Affiliate Faculty Research Incubator Program

This project is supported in part through NASA and Oregon Space Grant Consortium, cooperative agreement 80NSSC20M0035.

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Modern Eddington Experiment For Everyone

In Preparation for the 2024 Solar Eclipse

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Abstract

The purpose of the Python Telescope Control software is to construct a Python-based user interface that communicates with astronomical hardware allowing for interaction between the user and astrometric equipment. The Python program, with a User Manual included, is designed to be educational for users new to astrophotography, astrometry, and computer programming. Control of the telescope mount is composed of a user-friendly GUI to control the telescope mount and mounted CCD camera. The mount movement data includes position in right ascension and declination (RA, DEC), celestial coordinate selection, UTC time, and IP address. The CCD camera options include exposure rate, number of exposures, and gain selection. In preparation for the 2024 total solar eclipse, our team has developed an expandable open-source Python-based user interface to collect astrometric data to measure gravitational deflection by the Sun.

Figure 1: From left to right, team photo with Kyle Gourlie, faculty advisor Heather Hill, and Austyn Moon.

Work Cited

MEE. *GitHub - MEE-2024/MEE*. GitHub. https://github.com/MEE-2024/MEE

Berry, R., & Burnell, J. (2000). *The Handbook of Astronomical Image Processing*. Willmann-Bell, Inc.

Berry, R. *Richard Berry's World-Wide-Web Site*. http://www.wvi.com/~rberry/index.html

Acknowledgements

Our team would like to thank Richard Berry for being an endless source of all information pertaining to astrophotography, CCD sensors, and astrometry. He has offered countless hours of support.

Equipment and Field Work

Figure 2: Image of the astrometric equipment used during the creation of the Python Program. Section (A) shows the refractive telescope, including the CCD camera and lens piece. Section (B) includes wiring connections for all the equipment. Section (C) is the telescope mount and tripod.

Figure 3: The first test-run of the Python Program in Dallas, OR. Image includes Kyle Gourlie to the left and Austyn Moon to the right analyzing how the program is running and viewing the FITS files taken of the night sky.

