Open architecture controller to operate a computerized numerical control machine

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***Abstract*— This paper presents an alternative for operating computerized numerical control (CNC) machine with the help of an open source controller. It takes G and M codes created by computer-aided design/computer aided manufacturing (CAD/CAM) software for a drawing file (.prt or .dxf) as input. The drawing file is obtained by converting a JPEG image into .prt or .dxf file with the aid of Img2CAD software. This drawing file is imported in UG Nx CAD/CAM software (Version 5) and scaled to the required dimensions. 2D manufacturing of the drawing is carried out in UG Nx and G and M codes for the same is obtained by carrying out post-processing operation. G and M code program is saved in a text file with extension .nc. This file is taken as an input by Universal Gcode Sender software which is connected to Grbl shield V5 and Arduino Uno hardware via serial port of laptop. Before executing G code program, the output can be visualized using G-Code visualizer option.**

***Keywords*—GRBL shield; Arduino Uno; Universal GcodeSender; UG NX; CAD; CAM**

I. INTRODUCTION

CNC machines play a vital role in manufacturing industry and it has become challenging to create more agile and adaptable solutions. Majority of the operations like milling, cutting, drilling are performed by CNC machines without having the ability to control and enhance inputs. CNC machines require heavy initial investment and its proprietary control prevents modification to the program codes which is generally retained by vendors who distribute the software in compiled form. By eliminating proprietary control, it will enable provision for customization allowing users with controls to boost performance. Continuous improvement can be achieved which will greatly increase investment returns. Windows based CNC control provides better traceability, scalability, connectivity and versatility enabling cost reduction and quality improvement.

CNC machines utilize G & M code language generated by Computer Aided Manufacturing Systems (CAM) that use Computer Aided Design (CAD) data. G and M code language is characterized by numerical codes such as G, M, F, T, S etc illustrating the operations of a machine. G and M codes generated by controllers of various vendors are not universal.

This report aims at presenting a method of utilizing a generalized or universal controller which will take G and M codes generated by any CAD/CAM software. The controller will then convert these codes into step pulses which will be sent as an input to actuator or stepper motor of CNC machine.

II. LITERATURE REVIEW

Banzi et al. (2005) along with other co-founders started Arduino as a project at the Interaction Design Institute Ivrea, Italy. Arduino is an open source platform with easy to use hardware and software. Arduino boards can read inputs such as light sensing and convert into an output by activating a motor or turning on an LED. Banzi's et al. (2005) Uno shown in Fig 1 was the first in the series of Arduino boards.

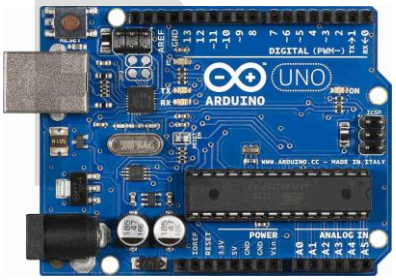

Fig 1: Arduino UNO

Banzi's et al. (2005) Arduino Uno hardware is an open source design and all its components are off the shelf. At the heart of the Arduino is microcontroller chip which can be programmed to do various operations. It also has timing crystal, power regulator, USB interface and power jack. It has 14 digital I/O pins out of which 6 provide PWM output. Uno Board also has 6 analog input pins along with power connection pins for 3.3V and 5V supply.

Banzi's et al. (2005) Arduino Uno software shown in Fig 2 is an open source in which desired code can be written and uploaded on the Uno board. It runs on Windows, Mac OS X and Linux.

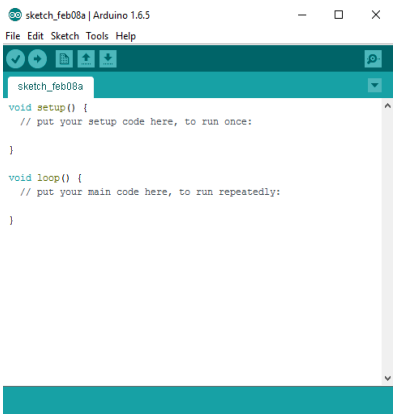

Fig 2: Arduino software (IDE)

Skogsrud (2009) graced the open-source community by releasing early versions of Grbl in 2009. Grbl is moving ahead under the new leadership of Jeon (2011) since 2011. Grbl shown in Fig 3 is a high performance, low cost, open source different from parallel port based motion management for CNC machine. It's written in optimized C which is compatible with and runs on Arduino Uno. The controller is written in extremely optimized C utilizing each clever feature of the AVR-chips to attain precise timing and asynchronous operation. It's ready to maintain up to 30 kHz of stable, disturbance free control pulses.

