Automated Geometric Centroiding System

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Abstract

This project was meant to help align and quantify the alignment error of the mirrors in the Navy Prototype Optical Interferometer. Mirrors in the interferometer have to be aligned with respect to each other to one tenth of a millimeter. Mirrors need to be realigned regularly to support reconfigurations of the telescope, but the current method is manually intensive and produces non-quantifiable results.

Our solution is to use image recognition techniques to accurately locate the center of the mirror by detecting the position of an LED marker that is attached to each mirror. Using the distance to the mirror being aligned, the distance that the mirror is misaligned can be calculated in millimeters.

Problem Statement

Many mirrors need to be realigned on a regular basis, this is a difficult task because….

- Mirrors must be aligned to within 1/10th of a millimeter
- Reconfiguration and thermal variations cause misalignment
- Current method (**Figure 2**)
- This method is manually intensive and produces non-quantifiable results

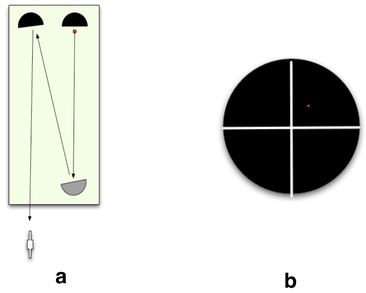

Figure 2: (a) Alignment process. Second mirror being aligned while third mirror's LED marker is activated. **(b)** View of mirror system through alignment telescope.

Challenges

Lack of domain knowledge

Circumvention: Multiple meetings with client and tour of NPOI got get information.

No Java TWAIN Implementation

Circumvention: Use Java Native Interface (JNI) to wrap existing TWAIN library to use in Java

LED hidden by crosshairs

Circumvention: Experiment with un-focusing and using pseudo centers

What is NPOI?

NPOI stands for Navy Prototype Optical Interferometer. It is a high resolution telescope used for astrometric observation.

- Optical Interferometery consists of combining two or more light waves into one
- Stars are targeted with 2 to 6 mirror mounts (siderostats)
- Light waves that are ahead of others are delayed with long delay lines

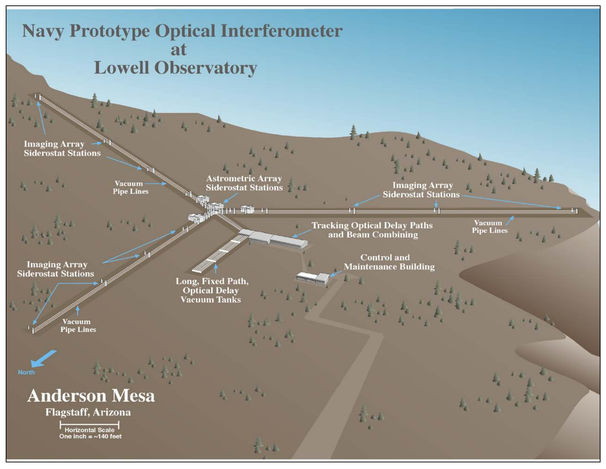

Figure 1: NPOI Site at Anderson Mesa

Solution

Software that…

- Accurately locates LED marker and its location in relation to the center of the crosshairs
- Quantifies error based on distance
- Records alignment error data and exports to excel

Image Processing Example

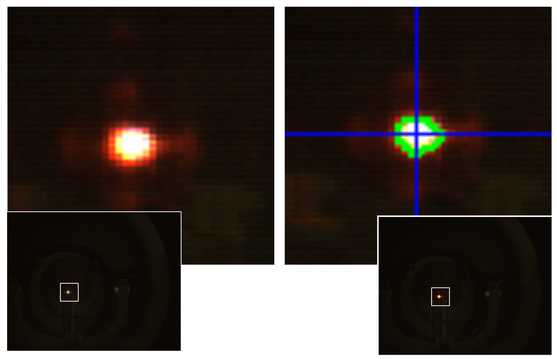

Figure 4: Image processing example

Design

Machine Vision

Use a camera mounted on alignment telescope to feed images into software

Image Processing

Analyze images to find precise error using image processing algorithms

Usability

Make a graphical user interface that is intuitive

Architecture

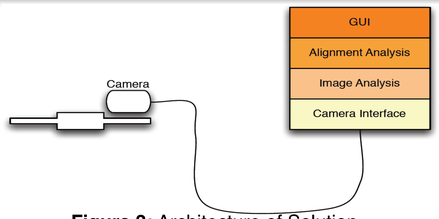

Figure 3: Architecture of Solution
Camera connected to PC via USB, images are analyzed and results are presented to the user through a GUI

Pixel Analysis

The above figure (**Figure 4**) shows how image processing successfully locates the center of a LED marker. LED markers are located using non-static threshold values, which will decrease until a LED marker is located. **Figure 6** to the right shows how many pixels are captured based on a particular threshold.

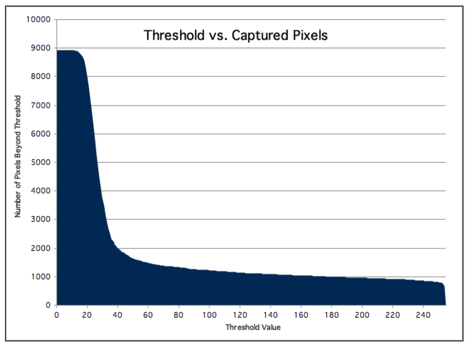

Figure 5: Graph of threshold behavior and captured pixels.

Graphical User Interface

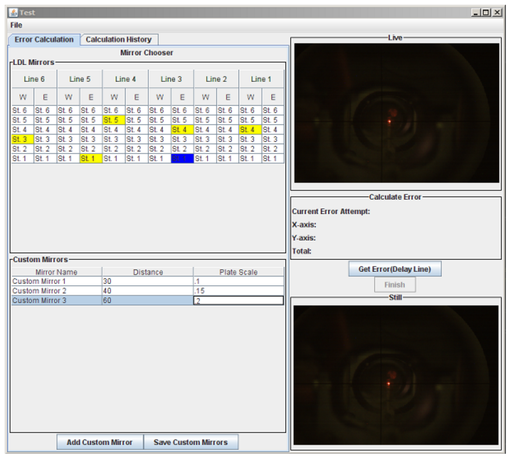

Figure 6: GUI Prototype