ARDUINO BASED AUTOMATIC MINI CNC MACHINE FOR DRAWING

Thiri Kywe[1], Thae Thae Ei Aung[2], Hnin Ngwe Yee Pwint[3]

[1]*Assistance Professor, Department of Electronic Engineering, Technological University (Meiktila), Myanmar*
[2]*Lecturer, Department of Electronic Engineering, Technological University (Meiktila), Myanmar*
[3]*Lecturer, Department of Electronic Engineering, Technological University (Meiktila), Myanmar*

Abstract

Today, the Growth of Technology and the use of CNC machine are rapidly increased. The idea behind this system is to design Automatic Mini CNC Drawing Machine with Arduino Microcontroller and CNC shield. This paper is going to help to design the Automatic Mini CNC Drawing Machine. This machine is going to operate like a CNC machine within the limited area. X-axis and Y-axis are used to move pen horizontally and vertically. Z-axis is used for the purpose of pen up and pen down. In this machine, two stepper motors are used to control horizontal and vertical movements. Metal gear servo is used to control the spindle. The cooling system is constructed with the temperature sensor and fan. The machine is going to be stopped when the temperature is beyond limit. As software implementation, the picture that wanted to draw is firstly converted to the SVG file. Then the SVG file is converted into corresponding G-code. All motors are only commanded by g-code which is created from the respective software. Moreover image processing and creating own SVG file is performing MATLAB and MATLAB is used to substitute premade vector graphics editor Inkscape in the system.

Keyword: Arduino, Servo Motor, Stepper Motor, MATLAB Software

1.INTRODUCTION

The first NC machine is created by Mr. John T Parsons around 1940s-1950s and he worked to attach X and Y axis of a machine to control them with computer. And then, today modern technology is CNC and it is the new generation of NC machines. With the development of technology and economy, new industrial requirements such as high precision, good quality and high production rates are increasingly demanded. With CNC technology, machine tools are able to automate and perform in a faster manner.
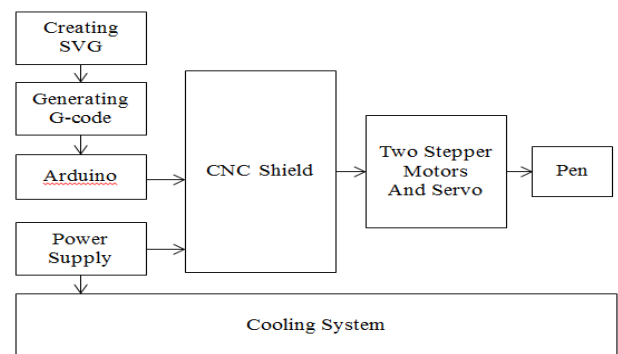

Figure 1. Basic Block Diagram of the Machine

Figure 1 depicts Mini CNC drawing machine is two-axis machine. It uses G-code to command a pen to draw images on any surface such as paper. Arduino and CNC shield are mainly based in the CNC machine. In this system, two kinds of motor are used to make movements. They are two stepper motors and a metal gear servo. Stepper motors are used to control the positioning X-axis and Y-axis. A metal gear servo is used to make pen up or pen down in Z-axis. Stepper drivers are used to control the stepper motors and CNC shield protects the driver from over current loading and provide power supply to the servo. Temperature sensor and fan are used for cooling system that provides the machine.

