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Development of Sensor Training Kit for STEM Education Application (Primary and Secondary School)

Umar Suaimi[1], Amirul Sadun[1]*, Suhaili Sari[1].

[1]Faculty of Engineering Technology,
University Tun Hussein Onn Malaysia Pagoh, 84600, Muar, Johor Malaysia

*Corresponding Author Designation

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Abstract: Recently there has been an increase in providing students with an initial knowledge of the rapidly evolving field of robotics especially in the field of STEM education in primary and secondary. The application of sensors without a good fundamental understanding of the operating structure will definitely make it difficult for students to understand more complex robotic systems. Therefore, a STEM training kit needs to be developed to teach them the basics of different types of sensors is important, especially the use of STEM education. This STEM Sensor Kit will have multiple types of sensors. This project utilizes LabVIEW GUI to train the students basic function of various sensors incorporating Arduino UNO as data acquisition device. Through the analysis, it was concluded that the sensor training system was highly effective in teaching students the fundamentals of sensor technology in a way that is easy to understand.

Keywords: STEM Sensor Kit, Sensor Kit

1. Introduction

In today's world, sophisticated technology can be seen increasingly. Technology is the application of scientific knowledge to the practical goals of human existence, or, as it is sometimes called, the modification and transformation of the human world. The robot is one of the examples of technology. Robots are one of the most advanced technologies of the century. This is because robots can do everything that resembles a human. Today various programs can be seen trying to attract young people to approach the field of robots. One of the programs is called STEM. The robot is one of the fields that can be discovered when the student joins a program STEM. To meet the difficulties of Industry 4.0, the new generation, especially, must grasp STEM subjects. This is done to develop skilled human assets in the realm of technology in the future, which is at the heart of Industry 4.0[1].

There is a need of a method to train related sensory functionality that could be integrated with robotic applications. However, there is still lack of tools in the form of STEM kits that teach children and teenagers about the basics of a sensor especially primary and secondary student. There is a need to

*Corresponding author: amirul@uthm.edu.my

create a basic teaching system training system related to robotics especially sensor systems. The objective of this project is to develop a STEM Sensor Kit that suitable to be used for STEM education in primary and secondary school. Next, to develop an interactive LABVIEW GUI that capable of responding to multiple types of sensors.

This project concentrated on the using Arduino UNO as DAQ to cut the budget in creating the product. The sensor kit must be easy to carry since it uses focus for student. This kit is for primary and secondary student to use, so this project must be easy for student to understand.

1.1 Literature Review

Table 1: Previous Projects Summary

No	Author	Title	Main Feature
1	S.Kamilya, Y.PSingh, Y.VTyagi, Y.Singh and Nidhi Sharma	Design and Implementation of Auto(Light) Intensity Controlling System Using IOT and Without IOT. [2]	1. ESP8266 Node MCU Wi-Fi Devkit as microcontroller 2. LDR 3. IR proximity sensor 4. MQ-7 gas sensor
2	Sagar A. Mahajan and S. D. Markande	Design of Interlligent System For Indoor Lightning. [3]	1. AT-Mega328P as a microcontroller 2. PIR sensor 3. BH1750 light sensor
3	S. A. Bhosale and T. Ankalkote	Modern Street Lighting System with Intensity Control based on Vehicle Movements and Atmospheric Conditions using Zigbee. [4]	1. The 802.15.4 XBee modules provide two friendly modes of communication 2. LM35 temperature sensor 3. LDR sensor 4. PIR sensor
4	L. Koval, J. Vaňuš, and P. Bilík	Distance Measuring by Ultrasonic Sensor. [5]	1. Arduino AtMega 2560 as a microcontroller 2. Ultrasonic sensor 3. Solar panel 4. An alarm IC module to create warning sound
5	P. Sadhukhan	An IoT-based E-parking system for smart cities. [6]	1. Arduino Uno Atmega328 as microcontroller 2. Infra-red sensor 3. Sensor Control Kit
6	A. Saleem, A. Iqbal, A. Sabir, and A. Hussain	Design and Implementation of an Intelligent Dust Cleaner Robot for Uneven and Nonstructural Environment. [7]	1. Arduino Uno as microcontroller 2. Ultrasonic sensor 3. DC motor 4. Relay board 5. Solenoid valves

2. Materials and Methods

It is about the flow to create the STEM Sensor Kit from zero. It is consisting of material, general block diagram, program flowchart and method of testing and analysis.

2.1 Materials

Since the design of this project was made for student. It must be easy to carry. Firstly, the size of the plastic box must be chosen accordingly. Next the position of each component must be appropriate. So that the interactive between the user and sensor can move smoothly.

