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NATIONAL INSTITUTE OF BUSINESS MANAGEMENT
HIGHER NATIONAL DIPLOMA IN SOFTWARE ENGINEERING
COURSEWORK TWO

ROBOTICS APPLICATION DEVELOPMENT

Title of the Project
Mini CNC Plotter

SUBMITTED BY

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Date of Submission: 2024.02.01

DECLARATION

"We certify that this project does not incorporate without acknowledgement, any material previously submitted in any institution and to the best of my knowledge and belief, it does not contain any material previously published or written by another person or myself except where due reference is made in the text."

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SUMMARY

The project involves the construction of a mini-CNC plotter 2D printing machine designed to automate and enhance precision in drawing tasks. The purpose is to provide an efficient alternative to manual plotting operations, supporting various tools like pens, laser cutters, or milling cutters for applications such as PCB design and logo creation.

The specific requirements include precision, CNC capabilities, compatibility with different plotting surfaces and tools, appropriate size and workspace, speed, efficiency, user-friendly interface, and durability.

The X and Y axes use stepper motors from DVD/CD drives, while the Z-axis employs a servo motor for pen movement. The Arduino-based circuit incorporates an ATmega328 microcontroller and L293D motor shield. The entire assembly is powered by a 5V-2A power supply.

The building process involves disassembling DVD/CD drives, soldering cables to stepper motors, connecting the motor shield to the Arduino board, and assembling the structure with 3D printed parts. The programming aspect involves using G-code, a CNC machine language. Inkscape software and a G-code library are used to convert images into G-code, which is then sent to the machine via Universal G-Code Sender.

The resulting CNC plotter offers an automated and cost-efficient solution for precise 2D drawing applications, with flexibility for various tools and materials.

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CHAPTER 01

1.1 Introduction

This project utilizes the components salvaged from 2 DVD/CD ROMs to create a compact and efficient CNC plotter.

The X and Y axes are driven by stepper motors and rails, offering precise control over a printing area of up to 4x4cm.

To bring your designs to life, the process begins by converting image or text files into G-code using the Inkscape software.
This G-code, which represents the instructions for the CNC plotter, is then fed into the machine using Processing software.
This two-step software workflow provides a user-friendly interface for translating your creative ideas into tangible results.

At the heart of this project is the Arduino Uno, featuring the ATmega328P microcontroller. The Arduino Uno acts as the control device, seamlessly converting the G-code into a set of machine language instructions.
These instructions are then sent to the motor drivers of the CNC plotter, orchestrating the precise movement of the stepper motors along the X and Y axes.

1.2 Features of the Product

Compact Size:
Mini CNC plotter machines are generally designed to be compact and portable, making them suitable for small spaces or on-the-go use.

Dual DVD Drivers:
The use of two DVD drivers indicates a dual-axis system, allowing for movement along both the X and Y axes. This configuration enables the machine to move in two dimensions, facilitating precise plotting or drawing.

Drawing/Plotting Capabilities:
The primary function of the mini-CNC plotter is to draw or plot designs on a flat surface. This could be done using various tools such as pens, pencils, or markers.

Control System:
The machine would likely be equipped with a control system, either through a computer interface or a dedicated control panel. This allows users to input designs and control the movement of the CNC plotter.

Material Compatibility:
The mini-CNC plotter should be capable of working with various materials such as paper, cardboard, or thin sheets, depending on the specific design and construction of the machine.

Precision and Accuracy:
The CNC plotter is expected to offer a reasonable level of precision and accuracy in its movements, ensuring that the plotted designs match the intended specifications.

Ease of Use:
User-friendly features, such as simple setup procedures and intuitive control interfaces, may be incorporated to make the mini-CNC plotter accessible to a wide range of users.

CHAPTER 02

2.1 Problem Identification

a. Identifying the purpose of the construction.

The purpose of the construction of a CNC plotter 2D printing machine is to provide an efficient and automated alternative to manual plotting operations. Unlike traditional printers, CNC (Computer Numerical Control) plotters use a computer-controlled mechanism to guide the movement of a pen or other drawing tool across the material, creating accurate and intricate 2-dimensional drawings.

The machine is cost-efficient, and once set up, it can operate autonomously, reducing labor costs and potential errors associated with manual work.

The plotting operation can be replaced by any other tool like a laser cutter or milling cutter.

It can be used for purposes such as PCB Design, logo design, etc.

b. Identifying specific requirements.

Precision and Accuracy: This ensures that the plotted drawings match the digital designs exactly.

Computer Numerical Control (CNC): The machine must have a CNC system that allows it to interpret digital designs and convert them into precise movements of the plotting tool.

