

Proposal: **Laser Lighting Display and 3D Scanning**

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1. Introduction

The ability to point a laser with speed and precision enables several interesting technologies. For example, using the laser as an output, it is possible to display images from files or patterns from signal generators such as an audio input. Conversely, using the laser back-scatter as an input to a camera enables the ability to extract 3-dimensional contour data from objects in its visible field. To demonstrate these technologies, we propose a multifunctional laser display/scanning system using an FPGA for signal processing and a two axis mirror galvanometer setup to direct the beam.

2. External Components Required

2.1 Laser Diode

A red laser diode will be used as the laser source for both projecting images and scanning object.

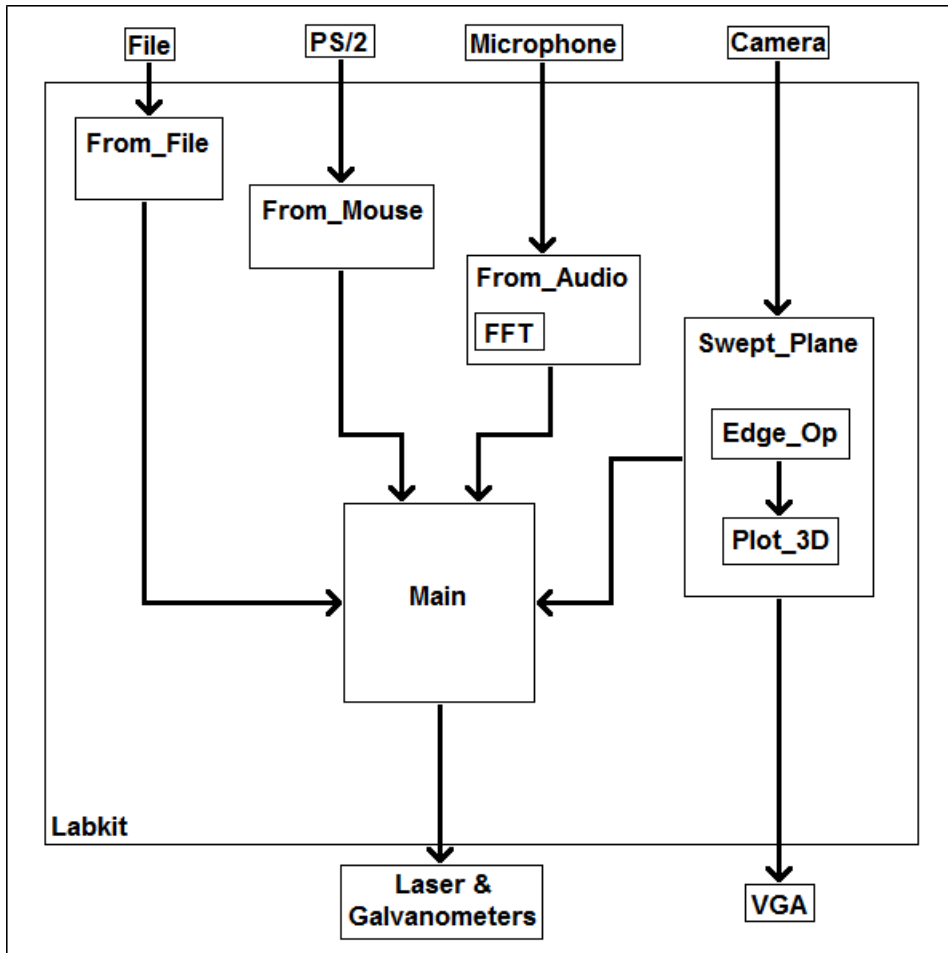
2.2 Mirror Galvanometers

Two mirror galvanometers will be used to control the horizontal and vertical position of the laser source on the projected surface.

2.3 Digital Camera

A digital camera will be used to capture images of the object being scanned with the laser source for analysis.

3. Block Diagram (rough draft)



4. Modes and Major Modules

4.1 Display Mode

In display mode, the device accepts various inputs to direct the laser into visual patterns or images. The inputs can include data from a mouse or pre-written coordinate file, as well as audio signals and possibly video streams (assuming the laser can scan quickly and accurately enough). A state machine would be used to select which input to process and pass to the main module.

4.1.1 Main

The main module accepts the current laser target position as a set of normalized x,y coordinates and a command to turn the laser diode on or off. Using trigonometry, the x,y coordinates are converted into

corresponding angular deflections for the mirror galvanometers. The angle commands are then converted into the appropriate signals to be output to the galvanometer drivers. The laser diode power signal timing can be controlled to allow image tracing with discontinuities and possibly even video projection with low frame-rates.

4.1.2 From File

An image can be projected using a laser by rapidly tracing a programmed outline. To do this, the outline must first be described as straight line segments connecting a series of coordinates in order. This requires a file containing a list of all the target points the laser is to aim at, as well as whether the laser should be on or off for the line segment preceding a particular point. A module would read input files, store them in RAM, and then loop through the list of position and light commands which are passed to the Main Module to generate the display.

4.1.3 From Mouse

Manually writing coordinate files to describe an image can be tedious, especially for detailed images requiring many line segments. To make this easier, a drawing module using a mouse as an input can be included. The mouse coordinates would directly aim the laser as a cursor while clicking would record the current position and add it to a coordinate file. The previously selected coordinates would be looped over and fed to the main module with an extra coordinate for the current mouse location between each loop. This would continuously project the partial image plus a dot for the cursor to provide visual feedback during the drawing process. When complete, the coordinate files can be saved for later use.

4.1.4 From Audio

The main purpose of the *From_Audio* module is to have the lighting display generate real-time patterns or acoustic spectrograms synchronized with an audio signal connected to the microphone, similar to visualizations offered by most digital media players.

The module will first perform a spectrum analysis using Fast Fourier Transform. Then, it will identify changes in loudness and, by isolating the desired frequencies in the frequency domain, specific events such as beats. The information generated by the analysis will then be converted into pre-defined x-y coordinate motions and will then be passed into the main module for display.

4.2 Scanning Mode

The scanning mode will utilize both the laser display and a digital camera. While in the scanning mode, the main module of the display mode will generate a thin laser line that is repeatedly swept across an object of interest. By analyzing the images captured by the digital camera, a 3-dimensional model will be generated and displayed on an external monitor.

4.2.1 Edge Op

This module will use an edge detection algorithm such as the Canny Edge Detection to find the laser line in the image. Knowing the angle between the laser source and the camera, this module will be able to calculate the relative depths of the object of interest at that particular plane. Knowing the rate at which the laser source scans, this module will be able to accurately collect depth information as the laser line sweeps across the object. The information is then converted into 3D coordinates and passed into the *Plot_3D* module.

4.2.2 Plot 3D

This module will first calculate a 2D projection of the 3D coordinates (from *Edge_Op*) from an initial perspective; then it will recalculate the projection base on the change in perspective. The perspective can be changed through a click-and-drag of the mouse. The projection data is passed into the *Swept_Plane* module for display.

4.2.3 Swept Plane

This module will be the main module for the scanning mode. It stores the image from the camera so that the *Edge_Op* module can analyze it. After the *Plot_3D* module computes the projection, this module will then process the projection data and convert them into VGA signals. This module is also responsible for laser line generating and sweeping.

5. Team Responsibilities

Shuyi Chen will design the modules in the Scanning mode and the *From_Audio* module in the Display mode.

Gaston De Zarraga will assemble the laser/galvanometer setup and design the modules in the Display mode except *From_Audio*.