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Hardware Graduation Project

CNC Drawing Machine

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Contents

Acknowledgment.....	2
Abstract.....	5
Chapter 1: Introduction.....	6
Chapter 2: Literature Review.....	7
2.1 CNC Laser Cutter.....	7
2.2 CNC router.....	8
Chapter 3: Constrains.....	8
3.1 Appropriate equipment and components.....	8
3.2 Motor drivers instead of shields.....	9
3.3 Two Modes.....	9
Chapter 4: Methodology.....	10
4.1 Overview.....	10
4.2 Equipment's and Components.....	11
4.2.1 Arduino UNO.....	11
4.2.2 Stepper Motor 4401.....	12
4.2.3 Stepper Motor Driver a4988.....	12
4.2.4 8 Channel Relay Module.....	13
4.2.5 Gyroscope Sensor GY-521.....	13
4.2.6 Servo Motor SG90.....	14
4.2.7 HC-06, HC-05 Bluetooth.....	15
4.2.8 12V Power Supply.....	15
4.2.9 Breadboard.....	16
4.2.10 Linear Guide Rail HGR20 and Linear Motion Guides HGH20CA.....	16
4.2.11 Pulleys and belts.....	17
4.3 Implementation.....	17
4.3.1 Build the Structure.....	17
4.3.2 Test the movement.....	18
4.3.3 Install GRBL firmware.....	18

4.3.4 Inkscape, LaserGcode and generate gcode commands.....	19
4.3.5 Controller remotely via bluetooth using app.....	20
4.3.6 Manual mode.....	20
Chapter 5: Results.....	21
5.1 Automatic result.....	21
5.2 Bluetooth control result.....	22
5.3 Gyroscope control result.....	22
Chapter 6: Discussion.....	23
Chapter 7: Conclusion.....	23
Chapter 8: References.....	24

Abstract

Our project is a CNC drawing machine that allows the user to draw what he wants in different sizes automatically or manually, as it is possible to switch between the manual system and the automatic system by phone via Wi-Fi or Bluetooth.

In the automatic system, the desired drawing can be drawn through the computer programs automatically without any user intervention in different sizes by specifying the required size for the drawing.

In the manual system, the user can control the movement of drawing the machine by phone via Bluetooth or Wi-Fi, and by drawing manually through.

Chapter 1: Introduction

The CNC drawing machine printer project involves designing and building a functional CNC drawing machine using an Arduino Uno microcontroller, 4401 stepper motors, and A4988 drivers. The objective is to create a printing system capable of reproducing 2D patterns or shapes on a flat surface.

The majority of printer projects are limited to drawing automatically only by giving a drawing to the machine, but our project, in addition to automatic printing, there is another mode to control the machine manually in several ways.

Our project allows users to send Gcode commands of any drawing through Gcode sender and the machine will draw it automatically.

Either manual mode allows the user to control the machine in different ways manually, first, the user can control the machine through Gcode sender software, second, control the machine through grbl controller app via Bluetooth, and this app also allows sending Gcode commands to the control machine. Finally, the user can control the machine with a gyroscope sensor.

The two modes will work separately, and the user can switch between them via an application that uses Bluetooth.

Chapter 2: Literature Review

CNC machines are among the important inventions of our time, and they facilitate many of the existing works, such as making shapes for wood in carpentry shops and making shapes for iron in Blacksmith's workshop. And it's receiving increased attention. Some of its inventions:

2.1 CNC Laser Cutter

is a method that creates a cut edge by vaporizing materials with a laser. Although it was originally only utilized in industrial manufacturing settings, today it is also employed by small businesses, architectural firms, and amateurs. The mechanism behind laser cutting is the typical use of optics to focus the output of a high-power laser. The laser beam is aimed at the material using laser optics and CNC (computer numerical control). A commercial laser used for cutting materials uses a motion control system to adhere to a CNC or G-code of the design that needs to be cut onto the material. The material is exposed to the concentrated laser beam, which causes it to either melt, burn, vaporize, or be blasted away by a jet of gas, leaving an edge with a superior surface polish.