- Arduino Uno
- Rain Sensor
- IR Sensor
- MQ-135
- LDR Sensor
- FlexiForce Sensor
- Flame Sensor
- Sound Sensor
- IR Analog Sensor
- Inductive Sensor
- Pulse Sensor
- 5V Power Adapter
- Plastic Box

2.2 General Block Diagram

Figure 1 below shows the entire flow of this project. Firstly, for the input of this project there are 10 main inputs. There is rain sensor, IR sensor, MQ-135, LDR sensor module, FlexiForce sensor, flame sensor, sound sensor, IR analogue sensor, inductive sensor and pulse sensor. The function for rain sensor is to detect water. IR sensor in this project is to detect object in front of the sensor. MQ-135 is to check the quality of air. LDR sensor module is to measure the light that was expose to it. FlexiForce sensor is to check the pressure that was applied to provided place. Flame sensor is to detect the presence of fire. Sound sensor is to detect the presence of the sound at surrounding area. While for IR analogue sensor is to measure the of object. An inductive sensor is to detect any metal object. Lastly, the pulse sensor generates IR or red light from the skin to monitor pulse signals.

Next, for the process of this project will use Arduino Uno. Because it is a low-cost, low-power system on a chip microcontroller and can be integrated into advanced projects, the Arduino Uno was chosen as a microcontroller in this design.

Lastly, the output of the project will be displayed in laptop through LabVIEW software. In this project, LabVIEW used as a software that can interact with hardware.

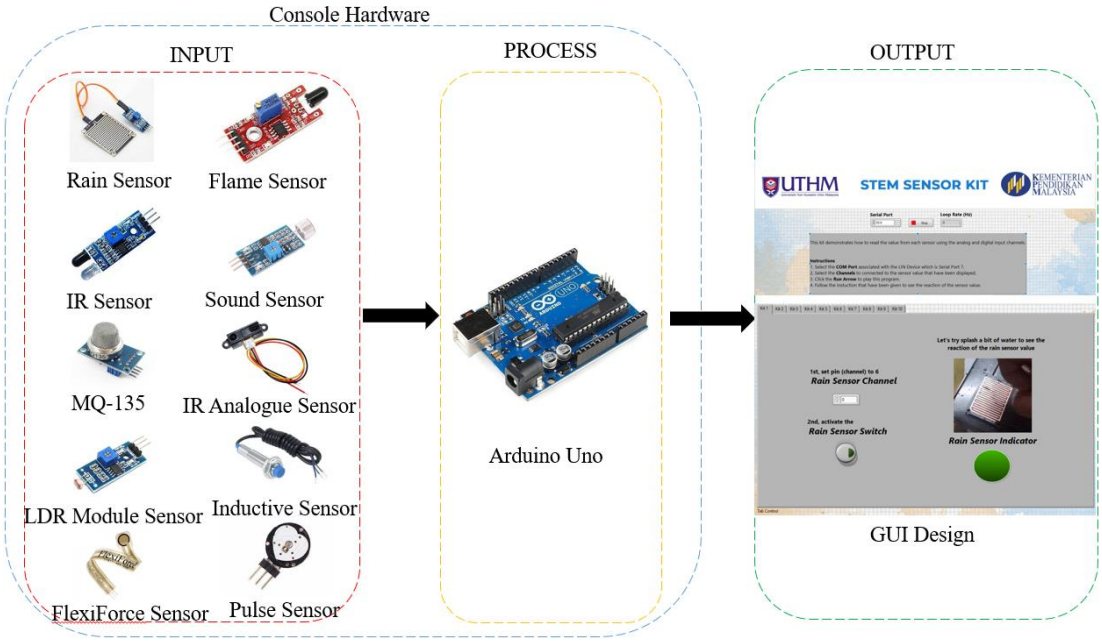


Figure 1: Block Diagram of the Project

2.3 Programming Flowchart

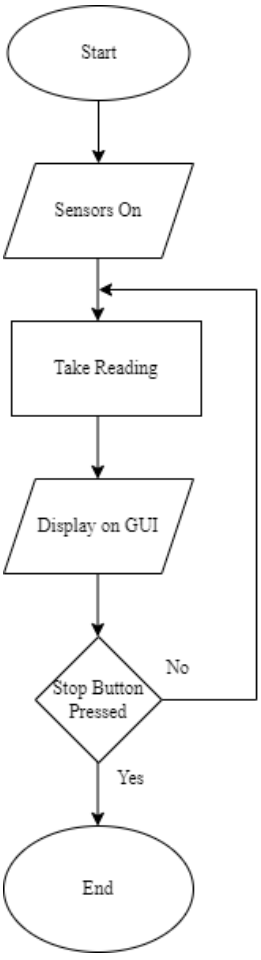


Figure 2: Programming Flowchart

Based on Figure 2, the start phase is when the program run was clicked. Next, at the phase sensors on, it is where all the sensors will activate by turn on the switch. The sensors that will be use such as rain sensor, IR sensor, air quality sensor, LDR sensor, force sensor, flame sensor, sound sensor, IR analog sensor, inductive sensor and pulse sensor. Then, the sensors will take reading. After the process of take reading, the output will be display at GUI that have been ready on the laptop screen. The whole process will be always run until the sensor is turn off or the stop button has been pressed.

