Reinforcement Learning for Spacecraft in Stochastic Environments

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Stochastic Environments

- **Stochastic Differential Equations (SDE)**
  \[ dX = f(X(t))dt + g(X(t))dW(t) \]

- **Mountain Car**
  \[ d\vec{r} = \vec{v} \]
  \[ d\vec{v} = \vec{a}_{grav} + \frac{\vec{u}}{m} + \sigma dW(t) \]

- **Orbits**
  \[ d\vec{r} = \vec{v} \]
  \[ d\vec{v} = \frac{\mu}{r^3} \vec{r} + \vec{a}_{pert} + \frac{\vec{u}}{m} + \sigma dW(t) \]
Reinforcement Learning

- Agent Seeks to Accumulate Reward

- Bellman Function

$$V^\pi = R(s, \pi(s)) + \gamma \sum_{s'} P(s'|s, a)V^{\pi^*}(s')$$
Conclusions & Future Work

• Noisy Environments
  • Stochastic Value Gradient (Heess et al., 2015)

• Sparse Rewards
  • Potential-Based Reward Shaping
  • $F(s, a, s') = \gamma \phi(s') - \phi(s)$

• Reward Design in Orbital Environment
  • Keplerian vs. Cartesian

• Future Work
  • More Realistic & Complex Orbit Environment
  • Augmented Experience Replay
  • Incorporating Approximations of Fokker-Planck