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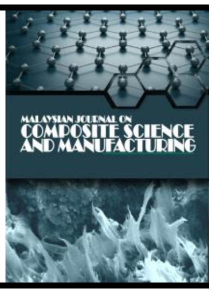

Design of an Internet of Things Based Electromagnetic Robotic Arm for Pick and Place Applications

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ABSTRACT

In this generation, industrial robotic arm has been widely used in fields separated from the human society. It is limited because it is not possible to manipulate and interact with people. To depict robotics technology with human-machine interaction and wireless communication, interactivity is possible in real time with virtual objects that makes some other technology needs to be developed which maximizes robot use to assist people with their work in an efficient way. The main objective of this project is to develop and design an interface of Internet of Things controller for robotic arm. The main purpose of making this interface is to remotely control the robotic arm using internet facilities. The robotic arm has four servo motor where all servo motor are assigned with single pulse width modulation which can be control separately. Furthermore, the NodeMCU board was used to receive signal from the Blynk app that authorizes monitoring and controlling the movement of the robotic arm to perform pick and place operations. Meanwhile, the results of this study are verified through manual test implementation. Two type of manual test were done for this project that is pick and place application and time delay to send the data. The pick and place operation of the robotic arm was observed to see whether the robotic arm capable to conduct the instruction precisely to move within their desired angular displacement degree. The time delay to send the data shows that the respond at each of the servo motor to move 180 degrees with no load was influenced by the Wi-Fi signal strength at particular places. Hence, this prototype of the robotic arm showed that the operational to control the robotic arm to perform pick and place application using internet facilities was successful.

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1. Introduction

The revolution of the Internet has brought robots together to our everyday life as its number has increase rapidly. The Internet of Things (IoT) has given benefits to our mankind by taking over the massive sources to itself. Besides that, IoT is an interconnection between many devices to themselves. The IoT let an object to be controlled or sensed across the infrastructure of a network where data exchange happens. Therefore, this will increase the efficiency and the productivity to the user. It is known that the IoT has its unique identifiable in an implant of computer system where it is able to practically communicate in the boundary of the internet infrastructure. The combination of robots and IoT will bring a big impact in the implementation of the new technological implication [1-2]. In the manufacturing industry, industrial robot has been changing crucially over the past few years. The evolution towards industry 4.0 and future digital factories has brought industrial companies with brand new challenges. Moreover, there is a need for intelligent, digitally network systems that will enable sustainable and self-managing production process possible and improve both efficiency and quality [3]. On the other hand, the Industrial Revolution 4.0 is autonomous production powered by robots that focus on safety that needed no isolation of working area as its integration into human workspaces have become more economical and productive [4-5].

The scope of this project is to design the robot arm with 4 degree of freedom for pick and place application, develop the interface for the controller of robot arm by using Blynk app and Arduino integrated development environment that is written in programming language Java. Basically, this robot arm has 4 degree of freedom which means it has 4 rotational joints contained within the designation of the robot. Its motion at the base is limited to a circular path only and four discrete axes motion compatible with the task given. Other factor to look out is the payload by considering the design of the arm, how much it can lift and the type of the motor at the arm. The material that being used in the making of the robot arm body is acrylic due to its lightweight and high strength of material [6].

In this project, an interface of IoT platform was used to design a controller for an electromagnetic robotic arm. There will be four servo motor at each rotational joints depending on the design of pulse width modulation (PWM). The Arduino integrated development environment was used to program four of the servo motor for controlling the angle of rotation for pick and place applications. Besides, the PWM output was used to drive the servo motor and each servo are designed to perform specific task with specifying pulse [7]. Furthermore, IoT cloud are accessible through the internet whereas the robot arm can be controlled from any places. In the other words, the user can control the rotation of servo motor on an app. Users can easily access the app by using their smartphone as long as their devices are connected to the internet via Wi-Fi [8].

2. Methodology

2.1 Circuit Diagram

Fritzing software was used to develop the design of the electronics wiring diagram. It is the stage for prototyping process before moving to the permanent circuit. To build a circuit, either a breadboard or a PCB (printed circuit board), then Fritzing is a great choice for a tool that can link a schematic to a physical layout. It can handle both simple PCB layouts and breadboard layouts. The electronic parts used is shown in Figure 1.

