

Development of Low-cost plotter for educational purposes using Arduino

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Abstract. With the development of CAD/CAM/CAE concept to product realization time has reduced drastically. Most of the activities such as design, drafting, and visualizations are carried out using high-end computers and commercial software. This has reduced the overall lead-time to market. It is important in the current scenario to equip the students with knowledge of advanced technological developments in order to use them effectively. However, the cost associated with the systems are very high which is not affordable to students. The present work is an attempt to build a low-cost plotter integrating some of the software that are available and components got from scrapped electronic devices. Here the authors are introducing G-code plotter with 3-axis which can implement the given g-code in 2D plane (X-Y). Lifting pen and adjusting to the base component is in the Z- axis. All conventional plotting devices existing until date are costly and need basic knowledge before operating. Our aim is to make students understand the working of plotter and the usage of G-code, achieving this at a much affordable cost. Arduino Uno controls the stepper motors, which can accurately plot the given dimensions.

1. Introduction

The use of technology in education has become indispensable[1]. However the cost associated with the advanced technologies is very high. Computers, software and the interface which is available between the hardware and software has taken education a step ahead of the old days where visualization, verification was so very difficult[2, 3]. To control machines we use electronic devices in this modern era. With the automation in the field of microcontrollers which are easy to use and economical, it gives full control on equipment with flexibility to change the programme when needed and understand the feedback from sensors for precession and accuracy. They help in saving time and labour which also consumes less power, making the equipment power efficient. The aim of the present work is to build a low-cost plotter that can be used for educational purposes[4]. The authors have also found that there is lot of scope of improvement in this work which can be used to teach advanced concepts to the students. Plotters are generally used to make 2D plots, it is digitally controlled. The present work adds an extra dimension where the pen can be lifted along the Z axis. The head can be replaced with cutters (cutting tools) which can enable the built device can be used for milling (metal cutting operation). The head can also be replaced with laser source which can be used for cutting of different materials. In short this work can serve multiple purposes at low cost. The overall cost of the project did not exceed few thousands. Low-cost robots serve a lot of purpose in



education [4-9]. The design, working, interfacing of software and hardware and the cost of the low-cost plotter will be details in the future sections.

2. Modelling

CAD/CAM software enable us to quickly visualize the concepts, model them and manufacture them [10]. The idea was conceived and the 3D model of the low-cost pen plotter was modelled using commercially available CAD software. The 3D model of the same is shown in Figure 1.

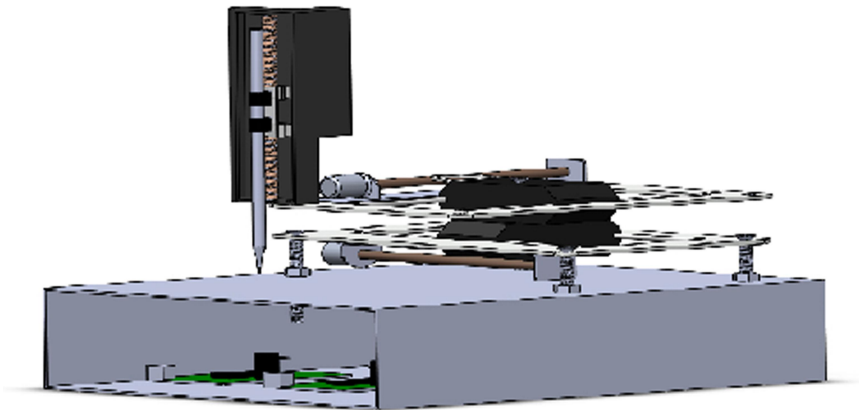


Figure 1. 3D model of the Plotter.

The plotter has 3 degrees of freedom. The pen can move up and down in the z- axis and the pen is free to move along a 2D plane (X and Y axis). The setup has a base to enclose the circuitry. Above the base mechanisms to move the plotter in X and Y direction and a head which carries the pen is assembled on the base.

3. Methodology

The block diagram shown below gives an overview of the methodology that has been adopted in the present work. The Figure 2. explains the methodology that was adopted.

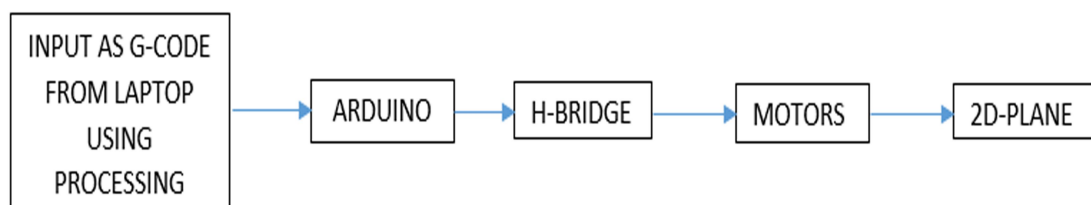


Figure 2. Methodology adopted for the driving the plotter.

The required 2D design can be drafted using any software application. The 2D design is reduced to G-codes. The concept is similar to that is being used in CNC machines [11]. Once we get the G-codes the same is given as an input to Arduino. This is a microcontroller which can operate with different inputs and outputs [12, 13]. Arduino provides the user with the flexibility of controlling devices which

interact with the environment using sensors and actuators. Present work uses Arduino code which controls steppers by interacting with the Processor code which calls the G-code and writes the instructions into Arduino helping the stop and start positions along with the pattern. With the control of speed and steps of stepper making it plot the given points exactly as instructed in the G-code. The power delivered by the Arduino is less from the 5V output pins. So, we use H-bridges which use output from Arduino to control the motor delivering 12V to the steppers and dc motor used for lifting pen. Which are placed horizontally one above other used to move pen in 2D plane. The complete circuitry is shown in Figure 3.

