Reinforcement Learning **for Spacecraft Mode Control**

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Project Description

Motivation

- High operations cost makes autonomy a priority
- On-board autonomy eliminates need for ground contact
- ML techniques could provide planning robust to dynamic environment

Project Description

- Apply reinforcement learning to determine the best series of actions for a spacecraft to enter and maintain an orbit about a planet in deep space.
- The goal is to minimize error relative to a nominal orbit and perform the prescribed science mission.

Proposed Work

Training Data

- Training data will be simulated with linear relative error and state dynamics models.
- High performance nonlinear orbital mechanics models will be used for later phases.

Why use Machine Learning?

- Reinforcement learning has had success in vehicle autonomy and control.

Approach

Linear

- Develop models for learning environment. (Consider error states that grow and shrink linearly)
- Temporal difference Q-learning
- Model-Based Maximum Likelihood methods

Nonlinear

- Apply learned algorithms to “true” nonlinear system.

Problem Statement

State Description

- $\mathrm{X} = [\mathrm{r}, \mathrm{v}]^{\mathrm{T}} \in \mathbb{R}^6$: true state
- $\mathrm{X}_0 = [\mathrm{r}_0, \mathrm{v}_0]^{\mathrm{T}}$: reference trajectory
- $\widehat{\mathrm{X}} \in \mathbb{R}^6$: state estimate
- $\mathrm{x} = \mathrm{X} - \widehat{\mathrm{X}}$: estimation error
- $E \in \{0, 1\}$: error indicator

Action Model

- Orbit Determination - $\mathrm{x} \to 0$
- Orbit Control - $\hat{X} \to X_0$
- Mission Maneuver - $\Delta V \gg 0$
- Science Operations - obtain reward
- Safe Mode - $E \to 0$