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Arduino Based CNC Pen Plotter

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Abstract
With the advanced technology, demand for Computer Numerical Control (CNC) plotter machines in Educational Institutions and Laboratories is rapidly rising. The low-cost manufacturing of Printed Circuit Board (PCB) has become a basic need in electronics laboratories. The CNC XY Plotter is used to plot two dimensional continuous or discontinuous data on a rectangular coordinate system. This paper is done to fabricate a XY plotter using independent motion along X-direction and Y-direction, and microcontroller system (Arduino) to control those motions. At first, the user needs to convert any image file into G code using Inkscape software and then feed it to the machine using Processing software or Universal G-code sender.
Keywords: Computer Numerical Control, Inkscape, Arduino, Machine Language, G-code, stepper motors

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I. INTRODUCTION

The use of technology in education has become more. However, the cost related with the advanced technologies is very high. Computers, softer and the interface which is available between the hardware and software has taken education a step ahead of the old days were visualization, verification was not so very easy. All those can be achieved through the machines that are controlled by computers such as CNC machines. The computer numerical control is an advanced form of softer automation developed to control the motion and operation of machine tools.

Today's industry requires producing large quantity and quality products with low production and installation cost. These tasks can be easily completed by machines that are controlled by computers to make work easier with ultra-precision and less human-caused errors. These are commonly known as CNC Machines. The CNC stands for Computer Numerical Control. Different CNC machines cover an extremely large variety. Their numbers are fastly increasing, as technology development advances. The fabrication of a low-cost CNC machine is used to reduce cost and complexity.

CNC Machining is a process used in the manufacturing sector that content the use of computers to control machine tools. Tools that can be controlled easy in this manner include lathes, mills, machines, and grinders. The CNC stands for Computer Numerical Control. Inspiring from this CNC technology and revolutionary change in the world of digital electronics & Microcontroller, we are presenting here an idea of a CNC pen plotter using custom-built PLC. The idea behind this paper is to make a small CNC machine that can draw images or pictures on the surface which can be a paper or anything. It uses two stepper motors as linear actuators mounted on each axis X & Y. While printing/drawing, the proper synchronization of this entire two-axis i.e. stepper motors, is the most challenging task.

A Plotter is a special type of printer that uses a pen to draw images on any solid surfaces. In Computer Numeric Control (CNC), the microprocessor is used which is capable of processing logical instructions communicate with a computer. The logical instructions are provided by using a computer in the form of code or text or image which is then converted into a machine language by the microprocessor to be executed by the machine. A CNC plotter machine is a 2D plotting machine that uses a pen to draw text or image on any given solid surface. It can be used for purposes such as PCB Design, logo design, etc. This technique is based on the

CNC plotter machine. With the increasing demand for the use of CNC plotters in universities as well as in laboratories, a cheap and less complex design is an absolute need. The components used for the plotter in our paper are easily available at a very low price and spare parts are also used. The construction is very simple and robust.

II. LITERATURE SURVEY

A modern era of manufacturing and production, computer numerical control, or CNC, goes back to the 1940s when the first Numerical Control (CNC) machines emerged. However, turning machines appeared before then. In fact, a machine used to replace old handcrafted techniques and increase precision & accuracy was invented in 1751. It would be unique until the concept would take on the capabilities of a modern CNC production company.

Venkata Krishna and Pabolu A let designed and implemented a two-dimensional CNC machine in the month of November 2010. It elevates the requirement for adaptability and cutting-edge quality. On the.NET platform, visual C# was used in this system. There are three primary categories of computerised numerical controllers in this:1. ASIC- equipped multiprocessor 2. Front end of a computer. 3.A PC and motion control card. This system's layout is user- friendly, provides accurate results, and is adaptable for users. RTOS is extremely expensive, not user-friendly, and impossible to utilise with such a system.

Drawing images, sketches and PCB layouts with a CNC machine by Mohammed Khaled Akel, Hisham Fathi Ali, Abdussalam Ali Ahmed, and Abdalla Milad Faraj during May 2022. The need for computer numerical control machines in businesses is expanding quickly because of an increase in workplace accidents, issues with complicated parts produced by traditional machining, such as poor quality and the requirement for lengthy production processes, and technological advancements. The major machinery where computer numerical control (CNC) is used include lathes, drills, milling machines, etc. The two-dimensional computer numerical control system in this study is capable of drawing images, sketches and words and was designed and built in a cost-effective and efficient hardware architecture.

