ELECOMP CAPSTONE SUMMIT
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THE UNIVERSITY OF RHODE ISLAND

THINK BIG WE DO™

Automatic Laser Optimization

Autolase

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IRADiON
Ceramic Core CO_2 Lasers

Technical Director: Robert Milkowski

Project Motivation

As Iradion further grows its product line and customer base, the ability to deliver the highest quality lasers in the allocated time becomes more and more challenging with traditional laser tuning methods. These methods consist of entering the laser with long screw drivers, making inaccurate manual adjustments, and using the laser beam to calculate complicated attributes. This process is very inconsistent, time-consuming, and dangerous. The purpose of the Autolase project is to offer a faster, safer, and hands-off approach to laser tuning and alignment. The adjustment process will be fully computer automated by using customized actuators driven by customized hardware and software algorithms capable of reading specific laser attributes and making the necessary adjustments. Adjustments will now be far more accurate thus increasing the overall consistency of products being sold. No longer will production workers spend a large sum of their valuable time with the current trial and error process, or be required to enter the laser and place their hands next to powerful laser beams.

Key Accomplishments

Mathematical: We have discovered and tested the relationship between the position of the mirror adjustment screws and the position of the reflected beam. Using this relationship, we were able to create algorithms that allow us to move the reflection to any point within the mechanical bounds of the mirror structure. This correlates to being able to perfectly center the mirror using the three screws in a timely and efficient manner. The algorithm was derived from regulating the X and Y outputs from the autocollimator to zero. The built-in angle for the mirror mount allows one of the mirrors to reach the desired non-zero angle by emulating a perfectly horizontal mirror.

Mechanical: We have designed in SolidWorks and realized using 3D printing technology a functional actuator that couples onto the adjustment screws and uses stepper motors to turn them (Figure 1). The system and motors are offset from mirror to accommodate the extremely limited space between screws (Figure 2-3). Therefore, we use MXL timing belts and pulleys to transfer rotary power from the motors to the couplers. The system is fully adjustable for different sized components. The current design used all available space to create the most optimal gear ratio between the couplers and motors to maximize the torque of the design. This allows the motors full control of the screws such that the desired output is always accessible. The final design is assembled on an optical breadboard to allow for a precise connection of components (Figure 4).

Hardware: An FPGA is used to send the required signals to a series of stepper motor drivers to control the speed, direction, and number of steps. This allows our program full control of turning multiple motors in parallel for increased efficiency. An autocollimator was also used in the design, which outputs light toward the mirror which is reflected into the device. This reflection is sent into a camera that identifies its distance from the center. The light takes the shape of a crosshair, making it easy to align with the included optical axis (Figure 5). The device outputs X and Y distances from the center point in the form of micro radians to the C# program. Both the FPGA and the autocollimator communicate to the program over UART serial communication.

Software: The user can interact with the system through a simple application written in C#. The program shows the distance the reflection is from the center point. Once the user hits the start button, the *find* algorithm will start. The resolution on the autocollimator is extremely precise, and most mirrors won't show the crosshair of light at the start of the centering process. This algorithm turns all the screws in a specified pattern searching for the crosshair to appear within the area of influence. Once the crosshair is visible, the *adjustment* algorithm takes several runs of turning various screws to reach the regulated point. Once completed, the program waits for the user to signal a new mirror is ready.

