IAF ASTRODYNAMICS SYMPOSIUM (C1)
Guidance, Navigation and Control (2) (4)

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FUEL-OPTIMAL TRAJECTORIES OF THE PERTURBED CIRCULAR RESTRICTED THREE-BODY PROBLEM FOR LUNAR OCCULTATION APPLICATIONS

Abstract

In the interest of performing Lunar occultations for astrophysical purposes, nonlinear programming is used to constraint the position of the spacecraft to the eclipse point of the shadow of the Moon for monthly observation of the Solar corona in the framework of the perturbed circular restricted three-body problem. More precisely, GPOPS-II is used to transcribe the continuous-time optimal control problem using variable-order Gaussian quadrature methods to a sparse nonlinear programming problem (NLP). In this context, IPOPT is used as a NLP solver to determine the optimal control sequence that satisfies the two-point boundary value problem subject to the physical limits of a low-thrust electric propulsion system while maximizing the final mass of the spacecraft under the presence of perturbations to ensure fuel-optimal trajectories. The perturbations considered in this study include the gravitational attraction of the Sun, Solar radiation pressure, and the effect of the eccentricity of the orbit of the Moon. In this formulation, the 5.145° inclination of the synodic plane relative to the ecliptic is considered to account for a more realistic case both in the perturbation model and the eclipse point constraint using the conical shadow model. The results of this paper highlight convergence to non-planar fuel-optimal trajectories in the vicinity of the equilateral libration points using 1.5 km/s of ΔV and 400 μN of thrust for a mission of

three years of duration. Moreover, low angular velocity of the spacecraft relative to the Moon is achieved in the arc-second/second level for exemplary angular resolution of the Solar corona. Furthermore, as a means to extend the scientific objectives of the mission, Lunar occultation events of distant stars are proposed for the periods of time the spacecraft is not within the allowable eclipse zone to observe the Solar corona. Lunar occultations of distant stars allows the study of stellar properties such as surface temperature, energy production, evolution, and formation.