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OPTIMAL TRANSFER TRAJECTORIES BETWEEN RELATIVE QUASI-SATELLITE ORBITS

Abstract

In recent years, there has been growing interest in space exploration, particularly in exploring the Martian system. The moons Phobos and Deimos of Mars may hold the key to understanding how the Solar system formed. As a result, space agencies like NASA, CNES, JAXA have proposed numerous missions to study these bodies in the last few decades. Martian moons exploration (MMX) mission is JAXA's upcoming robotic sample return mission to explore martian moons. MMX uses distant retrograde orbits (DROs) or quasi-satellite orbits (QSOs) as parking orbits before landing on Phobos. One of the most significant challenges in this area is developing efficient transfer techniques between different orbits. In this paper, we investigate the problem of optimal transfer between relative distant retrograde orbits around Phobos using convex optimization techniques. This paper introduces the framework to design low-thrust minimum-fuel and impulse transfer trajectories between relative QSOs around Phobos through convex optimization and beam search method.

The optimal transfer methodology involves the formulation of a convex optimization problem, which incorporates the departure and arrival phases as optimization parameters. The optimization process seeks to determine the optimal position and velocity of the initial point on the departure QSO, the final point on the arrival QSO, the entire transfer trajectory, and the control inputs. A set of initial estimates is generated by selecting intermediate bifurcated QSO from a family of QSOs that are located between the departure and arrival QSOs, and these intermediate bifurcated QSOs guide the transfer trajectory. The choice of intermediate bifurcated QSOs plays a crucial role in obtaining the optimal solution, and therefore, the beam search algorithm is incorporated into the proposed framework to determine the optimal sequence and number of intermediate bifurcated QSOs. The transfer methodology and analysis presented in this paper can be extended for optimal transfer opportunities between retrograde orbits around any planetary satellites in the solar system.