2.OPERATION OF SYSTEM DESIGN

The design of the system is divided into two parts:
- ❖ The Hardware Implementation system
- ❖ The Software procedure of the system

Hardware implementation of the mini CNC drawing machines are as follows:

- ❖ 8mm width linear rod are cut into two 60cm, two 40cm and two 8cm. Threaded rod are cut 63cm to control the base of the machine. For X-axis, two 60cm linear rod is set into the upper level of one motor holder and two threaded rods are into the base.
- ❖ Stepper motor is fixed with the axis pulley and it is held to one motor holder.
- ❖ Linear ball bearings are put into the two center blocks and servo holder. Eight piece of the ball bearing with 3mm screws are set inside the center blocks. Then two center blocks are overlap in opposite directions and fixed with the screws and nuts.
- ❖ The lower floor of center main block is set to the X-axis and the other Y-axis motor holder with motor block it. And then, two 40cm linear rods are set to the upper part of the center main block and Y-axis is formed.
- ❖ On Y-axis, the tail part is set and fixed with screws and nuts. Servo is fixed on the servo holder and servo holder is set on the other end of Y-axis. Under servo, machine pulley is fixed.
- ❖ Pen holder with pen is fixed to the head part of the machine and this head part is set to the servo holder with 8cm linear rods.
- ❖ Open timing belt is connect in this ways : tail slot – center ball bearing – motor axis – center ball bearing – machine pulley – center ball bearing – motor axis pulley – center ball bearing – tail slot .

The hardware implementation is done. And then, CNC shield V3 is mounted on the Arduino board. Two A4988 microstepping motor drivers are set on the X-axis and Y-axis slot of the shield and Nema 17 stepper motor are connected with the driver. Power supply is connected with the CNC shield. The machine is at the pen up stage and is ready to run as shown in Figure 2.
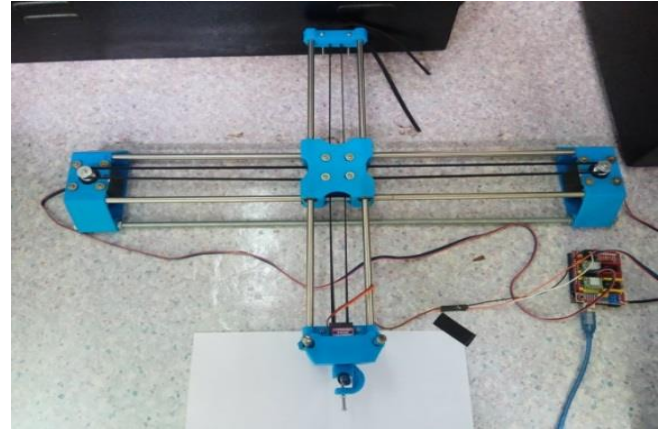

Figure 2. Hardware of the mini CNC Drawing Machine

The system is discussed the picture that wanted to draw is changed 'plain SVG file' with Inkscape software. After generation of the plain SVG, gcode is created with the LaserWeb software. And then gcode is fed to the arduino in which GRBL coreXY firmware is uploaded.
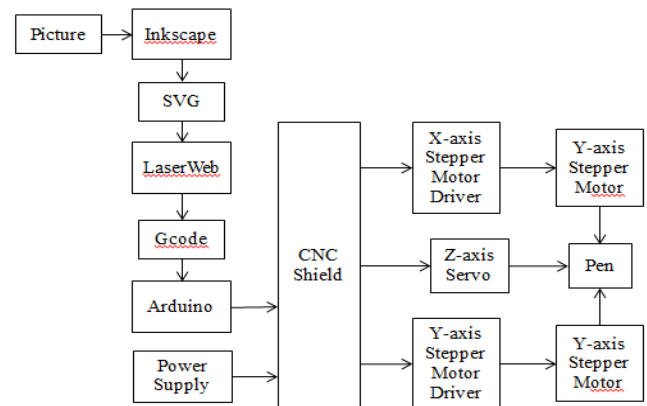

Figure 3. Block Diagram of the Drawing Machine to Perform with Software

The power supply (12V) is connected with CNC shield and CNC shield accepts the data from the arduino. Signals from the CNC shield run to the axis drivers and spindle signal to the servo. The block diagram of the mini CNC drawing machine procedure is as shown in Figure 3.