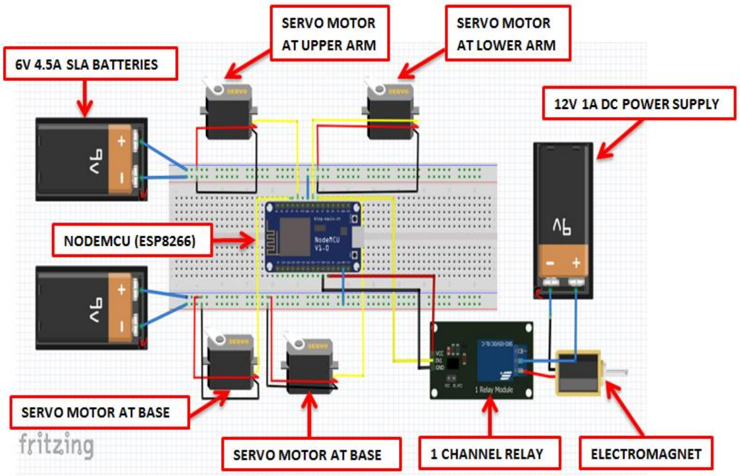


Fig. 1. Fritzing wiring diagram

As shown in Figure 1, there are three power supply in which two are of the same specification and one more is from the 12V 1A direct current power supply. The two Seal Lead Acid (SLA) 6V 4.5Ah batteries are used to supply separate current to two servos, which means one battery for two servos. As for the servos, there are two types of servo used to actuate rotational movement at each joint. The reason of using two different type of servos is because for each rotational joint there is different load and require maximum torque to withstand the load. The servo that was used at the base, lower and upper arm was the high torque metal gear dual ball bearing servo, weighing at 55g and have the stall torque of 9.4 kgf.cm (4.8 V) and 11 kgf.cm (6 V). It has a stall current of 2.5 A (6 V), stable and shock-proof double ball bearing design.

Meanwhile at the wrist, SG90 was used because it has stall torque of 1.8kg.cm (4.8 V) which was lower than the servo used at base, lower and upper arm but its gear are made of Polyoxymethylene (POM) that provide high stiffness, low friction, and excellent dimensional stability. Besides that, one channel relay was used to control the electromagnet from magnetized and demagnetized during the pick and place application. The electromagnet uses 12V 1A dc power supply to operate while the relay was using 3V from the microcontroller NodeMCU (ESP8266).

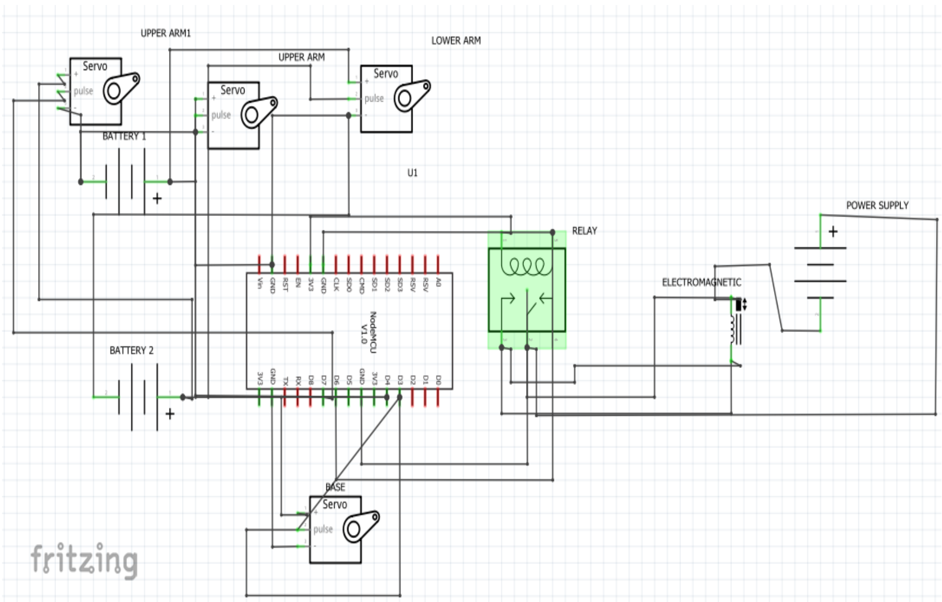


Fig. 2. Schematic diagram

The point when making a schematic for the reason of building a circuit was that these devices need to represent each pin on the device. There are unconnected pins (in red) in the Fritzing screenshot shown in Figure 2 because Fritzing should get on a breadboard (or PCB). Each of physical pins would include in the symbols even though some of the pins are not connected. Like most physical layout tools, Fritzing synchronizes the schematic devices and connections with the layout view.

