EduBot: An Educational Robot for Underprivileged Children

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***Abstract*--Block based programming is getting increasingly popular in a lot of countries. In this paper we have described a block based self-compiling education robot that uses Blockly to perform programming operations. The system provides a simple affordable platform to practice and learn programming and other STEM modules to enhance competency, efficiency and develop interest of students. STEM education is an interdisciplinary teaching concept that integrates the Arts with the traditional STEM subjects: Science, Technology, Engineering, and Mathematics. It emphasizes practice-based learning instead of, as traditional education does, theoretical knowledge. We have discussed the principles, hardware and other necessary modules incorporated to our system in this paper.**

Keywords--STEM education, Blockly, Block programming, Integrated hardware.

I. Introduction

Programming presents many challenges to the novice learners, with issues arising due to the radical novelty of concepts and material [1], as well as from difficulty in understanding the syntax of a language or algorithm which demotivate learners [2]. Often these issues result in a confusion between how programs actually work and how learners think they work [3][4][5]. Due to this, lots of people find it complex and lose interest to learn. In order to learn or practice programming, one must need a computational device. However, in most of the third world countries, very less amount of people has the ability to afford a computer. On the other hand, smartphones are available all over the world and even rural people are widely using it in recent days. We have noted this point and have used this as a motivation for proposing a solution for the students, or anybody, who wants to learn programming using the smartphone that a household has.

The solution that is proposed by this paper is a robotic tool which will help to learn programming, robotics, mathematics, science (STEM education). It encourages students to participate in projects that are related to their daily lives, or part of their own interests. By finding ways to solve problems on their own, students gain comprehensive skills over a range of subjects. Several sensors, such as humidity sensor, Gas sensor, Distance Sensor (Sonar), Temperature Sensor, Color Sensor, IR Sensor and Line Follower Sensor are integrated with the bot. All of the processing unit, sensors and other electrical parts are integrated in a mechanical structure and motors. This compact module will smoothen out the learning process. Especially for Bangladeshi students, language can be changed as 'Bengali' or 'English'. The application can be localized in any language such as Bengali, Hindi and many more. Block programming is introduced so that novice learners gain the basic knowledge of programming and develop situational interest [6] and find it enjoyable [7]. Basic programming concepts such as loop conditions, if-else condition, and simple programming problems are given as blocks. One can select any block and run it to see the result. Codes can be modified, and built-in libraries can be accessed according to given command. Compilation of codes will be completed through the application.

II. Related Work

Modern technologies in general, and specifically robotics, make different kinds of learning opportunities possible, including many opportunities for creativity, learning, and cognitive development. Educational robotic kits are a new generation of learning approach that helps children and learners of any age develop a stronger understanding of science, technological and mathematical concepts such as number, size, and shape in much the same way that traditional materials like pattern blocks, beads, and balls do [8].

We have placed our work based on other block-based programming operational robotics tools. It can be said that block-based programming is a recent addition to the long line of programming languages and environments designed

explicitly for the beginners [9][10][11]. The Logo language introduced a number of characteristics that feature prominently in block-based programming environments, notably, the use of egocentric motion commands like move forward or backward and turn right or left, the presence of on-screen avatars to carry out those commands (Logo had the turtle, while newer environments have sprites), and language primitives and syntax designed to be accessible to novices [12]. Beyond features of the programming interface, the types of activities supported by block-based tools draw from the constructionist tradition that emphasizes learner-directed construction and exploration and the importance of learners creating public, sharable artifacts, often in the form of artwork, games, and interactive stories [13][14][15].

Besides Logo language environment there are some well known block based programming environment such as 'Scratch' [16], which is a development project for graphical programming blocks and a drag and drop application used for narrative programs or 3D games [17]. Scratch is built over Blockly, and any 3D feature is not required for the proposed solution accumulate the low processing power of budget smart phones. Understanding the necessity of blocks-based programming and how it prepares beginners and self learners for future text-based programming is crucial and it is needed to be identified what features of blocks-based programming learners find salient and how they perceive them appropriate to more conventional programming [15].

