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Paper and Fabric Cutting Solution Using Automated Cutting System

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Abstract:

Robots have been utilized as a vital piece for different applications in the industry as well in the academe. In instance, for personal services, robots are being used in the variety of task. In this study, the researchers focused on a new concept of an Arduino-based Microcontroller wheeled laser cutting robot. The researcher is motivated to develop an alternative solution for manual cutting or engraving that could set out to give artists, illustrators, designers and everyone in between have an easy access to laser cutting so they could make their designs a reality. The developed prototype uses 2.5W Blue-Violet and an Arduino NANO that serves as the brain of the robot which the application involves firing a laser which cuts by melting, burning or vaporizing a material. The developed laser cutting robot have passed technical evaluation and testing for the overall functionality and with regards to the results, it indicates that the laser cutting robot is in a good quality as an instructional tool.

Keywords — **Arduino NANO, Cutting Robot, Laser, Benbox**

I. INTRODUCTION

The growth rate of laser technology expands the application areas of laser machines. These machines are using for shaping metal and non-metal plates [1]. Laser has been widely used in modern manufacturing industry with the characteristics of high brightness, high directivity and high coherence [2] in line, cutting, welding, and marking.

Laser cutting is widely used in electronics, automobile and other industrial fields. It takes part in the improvement of product quality and production efficiency.

Nowadays, cutting such complicated design may give minor problem from an artist, illustrators, designers, or even students who wanted to cut complex designs but cannot be manage by their own bare hands. It can be solve by seekingsome help but obviously can cause another capital or even consume much more time.

Book or paper artists failed to utilize the possibility of using the laser as a tool for cutting and engraving paper. Many of these artists use hand cutting and scoring in their work, unaware that the laser cutters can assist.This project explored and demonstrated the potential of the laser cutter as a creative tool in terms of design, structure and construction [3]. The precision levels and edge quality achieved with laser cutting machines are better than traditional cutting methods, as the laser beam will not wear during the laser cutting process. Laser cutting technology also enables us to cut complex shapes without the need for tooling and at a similar or faster speed than other cutting methods [4].

Advances in laser technology and paper handling have combined to lower equipment costs and increase both speed and capacity. It rapidly is becoming the tool of choice for many cutting operations where extremely detailed work is required [5].

Since laser-cutting robot provided significant contribution to the industry, this study is motivated to replicate the aforementioned technologies in the hope of helping our local artists, illustrators or even the students in the academe.

This study intends to design and develop a laser cutting robot utilizing Arduino based microcontroller that will help address the problem of our local artists, illustrators and designers and even students in cutting and engraving items from flat sheet materials like plastic, wood, fabric and paper.

II. METHOD

The fig. 1 is the laser-cutting robot set-up. It consists of stepper motors and a laser module. The stepper motors are used to achieve very precise positioning and/or speed control of the synchronous belt that guides the laser in positioning.

The research presents the development of a laser-cutting robot that can perform to cut or engrave most of the flat-sheet materials. It has only 2 axis direction, the X and Y axis that is operated by stepper motors and where the laser diode is placed and controlled. The Benbox v3.7.99 software is used as a tool to aid in material engraving.

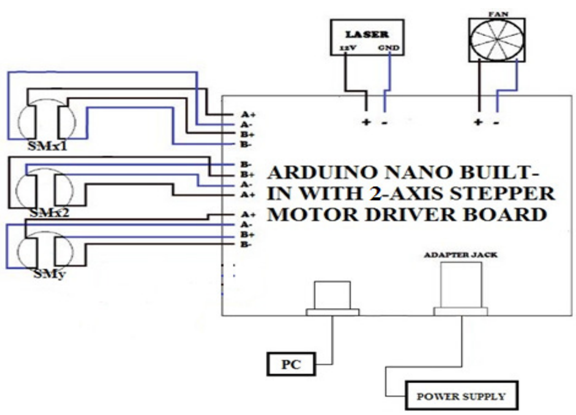

Fig. 1 System Set-Up Diagram

Legend:
SMx1: First Stepper Motor in the Upper X-Axis
SMx2: Second Stepper Motor in the Upper X-Axis
SMy: Stepper Motor in the Y-Axis

A. The Stepper Motor

The fig. 2 below is stepper motor used in the robot. It is used to control the x-axis and the y-axis of the robot which is assigned to manipulate the desired position of the cutting material that creates sharp movements. Typically it has more than two wires that are needed to control it. A stepper motor needs an electrical circuit to work.

