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Generation of Human Care Behaviors by Human-Interactive Robot RI-MAN

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Abstract— **Recently, active researches have been performed to increase a robot's intelligence so as to realize the dexterous tasks in complex environment such as in the street or homes. However, since the skillful human-like task ability is so difficult to be formulated for the robot, not only the analytical and theoretical control researches but also the direct human motion mimetic approach is necessary. In this paper, we propose that to realize the environmental interactive tasks, such as human care tasks, it is insufficient to replay the human motion along. We show a novel motion generation approach to integrate the cognitive information into the mimic of human motions so as to realize the final complex task by the robot.**

I. Introduction

This research studies on how to perform complex environmental interactive tasks, such as human care tasks, by a robot through learning from human. It is understood that to learn these tasks, it is important to take into account of the human's motion dynamics as well as his/her cognitive feelings. Therefore, we propose a novel task learning approach called "learning through feeling" instead of the traditional "learning by showing".

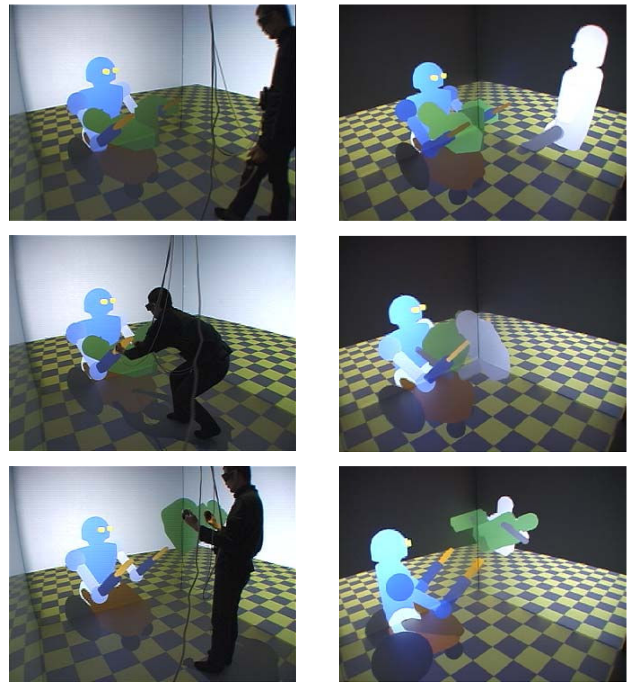
As a detailed example of the human care task, we consider on how to hold a human by cooperating two arms and body.

II. Learning approach

The detailed learning approach includes two phases. In the first phase, we ask a human subject to perform the specific task such as to hold up a person by full body interaction for many times as shown in Fig.1 (a).

By using immersion-type dynamic simulation technology [1], [2], we developed a virtual robot which can not only follow up the motion of the human subject but also capture the vision and tactile information while interacting with the virtual cared person. Based on the measured information of motion trajectories and the corresponding vision and tactile feelings, we then derive a specific model using DP matching to formulate the interactive task.

Based on the obtained human task model, in the second phase, we then generate motion trajectories for the robot to perform the same task. Even for the same task requirement, the initial situation faced by the robot may be different from what the human subject experienced such as the relative position and configuration between the robot and the cared person.



(a) Teaching motion (b) Imitation behavior

Fig. 1. Example of holding task

Therefore, the motion trajectory generated from the human's model can not applied directly to the robot. The robot's motion should be adjusted considering the real vision and tactile feedback from the robot during performing the task.

Here, we propose two adjustment algorithms[3]. Initially we adjust the relative position between the robot and the cared person spatially and then during the interaction we adjust the robot's motion temporary by comparing the robot's real tactile information with that in the human model as shown in Fig.2.

Fig.1 (b) shows the result of our approach in the immersion-type dynamic simulation environment. And the success rates are given in TABLE I.

III. Application to real robot

The same learning approach is also applied for a real robot arm to perform an object rotating task by its arm interaction. Two sheets of tactile sensor[5] are attached in this arm as shown in Fig.3.

