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Educational Robot for Learning Programming through Blockly based Mobile Application

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***Abstract*— Education is progressing to get ready students for the up-to-date sociotechnical advancements. An expanding attempt to familiarize programming and other science, technology, engineering, and mathematics (STEM)-oriented subjects into the fundamental set of courses of primary and secondary education is emerging globally. Learning through robot has been considered as a powerful teaching instrument in the recent decade. This paper proposes a prototype of an educational robot that can be programmed by a mobile application through Bluetooth communication with drag and drop block-based programming interfaces well-known as Blockly. It will not directly teach any programming language but it will develop a learner's logic developing capability which will work as the backbone of learning any programming language. Hardware development consists of micro-controller, motor, battery, sensors, etc. modules for the execution of the given instructions. The proposed educational robot has the capability to increase the learner's skills of problem-solving, logical thinking, and divergent-thinking. Overall it offers an alternative method of learning which can be called learning through playing.**

Keywords— Educational Robot, Bluetooth, Mobile Apps, Blockly, BLE, STEM.

I. INTRODUCTION

The evolution of robotic technology has been increasingly involved in human lives to make human lives more convenient [1]. For instance, mobile robotics, which is one of the technological fields that witness incredible advancement over the last decades. There are many applications in areas like automatic cleaning, space exploration, military, etc. Besides, mobile robotics has also been involved in education [2]. Moreover, mobile robotics is also an excellent domain suitable for education because it integrates mechanics, electronics, artificial intelligence, automation, computer science, and especially computer programming [3]. With the advancement of modern technology such as wireless communications [4] - [8], internet of thing [9], antenna design [10], remote sensing [11], bio-sensing [12], [13], position tracking, renewable energy[14], [15], reliable power system [16] and radar system, the world is entering in the new era, which is known to technology lovers. As a result, the robot is becoming more popular day by day.

In today's digital world, coding is a fundamental skill alongside math and reading, but too few kids can learn to program because the traditional programming teaching method is tough for them. For programming robots and to outline robotic-oriented courses a behavior-based application has been presented in [17]. Authors in [2] and [3] illustrated the possibilities of initiating educational robotics into the teaching-learning process. In [3], the author refers to the capability of using a modern, cost-effective robot in science, technology, engineering, and mathematics education. The impact of the learning system has been illustrated in [18] by proposing a four-stage experimental procedure.

"Block-based programming" is one of the most encouraging ways of learning programming. Alice [19] or Scratch [20]; well-known instructional gears, deliver graphical atmospheres to develop programs with blocks. Besides, in recent times, for creating their own "block-based" languages, Blockly [21] has set up much attention as an educational tool from developers. All that kind of instructional gears make available attention-grabbing features to learn to code: they overcome syntax-oriented complications related to conventional programming languages, expedite learning as well as coding moreover up-surge satisfaction [22]. These well-known block-based meth-ods are also a nice choice for learning to program utilizing robots. The most famous and recognized programming back-grounds are established on Scratch, for example, Mblock [23] for Makeblock robotic kits [24], or Blockly, as Makecode [25] from Microsoft for the Micro: Bit device [26]. Loosely coupled software architecture based LearnBlock, a new educational programming tool, is proposed in [1].

Blockly is an open-source developer library by Google which provides syntactically perfect code so that it would be easier for the young learners to tinker with their ideas without having to consider the syntactic details of a textual programming language, Blockly provides a quick way to learn to program. Blockly is designed especially for ages 8 to 16 but is used by people of all ages. Not only Blockly can be used for middle school students to control a robot but also for an IT tech to configure a router. This article represents an integration of Blockly based educational mobile robot platform with the BLE wireless network protocol. The goal of this mobile robot as an educational platform is that it should be suitable for inexperienced users and anyone can understand and learn to control the robot while playing with it.

