Advance Sustainable Science, Engineering and Technology (ASSET)
Vol. 4, No.1, April 2022, pp. 0220102-1 ~ 0220102-6
ISSN: 2715-4211 DOI: https://doi.org/10.26877/asset.v4i1.11648

CNC (Computer Numeric Control) Machine Design Mini Plotter for Arduino Based Souvenir Craft

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Abstract. The plotter is a graphic printer that draws using ink pens, the plotter is also the first output device capable of printing large-sized images of architectural and engineering drawings. A plotter is a type of printer that is specifically designed to produce computer output in the form of images or graphics. There are many types of plotters, one of which is the pen plotter, which has one or more colored pens for drawing on transparent paper or plastic and producing a line output. CNC (Computer Numerical Controller) is one of the machine control tools in large industrial factories. With the CNC can control most of the tools one example is as a controller of a 2-dimensional plotter. This research designs a 2-dimensional plotter using Arduino UNO-based CNC. This 2-dimensional plotter has an accuracy of 97.947% and a precision of 99.985%. This 2-dimensional plotter is capable of operating up to a distance of 4cm with a resolution of 0.01cm.

Keywords: CNC, Arduino UNO, Servo Motor, Stepper Motor

(Received 2022-04-01, Accepted 2022-05-18, Available Online by 2022-05-31)

1. Introduction

Technological advances are countless, more and more technology is used and utilized to develop a system that can help work and even daily human activities. So the use of electronic and computer technology is used as much as possible, for example in the field of crafts to get products that have good quality supporting tools are needed including a CNC (Computer Numerically Controlled) machine which is a machine controlled by a computer and uses Arduino and uses numeric language (data command), with numbers, letters and symbols). For CNC example is CNC Electric Discharge, CNC Plasma Cutter, Router CNC, Milling CNC. The work system of CNC machines is more synchronous between computers and mechanics when compared to similar machine tools, so CNC machine tools are more accurate, precise, and flexible [1].

In the research conducted by the author, the author found one of the merchandising business places where at that place still uses transfer paper to print both images and writing on wood media, where the human resources owned by the company are very limited so that when many merchandise orders experience a little difficult because it meets the many requests from consumers. One of the difficulties experienced was that the company was only able to complete production in a day ranging from 50 pcs to 65 pcs, processing one key chain merchandise with writing took 10 minutes, the second difficulty was that the workers had difficulty when consumers asked for the products he ordered to be detailed. and neat because of limited resources, not a few are also less than optimal products [2].

Mini CNC machines are machines that are cheaper in terms of purchase price, maintenance and operational costs, but the complexity of the program is reliable, where the program used is the same as a large CNC router machine. Its use is also very easy because the CNC operation uses a program that is controlled directly by a computer and Arduino. The prototyping method is a step aimed at transforming the abstract properties of an idea into a more tangible one. This stage is not only in the form of an idea visualization process but also an idea development process. In general, Prototype has two categories: low-fidelity and high-fidelity. The prototyping process used in Design Thinking is low-fidelity or Rapid Prototyping. This process emphasizes on making a fast, easy, cheap and basic manufacturing process [3].

Based on the problems above in this study the author will make a prototype tool from CNC, using the Arduino Uno microcontroller as the controller of the CNC machine. In this study, the author uses Arduino IDE as a tool to upload programs to control several peripheral sensors from the sensors used. The software interface on the Arduino UNO-based Mini Plotter CNC tool is an image program that has been converted into machine language or G-Code, then this machine language instructs the tool/machine to perform an action, in its use it will use the gctrl.pde processing program, this program sends G-Code image to CNC plotter in other words G-Code is a file with X, Y and Z coordinates. Before installing, first connect the computer with USB to serial communication via a USB cable to the Arduino UNO microcontroller circuit [4].

2. Methods

2.1. Design

Design is a means that has a purpose to complete a system, when the system analysis term is running, the design is the next term. Design is the process of planning everything in advance. Design is a visual form resulting from creative forms that have been planned. The initial step in designing the design starts from things that are not regular in the form of ideas or ideas then through the process of cultivation and management will produce things that are orderly, so that things that are already in order can fulfill their functions and uses properly. Design is a drawing, planning, sketching of several separate elements into a unified whole and functioning [5]. "Design is the preparatory stage for the design and implementation of a system that describes how a system is formed which can be in the form of drawing, designing and sketching or arrangement of several separate elements into a unified whole"[6]. Based on the above design theory, it can be understood that the design is a process leading to the development of newer processes, methods, details based on the recommendations of the results of system analysis and is a preparation in the design of a system [7].