Figures

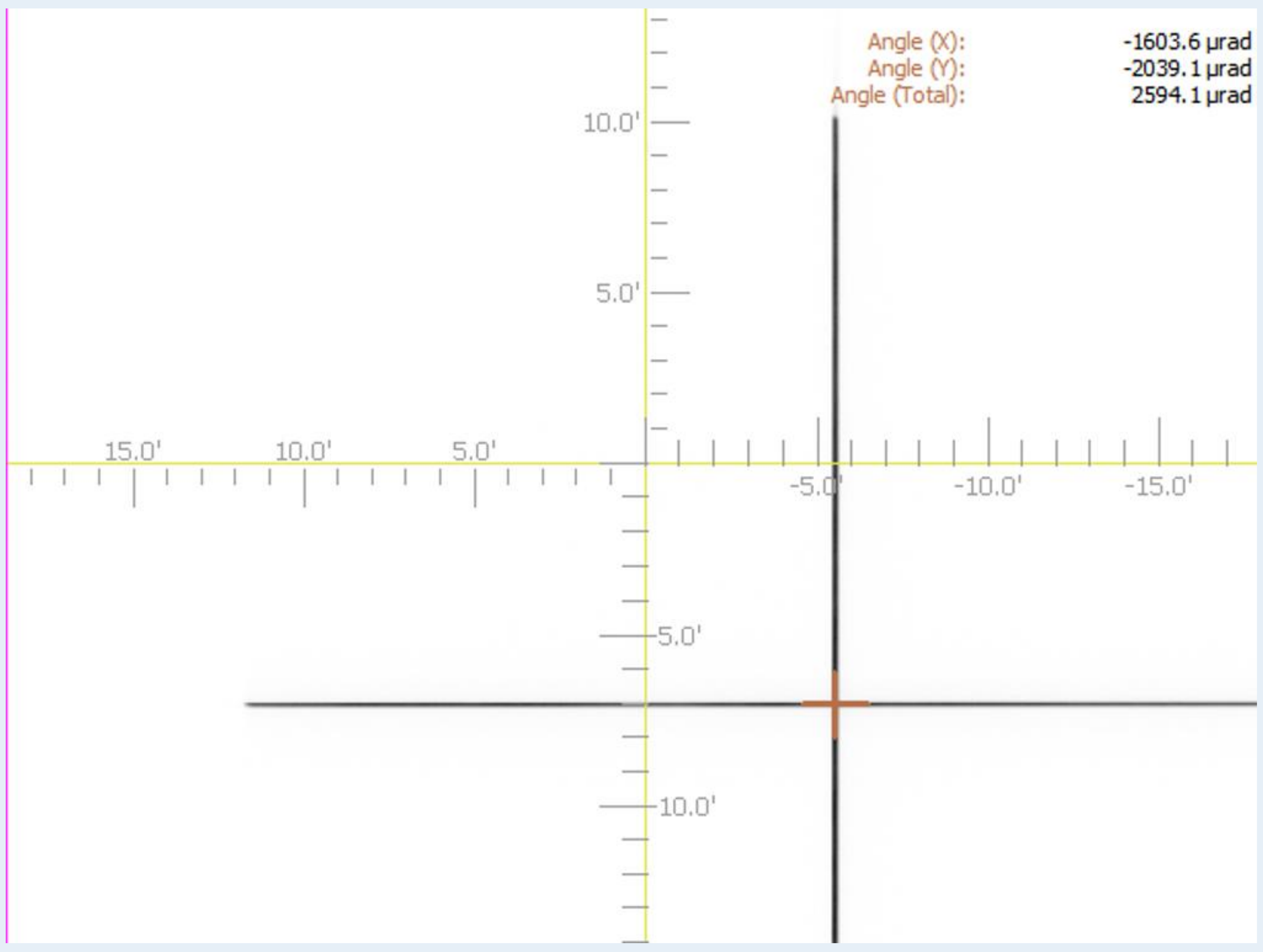

Figure 5: Autocollimator output; Black crosshair is the reflection from the mirror, scale marks the center point.

Anticipated Best Outcome

The best outcome of the project would be to the create software and hardware needed to automate the alignment of mirrors such that mirror's reflection is centered relative to a known point. The alignment also needs to ensure each screw is applying pressure to remain in position, but not enough such that the mirror membrane bends. This will be achieved with a feedback loop that will take in measurements of the current attributes, and simultaneously adjust the laser in order to produce the desired output. A user friendly GUI will be used to interact with the system. The system will be portable, hands-off, meet accuracy and safety standards, and fit the required dimensions.

Project Outcome

The Anticipated Best Outcome was achieved.

