International Journal of Advanced Smart Convergence Vol.8 No.4 147-153 (2019)
http://dx.doi.org/10.7236/IJASC.2019.8.4.147

IJASC 19-4-18

Robot-based Coding Education System with Step by Step Software Training

Jun Lee and Yong-Ho Seo

** Ph.D candidate and Professor, Department of Intelligent Robot Engineering, Mokwon University, Republic of Korea*
e-mail: yhseo@mokwon.ac.kr

Abstract

Recently, the perception of software education, which had been considered as a field of education for programmers in this field, is changing in response to recent changes with the trend of 4th industrial revolution. Major counties competitively invest in software education and the target age group for software education is also on the decline. However, the traditional text-based programing languages such as JAVA and Python, have a high entry barrier. To address the shortcoming, a variety of methods have been recently proposed for the effective software education for kindergarten and elementary school student. In this paper, we propose a robot-based coding education system with steps for coding education for effective software education. The proposed method is divided into three stages, depending on the level of the student being trained in the software coding education to interact with robots. The proposed stages consists of unplugged coding using a remote control, coding using a graphic-based programming language and text- based coding. We conducted an experiment with performing separate missions while providing propoer tutorials for each stage to verify the effectiveness of the proposed software education system.

Keywords: *Software Education, Robot-based Coding, Smart Toy Robot, Unplugged Coding*

1. Introduction

The fourth industrial revolution as a biggest social issue is regarded as an era of revolution achieved through the convergence of information and communications technologies (ICT). This represents a change in the industrial environment in which automat-ion and connectivity are maximized based on ICT technology for the interested parties in the industry and society. According to these changes, the importance of the software industry in these social changes is increasing each day. In such a "software-driven society", each major country implements a software education policy to foster talent with software capabilities [1, 2].

The recent software education in major countries not only becomes mandatory, but also increases the share of formal education including effective courses. In addition, the current trend of software education, which

Manuscript Received: October. 29, 2019 / Revised: November. 6, 2019 / Accepted: November. 11, 2019
Corresponding Author: yhseo@mokwon.ac.kr
Tel: +82-42-829-5720, Fax: +82-42-829-7909
Professor, Department of Intelligent Robot Engineering, Mokwon University, Daejeon, Republic of Korea

traditionally carried out in the middle and high school curriculum, is extended to lower age group such as elementary school and pre-school education over the world [3].

However, the problem is that software education using text-based programming languages such as JAVA and Python is not suitable for the trend of software education which requires easier ways for lower age groups. To address these shortcomings, various attempts have been made to lower the barriers in entry of software education worldwide [4].

In this paper, we classified the levels of software education into three classes: beginner level with unplugged programming, intermediate level with graphic-based programming, and advanced level with text-based programming as shown in the following Figure 1.

Figure 1. Step by Step Software Training

2. Robot Platform

The robot platform that we used for the proposed coding education system is named as Bingle-S. This robot is a smart toy robot platform developed by XBOT for software education and smart toy for kindergarten and elementary school student. This robot supports visual expressions with built-in OLED screen, speech recognition, Bluetooth speaker, autonomous driving with various output devices such as DC motors, servo motor and various built-in sensors. The following Figure 2 illustrates the specifications and built-in functions of Bingle-S.