2.2. CNC PLOTTER

Computer Numerical Control (CNC) is an automatic machine tool system that is executed by commands from an abstract program and will be stored in storage media. In order to make CNC machines, it is different from the way machine tools work in general which are controlled using hand rotation or simple automation using CAM. To produce certain movements and positions according to the image to be printed, the CNC machine will be controlled electronically.

CNC technology is the key to machine tool technology, which is the basis of industrial computerized units. CNC machines are operated by controllers, each of which has a software module known as an

interpreter to retrieve data from the CAM system generated code and convert it to controller motion commands. However, with the development of numerical control technology, existing CNC systems are limited with translators to overcome this problem. A new software system conceptual module is presented [8].

In CNC the assembly will consist of mechanical parts that have three degrees, namely, a driving motor in the form of 2 stepper motors, an electronic circuit that functions as a stepper motor drive, a parallel port interface, and software for G-code translators of CNC machine language. In today's industrial competition, it is very necessary to update tools that can combine electronics, mechanics and software at the same time in order to create tools that can meet the needs in one tool, such as a CNC mini plotter machine (Figure 1) controlled by software, mechanisms in designing CNC machines using motors. stepper and pulley and belt, namely a pair of machine elements used to transmit power from one axle to another [9].

Figure 1. CNC Mini Plotter

The way a CNC machine works is that it starts with software that will make the initial design of the image which will then be forwarded via USB (Universal Serial Bus) to the Arduino Uno microcontroller which has loaded the program command code to run the CNC machine, via a stepper motor that gets commands from Arduino in the form of pulses. towards the stepper motor, namely the L293D motor shield. As a result, the stepper controller will control the stepper motor to the X axis and Y axis, the servo motor to the Z system. In this final project, the author has described the integration in electronics and mechanics in the design of a mini plotter CNC machine. X-Y Plotter Prototype Design with Arduino Based G-Code Interpreter was made using 3 servo motors for each axis. The movement of each axis is controlled by instructions G00 and G01 via a computer connected to USB serial communication [10].
The programming methods used in CNC machines are:

1. Incremental Method
   A programming method where the reference point is always changing, that is, the last point to be addressed becomes a new reference point for the next measure.
2. Absolute Method
   A programming method where the reference point is always fixed, that is, one point/place is used as a reference for all subsequent measures

Models in terms of type, CNC machine tools can be divided into three types, including:

1. The CNC 2A machine is a 2-axis CNC machine, because the tool movement is only in the direction of the two coordinate axes (axis), namely the X-coordinate and the Z-coordinate, otherwise known as a CNC lathe.
2. 3A CNC machines, namely 3 axis CNC machines or machines that have the main axis movement towards the X, Y, and Z coordinate axes, otherwise known as CNC milling machines.
3. Combined CNC machines, namely CNC machines that are capable of doing both lathe and milling work at the same time, can also be equipped with measuring equipment so that they

can control the quality of turning/milling on the resulting workpiece. In general, the most common CNC machines are CNC 2A (lathe) and CNC 3A (milling) machines [11].

2.3. G-Code

A programming language is a command format that exists in a block that uses and uses alphabetic codes, numbers, and symbols. Inside the CNC machine tool there is a computer device called the Machine Control Unit (MCU). This MCU serves to translate the coded language into the form of tool movements according to the shape of the workpiece. The language codes on CNC machine tools are also known as G and M codes, where these codes have been standardized by ISO or other international bodies. In the application of alphabetic codes, numbers, and symbols in CNC machine tools, they vary depending on the control system and the type of machine used, but the principle is the same. So that for operation in CNC machine tools using different types, there is no significant difference.

G-Code is a language that will be used in the Numerical Control programming language which contains information on the position of a tool to do a job. The G-Code is a preparatory code, contained in their CNC program starting with the letter G and driving the machine. Actions that are generally directed by the G-Code include: turning a pallet, rapid movement, a series of controlled feed movements, producing a piece of goods, drilled holes or decorative shapes, controlling feed movement, in arcs or straight lines, and setting tool information [12].

3. Results and Discussion

3.1. Research Results

CNC Mini Plotter is a combination of computer software and mechanical electronic structure. The stage in the design of the tool is divided into two, namely designing a software program as the operation of the tool and also as an initial design and converting it into GCode which is understood by the tool so that it can be continued to print as the desired output. The second stage is to design the hardware components that will be used, with the aim of producing the desired output and also shortening the time required for work.

