ARDUINO BASED CNC PLOTTER

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Abstract : The CNC machine which was introduced in the late 1970s has improved its utilization drastically over the years. The goal of the project is to design a cost-effective three-axis CNC plotter machine with multiple applications. The 3-axis plotter machine works with the use of a stepper motor, Arduino UNO and microcontroller software. Its framework involves mechanical system design, wiring and software tools. The principle behind the plotter machine is computer numerical control which gives input to the plotter from a computer program. The Arduino UNO and CNC shield drivers enable consistent and accurate step control of stepper motors. The Inkscape is utilised to transform any desired picture into a Gcode file for the machine to work.

Index Terms : Arduino, CNC, stepper motors, Inkscape software, G-code file

I. Introduction

The computer numerical control (CNC) is majorly utilised to replace manpower, increase reliability, and precision, and reduce time consumption. The CNC is obtained by integrating a computer processor that enables the programs to be edited and stored in computer memory. The plotter machine executes its functions based on special instructionsor commands known as the G-codes. The G-code gives the direction to the tool for the movement of all three axes. The tool can also be chosen based on the desired outcome. It can be a marker pen, laser cutting, milling etc., and it can be utilized for a diverse range of applications. The axes have the potential to create 3-D or 2-D images on plain surfaces or any other material. The plotter machine is so versatile that it can be used for everyday simple tasks to the most specialized, complex tasks as well. The position of the toolis controlled by a stepper motor to provide high accuracy in movements. The plotting area can be increased for commercial purposes as per requirement. The closed-loop control system is most preferable in providing the reliability,speed, and accuracy needed for commercial machines.

II. Literature Review

In this section, a brief summary of the research carried out by various authors on CNC plotter machines is mentioned.

[1] R. R. Jegan, E. Gnanasundaram, M. Gowtham, R. Sivanesan and D.Thiyagarajan 2018 "Modern Design and Implementation of XY Plotter". The objective of this research paper is to develop the XY Plotter, which is an accurate, and adaptable pen plotter that can write or draw. This research paper gave an idea about the working of a CNC plotter machine using X-Y coordinates.

[2] Y. M. Hasan, L. F. Shakir and H. H. Naji 2018 "Implementation and Manufacturing of a 3-Axes Plotter Machine by Arduino and CNC Shield". The objective of this research paper is to construct a plotter and build open-source software to operate the machine. This research gave an insight about how to construct a cost-effective Arduino plotter machine with XYZ coordinates using open-source software and hardware.

[3] Rahul Somalwar2, Namesh A. Kale3, Ashish J Nandeshwar4 and Antariksh V 2020 "Short paper on CNC PCB milling machine". The goal of the research paper is to reduce the cost of CNC machines and

meet the growing needs of large-scale industries in minor applications. This research gave an idea on how to develop, assess, and install a low-cost CNC-based PCB milling machine that can be employed in small firms.

[4] Aneeta Pinhiero, Beljo Jose, Tinsemon Chacko, Nazim TN 2016 "Wireless CNC Plotter" The goal of this research paper is to develop a small three-axis CNC plotter machine This research paper gave the clarity about the concept of a wireless CNC plotter that can be used for PCB layout and drilling.

[5] M.Bhavani, V.Jerome, P.Lenin Raja, B.Vignesh, D.Vignesh 2019 "Design and Implementation of CNC Router". The objective of this article is to develop and build a CNC plotter machine-based router machine for wood engraving. This research gave an idea about the design and fabrication of a mini–CNC Plotter Machine that can be used for engraving.

III. Objective

The major purpose of the CNC plotter machine is to create 2-D, and 3-D images on a plain surface or any other material by using a 3-D printing mechanism and microcontroller. The machine is cost-efficient. The plotting operation can be replaced by any other tool like a laser cutter or milling cutter. The distinctive feature of this machine lies in its flexibility as it is capable to execute a wide variety of applications.