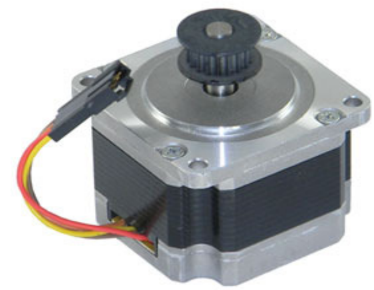

Fig. 2 Stepper Motor

B. Laser Cutter Module

Fig. 3 is a 2.5W Blue-Violet Laser Module with heat sink for DIY Laser Cutter and Engraver must be used in assembling the prototype. The LASER is a device that emits light through a process of optical amplification based on the stimulated emission of electromagnetic radiation. In the laser module, a pair of mirrors located on either end of the lasing medium. These mirrors cause the photons of light to reflect back and forth through the lasing medium. As they travel back and forth, the photons encounter other electrons and cause them to emit photons of the same wavelength and direction. The process ensures that the light is monochromatic, coherent, and directional. One of the mirrors at one end of the laser is “half-silvered,” which means that it reflects some light and allows some light to pass through. The light that passes through this mirror is the light that we see as the laser.

Fig 3 Laser Cutter Module

C. Timing Belt

The laser cutting robot used an Open Ended Single-sided Timing Belt for co2 laser engraver (15mm Width, Pitch 3mm). It is used in the robot to manipulate the axis that the module has been positioned. It is using Japan imported high quality synthetic neoprene and match into many different uses of rubber materials; Skeleton materials imported from Japan for high quality glass fiber cord; Tooth surface with nylon 66 high stretch do protection.

D. Arduino NANO

One of the primary components of the laser cutting robot is the microcontroller as shown in fig. 4. The researchers used an Arduino NANO that serves as the brain of the robot, where the program of the robot uploaded using Benbox 3.7.99. Arduino NANO is a microcontroller board based on the datasheet. It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz quartz crystal, a USB connection, a power jack, an ICSP header and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power with an AC-to-DC adapter or battery to get started. Arduino NANO is built-in with 2-axis stepper motor driver. Stepper motor driver provides an individual circuit to drive the stepper motors for the axis of the robot and the connection is taken from the slave processors output ports.

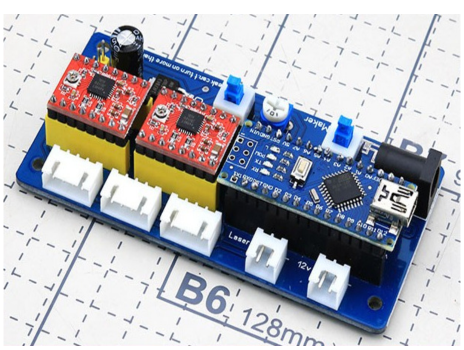

Fig 4 Arduino NANO with built-in 2-Axis Stepper Motor Driver

E. Design of the Laser Cutting Robot

After deciding on what components to be incorporated, the researchers then started on design and develop a laser cutting robot based on the design considerations that the laser cutting robot not only durably accommodates the components to be used, also ensures safety and convenience of the users while using the laser cutting robot. Designing software's such as Google Sketch-up are to be used in designing the laser cutting robot.

Fig. 5 shows the isometric view of the prototype. This section also shows the visualization of the prototype on how it would actually look like after assembling.

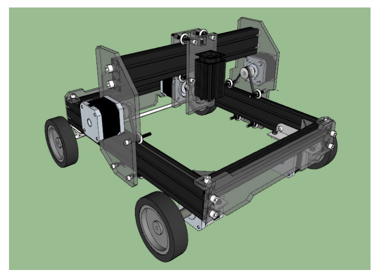

Fig. 5 Isometric View of the Prototype

Fig. 6 shows the left side portion of the prototype's body where the location of a stepper motor that drives one of the upper X-axis.

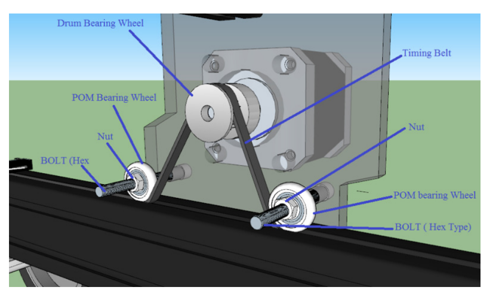

Fig. 6 Left X-axis Driver

Fig. 7 shows the right side stepper motor that drives one of the upper X-axis for the prototypes body.

