**California State University Sacramento**

**Electrical and Computer Science Department**

**EEE 193A/CPE 190 - Product Design Project I**

**Final Project Report**

**CNC Laser Cutter and Engraver**



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**Abstract-**

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# Design Overview

## ****Introduction****

In the industry, a widely used component for cutting and engraving materials is a CNC laser cutting machine. The machine operates through the use of a high-energy infra-red laser light beam. By implementing a focusing lens towards the laser diode, the light beam is concentrated into a single focal point. The focal point allows maximum melting and vaporization of the desired material of interest. In order to alter the position of the laser into a desired location, a computer program known as CNC drives the positon of both the x and y axes. Asides the orientation of the axes, CNC codes can adjust the intensity of the laser to enhance the engraving or cutting of the material. Finally, by using machine vision, we can determine the position of the object relatively to the workspace through the process of object orientation. This process allows finer cutting and engraving for better result. The construction and programming of the CNC Laser Machine will be conducted into four different parts: the mechanics will handle the positions of the CORE X-Y axes, the Laser Diode will generate the light beam for the cutting and engraving, the CNC software will allow for control and intensity of the overall system, and finally detection system will detect the workspace for maximum efficiency.

## ****Equipment List****

1. Mechanical Parts:
   1. Stepper Motor (2x):
   2. Belts(2x)
   3. Linear Rods(4x)
   4. Linear Bearings(6x)
   5. LED strip(1x)
   6. Aluminum Extrusions(7x)
   7. 3D Printed Parts:
      1. X-Y Carriages()
      2. Toolhead()
      3. Linear Rail Mounts()
2. Laser System:
   1. Laser Diode: 2W 445nm M140 Blue Diode in Copper Module W/Leads
   2. Laser Lenses:405-G-2 Glass Lens for Aixiz Laser Module 405nm 445nm
   3. Laser Driver:
3. 1.8 X-Drive V6 Laser Driver-M140-PLTB450-PLTB450B-NDG700-NDG7475
4. 12V TTL 200mW to 3W 445nm 450nm Laser Diode LD Power Supply Driver
5. 2.5 Amp Adjustable Safety Compliant Laser Diode Driver Kit, for UV-Blue diodes, with International Power Adapter
6. Computer Vision:
   1. Web Cam (x1): Logitech C270 720p 3-MP
7. Microcontroller:
8. Arduino Mega with a RAMPS 1.4 motor shield
9. ACE 2510S 5V Cooler Brushless DC Fan 25\*10mm Mini Cooling Radiator(2x)
10. Meanwell Style Power Supply(12V 30A)
11. Arduino Shield:

## Team Member Summary

*Ammar Ahmed -* Ammar has focused his classes in control systems. His part of the project will be focused on the computer vision. Although he does not have experience with computer vision related topics, he will be doing extensive research in the subject and he will also get help from his team member if needed.

*Thomas Bock –*

*Tan Hua –*

*Michael Golez -*

## Detailed Description

In order to design the CNC laser cutter and engraver, research was made on the components needed to build the system. After spending a good amount of time researching and reading about specifications and features included in other CNC laser cutter machines, the team had a brainstorming meetings to come up with new features to make a better product. Our approach was to add more features to make the design simpler and enhance the interface and operating of the device. The following section discuss the four main parts that the team focused in order to design the product:

### Mechanics

The design in general depends heavily on the mechanics.

### Laser System

The operational function of the laser system will be solely dependent upon the microcontroller and laser driver attached towards the laser diode. A simple laser diode will conduct a high-energy beam that can cut or engrave a material prior to user command. However, both the microcontroller and laser driver will work on conjunction with each other. The overall purpose of the laser driver is to deliver a constant current source towards the laser diode in order for the system to operate at a particular application. However, regulating the intensity and precision of the engraving/cutting required the alteration of PWM. A controller is needed to vary the output of the laser so that upon engraving/cutting a material of interest it becomes precise and accurate to the desired requirement.

In order for the laser diode to function operationally, different types of drivers were tested and applied towards the laser diode:

1. 1.8 X-Drive V6 Laser Driver:

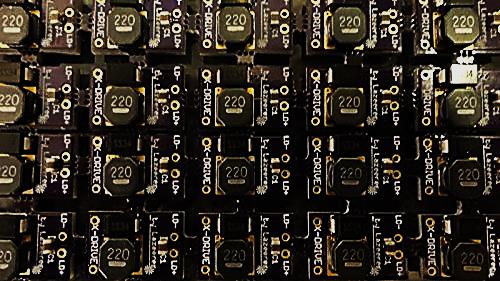


Figure 1

The 1.8X-Drive V6 Laser Driver was the first chosen laser driver to operate the laser diode. The reasoning for combining both the laser diode and X-Drive was the compatibility factor of the circuit with the 2W 445nm M140 Blue Diode. Further review listed from the vendor guaranteed that the driver has low noise capabilities along with self-bleeding caps to prevent spikes created by charged output caps. The circuit component became unnecessary because upon further inspection TTL was not compatible with the device. Another version known as the 4A Super X-Drive Laser Driver was considered, but upon inspection compatibility was not successful with the laser diode.