2.4 Method of Testing and Analysis

Each type of sensor, there is different way to observe in term of detection and GUI output. Such as digital output, only rain sensor, IR sensor, flame sensor and inductive sensor can be category in digital output. It is when the sensor is activated whether the output 0 or 1 in binary form. Next, for analog output such as air quality sensor, LDR sensor, force sensor, sound sensor, IR analog sensor and pulse sensor. The output of these sensor is based on their designated value, it's meant every sensor in analog category has different value of output.

Figure 3: Sensor Data Analysis

Figure 3 show, each sensor will have its own tab (window). Data will be recorded by DAQ (Arduino) and will be displayed in graphical form (for analog voltage) and light indicator (for digital sensors). Each sensor will be tested, and observations will be made for each response on the GUI.

3. Results and Discussion

This chapter is about the results that have been produced by interacting with the STEM Sensor Kit. The result and observation have been recorded in development in this project.

3.1 Final Product

It is about the actual product which is spend 11 weeks to create with the hardship, research and try and error. It's as much about product design as it is about sensors and switch placement and the creativity to create this product.

Figure 4 below shows, at the front of the product, it is showing every sensor with a label such as rain sensor, IR sensor, air quality sensor LDR sensor, force sensor, flame sensor, sound sensor, IR analogue sensor, inductive sensor and lastly, pulse sensor. Figure 5 below shows, at the top of the product its show the switch, jack connector and USB port for plug in Arduino uno.

