INDIAN INSTITUTE OF TECHNOLOGY KHARAGPUR

ROBOTIC DRAWING MACHINE

A Project by

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ABSTRACT

The main objective of this project is to provide an alternate system to printing machines which is more energy effective , cost effective and portable. Moreover , this project opens the future possibility of use of robotic technology in the world of arts.This robotic X-Y plotter is a robot which provides a decent fast way to powerfully produce very large drawings. This sketching robot will be able to print by moving a marker pen or other supplementary writing device across the surface of sheet of paper. This gives us a brief idea that sketching robots or 2D plotters are vector graphic devices,(i.e. these devices are contained of tracks, that are well -defined by a starting and finishing points, alongside with further points, curves, and angles traced in the way.) rather than video display, or pixels formation graphics (i.e. it does not uses raster graphics, which is a dot matrix figure arrangement, demonstrating usually a rectangular lattice of pixels, or points of colour accessible by monitor or paper). Pen plotters can draw difficult line art, comprising texts, but also do work slowly due to motorised movement of writing devices such as pen. This can also be used to produce hard copies of Images, graphs, maps, architectural plans and even braille signs for blind people.

CONTENTS

CHAPTER - I

1.Introduction

A drawing machine is defined as a machine that draws or assists in the act of drawing. While an apparently simple definition, it is in the expression “act of drawing” that the nature of these machines is revealed. The act of drawing refers to the “slow reveal, the gradual accumulation of contours and marks into an image”. Photography and inkjet printers are certainly ways to mechanise the image-making process, but are not considered drawing machines. A drawing must be drawn.
So by the very name of our project we have made a robotic machine that draws using stepper motors to make precise shapes on paper, combining the precision of a computer-controlled motor with the analog quality of a motorised movement of writing device such as a pen.

1.1. Motivation

At Present the printing machines are very costly , need high maintenance and very high energy sources. Also their work cannot be considered as drawing. In a world where humans are struggling with an energy crisis and where we think that we may fight a World War for energy resources, we cannot afford to waste energy over things which cannot provide us complete satisfaction. And humans creating a perfect drawing require a lot of practice, time and effort.

So , humans do need innovation in this field. An innovation which is cheaper and can work efficiently. An innovation which doesn’t lose the definition of drawing and can perform most of the tasks that a printing machine can do.

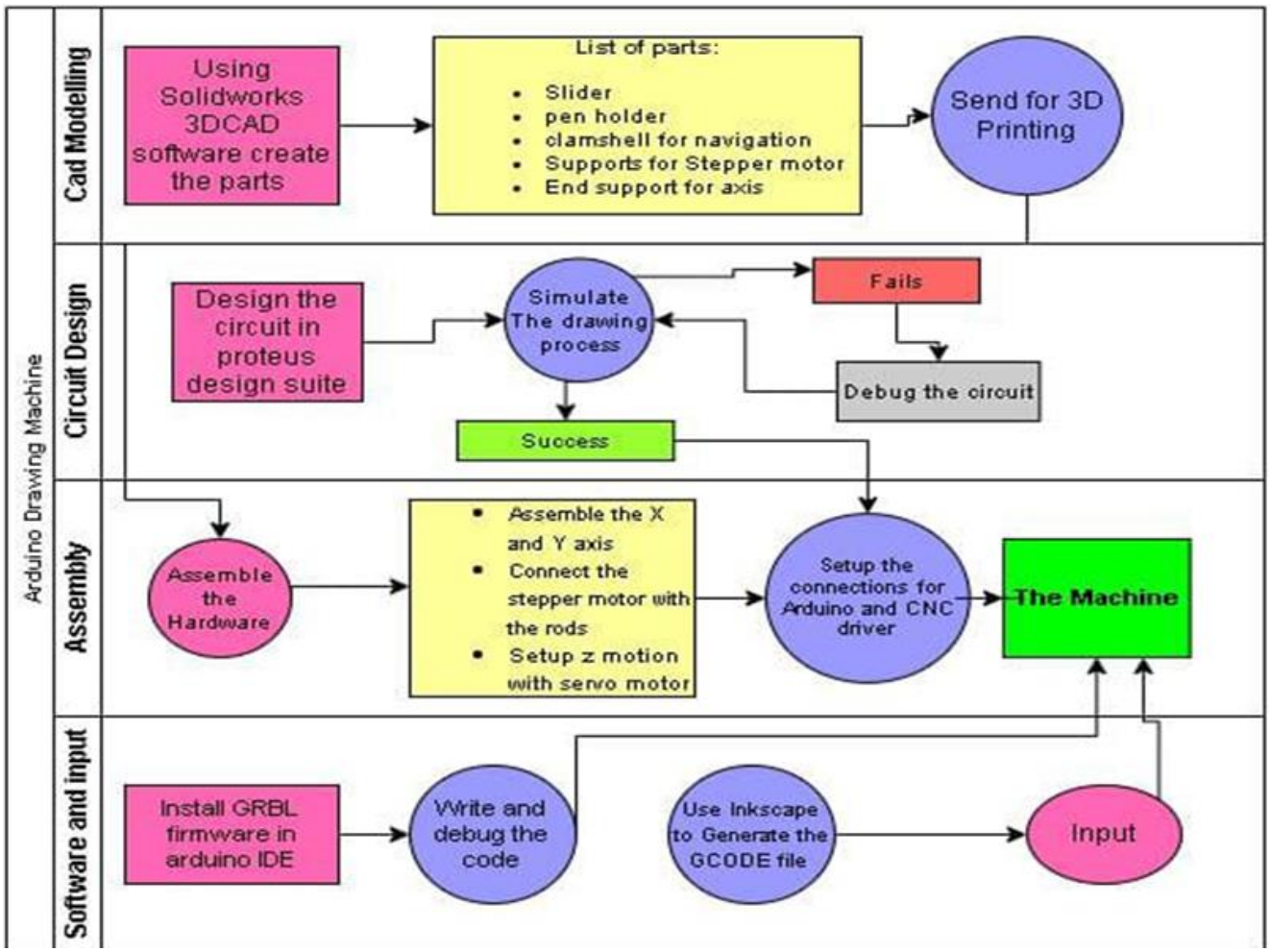
Robotic Drawing Machine is the perfect solution for this.