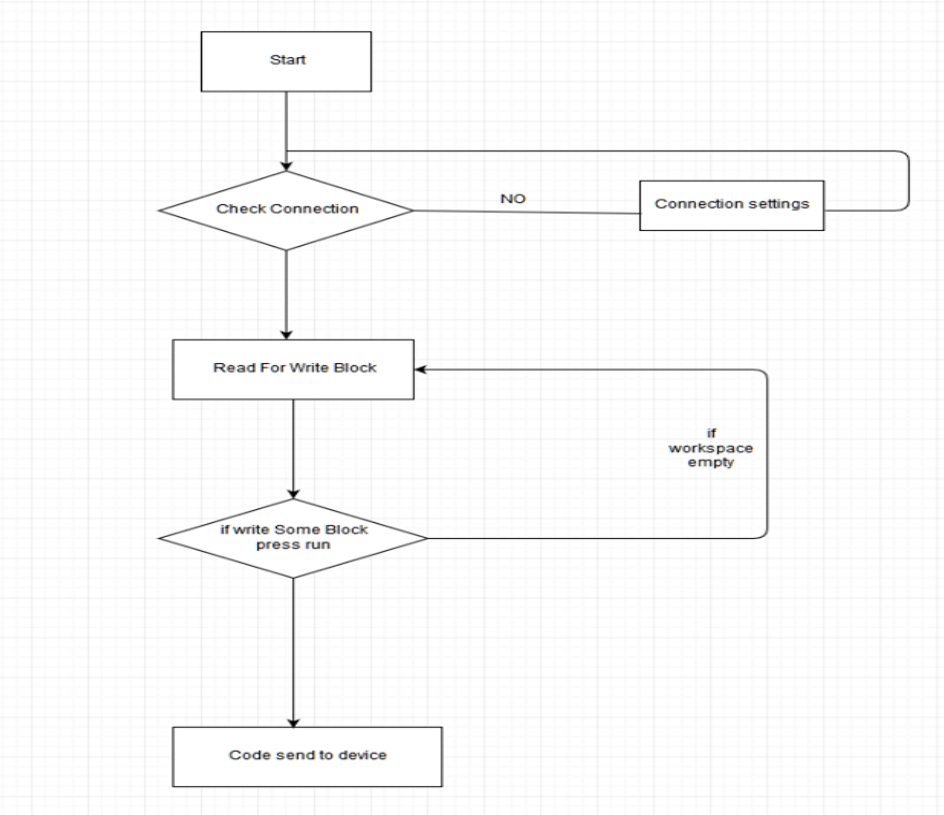

Fig. 1 Flow Diagram of Proposed Method

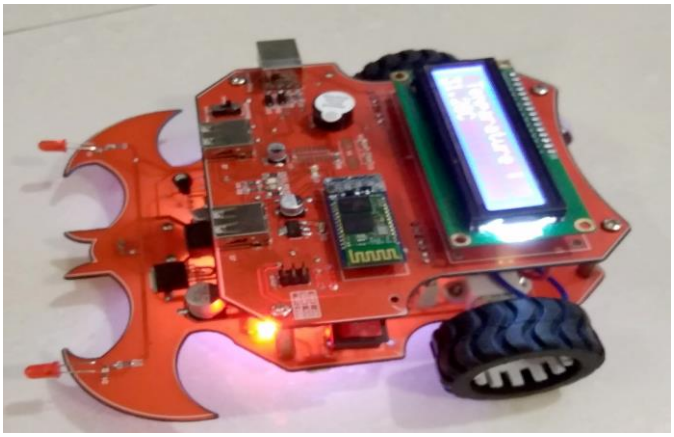

Fig. 2 Figure of Proposed Educational Robot

III. Procedure of Making Educational Bot

A. *Design Considerations*

The proposed design and toolkits are focusing to create a basic robotics kit for people of all age who are interested in learning logic and basic programming knowledge with their smartphone or any other computational device. In order to learn or practice programming, one requires basic computers which people in third world countries do not have access to. Edubot is focused on implementation in the Asia Pacific region, targeting population of a certain age group, who has

access to handheld smartphones or cheap microprocessors, for learning integrated STEM subjects using programming.

The design has been set to being economic. For example, the popular kid's software named Scratch which requires computer and internet connection to create games, stories and animations using simple logic blocks have been used as the reference software. EarSketch [18], similar to Scratch browser based educational programming, is a tool for kids for design solutions virtually but is not designed for real time performance in practical situations. However, our research start from this pain point and we want to support kids and older people to learn logic and programming. Edubot is providing a prominent solution for youths aged 9 years and older to learn - the basic programming process and logic building real time simulation using small integrated sensors in a form of a robotic kit which will enable them to understand sensory data manipulation, linkage to network protocols, for example bluetooth, experimentation of different sensory inputs and controlling the system using their output, basic logic learning using mathematics, learning plugins and basic concepts about electronic tools and so on.

B. Electrical System

The system has been designed to focus on ergonomy and vast economy. The electronics have been embedded innovatively for customization required upon users.

