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HUMAN EXPLORATION OF THE SOLAR SYSTEM SYMPOSIUM (A5)
Human Exploration of the Moon and Cislunar Space (1)

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OPTIMAL NOMINAL TRAJECTORY GUIDANCE ALGORITHM FOR LUNAR SOFT LANDING

Abstract

As the part with the greatest characteristics in the mission, the manned selenographic landing and the take-off phase needs the support system and could decide on whether the mission could succeed. In order to realize precise soft landing on manned lunar surface, a fully integrated guidance algorithm during the soft landing phase of a lunar mission is presented. As the soft landing mission can be figured out by solving the optimal control problem. Therefore, the lunar three-dimensional non-linear dynamics model is derived firstly. Fuel consumption is chosen as the performance index during the solution of optimal control problem, while the terminal position and velocity is taken as the restriction. The Legendre-Gauss-Labatto (LGL) pseudo spectrographic method is adopted to transform the optimal control problem of trajectory optimization into the nonlinear programming problem. The method follows the following three steps: 1) discretizing and transforming the time domain to LGL node, 2) discretizing the state variable and the control variable at the node, and 3) constructing the Lagrange interpolation polynomial to approximate the state variable and control variable. The SQP optimization algorithm is used to figure out the optimal nominal trajectory of the precise manned lunar soft landing. As the main idea, the search direction is calculated by solving the quadratic programming sub-problem which is constructed by approximating the lagrangian function with simple quadratic function. The proposed method can meet the requirement for optimality of fuel consumption, meanwhile the accelerated speed load that astronauts can bear, the factors such as visual inspection, manual control and etc. can be considered during the calculation. The simulation results, compared with the results obtained by the genetic algorithm optimization, show only a little difference in the optimized curve that, with the SQP, the landing time is a little shorter and the required fuel is a little less, about 6kg. Initialed with the optimal solution of genetic algorithm, SQP generates the same optimal solution rapidly. The whole process indicates that the programming guidance algorithm of optimal nominal trajectory featured rapidity and effectiveness, which increase the accuracy and reliability of selenograohic soft landing.