2.2 CNC router

is a computer-controlled cutting device used to cut a variety of materials, including wood, composites, metals, plastics, glass, and foams. Typically mounted as the spindle on the CNC router is a hand-held router. Many carpentry shop equipment, including the panel saw, the spindle molder, and the boring machine, can be replaced by CNC routers. They are also capable of cutting joinery like mortises and tenons. The idea behind a CNC router and a CNC milling machine is fairly similar. Tool routes are managed by computer numerical control rather than manual routing. One of the various tool types that have CNC variations is the router.

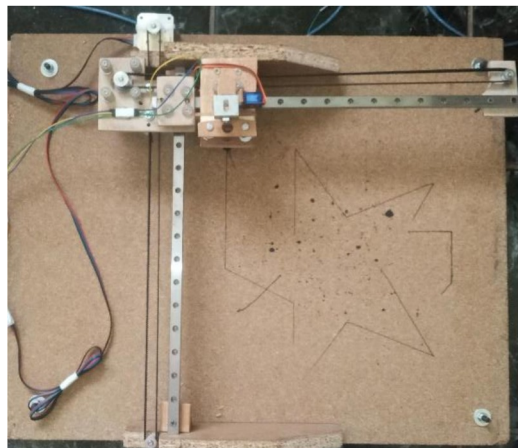
Chapter 3: Constrains

3.1 Appropriate equipment and components.

When we start work on our project, we search about structures of our CNC so we find different structures, so we want to find the most appropriate and least expensive design.

First structure we found two rails for x-axis and one for y-axis, the issue of this structure is how to design the two pieces that moves on the two parallel rails, there was two ways to design it, first way is to design it on 3d and it was so expensive, the second way is to design it manually, but was difficult we should design it completely similar to make the movement appropriate and accurate.

After many attempts we found this design, just one rails for each axis and the design of its pieces was simple to create it manually using wood.



3.2 Motor drivers instead of shields.

Using shields in our project is prohibited by the instructions of the project supervisors, so we have used a4988 drivers for stepper motors 4401.

3.3 Two Modes

In our project there is two types of mods:

1. **Automatic mode:** that draws that drawing depending on gcodes commands from grbl firmware.
2. **Manual mode:** move the CNC depending on instructions come from Bluetooth app or gyroscope sensor code.

The issue was how to make the two modes work separately and how to switch between them:

- First, we tried to switch between the two modes using the drivers en by enabling and disable the drivers for each mode separately, but this method did not work and caused many of our drivers to burn.
- Secondly, we managed to use the 8 channel relay module to switch between the two modes without any connection between the drivers and without burning any of our electronic pieces.

Chapter 4: Methodology

4.1 Overview

After we researched and collected ideas and information, we proposed to create a CNC drawing machine that combines all the previously mentioned things, from controlling the machine in two modes, automatically and manually, and switching between them.

The process of creating the machine went through several stages: choosing the appropriate and least expensive structure, then we started building the mechanical part, and we tested the movement of the motors, after that we worked on the automatic mode and downloaded grbl firmware and test it, then we worked on the manual mode and started first by controlling the machine via Bluetooth, then control it through the gyroscope, and finally we worked on how to switch between the two modes.

4.2 Equipment's and Components

4.2.1 Arduino UNO

The Arduino Uno is an open source board based on the Microchip ATmega328P microcontroller, and it's a very important component of our project. There are digital IIO and Analog Input Pins 14, 6 and others.



In our project we have used two of these, one has the GRBL firmware and this for the automatic mode, the other one for manual mode that has code to control the machine via Bluetooth or gyroscope sensor.

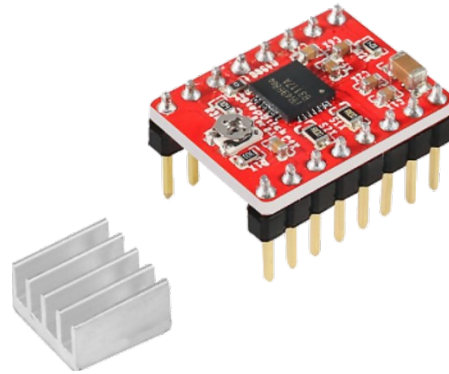
4.2.2 Stepper Motor 4401

The stepper motor is an apparatus that moves in a sequential motion, one step at a time. For applications where precise position control is desirable, like 3D printers, laser cutting or picking and placing equipment, it can usually be applied in a number of ways. This NEMA 17HS4401 bipolar stepper motor has a 1.8° step angle (200 steps/revolution) with 40N.cm (56oz.in) holding torque.



