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SAFETY-OPTIMAL IMPULSIVE RENDEZVOUS WITH TRAJECTORY UNCERTAINTIES

Abstract

The optimal rendezvous trajectory design is an important part of rendezvous mission design, and intensive work focusing on fuel-optimal or time-optimal, normal trajectory design have been made. Trajectory safety is one of the most critical aspects when defining the operational profile for a rendezvous mission, however it is seldom considered as an objective when designing rendezvous trajectories. The main goal of this paper is to study safety-optimal impulsive rendezvous trajectory design with considering the navigation errors and control errors. Firstly, adopting the 3-sigma ellipsoid based methodology and collision probability based methodology, the paper proposes quantitative performance index of space rendezvous trajectory safety with considering the practical uncertainties. Secondly, the optimization model is provided, in which transfer time, impulse, and the intervals of impulses influencing the trajectory safety are the optimization variables, and the trajectory safety performance index is the objective function. And the optimization approach based on evolutionary algorithms is investigated. Finally, a homing rendezvous mission design is taken as an example to compare the safety-optimal trajectory with the traditional fuel-optimal trajectory. The results show that our approach has a very quick convergence rate, and its time cost is acceptable for practical rendezvous mission planning. The relation among propellant cost, flight time, and trajectory safety can be demonstrated. This study of safety-optimal design provides one novel idea and means for the rendezvous mission scheme design, especially for autonomous rendezvous of deep space exploration.