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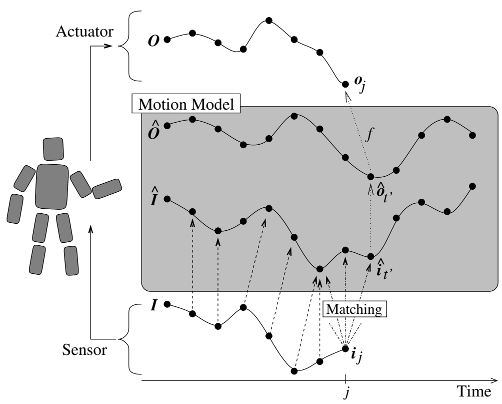


Fig. 2. Algorithm of our approach

Here, the succeeded motion model is generated not by the human but by the robot itself for some specific cases that the rotation tasks are successfully realized. Based on our approach, the robot can copy with the situation for the variations of the initial position changes of the object on the robot arm as shown in Fig.4 (a).

The human model derived within the immersion-type simulation is also successfully applied to the real robot RI-MAN developed in RIKEN BMC, which makes it possible to hold up a dummy up to 18 [kg] safely and reliably as shown in Fig.4 (b).

IV. CONCLUSIONS

In this paper, we proposed the control method for an environmental adaptive robot by generating human care behaviors in consideration of recognition information, such as tactile sensor feedback. Since imitation motion was adjusted spatiotemporally using the recognition results, a robot was successful at human care behaviors. We confilmed the validity of our approach through experiments using a simulation environment and real robot.

TABLE I

SUCCESS RATE OF HOLDING TASK.

	Position Tracking		Sensor feedback	
Success	14	(17.3%)	78	(96.3%)
Failure	67	(82.7%)	3	(3.7%)

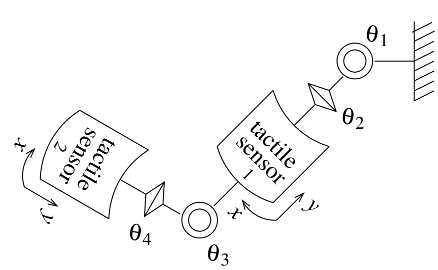
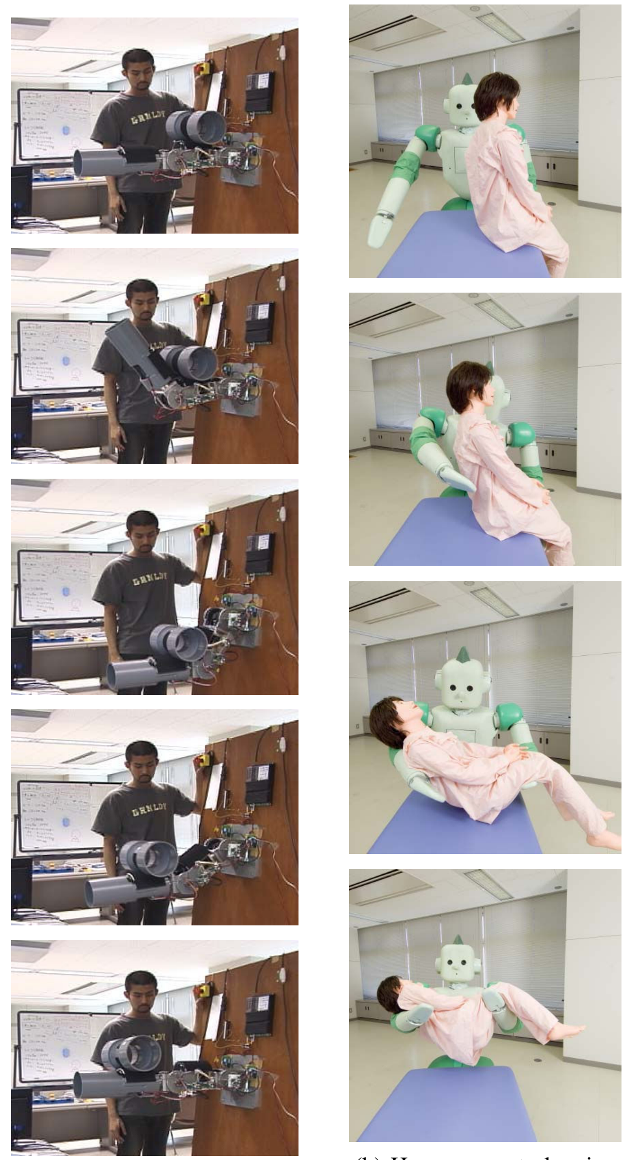


Fig. 3. Layout of joints and sensors



(a) Handling task using arm

(b) Human care task using RI-MAN

Fig. 4. Succeeded when using tactile information

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