Teaching Assistant Robot Development by PRINTEPS

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ABSTRACT

PRINTEPS (Practical INTEligent aPplicationS) is a platform for developing integrated intelligent applications. PRINTEPS integrates 5 types of sub systems (knowledge-based reasoning, speech dialog, image sensing, manipulation and machine learning). This paper presents how PRINTEPS has been applied to Teaching Assistant Robot where multiple people and robots cooperate.

CCS CONCEPTS

•**Human-centered computing →Interactive systems and tools;** *Human computer interaction (HCI); HCI theory, concepts and models;*

KEYWORDS

PRINTEPS, Teaching Assistant Robot, workflow

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1 INTRODUCTION

Currently, we are promoting the study of PRINTEPS (PRactical INTElligent aPplicationS)[1], a platform for developing integrated intelligent applications for cooperation between humans and machines, by only reconfiguring the software modules related to knowledge based reasoning, speech dialog understanding, image sensing, manipulation, and machine learning [1]. This paper describes the availability of PRINTEPS for Teaching Assistant Robot, where multiple people and machines (robots) cooperate, and explains how PRINTEPS has been applied to the actual educational environment in elementary schools.

[1]http://printeps.org/

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2 MULTI-ROBOT SYSTEM THAT COOPERATES WITH TEACHERS AND STUDENTS

2.1 System outline

Figure 1 shows the outline of the teacher and robot cooperation system proposed in this paper. This system is mainly based on cooperation channels between the actors shown in Figure 2. The workflow of each actor is decided according to these channels. Our classes have three main purposes: development of students' interest, imparting knowledge, and progress checking.

2.2 Robot used in the study

We used the following three robots in our study.

- NAO[2]:
  Communication robot of Aldebaran, which is capable of speaking and understanding speech and can be controlled with a touch sensor, and plays the role of the teacher's assistant
- Sota[3]:
  Communication robot of Vstone, which has a camera to capture images, and plays the role of the students' supporter, who is allocated by each test group
- Jaco2[4]:
  Robot arm of Kinova, which grips and moves an object. (NAO and Sota cannot perform such operations.)

The role of each robot corresponds to one of the three purposes mentioned earlier: NAO takes charge of imparting knowledge, Sota takes charge of progress checking, and Jaco2 takes charge of the development of students' interest.

2.3 Cooperation channel

The cooperation channels are paths for multiple robots and human actors, such as a teacher and students, to cooperate with each other. We first researched how the teacher developed students' interest and imparted knowledge in the normal classes, and designed the cooperation channels. We defined the following channel design elements for each actor:

- Cooperation partner
- Contents
- Media

[2]NAO, https://www.aldebaran.com/en/humanoid-robot/nao-robot
[3]Sota, http://www.vstone.co.jp/products/sota/
[4]Jaco2, http://www.kinovarobotics.com/service-robotics/products/robot-arms/