1.1.1. Remarks

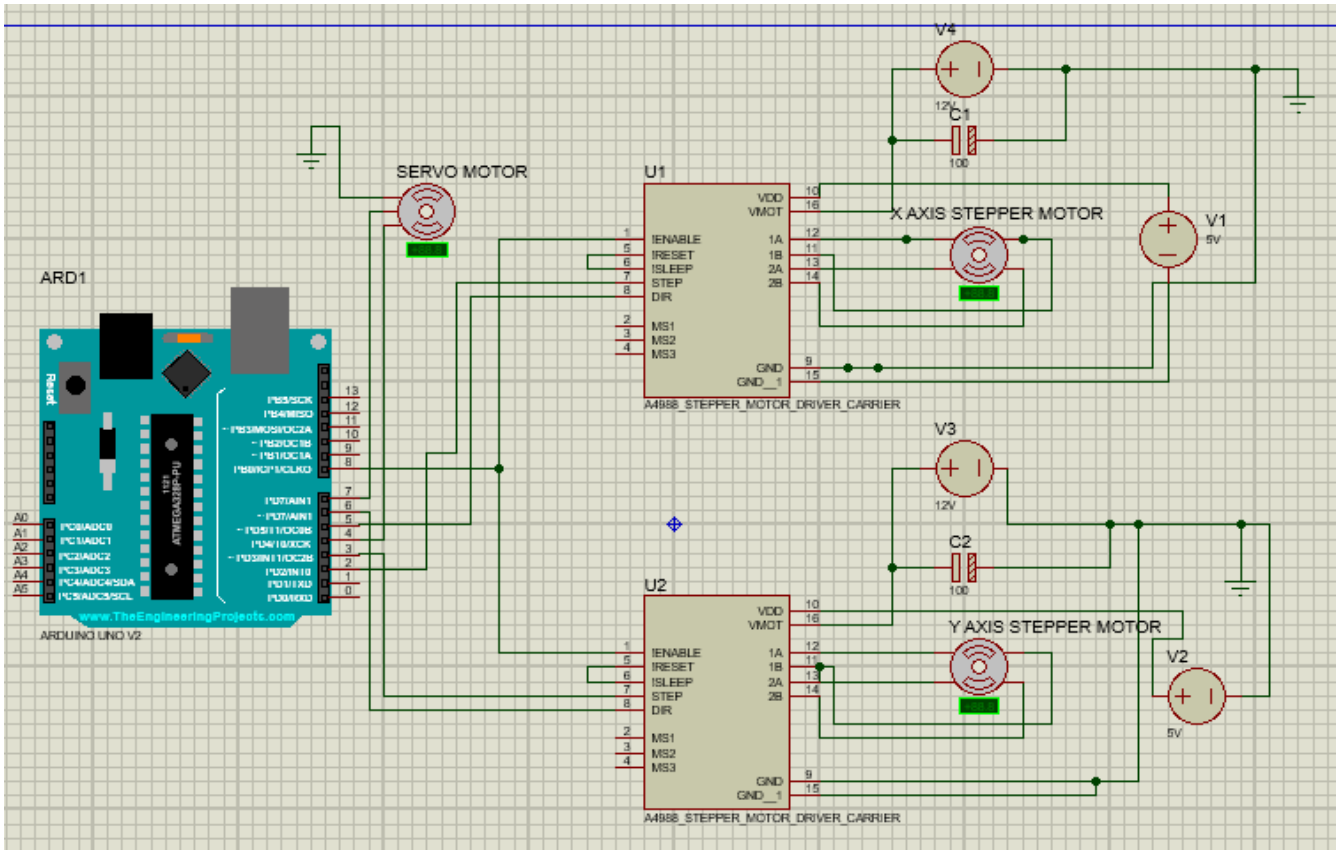
The project that we have developed can create sketches and any writing material perfectly with proper commands. With some more upgrades like providing arms for each colour in both axes and the same for paint brushes , we can make it do everything that a printing machine does. There is a high possibility that such devices with AI and some guidance ,may create completely new art pieces as humans do.

