Paper ID: 59108
student

18th IAA SYMPOSIUM ON SPACE DEBRIS (A6)
Virtual Presentations - 18th IAA SYMPOSIUM ON SPACE DEBRIS (VP)

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A PATH PLANNING METHOD OF MULTI-MICRO SATELLITES FOR PROXIMITY MANUVER TO SPACE NON-COOPERATIVE TARGETS

Abstract

It is a new development direction of in-orbit service technology to use space microsatellites to clean up space failed targets, to recover the movement capability of failed targets or to carry out monitoring missions on spacecraft. To achieve this goal, the premise is to plan a reasonable and safe proximity path to the noncooperative targets.. In this paper, a novel approach for the formation configuration design for a noncooperative target proximity maneuver is developed, and based on which a collaborative formation path planning method for multiple small satellites considering collision constraint, time constraint and other multi-constraint conditions is proposed. First, the initial envelope configuration is generated for the multi-satellite cooperative close control mission, and the final envelope configuration of the small satellite formation is designed for the space noncooperative target envelop caging. The second step, considering the multi-constraints of the proximity maneuver mission, the final configuration of the servicing satellites is designed. Then, based on the proximity dynamics model, the path planning problem is transferom as a nonlinear programming problem. The third step is to use the evolutionary particle swarm optimization method to solve the single star path planning problem in the discrete formation.According to the characteristics of the relative motion models of satellites in formation reconstruction, the generation method of the initial positions of particles is designed to ensure that the positions of each evolving particle can meet the constraints of the dynamic equation of the satellite,thus overcoming the shortcomings of particle swarm optimization (pso) in solving constrained optimization problems, such as poor processing power and long calculation time. According to the characteristics of the reconstructed trajectories of satellite formations, a new updating formula of particle swarm velocity is proposed, which makes the particles converge to the optimal solution rapidly in the evolution process, thus greatly speeding up the optimization speed of particle swarm. In the fourth step, based on the previous step, based on the distributed characteristics of satellite formation flight, the method of coevolution particle swarm method is proposed. Each satellite is endowed with a particle swarm, so that the satellites can exchange position information with each other while optimizing independently, so as to avoid collision.To solve the problem of collision avoidance, the method of excluding the ball and combining cost function is adopted by treating the other small satellites of the cluster system as dynamic obstacles.At the same time, for the time consistency problem in the formation reconstruction process, the method of limiting the total planned time of each satellite is adopted in the planning algorithm.Finally, the effectiveness and applicability of the planning algorithm are verified by establishing a multi-star simulation environment.The results show that the formation centroid can stay in the target centroid field for a long time,and demonstrate the efficiencyof the porposed approach. The advantages of the trajectory planning method is that it greatly reduces the computational burden of the multi-micro satellites collaborative path planning method and overcomes the shortcomings of particle swarm optimization (pso) in solving constrained optimization problems, such as poor processing power and long calculation time.It can be used in the later multi-micro satellites in-orbit service path planning missions in future.