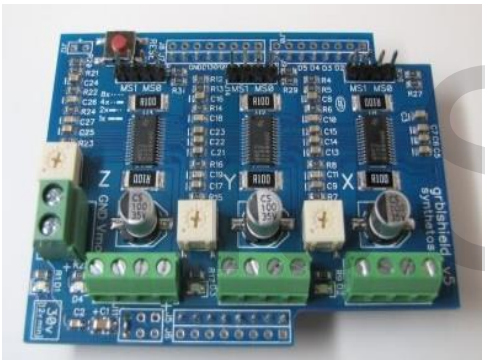

Fig 3: Grbl Shield V5

Grbl is for three axis machines. It accepts standards-compliant g-code and has been tested with the output of many CAM tools with no issues. Grbl interprets a subset of RS274NGC standard gcode. Arcs, circles and helical motion are completely supported, as well as, all different primary g-code commands. Grbl includes full acceleration management with look ahead which means the controller will look up to 18 motions into the future and set up its velocities ahead to deliver smooth acceleration and jerk-free cornering. Grbl comprises of 12 V supply connection along with three drivers for stepper motors. It also has 3 trimpots for each axis to control amount of current flow. Micro stepping provision up to 8x is also present on the Grbl.

Saunders (2014) has demonstrated the running of Nema stepper motors with the aid of Arduino Uno-Grbl shield as main hardware and Universal Gcode sender software via computer. In next section detailed methodology for current research has been presented.

According to Rane et al. (2005), CAD/CAM software can be interfaced to control CNC machines by eliminating NC codes. Rane et al. (2006) has demonstrated features of Open architecture CNC for reducing the equipment investment cost. Further this reduction in investment will also lead to successful lean implementation (Rane et al. 2016) in manufacturing system.

III. Methodology

The block diagram in Fig 4 describes the research methodology used for current work.

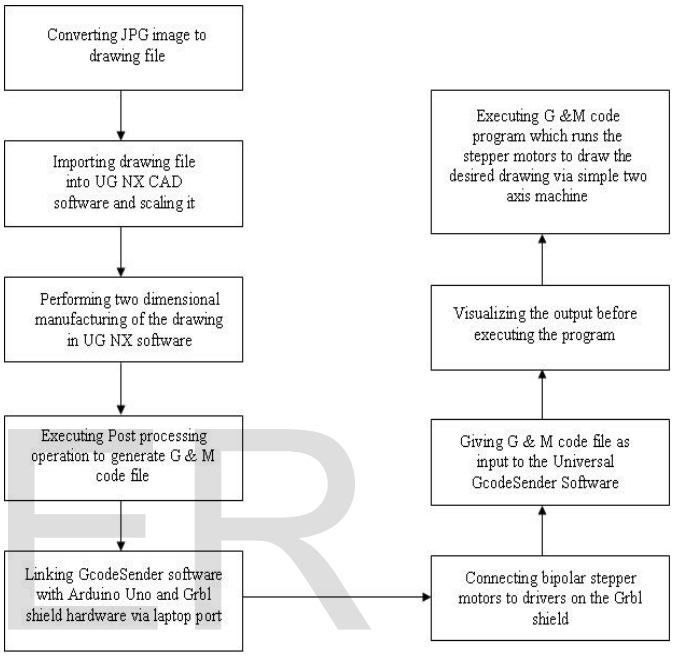

Fig. 4: Block diagram of research methodology.

JPEG Image to be drawn is converted into CAD file (.prt or .dxf) using an Img2CAD converter software as shown in Fig 5.

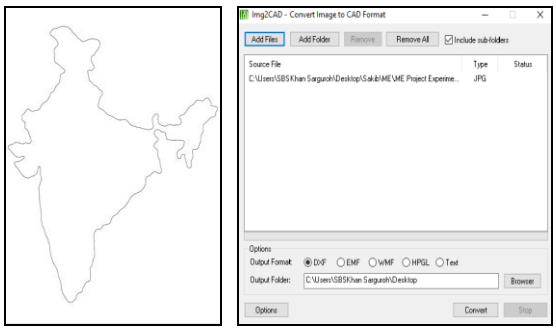

Fig 5: JPEG Image and JPEG to CAD drawing converter

This file is then imported into UG NX 5.0 software where it is scaled to required dimensions as shown in Fig 6.

