ASTRODYNAMICS SYMPOSIUM (C1)
Orbital Dynamics - Part 1 (3)

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NATURAL PERIODIC RELATIVE ORBIT SOLVING USING FOURIER SERIES

Abstract

Natural periodic relative orbits are a set of orbits that in virtue of natural forces as much as possible. This set of orbits are very important for long-term and high accuracy spacecraft formation flying, for more natural relative orbits can not only save fuel, but also reduce the requirements on the controller. Simple models such as the CW equations with appropriate initial values can yield periodic relative orbits, but such relative orbits will drift away inevitably due to a variety of perturbations and uncertainties in real environment. Thus, the control system is adopted to compensate the drift, which will lead to unnecessary fuel expenditure. If the periodic relative orbits are solved based on a more realistic model, i.e. incorporates various effects, unnecessary fuel expenditure can be avoided.

Periodic orbits are usually derived from the analytical solutions of the relative dynamical models; however, it's not always easy to obtain the analytical solutions, especially when the model is very complex. In this paper, relative dynamical model considering eccentricity, nonlinear terms and J2 perturbations was presented. Considering that periodic functions can be expanded into a Fourier series, we represented the periodic relative orbits by Fourier series. However, the periodic condition should be satisfied first, which was obtained using energy matching method. Coefficients of the Fourier series or their relationships were determined according to the more actual relative dynamical model we presented using undetermined coefficient method. Thus a set of natural periodic relative orbits in the form of a Fourier series were obtained.

Finally, numerical simulations were carried out and the method solving natural periodic relative orbits derived in this paper was applied to a specific LEO formation (PRISMA), and realistic simulations clearly show the feasibility and effectiveness. Simulation results also showed that the periodic solution was valid for both circular and elliptical reference orbits and presented a characteristic of high accuracy compared with CW equations, especially in elliptical orbits, which is suitable for long-term accurate formation flying.