CHAPTER-II

2.0 Work flow Diagram

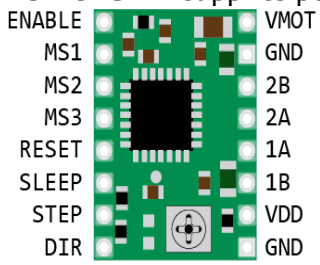


2.1. CIRCUIT



For building the machine we will need to control a bunch of stepper motors. And having one Arduino control all of them can take up a lot of the processing and not leave you a lot of room to do anything else; So we use a self-contained dedicated stepper motor driver – A4988. It can control both speed and spinning direction of a bipolar stepper motor like NEMA 17 with just two pins.

- VDD & GND is used for driving the internal logic circuitry which can be 3V to 5.5 V.
- VMOT & GND supplies power for the motor which can be 8V to 35 V.



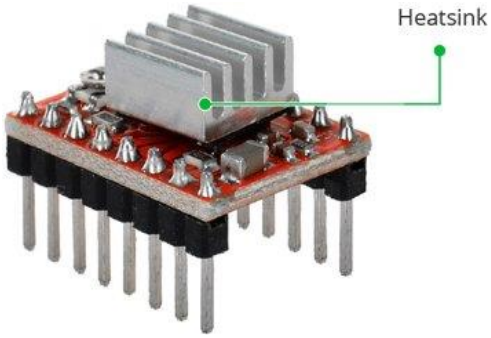
- MS1,MS2,MS3:

The A4988 driver allows microstepping by allowing intermediate step locations. This is achieved by energising the coils with intermediate current levels.
The A4988 driver has three step size(resolution) selector inputs viz. MS1, MS2 & MS3 .
By setting appropriate logic levels to these pins we can set the motors to one of the five step resolutions.

STEP input controls the mirosteps of the motor. Each HIGH pulse sent to this pin steps the

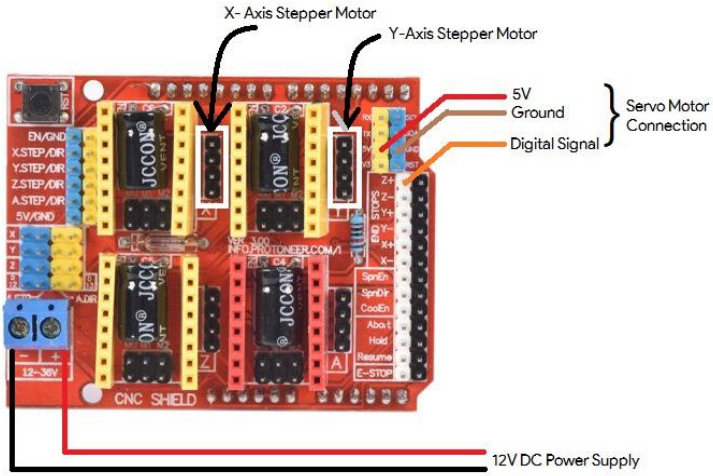
motor by the number of microsteps set by Microstep Selection Pins. The faster the pulses, the faster the motor will rotate.

