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HP-ADAPTATIVE PSEUDOSPECTRAL CONVEX OPTIMIZATION FOR MARS PINPOINT LANDING

Abstract

In recent years, with the continuous development of deep space technology, Mars exploration and Mars migration plans have attracted wide attention worldwide. On the one hand, future missions such as manned landing, Mars base construction, and hazardous area exploration put forward high precision requirements for Mars landing. On the other hand, Since Mars is far away from Earth, autonomous guidance is of vital importance. There has been a variety of research on the onboard trajectory optimization of pinpoint powered descent guidance. Polynomial guidance has been applied to practical missions. Meanwhile, guidance algorithms based on lossless convex optimization have also achieved great success and extended to missions such as low-thrust transfer, rendezvous and proximity operations. In the convex optimization method, the Eulerian discretization method is used in most studies to transform continuous problems into discrete problems. In contrast, the pseudospectral method using nonuniform orthogonal discrete points provides a more accurate and smoother solution with fewer nodes. There have been studies combining pseudospectral methods with convex optimization. However, the number of segments and collocated nodes is not easy to determine. As a result, as many segments and nodes as possible are needed to ensure the accuracy of the solution. Considering the limited computing power of onboard computers, the pseudospectral convex optimization is integrated with the hp-adaptative method. The proposed method ensures the guidance error is within a pre-set threshold throughout the process with as few nodes as possible. For one thing, the residual error of the midpoint of collocated nodes is calculated as the accuracy of the solution. For another thing, an adaptative approach is proposed when deciding to increase the number of segments or nodes. Furthermore, trust amplitude and cone constraints are considered in the paper to get closer to the actual situation. Finally, numerical simulations are presented to demonstrate the feasibility of the proposed hp-adaptative PCO method. The analysis compares the results with standard convex optimization methods and gpops precise solutions. The results show that the proposed algorithm can obtain accurate guidance trajectories under different initial conditions. A more accurate numerical result is presented compared to the standard convex optimization method. Therefore, the proposed algorithm in this paper can effectively solve the fuel-optimal pinpoint landing problem both quickly and accurately.