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APPROXIMATE SEMI-ANALYTICAL OPTIMAL RECONFIGURATION CONTROL FOR NONLINEAR RELATIVE MOTION

Abstract

Traditional analytical methods used to solve the energy optimal reconfiguration problem governed by linear relative motion equations are not applicable to solve that governed by nonlinear relative motion equations considering the eccentricity of the reference orbit, J2 perturbation and the nonlinear terms of the differential gravity at the same time. A semi-analytical method using the perturbation approach and double time layers spline integral is proposed in this paper. The augmented relative motion equations including the state and costate equations can be divided into a fundamental equation and a perturbed equation. Using the perturbation approach, an approximate analytical optimal reconfiguration control law can be obtained. Since the state and costate transition matrices are not analytical, the double time layers spline integral is explored to evaluate the key integrals in the optimal control law. Thus, an approximate semi-analytical optimal reconfiguration control law is obtained. Finally, numerical simulations are performed for satellite reconfiguration cases on elliptical reference orbit to validate the effectiveness and advantages of the optimal control law obtained in this paper. Results show that the reconfiguration precision under the optimal control law considering both J2 perturbation and the nonlinear terms of the differential gravity is much higher than those are not considered. Furthermore, the corresponding optimal reconfiguration trajectory can be used in closed-loop reconfiguration control, which has potential to save fuel in satellite formation reconfiguration mission.