2.2 Blynk IoT Platform

Blynk is an app builder that allows users to create intuitive interfaces for their work by using different widgets. It can be used on Android and IOS platforms. Blynk server is the head of all communications between the Blynk app and hardware on mobile device. Blynk Library enables the hardware to communicate and process all incoming and outgoing commands with the server. The Blynk Cloud can be use or the private server can be run locally. Blynk Server is a remote server that Blynk has installed and run. Each user has free access to it. This is a Local Blynk Server, which can be installed on machine in the open source software. It is written on Java, so it can be run anywhere Java works [9-10].

2.2.1 Virtual pins

Virtual Pin is a concept for data exchange between hardware and mobile application Blynk. The digital and analog input/ output (I/O) pins are different in virtual pins. They are the physical pins that connect sensors and actuators to the micro-controller board. Think of Virtual Pins as a box and anyone with access to this box can see this value. The display and sending of data from hardware to the Blynk app is a powerful feature. Remember, there are no physical properties for virtual pins [11].

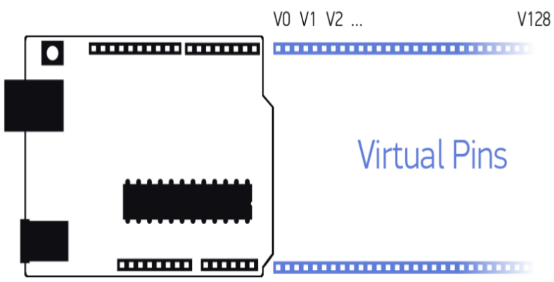


Fig. 3. Schematic diagram

To send data from hardware to Blynk, the GPIO Pinout that was used need to be determine before the widget in the Blynk can be setup. In this case, a slider and button are used to control servo and the electromagnet. Each of the slider and button have different virtual pins that are linked to the GPIO.

2.2.2 Arduino IDE

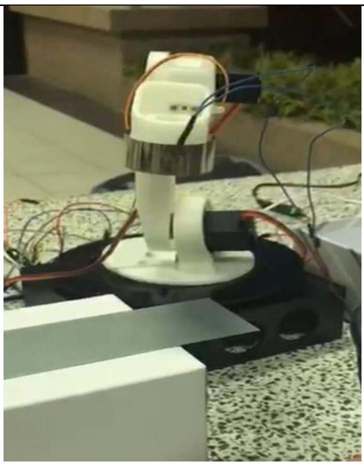
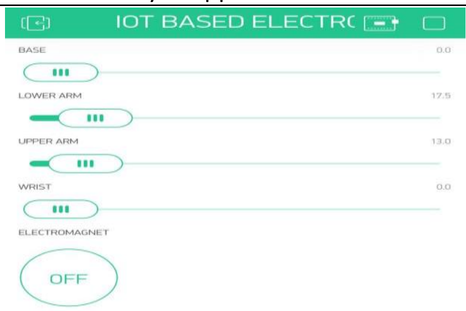
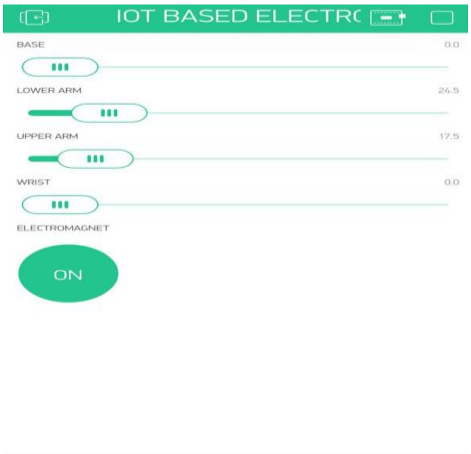
The main editing program for Arduino is the Arduino Integrated Development Environment (IDE). This is where the code is entered before uploading it to the programming board. Code of Arduino is known as sketches. In addition to special methods and functions, Arduino code is written in C++ which will be mentioned hereafter. The programming language C++ is human-readable. The machine language will be processed and compiled when a "sketch" (Arduino code file) is created. In order to control the Arduino using Blynk, the Blynk library should be installed and kept inside the Arduino sketchbook folder [12].