Figures

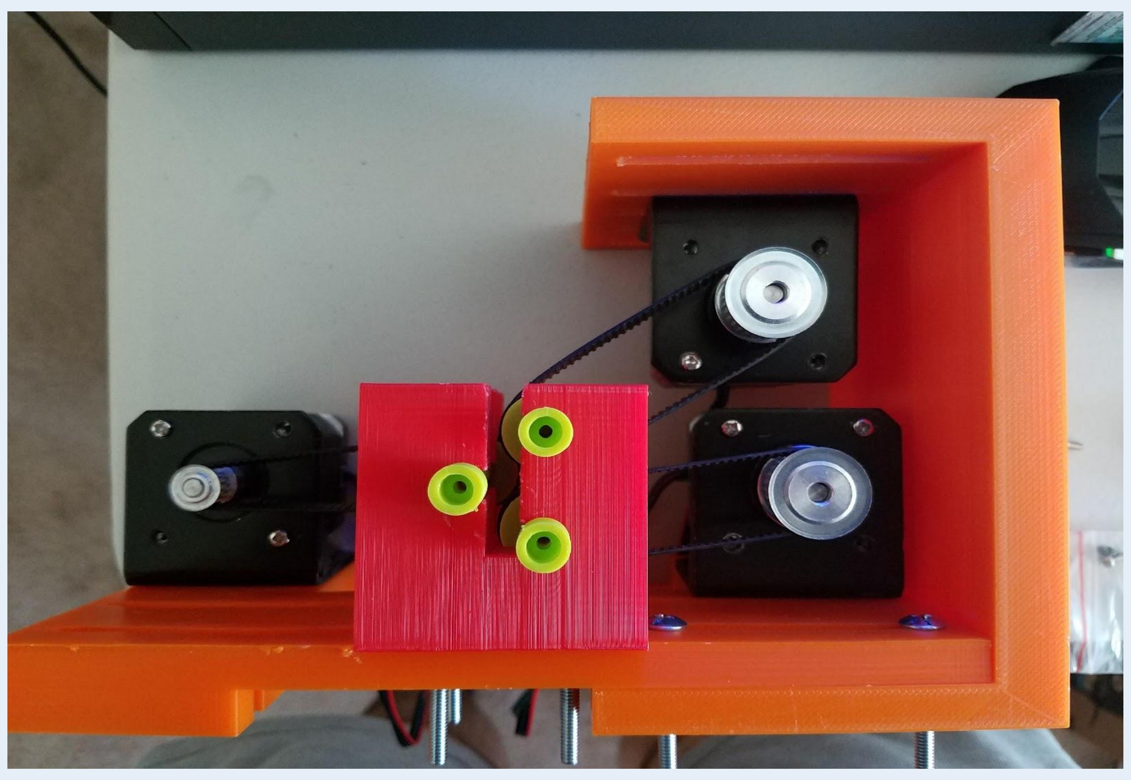

Figure 1: 3D printed hardware that turns the screws.

