MECE 6388: Optimal Controls Project Proposal

Mars Rover 3D Position & Velocity Tracker

With the push to return humans to planetary bodies like the Moon and Mars through NASA's Artemis program, and SpaceX's advancements towards establishing a permanent human presence on these celestial bodies, surface habitation technologies are becoming critical. These include extraterrestrial habitats, resource refuelling systems, and navigation methods that can support surface operations without GPS. This project aims to tackle one of these challenges: developing a system to accurately track the position of a rover relative to a set of ground-station beacons, a technology vital for supporting surface operations in GPS-deprived environments like the Moon and Mars.

The goal of this project is to develop a nonlinear Extended Kalman Filter (EKF) to track the position and velocity of the rover relative to ground-based beacons. The EKF is considered suitable for handling the fusion of various sensor inputs, such as IMU and ranging measurements from the beacons. Essentially, the EKF will use IMU data to integrate the kinematic motion of the rover and employ classic triangulation techniques to refine the accuracy of the estimated state.

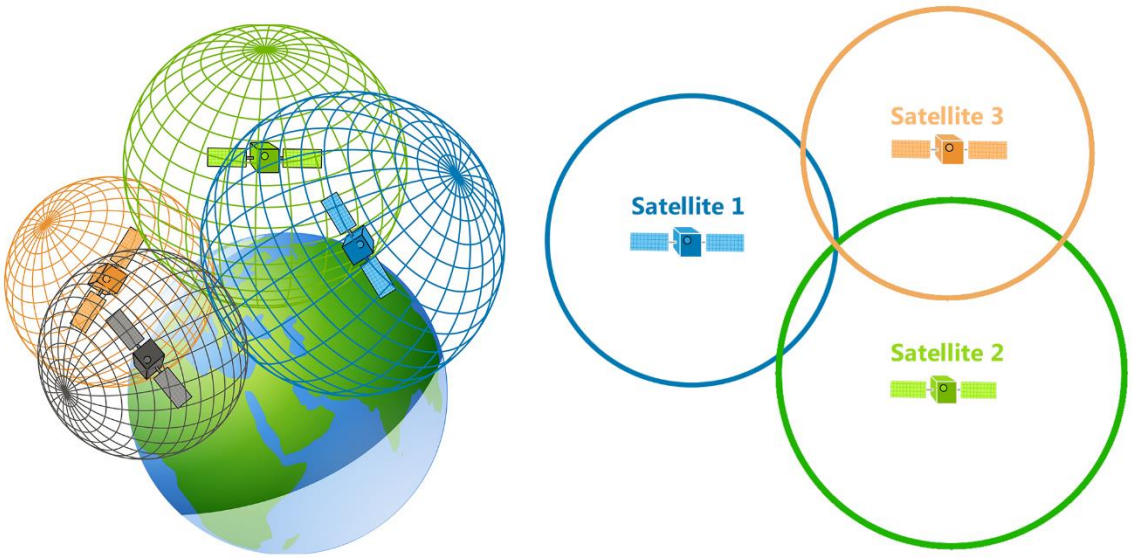

Figure 1: Classic triangulation problem illustration

A physical rover will not be used; instead, all the onboard sensors of the "rover" — such as the IMU, UWB radio, and others — will be mounted on a thin piece of plywood. This setup will be moved manually by the experimenter in real time to simulate the rover moving across

the region and performing a mission. To assess the system's accuracy, a GPS will be installed on both the rover and the ground station to compare the estimated relative positions with the true GPS positions.

The tasks for this project are as follows:

- Rover Monte Carlo simulations: Simulate the system under various conditions to confirm EKF convergence.
- Port EKF to embedded software: After validation in simulation, implement the EKF in real time.
- Build the ground station:
    - Assemble the hardware.
    - Implement the ground station software.
- Build and assemble the rover hardware.
- Perform tests to assess the accuracy of the rover's tracking system.
- Develop a communication script to transmit telemetry data between the rover and ground station to a laptop to access accuracy of system in real time.
- Optional or if time allows: Track orientation of the rover