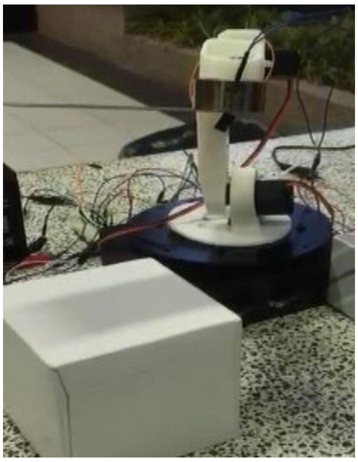
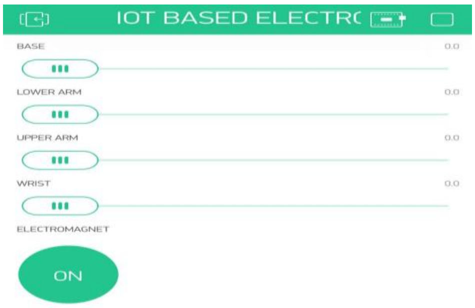
3. Results

3.1 Pick and Place Application

Thus, implementation of pick and place robot is done by using Blynk app. The pick and place operation can be performed by the user only by clicking at the slider button available on the Blynk app. The robotic arm will then perform the pick and place of an object. As can be observed in Table 1, the robotic arm has successfully conducted the instruction precisely to move within their desired angular displacement degree [13-14].

Table 1
Movement of the robotic arm

Movement	Blynk app interface	Description
		At the initial position, the servo motor at lower and upper arm was moved to the 17.5 and 13.0 degree angle.
		The robot arm was moved towards the object by sliding the slider widget at lower arm 24.5 degree and upper arm 17.5 degree angle. The electromagnet was then switch on to magnetized the electromagnet to pick up the metal sheet.

<table>
<tr>
<td></td>
<td>
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<td>After successfully picking up the objects, the robot arm was then moved to the initial position to get ready for the next process.</td>
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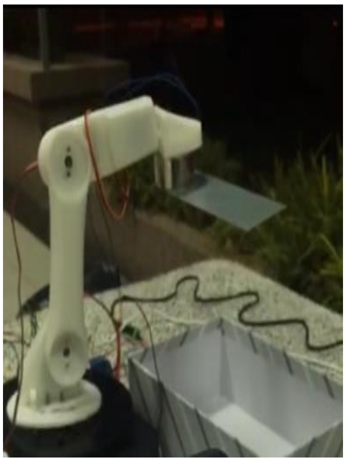
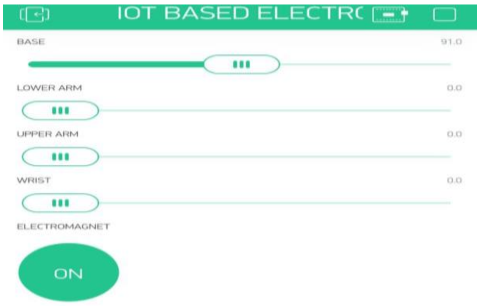
<td></td>
<td>
</td>
<td>The servo motor at base was moved at 91 degree angle to place the sheet metal at the box provided.</td>
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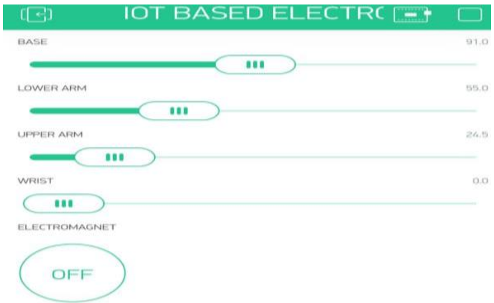
<td>
</td>
<td>The base remained at its position while the lower arm was moved at 55 degree angle and upper arm at 24.5 degree angles. To place the metal sheet, the button for the electromagnet was press once again to turn it off.</td>
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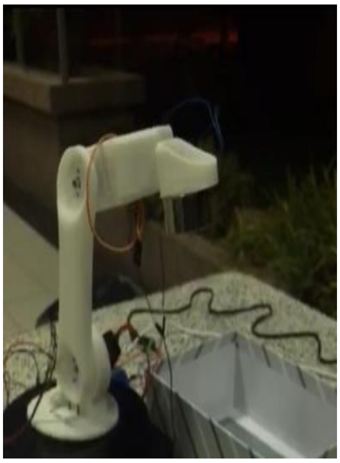
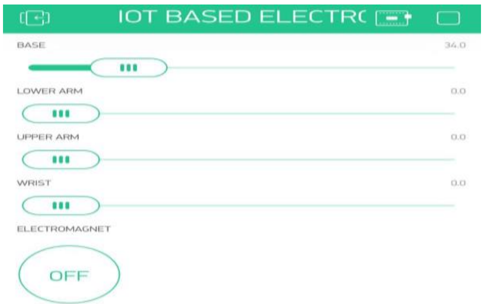
<td></td>
<td>
</td>
<td>The final position of the robotic arm after finished doing the pick and place activities.</td>
</tr>
</table>