In our project we have used two stepper motors one for x-axis and one for y-axis.

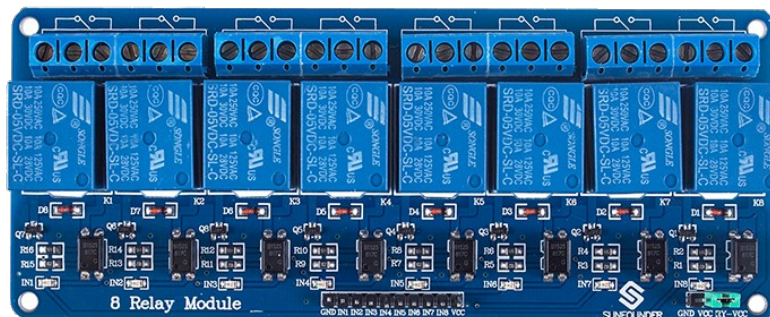
4.2.3 Stepper Motor Driver a4988



For the control of stepper motors in a variety of applications, the A4988 Driver is an interchangeable driver. The A4988 has the ability to control a stepper motor with great accuracy and efficiency when using it in combination with an Arduino UNO microcontroller.

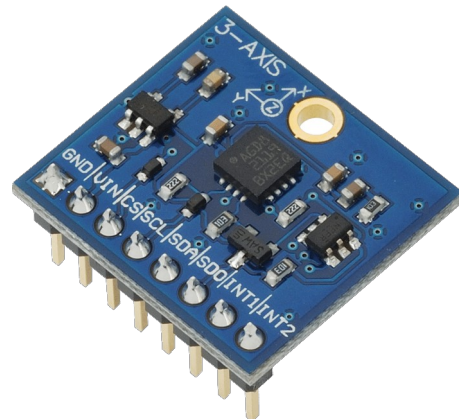
4.2.4 8 Channel Relay Module

It's an 8 channel low level trigger relay, which you can use with Arduino and the Raspberry Pi. For the purpose of driving electronic equipment like lamps, electrical motors and air conditioners, you can use a relay. By connecting it to an MCU, a relay can control high and low voltages at the same time.



In our project we have been using it to switch between two Modes.

4.2.5 Gyroscope Sensor GY-521



Gyro sensors are tools that detect angular velocity. They are sometimes known as angular rate sensors or angular velocity sensors. Angle of rotation. Angular velocity is the change in rotational angle per unit of time, to put it simply. The unit of measurement for angular velocity is degrees per second (deg/s).

We have been using it to control the movement of the machine manually, ex. when moving it to the right or left the machine moves horizontally.

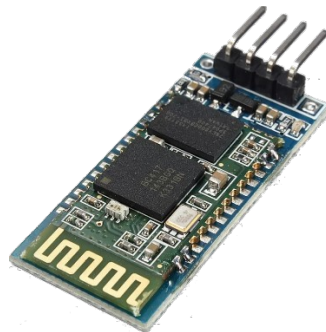
4.2.6 Servo Motor SG90

Little, light, and powerful. A smaller version of a regular servo that can rotate about 180 degrees (90 in each direction). These servos can be controlled with any servo code, hardware, or library. Good for novices who wish to move objects without developing a motor controller with feedback and gearbox, especially because it can fit in tight spaces. Hardware and 3 horns (arms) are included.



We have been using it to control the z-axis. We connect the pen to its white piece and we send a command to move it up, the pen goes up and so on.