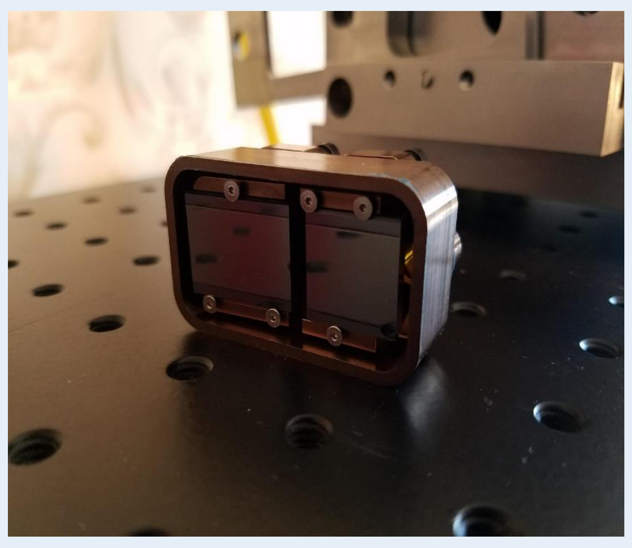

Figure 2: Z Mirror Frontal View

Figure 3: Z Mirror Rear View

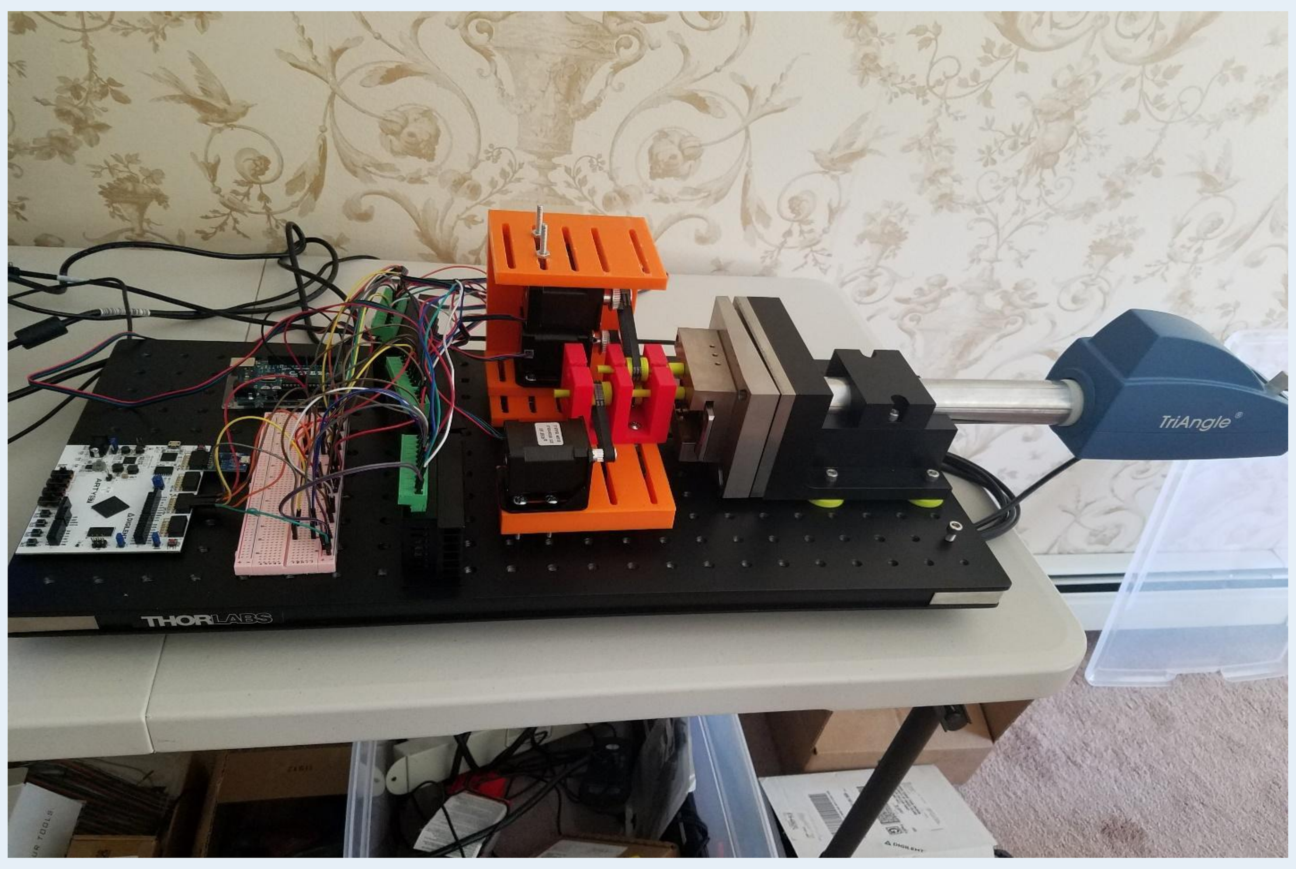

Figure 4: Complete hardware design including the Triangle autocollimator, mirror mount, actuator, and hardware drivers.

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