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OPTIMIZATION OF WIDE-SCOPE AND RAPID ORBITAL TRANSFERS WITH MANY BURNS

Abstract

Security of LEO spacecrafts, especially most remote sensing satellites, has been threatening seriously by more and more space debris in recent years. In order to improving the viability, remote sensing satellites have to carry out wide-scope and rapid orbital transfers based on minimum fuel consumption when necessary.

For a remote sensing satellite, the descending nodical local time of fore and after the orbital transfer to be unchangeable is required, so that high-resolution satellite remote sensors are able to obtain observation information of the same region under the same illumination condition at the same time of day. Moreover, considering that the main factor influencing a transfer for a remote sensing satellite is J2 perturbation, it would help to improve the precision of the orbital transfer with full consideration given to the influence of J2 perturbation.

Based on the analysis above, considering that most present remote sensing satellites are in sun-synchronous circular orbits, the problem of optimal rapid non-coplanar circular orbital transfer with finite thrust and changeless descending nodical local time under the influence of J2 perturbation is studied in this paper. According to engineering practice, an optimal multiple-burn transfer strategy with steady thrust magnitude while burning is considered.

The contents of the paper are listed as follows: (1) A dummy target satellite, which is supposed to be in the target orbit, is introduced. Thus the problem of orbital transfer is turned into a problem of space rendezvous, which could significantly simplify the terminal boundary conditions of the two-point boundary value problem studied. Based on this hypothesis, a dynamic model for these satellites with J2 perturbation in geocenter equatorial initial coordinate system is presented. (2) Both of the initial position and velocity of these satellites are determined based on changeless descending nodical local time fore and after the orbital transfer. (3) Control variables to be optimized are determined considering many-burn transfers and invariable thrust magnitude. (4) On the basis of fixed orbital transfer time, the simplex algorithm with functions of multi-independent variables is used to optimize the control variables, with a performance index considering minimum fuel consumption and final positionconstraints, and then the optimal transfer trajectory is acquired.

The validity of the optimal transfer strategy designed for optimal orbital transfer in this paper has been verified by simulation results, and it can be used for reference to engineering application of orbital transfer for remote sensing satellites.