RobotMeme

—A Proposal of Human-Robot Mimetic Mutual Adaptation—

Daisuke Komagome, Michio Suzuki, Tetsuo Ono and Seiji Yamada

Abstract—**In late years, as new media turning into PC or mobile phone, a study about communication robots is prosperous. Robots are different from the conventional media, because robots have physical bodies like humans, so it is reported that humans bemust robots socially. Therefore, we decide to apply a concept of meme as a cultural gene to an interaction design with humans and robots in this study. By this design theory, we will realize Mimetic Mutual Adaptation by humans and robots imitating and adapting each other, exceeding a conventional form of one-way adaptation from humans to the media. Therefore, we called cultural information transmitted from robots "RobotMeme", we try that robots acquire cultural behaviors shared by human society and the robots transmits these meme to other robots by Human-Robot Mimetic Mutual Adaptation. Furthermore, we suggest "A Design of RobotMeme" to realize that robots create new cultural behaviors through human-robot interaction. In this paper, we describe an early stage of experiments to inspect whether RobotMeme were transmitted to human and observed that humans acquired original cultural behaviors of robots by imitation. From the results of these experiments, it is suggested that robots and human are going to be able to form the relations of interdependence by imitating each other.**

I. INTRODUCTION

"I want to create robots which have bodies and behaves like human in order to adapt to the society of human," many researchers on robotics have such strong wishes, and various robots have been developed in late years. The researchers have constructed models of intellectual development, and they have driven for designing robots that adapt to human society in robotics. But, traditional artificial intelligence could cover only limited field such as chess games. Therefore, many researchers on robotics are interested in casual intelligence and embodiment of human being. In such background, there are a lot of researches about communication robots such as ASIMO or wakamaru that behave like humans with physical bodies such as heads or arms in recent years. The meanings of that robots which have the bodies like humans are adaptation to human society. Brooks stated that robot will be able to natural interaction to human, and support human sharing environment designed for human using rich non-verbal information with physical bodies liked human [1].

In addition, Sakamoto showed robot's sociability among three persons relation (two persons and a robot) based on the balance theory, therefore it is inspired the possibilities of that robot has a influence on a relation between humans not only a person as a social media [2]. That is to say, we must design robots adapting to human society, and robots need to acquire society and social skill for adapting to environments.

Therefore, we need to design robots as social media through a new approach. In the traditional media design, it aimed to adapt artifact to human based on ergonomics or cognitive engineering. However, we consider that it is not enough for robots to adapt to human one-sidedly in order to establish friendly relations between human and robots. Ueda performed experiments showing that human and agent formed smooth relation through mutual adaptation learning, and inspired the possibilities of that humans and agents are co-development by adapting to each other [3]. From this, the phenomenon of mutual adaptation will be important in order to consider the methodology of Human-Agent Interaction.

However, our purpose is realization of collective intelligence of robots by sharing adaptive knowledge and methodology provided from mutual adaptation learning between human and robots. Therefore, we apply "meme" suggested by Richard Dawkins to Human-Robot Interaction [4]. By this idea, in the future, robots living with us spread the best interaction skill which was acquired through interaction with humans to other persons or robots, robots will be adapt to human society gradually and robots will be the media offering a new cultural knowledge to people. We expect that humans and robots will form interdependent relation and they maintain stable balance in long term by exchanging and co-creating their own valuable knowledge or technology each other.

Therefore, we performed pilot experiments in order to inspect whether the third person imitates robot's original communication method through Human-Robot Interaction. It is understood that humans sympathize with robot's behaviors, but real-time imitation can't indicate that humans acquire robot's original behaviors. Therefore, if humans express robot's original interaction behaviors by delayed imitation, there is strong possibility that humans imitate robot's original behaviors from now on, and it is suggested that the interaction design of robots based on "RobotMeme" will be useful in order to build interdependent relation between humans and robots.

In this paper, we propose a concept of meme in Section 2, and explain a summary of "Mimetic Mutual Adaptation in

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Section 3. Furthermore, we refer to the methods and results of the experiments of robot meme transmitting in Section 4, and we discuss a concept of RobotMeme and Human-Robot Mimetic Mutual Adaptation (HRMMA) from results of the experiments in Section 5.

II. IMITATION AND MEME

In this section, we discuss the important essence of a concept of meme that is the base of an idea of RobotMeme and Mimetic Mutual Adaptation we propose, and we state meme and diffusion of meme in this section.

