Paper ID: 6940

ASTRODYNAMICS SYMPOSIUM (C1)
Mission Design, Operations and Optimization (8)

Author: Dr. Mai Bando
Kyoto University, Japan, mbando@aero.kyushu-u.ac.jp

Prof. Hiroshi Yamakawa
Kyoto University, Japan, yamakawa@rish.kyoto-u.ac.jp

APPLICATION OF GLOBAL SOLUTION OF HAMILTON-JACOBI EQUATIONS TO OPTIMAL LOW-THRUST MULTIPLE RENDEZVOUS PROBLEM

Abstract

This paper presents a procedure to design multiple flyby missions. When the missions to observe space debris or near Earth asteroids (NEAs) are considered, it is more efficient to achieve many observations by a single spacecraft during the flight. For trajectory design of multiple flyby mission, the conventional method is to divide the sequence into subsequences and then to find a trajectory candidate by connecting each subsequence. However, it is difficult to find candidates among a huge number of combinations of subsequent trajectories. To find the optimal sequence, we need to evaluate the total amount of velocity changes for all the possible trajectories. Using the generating functions of canonical system, two-point boundary-value problem can be solved by function evaluations. Using this property, a strategy to optimize the multiple flyby sequence is investigated. The evaluation of total fuel cost becomes much simpler for both impulsive and continuous thrust problem. This enables us to choose an optimal sequence among a long list of targets in which minimum fuel consumption is achieved. Recently, we investigate the method to construct generating functions associated with the original nonlinear dynamics. Our approach is based on the idea to solve Hamilton-Jacobi equation associated with canonical transformations as the infimum of optimal cost which is effectively solved by the Galerkin spectral method with Chebyshev polynomials. The emphasis is that this approach enables us to find optimal sequence to multiple two-point boundary problem not by a global search but by function evaluations. In this paper, we propose a new low-thrust trajectory optimization method to find the optimal trajectory in analytical form. The resulting control law is a feedback control, so that it is effective in overcoming sensitivities to small variations in initial orbit and thrust profile. This study determines the optimal approach to find an effective control law to sequential transfer problem. For comparison, optimal sequence using impulsive and continuous thrust method are investigated. Our approaches are illustrated through the trajectory design of the multiple flyby mission and resulting fuel costs are compared.