CS486C – Senior Capstone Design in Computer Science

Project Description

Project Title: NPOI Dashboard Web Application	
Sponsor Information:	**Jim Clark**, Director Navy Precision Optical Interferometer Naval Research Laboratory, Remote Sensing Division, Code 7216 Jim.clark@nrl.navy.mil Adam Schilperoort, Software Engineer aschilperoort@lowell.edu Peter Kurtz, Software Engineer pkurtz@lowell.edu Lowell Observatory

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 astro-physical 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.

A variety of sensors are distributed across the array which allow for monitoring of instrumentation data including temperature, pressure, humidity, and spatial displacement. This data is used to monitor the health of the instrument and ensure operators are aware when tolerances are exceeded. In addition to instrumentation data, throughout an observational night, a variety of additional information is collected. This includes generic metadata such as date, time, and operator name, as well as categorized stellar data. Data pipelines process this data and output to an organized and condensed format.

The Problem:

Although a vast amount of data is collected to inform instrument health and performance, this data is dense, located on different machines and directory trees across the network, and in a generic text format. This means without an organized way to view, download, and analyze the data, it is difficult for administrators to understand the state of operation of NPOI. These data sets are also relatively inaccessible to engineers and observers who would otherwise use the data to understand how environmental factors affect the instrument. What is needed is an easy to use web-based interface which allows users to view and interact with the variety of data at NPOI.

The Envisioned Solution:

The goal for this project is to create a web-based dashboard that displays relevant information about the NPOI so that interested parties (astronomers and engineers) can quickly and elegantly browse recent observational data to assess observational performance. Users should be able to interact with graphs of star data to determine which stars were observed over a period of time as well as see the available generated data files from a specific night after the data was collected and processed. Some key features of the software product will include:

Level 0 - Minimal viable product:

- A web page will be deployed to the server at NPOI with graphs
- Users will be able to see the most current observational data
- Users will be able to interact with the webpage to edit the configuration of NPOI
- Users will be able to view instrumentation data as plots organized by date

Level 1 - Some nice additional features:

- The graphs will be interactive with the user being able to highlight different parts or statistics they want to see
- Graphs will be able to be sorted by metadata, ex: observer name, month, day, and year

Level 2 - Stretch Goals:

- Migrate an existing parser to be able get more information out of a large data set
- Generate a celestial map of the observed stars from a night of observation
- Display maintenance emails on the webpage

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 joint project 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 particular project is a small piece of a much larger system, implementing this dashboard grants NPOI a powerful new tool.

Knowledge, skills, and expertise required for this project:

- Fluency with web-app development tools (HTML5, CSS, JavaScript, PHP, etc.)
- Knowledge of server-side processing
- Familiarity with GNU/Linux and the GNU/Linux file system structure
- Experience with data processing from large data sets
- Some experience with writing GUIs

Equipment Requirements:

- No special external equipment or software should be required, other than a basic computer and software/tools freely 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 web-based application capable of displaying updated interactable graphs and charts as well as showing updated data file lists, deployed on a server located at NPOI.
- Professionally-documented source code, delivered to both NPOI's internal wiki and central computer.