Probabilistic Collision Avoidance for Long-term Space Encounters via Risk Selection

This paper deals with collision avoidance between two space objects involved in a long-term encounter, assuming Keplerian linearized dynamics. The primary object is an active spacecraft originally set on a reference orbit. The secondary object represents a threat to the primary. The collision avoidance problem addressed here aims at computing a fuel-optimal, finite sequence of impulsive maneuvers such that instantaneous collision probability remains below a given threshold over the encounter and that the primary object goes back to its reference trajectory at the end of the mission. Two successive relaxations are used to turn the original hard chance-constrained problem into a deterministic version that can be solved using mixed-integer linear solvers. An additional contribution is to propose a new algorithm to compute probabilities for 3-D Gaussian random variables to lie in Euclidean balls, enabling us to numerically validate the computed maneuvers by efficiently evaluating the resulting instantaneous collision probabilities.