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OPTIMAL ATTITUDE MANEUVER PATH PLANNING FOR SPACECRAFT UNDER COMPLEX GEOMETRY CONSTRAINTS

Abstract

Amount of attitude maneuvers should be accomplished for the spacecraft to complete the missions of observation and communication. During attitude maneuver, the light beam of the sun should be avoided to enter optic attitude sensors, otherwise the sensors may be invalidated. In the mean time, some communication devices should be kept to point to the ground station. The pointing limitations of optic components and communication devices bring complex geometric constraints to spacecraft. The optimal attitude maneuver path planning for spacecraft with complex geometric constraints is investigated in this article.

Firstly, path planning model is established. The spacecraft attitude is depicted by modified rodrigues parameter(MRP), and the dynamic model of the attitude maneuver is established. The constrained conditions are the attitude pointing limitations during the attitude maneuver. This article deduces the analytical relationship of geometric constraints, and the attitude permit zone is depicted in MRP zone by hypersurface during the attitude maneuver. The energy consumption of maneuver is employed as the cost function, which is the sum of square norm control torque, and the optimization objective is to minimize the energy consumption.

Secondly, path planning arithmetic is studied. Gauss pseudospectral method(GPM) is used to transform the optimal control problem(OCP) into a nonlinear problem(NLP). The control variables and state variables need to be optimized are dispersed. The optimum values are obtained by using the sequential quadratic programming(SQP).

Thirdly, the feasibility of the solution is validated by simulation. Considering that the solution obtained by GPM is a sequence of dispersed control variables and state variables on gauss points and that the variables on the other area do not satisfy the differential equation constrains, the simulation validation is necessary. All the continuous control variables are obtained by the lagrange interpolation, and all the continuous state variables are obtained by the integration of the differential equation. The feasibility of the optimal result is decided by the consistence of the simulation result and the programming result.

Solution demonstration is executed for different initial and terminal attitudes and different geometric constrains. The result shows that the optimal attitude maneuver path that satisfied the complex geometric constraints by this method performs practicably and effectively.