II. SYSTEM ARCHITECTURE

The system consists of two major parts, the hardware system, and the software system. As shown in Figure 1 the robot and the software communicate through Bluetooth. The robot can be programmed from the software by a Bluetooth

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enable mobile once there is a successful connection established between the robot and mobile with. This section is going to describe both the hardware and software system.

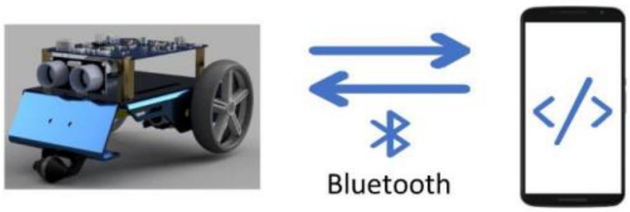

Figure 1. The communication process of conceptual design.

A. The Hardware System:

The Hardware part is divided into several modules which are the motherboard, aluminum chassis, a pair of DC gear motor, wheels, a caster wheel, a battery case with battery, and some nuts and bolts. In addition, there are two extra modules one of them is an ultrasound module for distance measurements and another one is an infrared sensor module for color detection. In Figure 2 all the hardware parts have been shown.

Figure 2. Photograph of the prototype robot components.

The motherboard, which is the core of the system uses an atmega328p 8-bit microcontroller. The microcontroller connected with an HM-10 BLE wireless networking module [27], which is used for receiving and transmitting commands to the mobile. The Bluetooth module is a Bluetooth 4.1 supported device. The whole circuit runs on 5v dc power supplied by the batteries. For the power input, a jst-ph 02 connector is used in the PCB. Although the power connector is a right angle connector, there is a reverse polarity protection circuit for extra security by using the PMV65XPVL MOSFET. The motherboard has a smart dc to dc step up power converter to boost the input power up to 5V and to provide stable power to the circuit. For the power converter, TPS61200DRCT IC from Texas Instruments has been used, which can supply 5V 600 mA constant power output. A piezoelectric buzzer is used to generate 8-bit mono sounds. In addition, two addressable RGB LEDs have been used to show different light combinations. Moreover, there is a lights sensor that can measure light in its surroundings and give analog values according to the light intensity. To drive the motor, TB6612FNG, a dual motor driver IC from Toshiba has been used. This driver can run the motor individually with PWM options. There is two jst-ph 04 right angle connector present in the motherboard, which is for connecting the Infrared and Ultrasonic sensor module. Figure 3 illustrates the 3D rendered PCB diagram.

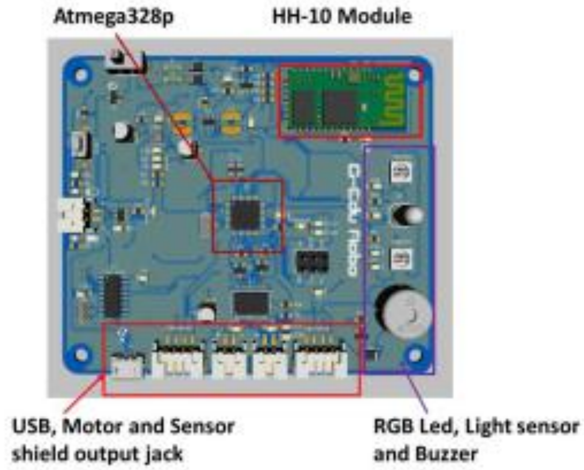

Figure 3. Software simulation of motherboard PCB design.

When the board has powered up it initializes the Bluetooth, ADC, and other modules. After that, it waits for pairing to a mobile device. If the robot is paired successfully then it waits for incoming data. After receiving data, it is decoded, and the instruction is executed. The whole working process of the hardware is shown in Figure 4. It contains ch340g USB to TTL Serial communication IC which uses a micro USB to communicate from the PC to the robot in order to program the bootloader and firmware. The PCB of the motherboard is 1.8 mm double layers PCB.