IV. Block diagram
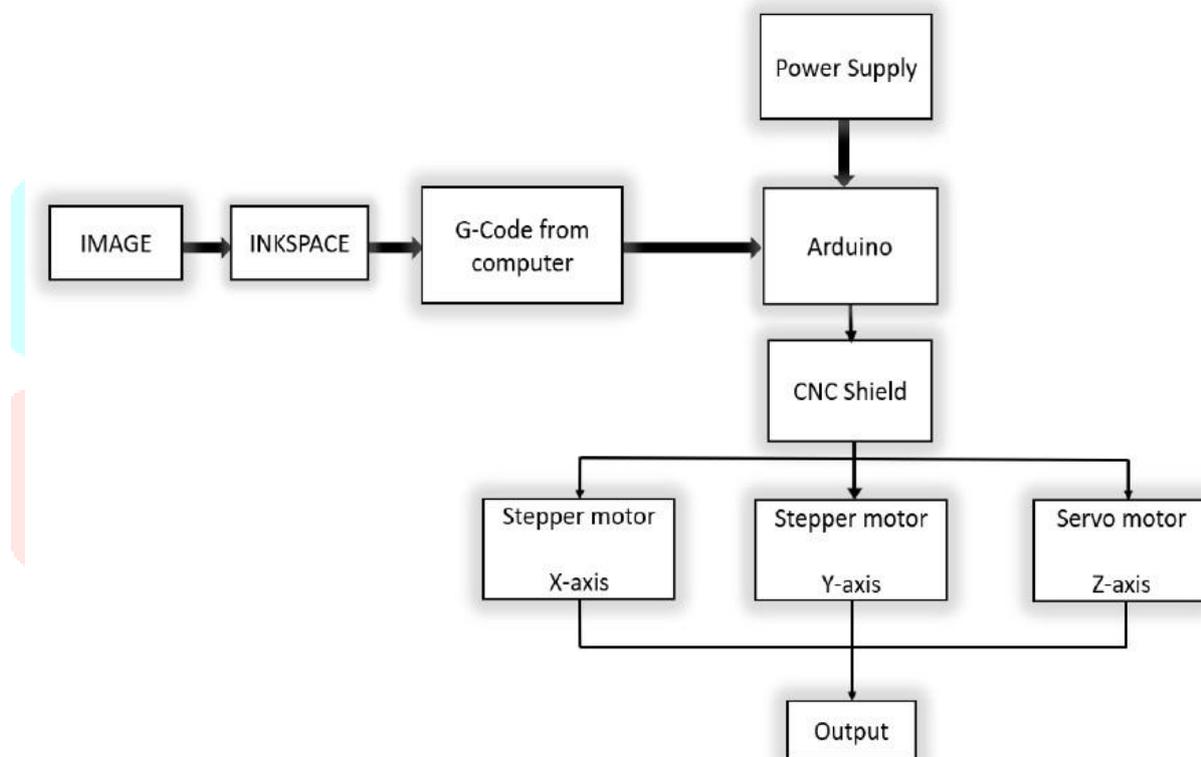
The CNC machine works with input as a G-code file. The G-code file is obtained from Inkscape software and further, the G-code file would be sent to the Arduino controller over Universal Serial Bus (USB) by the Processing IDE. The input functions as an electrical signal to the stepper motor and servo motor. The X, Y, and Z axes work according to the instructions given to the control unit. The controller unit also determines the drawing speed and the tool cutting and depth speed.

V. Components
(a). Software components
1. **Inkscape software (version 1.4.3)**
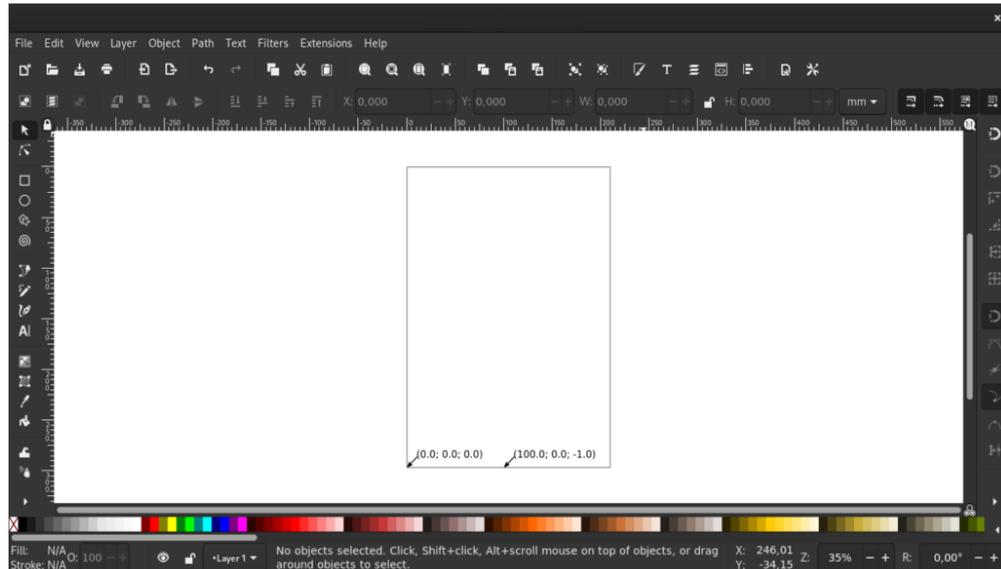
The Inkscape software will convert any desired image or text into a G-code file. It is a free and open-source vector editor. The main purpose of the software is to trace the images or text. The tracing of the image is carried out by the following steps, open the Inkscape software version 1.4.3 and set the document properties. Further, select the size of the page accordingly millimeter or centimeter (mm or cm) according to your page size, then drag and drop or import the particular image needed. The image can be resized according to the paper size. Now go to Trace bitmap. After trace bitmap, two photos will be available, delete the original one and keep the traced one. After that select go to Path- object to path. Hence, the traced image is obtained which indicates that when will pen or the tool will go up and pen down. The Gcode file obtained can be saved in the desired location.

