Development of Teaching Materials for Robot Programming for Junior High School Students: Student-Based Educational Activities

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Abstract

With the extensive use of robots in recent years, an age of co-existence between humans and robots is expected to arrive in the future. Therefore, providing robot education in the early stages of elementary and junior high school is necessary to stimulate students' interest in robots. Furthermore, educational institutions are becoming more active in robot education as a part of their contribution to the local community. For elementary school students, a Beauto Racer (Vstone) has been adopted as a teaching material for robot education, and teaching materials have been developed for teaching line tracing. In this study, we will develop educational materials for junior high school students on maze exploration using a Beauto Rover (Vstone). The students of Matsue National College of Technology took the initiative in this activity. The purpose is to improve their teaching skills.

Keywords: Robot education, Programing, Maze search, Student-based educational activities

1. Introduction

AI robotic research is being promoted at an accelerated pace, as obvious from RoboCup's goal of "building an autonomous robot team that can beat the world champion soccer team in 2050" [1]. Thus, an era in which humans and robots will live together in harmony is expected in the near future; therefore, providing a strong awareness regarding robots to future children at an early age is critical. As shown in Table 1, many lesson designs use commercially available microcomputers.

As an example of robotic education using Lego Mindstorms NXT, the company offers numerous courses in robotic education for students belonging to first to sixth grades. This includes student-centered robotic contests centered on line tracing [2].

Furthermore, robotic education using Beauto Racer (Vstone) is being developed as a curriculum for elementary school students to learn programing on the theme of line tracing [3].

In a junior robotic contest, participants used Lego Mindstorms EV3 to perform line tracing for simulating tomato harvesting [4].

Moreover, embedded programing using Lego Mindstorms NXT was employed to teach maze exploration programing [5].

Table 1 Commercial microcontrollers for robotic education

Commercially available microcontrollers	Lesson content	Literature
Lego Mindstorms NXT	Line trace Maze Search	[2][5]
Beauto Racer (Vstone)	Line trace	[3]
Lego Mindstorms EV3	Line trace	[4]

While most of these efforts are faculty-led, there are also student-led collaboration activities in the community that are aimed at improving the basic skills of students and other members of society ([6]).

A student-led working group was organized in this study to produce educational materials that will enable students to quickly and easily learn maze search programming.

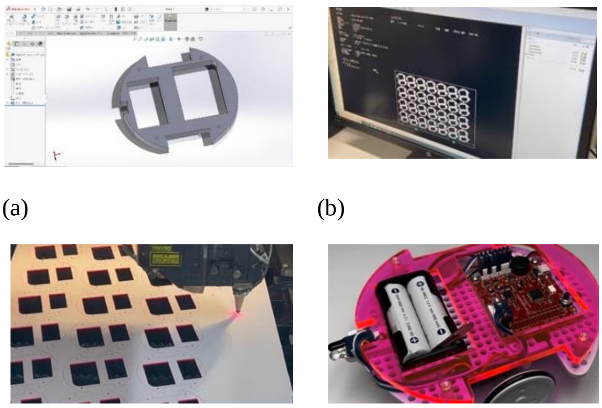
The rest of this study is as follows: Chapter 2 introduce information on lesson design and microcontrollers to be used for maze exploration programming . Finally, we present the summary and future tasks.

2. Planning and Preparation

2.1. View trovers and educational equipment

A Beauto Rover (Vstone) was used as the microcontroller for robotic education. To organize multiple wiring, a body is designed for it, as shown in Figure 1. It was designed using Slid Works (Figure 1(a)), prepared for processing by SPACEGEAR-U44 (MAZAK) (Figure 1(b)), and laser was processed using an acrylic plate (Figure 1(c)). This plane has a rectangular shape with dimensions of 90 [mm] × 125 [mm], and an image of the microcontroller after attaching the protective cover is provided in Figure 1(d).

As shown in Figure 2, a single infrared sensor (①) was mounted on the head of the mechanism. First, the power switch of the microcontroller (②) was turned on, and then a program created by an application on a PC was sent to the CPU board (③) by connecting it to a USB connector (④). Finally, the program proceed button (⑤) to execute the program is turned on, and the front tires (⑥) rotate to perform the motion on execution.