A.Meme

"Meme" was named by Dawkins, and it means "a cultural information which descended by imitation" [4]. Meme is the unit of information transmitted by imitation repeating preservation, variation and selection similar to gene's behavior. As examples of meme, we give technical cultures such as usage or dance, and favorite phrase or greeting which shared in a community such as family or friends. We consider that meme has intention of self-preservation same as gene, and spreads from a brain to other brains like virus without being conscious of doing or not. Blackmore insists that human beings are different from other creatures, because the evolution of human beings is affected by meme, and meme is the major factor in acquiring huge brain and special ability such as language [5].

Figure.1 shows the image of meme spreading. It is clear that when a person who acquired knowledge or technique such as how to use tools or technical ideas that adapted the situation heuristically, these knowledge and technique are spread to other people by imitations. As a result, our civilization was highly developed. In this study, we apply this idea to interaction design of robots as the most important essence of a concept of meme.

B.Transmission of Meme

For the spread of meme, imitation in communication plays an important role. However, the spread of meme does not always occur from direct communication. For example, the way of greeting or usage of honorific will be able to acquire by seeing the interactions of other person without gazing from a viewpoint of the third person. In addition, it is said that people synchronize their bodies rhythmically with their partner in interaction [6]. We consider the third person acquired the methods of natural communication from those synchronized interaction.

In other way, meme is also spread not only from the interaction between human and human. For example, there is a phenomenon that people often imitate other people in front of them, because of cultural difference. In addition, a lot of people had the experience that they were infected with hums and phrases other people have without notice. In other words, a difference between the spread of meme and the spread of information is that meme transmits by unconscious imitation.

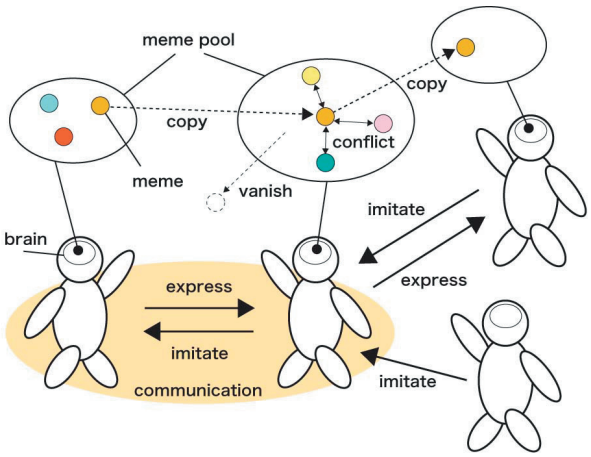


Figure.1 An Idea of Meme Theory. Meme moves to other humans by communication and imitation. Meme bahaves like gene (repeating preservation, variation and selection).

III. MIMETIC MUTUAL ADAPTATION

In this section, we state four purposes and methods to realize Human-Robot Mimetic Mutual Adaptation (Figure 2).

1.Robots learns humans meme

Human → Robot

2.Humans learns cross-cultural meme through robots

Robot → Human

3.Robots transmits the most adaptive meme to others

Robot → Robot

4.Robots spread the varied meme it created to others

Robot → Human & Robot

Robots learning meme by imitation humans

At first, we will get motion data of a natural interaction between humans by motion capture system, and make the robot learn Human Meme. We consider robots will be able to communicate and sympathize with humans naturally by the robots acquiring social skill [7]. Therefore, robots need to learn various meme, and we must grope for the methods to divide motions blocked with a meaning.

Humans learning culture by embodiment of robots

We try to promote understanding of embodied intelligence that is difficult to acquire by traditional static archives, and transmit meme with physical movement such as greetings or dances to human through robots not only interaction skill. Robots seem to be considered the media which saves every cultural physical movement as dynamic archive, therefore we expect that robots is used by cross-cultural education or coaching [8]. Consequently, we must consider the structures that extracting characteristic points of physical behavior and

promoting physical learning.

Robots acqure the most adaptive meme and adapt to community

When a robot communicates with persons, the robot discovers the meme which adapted the environment while making trial and error from the meme which the robot learned in the upper of Figure.2, and we approach to make the whole robots adapt itself to community such as schools or companies by spreading the most adaptive meme to other robots. Robots are the media that can move in real world autonomously, therefore we expect that robots become the social being adapting to every community. For example, robots must select the greetings the same as children in elementary schools, and robots must speak slowly in nursing homes. In this study, using Classifier System (CS), we consider the robot system that learn the meme adapting to real environment changing dynamically in interaction with humans repeating genetic behavior, and spreading the most adaptive meme to other robots. In the case of the meme spreading, we must treat motion data abstractly to transform differences of the structures of robots.