2. **Arduino IDE 1.8.16**
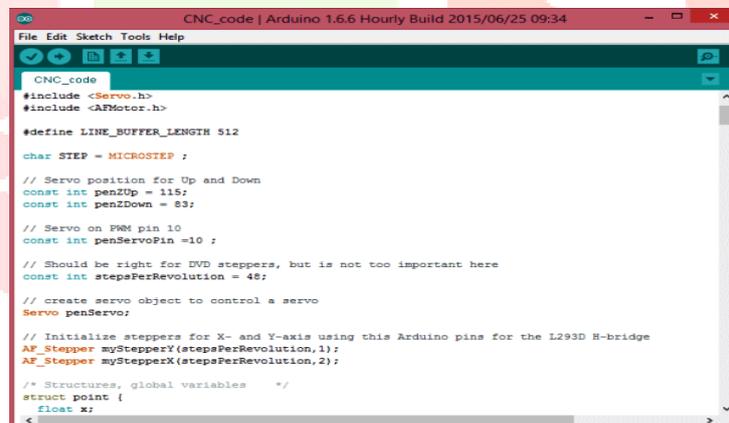
The open-source Arduino Software (IDE) allows us to write code and upload it to the board in real-time. Arduino IDE works within Windows, Mac and Linux operating systems. The Arduino IDE acts as a channel between the computer and the motor drive. The CNC shield and motor shield are used to interface the motor drive.

3.   Python IDE
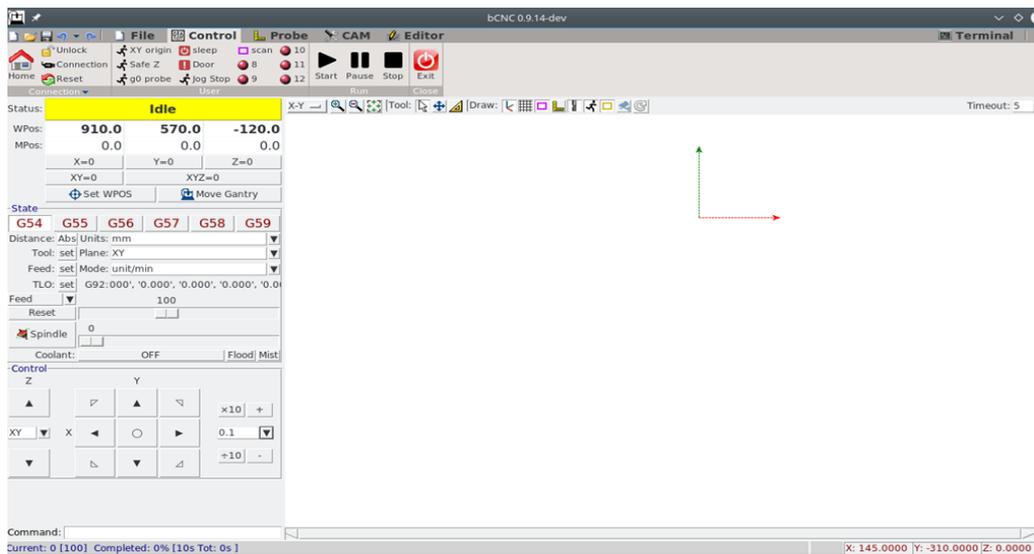
Processing is an open-source software specifically created to be used by electronic artists and visual designers. The Gcode file is sent from the user interface to the CNC plotter machine using the software. This will allow the plotter machine to operate. To send the G-code file to the system following steps are carried out, open GTCRL (processing software) and RUN the GTCRL program. After Running the program, a small pop-up command window is displayed. Further, Press (P) to select the port, on which the Arduino board was previously connected. Then press (G) to extract the G-code file from the PC. The command window of processing software is displayed that indicates that the CNC plotting machine is active and it is ready to take the G-code file from the PC. Hence the CNC machine will begin to function.

(b). Hardware components
1.   Arduino UNO

The Arduino board controller was advanced, viable, quick and better accomplishment of force framework control and administration utilizing installed segments. It containing the oscillatory circuit, reset, equipment segments and so on. The MCU is essential thought of the PWM for controlling DC Motor. The output devices are used a LCD display which is connected on digital output of board. This LCD screen is used to display real time value of PWM and information for individual in-wheel DC Motors or otherwise voltage across each motor terminal.
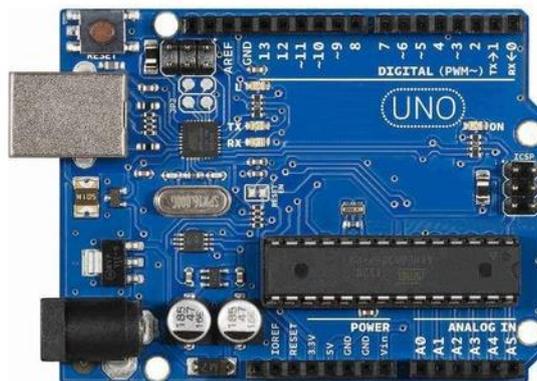
Function of each part explained below:

• **PROGRAMME MEMORY:** - kind of flash memory used to store the Arduino sketch, the memory can be stored and cleared more number of time.

