

IoT-Based Lab System for Teaching Methods in Times of Crisis

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Abstract— The revolution of communication technology has enabled people to communicate easily with others and perform many tasks from a distance. The Internet plays an important role in communication and helps to perform tasks and make people's lives easier. It led to the introduction of the Internet of Things (IoT) technology, where physical objects are connected to the Internet to perform a specific task. So that IoT can be a valuable tool in times of crisis, most modern industries can produce their products automatically and remote monitor and control the system. The same technique can be applied to overcome face-to-face teaching in science and engineering education during times of crisis. This research proposes the design and development of an IoT-based hands-on laboratory system that can be operated remotely. The methodology has been implemented and worked based on the concept of virtual reality. The research has been carried out for two simple electrical laboratory experiments: the basic logic gate and Ohm's Law experiment. The experimental results show that the system can be implemented since the results obtained are satisfy their theoretical results. Furthermore, an improvement can be made so that the system can be integrated with the Internet and the system can function efficiently.

Keywords: *Internet of Things, IR4.0, hands-on laboratory, hardware-based language, Arduino*

1. INTRODUCTION

With the improvement of Internet connection such as Wi-Fi implementation and the enhancement of 5G mobile networks, even common electrical appliances can be linked to the Internet using IoT networks to perform as smart devices [1,2]. The example of IoT applications is the intelligent home system, intelligent health care system, smart traffic light system, smart voice recognition system, and many more. Besides, the IoT applications can also bring benefits in education, targeting specific groups of individuals, such as undergraduate students [3,4]. This technology has the potential to be used in various applications, such as implementing a sustainable IoT-based hands-on lab system for engineering and science teaching methods during a time of crisis. This research is under the UNESCO world Sustainable Development Goal number 4 (SDG-4), quality education [5].

Students and lecturers can use this application during a time of crisis, such as Covid-19. Students can have their hands-on lab sessions without going to the actual lab, and the lecturers can have their lab syllabus covered throughout the semester. This application can be made by using a simple Arduino microcontroller and software, as it is easily available to purchase online and is plentiful in the local market. It is a positive environment in which students can adapt to self-learning. Figure 1 shows a basic concept of how IoT technology can be used to connect and control different devices.

The IoT is a fundamental concept of integrating smart devices as part of a vast system. It also provides the ability to the object to perform a particular task through the Internet connection. The idea of IoT is to improve daily life's quality according to the current trend of modern life. In the end, everything around us would be automated and control by using IoT technology [6]. There are three basic IoT components which are the hardware, middleware, and presentation. The hardware component consists of field sensors and actuators, embedded controllers and communication systems. The middleware is used to perform cloud storage to store data.

On the other hand, the presentation component is an easily accessible tool designed for various types of applications. These components can be further divided into five (5) layers: perception, network, middleware,

application, and business layers [7]. Figure 2 shows the usages of the different layers of the IoT structure.