Atmega328p has been used as the processing unit, as it is a single chip microcontroller and proceeds with low power consumption [19]. The Atmel 8-bit AVR RISC-based microcontroller combines 32 KB ISP flash memory with read-while-write capabilities, 1 KB EEPROM, 2 kB SRAM, 23 general purpose I/O lines, 32 general purpose working registers, three flexible timer/counters with compare modes, internal and external interrupts, serial programmable USART, a byte-oriented 2-wire serial interface, SPI serial port, 6-channel 10-bit A/D converter (8-channels in TQFP and QFN/MLF packages), programmable watchdog timer with internal oscillator, and five software selectable power saving modes. The device operates between 1.8-5.5 volts.

L298P has been deployed as motor driver which is from ST is an integrated high voltage and high current Dual Full-Bridge Driver [20]. The device is designed to accept standard TTL logic and drive inductive loads in Relays, Solenoids, DC and Stepper Motors. Two enabled inputs, allow the L298P to be enabled or disabled independently of the input signals. The emitters of the lower transistors of each bridge are connected and the corresponding external terminal can be used to connect an external sensing resistor. In addition, a supply input is provided so that the logic works at a lower voltage.

Bluetooth HC05 module has been utilized for communication purposes as its operation is very simple [21]. It is a simple user friendly SPP (Serial Port Protocol) module which is used for wireless connection setup. Serial port Bluetooth module is fully qualified Bluetooth V2.0+EDR (Enhanced Data Rate) 3Mbps Modulation with complete 2.4GHz radio transceiver and baseband.

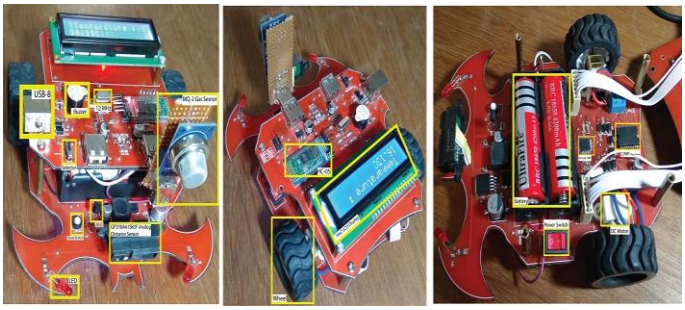

Fig. 3 Figure of Deployed Sensors

It consumes low power while operating and by default it connects with the last connected device when power is on. It also automatically reconnects in 30 minutes if there is a communication break due to connection going out of range.

The PCB is designed from scratch and a number of different types of capacitors and resistors are integrated into the main board. 220-ohm resistors have been used in serial communication port (TX and RX), otherwise the capacitor will slow edge down which is not suitable for signal integrity.

The system has been designed to accommodate multiple sensory inputs. To measure the environment temperature, the LM35 is used here [22]. For instance, LM35 which has a series of precision integrated circuit sensors whose output voltage is linearly proportional to the Celsius temperature. It operates linearly to about +/- 10.0mV/°C scale factor with 0.5°C accuracy. It can operate in remote conditions and the pricing is comparatively low than other sensors available in the market.

For avoiding obstacles and measuring some distance, integrated to its physics, GP2Y0A41SK0F, which is a distance measuring sensor unit, composed of an integrated combination of PSD (position sensitive detector), IR-LED (infrared emitting diode) and signal processing circuit, has been used to serve the purpose of measuring distance [23]. The variety of the reflectivity of the object, the environmental temperature and the operating duration are not influenced easily to the distance detection because of adopting the triangulation method. This device outputs the voltage corresponding to the detection distance using (1) where d is distance in centimeter and VR is Voltage Ratio and its output type is analog. So, this sensor can also be used as a proximity sensor. The maximum range of distance is about 30 cm.

$$d(cm) = \frac{4.8}{VR - 0.02} \qquad (1)$$

The sensor model 3190 is used here, which is a light dependant resistor [24]. Two cadmium sulphide (cds)

photoconductive cells with spectral responses are similar to that of the human eye. The cell resistance falls with increasing light intensity. It is used for light switching.

Sensitive material of MQ-2 gas sensor is SnO_2 with lower conductivity in clean air. When the target combustible gas exists, the sensor's conductivity is higher along with the gas concentration rising. MQ-2 gas sensor has high sensitivity to LPG, Propane and Hydrogen and also could be used to detect Methane and other combustible steam with low cost, suitable for different application [25].

