Evaluation of Robot Based Embedded System Study Environment in Technical High School

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Abstract. This paper describes the modeling, the development and the evaluation of embedded system study environment using robot and a note on experiment at technical high school. This paper discusses about the following points:(1) visualizing the behavior of embedded system in synchronization with the robot's behavior, (2) integrating environment from concept based learning to implementation based learning, and (3) validating the efficiency of the system through the lecture and the evaluation at technical high school. This report is a summary of this environment, learning courseware of embedded system and research result at study of a technical high school.

Keywords: Educations, Robot, Programming.

1 Introduction

Education of embedded system is indispensable for students who learn computer science or information technology. Robot is often used in learning of embedded system. The embedded system education that uses robots attracts learners' interests easily, and is effective as the teaching material that can maintain their motivation. However, it is difficult for existing educational environment using robot to support embedded system study. Since existing embedded system is invisible, system's internal process within a robot is difficult to understand.

In order to solve the problem of the existing environment, we developed the robot programming education support environment by visualization based debugging and by simulation that uses movie. This environment integrates visualized educational support of the system software which learners can utilize from application layer to hardware layer based on their course needs. For this study, we have evaluated this environment about the understanding of embedded system's behavior compared with previous methods at technical high school.

2 Implementation

Figure 1 shows a screenshot of the monitoring tool. Movie (upper-left), input/output devices (right side), source code (lower-left) and device history (lowest horizontal) are displayed within one window. Vertical red line shows current focus of data. All the data is synchronous transition.

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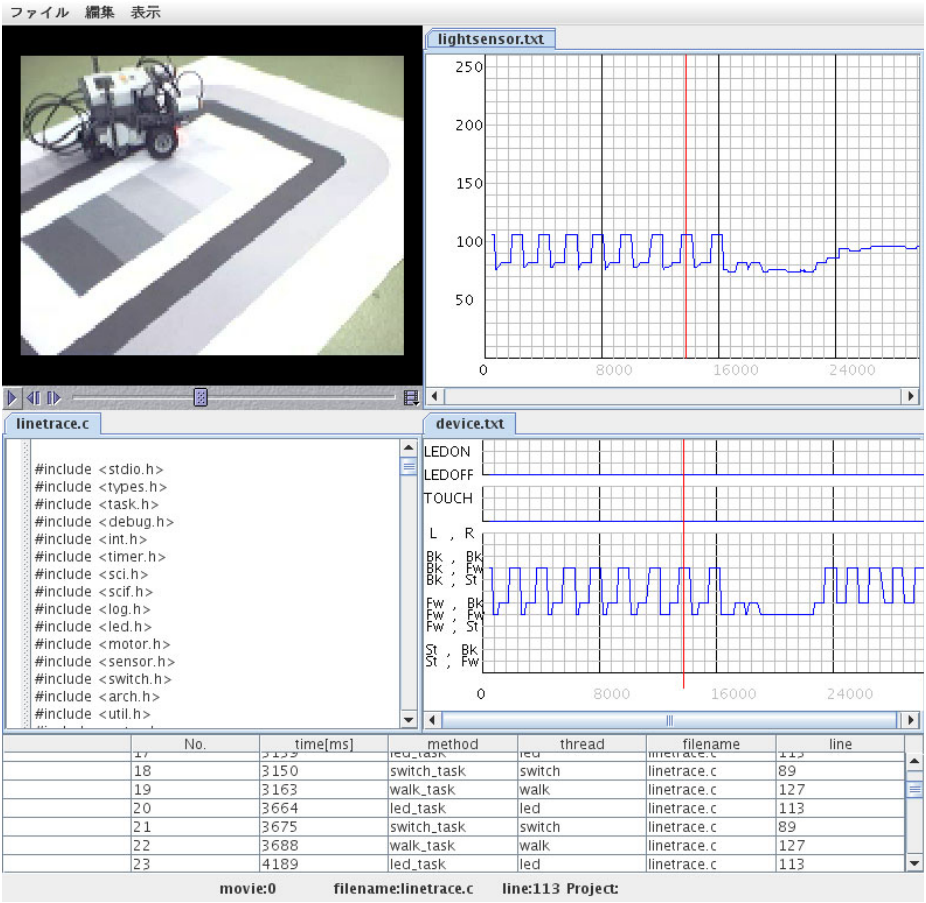

Fig. 1. Screenshot of the monitoring system

The learners can control robot with this panel to transfer the user/system program, reboot the system on the robot, acquire the log data, and start and stop the robot.