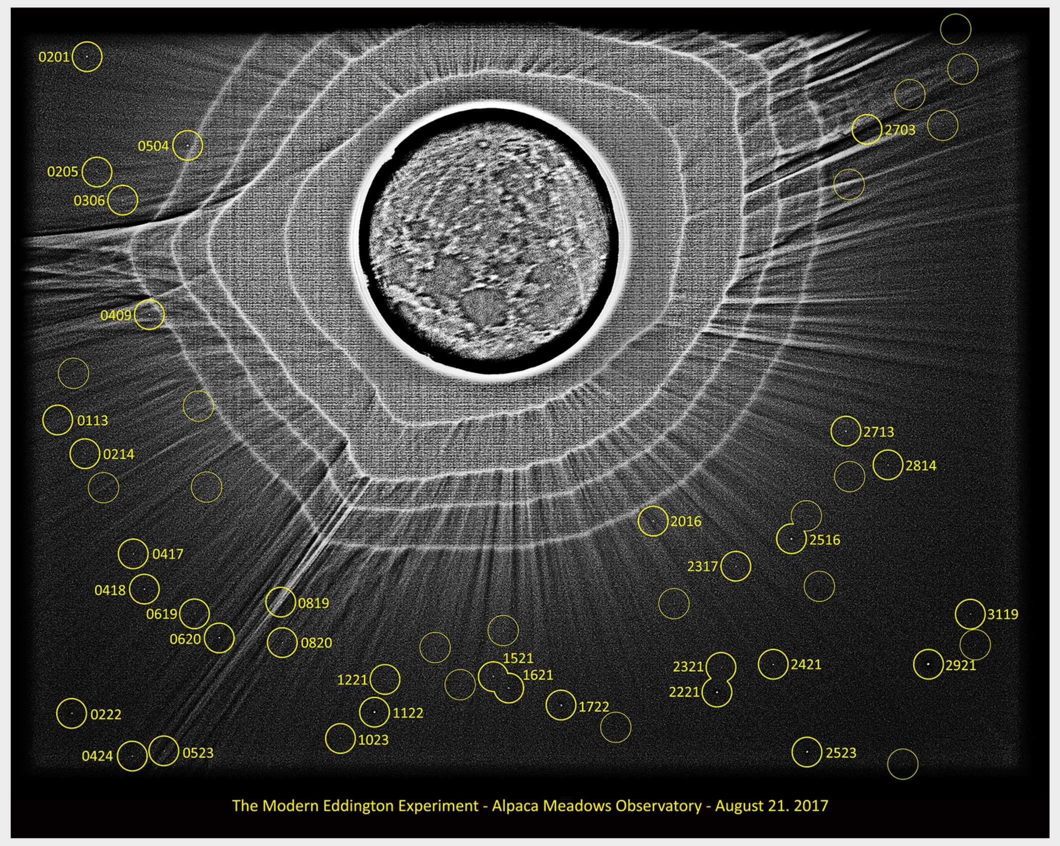

Figure 4: An image of star finding that we are trying to recreate using Python. This processed image of the Sun was taken and analyzed by Richard Berry of Dallas, OR at Alpaca Meadows Observatory following the 2017 total solar eclipse (Berry, n.d.). Berry is a local professional astronomer involved in mentoring our group.

