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Development of Smart Controlled Precision Motorized Positioning System

Nor Nabila Aisyah Mohd Shukri[1], Ahmad Hadi Ali[2*]

[1, 2] LASERG, Photonics Devices and Sensor Research Centre (PDSR),
Department of Physics and Chemistry,
Faculty of Applied Sciences and Technology,
Universiti Tun Hussein Onn Malaysia (Pagoh Campus),
84600 Pagoh, Muar, Johor, MALAYSIA.

*Corresponding Author Designation

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Abstract: Motorized stage is generally a foundation to a certain application such as laser, CNC machine, 3D printing and microscope. Operational CMS controlled by humans can lead to human error and hazard while working. Applications such as lasers can be harmful to people working in high power laser field. The hazardous of laser including handling the laser while micro-position the laser. WCMS consists of four main parts which are the mechanical stage, motor driving circuit, software controller and interfacing devices. The mechanical stage x-axis sliding table was designed and developed. The material of the mechanical stage is aluminium. The motor driver of WCMS is L298N and was used with a NodeMCU ESP8266 microcontroller for the WCMS. The system was powered by 12V and 3A power supply. Smartphones was used to control the WCMS using Wi-Fi and Blynk application was used for the interface. To control the WCMS, programming codes were developed by using Arduino IDE and send wirelessly via Wi-Fi to Blynk and NodeMCU microcontroller. WCMS can be operated anywhere, as long as the smartphone and the WCMS is connected to the Internet. As the stepper motor is moved, the stage of WCMS also experiencing movement.

Keywords: Motorized Stage, Control System, Wireless, Stepper Motor, Arduino

1. Introduction

A motorized stage (MS) is used to precisely move and position an object along in a single axis or a multiple axis. MS is a moving platform and a stationary base connected by a bearing system and another option for MS is a belt-driven stage. MS is usually wired to the computer [1]. MS is a device that used in industrial and scientific automated motion application. Application of MS such as laser is in various of field of manufacturing process machining of engineering process. Since it has high power density, high directionality and better focusing characteristic that is useful for machining process such as, cutting, forming, joining, and drilling [2].

*Corresponding author: ahadi@uthm.edu.my

Wired motorized stage limit the user in term of mobility, damage, and expansion of the Control Motorized Stage (CMS). To operate the MS more safely and precisely, Wireless Control Motorized Stage (WCMS) is a perfect option in order to conveniently and safely control the MS. WCMS is combination of electronic components with microcontroller NodeMCU, motor driver, stepper motor and mechanical stage. The wireless control eases the user to input the command for the CMS to move accordingly. As in micro-positioning, it refers to the mechanical movement that can be controlled since it has high accuracy of positioning suitable for this application.

In this study, WCMS has the combination of mechanical stage, NodeMCU and motor driver to operate. NodeMCU is a microcontroller with build in Wi-Fi module. It can hold the command from Arduino IDE and send the data to the CMS [3]. Motor driver act as interfacing device within NodeMCU and stepper motor. It acts as a controller to control the speed and direction of stepper motor. To control the CMS wirelessly, Wi-Fi was used to connect WCMS to a smartphone. User able to control CMS from a distance wirelessly via smartphone. As long as the smartphone and the WCMS has connected to Internet, user can control the CMS from anywhere.

2. Design of WCMS

Figure 1 shows the block diagram of interfacing circuit of WCMS. Controlled motorized stage, stepper motor and motor driver were integrated to NodeMCU board. Interfacing coding were developed to establish the interfacing circuit and as for controller, a smartphone will be used to control the CMS by connected to the Wi-Fi integrated microcontroller.