3.SOFTWARE PROCEDURE

The steps of the software procedure to run or work the mini CNC drawing machine are as follows:

- ❖ Uploading GRBL coreXY firmware by using of Arduino IDE software.
- ❖ Creating the SVG (plain SVG) file with Inkscape software.
- ❖ Generating g-code and run the machine with the LaserWeb software.

3.1. Uploading GRBL coreXY Firmware

There are two types of firmwares : GRBL firmware and GRBL coreXY firmware. GRBL firmware is used in some CNC machines which don't use CNC shield. And CNC machines with CNC shield use GRBL coreXY firmware. In this thesis, CNC shield is used to protect the drivers and to be a compact design. GRBL coreXY firmware is also free from the internet and is able to be downloaded from 'https://github.com/arnabdasbwn/grbl-coreXY-servo'. The downloaded file is .zip file and extracted to a proper location.

To upload firmware to the Arduino uno board, Arduino IDE software is required. The Arduino IDE software is free and is able to download from its original site, 'https://www.adruino.cc/en/Main/Software?'. Firstly, the software is installed in the computer and open it. The window is going to be appear as shown in Figure 4.

Figure 4. Opening the Arduino IDE Software

- ➤ Firstly, the software is installed in the computer and open it.
- ➤ To add the library file of the firmware to the arduino board, click the 'Sketch' from the tool bar and then 'Include Library' and again choose 'Add .ZIP Library' options and click.

- ➤ Another window is appeared and choose the location where GRBL coreXY firmware folder. Then, choose the folder and click 'open'. Adding the library of the firmware is done to the Arduino IDE software.
- ➤ After adding the library file to the software, click 'File' from the tool bar and choose the 'Open'.
- ➤ The new window appears. The location of the 'grblupload.ino' (previously the same location of the library file) is find and it is opened in the software.
- ➤ Then the prewritten program of the GRBL coreXY and It is going to be needed to compile and upload to the arduino board.
- ➤ Then, click the left fist top icon (namely 'verify') to compile the program. When it is done, choose 'Tools' from the tool bar and the box is going to be appeared and choose Arduino/Genuino Uno Board.
- ➤ After that, the serial port COM7 (Arduino/Genuino Uno) is chosen. The com port numbers is going to be different such as COM1, COM2, COM3, etc.
- ➤ After choosing the correct board and port, click the left top second icon (namely 'Upload') to upload the program to the arduino uno board. The software read the firmware and writes it into the arduino board.

3.2. Creating SVG File with Inkscape Software

After uploading the firmware to the arduino, SVG file is created with Inkscape software. Inkscape can be downloaded from 'https://inkscape.org/en/release/0.92.3/'. Then, extract the downloaded zip file and install it. After the installation, open the inkscape software to create plain SVG file.

SVG file is an XML (eXtentable Markup Language) based vector image format for two-dimensional graphics with support for interactivity and animation.

The window is going to be appeared. Then, click 'File'. The box appears and 'Document Properties' is selected to make adjustments to the area that is used to add the picture.
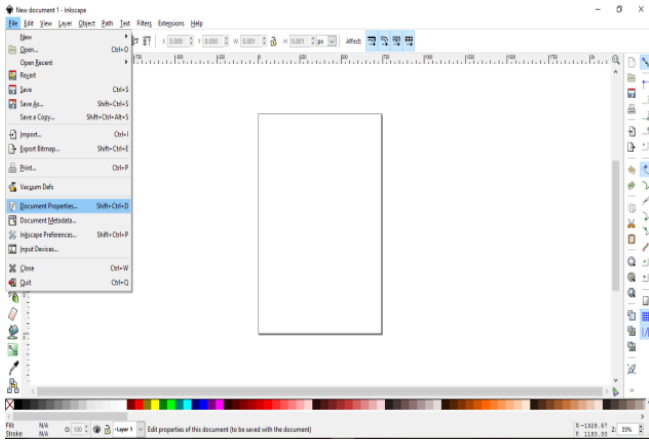
Figure 5. Opening the Inkscape and Making Adjustments to the Area

➢ The small window is appeared and change the 'Default units' to mm (millimeters). In custom size, set the value that needed and units as mm. In this procedure, 100 width and 100 height is set. Then, the area is formed a square.

