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ZERO PROPRLLANT MANEUVER PATH PLANNING OF SPACE SATTION UNDER MULTIPLE CONSTRAINTS

Abstract

Zero propellant maneuver (ZPM) is an advanced concept of the spacecraft attitude control that has recently been applied to International Space Station (ISS). ZPM selects Control Moment Gyroscopes (CMGs) instead of thruster for the large angle attitude maneuver, which has practical significance for reducing fuel consumption, prolonging on-orbit time and enhancing the safety of space station. However, CMGs may easily encounter the problems of singularity and saturation. Therefore, planning an attitude maneuver path that satisfies the singularity and other constraints in advance is the focus of current ZPM technology.

ZPM was first demonstrated on the ISS in 2006, which used double gimbal control moment gyroscopes (DGCMGs). However, for the China's Space Station (CSS) that will be built in 2022, the actuators will be single gimbal control moment gyroscopes (SGCMGs) with pentagonal configuration. Most of the existing research only considers the singularity and boundary constraints, ignoring the attitude axis constraints in the space station task, such as the pointing constraints of the solar panels and sensors. In addition, the existing ZPM path planning methods mostly use pseudospectral method for global offline planning, so there is a need for online ZPM path planning methods.

In order to support the CSS project, an online hybrid programming method for ZPM path planning is developed to avoid multiple constraints for SGCMGs systems in this paper. Firstly, according to the actual mission characteristics of CSS, the corresponding pointing constraints and singularity performance indicators are proposed and analyzed. Secondly, the multi-constrained optimization model of SGCMSs including singularity and pointing constraints and other constraints is established. Then, a hybrid programming method combining differential evolution method and obstacle avoidance method is proposed, in which differential evolution is used globally and obstacle avoidance is carried out partly. Finally, the simulation is performed to verify the effectiveness of the proposed method.