An Embedded Approach for Design and Development of the Mini CNC Cutter

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Abstract - *Mini CNC Machine' is an embedded system that works based on the principle of Computer Numerical Control (CNC). CNC Cutter basically works with two CD-drives for Z and Y axis and one CD-drive for X axis, wherein the CNC Cutter plots the input given from the computer from the drawing board using on an open-source physical computing platform Arduino Uno. The CNC Cutter has a two CD-drive axis control and one single CD-drive to raise and lower the cutter. The X and Y axis mainly consists of stepper motors taken from CD-drives. The software used for programming the Arduino board is namely Inkscape and processing software. The correct and efficient arrangement and proper use of the programs along with the circuit makes up an efficient CD-ROM based mini CNC Cutter.*

*Key Words***:** *CNC machine, Inkscape, Processing, Servo motor*

1. INTRODUCTION

CNC means Computer Numeric Control. A CNC is the automation of machine tools by which we can draw different type of letter, pictures provided by the computer using software's into its controller. This means a computer converts the design into number which the computer uses to control the cutting and shaping of the material. The code used to program CNC machines is generically called G code. However, G-code instructions are only part of programming language.

The rest of the paper is organized as follows: Section II provides the brief discussion on the literature review related to CNC based machines. Section III highlights on the theoretical background of the proposed architecture followed by Experimental set up and results in Section IV. Section V provides conclusion.

2. LITERATURE REVIEW

Many researchers have worked in the area of CNC based automatic plotting and cutting.

Linyan Liu et al [1] presented a framework for the VMC machine tool design and development (D&D) with the integration of process and knowledge. The reported a framework consists of process integration model, process simulation, process execution and knowledge objects management modules.

Venkata Krishna pabolu et al [2] discussed the design and implementation of low cost three dimensional computerized numerical control system (CNC) for industrial application. Embedded CNC machine was created and details were reported in their paper. Natural frequency of the gantry structure rose slightly above 200Hz. The research results show that the designed CNC gantry machine was capable of functioning at a speed of 12,000rpm.

Monika Nowak et al. [3] formulated methods of selection of geometric and physical structure of the mobile machine by specifying the design requirements and the development of the elimination conditions based on these requirements.

Grzegorz Szwengier et al.[4] reported the results of research on selection on geometric-kinematic structure of newly designed milling machine. There was various types of structure combination available for milling machine, author suggested best procedure and help to select useful combination of machine parts with desired output provided with constraints of machine.

With the extensive literature survey, we found that there is scope for design and development of the mini NC machine which can be used for variety of applications. And the application that's reported here is cutter which is able to cut the smooth objects. The next section elaborates the detail discussion on system block diagram.

3. THEORETICAL BACKGROUND

The embedded system is designed for cutting the smooth objects in the required shape. The block diagram of the system is shown in fig 1. The shape which is to be cut is given as an image. G-codes are generated by Inkscape software and then simulated by Processing 3.01 software. The simulation runs the stepper motors of CD-drives results in to the useful mechanical output at the cd-drives where carriage reciprocates as per signal given by software.

Machine works on mainly three axis. Thus will be made by using two DVD/CD drives and one mini servo motor to build hardware design. Now that we have our Contraction ready, it's time to build the circuit and test stepper motors (X and Y axis). Arduino uno is used for this system. Processing software will be used to interface this machine hardware with software and controller.

