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SEQUENCE OPTIMIZATION METHOD FOR LARGE-SCALE INTERPLANETARY MISSIONS BASED ON MONTE CARLO TREE SEARCH

Abstract

Interplanetary Missions including space debris removing, multiple gravity assists optimization are essentially sequence optimization problems. Numerical computational algorithms for solving sequence optimization problem have been proposed in previous literature, and they can be generally categorized as exact algorithms and heuristic algorithms. For an exact method, the purpose is to find the global optimal solutions. However, when the scale of problem is too large, the solution space can be super huge. Solving it optimally is not tractable. To efficiently solve the large-scale scheduling problem, many researchers have been engaged in heuristic methods, including tabu search algorithm, the greedy algorithm, the ant colony optimization method and the genetic algorithm, etc. However, these heuristic methods still require large numbers of calculations to find an approximate optimal solution in some complicated problems. Monte Carlo Tree Search (MCTS), by contrast, shows better performance in both computational efficiency and global optimization result when applied to AlphaGo, which also has enormous search space. In fact, MCTS is an algorithm that combines the accuracy of tree search with the generality of random sampling, and thus balances the exploitation and exploration of the search space. Besides AI games, MCTS also has great potentiality in aerospace sequence optimization.

This paper proposes an improved method for sequence optimization based on MCTS, in which each node is considered part of the sequence. To improve efficiency with a huge search range, we limit the width of layers and build trees in parallel. To find better global optimization, we test a number of modifications and analyze the impact of different parameters. In addition, a topological structure of adding and pruning branches is combined to this method for further demands. Applications and verifications in some specific problems are presented, and the results are also compared to traditional MCTS and other heuristic methods. Numerical results show that the proposed method possess better optimality.