• **EEPROM:** - this is ordinarily used to secure the basic data that should not be lost, even though the power supply unexpectedly stops.

• **RAM: -** Temporary or volatile memory utilized for paper execution.

• **Analog and Digital port: -** used to connect the controller and outside world. This has six Analog pins, and fourteen digital pins.

- **Central Processing Unit: -** Atmega328P microcontroller is a heart of the Arduino Uno boards. This block and executes the program.

- **Small controller** ATmega16U2 on the board makes serial communication port to software on the computer.

- **Peripherals: -** The Arduino Uno external connections are used in this paper as follows, they are

General purpose I/O Ports:

- **Port C/ pin A0**   : analog input

- **Port D**   : RX and TX pins for USB to serial port

- **Port D/digital out 3, 4, 5, 6**   : Used for LCD Display

- **ADC/digital out 6, 9, 10, 11**   : PWM output port

- **USB**   : Serial Communication

2.   Stepper motor

A stepper motor is an electrical motor that transforms electrical input in the form of discrete angular movements, sometimes known as steps, from sequence of pulses. The motor completes one step for each input pulse during this conversion, which operates on a one to one basis.

A stepper motor is an electrical motor that transforms electrical input in the form of discrete angular movements, sometimes known as steps, from sequence of pulses. The motor completes one step for each input pulse during this conversion, which operates on a one to one basis. When the stators are powered, or it moves to have the smallest possible gap with the stator (in case of a variable reluctance stepper motor). In this manner, the stators are sequentially powered to turn the stepper motor.

3.   Servo motor

We are using a 5v DC geared motor in order to provide the robot movement and for the rotation of cartridge (pen). A geared DC motor has a gear assembly to the motor in order to control its speed & it is counted. A servo motor is an electrical device which can push or rotate an object with great precision & accuracy. If you want to turn or rotate an object at some specific angles or distance, then you use servo motor. It is just made up of simple motor which run on servo mechanism. If servo motor is used is DC powered then it is called DC servo motor, and if it is AC powered motor then it is called AC servo motor.

4.   Motor driver

This L298N Motor Driver Module is a high-power motor driver module for driving & controlling DC Stepper Motors. This module consists of an L298 motor driver IC and a 78M05 5V regulator for controlling motor. L298N Module can control up to 4 DC motors, or 2 DC motors with directional and speed control.78M05 Voltage regulator will be enabled only when the jumper is placed. When the power supply is less than or equal to 12V, then the internal circuit will be powered by the voltage regulator and the 5V pin can be used as an output pin to power the microcontroller. The jumper wire should not be used when the power supply is greater than 12V and then separate 5V should be given through 5V terminal to power the internal circuit. ENA & ENB pins are speed control pins for Motor A and Motor B while IN1& IN2 and IN3 & IN4 are direction control pins for stepper Motor A and B.
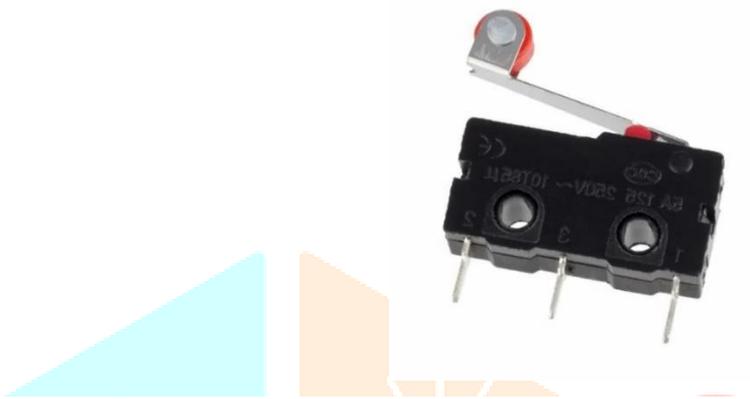
5.   Bearings

6.   Clamps

7.   Limiting switch

Actuator: A moving part (roller, plunger, whisker, or lever) that physically touches the object.