Methodology

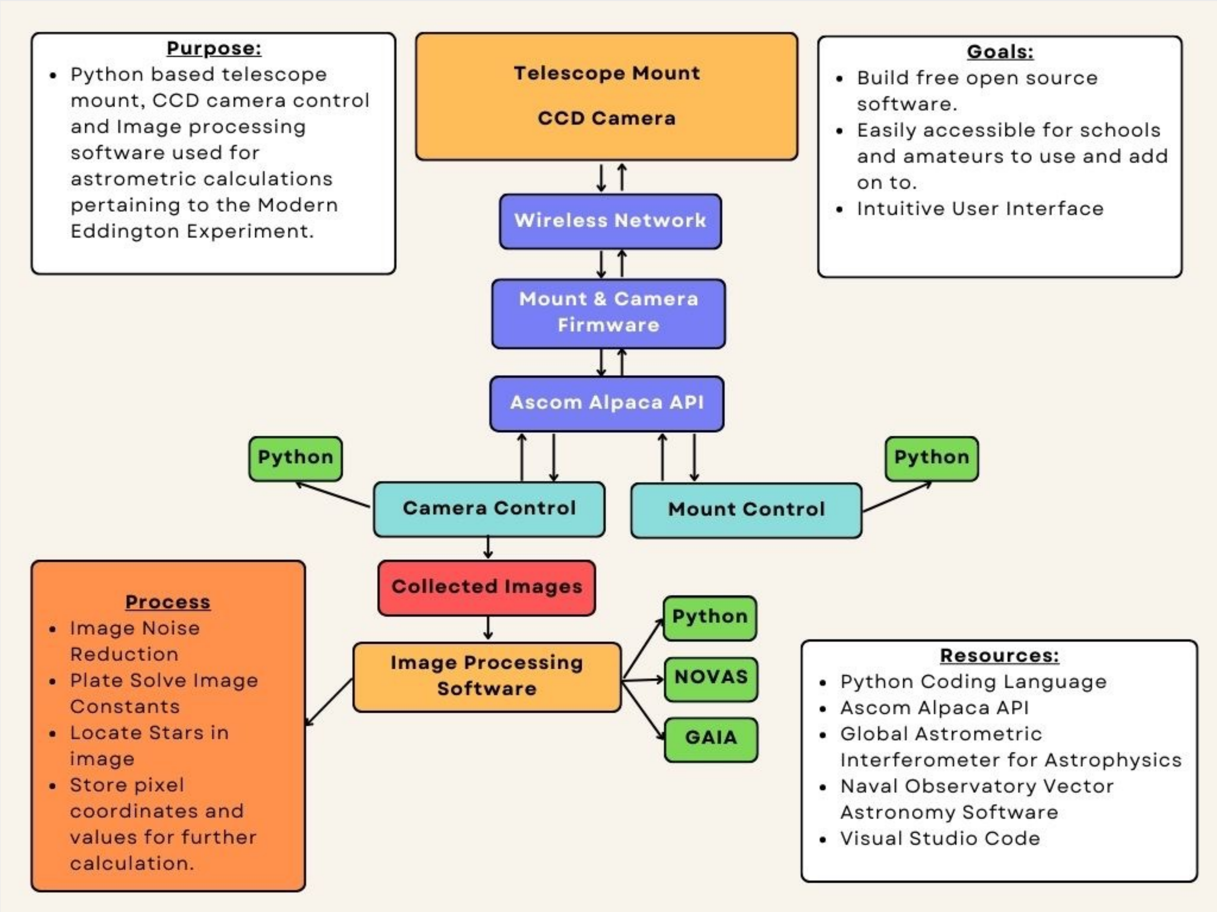

Figure 5: This flowchart overviews the software/hardware process of the program we built.

Using Python and ASCOM, we were able to build a program that communicates with our telescope mount and camera. The implementation of ASCOM's API, Alpaca, made it possible to control the hardware from the Python IDE. The Python module used was *Alpyca*. This module is required to bridge the connection between the Python environment and the astronomical hardware drivers. The API ASCOM allowed the use of a single application to transmit JSON commands to the hardware. The full connection is created by the Python program linking with the Alpaca server, which directly communicates with the hardware via the computer's COM ports. The ability for the Python program to couple to the server is due to *Alpyca*.

The overall automation and image processing aspect of the Modern Eddington Experiment (MEE) 2024 will encompass not just the use of *Alpyca*, but other numerical analysis modules. Since all the data gathered from the CCD camera is in a FITS file format, *Astropy* will be used to analyze and compile the data for further calculations. The Global Astrometric Interferometer for Astrophysics (GAIA) database provides the parameters for each star found in the FITS file such as its right ascension, declination, epoch, and error measurements for each piece of information.

The end goal of this entire process is to find the apparent location of stars in a captured FITS image and compare them to their known locations using reference stars captured in the image and using collected header data to query the GAIA database. Once all the best fit data is gathered from GAIA, we can mathematically transform between measured or pixel coordinates and three-dimensional spherical coordinates to match the celestial sphere. From here, it is possible to compare observed star locations with star locations determined by GAIA. This comparison will allow for a calculation to determine any gravitational deflection by the Sun.