DIR input controls the spinning direction of the motor. Pulling it HIGH drives the motor clockwise and pulling it LOW drives the motor counterclockwise.
If you just want the motor to rotate in a single direction, you can tie DIR directly to VCC or GND accordingly.



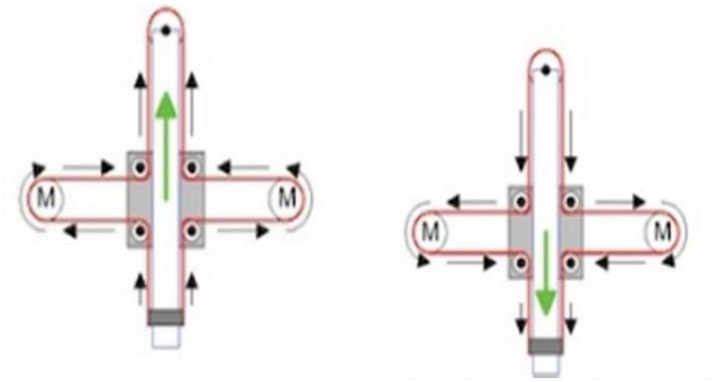
Excessive power dissipation of the A4988 driver IC results in the rise of temperature that can go beyond the capacity of the IC, probably damaging itself.
Even if the A4988 driver IC has a maximum current rating of 2A per coil, the chip can only supply approximately 1A per coil without getting overheated.
For achieving more than 1A per coil, a heat sink or other cooling method is required.

Arduino CNC shields provide an Arduino microcontroller with the power necessary to drive stepper motors and run all the other functions that contribute to the machine's operation. Depending on the shield, this could include end stops, spindle speed control, and probing.
The CNC shield connects all the components of the circuit and facilitates the working of several components together, thus eliminating the need to control the stepper motors separately.

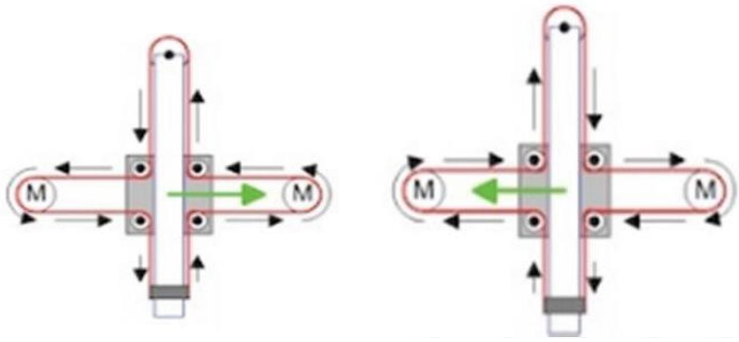


The connection to the Arduino and the motors is established by the corresponding terminals on the CNC Shield as shown.
We will use an AC to DC convertor adaptor cable which gives 12V DC output to give power to the machine.

MECHANISM OF MOVEMENT

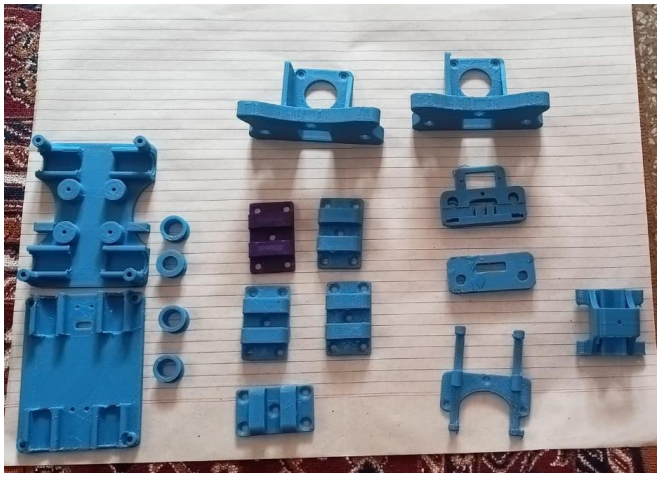


Rotating the 2 stepper motors in opposite directions moves the Pen along the Y axis due to shortening of the cable on one side and increase in length on the other side, thus pushing the Y-Axis Gantry in the required direction.