Contacts: Inside the switch, these contacts are either normally open (NO) or normally closed (NC).
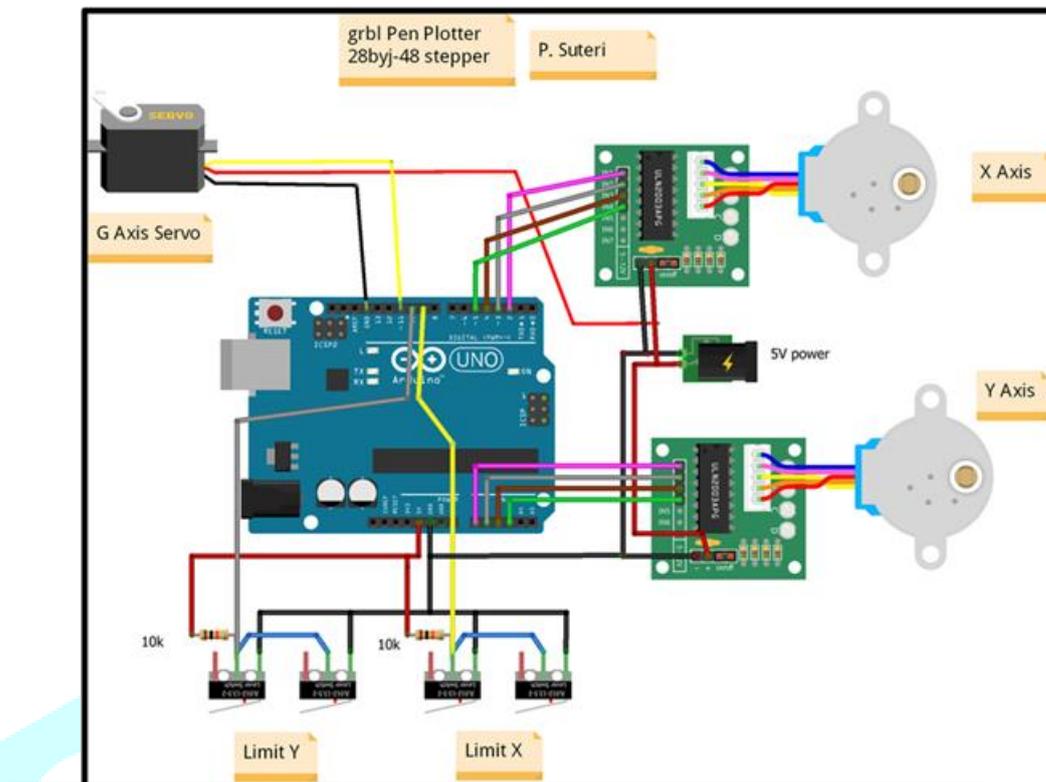
Trigger: When an object hits the actuator, it moves the internal mechanism, changing the state of the contacts (e.g., closing an NO contact or opening an NC contact).

Signal: This change in electrical connection sends a signal to control circuits, telling machinery to stop, reverse, or perform another action.

8.   Belt drive & pulley

VI. Working of machine

To complete the entire project three software is used-

• Arduino IDE

• Inkscape

• Processing

A. Arduino IDE

The Arduino Integrated Development Environment, (Arduino IDE) contains a text editor for writing code, a massage area, a text console, a tool bar with buttons for same function and series menus. It interface to the Arduino and Genuino hardware to upload programs and communicate with them.
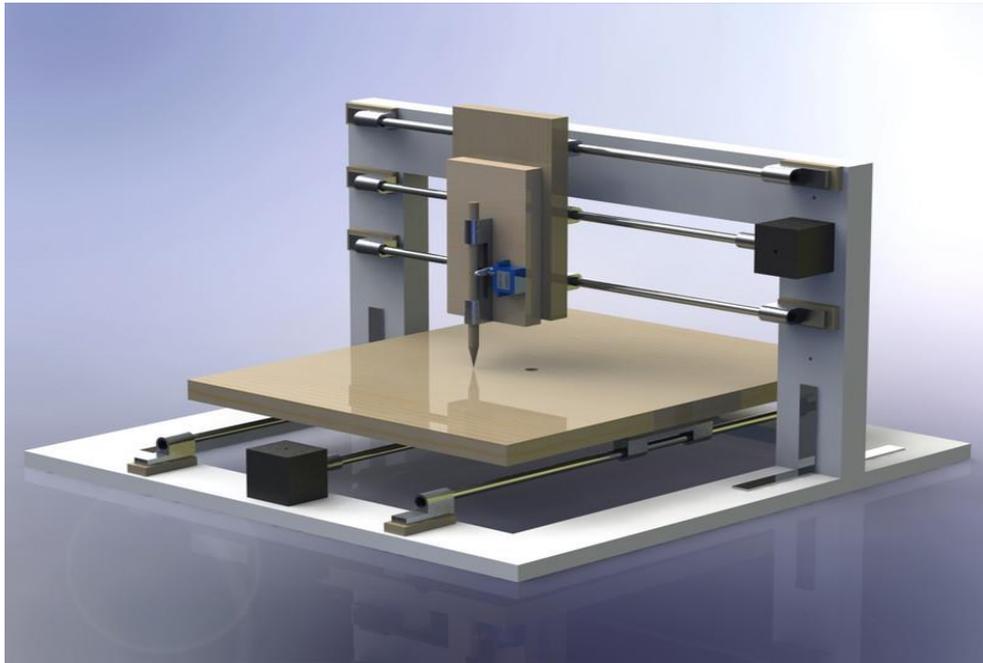
B. Inkscape

