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Development of Cultivate Computational Thinking using Finger Robot

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Abstract

Computational Thinking is one of the necessary skills for children who live in modern times. Therefore, in this research, we aim to design lesson that can cultivate Computational Thinking. In this research, design a lesson that cultivates Computational Thinking by moving a robot to the specified finger state using a finger robot. At that time the children can know that by using the notion of "binary" you can count many numbers by bending and extending your fingers. By using a finger robot, it is thought that children will motivate themselves to teach and to understand easily.

Keywords: Computational Thinking, Programming Education, Binary number, Robot, CS Unplugged

1. Introduction

In modern times, it is said to be called the fourth industrial revolution. In Japan, the National Curriculum was revised in 2017, and in the elementary school a new national curriculum will be implemented from FY 2020. In the new national curriculum, programming education at elementary school level is compulsory. Worldwide, in England the subject "Computing" has already been compulsory in the primary education stage since 2014 [1]. From the world viewpoint, it can be seen that knowledge, skills, qualities and abilities of computers and programming are considered necessary in future times.

Towards 2020, lessons using visual programming languages, lessons using robots, etc. have been tried as practices of programming education in various regions of Japan [2, 3]. According to a lesson using a robot, a robot can draw interest even if the degree of interest and understanding of the scientific concept of the child is not high. It is also excellent for thinking trial & error. And it is reported that children can work on programming with enjoying.

Many of the robots used in programming lessons are mobile robots. The mobile robot has the advantage that the operation at the time of program execution can be observed as the behavior of the robot and it is possible to understand the control structure and its necessity in stages by repetition or case classification at the time of collision.

However, there are problems that teachers who can instruct robot programming are few, and it is difficult for children to understand and program sensors and motors.

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By developing robot teaching materials that are simple in programming and operate without having a deep understanding of sensors and motors, robot programming with many advantages in programming education becomes easy.

As an approach to teaching information science to primary school students, there is "COMPUTER SCIENCE Unplugged" (Next, CS Unplugged) developed by Dr. Tim Bell of New Zealand and others [4].

CS Unplugged is a method that learns basic principles of computers easily in elementary school students. Examples include binary numbers, image representations, text compression, and the like. In the world of computers, information is represented in binary notation. In the process of learning programming, learning the structure of the computer makes it possible to deepen the understanding of computers and programming.

It is thought that educational materials that can learn programming and basic principles of computers simultaneously are necessary in the future. In this research, we develop robot teaching materials that can simultaneously learn binary numbers and learn programming.

2. Educational robot teaching materials

Fig. 1 shows the appearance of the robot teaching material (Next, finger robot). The finger robot uses ARTEC Corporation's parts of ARTEC Robo. Finger robot model human hands. By programming, children can move each finger. By associating the hand shape of the finger robot with the binary number representation, the child can know the binary number representation. A decimal number stretched over the front of a finger robot is an aid for associating the shape of a hand with a binary number and a decimal number. Children associated with finger shape and binary numbers can also associate binary numbers with decimal numbers.

2.1. *Binary number*

Binary number is a number expressed using two numbers of "0" and "1". In the method of counting binary numbers with fingers, "0" and "1" correspond to the bending and stretching of the finger [5]. Fig. 2 shows the idea of binary numbers using fingers. Fig. 2 (a) shows the correspondence between fingers and digits, and (b) shows an example of representing binary numbers with fingers.