Rotating the 2 stepper motors in the same sense(Both clockwise or both anticlockwise) moves the Pen along the X-axis by moving the carriage in the required direction.

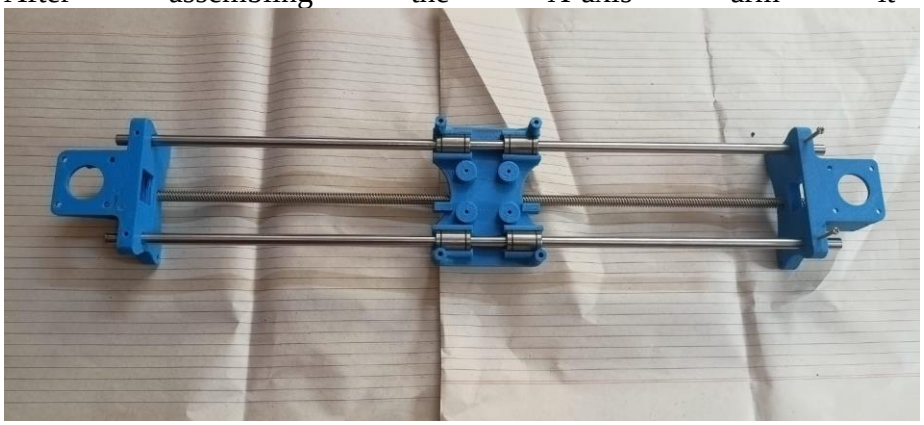
2.2.MODELLING



We 3D printed following parts

1.ARMS

After assembling the X-axis arm it looks like



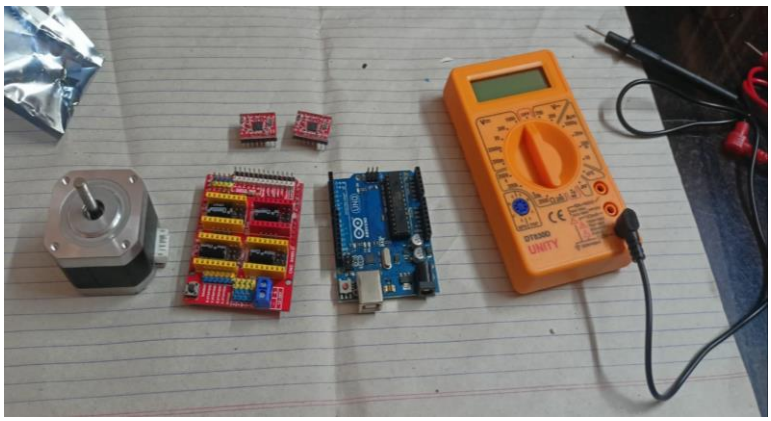
The rods have been inserted and secured in their appropriate positions. The Y-axis Gantry was also assembled in a similar manner.

The threaded rod in the middle has been used to keep the 2 stands and stepper motor holders in a fixed place. This ensures that the length of the rod on which the carriage moves while drawing is constant.

2.BEARINGS

The LM8UU bearings have teeth as seen here which prevents smooth movement of the carriage and moves it in the steps. This allows the correct positioning of the pen according to the input image of short steps. The linear bearing fits into the M8 Steel Rods.

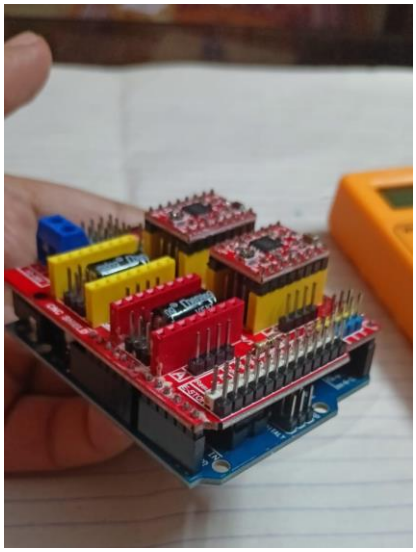
3.ARDUINO AND STEPPER MOTOR



Before using the Arduino to run the stepper motors through the stepper drivers, it was necessary to configure the Stepper driver such that the Maximum current per phase of the stepper motor is not more than 1A. This was done by using a small screwdriver to turn the Potentiometer screw present on the Stepper driver and measuring the reference voltage using the multimeter. The value of Vref is adjusted according to the equation:

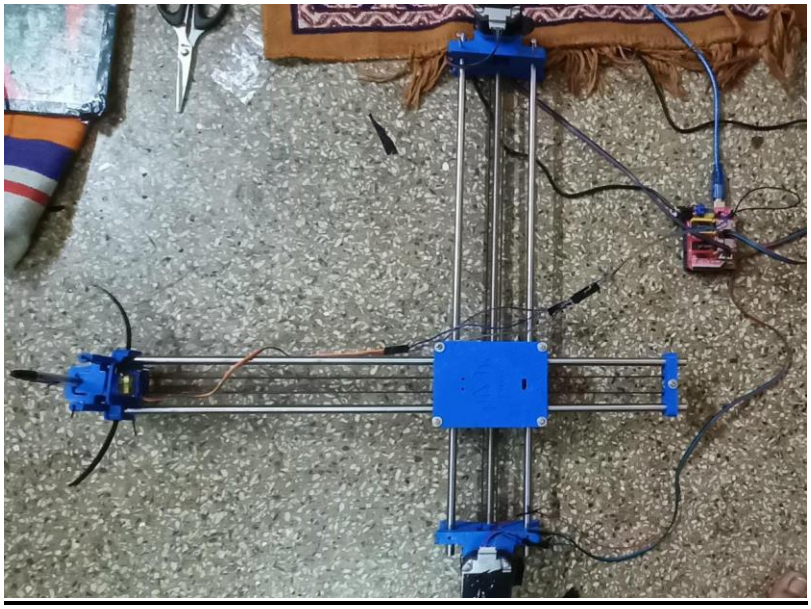
Current Limit = Vref x 2.5

Vref is the potential difference between Potentiometer pin and the VDD pin on Stepper driver



Here we can see the connections of the stepper motor driver with CNC shield and the Arduino Uno board. The CNC shield fits on the Arduino Uno making connections to the required terminals.

2.3. FINAL MODEL



After assembling the final model it looks like this.

How to use the machine

Inkscape software has been used to generate the GCODE from normal jpg/png image formats. There are 2 types of Gcode that the machine operates on :

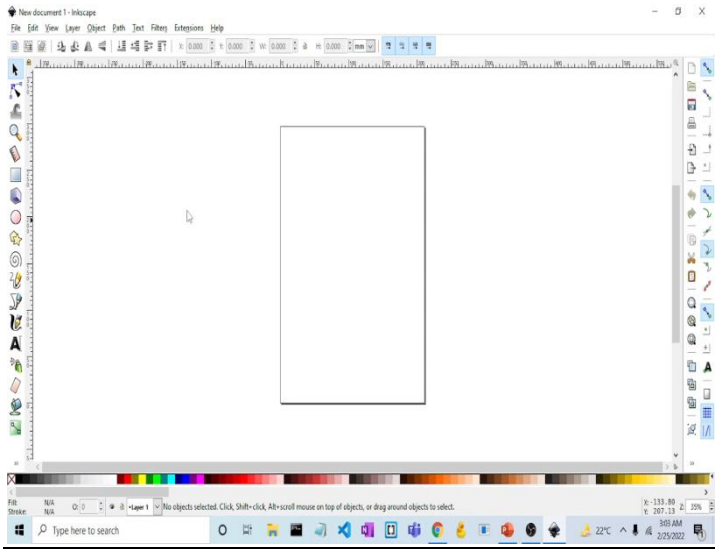
Raster Mode:

In raster mode the machine will scan the whole drawing area from [0,0] till the end line by line. Raster mode is slow and takes more time