Each sensor module has separate PCB holding sensors, indicator LED, and connecting port. When a module is snapped to the motherboard, the module will become active. The ultrasonic module is embedded with an HC-SR04 for distance detection. The Line follower module contains two RPR-220 sensors, one Op-Amp, some resistors, and led. The microcontroller then reads the value from its sensor and wraps it as a packet waiting for transferring to the Mobile. Each packet contains an integer value of the module. The modules are defined in such a way that each module has a specific connecting port. The microcontroller can recognize which kind of module is being connected. Both the modules have the same sockets for connecting with the motherboard and for this jst-ph 04 right angle connector has been used. The advantage of this connector is that it will only snap to the connection if it is placed correctly.

The body has made from an aluminum sheet, cutting it with a CNC machine and bend it to the desired shape. The robot has three wheels. Two wheels are steerable, connected, and driven by two DC gear motor to provide speed and distance information for all possible types of movement. The last wheel is lashed and is a passive wheel. The circuits are connected to the board by four copper spacer and screw for connecting with other modules.

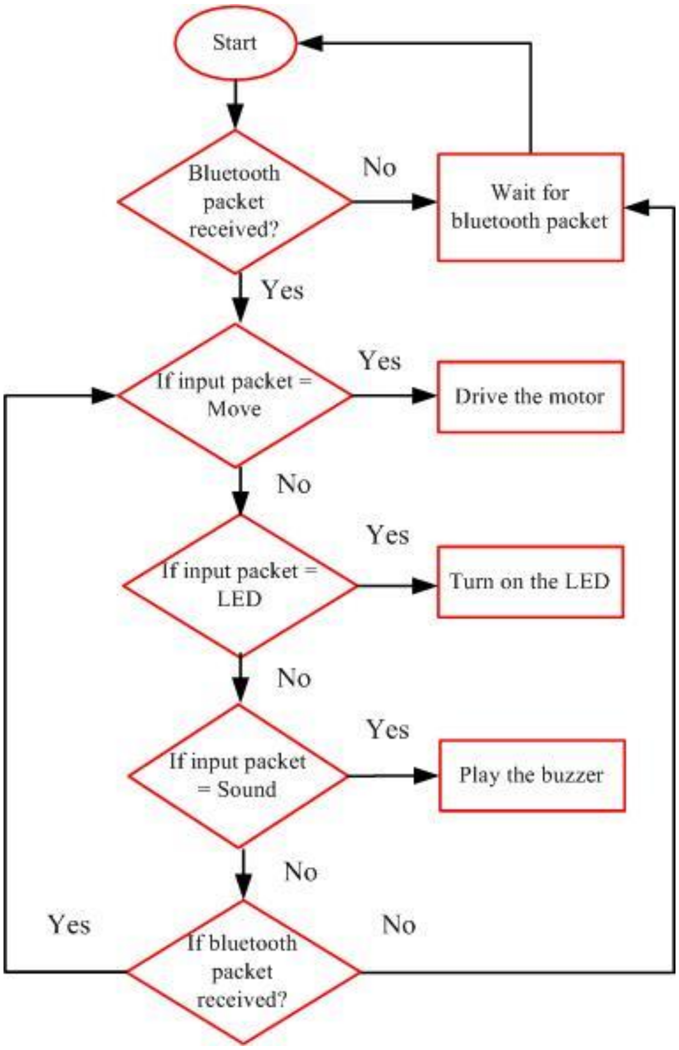

Figure 4. Flow chart of the robot framework process.

B. The Software System:

The software is assembled on Apache Cordova [28], [29] which is a cross-platform mobile application development framework. Cordova allows the user to develop mobile applications only using CSS3, HTML5, and JavaScript code. JavaScript is used for application logic and events where CSS3 for design and HTML to hold the whole structure. Figure 5 illustrates the typical structure of a Cordova Hybrid application.