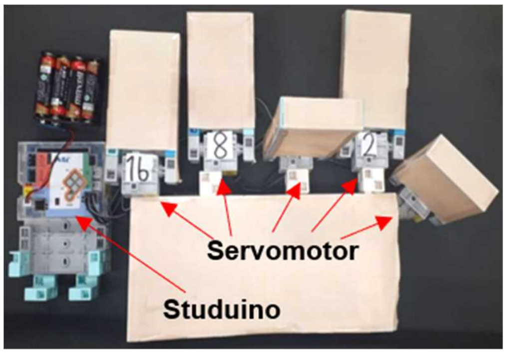
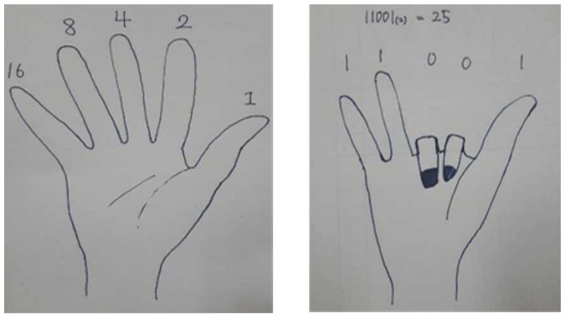


Fig. 1. Finger robot



(a)Digit correspondence (b) An example

Fig. 2. Concept of expressing binary numbers with fingers

Until now, efforts to teach elementary school students binary numbers using CS unplugged have been done. What has been used in CS unplugged is a method of expressing binary numbers on the front and back sides of a card on which points corresponding to the decimal number are drawn. In the CS unplugged, the back of the card corresponds to "0" and the front corresponds to "1". In the finger robot, the front and back of the card are replaced by bending and extending the fingers. Also, by moving the finger of the finger robot, the decimal number stretched on the front of the finger robot can be seen / disappeared. This also corresponds to representing on the front and back of the card.

2.2. *Hardware*

The hardware configuration is shown in Fig. 3. The finger robot uses four AAA batteries as a battery. The computer uses Studuino which is Arduino compatible base. Studuino is connected to a personal computer (PC) to use. As shown in Fig. 4, the PC is used to create a program to transfer to Studuino and to display the status of the finger robot.

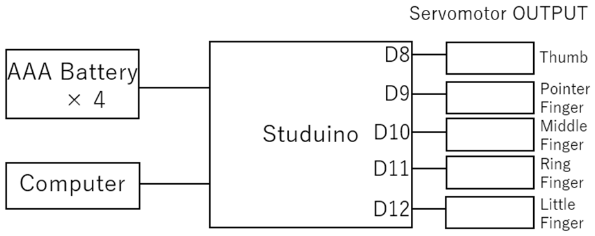


Fig. 3. System diagram

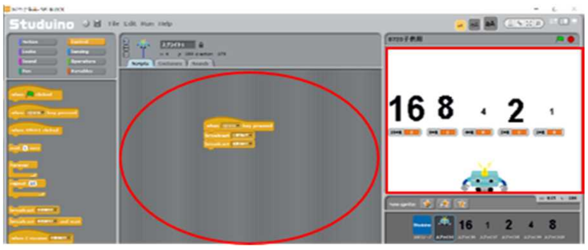


Fig. 4. Program creation screen

Fig. 5. Block that specifies the angle

In the finger robot, one servo motor is used for each finger, and a total of five servo motors are used. Human hand fingers, the thumb has two joints, and the other fingers have three joints. However, as it is considered difficult for elementary school students to think of multiple joints when programming, only one joint of a finger robot is considered. By connecting the terminal of the servo motor to the port of Studuino, it becomes possible to move the servomotor. To control the servo motor, usually adjust the pulse interval. In Studuino, as shown in Fig. 5, the servomotor can be moved by directly inputting the angle (arc degree). There are two states of the finger part of the finger robot, that is, a bent state and an extended state. In the case of Fig. 1, the fingers (thumb) at the right end and the third finger (middle finger) from the right are bent and the other fingers are in a stretched state. The servo motor is in a state in which the finger is bent by 180 ° and the state in which the finger is extended by 90 °.

