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The Development of an Educational Robot and Scratch-based Programming

Young-Dae Lee*, Jeong-Jin Kang**, Kee-Young Lee***,Jun Lee****, Yongho Seo*****

[*] *International Promotion Agency of Culture Technology (IPACT), Korea*
**Dept. of Information and Communication, Dong Seoul University, Seongnam, Korea*
[***] *Department of Medical IT and Marketing, Eulji University, Seongnam, Korea*
[****] *Xbot Co.,Ltd*
[*****] *Dept. of Intelligent Robot Engineering, Mokwon University, Daejeon, Korea*
e-mail: youngday77@daum.net

Abstract

Scratch-based programming has come to be known as an effective programming tool because of its graphic instruction modules, which are designed to be assembled like the famous LEGO building blocks. These building block-like structures allow users to more easily program applications without using other more difficult programming languages such as C or Java, which are text-based. Therefore, it poses a good opportunity for application in educational settings, especially in primary schools. This paper presents an effective approach to developing an educational robot for use in elementary schools. Furthermore, we present the method for scratch programming based on the external modules need for the implementation of robot motion. Lastly, we design a systematic curriculum, titled "Play with a Robot," and propose guidelines to using the educational programming language Scratch.

Keywords: *Education robot, scratch, program block, elementary school, Aduino, Bluetooth communication*

1. Introduction

The introduction of new technologies in the primary school provides many opportunities; and their application can serve the achievement of various objectives. The new technologies can influence both the educational environment in its complexity and any particular process of learning and teaching. This is regardless of whether they are introduced as an independent subject of study, or used in a specific manner within other subjects of the curriculum.

Children of primary school age have a conception of robotics that has been formed from imaginary robots in films, TV, children's story books and as toys. This primitive conception is very different from the real robots, and their characteristics, that have specific application in the real lives of people. But their interest in this theme offers an opportunity to use their curiosity to learn about robotic reality. Thus, the robot education provides the students with the opportunity of high dimensional concept, inventive expression and discovery of new thinking[1][2][3]. Scratch was developed in MIT media lab by Lifelong Kindergarten group and was designed by constructing the visual programming interface and the community based web interface[4].

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Corresponding Author: youngday77@daum.net
Tel: +82-02-409-7718, Fax: +82-02-407-7716
International Promotion Agency of Culture Technology(IPACT), Korea

Scratch blocks are designed so that everyone can intuitively understand and they are adequately assembled each other. Thus, scratch makes the software programming easy especially for the beginners.

Robotics can be divided into followings from the view point of robot and students: (1) learning about robots , (2)learning from robots, (3) learning with robots. In this article, we report new development of an educational robot called as EPOR(Educational Programming Oriented Robot), which is controlled with the graphic assembly software such as Ardui block and the adequate curriculum for young students, which is entitled with “My friend, robot”.

We introduce the development of an educational robot named as EPOR(Educational Programming Oriented Robot), which are designed using various sensors and actuators especially adequate for the education of primary school students. The robot is manipulated by assembling the graphic command modules. Furthermore, we developed the suitable curriculum and applied it to the students in elementary schools.

2. Scratch

Scratch is the visual programming which uses images and sound using programming blocks, which allows children to easily create their own personally meaningful interactive content (interactive stories, games, music and art). It is educational programming tool, which aids the people who do not have knowledge for programming, to understand the programming concept[5].

Scratch projects are made up of objects called sprites. We can change how a sprite looks by giving it a different costume. We can make a sprite look like a person or a train or a butterfly or anything else. You can use any image as a costume: you can draw an image in the paint editor, import an image from your hard disk, or drag in an image from a website. We can give instructions to a sprite, telling it to move or play music or react to other. To tell a sprite what to do, you snap together graphic blocks into stacks, called scripts. Figure 1 shows the typical screen shot of Scratch.

Figure 1. The typical screen of Scratch

3. The Development of an Educational Robot

3.1 The Hardware of EPOR

Educational robots are a subset of educational technology, where they are used to facilitate learning and improve educational performance of students. Robots provide an embodiment and the ability to add social

interaction to the learning context and hence an advancement on purely software-based learning.

