Operando Optical Microscope

Overview

This project is part of San Diego State University's Mechanical Engineering course ME 490A Engineering Design Senior Project. Dr. Scott Shaffar is the course instructor, Dr. Kevin Wood is the project sponsor and customer. Dr. Wood is a professor at SDSU, currently conducting research on the behavior of highly dense lithium batteries.

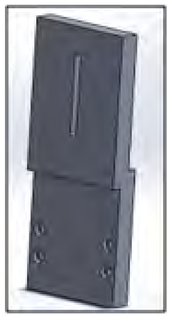
In order to properly conduct experiments, the customer needs to be able to properly locate the sample, precisely focus the image and maintain the focus during the length of the experiment. The current setup requires a person to manually position the camera that sits on a tripod and it is manually focused using a sliding rail. This procedure is time consuming and adds inconsistency to the experiments. The customer needs a system where the camera can be controlled remotely, be able to autofocus on a sample and remain in focus for the duration of the experiment. This system must be able to operate on a table-top and on a stand where it can record experiments that take place inside an air sealed glove box.

Design Requirements

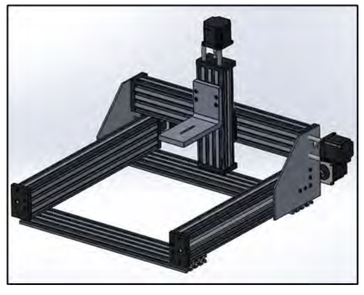
The goal for this project was to create a low-cost optical microscope that can take 4K resolution pictures and can auto-focus. These are the main design requirements for this project:

- Must have precise and smooth movement.
- Must be able to auto-focus through the duration of the experiment.
- Must be compatible with an observation stand for glovebox experiments.
- Must be able to sit on a tabletop.

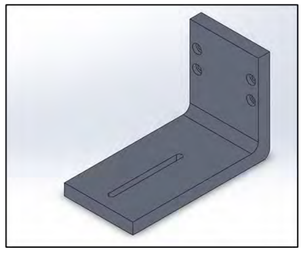
Final Design



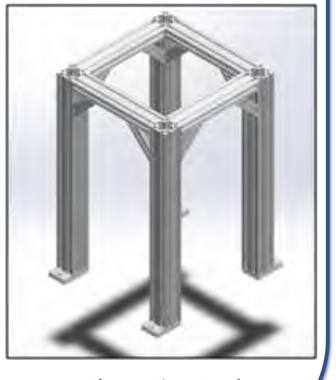
Vertical Bracket



Motion System



L Angle Bracket

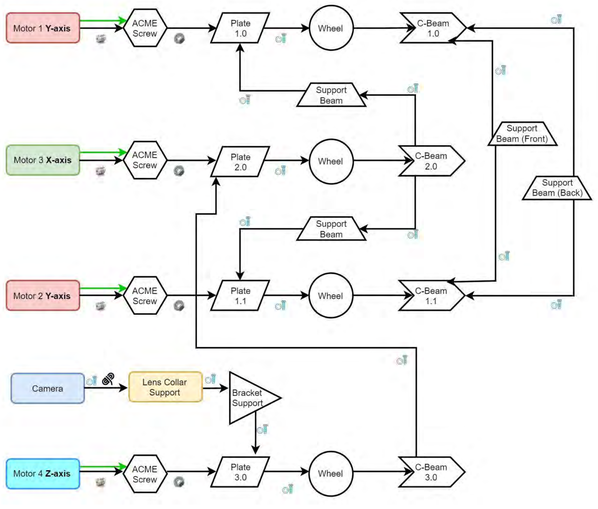


Observation Stand

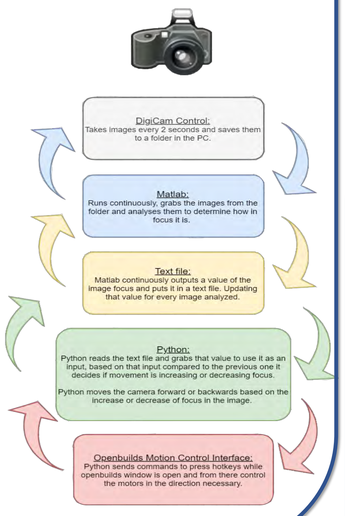
Assembled Operando Optical Microscope

System Level Diagram

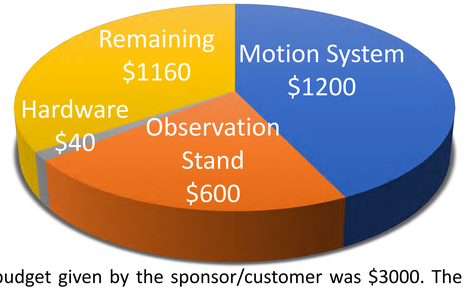
Hardware SLD



Software SLD



Budget



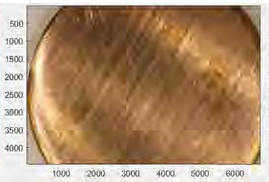
Our total budget given by the sponsor/customer was $3000. The team came under budget using only $1840. The project was under budget by $1160.

Analysis

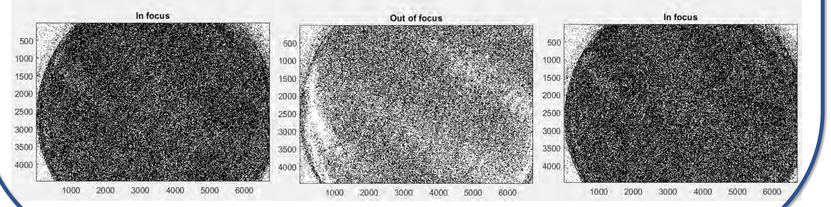
The pictures taken by our microscope are analyzed by MATLAB and given a global average partial (GAP) value depending on how in focus they are. The black section of the image represents the pixels that are in focus, the white pixels represent the ones that are not in focus. The highest GAP value means the image is more in focus. The microscope will be taking pictures continuously, since the experiment is having reactions, the images might get out of focus and the system will work to get them back in focus automatically. The images below show the transition and analysis of images during a test trial. The first image is the starting point of the trial, with a GAP of 3.3927, the second image was manually placed out of focus to simulate a reaction taking place during an experiment. The GAP went down to 1.8700. The third image is the image after the camera auto re-focuses using the focusing algorithm and motion control.

Global Avg. Partial: 3.3927443673

Global Avg. Partial: 1.8700750926



Global Avg Partial: 3.4116979866



Team

From left to right:
Design Lead: María Lerena
Software Lead: Gilberto Aldrete
Project Lead: Carlos Tellez
Manufacturing Lead: Adrian Alvarez

Acknowledgements

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