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FAINT TARGET PROCESSING (FTP) PIPELINE FOR SMALL ASTEROID PROBERS

Abstract

Recently the small prober becomes a popular approach for asteroid exploration due to its low cost and high flexibility. Optical navigation (OPNAV) is an inevitable technology for small asteroid probers as the ground operation is expensive and has long delay. However, the OPNAV of small probers still face many challenges. Owing to the limited onboard equipment, the imaging of faint asteroid targets takes long exposure time and is usually low-SNR and blurry. Consequently, OPNAV system fails as optical measurements cannot be extracted accurately. To overcome these problems, simple but well-performed faint target processing (FTP) technology is desirable for small asteroid probers.

In this paper, a new FTP pipeline is proposed to support the OPNAV of small probers for asteroid exploration. The proposed pipeline consists of three steps: pre-processing, restoration and fault measurement detection. In the pre-processing step, the main goal is to remove the background noise and localize the regions of interest (ROIs) containing targets. Then, a blur check is given based on the target sizes and intensity gradients to determine whether the image captured is degraded by motion. For the blurred image, a fast restoration method using star stripe phase information is applied to recover the image without the aids of other sensors. In the end, to enhance the system robustness, a fault measurement detection step is given via the innovation chi-square test. Only the image with measurements innovation within the fault threshold is accepted by the navigation system to update state estimation; otherwise, it will be rejected and a new frame of image will be taken immediately.

Numerical and semi-physical simulations are carried out to evaluate the performance of the proposed FTP pipeline. Results demonstrate that the proposed pipeline greatly facilitates extracting features from faint asteroid images and is effective for various kinds of imaging conditions. The proposed FTP pipeline can meet real-time requirements while maintaining good accuracy, and thus can be integrated into the navigation system of small asteroid probers.