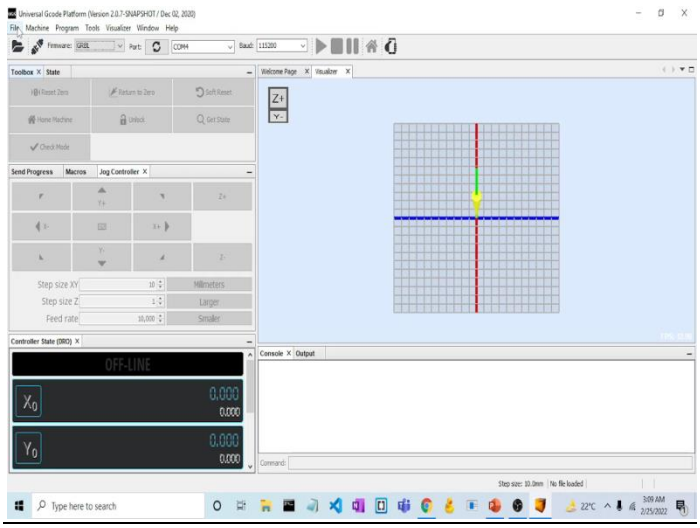
Vector Mode:

In vector mode the machine will scan the only the drawing area where lines are there. Vector mode drawing takes less time

The machine uses Core-XY mechanism which is commonly used in 3D printers. It involves 2 motors which rotates in specific directions and with the required speeds to facilitate movement of the pen along the 2 axis. The essence of this mechanism is that the 2 motors together brings about the motion of the pen along one axis.

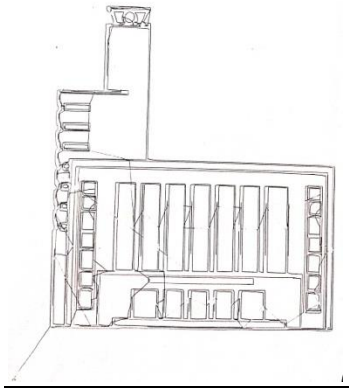


This shows the process of generating the Gcode file using an extension in Inkscape software. Here we have generated a vector gcode.



After connecting the Arduino Uno and uploading the GRBL firmware, the Universal Gcode Sender software is used to send the gcode commands to the device.

Some of the paintings and a signature drawn by our machine



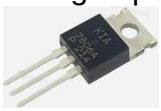

Kolkata
India

2.4. CHALLENGES

The major challenge was assembling and finding or creating proper parts. As our meet couldn't be arranged offline because of large distances between our living points. So, the best possible solution was one guy doing the task and others being present on a Video Call to give him the best possible assistance. Even after this, assembling was a hectic process because we were not experts in handling hardwares.

Another major challenge was to get all the parts. First we made two lists. One for parts which we'll buy . One for which we'll 3D print. In the first list getting 624ZZ radial ball bearings was tough and tough is just an understatement. Offline it wasn't available. Somehow after searching and waiting a lot we found it Online. In the list of 3D printed parts we committed mistakes in dimension then we corrected them by screwdriver.

Initially we tried to use the 5V power provided by the Arduino board to control the servo motors which would lift the pen holder.But this idea failed as we needed a stronger power source for the servo motor to hold up the pen. So we used this



LM7806 IC which gives 6V Power output from the total voltage connected across its 2 terminals .It was soldered into the terminals of the 12V power source, directly tapping power from it for running the servo motor.

CHAPTER-III

3.1. CONCLUSIONS

The Arduino based XY drawing Robot using atmega 328P microcontrollers is used in the arduino board which is used to draw fast and efficient drawings or pictures which can be taken from source converted to Gcode format given as a input. The input is fed in to the input port of the micro controller. Stepper motors are used to set the position of the pen to the origin and a servomechanism used to lift and the which displays the output on the paper. So we can easily draw the critical images also with less time.

It has been a great pleasure for us to work on this exciting and challenging project. We learnt many new things about cad modelling,3-D printing , tinkercard, circuit designing and coding . We also learnt the essence of teamwork and wonders by it.

3.2 CONTRIBUTIONS

SMARAK- Circuit designing , Hardware Assembling
DEVENDRA-CAD modelling
ABHISHEK- Coding and Software of the device
SHIKHARA- Circuit designing

3.3 FUTURE IDEAS

- We are Planning to build a system that allows automatic writing of text on paper by dictation, in a specified handwriting. A Speech to Text Neural Network Model will be used to generate the text from speech signals. This can be used to generate the gcode file for writing.

We also have an idea for a modification which allows drawing/writing in multiple colours by changing the pens used

ACKNOWLEDGEMENTS

First of all we thank this INSTITUTE for providing this opportunity for us to learn many new things and ideas. Thanks to our Professor Ganguli mam for giving us an introduction to all the required tools and guiding us through the project and providing us her valuable input along the way.