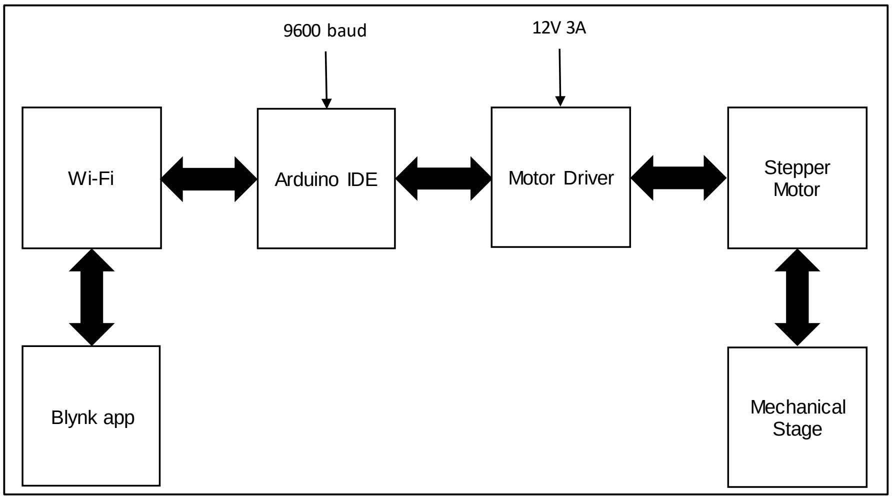

Figure 1: Block diagram of WCMS

3. Development of WCMS

WCMS is designed by integrating stepper motor into motor driver, motor driver to NodeMCU. NodeMCU has a Wi-Fi module integrated in the chip. While smartphone and NodeMCU is connected to the Internet, NodeMCU will execute all the process and command written in Arduino IDE for WCMS to moves using smartphone.

Figure 2 shows the schematic diagram of wireless controlled motorized stage. These input and output are important as to write and develop programming code in order to move the WCMS.

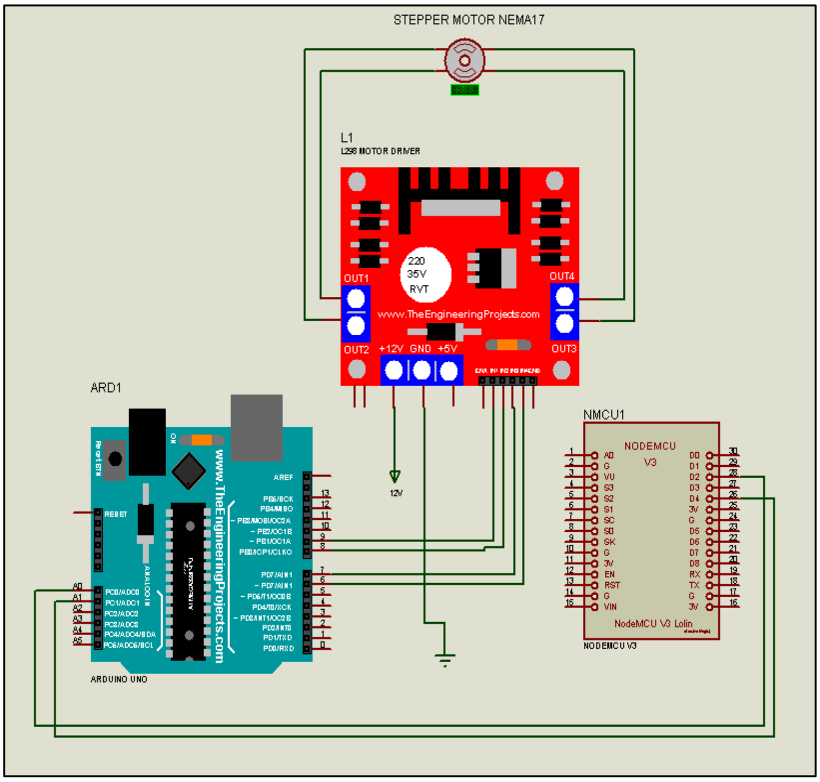

Figure 2: Schematic diagram of WCMS

3.1 Construction of Mechanical Stage

The rotational stage used is x-axis fine tuning linear stage manual translation displacement station platform [4]. There are 3 main parts of the mechanical stage. The main body is made of aluminium alloy. It also used stainless steel and brass as its material. The stage is lightweight and strong, friction-resistant, quite scratch-resistant, drop-proof and corrosion-resistant. The loading capacity is 10 kg and uses an M5 fixing screw. The sliding table is 40 × 70 mm. There are six parts of the stage as shown below on Figure 3.