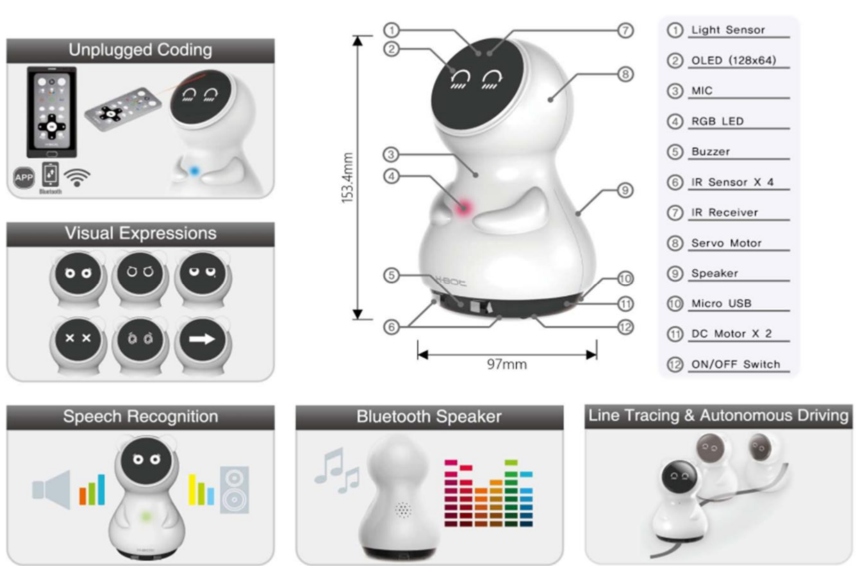

Figure 2. Specifications of Bingle-S

With a consideration of efficiency and stability in wireless communication between robot and computing devices including smart devices, Bluetooth communication is also utilized in transmitting data between the robot and the smart device [5]. A dedicated communication protocol is designed to control the robot with remote computing devices, and it is divided into two types, robot-smart device and smart device-robot. The protocol data has a certain length regardless of the type of output device. It is important to regularly check the robot status in real time to provide service to users in the system. The status of robot can be identified through real-time data of the embedded sensors in the robot.

3. Robot Coding System

3.1 Unplugged Robot Coding System

The first step of the proposed software training system is the software training with unplugged coding [6]. The unplugged coding method uses a robot platform with a dedicated offline interface. It does not need a remote computing devices such as PC or smart device and is intuitive coding method. This is the most popular coding education method for kindergarten and elementary school ages. However, there are limitations in expressing core concepts in software education such as limitation in inputs and branching due to hardware constraints that robot platform itself performs as an interface. The proposed system supplemented the limitations of existing input method by utilizing an IR remote control interface and introduced the concept of branching statements using embedded sensor data in the robot. The following Figure 3 illustrates a flow chart of the proposed unplugged coding system remote control design utilized as unplugged coding interface and the commends associated with the each remote control button.

