ASTRODYNAMICS SYMPOSIUM (C1)
Guidance, Navigation and Control (1) (3)

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OPTIMAL GUIDANCE FOR SOFT LANDING ON IRREGULAR-SHAPED ASTEROIDS USING SLIDING-MODE CONTROL

Abstract

An optimal guidance method consisting of optimal trajectory design and sliding-mode control for soft landing on irregular-shaped asteroids are presented. In order to ensure the validity of the method, a high-fidelity dynamics model is required. A polyhedron shape model is used for accurately modeling the gravitational field of an irregular-shaped asteroid. Designing a fuel-optimal soft landing trajectory is transformed into solving a two point boundary value problem (TPBVP) by using Pontryagin's Minimum Principle. The initial state of the spacecraft is divided into two situations according to the type of the parking orbit. Both circular orbit and hovering orbit are discussed. To overcome the difficulties of solving Bang-bang control in the fuel-optimal problem, a homotopic technique is used. For purpose of improving calculating efficiency and accuracy, some other techniques such as normalization of initial co-state vector and switching detection are employed. After the optimal trajectory is designed, it is taken as a nominal trajectory for a feedback closed-loop control designing. The state of the spacecraft needed in the feedback control is estimated by using Kalman Filter. A robust tracking controller designed by sliding mode variable structure method is used to track the nominal trajectory. The uncertainties, which are existed in gravitational field model, measurement and propulsion system, are taken into account. A Monte Carlo method is applied to simulate the optimal guidance for soft landing. Simulation results show that the optimal trajectory design algorithm is efficient and the sliding-mode controller is robust.