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A NEW STRATEGY OF DESIGNING LOW-THRUST TRAJECTORIES IN ALTERNATE ROTATIONAL COORDINATES

Abstract

In recent years, the use of an electric propulsion system (EPS) becomes a trend in deep space missions because of its high Isp. Since EPS generates continuous low thrusts, however, it becomes more difficult to design trajectories. Usually this kind of trajectory is designed by complicated numerical optimization strategies.

A purpose of this study is to design this spiral trajectory without complicated numerical calculations. Firstly, new rotational coordinates are proposed. Angular velocity of these new rotational coordinates is defined by using a position of the spacecraft, that is, the angular velocity varies as the spacecraft moves. In these coordinates, the spiral trajectory is depicted in simple shape such as a straight-line. Secondly, a shape-based trajectory design strategy is used. In this strategy, the shape of the trajectory is defined in function form by hands. By substituting this function for the equations of motion, the thrust profile can be derived analytically. An important feature of these strategies is that the trajectory design can be conducted only by drawing lines in the same way as the trajectory design using chemical propulsion system.

In this paper, as an example, Earth to Mars transfer trajectories are designed in two-body problem and four-body problem respectively. By using these strategies, the two-point boundary value problem is easily solved without complicated numerical calculations even if the gravity perturbations of the planets are included. Moreover, if the shape function of the trajectory includes some parameters, many trajectories that satisfy boundary conditions can be generated only by changing these parameters. In a real mission, only we have to do is to choose one trajectory that has well property. In this way, by using these strategies, the trajectory design using EPS becomes simple drastically.