Plotting Surface: The machine should be capable of working with various plotting surfaces such as paper, cardboard, fabrics, or other materials based on the requirements.

Tool Compatibility: Depending on the intended use, the CNC plotter needs to support different plotting tools, such as pens of various thicknesses and other tools like a laser cutter or miller cutter based on the specific application.

Size and Workspace: The size of the plotting area and the overall dimensions of the machine should be suitable for the intended applications. Larger workspaces are needed for producing bigger drawings.

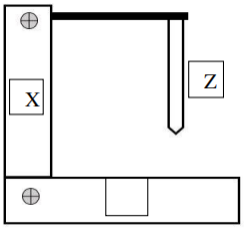
Speed and Efficiency: A balance between speed and precision is crucial. The machine should be able to produce drawings efficiently without compromising accuracy.

Ease of Use: The user interface should be user-friendly, allowing easy uploading of digital designs, setting parameters, and initiating the plotting process.

Maintenance and Durability: The machine should be robust and durable, requiring minimal maintenance to ensure consistent performance over time.

2.2 Research and Design

For the X and Y axes we will use 2 stepper motors and rails from DVD/CD drives and for the Z axis we will use a small servo motor that moves the pen up and down.
A pen is connected to the Y-axis and Z-axis is used to make pun up & down.



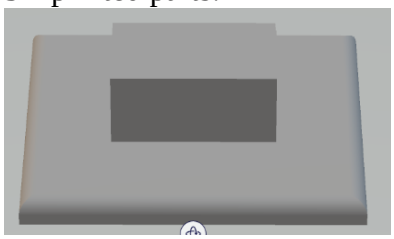
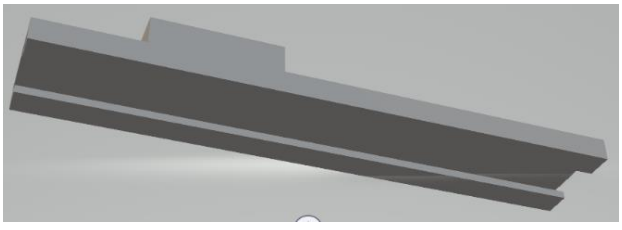
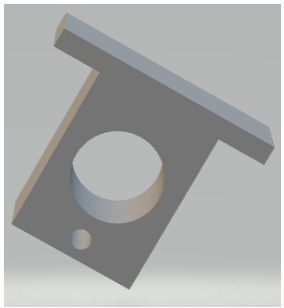
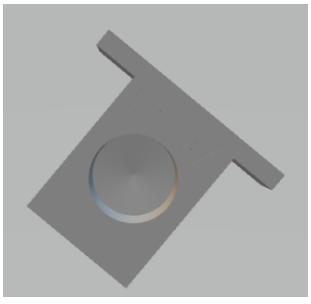
The Arduino-based circuit is using the ATmega328 microcontroller, L293D motor shield and a USB to serial module.

As name suggest plotter machine obvious draw or plotting a drawing as per given instruction. To give instruction to machine what to draw a special type of code called G-code is required. Image will be converted to G-code with the help of special type of software.
Afterwards this G-code sends to the controller and controller commands motors how to move.
As result, the machine will draw images on paper.

Components

(2) Old DVD/CD Drives
(1) ARDUINO UNO R3
(1) L293D Motor Shield
(1) Servo SG 90
Jumper wires
Power Supply(5V-2A)

3D printed parts:

2.3 Building the Robot

Steps

Disassemble the DVD/CD drives and take off the stepper motors.
Use the screwdriver to open and take off the rails.

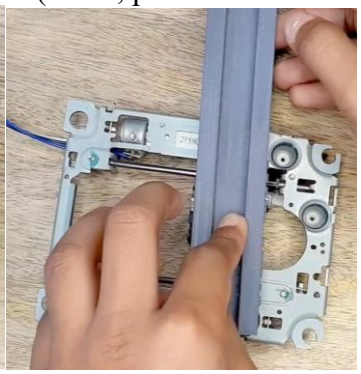
Now that we have the 2 stepper motors, we need to solder some cables on them.
We need to find the correct combination to drive and use them correctly, so take a multimeter with alligator clips and put it on "short-circuit" function.
Usually, the first and second cables close the circuit - the LED is turned on and a beep sounds - this means that we have found the first phase-motor of stepper motor.
The other two cables, third and fourth, use the second phase-motor of stepper motor.
(In my case, one of stepper motors uses the first and third cable for first phase-motor and the second and forth cable for second phase-motor.)

In this way I have 2 stepper driver mechanism.