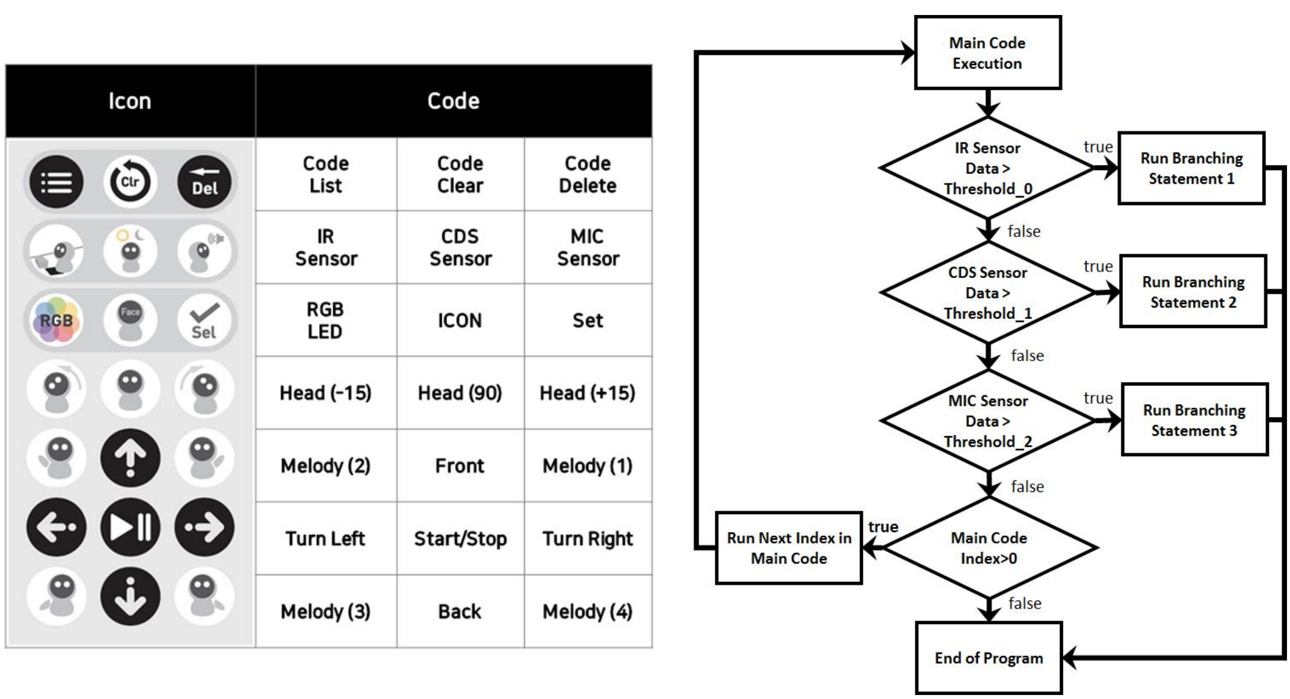

Figure 3. Unplugged Program Execution Process

While existing unplugged coding system consists of a single sequenced logic, the proposed system consists of four independent logics, and input signal from the remote control is entered through the built in IR receiver located at the face of robot. The entered code is included in one of the four logics depending on the program's authoring mode, and each logic represents the array of main, branching 1, branching 2, and branching 3. At that moment, the elements of the array are not entered in duplicate. A method using embedded sensor into the robot platform is proposed in this study to adopt branching statements in unplugged coding. Front and bottom IR sensor, microphone, and CDS sensor were selected as sensors to determine the arrangement conditions of each branching [7, 8]. The execution condition of branching statements is determined by Threshold Value of each sensor's value. At this moment, for the threshold that becomes a standard of branching statements, the optimized value obtained from experiment was used.

The program is executed by pressing a run button on the remote control. The execution order of the program is determined by the index of main program's arrangement, and the execution condition of branching arrangement is determined for each sequence of main program. If the branching execution condition is true, the code stored in corresponding branching statement arrangement is executed. At this moment, a decision of branching statement execution condition is executed by the order of branching statement 1, branching statement 2, branching statement 3, and if all branching statement conditions are false, the next main code is executed. If the next main code arrangement is empty, the program is exited and returns to authoring mode.

3.2 Graphic Based Coding System

The second stage of the proposed step by step software training system is the graphic-based coding system. The coding method using graphic-based language is the most popular method of coding education for low aged and beginners, and it is widely used in many countries and educational institutions. The most representative languages are Scratch developed in MIT and Entry developed by Entry Foundation. The mostly identifiable characteristic of graphic-based language is that one can be programming by visualizing modularized program code and simply combining the visualized codes. This type of graphic-based programming language has an effect of lowering the high entry barrier, which is the one major drawback of basic text-based program education [9, 10]. However, it is necessary to develop dedicated blocks for controlling each output device of the robot in order to control the robot using existing graphic-based programming language. The following Figure 4 shows the robot controlling dedicated blocks that the code was modularized to control the robot.