The use of Inkscape is to convert any image into graphics code that usually known as G-code. G-code formats are generated by integrating Inkscape with some necessary extension files.
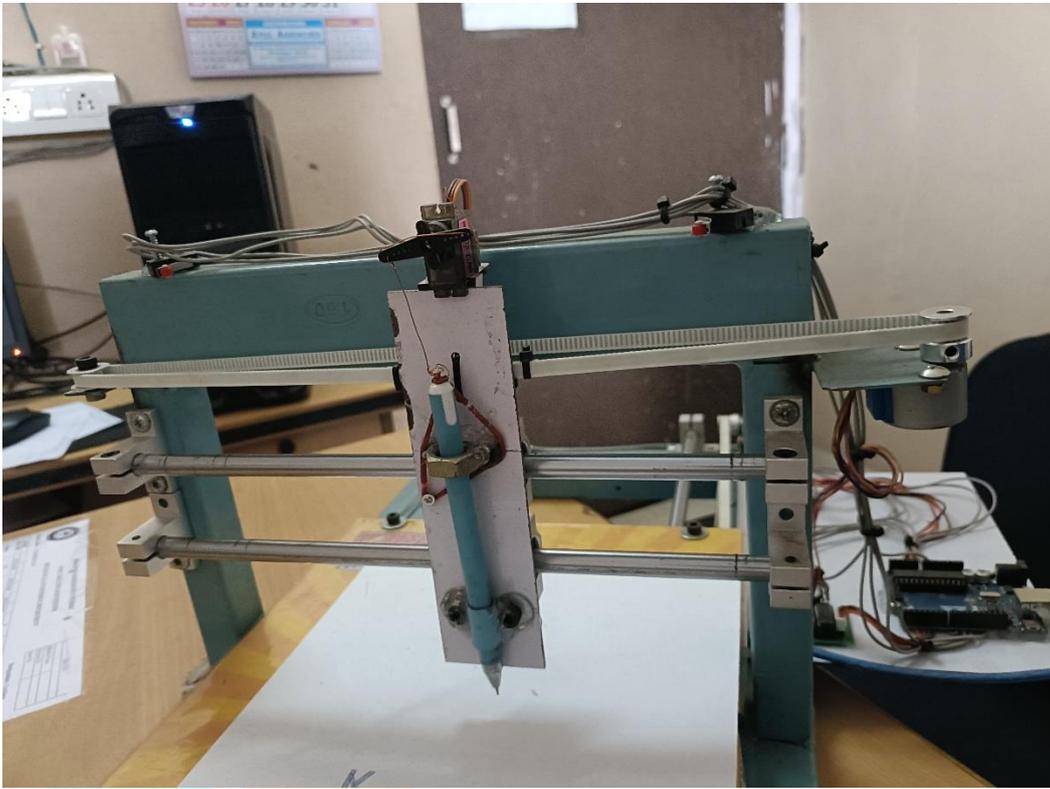
C. Processing