Remove yellow jumper from L293D motor shield.
Then connect the L293D motor shield to Arduino uno board.
To connect the power supply, connect red wire of power supply to the motor shield's VCC pin and blue wire to the ground pin.
Then connect the stepper motor to the L293D motor shield's M3 & M4 connector pins.

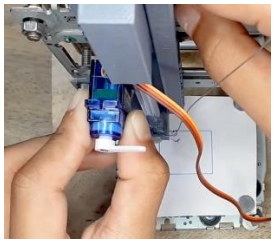
Then mark holes on DVD drive case to make arrangement for mounting for both stepper motor mechanism.
After drilling the holes in DVD drive case, fix the four M4 X 60 nut bolts at the 4 corner of stepper motor mechanism.
Then placed the stepper motor mechanism to its place and secure all 4 bolts with M4 nuts.

Fix the 3D printed parts (slider, plotter surface base) like in below images.

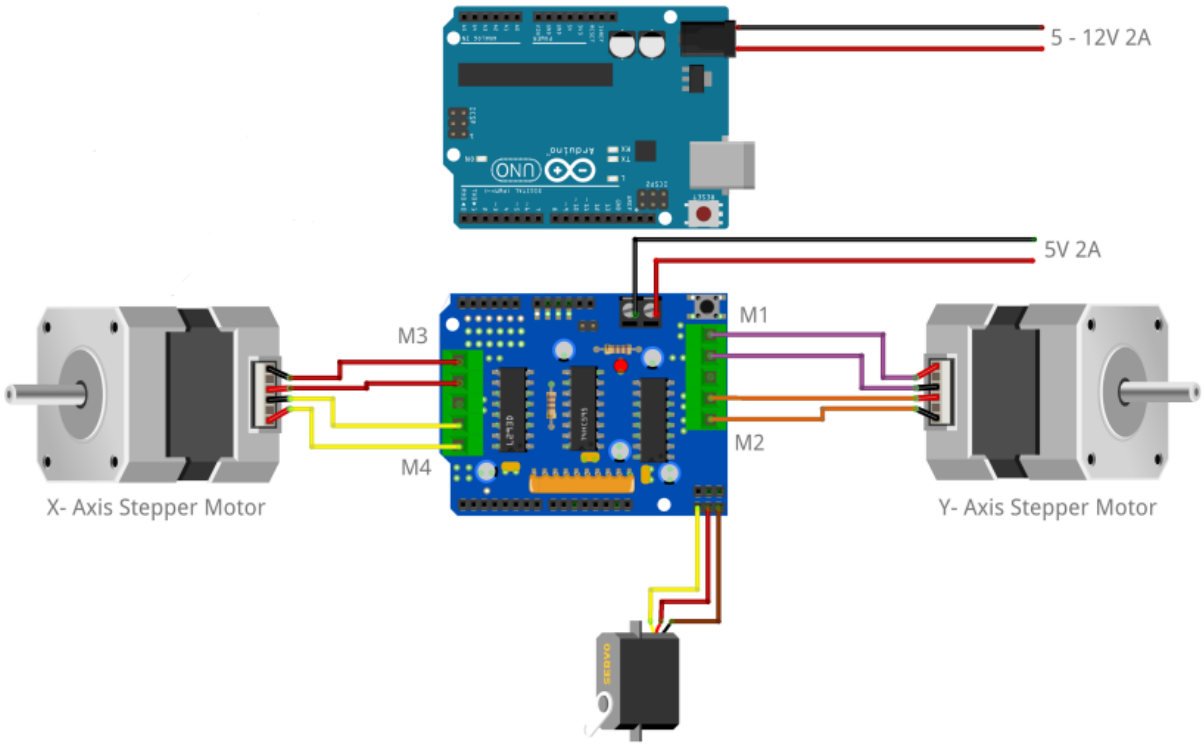


Take a spin (from bold point pen) and place it inside the 3D printed pen hole. And then fix it with our 3D printed slider.