Design which user want to cut will be converted into G-code file format. This file will be opened in processing software, and machine will cut the design successfully as per the design given by user.
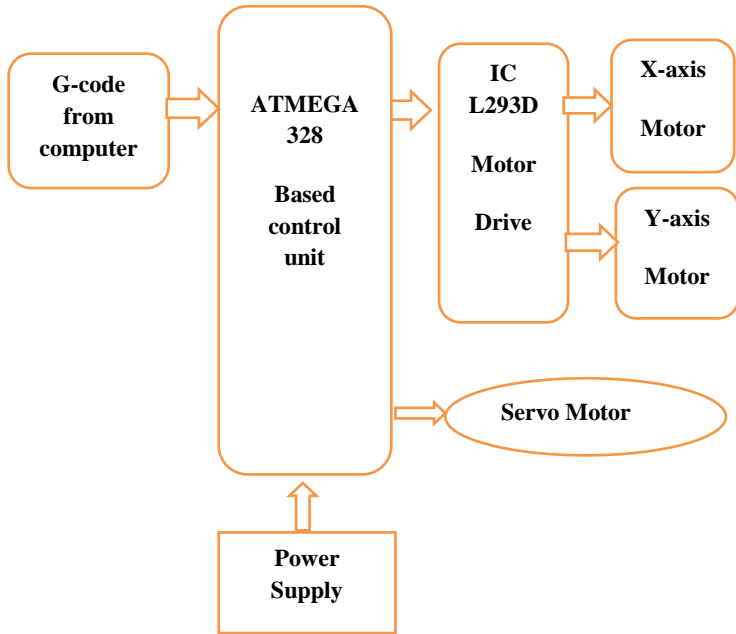

Fig -1: Block diagram of the reported Cutter

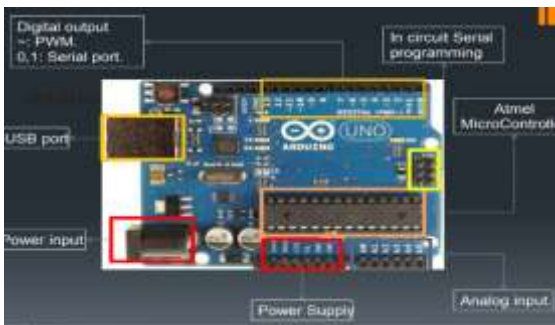*A. Hardware Tools used in the system:*

1. Arduino Board

Fig-2: Arduino Board

It simplify the process of creating any control system by providing the standard board that can be programmed and connected to the system without the need to any sophisticated PCB design and implementation. It is an open source hardware, anyone can get the details of its design and modify it or make his own one himself.

2. CD\DVD Drive:

Stepper motors are DC motors that move in discrete steps. With a computer controlled stepping you can achieve very precise positioning and/or speed control. In our project we use CD-ROM drive stepper Motor Automation of 3 Motors to control the coordinates (X,Y) of a driller head can be used as Cutter.
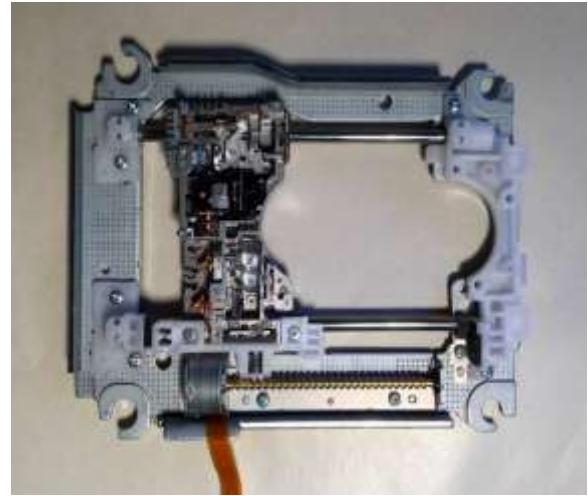

Fig-3: CD-ROM Drive

3. Servo Motor

Fig-4: Servo motor

Servos are controlled by sending an electrical pulse of variable width, or pulse width modulation (PWM) which determines position of the shaft, through the control wire. It is z axis.

4. Cutter

To cut the object in different shapes using the cutter.