Kajal J. Madekar, Kranti R. Nanaware, Pooja R. Phadtare, Vikas S. Mane Feb 2016 "Automatic mini–CNC plotter Machine for PCB drawing". To develop low-cost automatic mini-CNC machine for PCB drawing. This system reduces the cost of machine and increases the flexibility of machine. In this G code is interfaced with ATMEGA 328 on Arduino. CNC based controller by FTDI module which is used to convert the G code in convenient controller i.e. serial to USB converter, x moves to left & right, Y moves to Up & down. It gives better accuracy and reduces the work load. G code mark easy to find the information of locations of all stepper motor moving. In the GRBL support 2 axis of motion X, Y but does not support rotation axes (X, Y).

III. PROPOSED METHODOLOGY

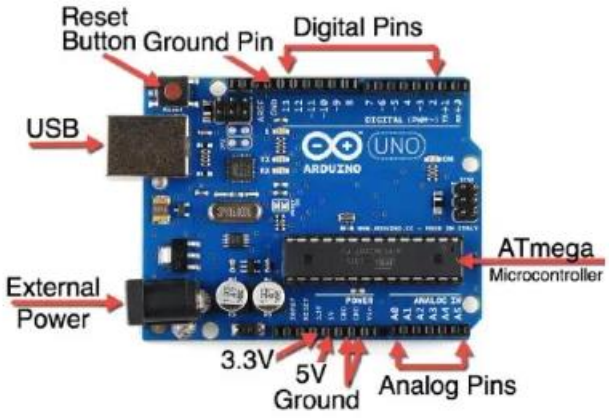
List of components:

Arduino Uno
Stepper motor
Servo Motor
Motor Driver
Power Supply
Jumper Wires
Steel Rods
Bearings

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



ARDUINO-UNO DEVELOPMENT BOARD

Function of each part explained below:
(i)PROGRAMME MEMORY: - kind of flash memory used to store the Arduino sketch, the memory can be stored and cleared more number of time.
(ii) EEPROM: - this is ordinarily used to secure the basic data that should not be lost, even though the power supply unexpectedly stops.
(iii) RAM: - Temporary or volatile memory utilized for paper execution.
(iv) Analog and Digital port: - used to connect the controller and outside world. This has six Analog pins, and fourteen digital pins.
(v) Central Processing Unit: - Atmega328P microcontroller is a heart of the Arduino Uno boards. This block and executes the program.
(vi) Small controller ATmega16U2 on the board makes serial communication port to software on the computer.
vii) 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

Stepper Motor Nema 17:

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.

Working

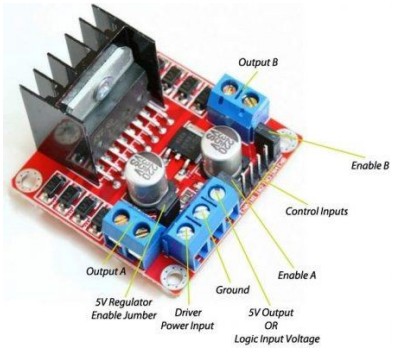
Stepper motors operate on the electromagnetic concept. The electromagnetic stators are encircled by a soft iron or magnetic rotor shaft. Depending on the type of stepper, the rotor and stator have poles with teeth or without teeth. In the case of a permanent magnet type stepper, the rotor moves to align itself with the stator

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.

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.

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.

Power Supply Module:

The Power Supply Module is an ultra-compact DIN rail mounted unit with connections for a single M-BUS network via screw terminals for supply and a patch lead socket. The Power Supply Module provides up to 800mA, 24V DC supply. Additional Power Supply Modules can be added if required.

