

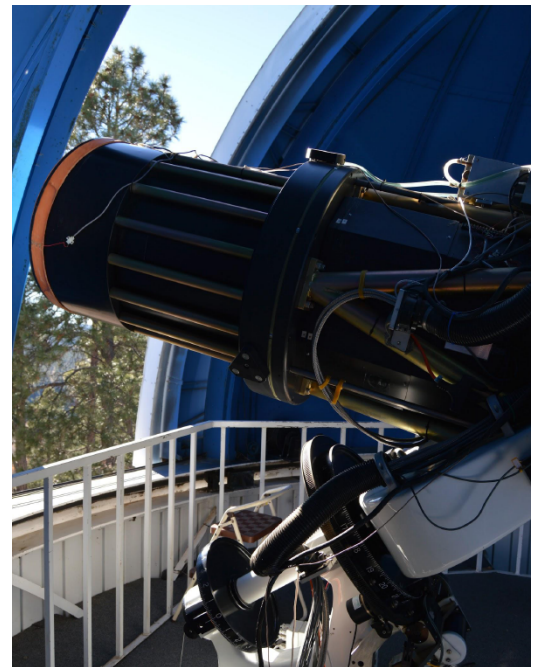
CS486C – Senior Capstone Design in Computer Science

Project Description

Project Title: FRoST Monitor - A diagnostic and data access GUI for the Flagstaff Robotic Survey Telescope	
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Project Overview:

The former Lowell Near-Earth Object Survey telescope is currently being refitted with a new camera and will work in a fully robotic mode as the Flagstaff Robotic Survey Telescope (FRoST). The 0.6 meter telescope is located close to Upper Lake Mary and will be used to follow up newly discovered near-Earth asteroids in order to improve orbit predictions and investigate their physical and compositional properties. FRoST results will improve our understanding of the near-Earth asteroid population and directly contribute to planetary defense aspects. Target asteroids are automatically selected based on observability and fed into the telescope queue system. FRoST will be unique: it will be able to characterize asteroids only hours after they have been discovered, enabling a better understanding of the asteroid's orbit and composition at the same time. While software to control the telescope and analyze the observational data already exists, there are many aspects of the project that have to be designed and implemented.



In this project, we are specifically looking for students who will design and implement a dynamic website that reflects the current status of the telescope and allow for overviews of data collected and flexible access to the data. Some key features must include:

- This website will provide the current status of the telescope systems, including, e. g., the camera status, the telescope pointing, and the orientation of the dome, as well as environmental information (dome temperature, ambient temperature, relative humidity, etc.), which can be obtained from an existing on-site weather station.
- Flexible access tools allow for inspection and interaction with the target list – including potential targets, targets that are currently in the telescope queue, and targets that have already been observed. Various graphical interfaces (target locations projected on all-sky camera images, see below), text and search/filter tools should be provided.
- Database interfaces to easily access datasets in the form of raw image data or measured properties; search and download specific data sets, e.g., “all observations of target <specify> in the last X years”, “all observations of asteroids larger than X”, etc.
- Statistical information on the data obtained, in both tabular and one or more visualized formats. Interfaces to asteroid databases maintained, e.g., at Lowell Observatory that provide information on the physical properties of asteroids.

- Design of a database system that provides access to raw data (telescope images) and reduced data (target brightness information); requires design of a data transfer protocol between individual telescope and data processing sub-systems.
- A real-time camera that allows for checking the cloud coverage and provides the current view of the sky as seen by the telescope. The image delivered by the camera will have overlays presenting the positions of targets that are currently in the queue, targets that have already been observed, as well as the current telescope pointing in the sky.
- Development of a protocol that allows for a direct ingestion of the observational data obtained into existing databases of asteroids, e.g., at Lowell Observatory.
- The interface should also include a password-protected “admin page”, where authorized personnel can remotely control the telescope, e.g., manually shutdown the telescope or interact with it.
- Must allow admin users to configure automated data transfers to servers at NAU or elsewhere; as well as monitoring this data transfer/distribution process.

The FRoST Monitor website will mainly be used by researchers in the field of Solar System science. Results obtained by FRoST – mainly positions and brightness measurements of near-Earth asteroids – will have an important impact on the understanding of the population of the smallest known asteroids, which are most likely to impact Earth. A proper presentation of the results through this website will enable researchers to better investigate the danger these asteroids pose to Earth. Also, it will allow the telescope support personnel to improve the throughput of the telescope, enhance its operations, and identify problems. Finally, a well-designed and easy-to-use website will attract interested people and strengthen the reputation of Flagstaff and NAU as an exceptional site for astronomical research and computer science.

Knowledge, skills, and expertise required for this project:

- Experience with dynamic website development in Unix environments. A modern web2.0 interface is highly desirable, not only to provide more reactive interface options, but to provide an up-to-date, future-ready basis for easy maintenance and future extensions.
- There are no constraints on the programming language to be used, but there is a strong focus on Python within this project.
- Will require some learning of image processing and database capabilities.
- There is no hardware development involved in this project; familiarity with or interest in physical aspects of telescope operations is not required, but might be useful.

Equipment Requirements:

- No special equipment is required for this project. Students will need to have standard development platforms and common open-source tools and IDEs. They will need to be able to log into Unix systems based at the NAU Department of Physics and Astronomy.
- The sky camera to be integrated into the site will be provided and installed by the sponsor. It is merely necessary to access this device and integrate the resulting imagery into site operations.

Software and other Deliverables: The result of this project will be a public and dynamic website as specified above. The specific features of the website can be divided into different achievement levels:

- **Minimum Product Features:** Design and development of a visually appealing dynamic website that provides information on the status of FRoST, its target list, and current weather conditions at the site in real time. Must be thoroughly tested with real end-users; we will provide access to end-users for usability evaluation and refinement stage. The website must also allow for interaction with the telescope through a

password protected area, as well as data access through customizable database queries. The code should be available on GitHub, BitBucket, or some other version control repository that we can fork to gain access to all code. Code should be fully documented to a professional level. A strong as-built report detailing the design and implementation of the product in a complete, clear and professional manner. This document should provide a strong basis for future development of the product.

- **Desired Product Features:** Integration of an all-sky camera that serves as a cloud sensor for the telescope. Additional visualization of the telescope operations and status, as well as the target list. Combination of the local observations database with existing databases on asteroid physical properties.
- **Exceptional Product Features:** Presentation of the telescope's pointing in the sky in real time on the all-sky camera's image. Production of nightly movies that visualize telescope operations for public outreach purposes. Implementation of code that automatically ingests the observational results into existing databases.