4.2.7 HC-06, HC-05 Bluetooth



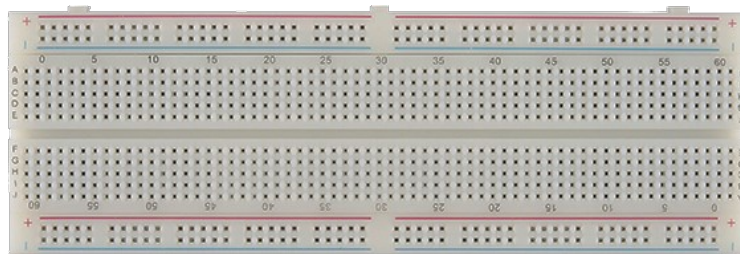
In our project we have been used to Bluetooth module one for each Arduino, for Arduino that have grbl code we used the Bluetooth to control the movement of machine, the second one connects to second Arduino that control manual mode, switching between two modes and it used to control the up down movement when we use gyroscope.

4.2.8 12V Power Supply



Stepper motor and Arduino needs 12v to work, so we take the power supply that provides 12v and connect it to stepper motors and arduinos.

4.2.9 Breadboard



We have used two breadboards in our project, one has 4 stepper motor drivers and we connect wires on it, and the second one we just connect the two Bluetooth modules.

4.2.10 Linear Guide Rail HGR20 and Linear Motion Guides HGH20CA



It is used for movement in each axis.

4.2.11 Pulleys and belts

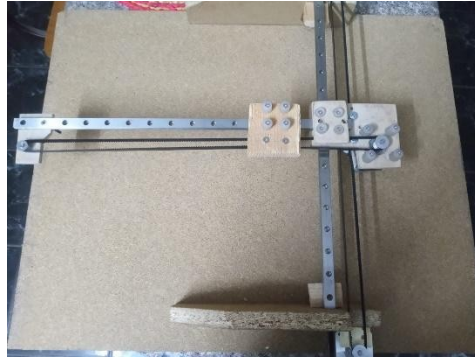


We have used 2 meter belts one meter for each axis and 4 pulleys 2 for each axis, in each axis there is 1 pulley on each side to make the linear guide motion moves.

4.3 Implementation

4.3.1 Build the Structure

First, we built the structure of our project:



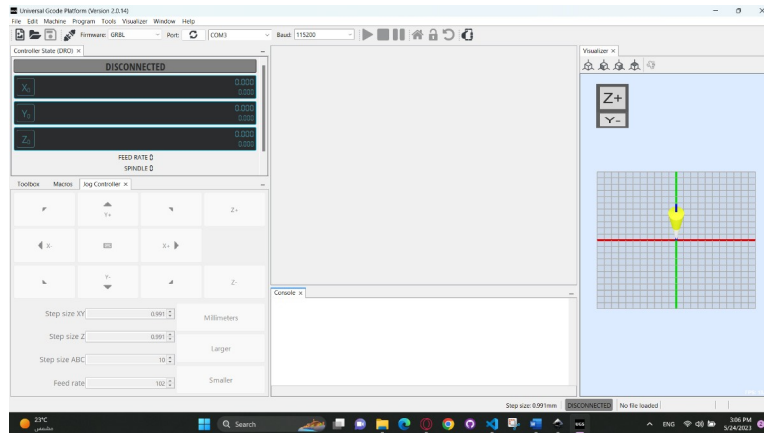
We establish each axis using linear guide rail and linear motion guides. and establish each motor on its axis and establish the pulleys with belt for each axis.

4.3.2 Test the movement

We test the movement by installing simple code on Arduino to the movement of motors.

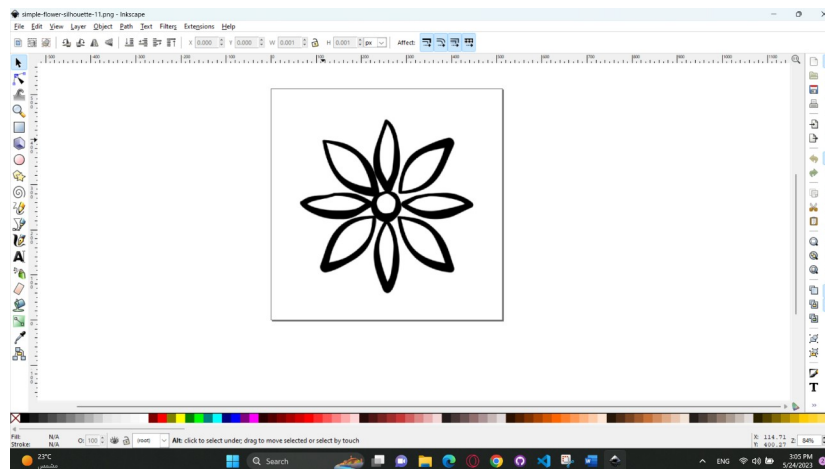
4.3.3 Install GRBL firmware

Then we installed GRBL firmware on the Arduino, then we used the UGS (Universal Gcode Sender) to send gcode commands for GRBL.