Robots create and spread their own meme to humans

When a robot acquires the meme which is the adaptive methods to the environment in the middle of Figure 2, we aim at acquisition of the new meme that humans couldn't acquire by robots creating it's own cultural behavior through verifying the meme which acquired using Genetic Algorithm (GA). We consider it is possible to improve the cultural adaptation of whole human society by humans acquiring the unknown methodologies not existed in human society through robots. However, it is doubted whether humans accepts the original behavior of robots as artifact. Therefore, we performed the experiments of RobotMeme transmitting in order to confirm that humans imitating robot's communication methods.

IV. EXPERIMENT

In this section, we explain the pilot experiment aimed at inspecting whether humans imitate the robot's peculiar methods of direction (RobotMeme) in detail. In addition, we define meme as "a communication method using physical behavior" in these experiments.

A.Outline of Experiments

In these experiments, experimenter instructs to participants to direct the experimental cooperator to do the task to move objects. We performed three kinds of experiments (experiment A, B and C) and each experiment has two conditions (condition A1 and A2, B1 and B2, C1 and C2). This experiment assumes the situation that participants direct to the experimental cooperator who can't understand words, we inspects that participants express the robot meme (the method of robots) transmitted from human-robot interaction. Therefore, we inspected the general instruction methods of human in the experiment A including condition A1 and A2. Based on the experiment A, we decided the

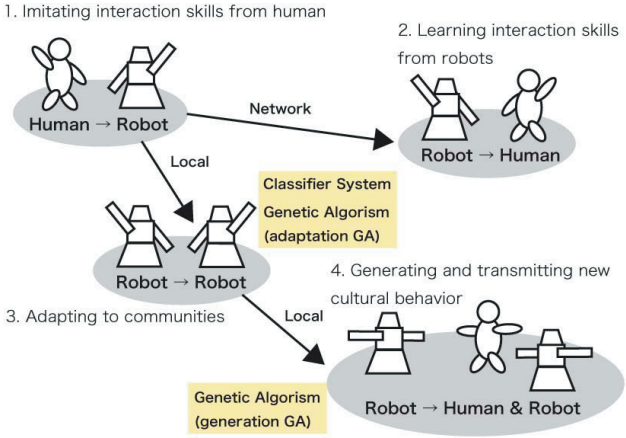


Figure.2 A Concept of Human-Robot Mimetic Mutual Adaptation (HRMMA). We set four aims. HumanMeme and RobotMeme spread out other humans or robots by imitating and communicating.

rational instruction methods for robot but not for human, and performed the experiment of RobotMeme transmitting as experiment B including condition B1 and B2. In addition, we performed experiment C (including condition C1 and C2) with the participants of the experiment B that changed the objects to direct and the experimental cooperator. Through the experiment C we inspected that RobotMeme is part of participants' nature.

Experimental environment

These experiments were performed in Media Laboratory of research center in Future University-HAKODATE. We used Robovie-R ver.2 that is a communication robot developed by ATR (Advanced Telecommunications Research Institute International) in these experiments. The experimenter instructed to participants in the Media Laboratory, and another experimenter operated the robot in another room (Figure.3). We used six figures have bodies like human in the experiment A and B, seven posing movie character's posters in the experiment C as the objects to direct (Figure.4).

Experimental conditions

The experiments have the following six conditions (three experiments and each experiment have two conditions). The setting of condition C1 was the same as condition C2, but we analyze the result of experiments as the participants of condition C1 are the same as condition B1 and the participants of condition C2 are the same as condition B2, therefore we divide condition between C1 and C2.

A1: Not giving any restrictions to the participants when they direct to the experimental cooperator.

A2: Instructing the participants not to move from the position approximately 4 meters away from the experimental cooperator, beyond that, not giving any restrictions to the participants when they direct to the experimental cooperator.

B1: The robot direct by pointing at the position approximately 4 meters away from the experimental cooperator, then the participants are requested to direct to the experimental cooperator instead of the robot.

B2: The robot direct by gesture at the position approximately 4 meters away from the experimental cooperator, then the participants are requested to direct to the experimental cooperator instead of the robot.

C1: Not giving any restrictions to the participants when they direct to the experimental cooperator.