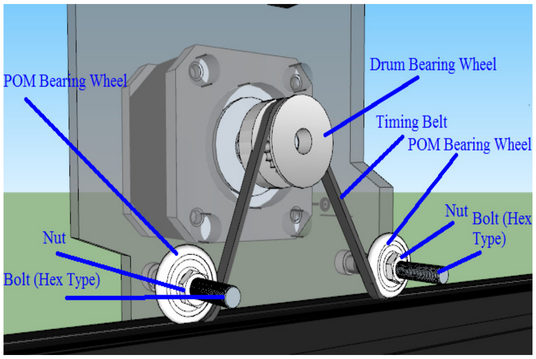

Fig. 7 Right X-axis Driver

Fig. 8 shows the different components found laser's side wherein stepper motor drives the laser module in a linear motion.

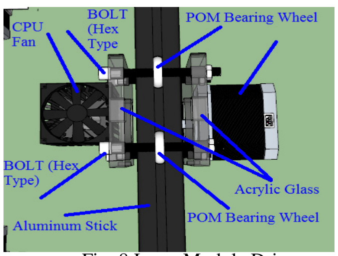

Fig. 8 Laser Module Driver

Fig. 9 shows the one of the stepper motors that drives the lower X-axis of the prototype.

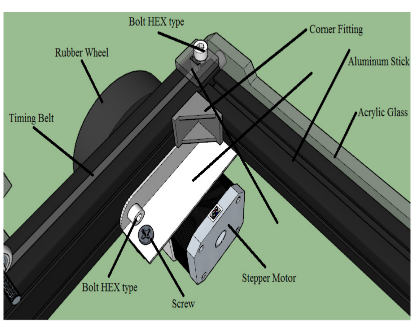

Fig. 9 Lower X-axis Driver

Fig. 10 shows the back side of the prototype wherein the brain of the robot is located.

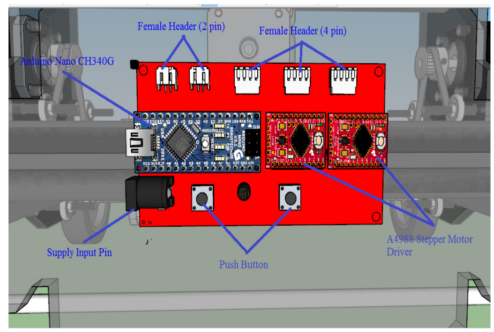

Fig. 10 Arduino NANO Location

F. Development and Prototyping

The designs generated by the researchers are then implemented in the prototyping phase of the project. In this stage the researchers started making the prototype limitations of the project. The researchers also sought advices from there instructor or to their fellow classmates who have their thoughts about the project and design.

The specific steps taken in this stage could be found in fig.11 as shown below.

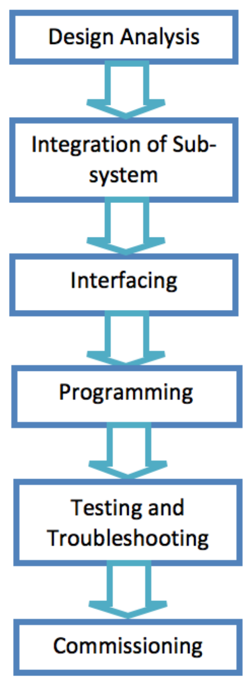

Fig. 11 Steps in the Prototyping Phase

G. Benbox Tool

The entire process of programming, the stepper motor involves the following steps; encoding the program and running the program, which are all processed by the developed microcontroller unit. In encoding the program, through Benbox v3.7.99 compatible software as shown in fig. 12, a sketch program that is developed on the system unit workstation and will be downloaded to the Arduino NANO microcontroller via USB cable. The program run through the execution of the specified programed by the robot.

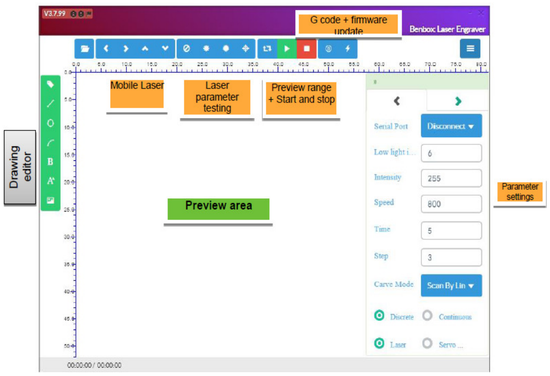

Fig .12 Benbox version 3.7.99 Software

III. RESULTS AND DISCUSSION

A. Prototype Development

In order to have the best design for the prototype, the researchers conducted some review on what should be the most applicable design parameters to be considered for developing the laser cutting robot that utilizes Arduino microcontroller.

Fig. 13 shows the front view of the prototype where the laser module is located. The module is driven by a stepper motor that moves in a linear motion particularly in the Y-axis of the robot.

