Adaptive Laser Shaping

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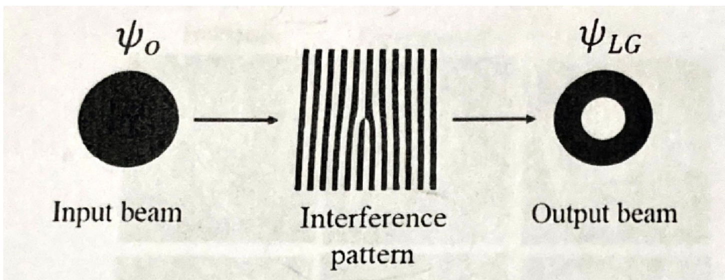
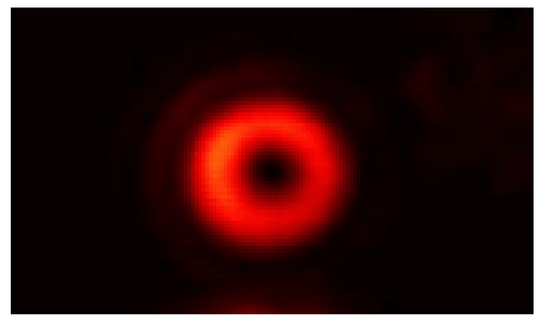
Introduction

The ability to control laser beam intensity profiles and the polarization of the beams is very important in material processing and other optical applications. This is done by creating various modes of operations, or laser beam shapes that result by changing the angles and mode of the incoming light waves. General-Gauss, Hermite-Gauss, and Laguerre-Gauss are a few examples of the different modes a beam can be shaped into. Shaping a beam is undergone by a spatial light modulator, which alters the incoming light wave by deconstructing it, producing the output wave:





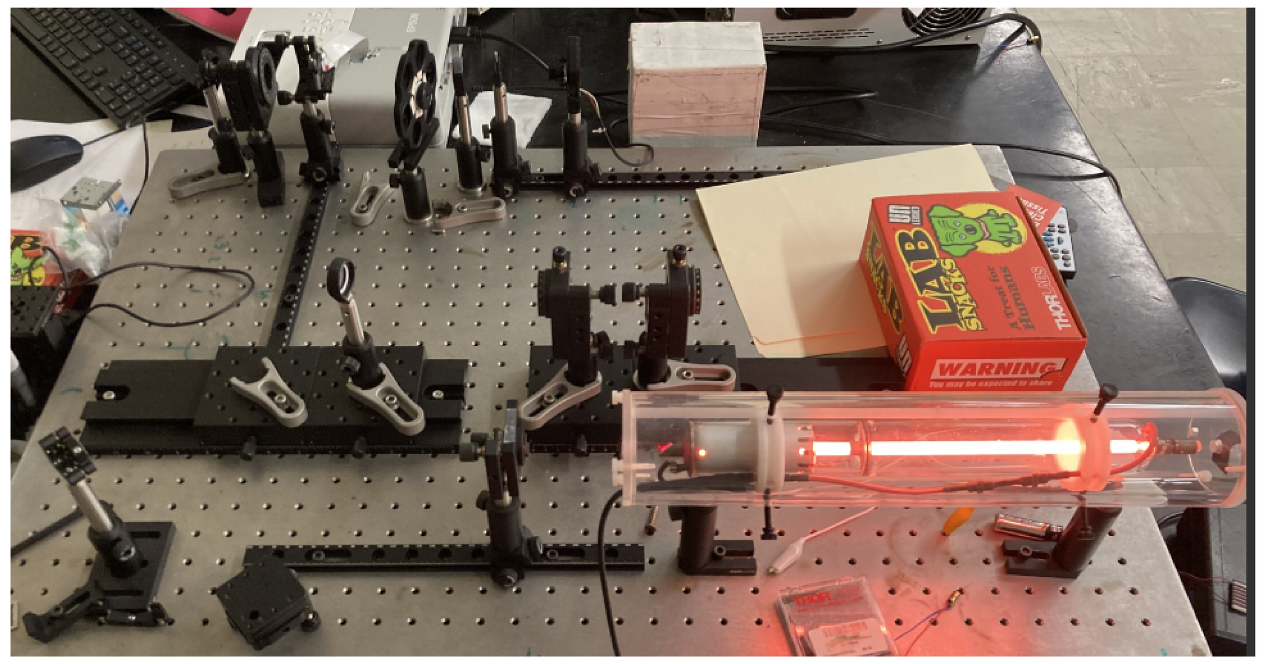
The output beam is not always precise as divergence of the input beam occurs, as well as varying with the programmed interference pattern on the SLM. This results in irregular beam distribution on the receiving optical device, or camera. Limiting divergence of a laser means that the laser will operate accurately and without many imperfections as there is little room to vary from the initial input beam. The goal of modern laser technicians is to limit the divergence and create "perfect" beams that can go across long distances. Finding an alternative for lasers to adaptively correct themselves would be a big step in laser technology. Algorithms can be utilized to create machine learning that will allow the laser to "learn" and be able to classify when an output beam is off target. The laser would then be able to correct itself and produce the ideal output.