➢ The picture that is wanted to created SVG file, is dragged into the Inskape.

➢ The size of the picture is fixed enough to be in the area and placed in the center of the area.

➢ Again, choose 'Trace Bitmap' from the 'Object' menu. Trace bitmap is used to make RGB colored pictures to B&W. Then trace the margin with the edge detection.

➢ After that, the new window appears. The value is set by the need and click 'Update' and 'OK'. The trace of the picture forms in the preview box. Then the picture in the area is automatically selected and it is the SVG.

➢ The original picture is under the result picture and the original picture is selected and moved outside of the area.

➢ The original picture is deleted. Then click 'Object to Path' from the 'Path' menu.

➢ Then 'Dynamic Offset' from the same menu is selected and the pointer is changed in a new one and click on the picture.

➢ After clicking on the picture, the file is ready to save plain SVG file to create g-code.

➢ Then, 'File' menu on the left top of the software is clicked. The window appears and the random name is typed in 'File Name' box. After that, 'Title' box is clicked and a window appears.

There are many types to save such as SVG (*.svg) , compressed SVG (*.svgz), portable document format (*.pdf), makerbot unicon gcode (*.gcode) and so on. Then, choose the 'Plain SVG (*.svg) is selected and the photo is saved as plain SVG.

3.3. Generating G-code and Running the Machine with LaserWeb Software

After creating plain SVG file, the g-code is going to be generated from that SVG file with LaserWeb software. The reason of the creating SVG file is that LaserWeb only supports SVG files.

Table 1. Some Examples of G-code

No	Function	G-code
1	Motions	G00 - rapid motion,
		G01 - linear movement,
		G02 - circular motion,
		G03 - counterclockwise movement
2	Plane Selection	G17 - XY plain,
		G18 - YZ plain,
		G19 - XZ plain
3	Absolute/Incremental	G90, G91
4	Units	G20 - inches,
		G21 - millimeters.
5	Feed Rate Mode	G93
		G94

There are many G-code that are used in CNC machine commands. Some examples of g-code are shown in Table 1.The full format of the g-code is G01 X1 Y1 Z1 F20 T01 MO3 S500. In the format, G is for motion, X is for horizontal coordinate, Y is for vertical coordinate, Z is for depth, F is for feed rate, T is for tool selection, M is for miscellaneous function and S is for spindle speed. And then, G## is used for motion declaration, X##,Y## and Z## are used for coordinate declaration, F## and S## set value, T## is for selecting item and M## is for switching something. And then M-code is a machine code and it performs the basic electrical functions.

LaserWeb is also known as CNCWeb. It is free and abletobedownloadedfrom'https://github.com/LaserWeb/LaserWeb4-Binaries'. It is used to laser cut and laser raster. In this thesis, the Laser cut is used in order to draw 2D objects on the plain. Extract the zip file and open it. It contains File, Comms, Control, Setting and About as shown in Figure 6.
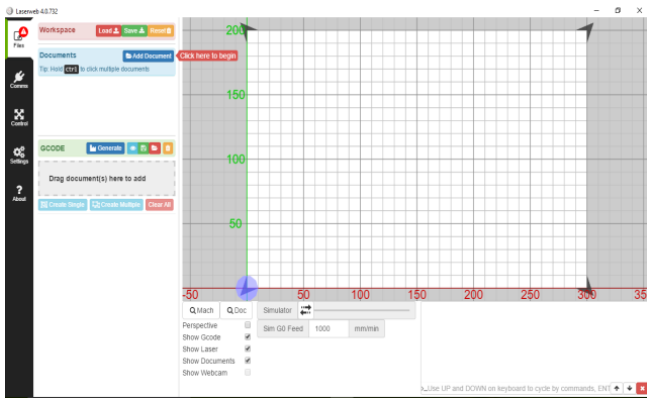
Figure 6. Opening the LaserWeb Software

