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UNIVERSAL FUNCTION AND PRIMER VECTOR THEORY FOR FUEL-OPTIMAL LAMBERT PROBLEM

Abstract

There are multiple roots in solving the traditional multi-revolution Lambert problem, which requires a practical judgment based on the number of different revolutions in the solution due to the variable number of flight revolutions. According to the engineering problem constraints, fuel-optimal and energy-optimal Lambert problems are generally derived. The energy-optimal Lambert problem can be derived from the primer vector theory to find the theoretical solution, which is simpler to solve. The fuel-optimal Lambert problem cannot derive an analytical solution similar to the energy-optimal Lambert problem, which has solving difficulties. In this paper, we propose a method for solving the fuel-optimal Lambert problem by integrating the primer vector theory and the universal function method of the two-body problem. The method transforms the original problem into a set of nonlinear equations based on the primer vector theory from optimal control theory into a boundary value problem, which is solved by the trust region method or the Levenberg-Marquardt algorithm. The calculation is solved by the two-body problem universal function method to avoid numerical integration, and the orbital state and costate are solved analytically by the two-body problem universal function method. The algorithm does not require numerical integration, is easy to calculate, and is insensitive to initial values, and can be applied to solve the Kepler problem for all conic curves such as elliptic and hyperbolic orbits, and can also avoid the singular problem of 180 degree orbital transfer. For the multi-revolution Lambert problem, there is no need to judge the number of revolutions flown. The solution can be solved and the costate of the original problem can be obtained simultaneously, so that further optimization of the original problem can be done based on the non-optimal primer vector theory. The algorithm in this paper builds a bridge between the primer vector theory based on the optimal control theory, the non-optimal primer vector theory, the Lambert problem, and the universal function solution of the Kepler problem.