C2: Not giving any restrictions to the participants when they direct to the experimental cooperator.

The robot shows OK signature by raising arms, when the experimental cooperator obeyed instruction of the robot correctly in condition B1 and B2. The experimental cooperator behaves likewise gestures or OK signature of the robot, and the experimental cooperator looks at the same direction of the pointing the robot behaves, so joint attention was formed.

B.Experimental Scenario

We explain the detailed procedure of each experiment.

1. Experiment A (Condition A1 and A2)
Instructing “Choose two figures in three on the desk of the left side, and direct that man to move the two figures you chose to the desk of the right side.” to the participants.

2. Experiment B (Condition B1 and B2)
At first, the experimenter explains the participants “From now, the robot chooses five figures in six on the desk of the left side, and direct that man to move the figures the robot chose to the desk of the right side,” the robot halts about 20 seconds after the third direction of the robot, and instructing “The robot has been broken, so choose two figures in three left, and direct that man to move the two figures you chose to the desk of the right side in stead of the broken robot.” to the participants.

3. Experiment C (Condition C1 and C2)
Instructing “Choose two posters in seven on the white-board of the left side, and direct that man to move the two posters you chose into the box of the right side.” to the participants.

C.The Methods of Evaluation

At first, we confirmed that the robot’s original methods of direction (RobotMeme) transmitted to the participants from video records. And, the participants fill their subjective evaluation in questionnaire (Table.1). The participants answered every question by five stages. The questionnaire asked three questions about the robot’s methods of direction (group Q1) and the subject’s methods of direction (group Q2). Three questions are that “Were the robot’s methods of direction easy to understand?,” ”Were those methods the best way?,” “Were those methods natural?.” At last, as group Q3, we asked impression of the robot to the participants. In addition, we asked why they answered like that in free format in the last of each questions.

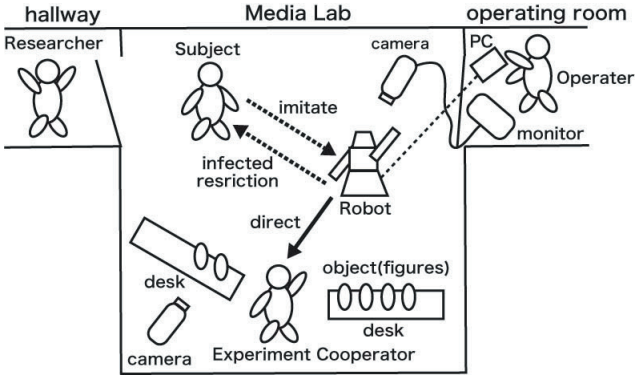
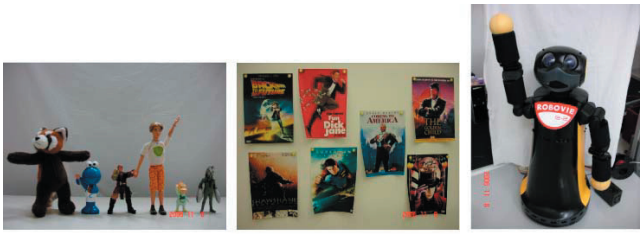


Figure.3 Experimental Environment (Experiment B). The participant see the robot directing to the experimental cooperator. After the robot broken, the participant select the robot's direction way.



Figures (exp.A and B) Movie Posters (exp.C) Robot (exp.B)

Figure.4 Robovie-R2(right) is the robot we used in experiment B. Figures(left) are objects used in experiment A and B. Movie Posters(center) are objects used in experiment C.

Direction 1 (close & point) Direction 2 (far & point) Direction 3 (far & gesture)

Figure.5 Methods of Directions. The participants close and point the objects in Direction 1(left). The participants don't close and point in Direction 2(center). The participants don't close and gesture in Direction 3(right).

Table.1 Questionnaires in experiment B. In Experiment A and C, we asked only group Q1 (Q1-1,Q1-2,Q1-3).

Q1-1	"Was your direction understood by the man ?"
Q1-2	"Was your direction the best way ?"
Q1-3	"Was your direction natural ?"
Q2-1	"Was the robot's direction easy to understand ?"
Q2-2	"Was the robot's direction the best way ?"
Q3-3	"Was the robot's direction natural ?"
Q3-1	"Was your impression to robots good ?"
Q3-2	"Can you trust robots ?"
Q3-3	"Do you want a robot ?"

