Problem Set 7

AA279D: Dyn, Nav, Ctrl of DSS
Spring Quarter 2022/2023
Due: May 24, 2023, Wed, 11:59AM PT
Prof. Simone D'Amico

Submission Instructions

Please briefly document all tasks outlined below in a report which will grow during the course. You should include a table with change logs since the last submission, and an index for sections at the beginning. Please submit your report as a single PDF file to the course Canvas website. It should include narrative, plots, tables, code, and interpretations. You should use typesetting software like LaTeX or Microsoft Word to produce your document. Do not submit extra files.

Topics

Week 7. Continuation of project. Finalize relative orbit control laws. Design and start implementing relative navigation system.

Problem 1: Finalize relative orbit control

Consolidate your work on the relative orbit control methods and their implementation. Provide proof of functionality, performance, and lessons learned. You will re-assess control once the navigation system is also drafted.

Problem 2: Kick-off of navigation system design

As discussed in class, the most popular filters used in aerospace applications are the Extended Kalman Filter (EKF) and more recently the Unscented Kalman Filter (UKF). As such, you will design and start implementing one or two such filters to estimate the state of your formation in this assignment. There are several important parameters to consider along the way:

1. What representation will you use for the state estimate within your filter and why? Examples are based on the Cartesian position and velocity, or based on orbit elements. Will you estimate absolute or relative states or mixes?
2. What dynamics model will you use to perform the KF state prediction and why? Will you perform the prediction using a numerical integration scheme or a state transition matrix? Will you perform absolute or relative orbit propagation or mixes?
3. What is the associated linearized dynamics model you would use to perform the EKF covariance update and why? Provide the state transition matrix and control input matrix you would use if you had to implement an EKF.
4. What sensors are available on-board your spacecraft, and what kinds of measurements do they provide and why? Examples of raw measurements:

pseudorange, carrier-phase, range rate, bearing angles. Examples of pseudo-measurements: relative position/velocity, orbit element differences, absolute position/velocity?

5. What is the nonlinear measurement model which allows to model the measurements from the current state?
6. What is the associated sensitivity matrix which you would use to perform the EKF measurement update step?

Produce or refer to simple test cases for each point above to gain confidence that your models are correct. This unit testing is very important to avoid issues with the implementation of the navigation system later on.

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