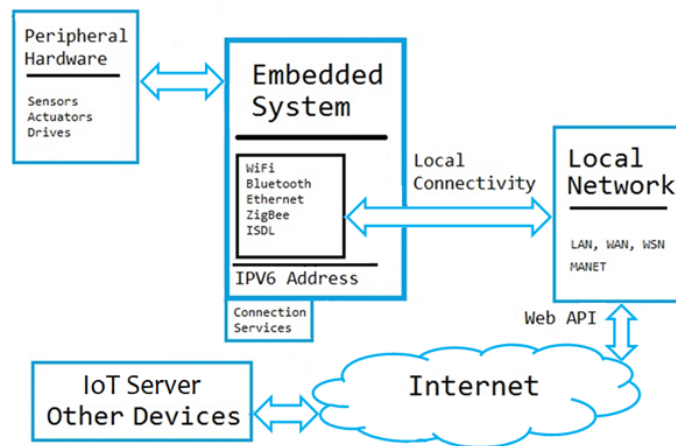


Fig. 1. A basic concept of IoT technology

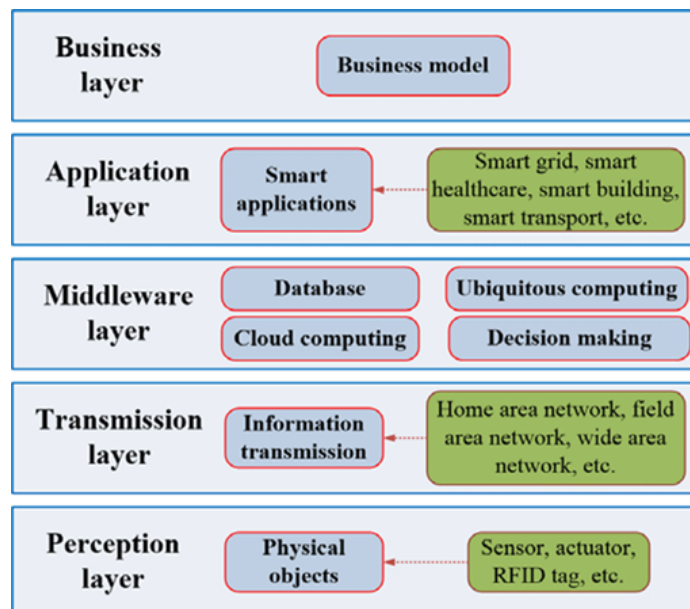


Fig. 2. Usages for different layers of IoT structure

The popularity of IoT has created the implementation of online laboratory systems that can be accessed for educational purposes. Most students need to do some practical work, although they are not physically inside the laboratory besides engineering and science students, to strengthen their understanding of certain theories [8,9]. The term accessible means it can be opened and used with the available gadgets such as PC (personal computers), tablets and smart mobile phones. Some of the developed examples are a low-cost type, which uses readily available hardware and software. An example of the most popular hardware used is the Arduino microcontroller. The Arduino RISC processor is an open-source platform that can be easily available and downloadable online. The Arduino based embedded system also is low-cost compared with the other platform, making it affordable. The working principle of Arduino is that it can send and receive information from various devices, including electronic devices [10]. It consists of hardware, Arduino UNO or Arduino MEGA circuit board and a software program that uses simplified C/C++. The program is transferred to the Arduino hardware using a USB cable from the PC to the hardware. An Arduino can help to obtain information from the input devices such as sensors and potentiometer and send information to the output devices such as LED, speakers, LCD screen, DC motor, and many more.

2. PROPOSED DESIGN

The proposed system includes the communication between the devices used, such as laptops or PC and mobile phones and the Arduino processor connected to the Internet using the ESP8266 Wi-Fi module. There are many ways to use the ESP8266 module for communication. The common ways to use it is to send and receive data online or regularly upload data. In addition, the Wi-Fi module serves as Access Point (AP Mode), providing access to the Wi-Fi network to other devices (stations) and connecting them further to a wired network. In other ways, the ESP8266 module acts as an interpreter between the devices and the Arduino microcontroller.

The ESP8266 module is connected to the nearby Internet or Wi-Fi hotspot to access the Internet and send data to the IoT server and authentication code. The authentication code is then sent to the device with the same authentication code and then, the device receives the data to create a secure connection between the device and the ESP8266 module.

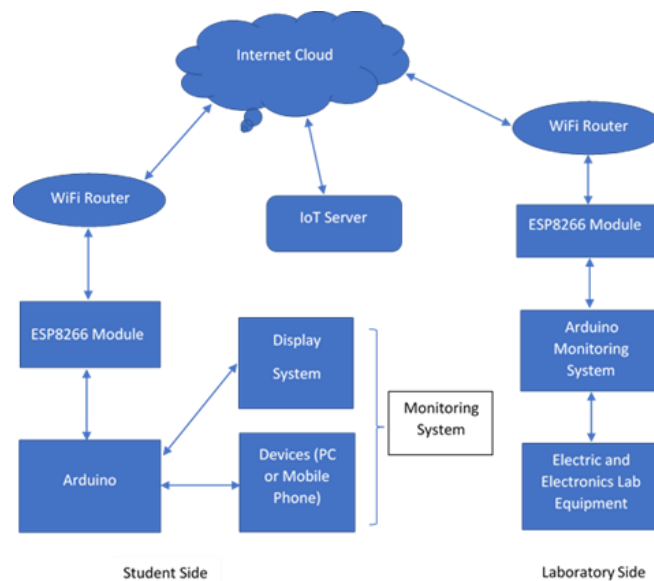


Fig. 3. Total flow diagram of the proposed hands-on laboratory systems

Figure 3 shows the flow mechanism of the hands-on laboratory system. The system is divided into two parts: the user and laboratory parts connected by the IoT server. The user uses their device, which includes the display system as the monitoring system sends the instructions to the laboratory devices—the instruction sends to the Arduino microcontroller connected to the ESP8266 Wi-Fi module. The IoT server sends the instructions to the Arduino monitoring system and then to the electrical and electronics laboratory equipment such as a potentiometer for them to operate. The equipment then sends the data back to the user through the IoT server as the system connection works in two ways.

3. RESULTS

The current work focuses on two simple experiments that are familiar to the electrical and electronics lab work. They are Ohm's law and logic gate simulation, respectively. For the Ohm's Law experiment, a circuit is constructed to investigate the effect of the different resistor values on the rotation angle of the servo motor. This is to show the effect of resistance value on the voltage and current. The types of equipment used are Arduino UNO, USB cable, SG90 Micro Servo Motor and jumper wires. The actual circuit constructed is shown in Figure 4.

A code was developed by using C language and Arduino IDE for the circuit to work. As the potentiometer was adjusted, the rotation of the servo motor was also changed accordingly. A protractor was used to measure the angle of the servo motor. Table 1 shows the rotation angle of the potentiometer and servo motor.

For the logic gate simulation, the simulation is done to demonstrate the mechanism of 3 basic logic gates, which are AND, OR and NOT gates. The simulation is done using the Arduino UNO and its peripherals. The types of equipment used are Arduino UNO, USB cable, 2 tactile switches, 1kΩ and 10kΩ ohm resistors, 3 LEDs and jumper wires. The schematic diagram for the logic gate circuit is shown in Figure 5.