D.Hypothesis and Prediction of the Experiments

We decided the following three ways of direction as the common ways of direction of human in experiment B by the results of the experiment A (Figure.5). And direction 1 is the most commonly way of direction.

Table.2 Result of participants' directing methods from video records.

Experiment & Condition	A1	A2	B1	B2	C1	C2
Number of Subjects	12	13	12	13	6	9
Direction1 (Normal)	11/12 (92%)	0/13 (0%)	0/12 (0%)	0/13 (0%)	3/6 (50%)	1/9 (11%)
Direction2 (Long Distance)	1/12 (8%)	11/13 (85%)	11/12 (92%)	2/13 (15%)	3/6 (50%)	1/9 (11%)
Direction3 (Gesture)	1/12 (8%)	1/13 (8%)	0/12 (0%)	11/13 (85%)	0/6 (0%)	7/9 (78%)
OK Signature	0/12 (0%)	0/13 (0%)	6/12 (50%)	10/13 (77%)	1/6 (17%)	2/9 (22%)

Table.3 Results of Questionnaire (Only who expressed Robot Meme in Condition B1, B2, C1 and C2)

Experiment & Condition	A1	A2	B1	B2	C1	C2
Number of Subjects	12	13	11/12	11/13	3/6	7/9
Average of Group Q1	3.75	4.05	3.82	4.09	3.78	4.14
Average of Group Q2	-	-	3.33	3.82	-	-
Average of Group Q3	-	-	3.27	3.64	-	-

Direction 1: Coming up to the objects going to be selected and pointing them.

Direction 2: Keeping the distance from the experimental cooperator and pointing the objects.

Direction 3: Keeping the distance from the experimental cooperator and gesturing at the features of the objects.

We considered that direction 1 is the most common way of direction for humans and direction 3 is the most rational way of direction for robots. Because, in this case, Robovie has the battery and a power source plug, therefore it is hoped that the robot works without moving. In addition, the robot doesn't have extremity such as fingers to direct in detail and the robot can't behave like humans, consequently we think that the way of gesture is more rational than the way of pointing for the robot. And, we set the OK signature as the method to affirm the behavior of the experimental co-operator the robot's original behavior. In this study, we determined the following four meme as characteristic behaviors.

* Pointing Meme (HumanMeme)
* Long distance Meme (RobotMeme)
* Gesture Meme (RobotMeme)
* OK sign Meme (RobotMeme)

In these experiments, we inspect the prediction based on the following hypotheses.

Hypothesis

The participants imitate the robot's original behaviors.
Furthermore, the methods of robots are part of participants' nature and express in similar environment.

Prediction

It is confirmed that the participants expressed RobotMeme mentioned above in condition B1, B2, C1 and C2 by video record.

Figure.6 Experimental Scenes of experiment A. Most of the participants selected Direction 1 in condition A1 (left). Most of the participants selected Direction 2 in condition A2 (right).

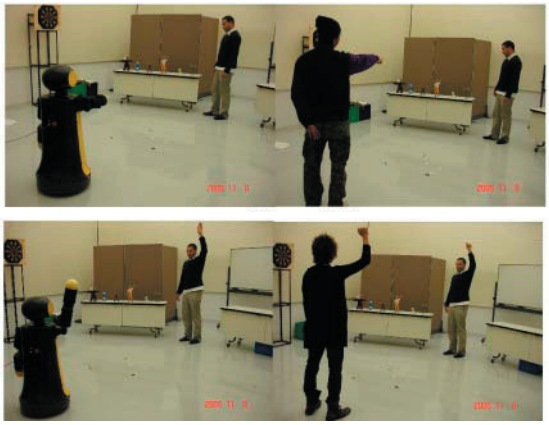


Figure.7 Experimental Scenes of experiment B. Most of the participants selected Direction 2 in condition B1 (upper). Most of the participants selected Direction 3 in condition B2 (lower).

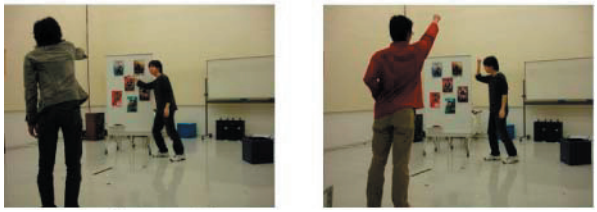


Figure.8 Experimental Scenes of experiment C. Half of the participants selected Direction 2 in condition C1 (upper). Most of the participants selected Direction 3 in condition C2 (lower).

