Paper ID: 57944
oral
student

27th IAA SYMPOSIUM ON SMALL SATELLITE MISSIONS (B4)
Small Spacecraft for Deep-Space Exploration (8)

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HIGH-EFFICIENCY TRAJECTORY OPTIMIZATION METHOD FOR SMALL SPACECRAFT OF ASTEROIDS BASED ON MACHINE LEARNING

Abstract

Recently asteroid's exploration is the new direction of the deep-space exploration. Landing to explore asteroids can help humans to understand the characteristics of asteroids. Therefore,landing asteroids for surface exploration is the development trend of asteroid's exploration in the future. At present,hopping solution is an important form for the surface exploration of asteroids, because the hopping probe is small in size and is comfortable with the micro-gravity field on the asteroid's surface. The surface exploration requires research on the dynamics of surface motion and trajectory planning of hopping probes. Nowadays many optimization algorithms are used to solve trajectory planning problems. To get an optimization trajectory every time, the optimization algorithm is executed once, so it causes problems such as long calculating time and low efficiency. In order to improve efficiency,a method to obtain the optimal trajectory efficiently is proposed using machine learning in the paper. With this method, as long as there are enough learning samples, it only takes a few seconds to get the optimal trajectory.

The research of the dynamics of surface motion is the premise of getting the optimal trajectory, so the dynamics of surface motion is researched firstly. Many numerical simulation are performed to study the influence of local topography on the trajectory shape and landing point. The results show that the the location of the landing points is concentrated in the recessed area. The simulation results prove the importance of the asteroid's topography for trajectory planning and design. During impact if the effect of the deformation force is not handled properly, the probe will escape from the asteroid. Aiming at this problem, a control method that the thrust is applied at the point of impact is proposed.

Finally,for the problem of slow calculation speed when using optimization algorithms, a method for obtaining the optimal trajectory quickly using machine learning is designed. In this method, in order to obtain a suitable sampling set, many optimization algorithms are used to solve the optimal control problem with the fuel optimization as the target. After getting the sample set, the mapping relationship between the initial value and the control variable is quickly obtained by the machine learning algorithm, and the optimal trajectory is directly obtained according to the obtained control variable. The results show that using the machine learning to obtain the optimal trajectory is faster than using the optimization algorithm and efficiency is greatly improved.