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LOW-ENERGY EARTH-MOON MISSION ANALYSIS USING LOW-THRUST OPTIMAL AND FEEDBACK CONTROL

Abstract

This work is focused on designing a low-energy orbit transfer in the Earth-Moon system, aimed at reaching stable capture in a target lunar orbit, with the use of low-thrust propulsion. The mission at hand includes three different phases: low-energy ballistic transfer starting from Earth, low-thrust minimum-fuel arc, and low-thrust lunar orbit insertion using variable-thrust nonlinear orbit control. First, a reference trajectory is generated in the framework of the Patched Planar Circular Restricted Three-Body Problem, leveraging invariant manifold dynamics. Trajectory propagation was performed using the Bicircular Restricted Four-Body Problem (BR4BP) model, with the inclusion of Sun, Earth and Moon gravitational attraction. Particle swarm optimization was applied for trajectory refinement and to detect the subsequent minimum-fuel low-thrust arc. Finally, the target lunar orbit is entered thanks to the use of variable-thrust nonlinear orbit control. Monte Carlo simulations demonstrate effectiveness of nonlinear feedback control, which enjoys quasi-global stability properties, in nonnominal conditions. The launch vehicle and the launch window are analyzed as well. Combination of the preceding design techniques is suggested as a viable and convenient approach for preliminary Earth-Moon mission analysis.