Processing is open-source machine programming language software which is used for electronic drawings. GTCRL processing program is required to send G-code file from user interface to CNC plotter. The port of Arduino Uno is selected by pressing 'P' button on keyboard hence 'G' button is required to Arduino. The full CNC code is uploaded in the Arduino then the Arduino will wait sometime for G-code file from processing software. When the processing software sent command to Arduino it will start plotting or drawing the G-code on 2D plane.
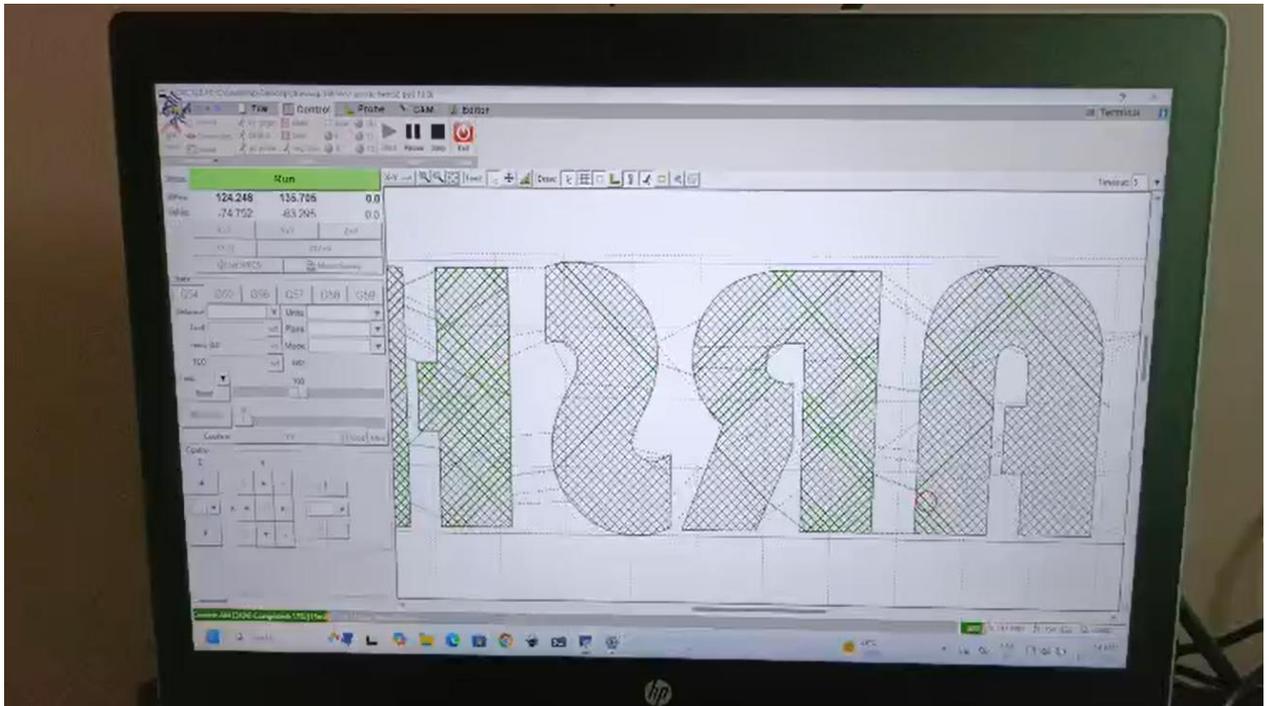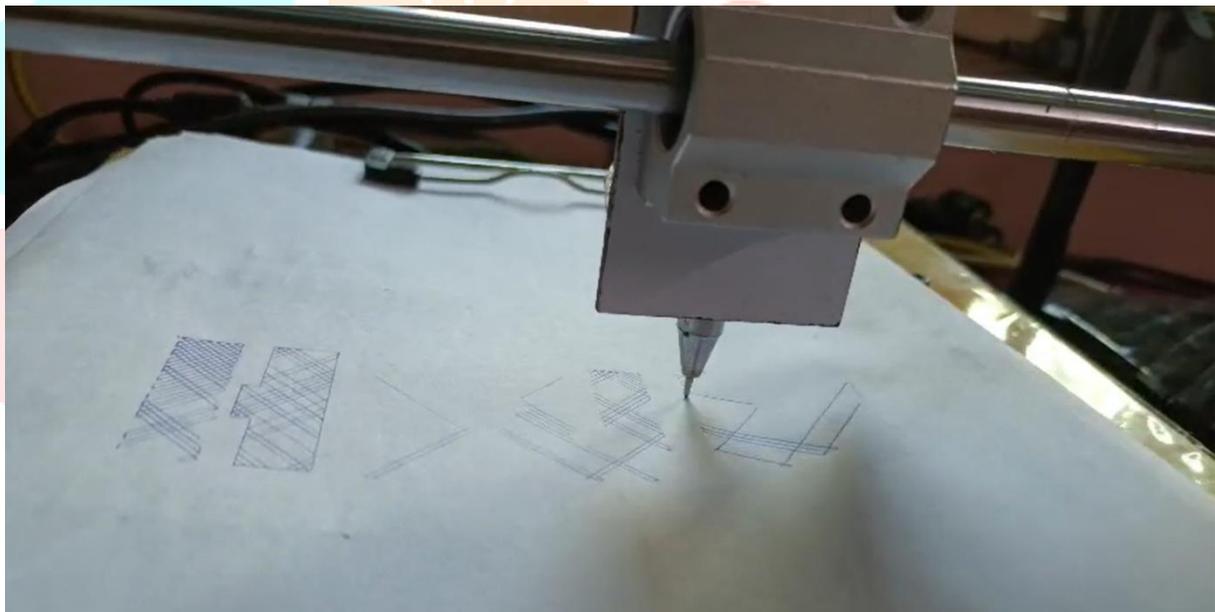
VII. Results