1. 12V TTL 200mW to 3W 445nm 450nm Laser Diode LD Power Supply Driver :

|  |  |
| --- | --- |
|  |  |

Figure 2

The 12V TTL 200mW to 3W 445nm 450nm Laser Diode (LD) Power Supply Driver replaced the X-drive because of its TTL capabilities. This circuit module provides both a current and voltage regulation towards the load, thus setting a constant source towards the laser diode. By having the user alter the output voltage and limit the current, the laser diode can operate within the region of operation. After setting the limit source, the TTL modulation can then vary the power of the laser by altering the PWM. The 12V TTL 200mW-3W Laser Diode Power Supply Driver was the main current driver used to power the laser until Compliant Laser Driver was purchased

1. 2.5 Amp Adjustable Safety Compliant Laser Diode Driver Kit, for UV-Blue diodes, with International Power Adapter:

|  |  |
| --- | --- |
|  |  |
|  |  |

### 

### Software

### Computer Vision

Computer Vision is a field that includes methods for [acquiring](https://en.wikipedia.org/wiki/Image_sensor), [processing](https://en.wikipedia.org/wiki/Digital_image_processing), analyzing, and understanding images and, in general, high-dimensional data from the real world in order to produce numerical or symbolic information, *e.g.*, in the forms of decisions.[1][2][3][4]Computer vision has a wide range of use and has been used more lately as cameras got cheaper compared to the past. Further, a lot of extensive research have been conducted in the filed which resulted in the development of more algorithms and tools for computer vision. Computer vision acts as human eye visual system for robotics and machines. In human beings, our eyes capture what we see and our brain process the visual images. In a similar manner, cameras are used to capture images and then a computer or microcontroller must be used to process images using different algorithms and tools such as Image Acquisition Tool in MATLAB or OpenCV libraries in either C++ or Python. For our project purpose, camera will be used to get the dimension of the object placed in the working space and the location with reference to the starting point of the laser. Different algorithms and tools will be used for this purpose which will discussed in details later in the paper.

# ****Proposals****

## Funding Proposal

## Product Proposal

# Work Breakdown Structure (WBS)

In order to accomplish our mission, the project has to be broken down into four main parts. Each person was assigned tasks to accomplish with consideration of each person background. The following is the outline of the WBS and project timeline that the team adapted and followed to accomplish our mission.

## Outline of WBS

For the first semester of senior design, the goal is to build a working prototype. As discussed earlier, to accomplish this requirement a plan was made for and the work breakdown structure is a follows:

### Mechanics

### Laser System

### Software

### Computer Vision

We need to be able to locate the dimension of the object to be cut or engrave in order for the laser to stay within the boundaries of the object. We also need to locate the object placed in the working space in order to specify the starting point for the cutting/engraving process. This feature of the project helps in satisfying both objectives by using camera and image processing tools and algorithms.

1. *Edge Detection:* This feature was first recommended to be used by team members. [Edge detection](http://www.mathworks.com/products/image/features.html) is an image processing technique for finding the boundaries of objects within images.[5] Although research was made on edge detection, it was not used for this semester. However, it might be applied next semester to eliminate some of the issue that we are facing now.
   * Estimated Research Time (hours): 7
   * Estimated Implementation Time (Time): 0
   * Estimated Cost: $0
   * Assignee: Ammar
2. *Image Processing:* This feature includes applying different image processing techniques such as image enhancing, image segmentation, region and image properties, and morphological filtering
   * Estimated Research Time (hours): 40
   * Estimated Implementation Time (Time): 5
   * Estimated Cost: $0
   * Assignee: Ammar

## Project Timeline

### Milestone I

### Milestone II

### Milestone III

# Risk Assessment

### A. Laser

### B. Mechanics

# User Manual

### Operation

* Safety considerations: Room Requirement, Objects to be cut/Engrave, Goggles

### Hardware Requirements

* Laptop: MATLAB, Inkscape
* Power Supply
* On/Off switch

### Software Requirements

* MATLAB, INKSCAPE, ReplicatorG

# Design Documentation

## Breakdown of Hardware Subsystems

### Camera

Camera issue at the begging and our issues with PS3 eye.

Non compatible camera system for matlab

### Laser Diode

### Arduino

### Block diagram

## Breakdown of Software Subsystems

### Object Detection Algorithm

### Generating of G-Code

### Laser control

### Flow Chart

## Mechanical Drawings and Documentation

## Test Plan for Hardware

## Test Plan for Software

## Integration Plans

# Accomplishment

# Conclusion

# Appendix A: References

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5. http://www.mathworks.com/discovery/edge-detection.html

# Appendix B: Code