Jumper wires:

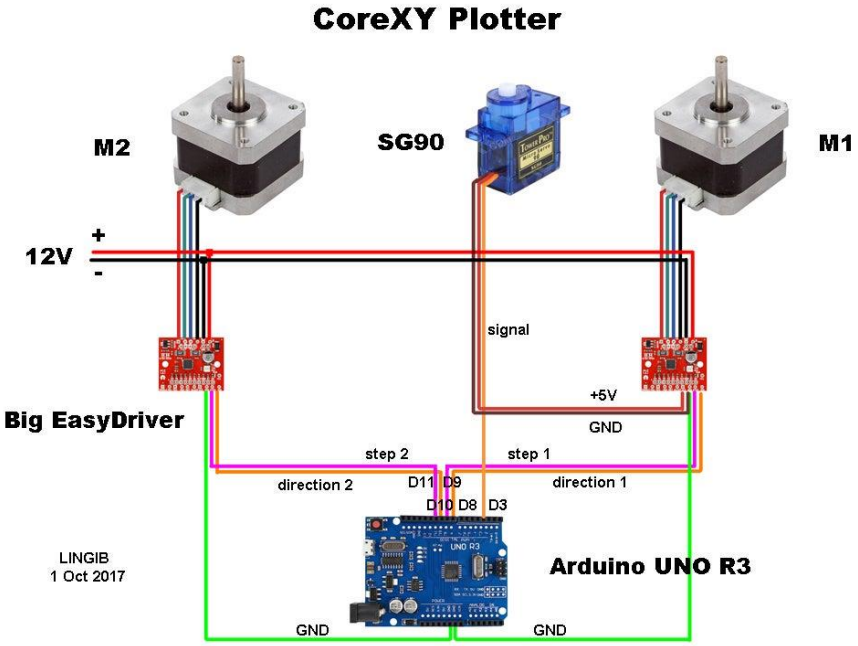
Bearings:

Steel rods:

Electrical component:

SR.NO	NAME OF COMPONENT	SPECIFICATION
1	Arduino uno	4 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz ceramic resonator, a USB connection, a power jack, an ICSP header and a reset button.
2	Steeper Motor	Unipolar/Bipolar, 200 Steps/Rev, 42×48mm, 4V, 1.2 A/Phase. This NEMA 17-size hybrid stepping motor can be used as a unipolar or bipolar stepper motor and has a 1.8° step angle (200 steps/revolution).

3	Servo motor	Required Pulse: 3.3 ~ 5 Volt Peak to Peak Square Wave; Operating Voltage: 4.8 ~ 6 V DC Volts
4	Motor Driver	Power Supply: DC 5 V - 35 V • Peak current: 2 Amp • Operating current range: 0 ~ 36mA • Control signal input voltage range: • Low: -0.3V ≤ Vin ≤ 1.5V.
5	Power Supply Module	Operating Voltage: 110 V AC / 220 V AC · Limits Voltage: 85 V AC to 265 V AC · Voltage Frequency: 50 Hz / 60 Hz · Output Voltage: 24 V · Maximum Output Current: 4 A