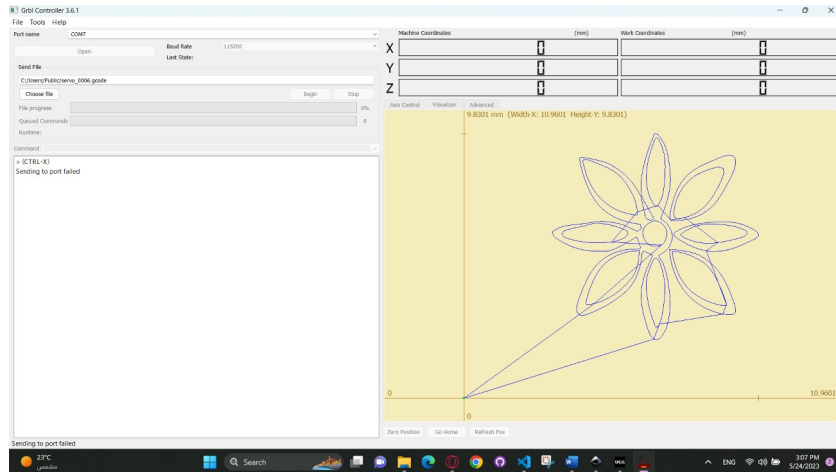


4.3.4 Inkscape, LaserGcode and generate gcode commands

Then we used Inkscape to draw, and generate gcode commands for this drawing. Then open the generated file on UGS and send it to Arduino to draw the drawing.

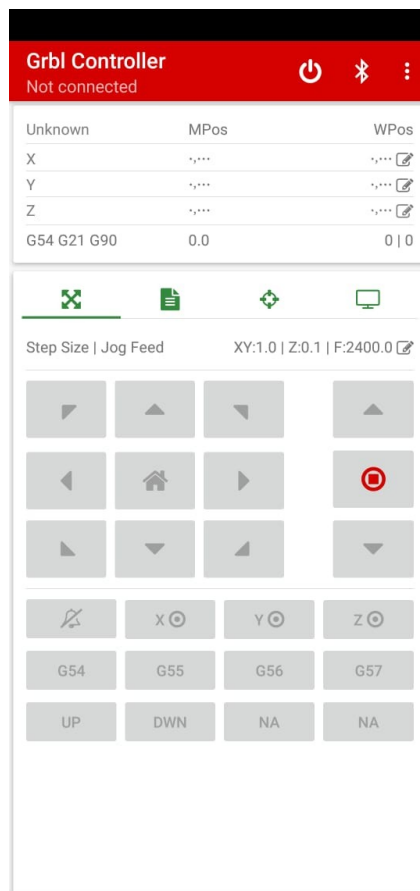


We also used LaserGcode on this software we can show the path of the machine to draw, this also use to send gcode for Arduino



