CS486C – Senior Capstone Design in Computer Science

Project Description

Project Title: Development of a control system for a fully robotic spectrograph at Lowell Observatory		
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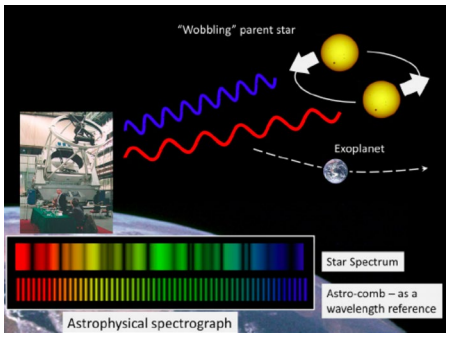
Project Overview:

Looking up at the night sky can be a truly emotional experience. Every dot of light you see could be a star, a galaxy, a planet. They are so much more than just small beads of light. Astronomers spend their careers observing these fascinating objects, characterizing their fundamental properties. Do these stars host planets that can harbor life? Are these galaxies the hosts of massive black holes at their centers? These questions quite literally keep astronomers awake at night.

Professional astronomers have a wealth of telescopes and instruments they can use for characterizing the night sky. One incredibly powerful tool is a spectrograph. A spectrograph splits the incoming light into its constituent wavelengths, allowing us to detect molecules and even the presence of orbiting planets. Indeed, one of the most promising methods for finding a true Earth analog i.e., a planet the mass of the Earth, orbiting at 1 AU, around a solar-type star is through the radial method.



Lowell Observatory is home to many such spectrographs. Our astronomers use these instruments nightly on multiple telescopes to scan the night sky and observe a wealth of celestial objects.

The newest spectrograph in Lowell's suite is a commercially available visible light spectrograph that is ideal for turning into a fully automated system. The spectrograph connects to a state-of-the-art telescope from PlaneWave systems to send starlight through fiber optic cables into the spectrograph that covers the optical spectrum of light. While this a very powerful system, the major limitation comes from requiring an observer to spend every clear evening controlling the spectrograph and telescope.

If you join this project, you would develop a complete control system for both the spectrograph, and, if time permits, the telescope. This will require the development of a back-end control system and, also, a front-end interface for astronomers to take observations, and to schedule a night of observing.

If successful, this project will enable us to fully utilize this amazing piece of astronomical instrumentation to its fullest potential. Since the spectrograph and telescope are commercially available there are other institutions using similar setups to us, so we could make this control system publicly available for use by others, widening the reach of this project to beyond Lowell and NAU.

Basic, minimum viable product:

- Backend control system
    - A "manager" application that can listen for requests from the various subsystems and also the front-end web interface. If the message is from the front-end then the manager should parse the request and activate / update settings on the relevant subsystems. If the message is from a subsystem the manager should parse the information and send it to the front-end interface.
    - The system should use a standardized messaging interface to ensure modularity and the ability for systems to be added / removed without breaking the whole system.
- Frontend interface
    - A modern and secure web2.0 application to provide users with an easy interface to the telescope and spectrograph controls. The application will also provide live status updates from the various subsystems and also a table of previous observations and their core meta data from the current observing session.
- Database
    - A SQL database with tables to keep logs of the various observations that have been taken, and targets that we observe.

Complete, a well-appointed app:

- Supports more dynamic searching of the database, e.g., being able to see observations from previous nights.
- Allows fully flexible visualization and analysis, e.g., zooming in on regions of interest from previous observations
- Supports user accounts, allowing users to specify and run "favorite searches", or set notifications when observations matching certain criteria are added to the DB.
- Fully developed interfaces to the backend components, in addition to a protocol to interface with the systems.

Advanced, stretch goals:

- Ability to call our reduction pipeline at the end of the night to reduce data and email the end-user when the reduction is complete with a directory listing of the reduced observations.

Knowledge, skills, and expertise required for this project:

- Modern web2.0 development frameworks and techniques.
- Front-end web development skills (e.g., HTML, Javascript, react)
- Database access and basic database organizational principles.
- Back-end development using tools such as SQL, Python, socketio, websockets.

Equipment Requirements:

- Our aim is to make all software developed publicly available for use by others with similar setups to us. We therefore only use open-source software.
- Students will be provided access to the computer that the spectrograph and telescope are attached to.
- Data storage will be handled by Lowell Observatory.
- No special equipment beyond a development station and access to publicly available development resources (IDEs) is needed.

Software and other Deliverables:

- The deliverable from this project will be a software suite consisting of a front- and back-end capable of serving and displaying data from our database of our spectrograph.
- All code must be well documented to provide a strong basis for future development of the product and to ensure ease of use for other telescopes aiming to achieve similar science goals as us.
- The final work package will be stored on GitHub.