We developed EPOR(Educational Programming Oriented Robot) for programming in primary school, which is based on Scratch and has the following motivation for development

1. Existing educational robots and robot differentiate into a variety of online training content support.
2. The latest graphic language and open hardware is compatible for robot education
3. Programming and fusion science education, can take advantage of a variety of smart learning

In addition, EPOR has the following functions.

1. Camera and Color Tracking
   A. Bluetooth based wireless image transmission
   B. Easy color tracking: Key mapping to implement various robot vision applications
2. Various Detachable Sensors
   A. Connectors on chest and bottom of EPOR
   B. Detachable sensors for various application : IR, Touch, VR
   C. Embedded sensor : MIC, CDS
3. Open Hardware Support
   A. Arduino UNO 100% compatible
   B. Compatible with various third party sensors and actuators for Arduino
   C. Educational contents support via online community

The appearance of EPOR is like shown as Figure 2.

Figure 2. The appearance of EPOR

Table 1. The Specifications

Parts	Features	Quantity
Main board	Compatible with Arduino UNO	1EA
Servo motor	1.8 kg/cm (4.8V), 2.5 kg/cm (6V) 0.1 sec/60degree (4.8V), 0.08 sec/60degree (6V)	3EA
Wheel motor	10 cm/s (3v), 15 cm/s (5v)	2EA
Communication LCD	UART communication, Bluetooth (v2.0 version	
The output and various sensors	1602 Character LCD RGB LED RGB LED JPEG cameras Light (CDS) sensor Microphone Sensors	1EA 1EA 1EA 1EA

	Infrared (IR) Sensors	1EA
	Speaker	2EA
		1EA

3.2 The Extended Modules of Scratch

The scripts of Scratch, which is shown like as in Figure 3, are designed to control the motion of EPOR and to detect the sensors. The script commands are categorized as digital inputs and outputs, analog input and outputs, RC servo motor control and DC motor control. By combining the conventional scripts of Scratch and the designed scripts of EPOR, users can not only gather the digital and analog sensor information but also can control neck and arm motion of EPOR using the implemented RC motors and DC motors. Figure 3 shows the examples to control EPOR motion using the stripes, to control clock wise and anti-clock wise steering, forward and backward movement, and stop command of EPOR.

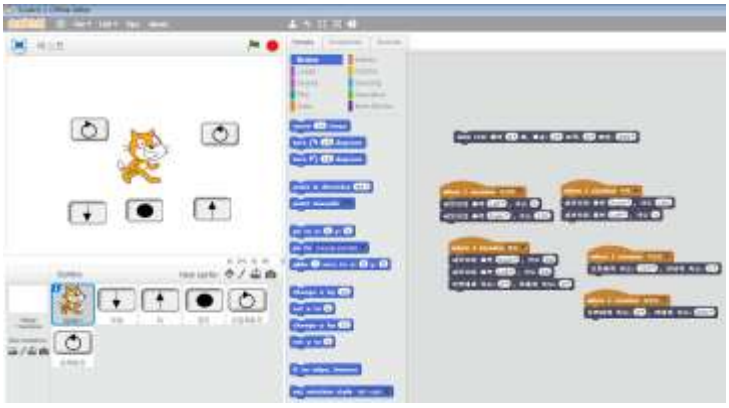

Figure 3. The motion control of EPOR using the extended script modules of Scratch

3.3 The Interface between EPOR and Scratch

For controlling EPOR and creating script, the process of preparing EPOR to be connected with PC is required. PC and EPOR are needed to be set via Bluetooth. So need XBOT Monitor program installation and operation for Bluetooth connection and COM Port setting. Figure 4 shows the concept of XBOT monitor program.

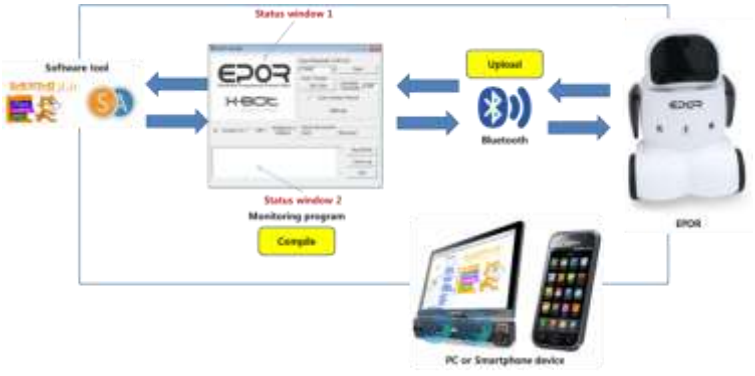

Figure 4. The concept of XBOT monitor Program

To control EPOR with Scratch2.0, 'EPOR_Eng.s2e' file is needed to be set. When Scratch2.0 operated, click ‘File’ menu(by Shift+left mouse click) and then click ‘Import experimental HTTP extension’. And