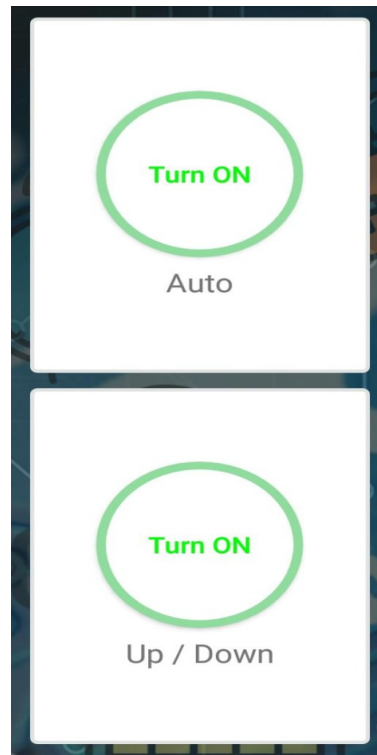
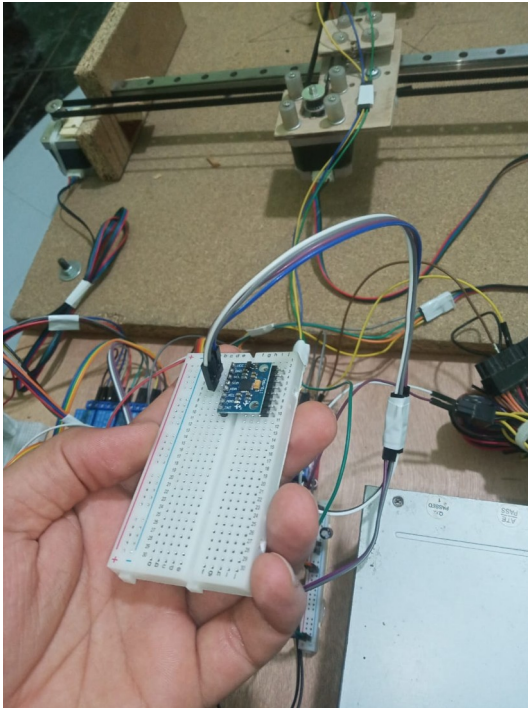
4.3.5 Controller remotely via bluetooth using app

Then we used Bluetooth, and connected it to Arduino, and then connected the device which has a controller app and use it to moved the machine manually using arrows.



4.3.6 Manual mode

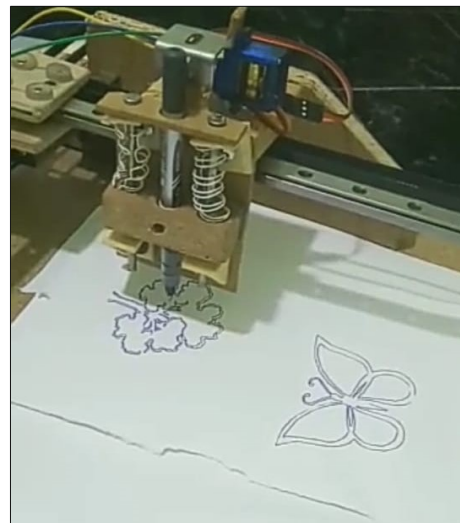
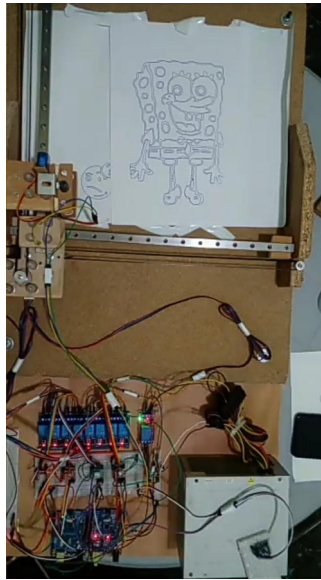
We wrote a code for manual mode and switch between two modes on the second Arduino and connect the drivers with 8 channel relay modules to switch between them. And move the gyroscope sensor to test the movement, and switch between the two Arduino via Bluetooth.



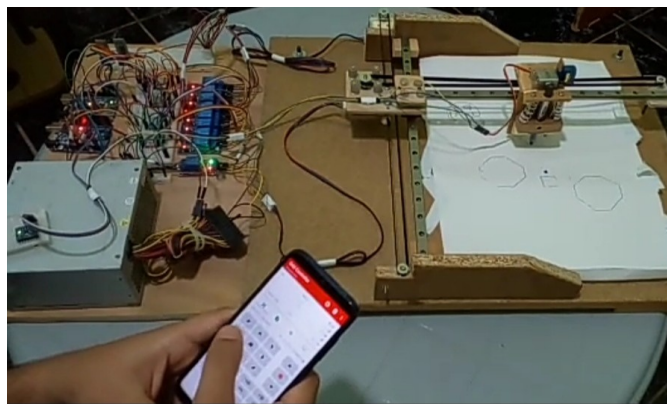
Chapter 5: Results

At the end of the project, we were able to build a CNC machine that can be controlled automatically and manually through the phone application or through a gyroscope sensor to track the movement of the hand, and we were able to draw many drawings using these three methods.

