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TRAJECTORY DESIGN CONNECTING INVARIANT MANIFOLDS OF PERIODIC ORBITS WITH CONTINUOUS LOW-THRUST

Abstract

Periodic orbits are useful for deep space explorations and astronomical observations. Future International Space Station (ISS) will be put into a L2 periodic orbit by NASA. In the circular restricted three-body problem (CRTBP), there exist invariant manifolds of libration point orbits and they are often used for low-energy trajectory designs. These manifolds contributed to the trajectory design of NASA's Genesis Discovery Mission. On the other hand, electric propulsion systems like ion engine have been utilized for deep space explorations and their high specific impulses contribute to the long-life and high accuracy missions. However, it is difficult to design trajectories of low-thrust spacecraft because the motion of low-thrust spacecraft is complicated by the low-thrust acceleration.

This paper extends the invariant manifolds of unstable libration point orbits through the application of continuous thrust. Jacobi constant along the low-thrust trajectory is not constant but depends on the thrust direction and magnitude. Considering the variation of the Jacobi constant by the work done by the constant external force, artificial periodic orbits to realize a heteroclinic orbit connection between forced periodic orbit and unforced (or forced) periodic orbit are found. It is shown that heteroclinic orbit connections are constructed by detecting intersection of manifolds on the Poincaré section. Then, the cost of orbit transfer between two libration point orbits are characterized by comparing ΔVs to perform transfers between L2 Lyapunov orbit and L1 Lyapunov orbit by two paths: (i) transfer trajectory designed by minimum energy control and heteroclinic connection between periodic orbits, (ii) transfer trajectory designed by minimum energy control and heteroclinic connection between forced periodic orbits.

The simulation results show that the proposed method can shorten the transfer time while decreasing the cost. The application of the proposed method includes design of periodic orbits and transfer trajectories in the perturbed CRTBP induced by the solar radiation pressure acceleration. Our future work includes trajectory design to combine two CRTBP systems like Sun-Earth system and Sun-Mars system.