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ROLLING COLLABORATIVE PLANNING METHOD FOR MULTI-TYPE OBSERVATION TASKS OF MEGA-CONSTELLATIONS

Abstract

With the reduction in satellite construction and launch costs, mega-constellations represented by Starlink and OneWeb have rapidly developed. China has also proposed the GW and G60 mega-constellations construction plans. Autonomous task planning technology is essential to ensure the efficient allocation of satellite resources and the simultaneous execution of multiple tasks within mega-constellations. However, when faced with multi-type observation tasks such as point, dynamic, and regional targets, the diverse task requirements make it difficult to evaluate the overall observation effectiveness, while the significant coupling of resources between tasks complicates the search for feasible solutions, thereby increasing the difficulty of task planning. Therefore, we propose a rolling collaborative planning method for multi-type observation tasks of mega-constellations.

First, multi-type tasks are decomposed into subtasks that can be observed individually, characterized by time, space, and resource scales. Type identifiers are introduced to represent different task types, defining the characteristic information of each type to lay the foundation for evaluating the overall observation benefit of multi-type tasks. For instance, the maximum observation interval between adjacent segments of dynamic target trajectories is represented from temporal and spatial perspectives to characterize the information of dynamic target tracking tasks. Next, a weighted overall observation benefit evaluation function is defined, incorporating both global and local optimization objectives and their respective weights. The earliest task completion time serves as the global optimization objective, while the dynamic target trajectory coverage and regional target coverage triggered by type identifiers are considered as local optimization objectives. Then, we propose a rolling collaborative planning method for multi-type observation tasks of mega-constellations. This method focuses on the subtasks identified from the previous planning results that are low-benefit with preset proportions and not planned for execution due to resource conflicts. Under the contract network architecture, these subtasks undergo time window calculation, time window screening and satellite selection in a rolling type. Satellite selection is based on the evaluation function of overall observation benefit, and the information regarding these subtasks and executing satellites is continuously updated based on the selection results. This process continues until all subtasks are scheduled to execution and the benefits of low-benefit subtasks tend to converge.

Finally, the simulation results demonstrate the method's effectiveness in reducing total observation time while maintaining dynamic target trajectory coverage rates and area target coverage rates above preset minimums, thus providing technical support for Chinese mega-constellations operation and management.