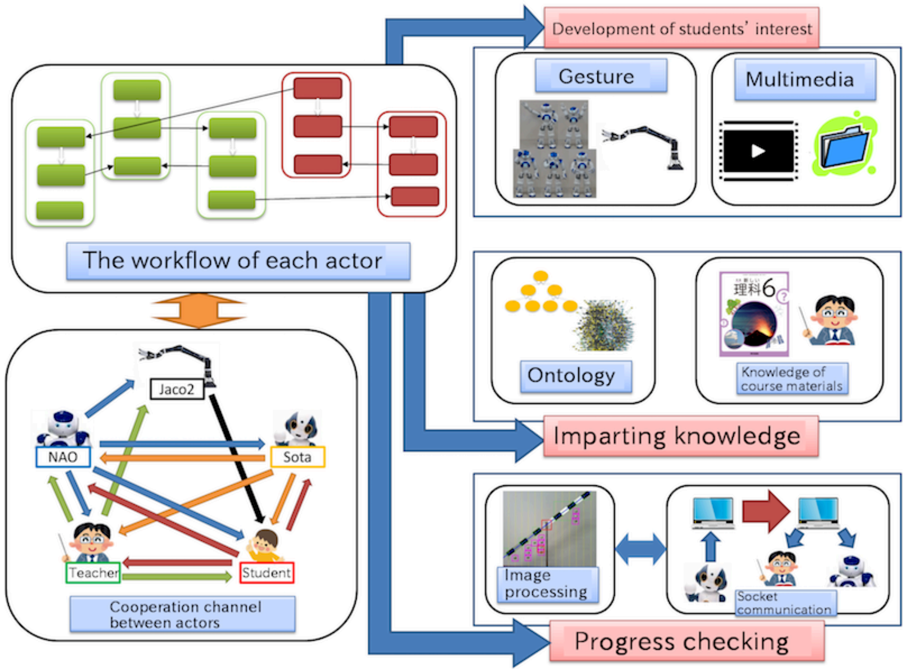

Figure 1: Outline of teacher and robot cooperation system

- Main purpose of cooperation
- Purpose of Cooperation

The main purposes of cooperation include management of flows to promote workflows, in addition to the development of students' interest, imparting knowledge, and progress checking. This section explains the cooperation channels for each actor in a simple manner.

2.3.1 Cooperation channel from NAO. We set up NAO at the teacher's desk. It had dialogue with the teacher during teaching, as an assistant to the teacher. The cooperation channels from NAO to people were mainly for speeches created by its voice synthesizing function, and gestures created by its motion creation software "Choregraphe [2]." Further, it was possible to use multimedia via the screen of the computer that was sending operating instructions to NAO. The channels from NAO to the robots were used when NAO sent operating instructions to the other robots to move them during teaching.

2.3.2 Cooperation channel from Sota. We set up Sota in each students' group mainly at the time of the experiment and exercises to understand their progress. Based on the result of image processing, which we used for understanding their progress, we also developed the students' interest by providing advice for their exercises with speeches and gestures from Sota.

2.3.3 Cooperation channel from Jaco2. The robot arm "Jaco2" lets the students become interested in its motion to grip and move an object, and impresses them. Currently, since the specification of Jaco2 provides no connection with cameras, it grips and moves an object with its arm by pointing at the object. In some cases, the teacher has to support Jaco2 by adjusting the location. Consequently, in this case, we set up Jaco2 at the teacher's desk.

2.3.4 Cooperation channel from teacher. The teacher had two cooperation channels to NAO: for speeches and for touching its head. Both channels were used for control of the teaching flow. The teaching flow could be branched according to the result of the speeches. As mentioned in section 2.3.3, the cooperation channel from the teacher to Jaco2 was to support Jaco2's motion to ensure its smooth operation.

2.3.5 Cooperation channel from student. The students could inform their reply to the questions to NAO with their voice. Then, NAO judged whether their replies were correct or not with its speech-understanding function, and branched the teaching flow according to that judgment result. In the case of Sota, the students could activate Sota to send information on the progress of their experiment and exercises to the teacher by pressing a button in Sota.

2.4 Workflow

Each of the five actors had a workflow. Among the cooperation channels mentioned in section 2.3, we used the channel that aims at managing the teaching flow to associate with each actor, for generating the workflow for the entire class. Figure 2 shows the workflow for the introductory part of the class we conducted in our case study. For more details of the case study, please refer to Chapter 4.1.

As shown in this sample, the flow expressed as an arrow connecting each actor associates the cooperation channel from the