2.3. *Software*

In the finger robot, each finger moves independently. The software that moves the finger robot uses Studuino

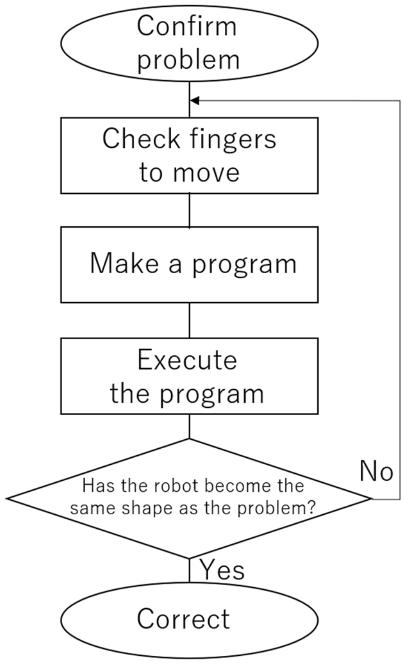


Fig. 6. Program creation flowchart

Software, a visual programming software based on Scratch. As shown in Fig. 4, Studuino Software creates a program by combining blocks. Therefore, even elementary school students can easily experience programming. Although it is written in English in the figure, when used by a child, it is used in Japanese notation. The boxed portion in Fig. 3 is a space called "stage". The decimal number displayed on the stage changes the appearance of the number corresponding to the state of each finger of the finger robot. In Fig. 4, "4" and "1" are small. This indicates that the finger robot is bent with fingers corresponding to "4" and "1". In addition, under the decimal number, the value corresponding to the state of the finger and the notation of the binary number is displayed. "0" is displayed below "4" and "1" in Fig. 4 so that it can be seen that the current finger state is "11010" when expressed in binary.

Children use Studuino Software for programming. As shown in Fig. 6, the child creates a program for moving the finger portion of the robot to a designated state (eg, a state in which only the ring finger and the thumb are bent). In the program that moves the finger part, we use functions prepared beforehand by the authors. As an example, the function to move the thumb is shown in Fig.7. This function is a function that changes the value

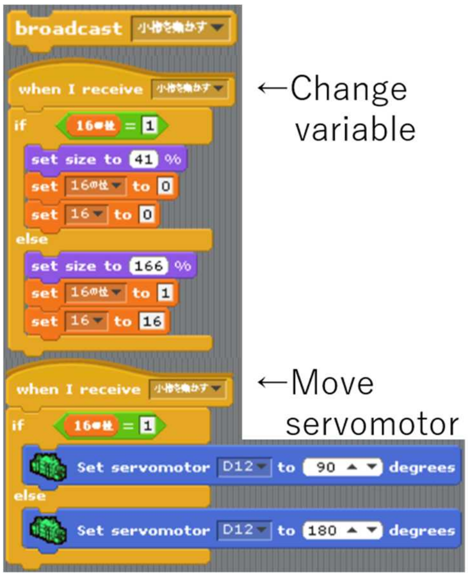


Fig. 7. Function example: To move thumb

of a variable when called. The variable has two variables, a variable representing the state of the servomotor and a variable representing whether the finger portion represents binary "0" or "1". The child does not create the contents of the function. The servomotor can be moved by merely using the function.

3. Activity

In lesson, children use finger robots in pairs of two child. The problem is presented from the teacher to move the finger robot to the specified state. The question is presented in four kinds of represents. Four kinds of problems are problems of fingers represented by photographs, letters, binary numbers, and decimal numbers. To these problems, consider a program in pairs. To get to the state expressed by the problem, think about which finger to move. From the current state to the state of the problem, execute the program once and transform it. Therefore, instruct that every time you make a mistake, the current state will not change.

4. Results of using teaching materials

The correspondence between the program and the movement of the finger robot is shown in Fig. 8. In the state shown in Fig. 8, when the program on the left of Fig. 8 is executed, the state is changed to the state shown in the lower part of Fig. 8.

Fig. 8. Program(left) Before robot(above) After robot(under)

5. Conclusion

In this research, we developed a teaching material called a finger robot which can be used for programming education in elementary school. Elementary school students can use the finger robot to know the idea of counting binary numbers with fingers while experiencing programming. Children can deepen their understanding of correspondence between binary numbers and decimal numbers by associating the state of the finger robot with the representation of binary numbers and decimal numbers. In the future, we plan to conduct durability tests assuming the use of children and setting tasks to cope with various developmental stages.

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