RBE 502 - MPC for Landing a Reusable Rocket

Teammates

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Project Proposal

1. Problem Statement

   How can model predictive control (MPC) be used to control a highly non-linear rocket system to land on a landing pad with minimal error?

2. Impact

   Solving the control problem of landing reusable launch vehicles, specifically rockets, is a highly relevant problem in the field of space exploration and commercial spaceflight. Precise rocket landings allow parts to be reused, reducing development, and launch costs, making access to space cost-effective and more sustainable. Moreover, traditional rockets leave a trail of discarded hardware, contributing to space debris and environmental pollution. However, without precise and reliable control systems, the potential benefits of reusability are compromised.

3. Scope
   a. Base goals
      i. Implement a successful model in 2D simulation in an ideal environment in MATLAB/Simulink
   b. Stretch goals
      i. Implement a successful model for ‘real’ rocket data using RocketPy simulation environment.
      ii. Add constraint to minimize fuel consumption
      iii. Add disturbances like wind, turbulence, landing base movement
4. Methodology

   a. Modeling:
   Modeling the nonlinear rocket motion dynamics
   b. Develop MPC controller:
   Create a controller to predict the rocket’s future behavior. We can then define a cost function that considers the performance and control effort and specify weights for this. Once the optimal control sequence is determined by the MPC, the first control input in this sequence is applied to the rocket. The rest of the sequence can be discarded. The rocket’s state will be constantly measured and fed back to the MPC controller.

This will ensure that the controller can react to disturbances or modeling errors.

c. Simulation:
   The system and controller will be simulated and plots of the states will be generated to analyze performance.
d. Tuning controller:
   Visualization of the simulation can be used to understand the system's behavior and tune the controller to achieve better performance.

5. Evaluation

   The controller's performance can be evaluated in simulation using:
   a. Positional steady-state error
   b. Rise time
   c. Settling time
   d. Overshoot
   e. Oscillatory behavior