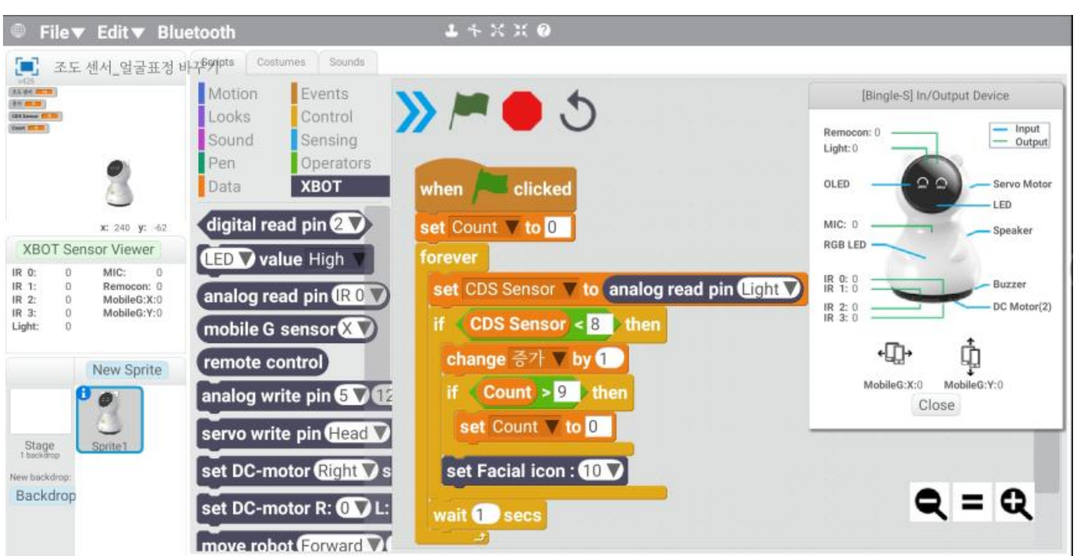

Figure 4. Example of Graphic-based Coding with Robot

3.3 Text Based Coding System

The last method is a software training of a conventional text-based coding with robot. Text-based software education is regarded as a traditional software education method and primarily utilizes various programming languages including C++, C#, JAVA, etc. In this study, Python was used as a programing language due to its low entry barrier and ease of learning. The educational course is divided into three parts consisting of creation of user interface, output of sensor data, and controlling robot output device. The education course also consists of implementing process of dedicated block function for controlling the modularized robot that was used in graphic-based coding process to lower the entry barrier. The course consists of 10 chapters, and the final 10th chapter includes advanced practice problems of controlling the robot using multiple input and output devices. The Figure 5 shows the examples of Python code which was converted from the example of graphic-based coding.

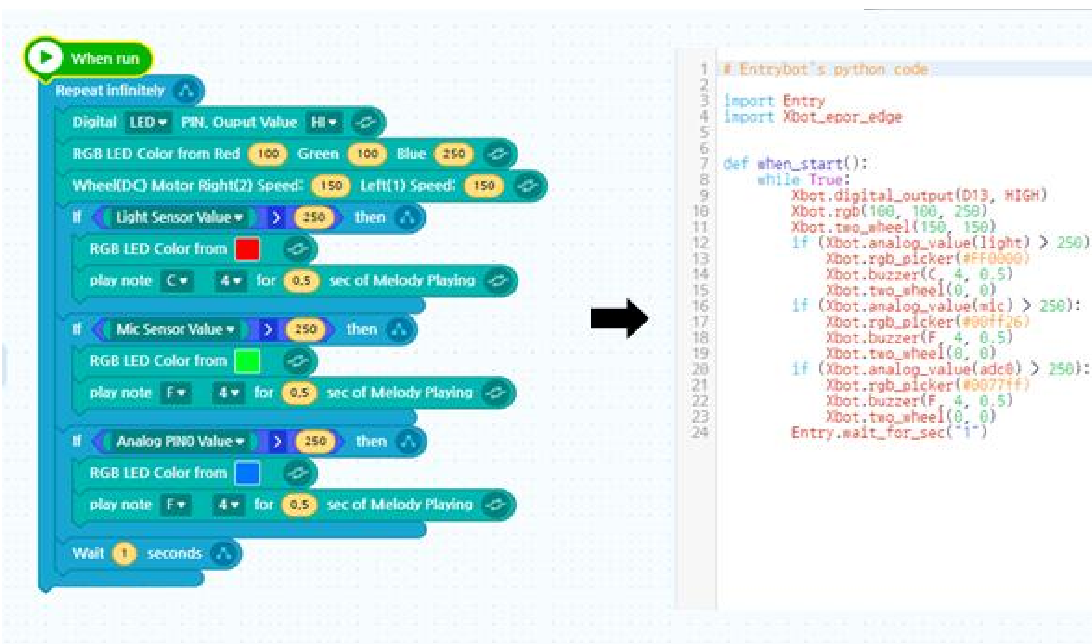

Figure 5. Examples of Graphic-based Coding(left) and Python(right)

4. Experimental Results

We conducted experiment by measuring the experienced difficulty of the learners for acquiring software education. Initially, the learners are divided into three groups. Each group was trained with 1-2-3 step, 2-3 step, and 3 step, respectively, and identical education time was provided. The experienced difficulty was finally measured through the questionnaire for implementing the robot control using multiple input and output devices which is the content of last chapter of Text Based Coding System. The following Table 1 summarizes the experienced level of difficulty per each group. And the following Figure 6 show the examples of each steps of software training of the proposed coding system.