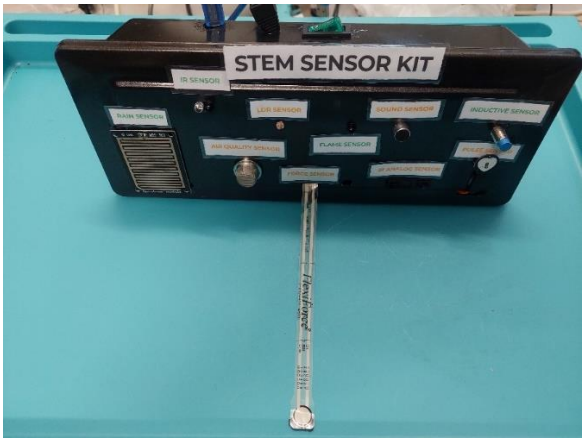


Figure 4: Front of STEM Sensor Kit

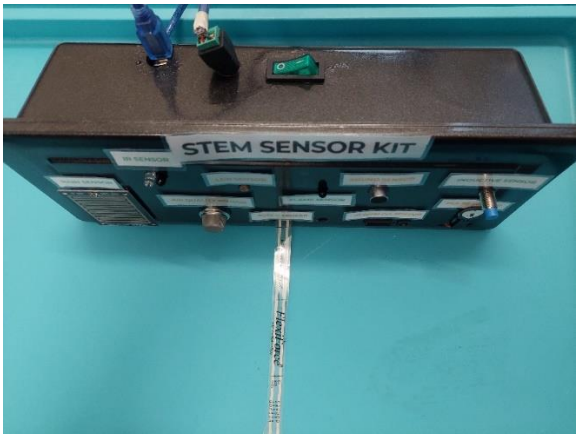
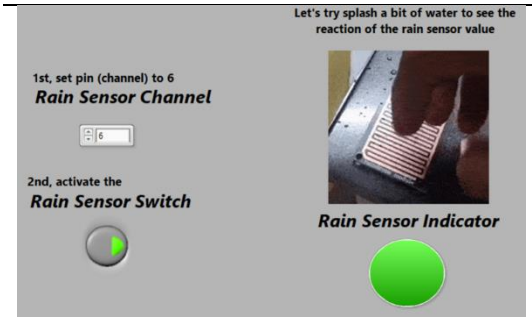
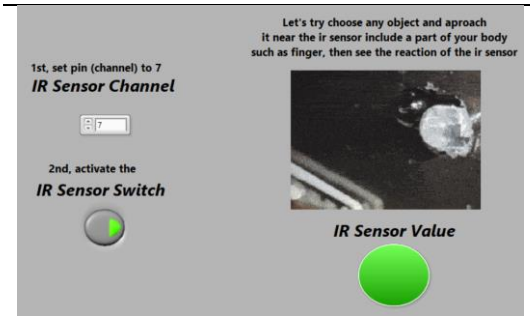
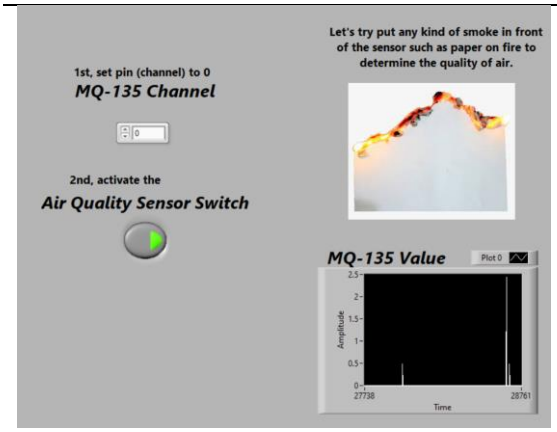
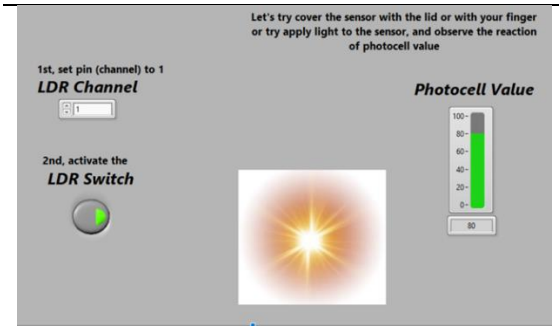


Figure 5: Top of STEM Sensor Kit

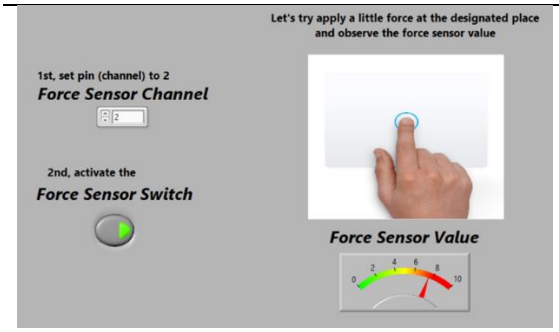
3.2 Product Testing Results and Analysis

Table 2: Product Results and Observations

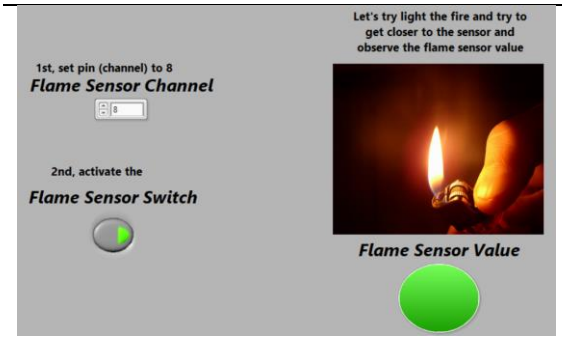
Result	Observation
	Activate the switch to supply the power to rain sensor. Then when rain sensor detects the water, the rain sensor indicator will light up. For this result, by using wet tissue and put on the rain sensor, then the rain sensor indicator will light up.
	Activate the switch to supply the power to IR sensor. Then when IR sensor detects the object, the IR sensor indicator will light up. For this result, by using index finger close to the IR sensor, the IR sensor indicator will light up.
	Activate the switch to supply the power to MQ-135 sensor. Then it will detect the surround quality of air. Unfortunately, because of the lack of power, this sensor cannot operate properly.



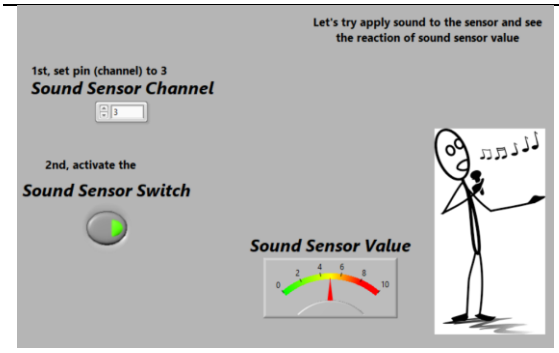
Activate the switch to supply the power to LDR sensor. Then when some object cover the LDR sensor, the photocell value will increase. When the lamp is lit to the LDR sensor, the photocell value will decrease. For this result, the higher photocell value could go is 80% or 90%.



