2012 IEEE RO-MAN: The 21st IEEE International Symposium on
Robot and Human Interactive Communication.
September 9-13, 2012. Paris, France.

# Behavioral Turing Test using Two-axis Actuators

Hirotaka Osawa, Kunitoshi Tobita, Yuki Kuwayama, Michita Imai, and Seiji Yamada

*Abstract*— **The Turing test is an imitation game for determining the intelligence of an agent. In spite of its simplified setting, the use of natural language between two agents in the test is still too high a hurdle for achieving fruitful results in the field of artificial intelligence. In this paper, the authors propose a variation of the Turing test with a restricted communication method. This modified test uses behaviors generated by two-axis actuators for communication instead of the natural language dialogue used in the normal Turing test. This reduction of scope reveals what kinds of features are essential for an imitation game, and broaden the application brought by Turing test. When we learn what sorts of communication become possible with restricted actuation, we can apply this knowledge to any kind of robot or device in the real world. First, we tried to determine what elements are critical for communication between a user and a robot through a preliminary experiment involving human-human communication. A human manipulator received a video image as input and controlled a "robot box" with two actuators in a way that would lead a user to put other objects into the box. The results indicated what kinds of behavior are required to show the intention of the manipulator to the user. Second, we analyzed the result of the preliminary experiment, organized a behavioral model from the result, and programmed the robot box to run the model. The behavior of the robot was programmed according to the user's head and hand locations as identified by a motion captures system. The robot automatically interact with a human without human manipulation with this program. Third, we conducted a behavioral Turing test in a communication task whereby the human collected items according to the instructions of the robot box. In this test, two actuators on the box is controlled both by human manipulator and our program. The answers of users suggests that the users could not identify which is controlled by a human manipulator or the program. This result indicates that the Turing test succeed in a restricted behavioral level.**

## I. Introduction

The Turing test is a test to judge the intelligence of an automatic system through an imitation game [1]. In it, one participant interacts with another participant by sending text messages. The test is passed by the participant sending the message is if the other participant decides it (or he or she) is human. The test was originally based entirely on natural language exchanges.

However, the Turing test depends on the evaluator's background knowledge, context, and conditions. Cohen noted that this dependency on participants makes it hard to evaluate intelligence appropriately [2]. Hayes showed that the ambiguity of judging prevents the Turing test from identifying useful AI applications [3].

The fields of theoretical artificial intelligence and human agent interaction are concerned with developing intelligence in virtual and real agents like robots [4]. These agents do not require the level of intelligence needed to pass the Turing test, but rather intelligent seeming behaviors that would attract users and maintain smooth interactions. For example, artificial agents in a video game are required to behave more intelligently because it is important to attract users to the game. Animal robots like AIBO and PARO also require intelligent behaviors to facilitate long-term interactions between themselves and the user [5][6]. Semi-automatic robots that account for human and robot behaviors also require intelligent behaviors. Glas et al. proposed that robot behaviors will soon be sophisticated enough for them to act as guides for humans under the condition that if the robot cannot understand the user's needs, it would give control to its human operator [7]. Semi-automatic interaction also has a potential to improve robotic puppets [8].

The pressing requirement for some level of intelligence in an agent mandates that we look at intelligence tests from a different aspect. An artificial "intelligence" need not pass the Turing test on natural language in order to be useful, but rather it should be able to pass a basic version of the test, one that tests the intelligence of, say, simple behaviors like motions or gestures.

In spite of its potential usefulness, previous studies have not examined the idea of a behavioral Turing test well. Mckinstry trial to use Boolean questions for Turing test called Minimum Intelligent Signal Test [9] is still hard challenge because of languages. Some have posited variations that use means other than natural language. A progressive example is TTT (Total Turing test) [10]. This test examines interactions with machines fully imitating humans. Ishiguro conducted a TTT using an android that copied his appearance, called Geminoid [11]. Although this android based study is a milestone in artificial intelligence, it is not appropriate method for today's technology to be usefully tested, because this variation includes all kinds of human features and is more difficult than the original test. To make applicable Turing test, we need to focus on 'shrinking' rather than expanding the features of the Turing test.