In Comms menu, choose the right USB/port and connect the machine. If machine is successfully connected, 'machine is connected' and 'firmware is detected' is going be appeared as shown in Figure 7.
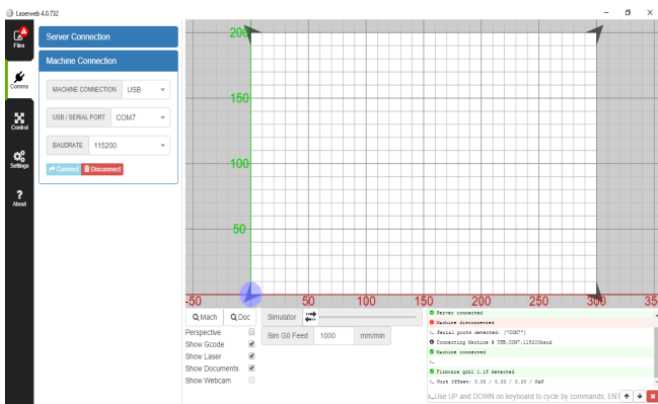

Figure 7. Connecting the Machine

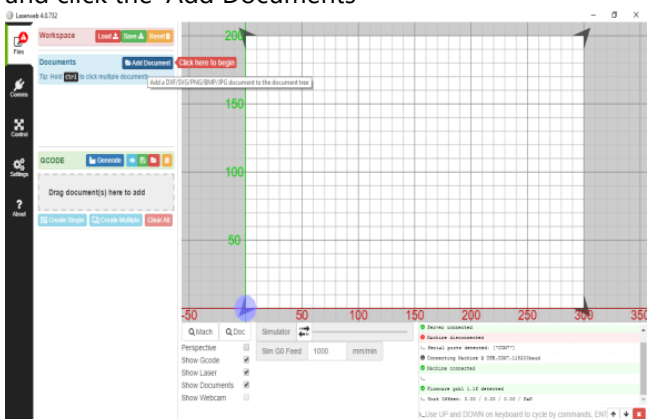If the machine is connected, choose the File icon and click the 'Add Documents'

Figure 8. Preparation to Choose SVG File

Then, the window is appeared and find the location of the plain SVG file that is created by the Inkscape. After opening the SVG file, the file is appeared under the 'Documents'. Then drag that file under 'Drag document(s) here to add' space as shown in Figure 9.

Figure 9. Dragging the SVG File to Work

A proper name is set in the 'Name' box and 2000 is set in the 'Cut rate' box. In coordinate box, change the coordinate of both X and Y to zero as shown in Figure 10. Moreover, the size of the picture is able to be resize by the coordinate block.
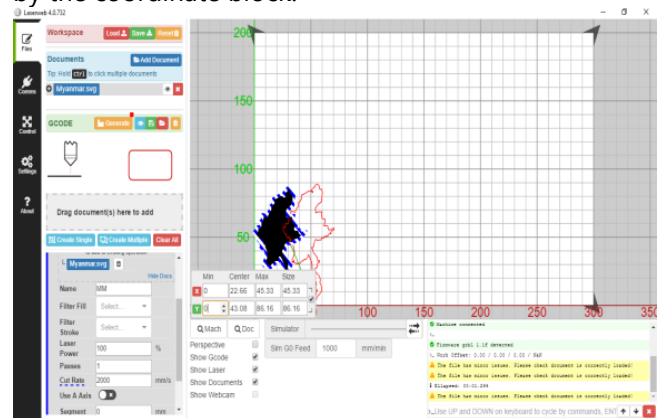