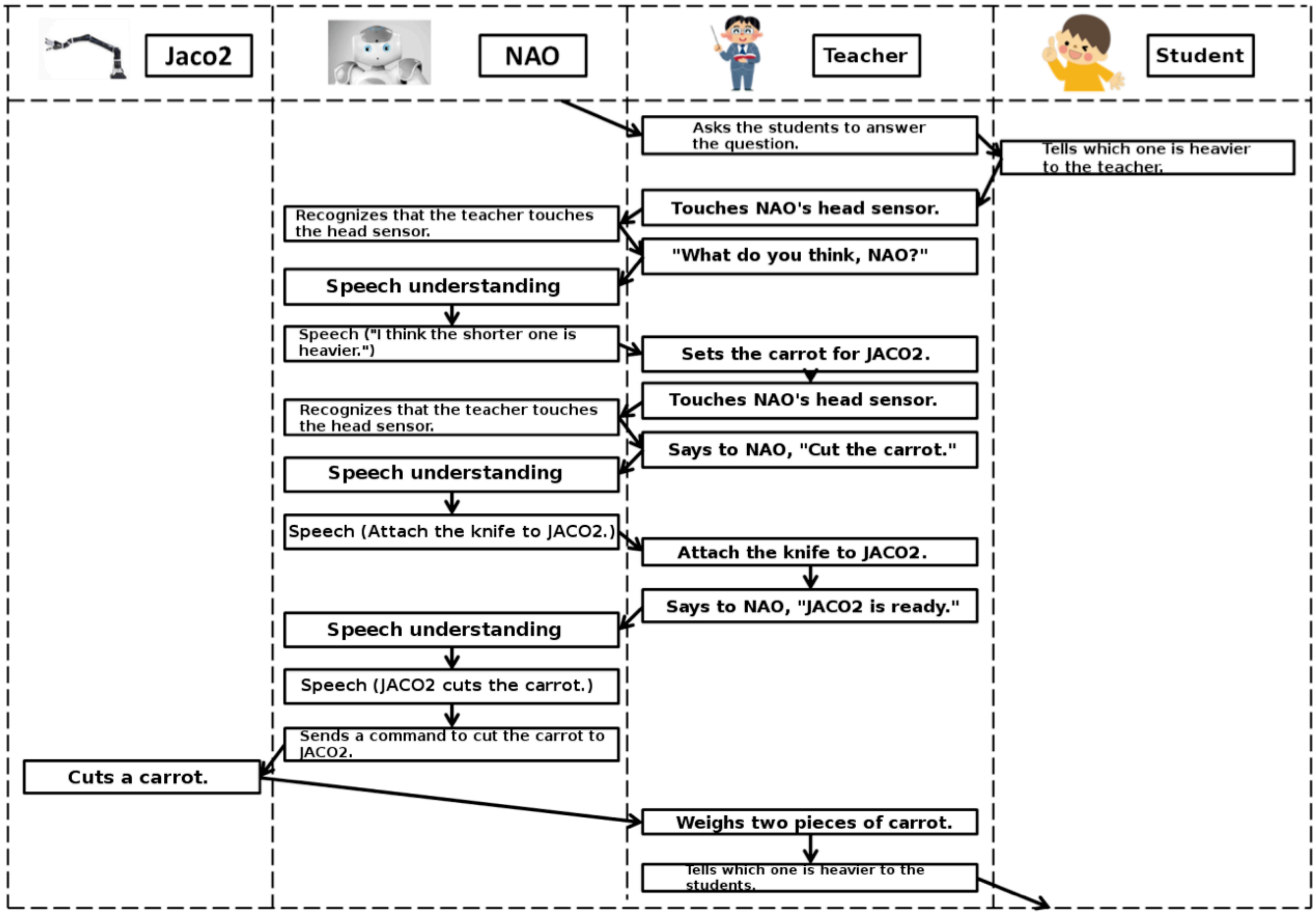

Figure 2: Workflow example

original actor (from where the arrow starts) with the channel where the actor pointed by the arrow is a cooperation partner.

3 ACTUAL APPLICATION OF PRINTEPS

Figure 3 shows the individual modules that make up the process called "Presentation of questions concerning experiment details to students", which was one of the services covered under "Introductory part of the class" in the case study mentioned in section 4.1. It can be seen that while setting the software modules with PRINTEPS based on the class workflow, we could easily apply the robot operations for the entire class. Moreover, the module in which the actor was a teacher or a student, was empty without any operation within the application, was used for taking brie notes.

4 EXPERIMENT AND EVALUATION

For the case study, we selected an experiment to find the regularity of leverage balance in the unit "Principle of leverage" in the scientific programs for sixth graders of elementary schools. To evaluate the system we proposed in this study, we conducted a class for the sixth graders of Keio Yochisha Elementary School, where a teacher, students, and multiple robots cooperated with this system. We reported our conclusions based on the experimental result, questionnaires given to the students after the class, and an interview with the teacher.

4.1 Case study

4.1.1 Preparation for experiment. First, we designed the cooperation channels mentioned in section 2.3 according to our empirical rules, and decided the specification after the interview with the teacher.