Imitation and learning by demonstration studies in robotics tried to create primitive behaviors for robots [12][13][14]. These studies focuses more about imitation of each behavior than interaction model. It is not enough to construct Turing test because their model was not directly compared with human manipulation. Gestural Turing test is one of the example to shrink the communication channel [15]. They

H. Osawa, K. Tobita, Y. Kuwayama and M. Imai are with Keio University, Address osawa@ayu.ics.keio.ac.jp, tobita@ayu.ics.keio.ac.jp, kuwayan@ayu.ics.keio.ac.jp, michita@ics.keio.ac.jp.

S. Yamada is with the National Institute of Informatics, Address seiji@nii.ac.jp.

used simple dots as communication channel with motion capture system. However, their artificial algorithms are reproduction of recorded gestures and imitation of participant's gestures. Both algorithms are less interactive for users behaviors. Their variation is too to create application from here.

To complete reasonable and applicable Turing test in interactive task, we tried a behavioral Turing test that is conducted with a two-axis actuator based robot. This variation limits the communication method between the user and the system. It uses the positions of the user's face and hands as the input of the system and uses a two-axis actuator as the output. The behaviors of the two-axis actuator are very simple. However, after referring several human robot interaction studies [16][17], we decided that that it would be sophisticated enough to construct useful interactions. This simplified communication situation makes it easy to apply this method to virtual agents and moving machinery like mobile robots and interactive home appliances.

First, we tried to determine what elements are required for communication between a user and a robot through a preliminary experiment. In the experiment, a human manipulator received a video image as input and controlled a "robot box" in a way that would lead a user to put objects into the box. The results indicated what kinds of behavior are required to inform the user about the intention of the manipulator. The results also indicate that there are three distinctive phases to informing one’s intention. Second, we programmed an automatic interaction system embodying the results of the preliminary experiment and copying human manipulator's behavior. The behavior of the robot was controlled by the program, and the program used the user’s head and hand locations, as picked up by motion capture sensors. The experiment reveals what behaviors and timings are used by humans to convey their intentions. Third, we conducted Turing test in a communication task whereby the human collected items according to the instructions of the robot box.

The rest of this paper is organized as follows. Section 2 describes the details about preliminary experiment. Section 3 models the results of the preliminary experiment, and the models were implemented in the automatic interaction system without human operators in Section 4. In section 5, we confirms behavior of our model. In the evaluation, the robot led the user to pick the right object. We conducted behavioral Turing test in section 6 and discusses the appropriateness of our test with statistical analysis. Section 7 concludes the paper.

## II. Preliminary Experiment: Human-human Interaction via Two-axis Actuators

The experiment involved two participants, a manipulator of the robot and a user of the robot. Two participants took turns acting as the manipulator (one female and one male). The experimenter gave the manipulator a controller for two actuators and instructed her/him on how to manipulate the robot by it. The tasks for the manipulators were as follows. First, the manipulator led the user to move all books on the desk into the robot box. Second, the manipulator led the user to sit down on the chair. Third the manipulator led the user to move all other objects on the desk into the robot box. Fourth, the manipulator stopped the user from standing up.

The setup of the experimental room is shown in Fig. 1. The manipulator tried to express her/his intention just through moving the robot. The manipulator was isolated from the user and could not interact with any auditory communication.

Eight participants (two females and six males) took turns as the users of the robot. They entered the experimental room and conducted 10 minutes of interaction. They were neither instructed what would happen in the room nor what was required. They also did not know that the robot was controlled by a hidden manipulator. The absence of explanation was to keep the user ignorant about the aim of the experiment. This setup prevented the user from exploiting any background knowledge about the interaction.

We set up a two-axis-actuator robot box in the experimental room. Figure 2 shows the robot outside (top left) and in the box (bottom left). The robot had two servo motors and could rotate $\pm 15$ degrees in pitch and $\pm 180$ degrees in yaw. The minimum step of the servo motor was 0.9 degree. The actuators and the controller of the manipulator were connected by wire, and the response time was less than 100 milliseconds. This delay period was short enough for the interaction to seem natural. The figure (right) shows a scene from the experiment.

### *A. Result of the Preliminary Experiment*

After 10 minutes of experimenting, we interviewed each participant while they watched the recorded video of their experiment. All users eventually understood that the robot wanted to them to move the target into the box. The result suggests that the humans could interpret intentions even if the communication method is restricted to two-axis actuators. The qualitative answers about the meaning of the movements are summarized as follows.

