Mission Overview
The Seeker mission is a NASA Johnson Space Center (JSC) project that aims to build capabilities relevant to the up-close inspection of spacecraft. UT ASE/EM professor Dr. Maruthi Akella’s research group is contracted to write software that enables autonomous visual inspection -- and the TSL is participating. A 3U CubeSat called “Seeker” will be deployed from an Orbital ATK Enhanced Cygnus spacecraft in low Earth orbit. We are training Seeker to recognize the target Cygnus and compute its relative position and orientation based only on inputs from a camera. These outputs can then be fed into the system’s guidance, navigation, and control loop, enabling the spacecraft to reorient and move itself relative to Cygnus after “seeing” it.

Subsystems
Work within the TSL on the Seeker mission has been divided into four subsystems:

1. Algorithms (ALG)
2. Camera Hardware & Software Development (CAM)
3. Flight Software and Hardware (FSW)
4. Modeling and Testing (MAT)

A description of the role of each subsystem within the overall mission as well as some of the skills deemed useful for each subsystem can be found below.
Algorithms (ALG)

Subsystem Overview
The goal of this subsystem is to develop and test software to estimate azimuth, elevation, and pose of an Orbital ATK Enhanced Cygnus Spacecraft relative to Seeker’s onboard camera. This is broken into first developing machine learning algorithms and training a convolutional neural network on the MobileNET architecture using TensorFlow for Cygnus detention, then developing computer vision algorithms using OpenCV for determining relative azimuth, elevation, and pose.

Some projects we have worked on so far include training a convolutional neural network on over 100,000 synthetic images of Cygnus to identify if the Cygnus spacecraft is contained within an image, using different edge detection techniques to contour and identify the 2D centroid of the spacecraft, using knowledge of the centroid and camera field of view to determine relative azimuth and elevation.

Some current and future projects include developing a metric for algorithm analysis, using TensorFlow’s Object Detection API to get more accurate edge detection, using depth analysis to identify a body’s 3D centroid, and exploring multithreading to improve performance.

Desired Skills
Software:
- Linux
- Python
- TensorFlow
- OpenCV

Hardware:
- N/A

Miscellaneous:
- Experience with multithreading
Camera Hardware and Software Development (CAM)

Subsystem Overview
The CAM team works with the camera, our primary sensor for the Seeker mission, in conjunction with the flight computer. The goal of our project is to be able to process photos and pass them to other subsystems for analysis.

The team has previously worked on understanding the C++ libraries necessary to work with a camera connected to an embedded system, and this team has spent time researching and understanding the necessary functions used to operate the camera and influence the quality of images. Since receiving the flight camera from NASA, we are now employing OpenCV and the Video4Linux API to operate the camera, save images, and pass them to other subsystems.

Our current goal is to fully understand OpenCV so that we can utilize its methods for camera operation. Our next goal requires hardware-in-the-loop testing with the Modeling and Testing team. During this we will be learning about the Vicon motion capture system to verify the algorithms implemented in a high-fidelity simulated environment. In the future, we will be working with various hardware in different projects, likely learning about how to operate them in embedded systems.

Desired Skills
Software:
- Linux
- Python
- OpenCV
- C++
- SolidWorks

Hardware:
- Embedded systems
- Camera experience

Miscellaneous:
- Research skills
- Debugging skills
Flight Software and Hardware (FSW)

Subsystem Overview
Seeker FSW is responsible for the successful implementation of software onboard the mission hardware; we work at the crossroads of the hardware and software divide. This allows for great flexibility in the work we do.

Currently, we are focused on installing all necessary libraries onboard the flight computer crucial to higher level software, and we are beginning work on the real-time system necessary to ensure mission success. Low-level flight code, primarily written in C, will facilitate communication between software modules, export or save mission data, and ensure all errors are handled safely.

Going forward, we will be evaluating the computational requirements of the system to identify program bottlenecks and ensure we will not put the rest of the spacecraft at risk. We will also be leading the charge on hardware-in-the-loop testing in the near future, using the Vicon motion lab and actual mission hardware to verify overall functionality of the system.

Desired Skills
Software:
- C/C++
- Python
- Familiarity with Linux (Any distribution will do, but we work primarily with Ubuntu)
- Bash
- Git

Hardware:
- Microcomputer/controller experience
- Printed circuit board design
- General electronics experience

Miscellaneous:
- Ability to solve technical problems independently
- Self-driven
Modeling and Testing (MAT)

Subsystem Overview
The Modeling and Testing subsystem (MAT) is responsible for the modeling of Cygnus - and the orbital environment surrounding it - for both machine learning and algorithm testing purposes. MAT is decidedly interdisciplinary. It is often accountable for tasks that span beyond one subsystem, contributing largely to mission integration.

An example of a previous project is the creation of a synthetic image library of Cygnus to be used for machine learning. This effort consisted of using software to texture the model spacecraft and import it to a virtual environment where images of it could be captured. Scripts were also written to systematically take virtual pictures of the model in different environments and at various positions. This array of images would then be used to train the neural network into identifying Cygnus.

Even though Seeker is focused mainly on software, MAT also handles elements of hardware. Aside from the virtual model, a physical model was also created using a 3D printer. In the future, this model will be used in conjunction with a motion caption system to test algorithms developed by other subsystems. Before this can be accomplished, MAT team members will be involved in interdisciplinary learning. Becoming familiar with the flight computer and camera will be essential to ensure seamless subsystem integration for hardware-in-the-loop testing.

Desired Skills
Software:
- C++
- Python
- Visual Studio
- Unreal engine
- Blender

Hardware:
- 3D Printing

Miscellaneous:
- Familiarity with Vicon system in Auto-GNC lab