The existing robot was not able to reproduce operation. This environment has linked internal process of the robot to behavior. And, behavior is recorded with the Web camera. As a result, the movement of the robot can be reproduced.

3 Practice and Consideration at Technical High School

3.1 Practice at Technical High School

We operated this environment in technical high school practices in order to verify its effectiveness. This experiment verifies the effectiveness of the robot teaching material and each tool of this environment in the control programming study that uses the robot. The students and the target lecture of the experimental class are as follows.

Object school: Tokyo metropolitan Fuchu technical high school
Subject name: Computer Practical Training (Grade 12)
Number of participants: 24 students
Number of class: Eight times from January to September (50 minutes eaclass time)

Experiment and control group: We implemented evaluation experiment to verify the effectiveness of this environment. For the experiment, the students were divided into two groups: one group using this environment as an experiment group and the other using ROBOLAB as a control group. Both groups have academically even level.

The lecture contents are about how to use of NXT, an outline of the control programming, how to use various sensors, and a programming corresponding to the input sensor value. Since the experiment used a block called LEGO which has high degree of freedom, we used the same structure of the block robot for both the experiment and control groups in order to avoid excessive intervention to the hardware. Because the students would try to manage problems by remodeling blocks when they confront the bags, we restricted them to not change the structure of the blocks in order to facilitate their study about the control programming and the understanding of the embedded system in this experiment.

3.2 Class Observation

This section describes students' performance in practices using two different environments, ROBOLAB and this environment, at a technical high school.

ROBOLAB. In practice that used ROBOLAB, even students with especially low knowledge of the programming could understood the programming interface in a short time thanks to a tile programming environment that enable them to understand intuitively. However, the robot behavior they imagined and the behavior it actually moved were sometimes quite different, and they changed the programming and the parameter many times in order to move it correctly. Also, even if quite different behavior appeared, some of the students did not understand why it happed because they did not understand logic in the first place. This would be because they did not understand the essence of the control programming or they could not image the internal process.

In addition, it was an inefficient practice. Because there is no reproducibility in robot behavior, external causes, such as the state of the battery, the lighting and start position, made the students to fix the program whenever error occurred.

THIS ENVIRONMENT. On the other hand, it did not seen that the students moved robots easily as seen in the ROBOLAB class because the students programmed using Java language.

However, since this environment is able to visualize the internal process and the sensor value and to reproduce behavior, the students were able to obtain expected results with several times debagging in fewer trial and error process.

3.3 Evaluation Experiment

The result was analyzed based on experimental control using problem solving. In concrete terms, the two groups were compared in the following two points; acceptance time to finish the problem of the line trace and the number of times to debag the program. Table 1 shows the result of the evaluation experiment.

Table 1. Shows the evaluation experiment result

Group	Acceptance Time(minutes)	Number of times to debag
THIS ENVIRONMENT (average 12 students)	44	12.1
ROBOLAB (average 12 students)	45.7	21.3

The group that uses this environment completes the task with less Acceptance time and fewer numbers of trials. While the deference between both the Acceptance times is not significant, the numbers of trials are significantly different. The result shows that the features of environment mentioned above, such as the reproducibility of operation using movie and visualization of sensor value, had great influence on the number of trials. After the evaluation experiment, all members in the experimental group using environment answered questionnaire survey. The students were asked to write their opinion freely.

In the questionnaire, one of the participants mentioned that he could understand the relationship among the program, internal process and robot behavior. Additionally, another participant answered that he could imagine how general embedded device are developed and operated. There are also positive feedbacks about the visualization of sensor value. On the other hand, the questionnaire shows, as negative feedbacks, programming using Java seems difficult for the students compared to tile programming environment (i.e. ROBOLAB).

4 Conclusion

In this paper, we designed and implemented the embedded systems learning environment that used the robot, and described efficacy of this environment through the evaluation experiments in the educational field. This environment can make the behavior of the built-in device visible in various aspects such as system data and physical phenomenon that synchronize with the robot, movie, and internal process.

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