- An effective negative response (shaking) consisted of shaking the entire robot box left and right.
- An effective positive response to the user consisted of moving the box up and down (nodding).
- The a directing motion toward the user helped to indicate front side of the object. The nodding motion also helped to indicate the front side of the object.
- Directing the upper side of the box toward the target was useful for informing the user to move the target into the box.

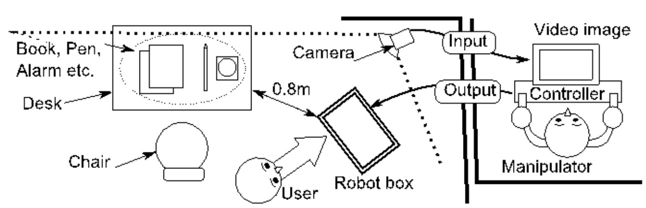


Figure 1. Setup of the preliminary experiment

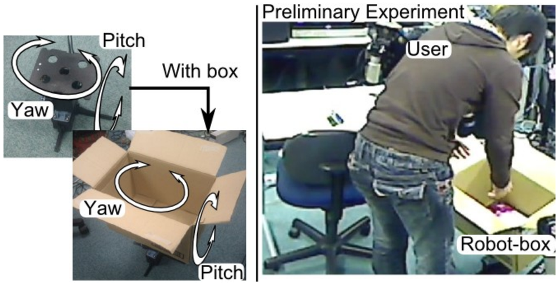


Figure 2. The robot box with two-axis actuator

- Users sometimes continued observing the robot even when they understood that the robot box wanted them to move the object into the box. The resulting misunderstanding required a waiting behavior to the user's turn taking.

## III. Model of the Interaction

This chapter discusses what kind of model is required to facilitate a successful interaction between the user and the robot with previous result. The model includes shape, behaviors, and interaction phases explained as follows.

### A. *Shape of the Robot: Determination of the Front Side and Functional Side*

The front side of the box was used to inform the user about the intentional direction of the robot (Fig. 3 left). The robot requires a front side to convey its intention to the user. The front side is determined by the robot's appearance and it behaviors.

In regard to the robot box, the front side is entirely determined by its behaviors, because the box itself is centrosymmetric. Some participants did not initially understand which side of the box was the front. Manipulators also did not initially choose the front side of the box. However, when it moved up and down (pitched up or down), the user and the manipulator were able to understand that the pitch direction indicated the front side of the interaction.

This finding can be generalized as follows. It is easy to determine the front side of the object if the object has a distinctive shape and texture to determine the front side. However, if there is no distinctive information to determine the front side of the object in it, the user determines the front side by movements. Simple spheres, cylinders, boxes, and cones need more information to determine a front side.

On the other hand, determining the functional side is easy for the user. The robot box has one open side to load or unload objects. Directing the opening side towards the objects was easily understood as the robot wanting to interact with an environmental object.

### B. *Behaviors of the Robot*

We categorized the robot's behaviors in the preliminary experiments as intentional gestures or regulative behaviors. Intentional gestures are:

- Nodding and shaking respectively mean affirmation and denial.
- Aiming the front side at the target suggests the direction of the intention.

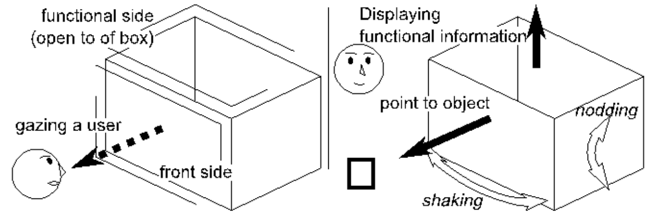


Figure 3. Front, functional side, and behaviors of the robot

- Aiming the front side at the user displays the robot's attention toward the user.
- Aiming the functional side at the user suggests that the user use the function of the robot.

We show each gesture on the Fig. 3 right.

Regulative behaviors were as follows.

- Repeating an action sequence helps a user to understand the rules from the motions and intention in the behaviors.
- Interruption during an action helps the user to imagine the next action that will be performed by the robot. This motion also supports user's understanding about the robot's requirements.

