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ANALYTICAL GUIDANCE SCHEME FOR OPTIMIZING THE ORBITAL ELEMENTS OF LOW-THRUST TRAJECTORIES.

Abstract

Because of the high propellant efficiency of electric propulsion with low-thrust, electric propulsion systems are drawing increasing attentions of researchers. Orbit propagation is a necessary procedure when optimization of low-thrust trajectories in numerical computation. However, what is disappointed is that there is a large amount of computational consumption of orbit propagation which is unacceptable for some time. Consequently, it is essential to explore the potential features of orbital dynamic equations. The existing solutions for optimizing the orbital elements are usually focused on situation of orbital elements change with certain direction of impulse. For the situation of low-thrust trajectories, it is difficult to find analytical method to simplify the integral of orbital dynamic equations because of the long-term low-thrust propulsion. Numerical methods are usually applied to integrate the orbital dynamic equations in some former research which are suffered from large time consumption. To address these issues, an analytical guidance scheme is proposed to optimize the orbital elements and to achieve a fast and less time consumption method used for orbit propagation.

In this study, the guidance scheme to optimize the orbital elements is established analytically of low-thrust trajectories corresponding to all kinds of initial orbits. Firstly, the Gauss's Perturbation Equations with respect to true anomaly is used as the dynamic model of spacecraft to simplify the general perturbation equation. Nonlinear programming theory is applied to find the optimal direction of low-thrust in order to optimize the orbital elements. And then, the orbital elements extremum in an orbit period by applying optimal control force and orbit averaging technique. Finally, the result of the former step is used in the Gauss's Perturbation Equations and the optimization of orbital elements is derived analytically. Comparing with the traditional methods to solve the orbital elements optimization problem of low-thrust trajectories, computation consumption of designing the optimal transfer orbits and orbit propagation is significantly decreased by using the proposed analytical guidance scheme. The proposed method makes it a step forward and large amount of numerical computation is avoided. Several scenarios with a large range of initial orbits are tested using the proposed scheme and demonstrate the high efficiencies of the proposed methods.