Paper ID: 64454
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19th IAA SYMPOSIUM ON SPACE DEBRIS (A6)
Joint Space Operations / Space Debris Session – STM Operations (10-B6.5)

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SPACECRAFT OPTIMAL MANEUVER STRATEGY FOR QUICK COLLISION AVOIDANCE OF SPACE DEBRIS

Abstract

Currently, a great number of space objects, including the active spacecraft and inactive debris, are orbital of the earth, which significantly increase the possibility of space collision.In particular, when a space object is disintegrated, it often generates vast space debris and further threats the safety of nearby spacecraft.To avoid the space collision and keep safety of close spacecraft, it is meaningful to develop an optimal maneuver strategy for quick collision avoidance of space debris clusters.At present, there have been great research advances in collision avoidance strategies for a single space debris, but only few literature focuses on the quick collision avoidance strategy of debris clusters.

Aiming at the design of the optimal maneuvering strategy for active spacecraft to avoid the space collision with debris clusters in emergency situations, this paper proposes an evasion strategy and optimization algorithm based on the representation of spacecraft relative orbital motion.A polynomial algebra method is discussed to establish a population orbit dynamic evolution model of the space debris clusters to analyze the collision probability between the active spacecraft and space debris clusters.Using the proposed orbit evolution model of space debris clusters, an orbit maneuver strategy for active spacecraft to avoid space collisions with debris clusters in near circular orbits or relatively close distances is proposed: Firstly, the new relative motion between the centre point of the space debris clusters and the active spacecraft or the space debris clusters are modeled; Secondly, based on the linearization idea, an analytical expression is derived, clearly describing the relative motion relationship between individuals and clusters of space debris.Finally, considering that the active spacecraft needs to satisty certain performance indicators and constraint requirements when evading the space debris clusters, the design of orbit maneuver of strategy is converted into an optimization fuel problem with inequality constraints, which can be solved using the Lagrangian multiplier method with slack variables effectively.The simulation results show that this method can evade the space debris clusters in the consideration of optimal fuel consumption.Its calculation time is less than 2% of the task duration time, and the collision probability can be reduced to 1%.

Keywords: space debris clusters; polynomial algebra; collision; avoidance strategy; fuel optimization