E.Results

Table.2 shows that the participants selected the same methods of direction as the robot in very high ratio in condition B1 and B2. However, the participants directed in same way of the robot in high ratio in condition C2, but half of participants selected direction 2 in condition C1. Comparing incidence of the OK signature in condition B1, B2, C1 and C2, more than half of the participants imitated the behavior of the robot in condition B1 and B2, and one-fifth of the subject imitated the robot in condition C1 and C2. From these results, it was supported that Robot Meme also transmitted to humans in various conditions such as the difference of the behaviors.

In addition, Q1 of Table.3 provided that the direction of the robot was evaluated higher than average in condition B1 and B2. Furthermore, Q2 of Table.3 provided that the participants who imitated direction of the robot tended to evaluate the direction of the subject oneself higher than the direction of the robot. In this connection, the participants who expressed Robot Meme in condition C1 and C2 tended to evaluate the direction of the participants oneself higher than that of in condition B1 and B2.

V. DISCUSSION

From the results of the experiments in Section 4, it is confirmed that irrational robot's original methods of direction transmitted to humans, and humans expressed RobotMeme. Therefore, it was suggested that humans are able to adapt to the media such as robots. Most of the participants imitated the ways of direction of the robot, because we think that robot's behaviors give some restrictions to the participants. This was caused that most of participants couldn't guess other ways in the situation of these experiments by free descriptions of the questionnaire and the oral interview. In addition, it is very interested that most of participants evaluated the robot's ways of direction that is irrational for humans best from Q1 of Table.3.

Furthermore, as the clues showing that Robot Meme transmitted to humans, the participants who selected the same way of the robot evaluated the way of participants oneself (Q2) higher than the ways of robots (Q1). In addition, it may be said that RobotMeme was part of participants' nature, because the evaluation of the way of direction in condition B1 is the same as that of B2. In other words, the participants imagined that the direction of the robot was rational way by expressing the robot's way of direction by oneself. From this, Robot Meme was part of participants' nature, and it is suggested that robot's original culture transmitted to humans. In addition, from the results of condition C1 and C2, the characteristics of direction will be able to effect to the rate of RobotMeme transmission larger than the generality of direction.

VI. CONCLUSIONS & FUTURE WORK

In this paper, in order to propose an idea of RobotMeme for Human-Robot Mimetic Mutual Adaptation (HRMMA), we showed that humans imitated the robot as artifact and affected by RobotMeme. If robots acquired the adaptive methodology that human society doesn't have yet, humans could continue cultural evolution adapting to robots and humans build the civilization dependent on Robot Meme by the results of this study. From this study, it is suggested that humans and robots are able to co-create cultures. We must discuss the idea of RobotMeme and HRMMA more concrete by the results of these experiments.

In this study, we understood that humans tend to adapt to robots by imitation. Thereupon, we are planning to design an experiment that is able to show phenomena of spreading RobotMeme between humans or communities. If RobotMeme spread among humans, they will able to acquire brand-new knowledge from Robot or Agent. We must discuss about how Robots able to discover or generate more adaptive skills or methods on and on.

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REFERENCES

[1] R. A. Brooks, ROBOT, Penguin Press Science, 2003.
[2] D. Sakamoto, T. Ono, "Impact Evaluation of the Robots' s Sociability on the Impression Formation between Humans", Journal of Human Interface Society, Vol.8, No.3, pp.61-70, 2006.
[3] K. Ueda, T. Komatsu, "Constitution theory of co-development", Origin of intelligent emergence, eds. H. Suzuki, pp. 179-203, Ohm-sha, 2006.
[4] R. Dawkins, The Selfish Gene, Oxford University Press, 1976.
[5] S. Blackmore, The Meme Machine, Oxford University Press, 1999.
[6] Y. Yamada, "Singing by sympathy, Bearing one's voice", Embodiment as Communication, eds. S. Nomura, pp.40-70, Taisyukan-syoten, 1996.
[7] D. Sakamoto, T. Kanda, T. Ono, M. Kamashima, M. Imai, H. Ishiguro, "Cooperative embodied communication emerged by interactive humanoid robots", International Journal of Human-Computer Studies, pp.247-265, 2005.
[8] T. OKUDA, "Technical Communication for Organizational Knowledge Creation," Proc. of the 2001 IEEE international Professional Communication Conference, pp.391-404, 2001.