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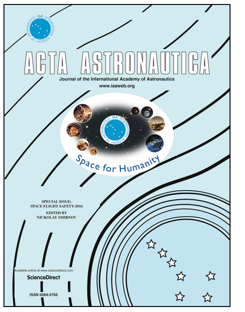

Modeling low-thrust transfers between periodic orbits about five libration points: Manifolds and hierarchical design

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Modeling low-thrust transfers between periodic orbits about five libration points: manifolds and hierarchical design

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Abstract

The low-thrust version of the fuel-optimal transfers between periodic orbits with different energies in the vicinity of five libration points is exploited deeply in the Circular Restricted Three-Body Problem. Indirect optimization technique incorporated with constraint gradients is employed to further improve the computational efficiency and accuracy of the algorithm. The required optimal thrust magnitude and direction can be determined to create the bridging trajectory that connects the invariant manifolds. A hierarchical design strategy dividing the constraint set is proposed to seek the optimal solution when the problem cannot be solved directly. Meanwhile, the solution procedure and the value ranges of used variables are summarized. To highlight the effectivity of the transfer scheme and aim at different types of libration point orbits, transfer trajectories between some sample orbits, including Lyapunov orbits, planar orbits, halo orbits, axial orbits, vertical orbits and butterfly orbits for collinear and triangular libration points, are investigated with various time of flight. Numerical results show that the fuel consumption varies from a few kilograms to tens of kilograms, related to the locations and the types of mission orbits as well as the corresponding invariant manifold structures, and indicates that the low-thrust transfers may be a beneficial option for the extended science missions around different libration points.

Key words: Libration point orbits; Invariant manifolds; Low thrust transfers; Circular restricted three-body problem; Trajectory optimization

1. Introduction

The dynamical structure associated with the five Earth-Moon libration points could become primary locations for performing space science missions with high performance requirements, such as designing suitable stations for long-duration activities, enhancing the opportunities for interplanetary exploration, and supporting the development of facilities on the Moon's surface [1-4]. The first Earth-Moon libration point mission, i.e., ARTEMIS, has successfully demonstrated the validity of the lunar libration point orbits (LPOs) to navigate and perform station-keeping operations. The two probes of the five THEMIS probes, named P1 and P2, primarily arrived at the Lissajous

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