figure 3: Hardware architecture

4 Conclusions

In this paper, we propose a robot "Mako-no-te" that walks with human side-by-side and hand-in-hand toward investigating "intersubjective relationship" between robot and human. In the future, we expect to explore what interaction of "Mako-no-te" and human build intersubjective relationship by conducting experiments.

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