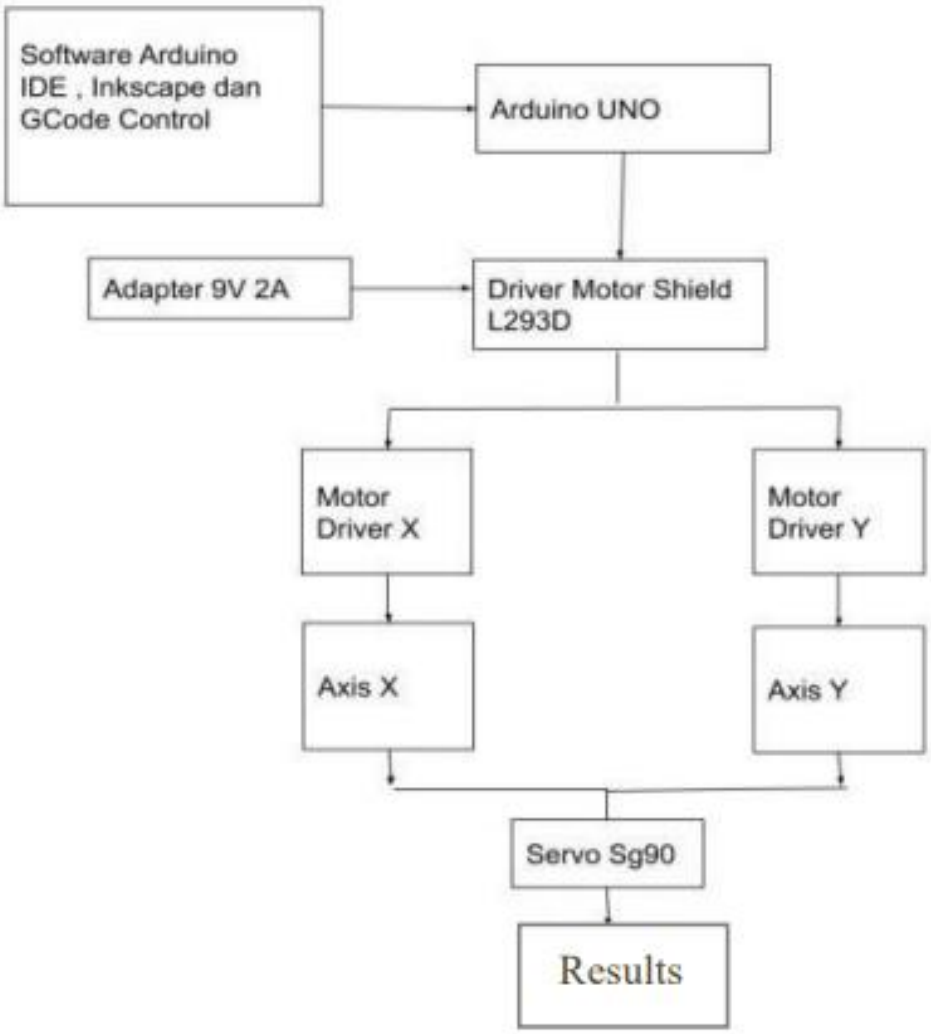
Take Servo motor and glue it to our 3D printed slider.



Here is the wiring diagram:



2.4 Programming



G-Code & Inkscape

In this project we are using Inkscape software and G-code library to generate G-code of image.

G-code is the language of CNC machine.

Download Universal G-Code Sender:
https://winder.github.io/ugs_w ebsite/download/

To make G-Code files that are compatible with this CNC machine you must use the Inkscape. Inkscape is professional quality vector graphics software which runs on Windows, Mac OS X and Linux.
Inkscape uses the W3C open standard SVG (Scalable Vector Graphics) as its native format and is free and open-source software.
Download the Inkscape:
https://inkscape.org/en/

CHAPTER 03

3.1 Results of the operation

The CNC plotter machine, constructed from 2 DVD/CD drives and an Arduino-based circuit, successfully achieved its purpose of providing an automated and efficient alternative to manual plotting.

It met specific requirements, including precision, CNC capability, versatility in plotting surfaces and tools, suitable size, speed, ease of use, and durability.

The construction involved stepper motors for the X and Y axes, a servo motor for the Z axis, an Arduino circuit with L293D motor shield, and carefully assembled 3D printed parts.

The machine's operation relied on G-code generated through Inkscape, and the Universal G-Code Sender facilitated the execution of accurate 2D drawings.

Overall, the CNC plotter demonstrated a seamless integration of hardware and software components, offering a reliable solution for diverse 2D drawing applications.

CHAPTER 04

4.1 Limitations, Recommendations

Limitations

We can’t change the pen in our project because we glued it.

Stepper motors are getting heated if we supply more than 5V.

CNC plotter's drawing area limits the creation of larger-scale designs because our printing area of up to 4x4cm.

Achieving a balance between speed and precision pose challenges, especially for intricate designs.

The machine's compatibility with specific materials might be limited.

Recommendations

Enhanced Tool Handling: Implement features allowing for easy interchangeability of tools, improving the machine's adaptability for diverse applications.

Expandable Workspace: Consider designs that allow for modular expansions to accommodate larger drawing sizes.

User-Friendly Software: Develop or integrate more user-friendly software interfaces to simplify the process of converting digital designs into G-code.

Material Compatibility Research: Explore options to enhance the machine's compatibility with a broader range of materials, expanding its usability.

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