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CONTINUOUS LOW-THRUST TRAJECTORY OPTIMIZATION BASED ON A SYMPLECTIC CONSERVATIVE PERTURBATION METHOD

Abstract

Trajectory optimization is a powerful technique to design a scenario in space mission. Differ with high-thrust trajectory optimization problems low-thrust systems operate for significant periods of the mission time, and the solution approach requires continuous optimization which has many new difficulties should be solved. For a space mission, the minimum-time transfer problem which is denoted as a two-point boundary value problem (TPBVP) of low-thrust spacecraft is always considered at the first instance, and an efficient optimal control algorithm should be studied. For it's difficult to solve the nonlinear TPBVP in a nonlinear optimal control system, and the associated optimal control approaches which numerically solve such problems by iteration methods are generally ill-conditioned, therefore, a symplectic conservative perturbation algorithm which has the accurate and efficient characteristics is applied to the minimum-time transfer problem. First, the nonlinear TPBVP is converted to a linear TPBVP by quasi-linearization theory in each iterative step, and the TPBVP can be described as an initialization problem with variable parameters. Second, adopting the conception of interval mixed energy which includes interval mixed matrices and vectors, the linear TPBVP can be divided as many intervals. Third, the interval mixed energy matrices and vectors can be calculated based on the mixed energy solution formula which is deducted and expressed as apparent form. Then the TPBVP of the low-thrust transfer problem is solved. The algorithm is symplectic conservative and can parallel calculate. Numerical results demonstrate the algorithm is fast and robust and easily convergent to an optimization trajectory.