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OPTIMAL LOW-THRUST SPIRAL TRAJECTORIES USING LYAPUNOV-BASED GUIDANCE

Abstract

It is difficult and time-consuming to search the optimal low-thrust spiral trajectories. This is because the analytical solutions for long powered arcs are not available, and hundreds or even thousands of orbital revolutions are involved in transfer trajectories. This paper describes an efficient optimal guidance scheme for the design of time-optimal and time-fixed fuel-optimal low-thrust spiral trajectories. The time-optimal solution is obtained with Lyapunov-based guidance, in which the artificial neural network (ANN) is adopted to implement control gains steering and the evolutionary algorithm is used as the learning algorithm for ANN. Moreover, the relative effectivity introduced in Q-law is analyzed and a periapis-and-apoapsis-centered burn structure is proposed for solving time-fixed fuel-optimal low-thrust orbit transfer problem. In this guidance scheme, the ANN is adopted to determine the burn structure within each orbital revolution and the optimal low-thrust orbit transfer problem is converted to the parameter optimization problem. This guidance scheme runs without an initial guess and provides closed form solutions. In addition, Earth J2 perturbation and Earth-shadow eclipse effects are considered in this paper. Finally, a comparison with solutions given by the literature demonstrates the effectiveness of the proposed method.