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TRAJECTORY OPTIMIZATION AND CHARACTERISTIC ANALYSIS FOR TRANSLUNAR DIRECT ABORT CONSIDERING REENTRY CONSTRAINTS

Abstract

Emergency return is a critical technique to ensure the safety of astronauts, and direct abort offers a shorter return time compared to other abort types. In this paper, direct abort trajectory optimization models are established for different scenario requirements, and a solution method is designed to achieve rapid and effective convergence of the problem. For scenarios requiring rapid return, a time-optimal direct abort trajectory is designed considering velocity increment and flight-path angle constraints. Simulation results indicate that trajectories originating from different return points exhibit proximate terminal reentry positions in the inertial coordinate system. The variation of the reentry points on the orbit plane is less than 1 when the velocity increment constraint is sufficiently small. For scenarios considering the landing site, additional constraints on the reentry point position and velocity direction angle are incorporated to formulate the trajectory planning model. The convergence of this optimization problem is sensitive to the initial guesses, and an initial value calculation method is proposed based on the aforementioned trajectory characteristics. Results indicate that by utilizing the multi-start solver and gradient optimization algorithm, this method enables rapid and effective convergence of the problem. Furthermore, under a velocity increment constraint of 2000 m/s, a total of 5 time-optimal direct return windows are identified in the translunar coast phase, with return time ranging from 16 to 55 hours. Adopting direct abort in the early stage of the translunar phase is shown to effectively reduce return time, thereby enhancing mission safety.