We also had a meeting with the teacher eight times to design a class scenario mentioned in section 4.1.2. In the meetings, we operated the robots to show their actual motions based on a rough scenario that we prepared, and asked the teacher to consider the scenario. We had to reconfigure our scenario based on the feedback we received in the previous meeting, and then the robots were re-programed.

In this case study, we could not use PRINTEPS at the time of scenario prototyping, and programed the robots by hardcoding. If PRINTEPS was available during this phase, we could have checked

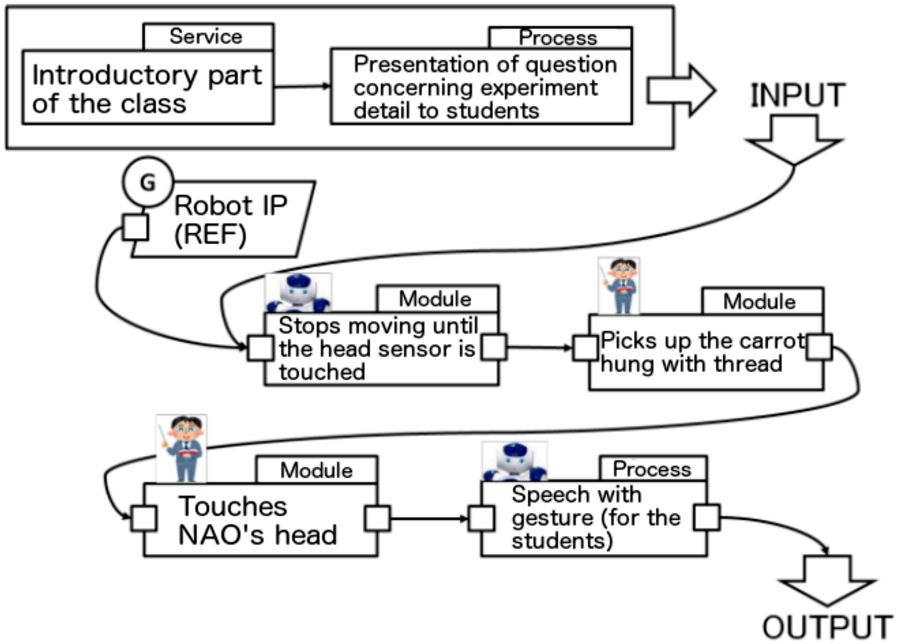

Figure 3: Actual application (part) of class in case study

and repaired the scenario by coupling the modules, and could have operated the PDCA cycle more easily; we consider that we can reduce the number of meetings if PRINTEPS is available.

4.1.2 Class flow. The experiment to find the regularity of the leverage balance in this case study had the following flow. Note that some details are skipped.

(1) Introductory part of the class
As shown in Figure 5, we started the class with a dialogue between NAO and the teacher. Jaco2 cut some carrots as shown in Figure 6, since cut carrots were necessary in this step.
(2) Explanation of the experiment
NAO explained the procedure of the experiment, and Jaco2 demonstrated it actually.
(3) Experiment for leverage balance
As shown in Figure 7, Sota helped the procedure and checked the students' progress.
(4) Checking answers and summary
NAO explained the result of the experiment.
(5) Application of the experiment
NAO explained the application cases.
(6) Summary of the class
NAO explained the summary.

4.1.3 Progress checking. One of the important things in this case study was "progress checking." Figure 4 shows the outline of the progress checking system.

In this case study, we performed the leverage balancing experiment according to the procedure in a worksheet. Whenever each student solved the question in the worksheet and attached a weight one by one, Sota captured the images of the leverage, and sent them to the image processing PC via socket communication, which detected the supporting point by template matching, and the weight and the point where the weight was attached, based on Haar-like feature. From the result, it judged whether the weight was attached as designated in the worksheet questions, and at the same time, judged whether the leverage was in balance.

When the leverage was in balance, it sent information via socket communication to the progress managing PC, showing that the question was solved, in terms of which group completed which question. The PC indicated this information with a bar graph on the display.

4.2 Evaluation of the class

We gave questionnaires to the students and interviewed them along with the teacher after the class, and evaluated our case study based on the results as follows.