(a) (b) (c) (d)

Figure 1 Process of creating a protective cover for the microcontroller: (a). designing using SolidWorks, (b). preparation for laser machining, and (c). laser processing. (d). Microcontroller with a protective cover mounted

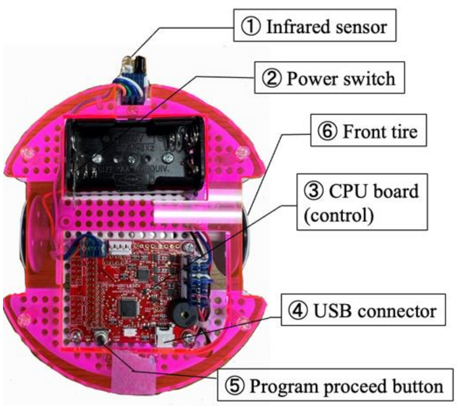


Figure 2 Function of each part of the robot

2.2. Lesson design for maze exploration programing

Assuming that we have lectured on how to transfer a program to the microcontroller and execute it, we will prepare problems 1–5, which are the key problems to be solved in a maze search. Table 2 shows the maze search programing materials (powerpoint-slide) prepared for the lecture.
The first problem is "1 second forward" and "turn right (90-degree rotation)." Participants were asked to think about the number of rotations and how much they have rotated with respect to time (Figure 3(a)).

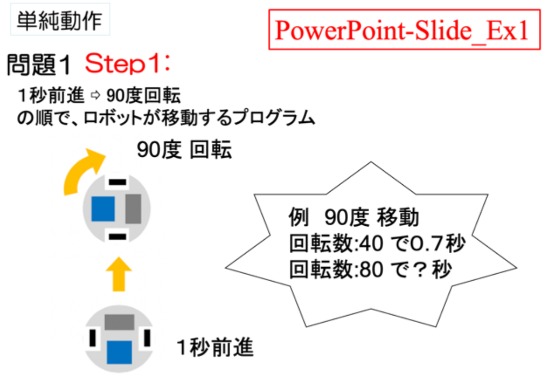
For problem 2, the exercise is to repeat problem 1 four times, where the useful "loop" function is taught and guidance is provided (Figure 3(b)). For problem 3, students are taught about conditional branching by helping them understand the relationship between senders and the IF function (Figure 3(c)).

A driving program is given as a mission in problem 4 to avoid obstacles when they are placed in predetermined positions (this would use the knowledge from problems 1-3) (Figure 3(d)).

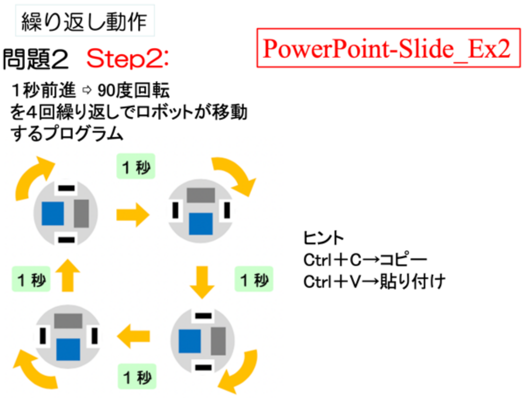
Problem 5 is implementing a program that will work with different placements of obstacles (note the difference from problem 4) (Figure 3(e)).

Table 2 Class design

	(data) item	Notes on the Guidance
Question 1	Actions for going straight and turning right.	Understand the relationship between the number of revolutions and time required to make a 90° turn (relationship between the number of revolutions and angle of the turn)
Question 2	Iterative operation	Ability to use the loop function.
Question 3	IF Function	Ability to use the role of sensors and IF syntax
Question 4	Traveling along an approximate known route	Summary of stationary, straight ahead, right/left turn (basic driving)
Question 5	Unknown Maze Running	Understand the difference between driving on an approximate known pathway



(a)