A Liquid crystal display (LCD) is a flat display that uses the light modulating properties of liquid display [26].They are common in consumer devices such as video players, gaming devices, clocks, telephones, computers, calculators etc. A (16x2) LCD panel consists of 16 columns and 2 rows. It can show up to 16 characters in 2 lines. It has been used to show the readings of temperature sensor and gas detector sensor.

C. Power System

The power system of the kit is kept clean and we have used 4200 mAh, 3.7V Li-ion battery [27]. It has no memory affect and can be recharged up to 1000 cycles. It is durable in low and high temperature options and is completely safe and user friendly. We have designed the charging circuit and used charging pot as micro USB type B and user can change using universal micro USB type B charger. The charging circuit is designed using xl6009 voltage regulator to charge the battery. The regulator has been built in N-channel power MOSFET and fixed frequency oscillator, current-mode architecture, resulting in stable operation over a wide range of supply and output voltages.

D. Software Configuration

We are focusing to design and develop a flexible and easy user interface which can be adopted by children. The block programming is the easiest way to learn programming basic and logic. We have used "Blockly" which is an open source library of Google for adding drag and drop block coding to an app [28][29]. This is primarily used for computer science education but can also give users a way to write their own scripts or configuration for an app. Blockly has libraries for Web (JavaScript), Android (Java), and iOS (Swift/Obj-C). We customized the blocks for children and also localized the blocks text and instruction in Bengali and English for now. Also, we are able to localize the app in different native languages. We have multiple block types of various levels. We have designed different levels for a variable range of basics to advanced level programming knowledge. In level 1: All of basic functions are like, send signal to LED, Program to control the motors, etc. After completing script by hitting run button all blocks are converted to code without any internet connection. We are sending those codes via Bluetooth technology which is received by a microcontroller (Arduino) via HC-05 module and run the code inside the microcontroller.

The full application is developed by native android programming. At embedded side, the Arduino programming is used to connect with mobile application using serial communications. The technology behind the research is properly planned and an approach for micro-engineering concept has been used to allow for the integration of science and applications related to micro technology [30].

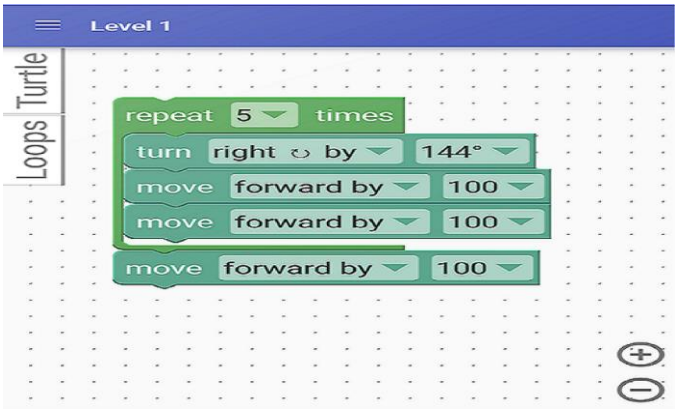

Fig. 4 Interface Blockly of Software in English

Fig. 5 Interface Blockly of Software in Bengali

The unique design of the bot is fully developed and designed by our team using basic embedded system technology. Using our application and Bot one can learn programming concepts, logic and sensor interface step by step. The default user interface of the Blockly editor consists of a toolbox, which holds available blocks, and a workspace, where the user can drag (from the toolbox) and rearrange blocks. The workspace also includes, by default, zoom icons and a trashcan for deleting blocks. Note that the editor can be customized by visual language developers to customize the editing features available, as well as limiting which blocks are available.

IV. CONCLUSION

In this paper, block-based programming operated education robot has been proposed and built with optimum low cost. The hardware equipments are deployed with the opportunity of customization. This paper also focuses on

providing an interactive method which makes programming open and amusing for all. STEM Education will be spread among all special children who will be greatly benefited from this enjoyable learning environment. Collaborating with smartphone technology and microprocessors makes involvement with children more interactive and easier.

V. Future Work

As we have already discussed, our objective is to create a platform by which people can easily learn and practice programming and use it as an educational tool. We intend to add some modifications to our EduBot in the near future. By adding some more features, we plan to upgrade current software system so that customized code by users can be uploaded through smartphones to the Edubot. This future feature will help users much more to learn programming and make the system more challenging, so that users of any age find it more interesting and helpful. Anyone can use this Edubot for their own prototype and test various sensor-based experiments. In future we are planning to design the Edubot to be compatible with multiple software end solutions.

VI. ACKNOWLEDGEMENT

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