then Open 'EPOR_Eng.s2e' file downloaded from official web site of XBOT(XBOT official web site/archives : http://xbot.co.kr/board/free/list.html?board_no=7). Figure 5 shows HTTP extension for Import EPOR blocks.

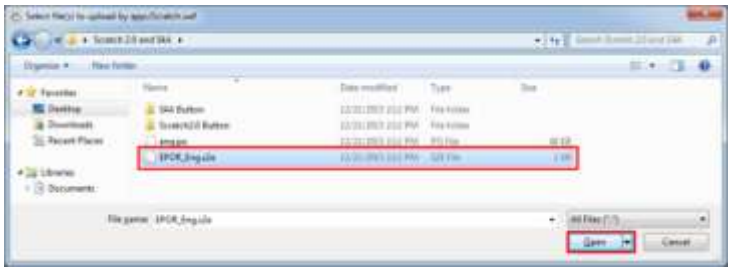

Figure 5. Experimental HTTP extension for Import EPOR blocks

When the file opens, it can be confirmed that the block of EPOR opens on 『More Blocks』 menu like as shown in Figure 6.

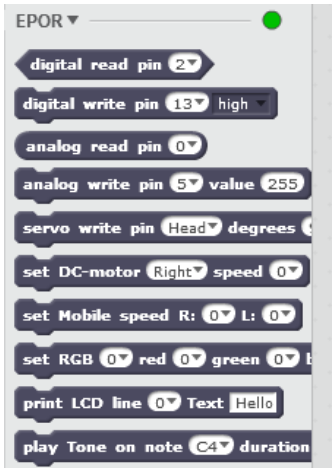

Figure 6. Blocks for controlling the EPOR

The descriptions of input and output pins used for controlling EPOR with Scratch2.0 are like as the table 2. The table shows the order of placement of analog input pins for sensors that can be attached to EPOR.

Table 2. Scratch 2.0 Robot pin-map

Scratch2.0 Input Name	Analog0	Analog1	Analog2	Analog3	Analog4	Analog5	Digital2	Digital3
Input Tyep	Analog Input	Analog Input	Analog Input	Analog Input	Analog Input	Analog Input	Digital Input	Digital Input
Robot	A0	A1	A2	A3	CDS Sensor	MIC Sensor	D2	D3

Scratch 2.0 Output	Analog5	Analog6	Digital4	Digital7	Motor8	Motor9	Motor10	Digital12	Digital13

Name									
Output Tyep	Analog Output(D5)	Analog Output(D6)	Digital Output	Digital Output	Servo Motor Output	Servo Motor Output	Servo Motor Output	Digital Output	Digital Output
Robot	PWM	PWM	D4	D7	Head	Right Arm	Left Arm	D12	D13

4. The Proposed Robot Curriculum

The curriculum for educating EPOR by Scratch consists of the followings. In the beginning of lecture, the instructor introduces robotics, and then he teaches Scratch programming. In the middle part of the lecture, he teaches manipulation of EPOR by Scratch. The theory and experiments are performed each by each during the lecturer. In the latter part of lecturer, the projects utilizing Scratch and EPOR are done by students, and finally, robot contest and a show is held by the groups of students.

The proposed robot curriculum for primary school students has the following features.

