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Research On The Optimization Of Satellite Mission Scheduling

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Abstract : Satellites play an important role in our daily lives, from monitoring the Earth's environment and providing real-time disaster imagery to predicting extreme weather events. As technology advances and demands increase, the tasks undertaken by satellites have become increasingly complex, with more stringent resource management requirements. A common challenge in satellite mission scheduling is the limited availability of resources, including onboard memory, ground station accessibility, and satellite power. In this context, efficiently scheduling and managing the increasingly complex satellite missions under constrained resources has become a critical issue that needs to be addressed. The core of Satellite Onboard Activity Planning (SOAP) lies in optimizing the scheduling of the received tasks, arranging them on a timeline to form an executable onboard mission plan. This study aims to develop an optimization model that considers the various constraints involved in satellite mission scheduling, such as the non-overlapping execution periods for certain types of tasks, the requirement that tasks must fall within the contact range of specified types of ground stations during their execution, onboard memory capacity limits, and the collaborative constraints between different types of tasks. Specifically, this research constructs a mixed-integer programming mathematical model and solves it with a commercial optimization package. Simultaneously, as the problem size increases, the problem becomes more difficult to solve. Therefore, in this study, a heuristic algorithm has been developed to address the challenges of using commercial optimization package as the scale increases. The goal is to effectively plan satellite missions, maximizing the total number of executable tasks while considering task priorities and ensuring that tasks can be completed as early as possible without violating feasibility constraints. To verify the feasibility and effectiveness of the algorithm, test instances of various sizes were generated, and the results were validated through feedback from on-site users and compared against solutions obtained from a commercial optimization package. Numerical results show that the algorithm performs well under various scenarios, consistently meeting user requirements. The satellite mission scheduling algorithm proposed in this study can be flexibly extended to different types of satellite mission demands, achieving optimal resource allocation and enhancing the efficiency and effectiveness of satellite mission execution.

Keywords : mixed-integer programming, meta-heuristics, optimization, resource management, satellite mission scheduling
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