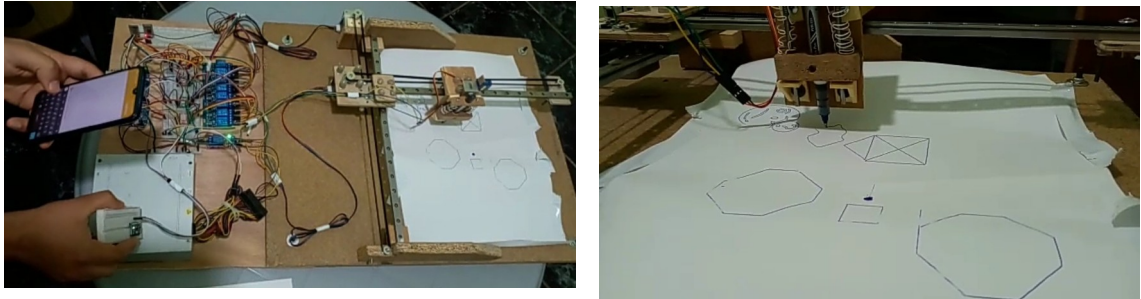
5.1 Automatic result



5.2 Bluetooth control result



5.3 Gyroscope control result



Chapter 6: Discussion

We were able to solve the problems required in this project, which include drawing automatically and drawing manually by remote control, talking about hand movement through the gyroscope, and switching between automatic and the manual modes easily and in a way that separates each mode from the other exactly as required.

And what we noticed from this project is that the control by means of the gyroscope is slower in terms of movement than the automatic one, due to the reduction in the number of steps that the motors move in the manual control for ease of control and reducing the percentage of errors during drawing.

With this project, we have presented a work that allows the user to perform many drawings or copy and rewrite articles only by photographing and rewriting them in an automatic or manual way in a fun and easy way.

Chapter 7: Conclusion

In conclusion, this project has successfully addressed the key objectives of designing a CNC drawing machine capable of automatic and manual drawing modes with remote control functionality. By incorporating a gyroscope for hand movement control, the system allows users to switch between modes seamlessly and precisely as required.

During the project, it was observed that the manual control using the gyroscope resulted in slower movement compared to the automatic mode. This was primarily due to reducing the number of motor steps for improved control and minimized errors during the drawing process. Nevertheless, the system provided an enjoyable and easy way for users to create various drawings or replicate written content by simply photographing and rewriting them either automatically or manually.

Key findings from this project include the successful implementation of the desired functionalities, highlighting the benefits and limitations of each mode. The automatic mode proved to be efficient and accurate, while the manual mode provided greater control and reduced the chance of errors. These insights demonstrate the potential for further enhancing the system's performance and usability.

To improve the work's performance, several cost-effective and feasible recommendations can be considered. For instance, optimizing the gyroscope control to enhance its responsiveness and reducing any latency in movement can enhance the overall user experience. Additionally, exploring advanced motor control techniques could potentially improve the efficiency of the manual mode without compromising accuracy.

In summary, this project has provided a valuable solution for users seeking an automated drawing system that offers flexibility in both automatic and manual modes. The findings and conclusions drawn from this work open up new possibilities for future research and development in this field. Future work may focus on refining the control mechanisms, incorporating intelligent algorithms for image recognition and interpretation, and exploring additional features to expand the functionality of the CNC drawing machine. Overall, this project lays a solid foundation for further advancements in the field of automated drawing systems.

Chapter 8: References

<https://2u.pw/LSCCds> (Arduino Documentation).

<https://github.com/grbl/grbl> (GRBL firmware).

<https://2u.pw/NaB6qX> (Gyroscope GY-521 doc)

<https://2u.pw/cAd3az> (Bluetooth module doc)

<https://2u.pw/EZyW8Y> (a4988 Stepper motor driver doc)

<https://2u.pw/1sUScH> (Nema 17 4401 stepper motor doc)

<https://2u.pw/Xi35oF> (8 channel relay module doc)