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FUEL-EFFICIENT DEEP REINFORCEMENT LEARNING FOR PLANETARY LANDING

Abstract

This work develops a fuel-efficient deep reinforcement learning based approach for planetary powered descent and landing. Future Mars missions will require advanced guidance, navigation, and control algorithms for the powered descent phase to target specific surface locations and achieve pinpoint accuracy (landing error ellipse ¡ 5 m radius). The latter requires both a navigation system capable of estimating the lander's state in real-time and a guidance and control system that can map the estimated lander state to a commanded thrust for each lander engine. In this paper, we present a novel fuel-efficient integrated guidance and control algorithm designed by applying the principles of reinforcement learning theory. The latter is used to learn a policy mapping the lander's estimated state directly to a commanded thrust for each engine, with the policy resulting in accurate and fuel-efficient trajectories. Specifically, we use proximal policy optimization, a policy gradient method, to learn the policy. Another contribution of this paper is the use of different discount rates for terminal and shaping rewards, which significantly enhances optimization performance. We present simulation results demonstrating the guidance and control system's performance in both 3-DOF and 6-DOF simulation environment and demonstrate robustness to noise and system parameter uncertainty.