Paper ID: 43502
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IAF ASTRODYNAMICS SYMPOSIUM (C1)
Interactive Presentations - IAF ASTRODYNAMICS SYMPOSIUM (IP)

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MULTISPECTRAL IMAGE PROCESSING FOR NAVIGATION USING LOW PERFORMANCE COMPUTING

Abstract

Space debris represents a growing threat for both current spacecraft and future launches. This is exceptionally alarming in the case of low Earth orbits, where chain impacts of existing debris generate even more fragments, increasing the probability of further collisions. The now defunct satellite ENVISAT represents one of the largest objects classified as space debris. The e.Deorbit mission will demonstrate active debris removal technology to successfully decommission ENVISAT and other non-functional spacecraft in orbit. This shall be achieved by deploying a chaser spacecraft to perform a non-cooperative rendezvous (NCRV) with the target object in order to capture and deorbit it. To this end, relative navigation solutions shall be employed using image processing algorithms, which entail the detection and matching of two-dimensional regions of interest. The acquired information can then be used in conjunction with visual mapping methods, such as structure from motion (SFM) or simultaneous localisation and mapping (SLAM), or in correlation with a known model, to generate a navigation solution.

In this work, multiple pattern recognition techniques are investigated for the detection and extraction of these features. This analysis of feature perception is achieved for the first time in the context of space NCRV across two different modalities: the visible (0.39-0.70 μm) and the thermal infrared (8-14 μm). Photo-realistic synthetic images of rendezvous manoeuvres with ENVISAT are generated for both wavelengths and multiple conditions, including sunlight and eclipse. The integrity of the solutions is examined for these scenarios using the developed framework. In particular, the performance of the Harris, GFTT, DoG, Fast-Hessian, FAST, and CenSurE detectors and of the SIFT, SURF, LIOP, ORB, BRISK, and FREAK descriptors is assessed. These algorithms are implemented in a dedicated, space-appropriate hardware processor to benchmark their real-time capabilities.

It is found that, while multiple combinations of detectors and descriptors fulfill the hardware requirements, Fast-Hessian coupled with BRISK is capable of providing adequate performance both in terms of matching score and computational efficiency when run for both wavelengths in parallel.