However, Cordova is a WebView of HTML and CSS so to access the internal hardware of the device 3rd party plugins are required. Cordova plugins are one of the most important parts of this application. They allowed native resources similar to camera, contacts, accelerometer, Bluetooth, geolocation, etc. Webview is a native container to run the application. Native container allowed the application to execute on different mobile platforms. Thus, we used the Bluetooth Low Energy (BLE) Central plugin for Apache Cordova. These plugins act as a middleware to communicate with the application and mobile Bluetooth.

The User Interface is developed using a library called Onsen UI. This is a very popular framework to design and develop a single-page Web Application within Cordova. In order to implement visual programming into the application user interface, it integrates the Google Blockly JavaScript library. Inspired by MIT Scratch, Google developed this awesome JavaScript library called Blockly. Blockly is a visual editor that enables the user to dram and drop the blocks to generate programming code.

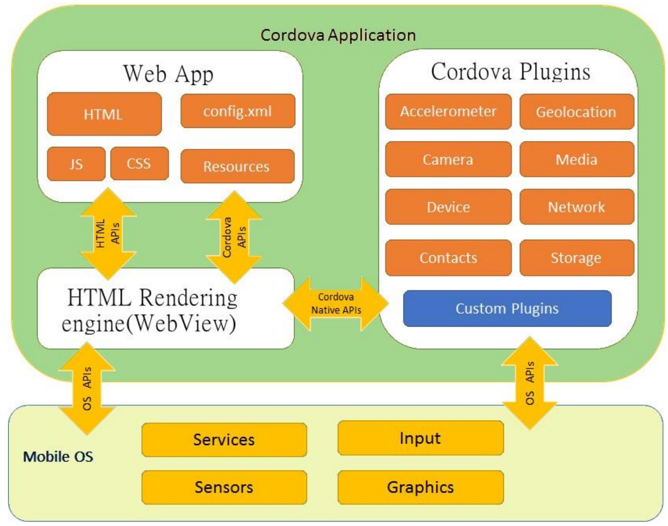

Figure 5. Hybrid applications architecture and usage of Apache Cordova tools: Application life cycle, regarding the cycle of its execution and usage.

As the robot is running on a custom framework, there is needed to make some changes to the default Blockly library. For example, there is no such code like 'drive Forward at speed fast for 1 second'. To make this kind of command understandable to the programming environment, few new instructions are added to the original library. For every instruction, the code generates a command and sends it to the robot through Bluetooth and the robot follows that instruction. Besides these customs blocks, there are basic programming elements such as variables, loop, basic mathematics, and conditional instructions.

To make the experience more exciting for children, this application offers two modes. One is Learning mode another one is Code mode which is showing in Figure 6.

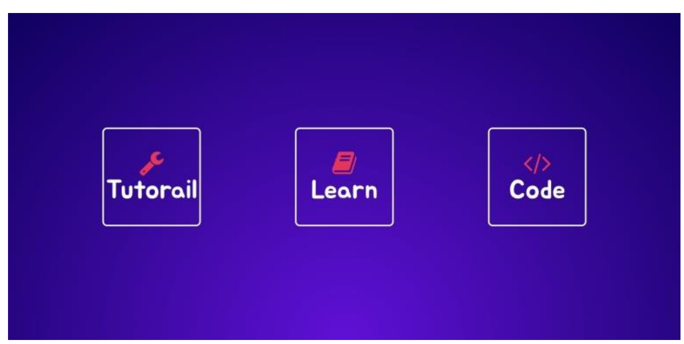

Figure 6. Home page of the application.

In Learning, there are six subdivisions that escalate from difficulty easy to hard. In every mode, the application gives tasks with instructions showing in Figure 7. If the user successfully completes the task it goes to the next task and after completing all the task it unlocks the next Learning mode. The coding mode is out of the box programming environment where a user can program their robot by their own will.