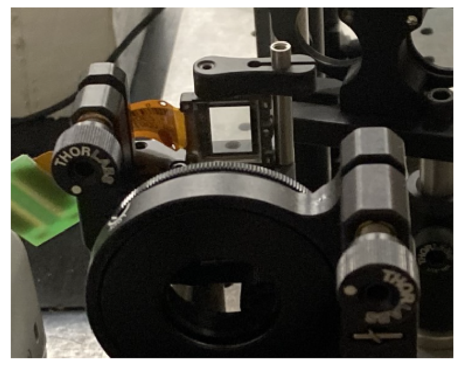
Research Purpose

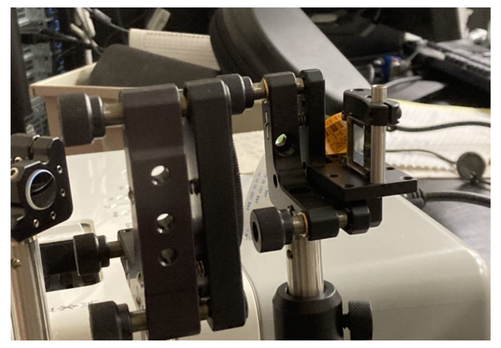
The purpose of this study is to create a methodology to produce a laser machine learning algorithm that allows a laser system to be able classify and correct improper beam outputs, so that precise beam outputs can be produced from the laser correction.

Method

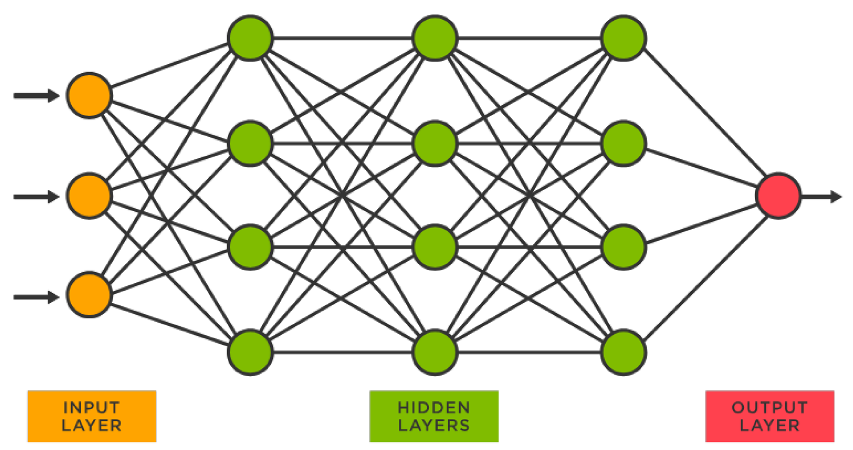
Utilizing a Helium-Neon Red Laser, mirrors, a projector homemade spatial light modulator, MATLab, and a detector camera, a programmed interference pattern was displayed and moved through several iterations to produce captured image test data.







From this test data a CNN will be pretrained, or developed, in order to classify the produce beam shapes as either correct or incorrect.



From this determination another algorithm will be produced to alter the incorrect shapes to produce the correct beam shape. Overall, this routine of collecting, classifying, and correcting will eventually be automatic within laser operation.

Analysis

The method for producing test data was coded on MATLab following previous project work through past semesters. The design into pretraining a CNN or designing a CNN through deepnetwork layout buliding is still underway. The goal now is to be able to classify the collected images to then build the algorithm of self correcting to the ideal outuput.

Findings/Results

The programmed SLM can produce a wide variety of test data by slowly cycling through the code using set parameters.
Deep networks contain many overlapping parameters in order to be able to accurately classify 2D and 3D images.
CNN's can be pre-trained and utilized in many different areas.

Discussion

The project is still underway, but currently the area of focus is developing a CNN either by training a pre-built network or by developing one in MATLab's Deep Network Developer. This will allow the images collected from the camera following the SLM to be used as training data for the laser systems as well as testing data for when a correction algorithm is deployed. The longest problem of this project is developing the CNN. It is essentially the most important aspect of the machine learning for laser as it is the "brain" that the laser will use to determine its corrections. Without a proper CNN the laser will be unable to effectively determine if its output beam is the correct position.

Conclusion(s) / Implication(s)

In conclusion the project is not yet finished as a CNN is still needed in order to classify the collected training data, as well as be able to signal to the laser that a correction to the encoded SLM is needed. In application this methodology for self correcting SLM patterns to move laser beam outputs will greatly improve material processing precision as well as detection on optical equipment. Lasers will be able to correct themselves by classifying improper beam outputs according to what is desired from the programmed spatial light modulator.
During the course of the project I received 2 certifications in MATLab and Deep Network Onramp

References

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