We found that the same behaviors did not always mean the same intention. Some behaviors are time restrictive. For example, a robot's moves will attract the attention of a user during a period from the start of the user's appearance and before user's attention toward the robot. Directing behaviors are understood once the user understands the front side of the robot. These must be conducted after the front side is understood. Nodding and shaking are more time restrictive. The shaking motion suggests the user should stop conducting an action and or that he or she conducted an action just after the finish time. These motions are understandable after the actions. These findings suggest that intentional gestures behave like nouns and verbs in the interaction, and regulative gestures control the syntax of the gestures.

### C. *Interaction Phases of the Robot*

We divided the interaction phase into three parts (Initialization phase, Observation phase, and Action phase), based on the findings of the preliminary experiments. The next three paragraphs describe how the robot and user act in each phase. Figure 4 shows the kinds of interaction in the three phases above.

The initialization phase is for the robot to show the user that it has an intention toward her/him. This is done by the user moving and the robot moving according to the user's actions. To show that the robot is an intentional agent, it should keep its front side toward the user. The user also needs to determine which side is the front of the object. Once the user understands that the robot has an intention and direction, the robot can proceed to the next state.

In the observation phase, the user pays attention to the object and understands the information given by the robot. Robot leads the user to use the functions of the robot. If a function is used for a different object, the robot redirects the user to the correct object. For example, if the robot instructs the user to take a book from inside itself, there is no need for it to use a directing motion. However, if the robot wants the user to move a book outside, it requires a directing behavior. At the end of each behavior, the robot faces the function side toward the user. This means the user should proceed to the next phase. If there is no action from the user, the robot repeats the above behavior.

In action phase, the user acts according to the robot's intention and observes the robot to get information about whether the action is right or wrong. The robot checks and waits for the user's behavior. When the user approaches an object, as instructed by the robot, the robot aims the functional side at the user. On the other hand, if the user moved differently from the robot's intention, the robot produces a negative gesture to prevent an incorrect action. When the user finishes the appropriate action, he or she finishes her/his turn and the system moves to the observation phase.

## IV. IMPLEMENTATION OF THE AUTOMATIC INTERACTION SYSTEM

We explain the automatic interaction system that embodies the interaction models of section 4. The user interacted with her/his head and hands to interact with the robot box. The system is controlled without any human manipulator.

This system used the positions of the head and hands for the interaction, as detected by a motion capture system. The user attached three or more markers to her/his head and both hands. The sensors detected two specific actions (touching the object and approaching the robot box). The system calculated the difference in the robot's direction and the user's head direction. If the difference was less than 45 degrees, the system estimated that the user faced toward the robot. When the hand was within 150 mm of the object, the system considered that the user was touching the object.

We also detected the social distance of the robot and the user in terms of the distance between the midpoint of the user's head and the center of the robot. We used the center of the two markers on the user's head as the position of the user. The system detected that the user was approaching the robot box when the head was 500 mm from the robot. We decided this distance according to the result of the preliminary experiment.

Examples of the behaviors are shown in Fig. 5. The position markers are attached as Fig. 5A. In state 1, the robot attracts the user and directs its front toward the user's position

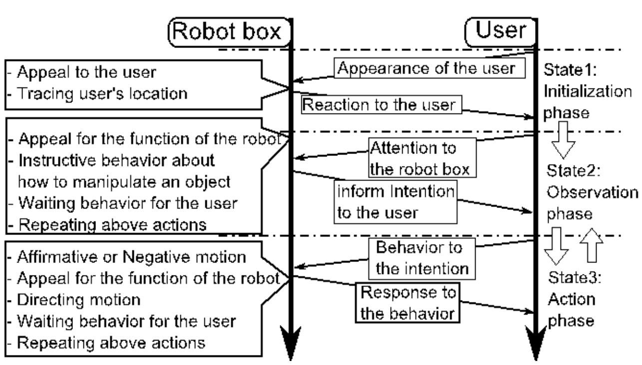


Figure 4. Three phases on the interaction

(Fig. 5B). The robot uses nodding to indicate the front side (Fig. 5C). The system moves to the next phase after five seconds of gazing by the user.