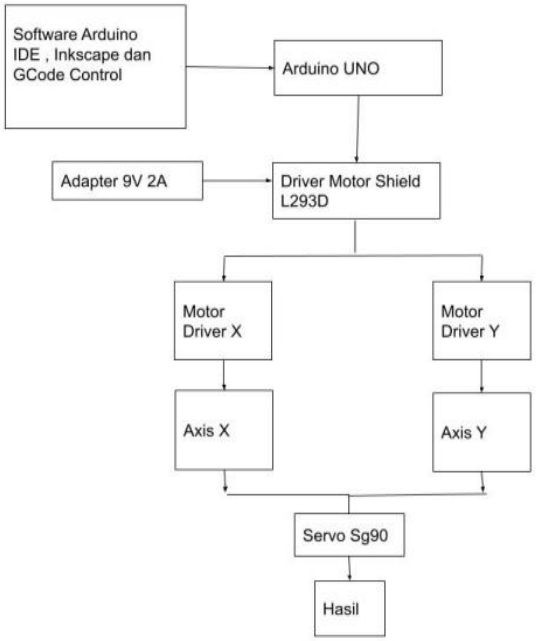

Figure 2. Diagram Blok CNC Mini Plotter

In this section is a discussion related to the design of the tool from the block diagram that the author is doing and researching. Based on the previous chapter, the tool block diagram that the author will

describe in the following sub-chapter is the result of how the tool runs according to the steps in Figure 2.

The first step that must be done in running the program is to open the Arduino IDE, Inkscape and GCode Controller software and initialize the Arduino UNO and GCode Controller ports. Then open the Inkscape software and enter the images, sentences, and both that you want to print, the images and text will be converted into G-Code format by re-saving with the gcode format in the Inkscape application, which has previously installed the additional MarketBot Unicorn G-Code library, so that images and text can be read by the GCode Controller application.

The next step is to design an Arduino program to operate the tool and control the movement of the servo and motor shield, which aims to calibrate the axis which will then calculate the movement of the y-axis and x-axis in a matter of millimetres. Then a compilation test of the Arduino program that has been made will be carried out, this is intended to test whether there are errors in the program created. After doing the compile test, the program will be uploaded to the Arduino. If there is an error in the program, the program will be reviewed and then tested, compile again and then forwarded to upload to the Arduino Uno, upload here is to enter the program as the main Arduino Uno command.

Furthermore, Arduino Uno will forward the command to the Motor Shield Driver, which is first given a 9v 2A adapter voltage to be able to drive and [illegible] the main axis, the motor driver available on the DVD Rom, each axis that is connected to the Motor Shield will move according to the Gcode. The servo motor will then operate according to the command, which must go up or down to adjust the pen that is drawing the output so as not to produce streaks of the y-axis movement later.

Results

3.2. Tool Design

Based on the results of conducting research and the diagrams that have been made in the previous chapter, it results in an implementation in the form of a prototype. The design of the tool that the author has done is based on the actual situation so as to get an overview of the tool to be designed later. This design can be seen in Figure 3.

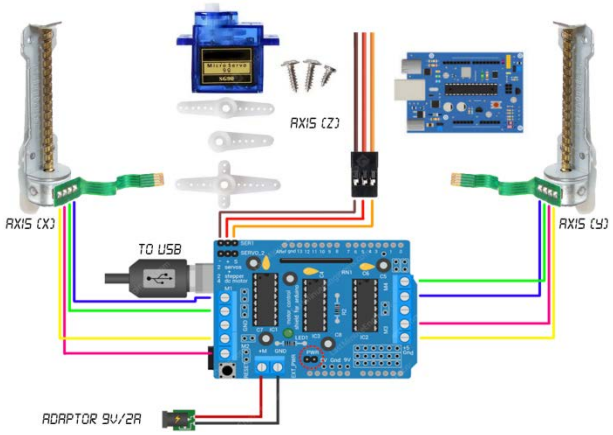

Figure 3. Tools design

4. Conclusion

The conclusion that can be drawn from this research is that the accuracy of the appropriate tool is 97.947% and the precision of the appropriate tool is 99.985% and the proper width (range) is 4 cm for the X-axis and Y-axis and the resolution of the appropriate tool is 0.1 mm.

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