1. Optimization for coding education for a beginner
2. Visualization and control of robot functions via visual coding
3. Curriculum for scratch 2.0

The proposed curriculum was examined by experts , who consists of three professors for robot education, three teachers of primary schools and two teachers of middle schools. The purpose and education contents for robot education in primary schools are overviewd like as shown table 3. Most of experts agreed on the purpose of education and however they suggested us to make minor modifications of detailed contents foreasiness of education and teachabiliy . We accepted their opinion like as in the table and made the final schedule of education program like as in table 4

Table 3.The recommendation by experts and modfication

	The overview experts	The detailed modifications
1	The general introduction for robotics is recommended	We added rhe introduction and dream of robot engieneers
2-6	The additional examples of Scratch are needed to understand the functions the Scratch	We divided the the examples by basic, middle and high level and added on the lecture
7	The introduction on EPOR is needed before experiments	We added the introduction on the concepts of EPOR
8-11	The overall senario for robot control is recommended	We added the experiment for overall motion control of EPOR
12	We recommend final robot contest	We added the show and contest utilizing EPOR and scratch

The curriculum consists of 12days , one day per a week and some of them are like shown as Table 4.

Figure 7 shows the EPOR contest held after the lecture.

Table 4. The Curricum of Robot Education

Title		Robot is my friend		
The used model		Focusing on experiments and project		
	Level	Subtitle	Contents	
1	Exploration on robotics	Understanding robotics	Introduction	What is robotics?
			Study works	Lecture and robot movie
			Ending	Discussion, dream of scientist
2	Understanding Scratch	What is Scratch	Introduction	Overview of Scratch
			Study works	Writing Scratch
			Ending	Hello script
3	Basic Scratch	Manipulation of Scripts	Introduction	Sprites and stage
			Study works	Learn script types
			Ending	Script manipulation
4	Middle level of Scratch	Scratch animation	Introduction	What is animation?
			Study works	Design of Scratch animation
			Ending	Presentation of student's works
5	Middle level of Scratch	Scratch game	Introduction	What is shooting game? Game demonstration
			Study works	Making shooting game
			Ending	Presentation by groups
6	Advanced level of Scratch	Cooki run game	Introduction	What is Cooki run game' Game demonstration
			Study works	Making Cooki run game
			Ending	Presentation by groups
7	Introduction of EPOR	Overview of EPOR	Introduction	What is EPOR?, Learn EPOR concept
			Study works	Parts of EPOR(sensors and motors)
			Ending	Learn EPOR HW
8	Demonstration of EPOR	EPOR interface	Introduction	EPOR interface
			Study works	Bluetooth communication and EPOR

				setting
			Ending	Demonstration of EPOR motion
9	EPOR Sensors	EPOR Sensors	Introduction	What is a sensor?
			Study works	CDS, IR, touch sensor
			Ending	Reading EPOR sensors
10	Motors	EPOR motors	Introduction	What is a motor?
			Study works	RC servo motor, DC motor
			Ending	Motion control of EPOR
11	Motion control of EPOR	Motion control	Introduction	Summary of EPOR motion control
			Study works	Sketch of scenario and motion control
			Ending	Taking a picture in the target point by EPOR
12	Contest	Evaluation of show and contest	Introduction	Sketch of works by groups
			Study works	Group contest and evaluation
			Ending	Presentation of works by groups

Table 5. The Lecture Evaluation

Students' opinion	Lecturer's evaluation
-The program is good because we have interest in robotics - It has the merit that we could manipulate an educational robot	- This lecture has differentiation comparing it with other conventional ones such as Scratch game programming because it uses the real robot based programming
-We could extend imagination by designing and solving problems -The time is short in making scripts of robot motion	- The students have interests because they handle scripts of Script commands to control robots
-The purpose of lecture is good due to usage of various scripts for robot motion -The cooperation of students is good to control EPOR motion	- The students have self-confidence and satisfaction by programming a real robot - We have hope that the environment of study is more advanced

Figure 7. The EPOR Contest

5. Conclusion

This work presents the development and education of robotics especially adequate for primary school. The designed robot implements the open hardware and the detachable sensor modules. The specification and interface of Scratch and the robot is described. Furthermore, we provide the wide contents and curriculum adequate for teaching and learning of robot education. Using Scratch based programming, students can learn the robot without difficulty in programming comparing with the conventional text based programming or coding.

The smart learning makes it easy to fuse knowledge for convergence of science, technology and engineering for primary school students. The students can concentrate on imagination and idea for robotics without learning the difficult coding languages such as C and Java language. The education results and survey of student's option show the validity and effectiveness of our approach.

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