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CNN-BASED ROBUST FEATURE TRACKING FOR THE AUTONOMOUS APPROACH TO AN UNKNOWN SMALL BODY

Abstract

In the approach to an unknown small body, OSIRIS-REx and other recent missions have relied on the extensive support of ground operators. To enhance the autonomy in estimating relative trajectories and properties of the body, the tracking of the body's terrain landmarks over multiple subsequent camera frames plays a crucial role. The tracking of the features, the 2D-projections of the landmarks onto the camera plane, remains a challenge for an autonomous spacecraft when no prior shape model of the body is available. The appearance of the landmarks dramatically changes due to fast variations in lighting and perspective determined by the small body's spin. The feature tracking of cutting-edge computer vision algorithms is severely affected by these conditions, thus yielding a systematic error in the navigation solution. This work proposes a Convolutional Neural Network (CNN), trained on synthetical images of both real and randomly generated small bodies, to increase the robustness and the accuracy of feature tracking in the autonomous approach to a small body. This deep-learning-based tracker, which aims to improve the detection and description components of the onboard feature tracking system, leverages the self-supervised training framework of SuperPoint to obtain a CNN tailored to small bodies navigation scenarios. The novelty of the proposed CNN is the enhancement in the detection, which has been until now a major source of error due to the changes in appearance and due to the high self-similarity of the body's terrain. To improve the localization's accuracy the features, after the first detection, are propagated between subsequent frames taking advantage of the known geometry of the shape model. Therefore, the training focuses on learning the evolution of the features' location with time, rather than on their instantaneous location. The description component is augmented by matching the propagated

correspondent features over non-consecutive frames. Finally, the performance of the above-mentioned CNN is investigated and compared against benchmark trackers by simulating the navigation scenarios to unknown small bodies of previous missions.