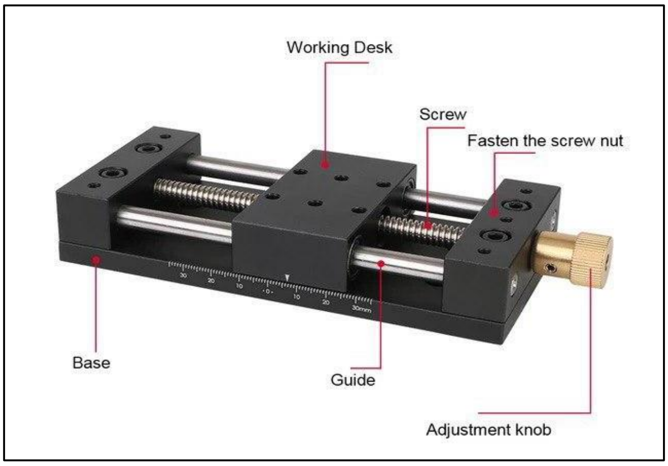

Figure 3: Design of motorized stage

3.2 Programming Code of WCMS

Figure 4 shows programmed codes used to upload to the system of WCMS. To connect NodeMCU to the Blynk server, Blynk Authorization Token need to be created. Wi-Fi ID and password also need to be defined in the programming code [5]. Next, the step per revolution needs to be declared based of the stepper motor before starting the program and Blynk. xVal value also need to declare. This is for the Blynk to control the value of stepper motor. The program runs on void loop. This means that the program will repeat itself when the program is running. The RPM of the WCMS can be change on the delay of stepper. Lower the delay, higher the RPM of the WCMS.

```
#define BLYNK_TEMPLATE_ID "TMPLx7fxZvhp"
#define BLYNK_DEVICE_NAME "FYP Project"
#define BLYNK_AUTH_TOKEN "LzIkRdx1BD_9dSeFCEh1q067AhRReVDH"

#define BLYNK_PRINT Serial
#include <ESP8266WiFi.h>
#include <BlynkSimpleEsp8266.h>

char auth[] = BLYNK_AUTH TOKEN;
char ssid[] = "project";
char pass[] = "1111aaaa";

void setup() {
 Serial.begin(9600);
  Blynk.begin(auth, ssid, pass);
   pinMode(D2,OUTPUT);
 pinMode(D4,OUTPUT);
   digitalWrite(D2,LOW);
 digitalWrite(D4,LOW);
}
void loop() {
  Blynk.run();
}
```

```
#include <Stepper.h> // Include the header file

// change this to the number of steps on your motor

#define STEPS 200

// create an instance of the stepper class using the steps and pins

Stepper stepper(STEPS, 9, 8, 7, 6);

int counter,wise;

void setup() {

 Serial.begin(9600);
 stepper.setSpeed(60);
 pinMode(A0,INPUT);
 pinMode(A1,INPUT);
}
void loop() {

  wise = digitalRead(A0);
  counter = digitalRead(A1);

  Serial.print("Wise: ");
  Serial.println(wise);
  Serial.print("Counter: ");
  Serial.println(counter);

  if(wise == 1)
  {
    stepper.step(1);
  }
```

```
  if(counter == 1)
   {
    stepper.step(-1);
   }

   if(wise == 0 && counter == 0)
   {
    setStepperIdle();
   }

}

void setStepperIdle() {
  digitalWrite(9, LOW);
  digitalWrite(8, LOW);
  digitalWrite(7, LOW);
  digitalWrite(6, LOW);
}
```

Figure 4: Programming code of WCMS

3.3 Software Controller

Arduino IDE was used to developed programming code for the WCMS [6]. Command was executed on the Arduino IDE and while Blynk and NodeMCU was connected to the Wi-Fi. Blynk application on the smartphone can be used as an interfacing device to control the WCMS [7]. Figure 5 shows the interface of the Blynk when connected to the WCMS. The switch button able user to control WCMS to move to the left and right.