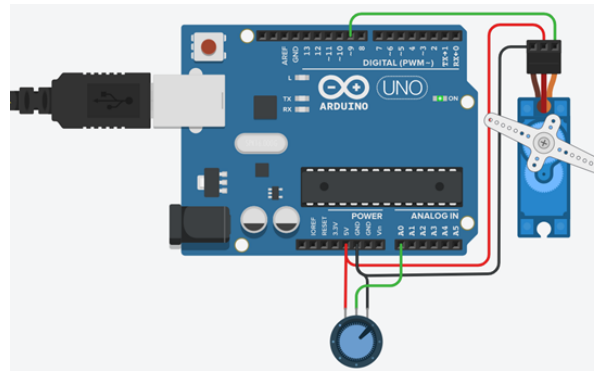


Fig. 4. Construction of actual circuit for Ohm's law experiment

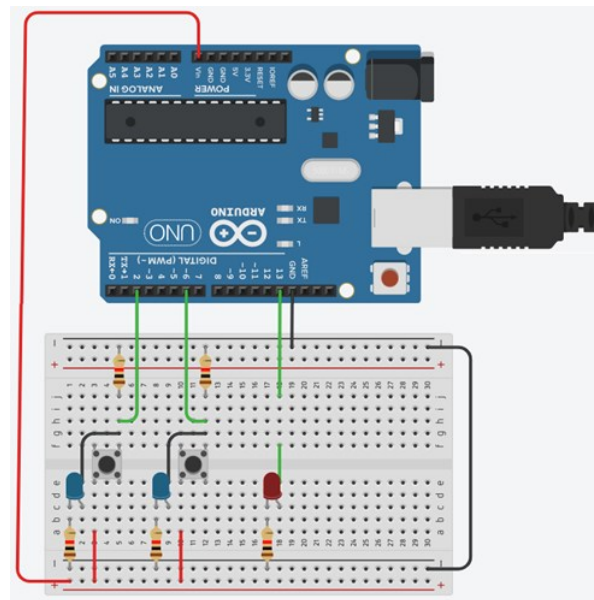


Fig. 5. Construction of actual circuit for logic gate experiment

Table 1: Rotation angle of potentiometer and servo motor

<i>Angle in Degrees</i>			
<i>Potentiometer</i>	<i>Servo Motor</i>	<i>Potentiometer</i>	<i>Servo Motor</i>
0	0	0	0
30	30	-30	-30
60	60	-60	-60
90	90	-90	-90
120	120	-120	-120
150	150	-150	-150
180	180	-180	-180

The circuit consists of 2 tactile push switches as the input, which are named switch SA and SB, respectively. Two LEDs are used as the input indicator, which is a green colour for switches A and B, respectively. A red LED is used as the output, which is named Z. For the circuit to work, a code was developed by using C language and Arduino IDE. When the LED is turned on, it is noted by the binary number '1' and when the LED is off, it is noted by the binary number '0'. The output LED will turn on based on the operation of different logic gates: AND, OR, NAND and NOR gates. The results for each logic gate are shown in Table 2 to Table 4.

Table 2: Results for AND gate

<i>Logic Input</i>		<i>Logic Output Z</i>	
<i>SA</i>	<i>SB</i>	<i>Theoretical</i>	<i>Experimental</i>
0	0	0	0
0	1	0	0
1	0	0	0
1	1	1	1

Table 3: Results for NOT gate

<i>Logic Input</i>	<i>Logic Output Z</i>	
<i>SA</i>	<i>Theoretical</i>	<i>Experimental</i>
0	1	
1	0	

Table 4: Results for OR gate

<i>Logic Input</i>		<i>Logic Output Z</i>	
<i>SA</i>	<i>SB</i>	<i>Theoretical</i>	<i>Experimental</i>
0	0	0	0
0	1	1	1
1	0	1	1
1	1	1	1

In Ohm's law, it is shown that the value of resistance can be changed from a far distance and thus can change the value of voltage and the current of the circuit. In the logic circuit simulation, the input LED A and B determines whether the output LED, Z turns on when the switch button turns on. The output Z turns on or off according to the truth table of the basic logic gates, which are AND, OR and NOT gates. These circuits are the basic circuit and would be expanded to perform complex tasks that are beneficial for the students for their lab activities. This is an important element for this research that enables students to perform their lab activities from a far distance. An improvement can be done so that the system can be integrated with the Internet and the system can function efficiently.

4. CONCLUSION

In conclusion, a system that enables students to perform their lab activities from a far distance can be developed by using the Arduino UNO microprocessor and its peripherals. Until now, the system development is focused on two simple lab experiments that are commonly practised by students, which are Ohm's law and the basic logic gate circuit experiments, respectively. The preliminary results were obtained satisfactory then still some improvements can be made for the system to improve the function efficiently. The Internet is the essential part of this research so that it can be used from a far distance.

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