In state 2, the user observes the motion of the robot. The robot alternately aims its front side at the object and its functional side at the user's head (Fig. 5D and 5E). Aiming the front side at the object implicates the object as a target of the interaction. Aiming the functional side at the user implicates use of the functional side of the robot. In this way, the user learns the robot's intention regarding the object. When the robot points the functional side at the user's head, it waits three seconds to lead the user to the next phase. The system goes to the next phase when the user approaches the object.

In state 3, the system observes the behavior of the user and determines whether it is right or wrong. If the user takes the wrong object (Fig. 5F), the robot shakes (Fig. 5G). This implies that the user did not understand the right object to pick up. When the user stops moving toward the object, the system repeats state 2 and instructs the user about the right object. When the user takes the correct object (Fig. 5H), the robot aims the functional side at the user and waits for the user's next behavior (Fig. 5I).

## V. APPLICABILITY OF THE INTERACTION MODEL

We evaluated the automatic interaction system. We placed three objects 1 meter from the box. The robot box tried to instruct the participant to move one of the objects into the box.

Ten people (two females and eight males, from 22 to 24 years of age) participated in the experiment. We did not give them any prior instruction on what would happen. Each participant waited the outside, and the experimenter made an announcement for him or her to enter the room. The robot stopped and the experiment finished when the participant moved the object into the box. When the participant could not

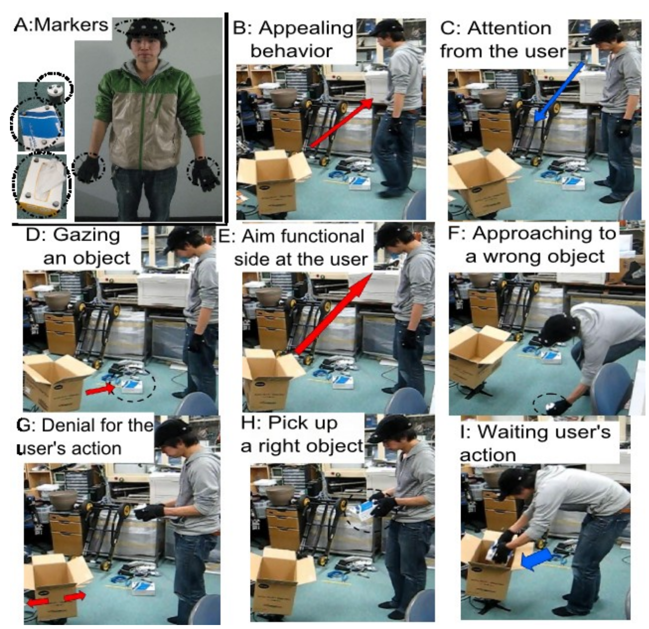


Figure 5. Examples of behaviors automatically generated

understand the intention of the box and started to observe other objects on the room, or her/he touched the object but left it where it was instead of putting it into the box, the experiment also finished as failure.

### A. Result and Discussion

All participants put some objects in the box. We observed the behaviors of the participants via a hidden camera. We categorized four levels of success and counted how many participants succeeded.

A) The participant touched the object targeted by the robot box as their first action (7 participants).
B) The participant moved the target object into the box as their first action (7 participants).
C) The participant moved the target object into the box at once during the experiment (9 participants).
D) The participant moved the target and kept it into the box until the end of the evaluation (8 participants).

Shaking (denial) motions occurred three times during the experiment. Two participants stopped their actions because of them. Two participants took two objects and showed them to the front side of the box.

80% of the participants succeeded in completing the experiment (D). This result indicates that our three-state interaction model worked. It also suggests that simplified interactions with two-axis actuators are enough for leading users.

## VI. Experiment: Behavioral Turing test using Two-axis Actuators

We conducted the behavioral Turing test using our model in the demonstration booth of our lab on the workshop. We placed the box based robot and three type of color cases on the ground of our booth. We placed three objects 1 meter from the box.

Each user tried three trial sequences. Automatic condition and manual condition is randomly assigned in these three sequences. In automatic condition, the robot box is controlled by the program. In manual condition, the robot box is controlled by a human operator who is hidden from the users. There are two human manipulators in the test. Each manipulator is randomly assigned for each experimental case. The manipulators in this experiment are different from previous manipulators in the preliminary experiment. They are forced to instruct the participant to move one of the objects into the box just by the robot box's behaviors. A user equipped a cap and gloves with motion capture markers. The user did not know which condition is selected in each sequence.

