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AUTONOMOUS LUNAR ORBIT RENDEZVOUS GUIDANCE BASED ON A HIGH ORDER PERTURBED STATE TRANSITION MATRIX

Abstract

This paper affirms that a high order perturbed relative motion state transition matrix (STM) can be adopted for the real-time optimization of multi-impulse rendezvous guidance of a lunar lander. The first few non-spherical gravitational perturbation terms J2, C22, J4, and J6 are considered analytically in this STM. A curvilinear coordinate system is used to minimize linearization errors in the transformation between the relative state and the corresponding differential orbital elements. The novel optimization method allows for a systematic design and refinement of the number of thrust impulses, their application times, and the mission duration. The gradients of the objective function and constraints are developed analytically by using a linear perturbation theory. Numerical examples are presented to demonstrate the accuracy and application of this approach in conjunction with a high-fidelity gravitational model. A performance comparison between the impulsive and finite-burn models is also presented. The results indicate that the use of the high order perturbed STM provides an accurate initial solution which can be further optimized on a high-fidelity and finite-burn models, leading to fast convergence of the optimization process. This procedure is well-suited for onboard, real-time control of lunar rendezvous missions.