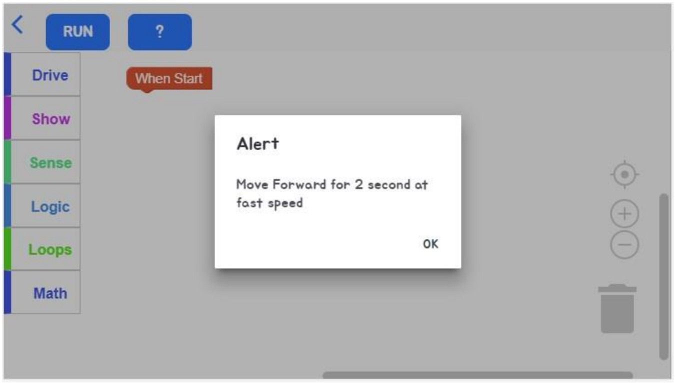

Figure 7. Inside the Learn segment.

III. RESULTS AND DISCUSSION

This section describes the prototype of the educational robot and some preliminary results from a small-scale user study. However, most of the results are qualitative from user experiences.

Seven children from ages 12 to 14 were taken part in the testing of this robot. Everyone successfully able to connect the robot to the mobile software and navigate through the menu without any problem.

Figure 7 is the first task from the basic learning part and everyone successfully completed the task. It is noted that those who completed tasks were not familiar with the traditional text-based programming. In contrast with the embedded programming language, visual programming provides a very easy way to understand the basics of programming.

For example, Figure 8 demonstrates the robot that has the abilities to play sound node using a piezo buzzer, Figure 9 shows that the robot can show a different color on its RGB led in a different interval. This visual output makes the user experience more fun.

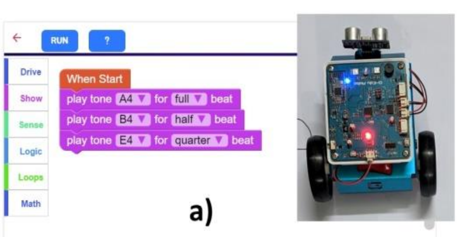

Fig. 8. Multiple functions of the prototype robot in part 3 stack of program block attached.

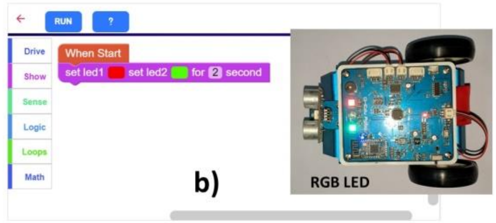

Figure 9. Multiple functions of the prototype robot in the part of lighting up both LED in red and green color at the same time.

Moreover, the robot can go forward, backward, left, and right at any given time in seconds. In another example, as shown in Figure 10, we drive the robot from point A to point B in about 1 second. Then the robot stops there. We run this program multiple times to determine the robot movement accuracy.

Figure 10. The robot is moving from point A to B.

Figure 11 shows a typical conditional statement and based on the condition we have assigned some tasks. Only using a few blocks a very complex condition can be developed.

Figure 11. Conditional Program.

Though this is exactly not a programming language or the user is not learning any programming language. However, it will help them to develop their understanding of programming logic. It is noticeable that in every programming language the logic remains the same. Besides, this article aims to explore the user's formation of logic, cause-and-effect, feedback, critical thinking, creativity, communication, and collaboration. We expect that Blockly will ease any beginner programmers to make a simple transition from a visual programming prospect to a general-purpose programming language.

IV. Conclusion

The main aim of this work to develop an educational robot based on the Google Blockly library system, which enables the learners to modify the program using the block module of the mobile application. This machine-based learning system has been established using the Bluetooth low energy wireless network technology. Moreover, it is a low power consumption device and can operate easily without knowing any programming language. After the detailed experiment, it is observed that the proposed robot is working satisfactorily and has the capability to increase the learner's skill. This new way of learning will makes the learner's creative and technology lover. In future work, we will update the robot by incorporating artificial intelligence, which will make the robot multifunctioning.

Conflicts of Interest: The authors declare no conflicts of interest.

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