Fig-5: driller to cut the object

Specification of Cutter:

- Speed 1000RPM
- Weight 17g
- Voltage 0.5V – 9V
- Current 0.11A

B. Software Tool

1. Inkscape:

Inkscape is a free and open-source Graphics editor. Here it is creating G-code for a particular image or letter.
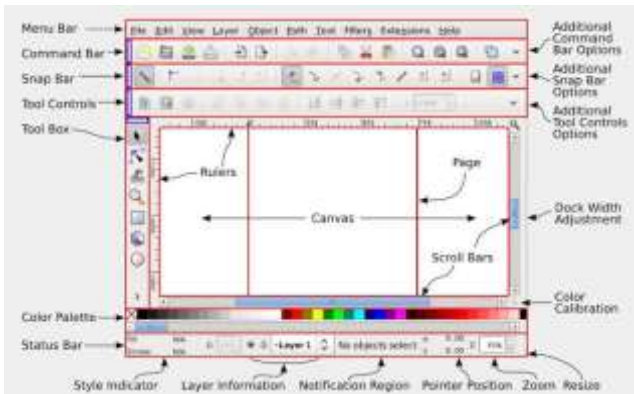

Fig-6: Snapshot of the Inkscape software.

2. Arduino:

Arduino is an open-source electronics platform based on easy-to-use hardware and software. Arduino boards are able to read inputs - light on a sensor, a finger on a button, or a Twitter message - and turn it into an output - activating a motor, turning on an LED.

3. Processing 3.0.2:

Processing is a flexible software a language for learning how to code within the context of the visual arts.
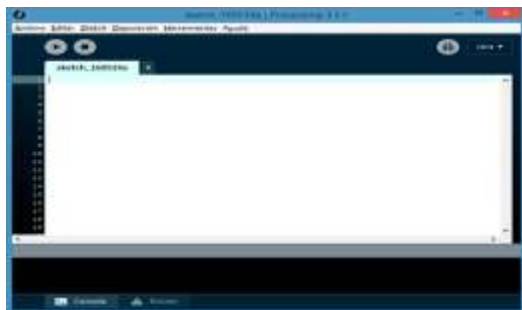

Fig-7: Snapshot of Processing software

4. EXPERIMENTAL RESULTS AND DISCUSSION

The experimentation is carried out on the smoother materials for cutting in the required shape. Panner was tested with the cutter. The shape for example circular is drawn in the Inkskape software which generates the G –code.

Creating G-Code File Using Inkscape:

The CNC Cutter of our project will work within 20cm×20cm area So we choose the document properties of the Inkscape 40cmx40cm (Width × Height) which is four times the working area of the cutter because the cutter can cut only in the first quadrant. So we have initially kept the axes at the nearest end of the motors which is considered as origin to easily modify the design. In Fig. 8 the working area of CNC cutter is shown with the pre-defined area. The text is selected using cursor and then select "object to path" from the drop down window to save the G code form of the selected text. To create G-code of an image, the file must have a transparent background.

The image should be dragged into the selected area then select "trace bitmap" from drop down window to create a transparent image. Scans are selected as 8 and "Edge detection" is selected to create black & white image. After adding this transparent image in the predefined area we`ve used "object to path" command to create the G-code file of the selected image by following the steps described earlier.

Processing is open source programming language software which is used for electronic drawings. GTCRL processing program is used to send G-code file from user interface to CNC plotter. The Fig. 7 shows the user interface of processing 2.2.1 software after running GTCRL program. The port of Arduino Uno is selected by pressing „P" button on keyboard hence G button is used to upload our desired G-code file. Immediately CNC machine will start sketching selected G-code file. Sketching can be stopped by pressing X button.

The Gcode is then given to the processing software which converts the G-code to the coordinates and according to that the motors are moved in the x, y positions as well in the up-down direction as well. To the stepper motor driller is connected so that the object is cut in the prescribed shapes.

Fig-8: Experimental set up of the system

Following steps are implemented:

  i.   Cut the object in different shape we need the Inkscape to generate the G-code of that image.
  ii. Use processing software to upload image G-code into Arduino and select the port and select the image G-code when it run.
  iii. Give the command through the Arduino to run the stepper and servo motor and cut the object in the given shape.

5. CONCLUSIONS

Using small machine tools to fabricate small scale parts can provide both flexibility and efficiency in manufacturing and reduce capital cost, which is beneficial for small business owners. In this project, a small scale three axis "MINI CNC CUTTER" is designed and analyzed under very limited budget which is beneficial for cutting object in the required shape.

By designing the stepper motor properly, the system can be used to cut any type of object which can be used in real time.

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