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DYNAMIC RECURSIVE OPTIMIZATION FOR OPTICAL NAVIGATION FEATURE SELECTION IN ASTEROID LANDING

Abstract

Asteroid landing is an important prerequisite of in-situ exploration and sample return. Due to the long distance of the object asteroid from the earth, there is an intolerable time delay with ground-based communication, leading difficulties to meet the needs of real-time navigation. Therefore, it is essential to carry out autonomous navigation technology during asteroid landing. Meanwhile, in order to avoid obstacles and achieve soft landing, high accuracy of navigation is also of essential importance. Autonomous optical navigation, an important navigation method for landing stage, can meet above requirements. Since asteroids have topographic features such as craters and opportunity features such as SIFT points, autonomous optical navigation captures above features with optical camera and directly calculates the state of the lander according to the geometric relationship. In the process of autonomous optical navigation, the amount and location of navigation landmarks are key factors that affect navigation accuracy. As the height of the lander gradually decreases when approaching asteroids, the visible optical features gradually vanish from the camera's view, therefore, new optical features should be extracted and matched to achieve precise navigation. However, the limited onboard computing ability cannot satisfy timely extraction and matching. In order to solve this problem, this article presents a fast preprocessing algorithm by introducing the recursive optimization into optical navigation. The main content is that the position of the lander at different times is recursively obtained according to the nominal trajectory under a given camera sampling interval, and the range of visible field is calculated by using camera parameters. Thus, a set of visual sequence ranges can be obtained considering uncertainties. During the initial stage of landing, the sequence visual range is estimated, and the Cramér-Rao lower bound is used as the performance index to optimize and select optical navigation features that are within the sequence visual range. Those dynamic sequential features can be brought into timely landing computation. In this article, one simulation result indicates that using this pre-processing method, compared with real-time image processing during landing, can dramatically reduce calculation amount. Another simulation result demonstrates that during the landing process, compared with navigation using fixed features, navigation using those dynamic features improves the navigation accuracy to a highly degree, which guarantees high-precision landing. In conclusion, using dynamic recursive optimization for optical navigation feature selection improves navigation accuracy and meanwhile reduces calculation amount.