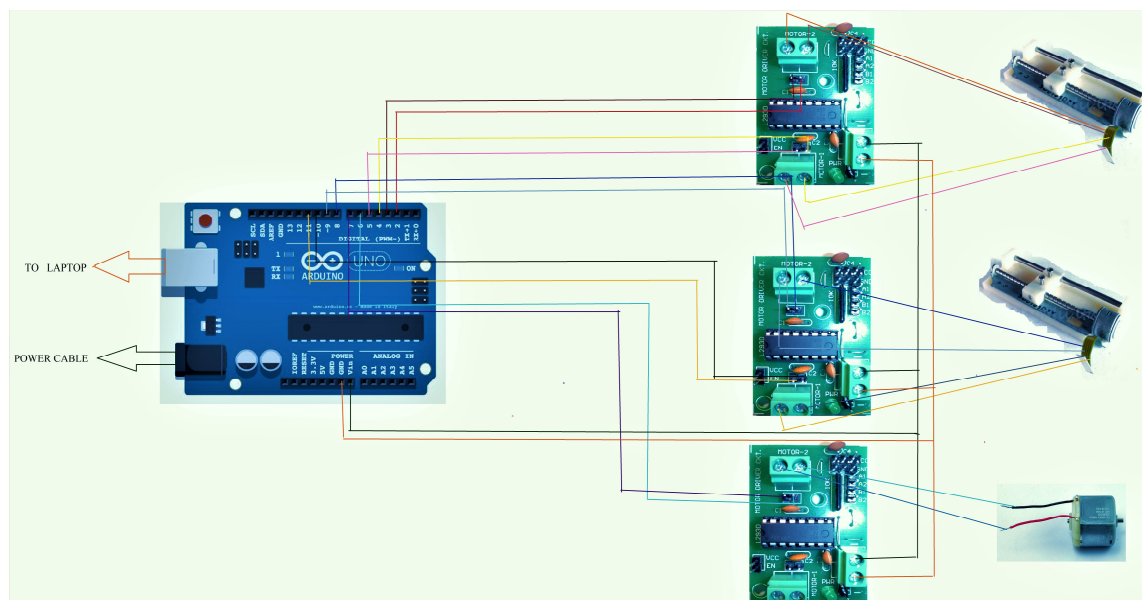


Figure 3. Circuit connecting interface device, Arduino, H-bridge

4. Construction

The focus of the present work is on to build a cost effective G-code plotter. The plotter uses decommissioned DVD drives obtained from electronic Scrap. X & Y axis movement is achieved by Disc ejection mechanism from DVD drives. These mechanisms were carefully disassembled from DVD drives. Ejection mechanism is driven by mini Stepper motor along with trapezoidal screw of pitch approximately 0.2cm, it can move lens of DVD in one direction, assuming it moves the plate in one direction, another ejection mechanism is used to move in Y-Axis (plate 2). By removing the lens part of the drive we have a hole of 0.45 cm diameter in the design on both the plates, by placing both plate axis perpendicular to each other and using the holes we can join them using plates screw and nut. With that assembly we can get the movement of plates in both X-Axis & Y-Axis. All the components are assembled on a casing that houses the circuitry using screw and nut by fixing the base plate (Y-Axis), movement in Y-Axis and X-Axis are free to move. For movement of the pen in the z axis bill cutter heads, used in ATM, Billing Machines to cut the bill paper is being used. Bill cutter mechanism uses DC motor (5V), 3 gears, 1 double threaded trapezoidal screw and a nut which holds small blade to cut paper. This setup was modified to hold a pen, to move up and down when required. The design of entire assembly is simple, easy to assemble and disassemble.

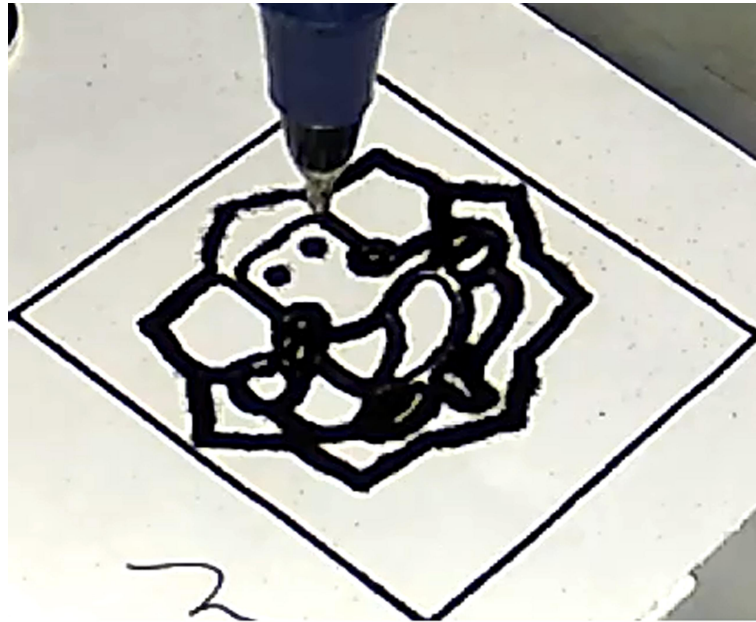


Figure 4. Pattern plotted by the plotter.

The pen plotter can be upgraded to CNC milling machine, which has multiple degrees of freedom. The same can be useful for milling chalk, wax. By using 12V DC Motor (Dimensions of 2cm height, 1.25cm diameter, and 0.2cm shaft diameter) speed up to 2700 rpm can be achieved. For milling cutter, modified screw driver star bit (0.3 cm Diameter) can be used, which is very effective in cutting wax and chalk. In this way the machine can be built and used for educational purposes at an affordable price and used for simulation purposes[15, 16].

5. References

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