Figure 10. Setting Name, Setting Cut Rate and Setting Coordinates to Zero

The orange bar 'generate' (with the red spot) is pressed to generate g-code as shown in Figure 11.
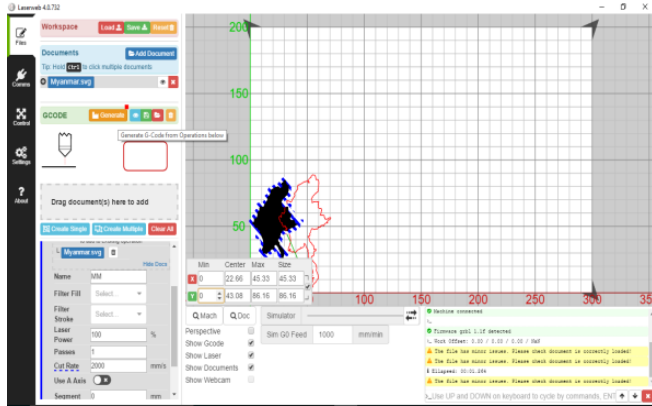
Figure 11. Generating G-code of the File

After generating g-code, the bar is going to turn blue and red line part of the file disappears as shown in Figure 12.
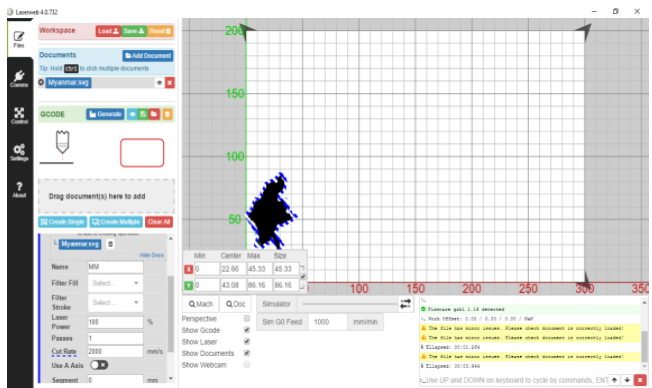

Figure 12. Work Done of G-code Generation

Generated g-code for the picture is able to be seen by clicking the eye icon beside the blue bar 'Generate'. The g-code generated is deleted by clicking the trash icon on the same bar. Figure 13. shows the g-code generated by the software.
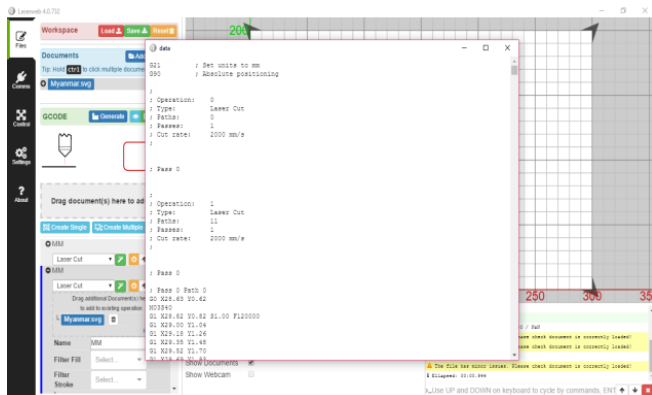

Figure 13. G-code of the SVG File

After the previous step, 'Setting' icon is chosen and a new window with Machine, File Setting, Gcode, Application, Camera, Macors and Tools is appeared in Figure 14.
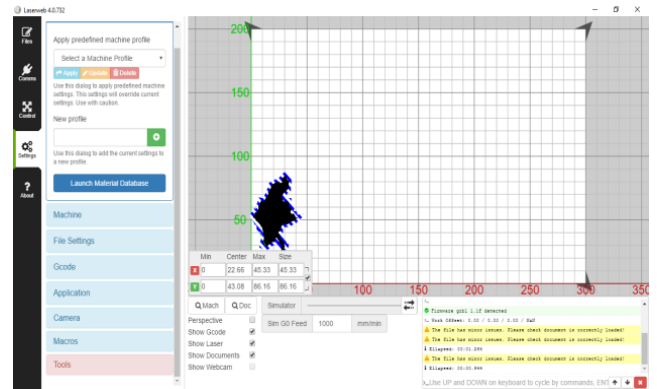

