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OBSERVABILITY-BASED ORBITER AIDED COOPERATIVE NAVIGATION FOR ASTEROID LANDING

Abstract

Optical navigation is an important technique for asteroid autonomous landing navigation. During landing, the lander camera captures natural landmarks on the asteroid surface. By matching those landmarks with the topography database, the lander state under the fixed coordinate can be estimated. However, the number of available landmarks within the landing zone are usually limited. Moreover, as the lander gradually descends, the visible landmarks gradually vanish from the camera's view. As a result, the number of observable landmarks gradually decreases or even insufficient, which will seriously affect the observability of the system, thus affect the navigation accuracy. This indicates that by adopting optical navigation alone restricts both observability and estimation accuracy of the landing navigation system. Therefore, it is necessary to develop a navigation method to expend measurement information and improve navigation accuracy. In this paper, the orbiter is introduced as a cooperative navigation system with the lander. Under this scheme, both the lander and the orbiter are equipped with optical cameras, and the relative measurement is established between orbiter and lander via radio sensors. Through optical navigation, the lander can obtain direction measurement using landmarks, but the radial distance information with landmarks is unobservable. Meanwhile, in the final landing phase, the number of landmarks observed by the lander is insufficient, resulting in observability reduction. It should be noted that the orbiter, with a high altitude relative to the asteroid's surface, could capture a larger number of landmarks compared with the lander. The orbiter, therefore, is able to estimate its own state by using the optical camera. Accordingly, introducing the relative measurement between the lander and the orbiter expands the measurement information, which in turn improves the observability of the lander state and achieves high precision navigation. To improve the observability of navigation system, the orbiter and the lander trajectories are optimized by considering the multiple mission constraints and taking the observability as the performance index. The simulation indicates that by introducing measurements between the orbiter and the lander, the navigation accuracy of the lander and the orbiter are improved. In conclusion, by adopting observability-based orbiter aided cooperative navigation for asteroid landing, the system navigation accuracy can be enhanced.