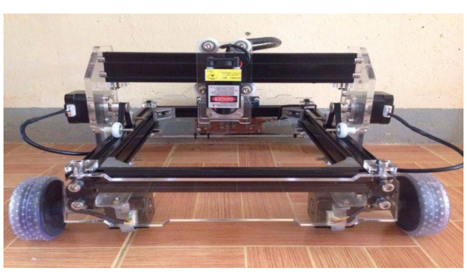

Fig. 13 Front View of Laser Cutting Robot

Fig. 14 shows right side view of the prototype. The stepper motor can be seen at the right side of the robot. It drives one of the upper X-axis. The stepper motor will move in a linear motion (back and forth)

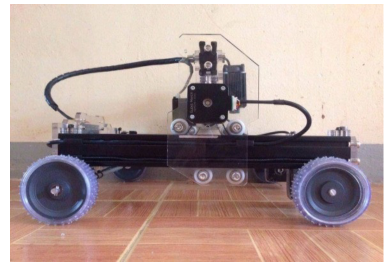

Fig. 14 Right Side View of Laser Cutting Robot

Fig. 15 shows the back view of the prototype. The Arduino NANO and the stepper drivers that serves as the brain of the robot are located at the back of the robot. The Arduino NANO that has been used is none programmable. So the input designs and sketches will be from its compatible CADD software which is the Benbox version 3.7.99 and inputs will be downloaded to the Arduino and the microcontroller itself commands what the stepper motors will do.

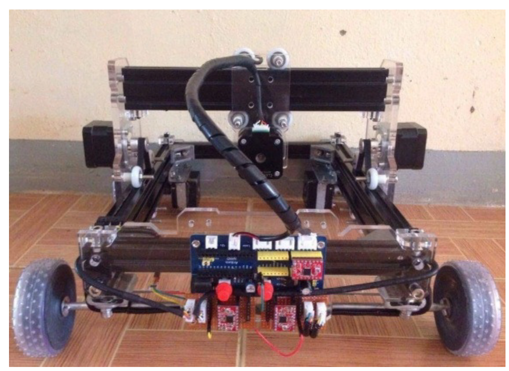

Fig. 15 Back View of Laser Cutting Robot

B. Prototype Perception Based Evaluation

This section presents the observation-based evaluation conducted for the developed laser cutting robot prototype. The evaluation parameters were:

1. Technical Functionality
2. Robot Mobility

C. The Laser-Cutting Robot Technical Functionality

The functionality of the robot is tested using a flat-sheet material specifically fabric and wood. Several designs are loaded into the Benbox software and the robot was able to function as desired. The laser cuts are perfectly preformed as expected. The Benbox software was used to put the robot into operation especially on the stepper motors function. The program was entered into Benbox and downloaded to the microcontroller.

D. The Robot Mobility

The mobility of the robot was also evaluated. It is rated according to its light-weightedness, compactness, durability, portability and movement-precision.

During the test there are some adjustments made due to lack in precision. However, after several tests conducted the robot achieved a high precision on its movement and yield excellent results in cutting.

IV. CONCLUSION AND RECOMMENDATIONS

The overall profile of the laser cutting robot is in excellent rate as well as how the components of the robot were arranged in terms of aesthetics. The operations and the overall functionality base in the input and output of the laser cutting robot is in good rate, have passed the evaluation test require and also for the functionality of the laser cutting robot from its programs in terms of its technical functionality.

The other researchers recommend that the laser cutting robot's working space, compact features and its programming concept should be improved. For the working space and compactness, they recommend that having a little space which components are closed together might be a little dis-organized for the robot to run freely. The researchers recommend also a possibility of adding another axis; explore wireless connection like Bluetooth, bigger dimension and a higher version on the application aspects. The laser-cutting robot can be used also as part of the educational facilities in USTSP. A complete workbook or manual should also be created for the users of the laser-cutting robot.

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REFERENCES

1. *Ugur, K., Ugur, Y., "Characteristics of Laser Cutting Observation Technology and Applications" IEEE, 2016*
2. *Xia, Z., Zhou, K., Li, X., Cui, X., "A Method of Robot Laser Cutting for Small Holes" IEEE, 2016*
3. *Swoden, T., "Drawing with Fire: The Art of Laser Cutting Paper", Monash University Publishing, 2011*
4. *"Laser Cutting Benefits" [Online], Available: http://www.laser-eng.com/laser-cutting-benefits.html*
5. *Hrutky T., "Trends in Laser Cutting Applications" [Online], Available: http://archive.fsea.com/article.asp?ID=112#.WU-cLKN7How, 2009*