Controlling Self-Landing Rockets Using CVXPY

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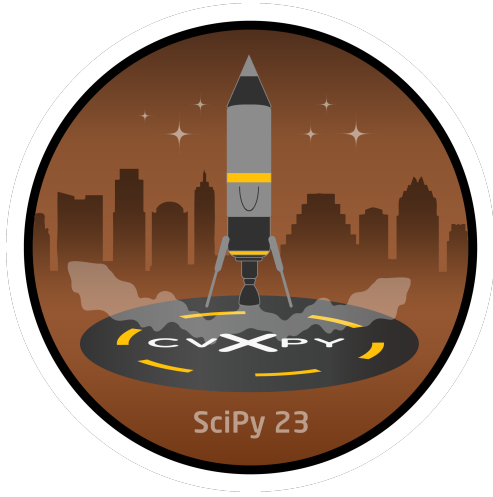


Outline

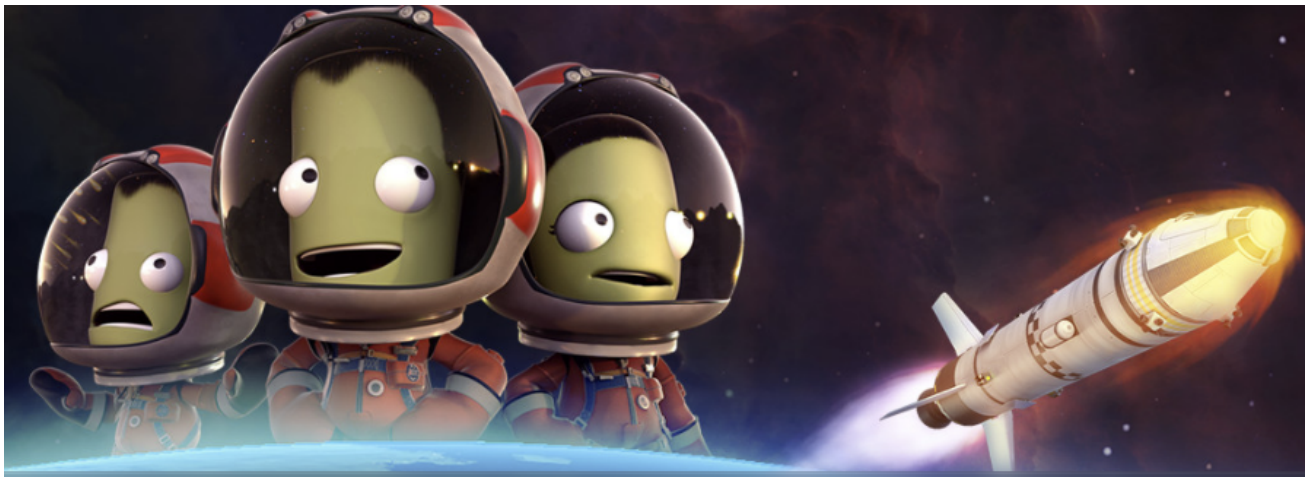
The mission

- simulate landing in the Kerbal Space Program
- use CVXPY to control rocket autonomously
- land the rocket back on the launch pad
- . . . ideally in one piece

- Others have done this before
- *e.g.*, https://github.com/jonnyhyman/G-FOLD-Python

The Kerbal Space Program

- space flight simulation game
- fundamental physics
- rocket design and construction
- space exploration



kRPC

- mod for KSP
- allows to control the game programmatically
- provides telemetry data
- . . . and a lot more
- https://krpc.github.io/krpc/

Model predictive control (MPC)

- Core idea: repeatedly solve the optimization problem
- At each time step, policy is the first step of the solution
- Even simplified models can lead to good results

Algorithm 1 MPC Loop

Require: $T^{\max} > 0$

  while true **do**

    $p_t, v_t \leftarrow$ update state

    If $p_t = p^{\text{target}}$; **break**

    solve optimization problem $P_{p_t, v_t, T^{\max}}$

    perform first step of optimal policy

  end while

Making the optimization problem robust

- We do not know the exact landing time T
- Current model does not account for early landing
- **Solution**: add small height penalty

- Model is agnostic to approach angle
- **Solution**: add penalty to x and y deviations

- Hard constraints are not robust
- Want to prevent infeasibility
- **Solution**: add soft constraints

Test flight!