- Model
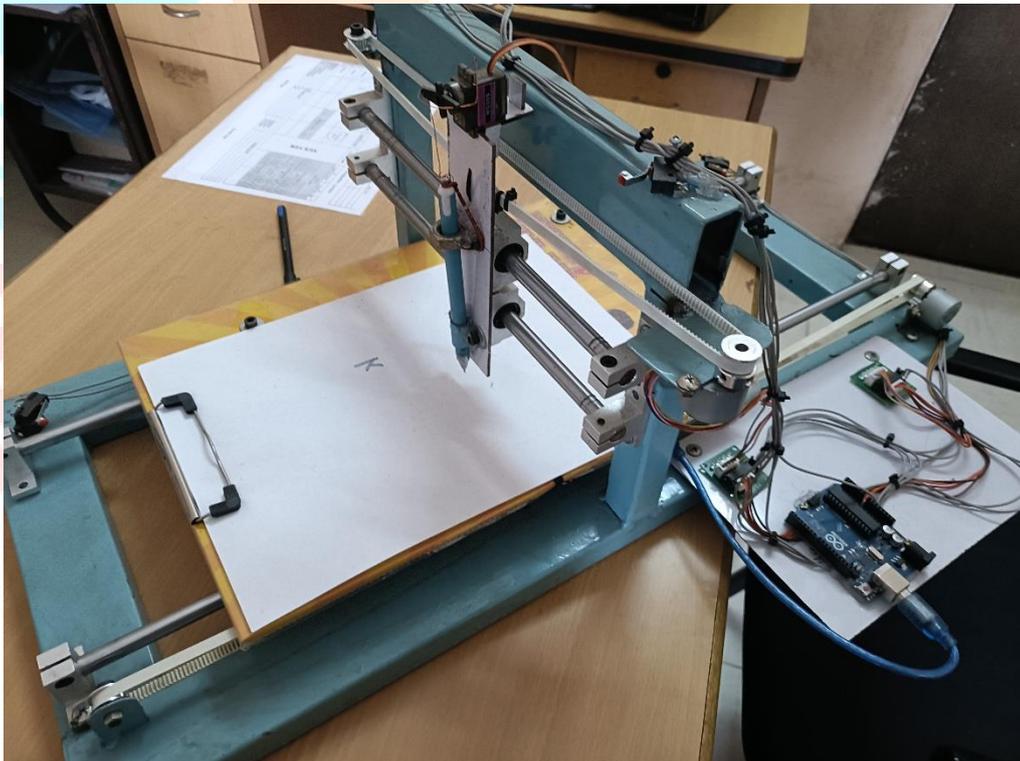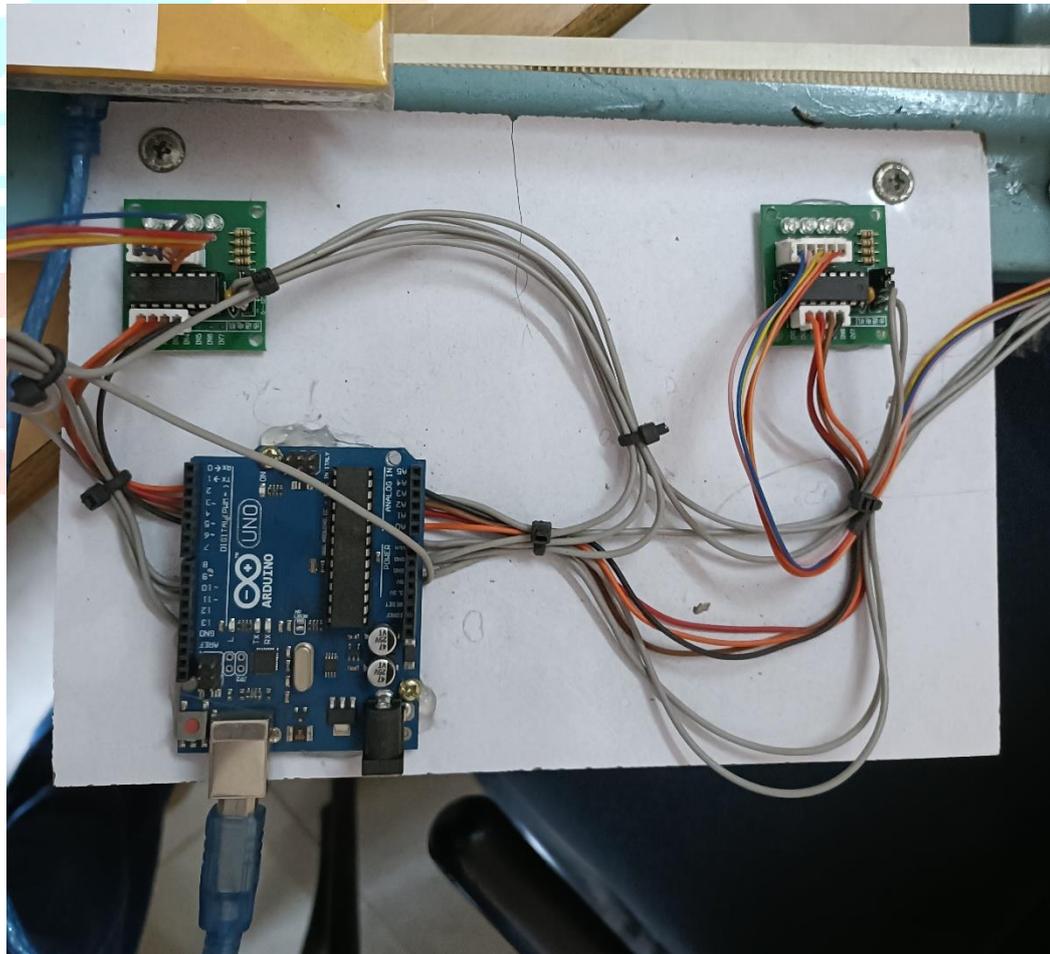
- G-code running through Phyton for output

- Output on 2d plane

Acknowledgement

Future scope

The machine can be improvised to a great extent to meet its commercial needs. The size can be enlarged and motors can be replaced with more powerful ones. Applications like laser cutting, woodcutting or milling are difficult when it is done manually, CNC machines can execute them with much ease.

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