Final Project

AA279D: Dyn, Nav, Ctrl of DSS
Spring Quarter 2022/2023
Due: June 14, 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

Final Week. Finalization of project. Catching up. Integration of navigation and control. Bonus material. Wrapping up.

Problem 1: Catching up (Required)

To finish up the course project, you have the possibility to go back to any previous homework to correct and/or upgrade your designs, implementation, and narrative. Please provide a detailed explanation of the modifications you made to improve each of the previous problem sets. These improvements can be categorized as:

a) Editorial and stylistic through improved or extra narrative and reporting
b) Fixing of errors/imperfections and associated analyses and reporting
c) Filling gaps in required functionality that you did not address

Problem 2: Integration of Navigation and Control (Required)

To finish up the course project, you will use the filter developed in Problem Set 7-8 to provide state knowledge to the control laws from Problem Set 5-6. Recall that the control laws were originally acting on ground truth state information; we wish to see how performance is affected when knowledge error is introduced. To this end, follow these steps:

a) Select the control laws you wish to analyze from Problem Set 5-6.
b) Alter the control law state input by corrupting the ground truth with some representative noise. This is the same process you used to generate your first set of measurements in Problem Set 7-8. How does your controller perform? What are the main differences compared to the original implementation?
c) Now use the extended or unscented Kalman filter from Problem Set 7-8 to feed the control law its state input. You should corrupt the ground truth with your true sensor model, then feed this to the filter before passing the state to the

controller. Note that you must now account for the introduction of control inputs in the prediction step of your EKF or UKF.

d) How does the controller perform now? Again, discuss the main differences when compared with the original implementation and b).
e) Evaluate the key metrics for navigation and control, e.g. convergence time (when error falls below percentage threshold), control tracking error and its statistics at steady state (formal and true), navigation error and its statistics at steady state (formal and true), post- and pre-fit residuals, control input history, delta-v, propellant consumption, comparison with expectations and objectives, etc.

Problem 3: Bonus Material (Optional)

We have touched many topics on dynamics, navigation, guidance and control for distributed space systems and certainly only scratched the surface of this fascinating area of research and development. In this sub-problem, you have the possibility to use your creativity for bonus points. You are free to pick an extension of your choice to work on for your project through a brand new functionality (e.g., collision avoidance, passive or active), an improvement in navigation or control performance (e.g., through MPC or advanced sensing), an improvement in scalability to multiple spacecraft (e.g., through deterministic swarms and/or decentralization), extra navigation and/or control algorithms for comparison (e.g., consensus-based, LQR, reinforcement learning), an improvement in computational efficiency (e.g., algorithm optimization), or an improvement in sensor or actuator modeling.

Problem 4: Conclusions and Way Forward (Required)

This is the last section of your documentation. We are interested in reading on the following topics:

a) Self-contained short summary of the project
b) Critical assessment of results
c) What have you learned? Lessons learned
d) Do you have ideas for potential continuations of this project?

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