Paper ID: 24222
oral
student

ASTRODYNAMICS SYMPOSIUM (C1)
Mission Design, Operations and Optimization (2) (9)

Author: Mr. Loic Chappaz
Purdue University, United States, lchappaz@purdue.edu

Prof. Kathleen Howell
Purdue University, United States, howell@purdue.edu

TRAJECTORY DESIGN FOR BOUNDED MOTION NEAR UNCERTAIN BINARY SYSTEMS COMPRISED OF SMALL IRREGULAR BODIES EXPLOITING SLIDING CONTROL MODES

Abstract

While most of the more massive bodies in the solar system are reasonably spherically-shaped, there are many smaller objects with very irregular shapes that are the focus of increasing scientific interest. Previous work from the authors is focused on the exploration of bounded trajectories in the vicinity of a simplified system. However, this dynamical model is an idealized representation of the actual dynamical regime and does not account for uncertainties in the physical properties of the bodies and other non-gravitational perturbing effects.

In this analysis, a trajectory design strategy to maintain a spacecraft near reference third-body trajectories that exhibit some desired characteristics is constructed incorporating Multiple Sliding Surfaces Guidance. Such a control law can be demonstrated to be globally stable and robust. In practical application, the exact physical properties of the massive bodies in the system are not known. It is reasonable to assume sufficient knowledge to construct an 'estimated' model that approximates the properties of the 'true' system. For the true system, each primary is modeled as a polyhedron and the 'estimated' system is an ellipsoid-ellipsoid model. Then, to maintain the spacecraft in orbit near a desired reference trajectory, a 'coast and thrust' scheme is proposed. The spacecraft coasts until it reaches a prescribed deviation from the reference path, at which point the spacecraft is driven back to the reference within a defined time. This process is repeated for as long as the spacecraft must be maintained in orbit.

To assess the performance of the scheme, the proposed strategy is simulated. First, consider a true system such that the first and second primary is a scaled model of the asteroid Eros and the moon Phobos, respectively. Moreover, consider an 'estimated' sphere-ellipsoid system such that the overall properties of the system are similar, yet not exact, to the fictitious 'true' system. Then, the reference trajectory is a three-dimensional 1:2 resonant orbit as computed for the estimated system. For one period of the reference orbit, two controlled arcs suffice to drive the spacecraft back to the reference orbit after drifting away during the coasting phases. Based upon the simulations performed, the design strategy achieves the objective under the perturbing acceleration due to the uncertainty in the system physical properties. Also, simulations that include the solar radiation pressure onto the spacecraft as additional perturbation near a known binary system, 1999 KW4, are also discussed.