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DATA-DRIVEN SPACE DEBRIS TRAJECTORY EVOLUTION AND ENCIRCLEMENT PATH PLANNING METHOD FOR MULTI-SPACECRAFT FORMATION

Abstract

Since the development of space exploration technology, the increasing intensity of space activities is inevitably accompanied by the growing number of on-orbit non-functioning spacecraft and debris, which results in an increasing threat to functioning spacecraft, mitigation and remediation of the space debris environment are becoming an issue of widespread global concern. However, there are many challenges ahead to the approaching and capture of space debris, including its non-cooperative characteristic and complex extraterrestrial perturbation, which will lead to the uncertainty of the dynamics model and relative state of debris, and its trajectory cannot be accurately predicted. Based on the above considerations, a data-driven evolution method is applied in this paper to predict the forward reachable set of space debris, which can realize the over-approximation of the short-term trajectory set of debris, and effectively avoid the need for dynamic model information. On this basis, to achieve the encirclement of debris, a spacecraft formation optimal planning algorithm is studied. Considering the essential missions, such as arriving at the desired position, velocity synchronization, collision avoidance between chasers, and collision avoidance between chasers and reachable set, appropriate reward functions are designed to solve the conflict between multiple tasks by assigning corresponding weights to different tasks. Furthermore, an adaptive dynamic planning method based on a critical neural network is introduced to realize the optimal coordination planning ability of multiple missions and improve the autonomy of the spacecraft formation system. Finally, simulation scenarios are performed to verify the effectiveness of the proposed scheme.

Keywords: Data-driven, Trajectory evolution, Optimal planning, Debris encirclement, Multi-mission coordination