(1) Evaluation of development of students' interest
The highest number of students answered that the motion of the arm of the robot Jaco2 to cut the carrots and attach the weights was the most impressive item. Accordingly, we consider that the cooperation channel successfully developed the students' interest as designed.
(2) Evaluation of imparting knowledge
In response to the question on the most important item about the class, more than two-third of the students gave their answers as "conditions of the leverage balance", which was the most important theme to be understood in this case study class. Further, the teacher told that he could convey the important points to the students equally well

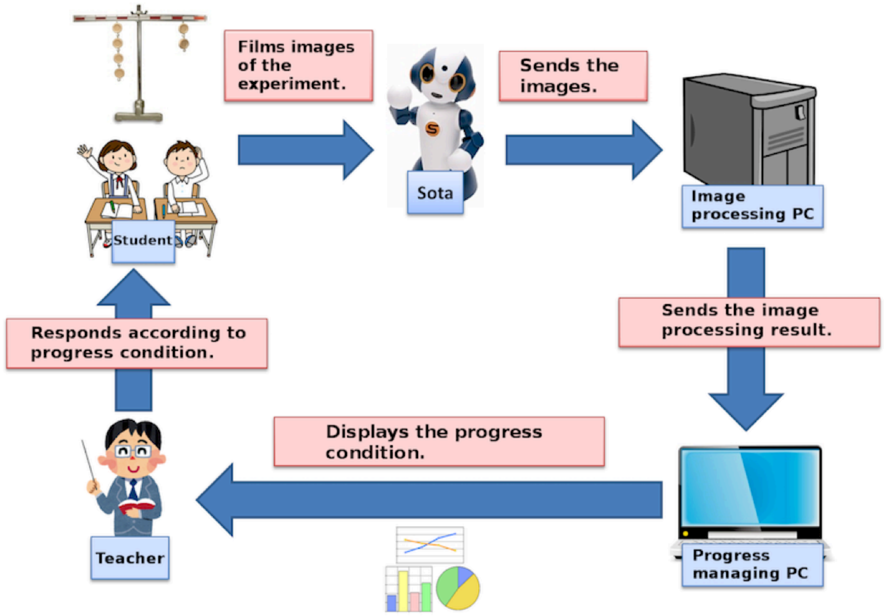

Figure 4: Progress checking system outline

Figure 5: Introduction of class by NAO and teacher

Figure 6: Demonstration of Jaco2, cutting carrots

or better than in the normal classes. Therefore, we consider that the cooperation channel imparted the knowledge sufficiently.

(3) Evaluation of progress checking

The teacher told that he could save the trouble of accessing each group to check the students' progress, thanks to the visualized progress checking. Therefore, we consider that the cooperation channel was sufficiently effective for progress checking.

(4) Evaluation of flow management

One of the cooperation channels that aimed at flow management needed speech understanding, and many of the students and the teacher were concerned about many mistakes found in speech understanding. Since we used NAOqi API for speech understanding, we cannot improve the software by ourselves. At the moment, we have to overcome this problem by taking measures such as creating a soundless environment for speech understanding.

5 CONCLUSION

In this study, to improve the educational effects in an environment where multiple people and robots cooperatively conducted scientific experiments in the elementary school program, we set up a system that focuses on the cooperation channels between the actors, and conducted an experiment with students and a teacher from a class.

Figure 7: Experiment of leverage, with Sota

As a result, we used cooperation channels that were designed for the effective development of students' interest, imparting knowledge, and progress checking. Since we designed the cooperation channels in advance, we could use them for each target or purpose, such as development of students' interest while adding and preparing a new teaching theme, and decide the method of cooperation between the actors in the class in a simple manner. Moreover, PRINTEPS makes preparation of the workflow easier, makes the repair time of the teaching workflow shorter, and allows simpler operation of the PDCA cycle.

In the future, if we can set up a sensor like a camera to film the conditions of the students in the classroom, independent of the robot cameras, and check how the students participate in each class, it may be possible to provide more individual and effective guidance and teaching for students who show less interest in the classes. However, for this purpose, it is necessary to design a cooperation channel related to the sensors.

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