Mako-no-Te: To Explore Side-to-Side Communication through the Intersubjectectivity

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Abstract: This study is motivated to build-up the concept of side-to-side communication when robot and human walking together with takes the hand of each other. The above context, robot and human have to communicate with by side-to-side to adjusting (non-verbal behaviors, directions, speed, distance etc) their interactions (intersubjectivity) within the comfort-zone. Therefore, we incite to explore what kinds of factors are essential for side-to-side communication and also examine how robot and human improving intersubjectivity toward side-to-side communication based in several interactive trials.

1 Introduction

HRI community is examining different communication behaviors and contexts [1] to establish the natural communication with humans, side-to-side communication also interesting to be explore which is quite novel in HRI. Therefore, in this study direct to explore to develop the interactive mechanism that perspective of side-to-side communication which is adjusting and self-referring their hands with respective behaviors (e.g. speed, directions, distance, etc).

We believe that concept of personal space, intersubjective, dynamic adaptations are the most essential factors to buildup the above interactive mechanism for side-to-side communication. Accordingly, as a preliminary stage, we like to explore what kinds of factors are essential to establish the side-to-side communication, and also examine how intersubjective is effecting toward side-to-side communication based in several interactive trials.

2 Design Concept for Mako-no-Te

Platform of Mako-no-Te is design with one-handed robot with small-scale head-appearance as its body. The platform is direct to establish the sympathetic communication between human-robot in the concept of side-to-side communication (Figure 1). The hardware architecture of "Mako-no-te" mainly consist a small PC (fit-PC2), 9 servomotors, and laser range sensor. A microcomputer is used to control those servomotors and a laser range sensor (placed in the lower body) in order to control its hand and measure the distance between human and robot. "Makono-te" uses two servo motors for moving which are placed in the robot's lower body. In addition, the upper body arms are equipped with servo motors that are configured by a total of six degree of freedom. Each servo motor that makes up the arm also serves as a sensor for detecting the role of the human condition as well as an actuator to move the arm. The system is recording to the distance between human and robot (with frame rate of 30FPS) and angle adaptation according to the human interaction.

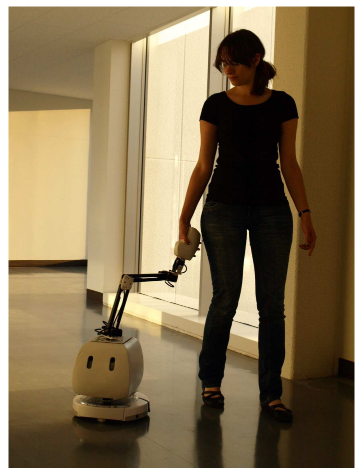

Figure 1: User is walking with robot

3 Toward Side-to-Side Communication

We have several interesting issues, when we consider scenario of robot and human walking together with takes the hand of each other. In this side-to-side communication both robot and human need to ground the intersubjectivity and self-referring to walking together; both human robots have to adjust their distance, hands, speed, etc as low-level parameters of the interactions. To buildup the concept of side-to-side communication, we have to explore/generalize

Table 1: Following table showed the mean value, standard-deviation, results of ANOVA, and Ryan based on operator's (robot controller) ratings

Questions	Trial 1		Trial 2		Trial 3		ANOVA F(2,12)	Multiple comparison (Ryan)
	ave.	(s.d.)	ave.	(s.d.)	ave.	(s.d.)		
Robot (operator) can understand where walker can go (Q1)	2.000	(0.894)	3.400	(0.490)	3.600	(0.490)	F=6.909, p<.05	1<2, 3
Robot (operator) can understand speed (walking) of walker (Q2)	1.800	(0.980)	2.600	(0.490)	2.800	(0.400)	F=4.421, p<.10	–
Robot (operator) indicate where to go (Q3)	2.200	(0.748)	3.600	(0.490)	3.600	(0.490)	F=6.323, p<.05	1<2, 3
Robot can predict the waling direction of walker (Q4)	1.800	(0.748)	2.800	(0.980)	3.600	(0.490)	F=5.545, p<.05	1< 3
Walker adjust speed (walking) based on robot intention (Q5)	2.200	(0.748)	3.200	(1.166)	3.200	(0.748)	n.s.	–
Robot can feel, its walking together with walker (Q6)	2.600	(1.020)	3.600	(0.800)	3.800	(0.748)	F=4.276, p<.10	–
Robot can feel both can understand each other intention (Q7)	2.400	(1.200)	3.600	(1.356)	4.000	(0.632)	F=7.429, p<.05	1<2,3

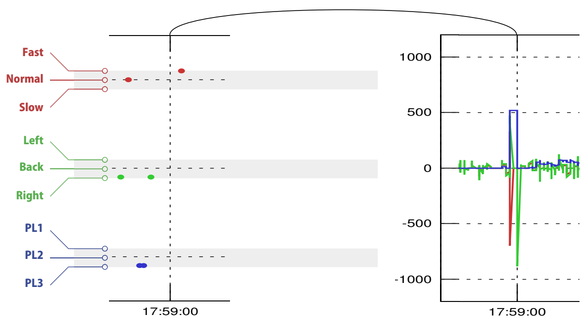

Figure 2: Figure showed robot's speed and parameter of robot's hand

how those behavioral parameters are effecting each other in dynamic interactions while maintaining comfortable walking with each other.

4 Experimental Protocol

The objective of this experiment to understand what kind of factors (walking speed, angle of robot hands, etc) is useful for side-to-side communication; also explore how robot and human improving their intersubjective toward side-to-side communication based in several interactive trials. In the experiment, pairwise participant were assigned; one participant is controlling robot through wizard of OZ from different room (referring other participant behaviors through the display) and other participant walking with robot by takes the hand of each other. We have setup collision object based route for the experiment, and it's interesting to explore how robot and human adjusting to those collision object. In this experiment, 12 university students were participated in age between 20 to 26. We conducted the three trials for each pair of participants and end of the each trial operator (robot controller) has to answer the same questionnaire in three times. During the experiment, we gather following information; speed of robot, distance between robot and participant, and parameters of robot's hand (torque, angle, and speed).

5 Results

Figure 2 showed that one of a pair data for robot's speed and parameter of robot's hand (torque, angle, and speed), as shown, when robot increase the speed, parameters of hand have changed and walker attempted adjust those parameters until attain to the comfortable status. Further, when robot increases its speed, then walker adjusted their angle and distance until both are in comfortable in side-to-side communication. Consequently, we applied the ANOVA to explore difference of operator's rating in each trial by considering the each of the question as separately, Ryan statistic use to compare and find the higher rating score within each of the trial. Operator rating indicated that, he/she feel that both can infer their intention when they walking together ($Q7$). Other questions (specially $Q1$ and $Q2$), indicated that operator attempted adjust his/her speed based on the partner, and also can gradually infer where partner can intended to go (intersubjectivity) when they have experience in several trails (based on the Ryan statistics).

All of the above questionnaire analysis and graphical analysis of robot's parameters indicated that the distance between robot and human, parameters of hand, and infer of partner intention are enormously important to explore side-to-side communication.

6 Conclusion & Future Works

Both robot and participants incrementally adapted/learn intersubjectivity toward side-to-side communication by considering the above factors when user and robot have experience on several interactive trials. In future, we expect to explore, how they maintain interpersonal space to establish the comfortable zone toward better side-to-side communication by adjusting the essential behaviors.

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References

[1] Y. Yamaji, T. Miyake, Y. Yoshiike, P. R. S. D. Silva, and M. Okada. Stb: Child-dependent sociable trash box. *I. J. Social Robotics*, 3(4):359–370, 2011.