Problem Set 6

AA 279D, Spring 2018

Due: May 23, 2018 (Wednesday) at 1:30 pm

Notes:

Up to this point in the quarter, the development of your project has been guided through relatively self-contained modules in which you explored the dynamics of relative motion. Moving forward, you will begin exercising control over the direction in which your project proceeds. In this problem set, you will investigate and implement your own control laws based on the needs of your mission.

Submission Instructions

Each student should complete Part 1 of this problem set by the due date. You will not be expected to complete Part 2 within the week, however you should demonstrate progress on the control law design and implementation if you wish to receive feedback on your direction.

Part 1. Control Law Requirements

To start things off, you will need to motivate the development of your control laws by defining some scenarios of interest and associated requirements. In the context of relative motion, we are generally interested in two types of control frameworks: those for formation keeping, and those for reconfiguration. As such, you should consider the following information in your formulation of requirements:

- What are the significant operational modes of your formation? Some examples may include safe-keeping mode, scientific observation mode, and rendezvous/docking mode, though the needs of your mission may vary. Be sure to define at least 2-3 modes.
- How are these modes defined? Think about the absolute and relative motions of your spacecraft. You might use sets of absolute or relative orbit elements to characterize each mode, for example.
- When operating within these modes (i.e. formation keeping), what sorts of control requirements may your formation be subjected to? You should consider parameters like allowable separations, necessary precision of knowledge and actuation, limitations on burns, etc.
- When switching between modes (i.e. reconfiguration), what kinds of control requirements are present? Some examples include time to reconfigure or any safety concerns.

Part 2. Control Law Implementation

Now that you have set up the necessary framework, you will design and implement your own set of control laws for your mission. As mentioned previously, the details of this implementation will be left to each student, however a base set of tasks will be provided below. Students who wish to deviate from this baseline should rationalize their choice.

Each student should plan to:

- Implement at least one control law for formation keeping and at least one for reconfiguration.
  - You should have at least one continuous and one impulsive controller. In other words, if you develop an impulsive reconfiguration scheme, you should perform formation keeping with continuous control.
  - Besides this, the specifics of these control laws are left entirely up to you (e.g. the tracked state, nonlinear vs. linear, etc.). You may choose from the formulations discussed in class or even look at other literature within the field. If you are involved in relevant research, this is an opportunity to apply your work.
- Justify design choices and describe the implementation in detail, including:
  - Dynamics model implemented for ground truth simulation
  - Selection of dynamics model for controller/maneuver planner
  - Actuator model (e.g. thrust level, specific impulse, bang-bang vs. proportional)
  - Sources of uncertainty (e.g. noisy sensors and actuators)
  - Relevant control law parameters (e.g. maneuver cycle for impulsive control, gain matrix/weights for continuous control, etc.)
- Discuss the performance of these control systems with visualizations and interpretations of results.
  - Include plots of control tracking error, maneuver scheduling, and ΔV over time.
  - Comment on the strengths and weaknesses of your implementation.
  - Compare the performance against your expectations regarding parameters like the ΔV budget or frequency of maneuvers.
  - If the controller does not work for the application of interest, explain why.
- Explore the feasibility of each solution, considering parameters like fuel consumption, necessary thrust, actuator cycling, minimum impulse bits, etc.