Results

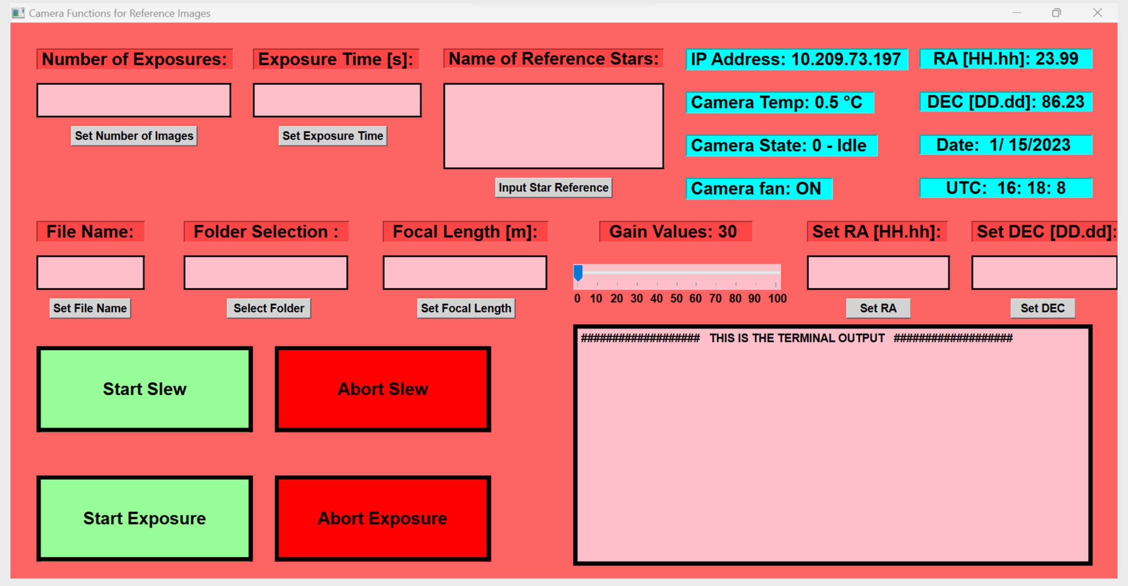

Figure 6: Here is the Graphical User Interface of the Python program. The functionality of the program includes setting the number of images taken, the exposure time for each image, file selection, selection of the celestial location in the sky, and other astronomical parameters.

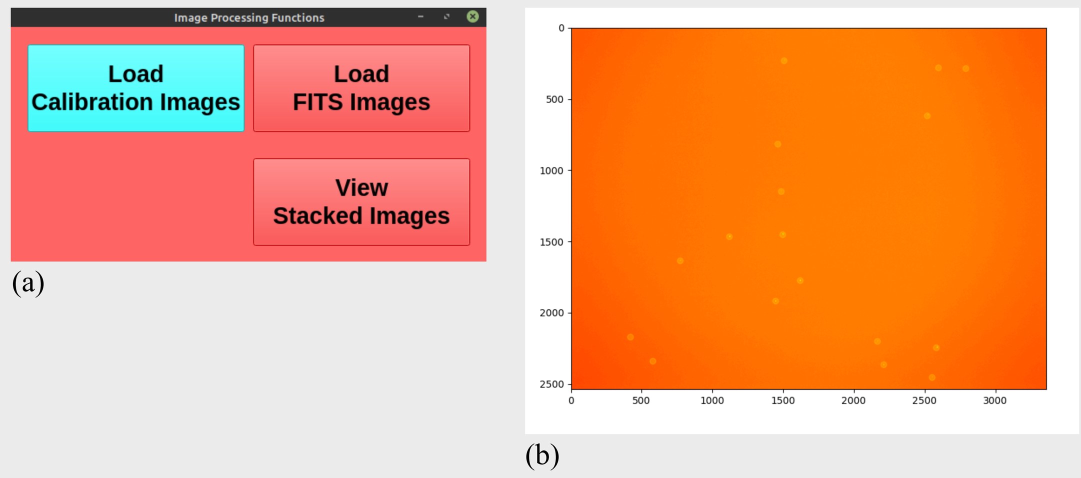

Figure 7: (a) The image to the left shows the GUI for our image stack/view and star finding program. (b) The image to the right shows the result of that operation with circled stars shown.

Conclusion

The creation of a user-friendly Python program that controls telescope hardware and CCD camera was a success. The telescope mount programming allows for full movement with the ability to select any celestial location in the sky, slew to it, and automatically track the star's movement. The Python program can take multiple images in the form of FITS files, in repetition, with a given exposure duration, and save all the data in a single file. Resources aided in the installation process of the software was created in the form of a User Manual located on our GitHub (https://github.com/MEE-2024/MEE).

Future Work

Physical hardware control is only a portion of the Modern Eddington Experiment for the upcoming 2024 total solar eclipse. Full implementation of the Python Telescope Automation Software requires both hardware control and image processing. Image processing methods are being explored by professional astronomers within a larger national collaboration. Methods of data analysis will need to be explored further to find the most accurate and efficient model.