CS486C – Senior Capstone Design in Computer Science

Project Title: NPOI Obsprep GUI	
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Project Description

Project Overview:

The central goal of all astronomical observation is to better understand our universe and how it works. Earth and our solar system are just one possible astrophysical arrangement, so what we can learn by looking around our own neighborhood is limited. By observing the billions of other systems out there, we can develop a better understanding of what other arrangements are possible, how they might have formed, and what the implications are for potential future off-earth explorations.

Just as when you view the world with just one eye, there are limitations to viewing celestial phenomena from a single point, i.e., a traditional telescope. Observation of many 2D features benefit from combining multiple views of the target from points that are spread out spatially, a technique called interferometry. For example, the centroid of binary systems changes as one star orbits its partner, and it is the centroid of the binary system that a single telescope measures to generate a catalog of stellar positions; other applications include star-spots (which have yet to be seen!), accretion discs (as the stars spin and toss out matter of different temperature and mass), star rotations (what is the spin rate and orientation of polar axis?) and other interesting science that single telescopes simply cannot measure; we may eventually be able to use nulling interferometry for exoplanet detection.

The Navy Precision Optical Interferometer (NPOI), an astronomical long-baseline optical interferometer, has been in operation on Anderson Mesa, just outside Flagstaff, Arizona, since 1994. An aerial view of the site, shown in Fig. 1, illustrates the general shape and layout of the 2.2 m to 437 m baseline array. The NPOI has a unique capacity for detecting and determining motions and orbits of binary systems. Many regional partners collaborate with NPOI to take advantage of its unique capabilities, including Lowell Observatory, Northern Arizona University, New Mexico Tech, Seabrook Engineering, and Tennessee State University.

The NPOI collects and combines light from up to six apertures simultaneously to form a high spatial resolution synthetic aperture. The wavelength range of operation is currently in the visible spectrum, 400 nm to 800 nm, and will soon include infrared wavelengths. Reconfigurability of the array generates baselines from 2.2 m to 437 m, and the light collected at each station is transported as a 12.7 cm beam through evacuated pipes to a beam combiner. Software automates micro-adjustments to mirrors along the optical path length to ensure extremely accurate tracking of stellar objects.

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Fig. 1 NPOI site, Flagstaff, AZ (Photo courtesy of Michael Collier)

For each night of observations, the observers at the NPOI pre-plan all the stellar objects they intend to observe in the night sky. This process involves selecting the desired observable objects, verifying the available observing stations (up to six, maximum, out of the thirty-four available) and inputting that information in a tool known as *obsprep*. *Obsprep* calculates the position of the stars over time in relation to sunset and sunrise and verifies that the stations selected will produce detectable data (known as fringes) for further analysis.

The Problem:

The current graphical component of *obsprep* is using deprecated technology and has an overly complex setup which becomes more complex trying to get the older software working on newer machines and non-Unix based machines. What is needed is a new graphical environment that observers can use on multiple types of machines to set up observations lists.

The Envisioned Solution:

The goal for this project is to create a cross-platform (Linux/OS X/Windows) GUI that can be easily set up for a fresh install on an observer's work machine. Users will be able to select desired stars they wish to observe for a specific night of observations. Additionally, the observers will be able to generate and save graphs of the rise and set of the sun and the stars that have been selected for a night. A text format of the information will also be able to be generated and be able to be saved.

Level 0 - Minimal viable product:

- A new GUI frontend for *obsprep*
- The GUI will be cross platform (Linux/OS X/Windows)
- Select stars and the stations that are in use

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Level 1 - Some nice additional features:

- Be able to generate and save graphs of the selected stars
- Be able to save a text format of the information and be able to reload that file at a later date

Level 2 - Stretch Goals:

• An installer script or program that performs all the installation for observers

Significance:

NPOI has the longest baselines of any optical interferometer in the world, which means during operation its instruments can also achieve the highest angular resolution among its peers. This unique capability means data collected by the instrument has immense research potential, assisting in the path of discovery for decades to come. NPOI's status as a collaborative partnership between the Naval Research Laboratory, the US Naval Observatory and Lowell Observatory, means that a successful product will provide each of these agencies a new capability to assess the quality of data being collected and monitor the performance of observational systems. Additionally, engineering and observation crews will more easily be able to identify and track down issues across the array, lowering down time and increasing observational potential. Even though this project is a small piece of a much larger system, implementing this GUI grants NPOI a powerful new tool to continue its nightly observations.

Knowledge, skills, and expertise required for this project:

- Some experience with writing GUIs
- Familiarity with GNU/Linux and the GNU/Linux file system structure
- Familiarity with generating graphs programmatically
- Experience in C/C++ and Python

Equipment Requirements:

• No special external equipment or software should be required, other than a basic computer and free software/tools available online.

Software and other Deliverables:

- A report detailing the design and implementation of the product in a complete, clear and professional manner. This document should exactly detail the development process such that any new developers wanting to work on the solution can easily and quickly understand the system.
- A cross platform GUI
- Professionally documented source code, delivered to both NPOI's internal wiki and central computer.