The user selects two of color boxes and put it in the robot box according to the instruction from the robot box in each sequence. We requested the user to judge whether the robot box is controlled by a human or a computer in the each sequence. The user answered whether the box is controlled by a human manipulator or a computer using 6 Likert scales after the sequence. A positive (+1 to +3) or negative (-1 to -3) score represents whether it is manipulated automatically or manually. The score represents each sequence's believability. For example, if the user strongly believe that the behavior is controlled by a human, the user gave a +3 point score. On the other hand, if the user fairly uncertainly believe that the behavior is controlled by computer, the user gave a -1 point score. When the experiment finishes, the user get an reward according to their scores. Scores are calculated by multiplying an absolute value in believability (1 to 3) with the right/wrong (+1/-1) answers. One point score counted as 75 yen (one dollar). If a total score became minus, the user did not get any reward from the experiment. This experimental setting motivates each user to estimate each sequence's believability seriously.

Fifteen people (three females and 12 males) participated in the experiment. Their ages are from 20 to 70. The robot stopped and the experiment finished when the participant placed the object in the box. We collected 45 sequences. Twenty-four manual conditions and 21 automatic conditions are totally assigned in these sequences.

### A. Result and Discussion

All participants put correct objects in the box according to the instruction from the box. In the manual condition, there are 12 correct answers and 12 incorrect answers. In the computer sequence, there are 9 correct answers and 12 incorrect answers (shown in table 1 left). We applied Pearson's chi-square test to these data and a p-value is 0.93.

| Answered as | Human | Computer |
|---|---|---|
| Right | 12 | 9 |
| Wrong | 12 | 12 |

| Believability | 1 | 2 | 3 |
|---|---|---|---|
| right | 10 | 5 | 6 |
| wrong | 9 | 6 | 9 |

Table 1. Validity in manual and automatic cases(left), and Relationship between believability and answers (right)

Table 1 right shows relationship between believability for each answer and its result. These results suggest that each believability is not related to whether it is correct or not. The average score of believability multiplied by right/wrong answers (+1/-1) is -0.13 (SD = 2.27) in manual condition, and -0.33 (SD = 2.00) in automatic condition. We applied t-test for these scores and the p-value is 0.74.

All participants succeeded in completing the task to collect objects. This result indicates that our three-state interaction model could instruct all the users to put objects in the robot box. The p-values show that the statistical method cannot distinguish user's answers from random answers because both p-values are more than 0.70. Because statistical analysis method cannot directly confirm the similarity of two groups, there is left a possibility that the data is not enough for finding a difference. However, this result roughly indicates that behavioral Turing test with two-axis actuators was successful.

### B. Contribution and Limitation

The result of evaluation and experiment show that our interaction model for two-axis actuators could convey the intention of the robot to the user, and also indiscernible from the behavior controlled by human operator.

The most important contribution of our study is to show an running behavioral Turing test in interactive and real-world based application. We think that our success is supported by minimization of the task between agents and simplified interaction channel. The model is generalized and separately applicable. For example, if we apply our model to two actuators in humanoid's head, the humanoid could lead a user to pick up object as same as human's control, even if other behaviors are not enough to achieve Turing test.

Simplified task and channels could engrave acceptable handrail toward steep mountain in Turing test. Our result propose another view to the Hayes's proposition that Turing test did not created fruitful goal in artificial intelligence field (Hayes et al. 1995). If we selected limited task and limited communication channel, we can set appropriate engineering goal with Turing test approach.

## VII. Conclusion

We proposed a variation of the Turing test that involves a restricted communication method. This modified test uses two-axis actuators for communication instead of natural language dialogue. This reduction of scope reveals what kinds of features are essential for an imitation game. This approach has the potential to evaluate several kinds of interfaces because two-axis actuators are used in many real-world applications.