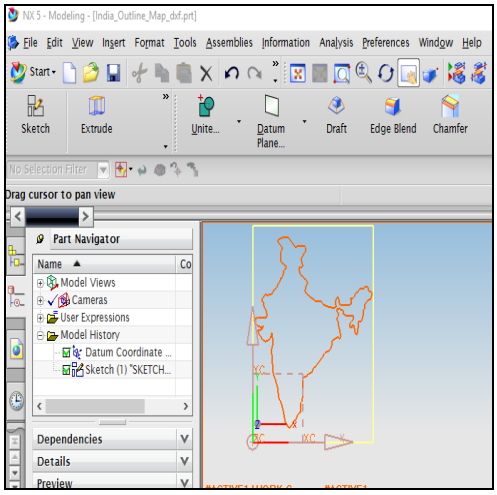

Fig 6: Drawing file imported in UG Nx 5

2D manufacturing is carried out onto the scaled drawing and post-processing is done to obtain G and M codes of the required drawing which is saved with extension .nc as shown in Fig 7.

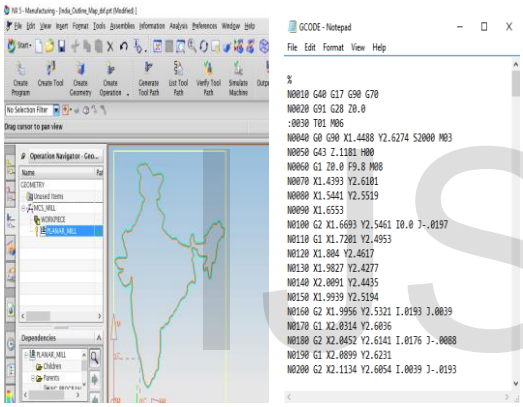

Fig 7: 2D manufacturing and Gcode generation of the image

This file is given as an input to the Universal Gcode sender software which is linked to the Arduino Uno and Grbl shield V5 hardware via serial communication i.e. Universal Serial Bus(USB) port of a laptop as shown in Fig 8.

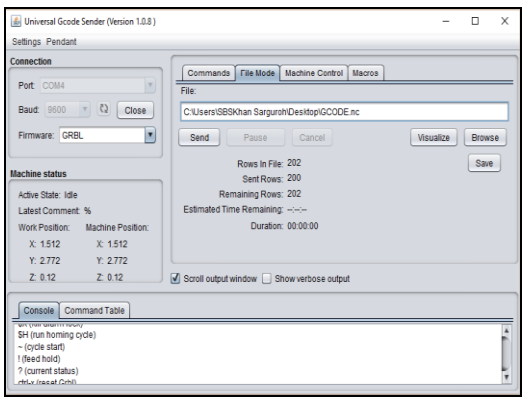

Fig 8: Gcode file sent to Universal Gcode Sender

The output to be obtained can be visualized before executing the program as shown in Fig 9.

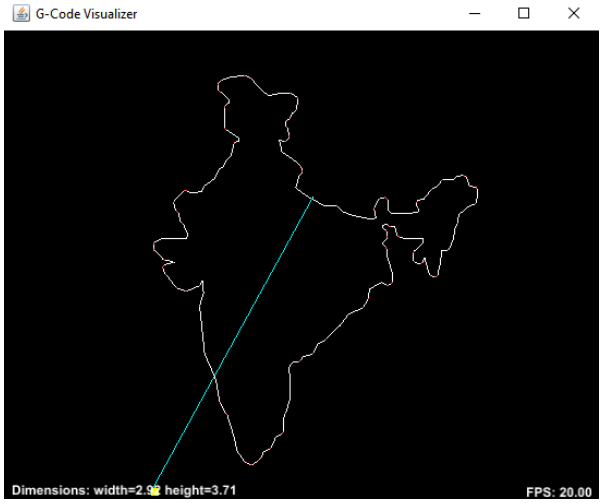

Fig 9: Gcode output visualizer

The program is then executed which runs the stepper motors connected to respective drivers on the GRBL shield.

IV. CONCLUSION

This paper presents a method to develop a CNC controller which provides flexibility to user by enabling access to inner features of hardware and software which is of closed nature in case of conventional controllers. This technology will not only provide adaptable solutions but also is cost efficient when compared to traditional CNC controllers.

A JPEG image was successfully converted into desired Gcode file which was executed by means of Universal Gcode Sender software to run stepper motors.

V. FUTURE SCOPE

Authors are further working for development of simple 2-axis CNC machine hardware which will incorporate stepper motors which will be run by Grbl shield V5 via Arduino Uno hardware and Universal Gcode Sender software along with other simple mechanical parts.

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