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TWO-IMPULSE ORBITAL TRANSFER BASED ON THE SOLUTION OF LAMBERT PROBLEM WITH OPTIMAL FLIGHT TIME

Abstract

The Lambert problem is a classical problem of celestial mechanics, which was formulated in the studies of Lambert and Euler to orbit determination of celestial bodies. Now this problem has acquired new significance and is often the basis to design the various types of spacecraft transfers. In this case, it is assumed that the orbit connecting two given positions is a transfer trajectory, the cost of which is calculated by the sum of two velocity impulses. So, by solving the Lambert problem, optimization of impulsive orbital transfers is carried out, hyperbolic excess velocity and launch windows of interplanetary missions are calculated, and much more. The traditional Lambert problem is formulated as a two-point boundary value problem in two-body model, in which the position vectors at two different times and time of transfer between them are given. Since the two-body problem admits an analytical solution, the boundary value problem is reduced to one nonlinear equation relating the time of transfer and orbit parameters. This equation follows from the Kepler equation and can be represented in a different way. There are many methods to solve the Lambert problem, which differ in the form of writing the equation, the numerical method to solve it, or the rule for choosing the initial guess. The typical time to solve the Lambert problem is very short. However, in optimization problems based on its, often, it is necessary to select all the initial inputs that are necessary for the solution. Such as the start and end position, as well as the flight time. This usually happens by adding a numerical optimization method to the Lambert problem (for example, gradient method). This greatly increases the computational complexity. Therefore, it is advisable to consider a problem similar to the Lambert problem, but providing for the optimization of the transfer parameters to minimize the total velocity impulse. The study presents an algorithm to solve the problem of optimal two-impulse transfer between orbits in optimal time, constructed similarly to the algorithms for solving the Lambert problem. The proposed technique is based on the formulation of the conditional extremum problem and allows us to include time optimization in the general solution algorithm. For the obtained algorithm, the computational complexity is compared with the solution of a similar problem based on the multiple solution of the Lambert problem. The examples of solving the problem of a transfer between non-coplanar elliptical orbits are considered.