First, we tried to determine what elements are critical for communication between a user and a robot through a preliminary experiment involving human-human communication. A human manipulator received a video image as input and controlled a "robot box" in a way that would lead a user to put objects into the box. The results revealed gestures, regulative behaviors, and three distinctive phases in the interaction that are used to make intentions clear. Second, we created an automatic interaction system embodying the results of the models. The behavior of the robot was programmed using the user’s head and hand locations, as identified by a motion capture system. Third, we conducted Turing test in a communication task whereby the human collected items according to the instructions of the robot box. In this test, two actuators on the box is controlled both by human manipulator and our program. The answers of users suggests that the users could not identify which is controlled human or computer. This result indicates that Turing test is achieved in restricted behavioral level.

## Acknowledgment

This work was supported by the JST PRESTO program.

## References

[1] Turing, A. M. 1950. Computing Machinery and Intelligence. *Mind* 59, 433-460.

[2] Cohen, P. R. 2005. If Not Turing’s Test, Then What? *AI Magazine* 26(4), 61–67.

[3] Hayes, P., and Ford, K. M. 1995. Turing test Considered Harmful. In Proceedings of the Fourteenth International Joint Conference on Artificial Intelligence, 972-977. Menlo Park, Calif.: International Joint Conferences on Artificial Intelligence, Inc.

[4] Fong, T. W. 2003. A survey of social interactive robots, *Robotics and Autonomous Systems* 42, 143-166.

[5] Fujita, M. 2004. On activating human communications with pet-type robot AIBO, Proceedings of the IEEE, 92(11), 1804–1813.

[6] Shibata, T., Mitsui, T., Wada, K., and Tanie, K. 2002. Subjective Evaluation of Seal Robot: Paro - Tabulation and Analysis of Questionnaire Results -. *Journal of Robotics and Mechatronics,* 14(1), 13-19.

[7] Glas, D. F., Kanda, T., Ishiguro, H., and Hagita, N. 2008. Simultaneous Teleoperation of Multiple Social Robots, *Proceedings of ACM/IEEE 3rd Annual Conference on Human-Robot Interaction*, 311-318.

[8] Lee, J.K., Stiehl, W.D., Toscano, R.L., and Breazeal, C. 2009. Semi-Autonomous Robot Avatar as a Medium for Family Communication and Education. *Proceedings of Advanced Robotics*. 1925-1949.

[9] Epstein, R., Roberts, G., and Beber, G. eds. 2009. Parsing the Turing test.: Springer Netherlands.

[10] Harnad, S. 1991, Other bodies, other minds: A machine incarnation of an old philosophical problem, *Minds and Machines* 1(1), 43-54.

[11] Sakamoto, D., Kanda, T., Ono, T., Ishiguro, H., Hagita, N., Android as a Telecommunication medium with Human-like Presence, *Proceedings of 2nd ACM/IEEE International Conference on Human Robot Interaction*, 193-200.

[12] Schaal, S., Peters, J., Nakanishi, J., Ijspeert, A.J., 2003. Control, planning, learning, and imitation with dynamic movement primitives. *In: Proc.Workshop on Bilateral Paradigms on Humans and Humanoids, IEEE 2003 Int. Conf. on Intell. Robots and Systems (IROS)*, Las Vegas, NV, 27-31

[13] Argall, B., Chernova, S., Veloso, M. M., Browning, B., 2009. A survey of robot learning from demonstration. *Robotics and Automation Systems*, Vol. 57, Issue 5, 469-483.

[14] Lopes, M., Oudeyer, P.-Y., 2010. Active Learning and Intrinsically Motivated Exploration in Robots: Advances and Challenges, *IEEE Transactions on Autonomous Mental Development*, Vol. 2, No. 2, 65-69.

[15] Ventrella, J., El-Nasr, MS., Aghabeigi, B., Overington, R., 2010. Gestural Turing test: A Motion-Capture Experiment for Exploring Nonverbal Communication. *AAMAS 2010 International Workshop on Interacting with ECAs as Virtual Characters*.

[16] Matsumoto, N., Fujii, H., Goan, M., Okada, M. 2005. Minimal design strategy for embodied communication agents, *Proceedings of Robot and Human Interactive Communication*, 335-340.

[17] Kozima, H., Nakagawa, C., and Yano, H., 2004. Can a robot empathize with people?, *Artificial Life and Robotics, Springer Japan*, 8(1), 83–88.