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ACCURATE TOUR TRAJECTORY DESIGN FOR THE JOVIAN SYSTEM USING PSEUDO-STATE THEORY

Abstract

Jovian system, consisting of the largest planet Jupiter in the solar system and its numerous moons, has significant science and exploration value. Not only Jupiter but also its four Galilean moons are the focus of future deep-space exploration missions. Due to the far distance and the expensive launch costs, an economical way is to visit all candidates in one mission. Therefore, the tour trajectory design is essential for the Jovian system exploration mission. The numerous moons of Jupiter, in particular the four massive Galilean moons, complicate dynamic environment. This makes the accurate exploration trajectory design of the Jovian system become very complex. Moreover, the fuel of spacecraft is limited. The gravity assist is a useful technique to decrease the velocity increment of spacecraft during Jupiter capture and inner transfer, which makes the problem more challenging. Traditional patched-conic methods ignore the perturbation effects, and solve the trajectory based on the two-body dynamic model. Compared with the true trajectory, their result is imprecise. If the three-body dynamic model that is more precise is applied, it will obtain the more accurate and fuel-efficient solution. However, the orbital propagation in three-body dynamic model is time consuming, which seriously restricts the efficiency of solving. A novel method based on the pseudo-state theory is proposed to rapidly design the accurate trajectory in the Jovian system. The perturbations of four Galilean moons and Sun are taken into account to obtain the accurate trajectory. The pseudo-state theory is employed to deal with these perturbations, which avoids orbital propagation in complex dynamics and improves computational efficiency. The principal assumption of pseudo-state theory is that the conic motion about the primary body can be combined with pseudo-conic motion about the perturbing third body. In other words, the mass of the secondary body is sufficiently smaller than the mass of the primary body. The whole trajectory is split into a number of transfer segments and gravity-assist segments. For the transfer leg, the primary body is the Sun, and the secondary body is Jupiter. For gravity-assist leg, the primary and secondary bodies are the Jupiter and the gravity-assist Galilean moon, respectively. Finally, these legs are matched at the sphere of pseudo-state by the shooting method.