Figure 14. Choosing 'Setting' Icon

Set M03S40 in 'TOOL ON' and M03S20 in 'TOOL OFF' for spindle servo. M03S40 means PWM (pulse width modulation) spindle is going to rotate clockwise direction and the next parameter means speed (RPM - revolutions per minute).
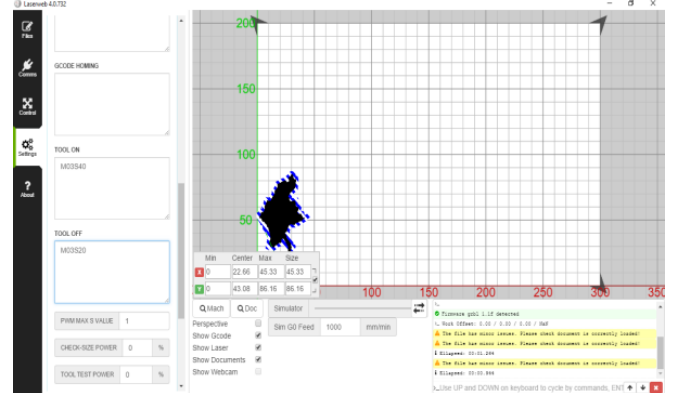

Figure 15. Setting Values in Tool On and Tool Off

In the 'Control' icon, X+, X-, Y+ and Y- are able to move along X and Y axis. Moreover, there are home all, run job, abort job, set zero and check size icons.

4.IMPLEMENTATION PROCEDURE OF THE IMAGE

Firstly, the photo that is wanted to create SVG is read by command 'imread( )'.The command 'figure' is to create the space to occur the figure and the 'imshow' is used to show the picture. Then, the picture read is converted to the binary (which means black and white photo) by 'imbinarize( ). The binary picture is shown and the tiny white spot is deleted by using 'bwareaopen(,)'. And then, when the black spot is found in the big white area, these spots are filled with white. 'imfill(,)' command is used to fill the black spots.
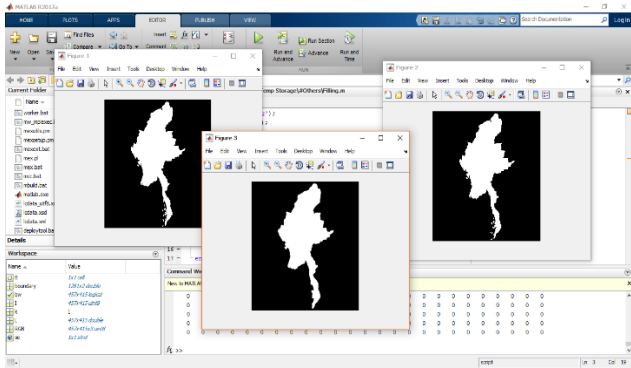

Figure 16. Generating SVG with the MATLAB

After the previous state, the photo is detected to find boundaries of the objects in it with 'bwboundaries(,'noholes')'. And the picture is shown and the detected boundaries of the photo is potted with a proper width and color line by the use of 'plot( )'. The MATLAB code is shown in Appendix B and properly run. The work done of the MATLAB is shown in Figure 16. The line plotted picture is saved as a SVG file.