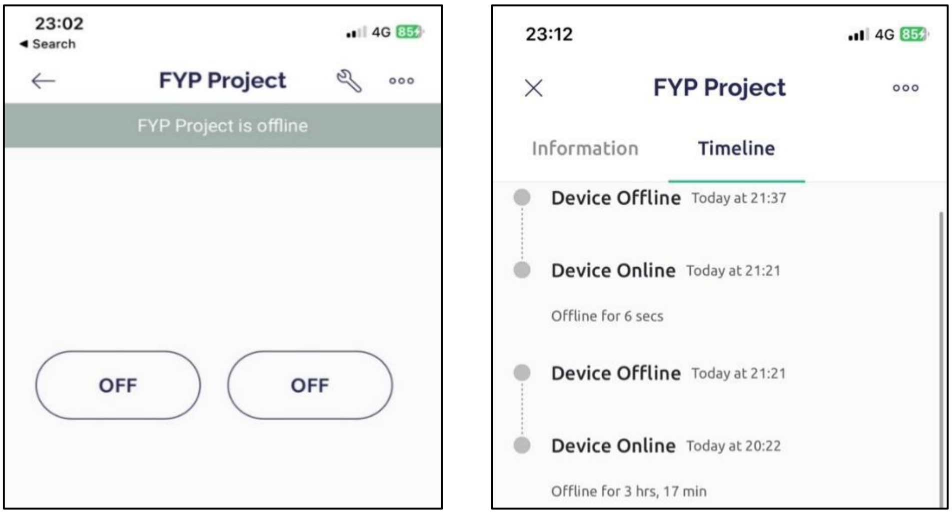

Figure 5: Interface of Blynk connected to the WCMS

3.4 Method of Testing

WCMS was tested by setting the frequency on the code at the Arduino IDE. The delay on the programming code can be changed to increase or decrease the rotation per minute of the stepper motor. By changing the RPM, the WCMS can be tested for the accuracy. The user can control the WCMS by pressing the Blynk controller to the left or to the right. The time taken for the stage will be observed when the stage is completed full one rotation. Eye observation was the method of testing for the measurement of time for the WCMS. Figure 6 shows the wireless control motorized stage.

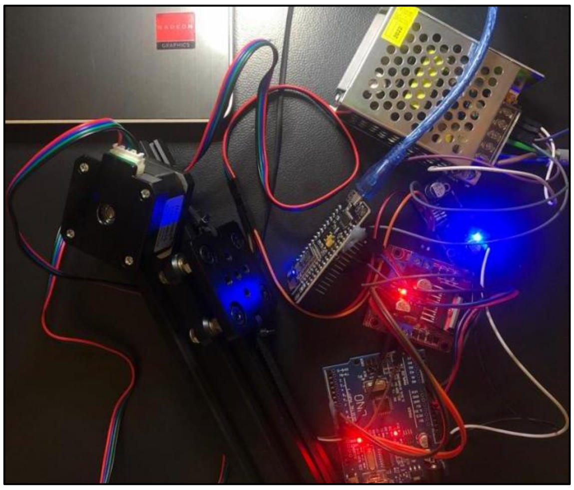

Figure 6: Wireless control motorized stage

4. Result and Discussion

WCMS were tested in term of micro-precision and the performance of the WCMS. Stepper motor moves in discrete step and 200 steps will make a full one rotation of the stepper motor. Three reading had been taken to measure the accurate value for the time taken using stopwatch. The time taken of the stage to move to left is 12.0, 12.1, and 12.3 seconds for each. The time taken of the stage to move to right is 12.3, 12.1, and 12.1 seconds respectively. Figure 7 presents the micro-rotation of the stage.