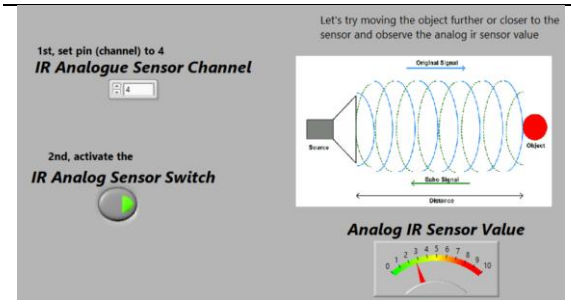
Activate the switch to supply the power to force sensor. Then when put the finger at the provided place and try applying some force at force sensor, the force sensor value will show whether the force that was applied strong or weak. For this result, the higher force sensor value could go is 8. At the red color it's indicate strong, while green color it's indicated weak.



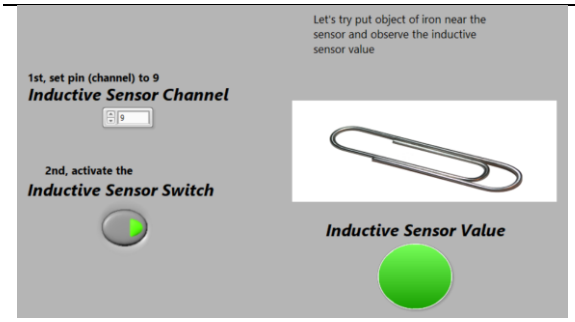
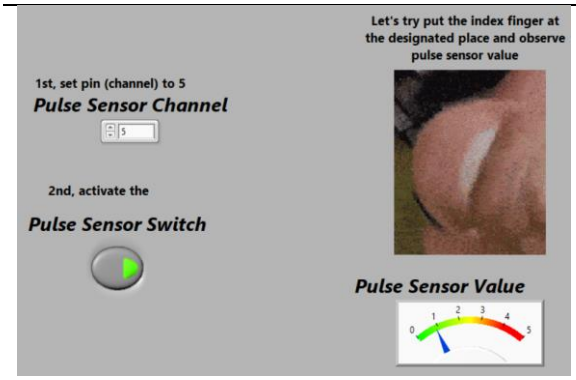
Activate the switch to supply the power to flame sensor. Then when flame sensor detects the flame, the flame sensor indicator will light up. For this result, the lighter will light up then the flame indicator light up.



Activate the switch to supply the power to sound sensor. Then it will detect the surrounding sound. Unfortunately, because of the lack of power, this sensor cannot operate properly.



Activate the switch to supply the power to IR analog sensor. Then when put the object in front of the IR analog sensor, then try moving the object further or closer to the sensor. It will show the distance of between the object and the sensor. The output is between 2 - 4 cm. Sometimes function sometimes not.

	Activate the switch to supply the power to inductive sensor. Then when inductive sensor detects any kind of metal object, the inductive sensor indicator will light up. For this result, by using scissor that have metal part close to the inductive sensor, the inductive sensor indicator will light up.
	Activate the switch to supply the power to pulse sensor. Then it will monitor the change of volume of blood vessel. Unfortunately, because of the lack of power, this sensor cannot operate properly.

3.2 Discussions

The design of the box that have been chosen; the sensors displacement has been decide. The sensor that was produce analog output; the power consume is higher that the sensor that was produce digital output. In theory, the MQ-135 sensor will detect the surrounding air quality for example if it detects dangerous air quality it will show a high value but if the air quality is safe the value will be low. Next, the sound sensor, when it's detected the sound the value will be high. The IR analog sensor will detect the distance between the object and sensor, then the value will be displayed. After putting the index finger at the designated place, the pulse sensor will monitor the change of volume of blood vessel, then the value will be displayed. If there is no finger at the designated place, the value should be zero. The STEM kit can detect water, object, light density, force, flame and any kind of metal object. Overall, the results for the STEM kit shows promising potential to be applied in schools and university by using the STEM Sensor kit.

4. Conclusion

Conclusion, sensor kit system with real time monitoring project have been developed. The objective of this project which is to develop a STEM Sensor Kit that suitable to be used for STEM education in primary and secondary school. have been achieve. With this kit, student understanding of the technology behind sensors will be better. The next achievement was to develop an interactive LABVIEW GUI that capable of responding to multiple types of sensors it was concluded that the sensor training system will highly be effective in teaching students the fundamentals of sensor technology in a way that was easy to understand.

Acknowledgement

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