Table 1. The Experienced Difficulties Depending on Level(%)

Group	Very Easy	Easy	Normal	Hard	Very Hard
Step 3	0	4	23	23	50
Step 2-3	0	10	50	13	27
Step1-2- 3	0	12	60	18	10

Figure 6. Examples of Software Training with Robot

5. Conclusion

In this study, we proposed a robot-based coding education system with step by step software training as a way to meet the trend of current software education that is effective especially for the lower age group such as kindergarten and elementary school student in consideration of the age of learners of coding is getting decreased. We classified the coding education levels into three steps of unplugged coding, graphic- based coding and text-based coding with consideration for user's level in the proposed coding education system. The proposed coding education system also uses a robot platform which supports three steps of software education. We also verified the feasibility and the effectiveness of the proposed coding education system with step by step software training by showing the experiments results so that it makes the learners are able to follow software education in stages depending on learner's capability through the measuring the difficulties of the learner's entry barrier of software education at each steps.

References

[1] K. Sezer, and H. Uzunboylu. "Importance of Coding Education and Robotic Applications for Achieving 21st-Century Skills in North Cyprus." International Journal of Emerging Technologies in Learning pp.1-12. 2017..
DOI: https://doi.org/10.3991/ijet.v12i01.6097

[2] S. Y. Pi, "A Study on Coding Education of Non-Computer Majors for IT Convergence Education." Journal of Digital Convergence 14.10. pp. 1-8. 2016.
DOI:https://doi.org/10.14400/jdc.2016.14.10.1

[3] C. Kursat, N. Kara, and C. C. Aydin. "Smart toy based learning." Handbook of research on educational communications and technology. Springer, New York, NY, pp. 703-711. 2014.
DOI: https://doi.org/10.1007/978-1-4614-3185-5_56

[4] Gary K. W. Wong, H. Y. Cheung, Edwin C. C. Ching and John M. H. Huen. "School perceptions of coding education in K-12: A large scale quantitative study to inform innovative practices." 2015 IEEE International Conference on Teaching, Assessment, and Learning for Engineering (TALE). IEEE, 2015.
DOI: https://doi.org/10.1109/tale.2015.7386007

[5] J. H. Han, et al. "The educational use of home robots for children." ROMAN 2005. IEEE International Workshop on Robot and Human Interactive Communication, 2005.
DOI: https://doi.org/10.1109/roman.2005.1513808

[6] TSARAVA, Katerina, et al. Training computational thinking: Game-based unplugged and plugged-in activities in primary school. In: European Conference on Games Based Learning. Academic Conferences International Limited, p. 687-695. 2017.

[7] C. Y. Chung and Y. D. Lee, “Dancing Motion and Emotion Control of a Toy Robot”, The Journal of The Institute of Internet, Broadcasting and Communication, Vol. 5, No. 2, pp. 56-62, Nov 2005.
DOI: https://doi.org/10.7236/JIIBC.2005.5.2.56

[8] K. Nuri, C. C. Aydin, and K. Cagiltay. "User study of a new smart toy for children's storytelling." Interactive Learning Environments 22.5. pp. 551-563. 2014.
DOI: https://doi.org/10.1080/10494820.2012.682587

[9] J. Lee and Y. H. Seo, "Design and Development of a Monitoring System based on Smart Device for Service Robot Applications" International Journal of Internet, Broadcasting and Communication Vol.10 No.3 35-41 (2018)
DOI: 10.7236/IJIBC.2018.10.3.35

[10] Y. D. Lee, J. J. Kang, K. Y. Lee, J. Lee and Y. H. Seo, “The Development of an Educational Robot and Scratch-based Programming,” International Journal of Advanced Smart Convergence., Vol. 5, No. 2, pp.8-17, 2016.
DOI: https://doi.org/10.1080/10494820.2012.682587