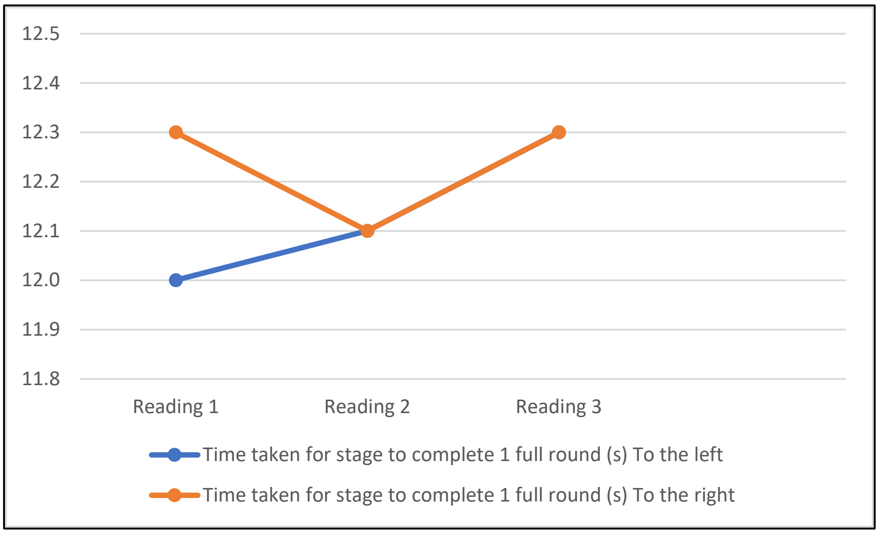

Figure 7: Graph of time taken for stage to complete 1 full round

For the performance of the WCMS, the stage was tested in the term of how long the belt in centimetre is used. It is measured by ruler by human eyes. The time taken for the stepper motor to complete one full round is 10.4, 10.5, and 10.5 cm respectively. Figure 8 shows the graph of the WCMS.

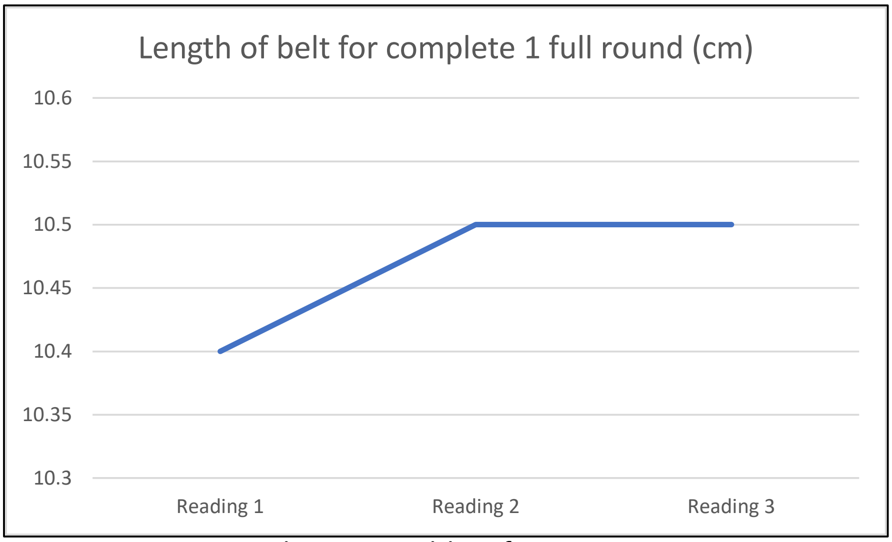

Figure 8: Precision of WCMS

This trend shows that there are not so many changes between each reading as the stepper motor already set up their performance earlier. Moreover, the perfection tooth on the pulley makes belt slippage more accurate to the previous testing.

5. Conclusion

As the conclusion, WCMS were designed and developed with NodeMCU, driver motor, stepper motor and rotational stage. WCMS was designed for a simple rotational movement. It is used for metrology, micro-robotic, sensor testing, laser movement or anything that calls for automated rotation. The Blynk application was used as an interface for controlling the WCSM using a smartphone. The stage moves according to the user command. Because WSCM was using Wi-Fi and the Wi-Fi server from Blynk, users can control the stage rotation from anywhere in the world as long as the user has a controller and Wi-Fi connection. The ability to control the stage from a long distance will solve the problem statement which states that to conveniently control the stage wirelessly to avoid hazards in working with a motorized stage. In addition, controlled WCMS via smartphone gives a convenience and safer distance for workers yet the positioning of samples will be more accurate hence able to avoid an inaccuracy in obtaining data or sample.

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