IV. WORKING / OPERATION 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.

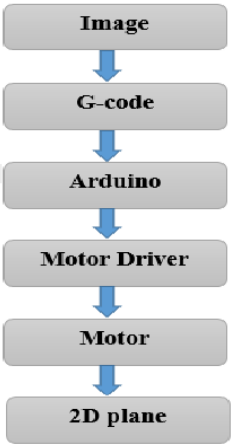
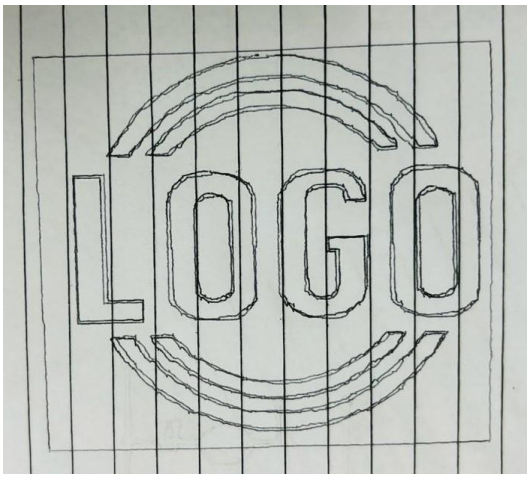
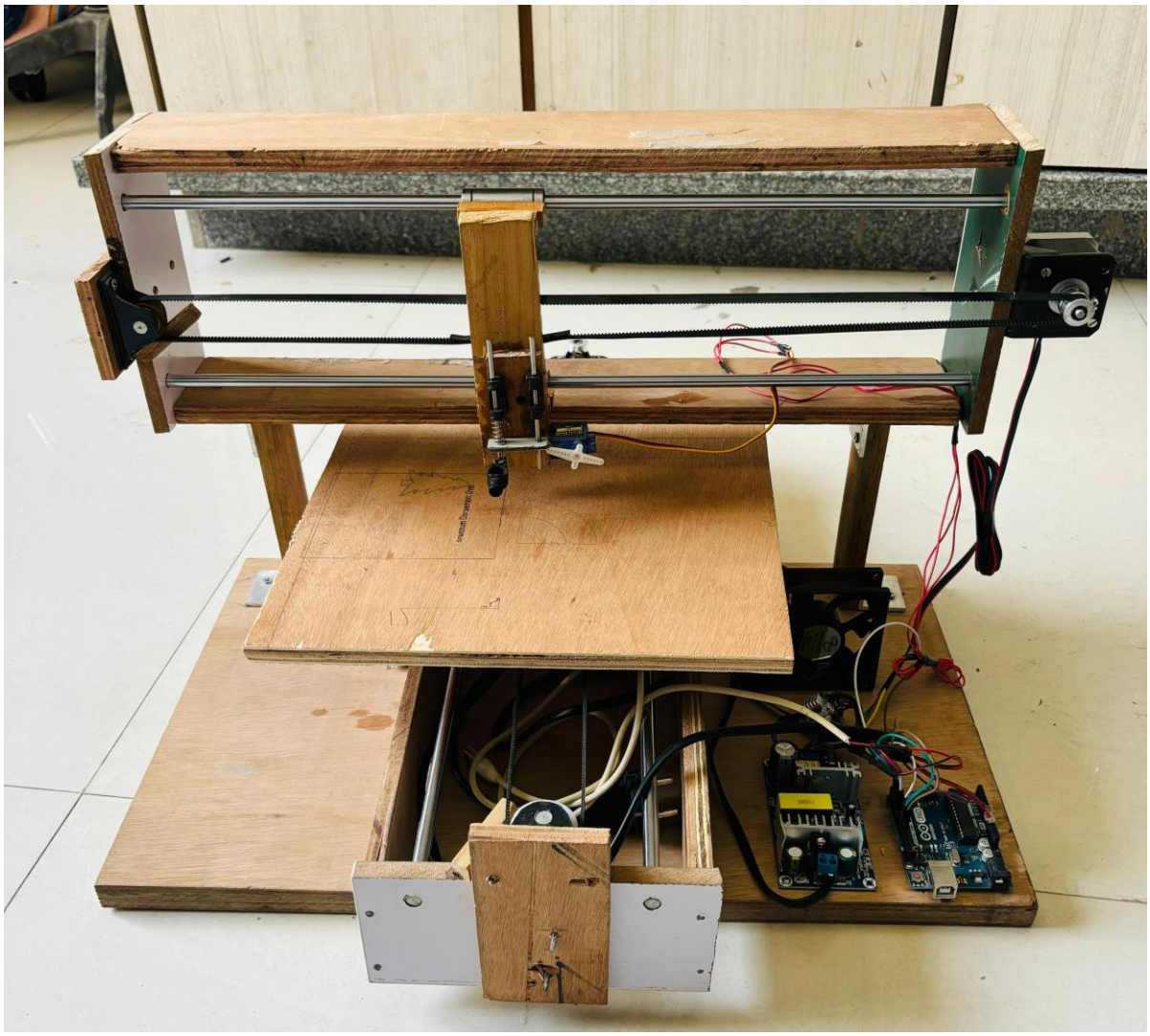


Figure 2: Block Diagram of 2D CNC Plotter

The coordinates are uploaded to the machine controller by a different program. The image file is converted into a G-code via software. Then the code is transferred to the microcontroller by which the stepper motor mechanism is instructed to draw image on soli surface. In this paper, we are going to present a low cost simple design for 2D plotter.

V. RESULT





VI. CONCLUSIONS

This paper is designed with a very simple construction scheme and can be carried anywhere without many efforts. A very simple algorithm is implemented which can handle any type of modifications made within the machine without rewriting it. Though the circuit is very complicated to handle so, it is preferred to create a compact one i.e. by minimizing the jumper wires, can easily be stick to the back of the machine. If we have an increase in the size or length of the lead coil, it will be free to make the large size of the design on paper Due to its compactness, the device is containing less area and simple to use. It is simple to put together and move anywhere. Although the paper's plotting area is tiny, this does not restrict its applicability. The region may potentially be widened.

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