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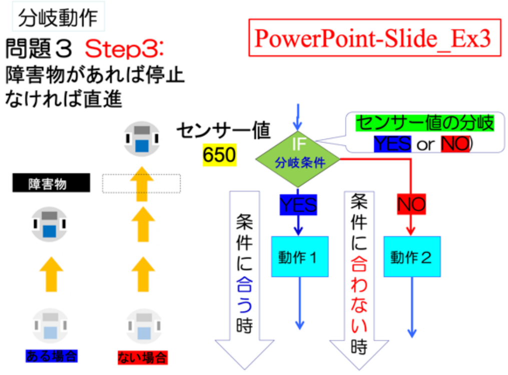
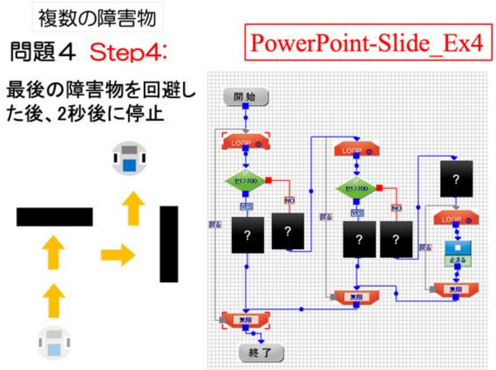
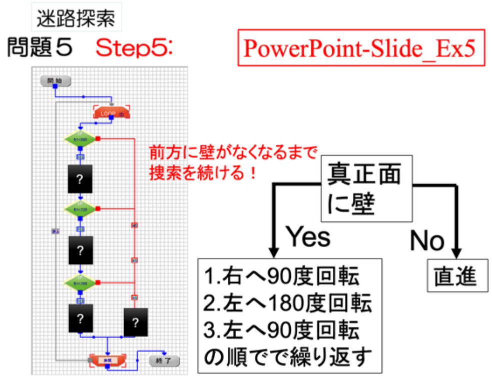


(c)



(d)



(e)

Figure 3 Maze search programming materials (powerpoint-slide for lecture) and five Processes. (a). Basic driving, such as going straight, turning right, and turning left. (b). Iterative operations, (c). IF syntax, (d). multiple obstacle avoidance, and (e). maze search.

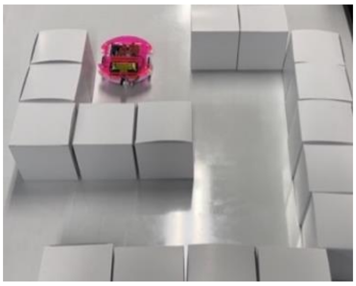
2.3. Maze selection

Obstacles were selected to create a maze, and three materials used for creating a maze are listed in Table 3. First one is recycling boxes, which are all around us and have a flat surface. They are relatively responsive to sensors, but their nonuniform size makes it difficult to freely change the maze path (Figure 4(a)). Further, in the case of paper cups, the size is uniform and its unit price is low. However, its shape resembles a part of a cone, and the infrared sensor light reflects irregularly and penetrates the gap between neighboring paper cups (Figure 4(b)). Finally, the sensors responded well in the cubic box case dimensions: 100 mm × 100 mm × 100 mm). This is because they have flat surface, and the infrared sensor responded relatively well because of its uniform size. Furthermore, with cubic box, it is easy to freely change the maze path (Figure 4(c)). Based on the above, cubic boxes were adopted as the obstacle for preparing maze.

The maze corridor's width should be set at 200 mm, which is equivalent to the width of two cubes. This allows the robot to turn right and left in the passageway.

(a)

(b)



(c)

Figure 4 Maze production choice: (a). recycled box, (b). paper cup, and (c). cube box

Table 3 Three candidates for maze production

Candidate obstacles	Advantage	Disadvantage
Recycling bin	Gather easily	Uneven size
Paper cup	Low unit price Uniform size	Sensor recognition is unstable
Cube box [100 mm per side] (commercially available)	High degree of freedom for placement Uniform size	High cost

3. Conclusion

In this study, a Beauto Rover (Vstone) was used as the microcontroller for robot programing. With only one infrared sensor attached to the back of its head, this microcontroller can be easily operated by junior high school students. To make robot programing learning feasible, we produced programing materials that provided steps for realizing a successful maze exploration.

We plan to conduct several workshops at our university using the developed robot programming material for future research projects. In addition, we plan to conduct pre- and postlecture questionnaires to investigate changes in interest and awareness on maze exploration and to evaluate the educational materials we have developed.

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Authors Introduction

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