MATLAB is used to substitute the auto made Inkscape. But the result SVG by MATLAB is not perfectly performed as the SVG of the Inkscape. It is not be scalable like the SVG by Inkscape. The boundary detection and plotting technique is used and this technique is able to perform or detect the white objects in the black background. Therefore, the original photo has to have the black colour or darker color background than the object (that is wanted to draw).However, the SVG by MATLAB is also able to run with the LaserWeb as shown in Figure 17.
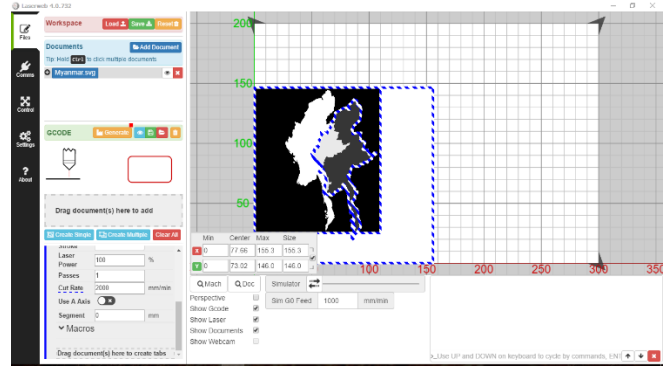

Figure 17. Working in LaserWeb with the SVG by MATLAB

To test the capability of the machine, the machine is connected with the computer as shown in Figure 18.

Figure 18. The Machine of the Thesis

When the result of the machine is formed, the result picture is compared with its original picture as shown in Figure 19.
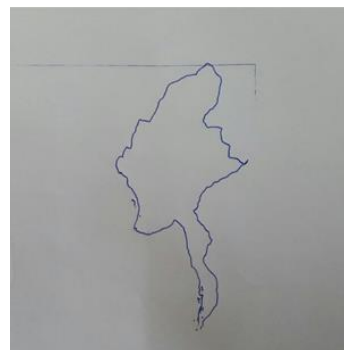
Figure 19. The Comparison of the Result and its Original Picture

And the SVG by the MATLAB is also used to run with the machine. And the results are as shown in Figure 20.
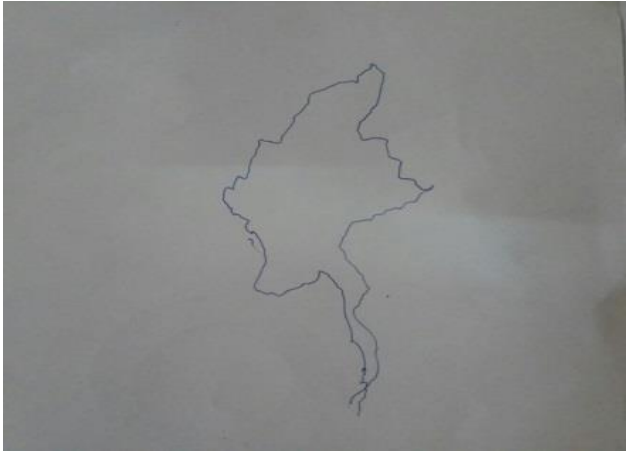

Figure 20. The Result of the SVG by MATLAB

5.CONCLUSION

The machine is easy to control, able to suddenly stop and pause with a click action on computer, handle with a low power supply and produce a high quantity of picture. The machine can perform more exactly with the more simple pictures. The hardware of the machine is compact and it is able to be used private productions. It is easily transportable and assembled everywhere in a short time.

REFERENCES

[1]   Anonymous, "Matlab Tutorials", 2018.
[2]   Github: *"LaserWeb",* June 29, 2018.
          https://github.com/LaserWeb/LaserWeb4.
[3]   Inkscape: *"Announcing the 0.92.3 Realease of Inkscape",* 2018.https://inkscape.org/en/
[4]   Pololu: *"A4988 Stepper Motor Driver Carrier",* 2001-2018. https://www.pololu.com/product/1182.
[5]   Tower Pro: *"Micro Servo Motor MG90s"*
[6]   Wikipedia: *"Arduino"*, 2018.
          https://m.wikipedia.rog/wiki/Arduino-IDE.
[9]   Wikipedia: *"Stepper Motor"*, July, 2018