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USING REINFORCEMENT LEARNING IN TRAJECTORY DESIGN FOR AN EARTH-MOON L2 CUBESAT MISSION

Abstract

This mission design study has been conducted as a part of the Skoltech University technology demonstration project to send a 6U CubeSat to Earth-Moon L2 Halo orbit. The satellite will be sent to geostationary orbit (GEO) via piggyback launch, and is, henceforth, to follow a predefined path to the L2 halo orbit.

The purpose of the mission is to test the capabilities of the new impulsive thruster developed to be used by CubeSats. The thruster is to perform all the maneuvers required for the transfer of the spacecraft to the selected halo orbit from GEO and subsequently provide station-keeping capabilities for at least one year. When in the halo orbit the CubeSat is to maintain continuous communication with the Earth. For technology demonstration mission, the halo orbit of the recently designed LUMIO mission is selected. For the trajectory design from Earth's orbit leading up to the Halo orbit, we utilize low-energy transfer methods available owing to the three-body dynamics. The resulting stable manifold trajectory is linked with the satellite's orbit around the Earth via Lambert's three-body problem arc. We perform multiobjective optimization for low-energy and mid-time transfers with the aid of a genetic algorithm. For station-keeping, the Target Point Method strategy is applied and cost analysis is carried out to assess and determine the fuel cost for the given mission lifetime taking into account various constraints.

After the initial mission design, we train a reinforcement learning control agent to reproduce the mission design part. The purpose of this is to compare and contrast the results obtained from the reinforcement learning framework with those from conventional methods. We believe that the reinforcement learning training can obtain better transfers by exploiting the Moon's resonances. This can serve as an insight into the potential of the RL framework for optimizing solutions in the three-body problem and would motivate further development of autonomous mission design process for spacecraft operating in high-fidelity models.