3.2 Time Delay for Sending Data

The result of the time delay for sending the data to the servo motor was recorded and observed manually. Wireless signal strength is measured in dBm (decibel milliwatts) and different range of Wi-Fi strength (dBm) was used to check the time delay for the data to be sent to the microcontroller. The response at each joint of the robotic arm was observed to see how long it takes for the servo motor to move at 180 degrees with no load. Table 2 shows the expected quality on each of signal strength [15]. Meanwhile, Table 3 shows the time delay for sending the data to the servo motor. The test was conducted manually using a stopwatch for measuring the time delay.

Table 2
Wi-Fi signal strength [15]

Signal Strength (dBm)	Expected Quality
-30	Maximum signal strength you are probably standing right next to the access point.
-50	Anything down to this level can be considered excellent signal strength.
-60	Good, reliable signal strength.
-67	Reliable signal strength.
-70	Not a strong signal.
-80	Unreliable signal strength, will not suffice for most services.
-90	The chances of even connecting are very low at this level.

Table 3
Time delay for sending the data

Range of Wi-Fi signal strength (dBm)	Connection with NodeMCU	Time delay at base (ms)	Time delay at lower arm (ms)	Time delay at upper arm (ms)	Time delay at wrist (ms)	Average time delay (ms)
-20 to -37	Connected	263	421	210	287	295
-40 to -62	Connected	280	443	272	311	327
-65 to -75	Connected	307	467	297	343	353
-76 to -88	Connected	313	474	330	323	360
No signal	Not connected	-	-	-	-	-

From the Table 3, it clearly showed that the higher the range of Wi-Fi signal strength the higher time delay for the servo motor to respond and starts moving to the desired angle. Even though the time vary depending on the range of Wi-Fi signal strength but it will never exceed 500 ms for the servo motor to respond. It might have a longer time delay if the internet connection on the certain places is very low due to unreliable signal strength. For the range between -20 to -37 the average time delay is 295 ms but started to increase as expected. Thus, it is utmost important to have a reliable Wi-Fi signal strength to ensure the practicality or capability of IoT for controlling the robot is not compromised.

4. Conclusions

In conclusion, the objectives of this project have been achieved by successfully design an interface of Internet of Things (IoT) to control the robotic arm using an application on mobile phone. The robotic arm can be remotely controlled using mobile phone connected to the Wi-Fi. This application has allowed users to use the Internet of Things to control the robotic arm from anywhere in the world [16-17]. Additionally, the robotic arm has successfully performed a pick and place and move within its desired angular displacement degree. Besides that, the test was conducted manually to measure the relationship between the time delay of each servo motor at rotational joints and the range of Wi-Fi signal strength. The time delay at servo motor is higher as the range of Wi-Fi signal strength is lower. Moreover, there are small delays for any systems that use the Internet depending on the speed of the network and distance from the network.

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