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STAR TRACKERS AS DUAL-USE SENSORS: OPTIMISATION FOR SIMULTANEOUS RESIDENT SPACE OBJECT DETECTION AND ATTITUDE DETERMINATION

Abstract

Growing levels of space junk and increasing numbers of spacecraft launches are threatening safe and continuous access to space. Accurate and frequent detection and tracking of Resident Space Objects (RSOs) is crucial to reducing risks such as future conjunction events. In this paper, we consider star trackers for the dual uses of RSO detection and attitude determination. Importantly, we consider simultaneous functionality and explore whether optimising for one use-case degrades the performance of the other. This improves on prior work in which optimisation of star trackers for RSO detection has either ignored effects on attitude determination altogether or resulted in unacceptable attitude determination performance.

To explore this problem, a full pipeline for attitude determination and RSO detection is implemented and tested using a high-fidelity image simulator. The simulator accounts for both the sensor noise characteristics and the scene dynamics during exposure, including moving stars and RSOs in the sensor frame. Optimisation and sampling methods — Bayesian optimisation and grid search — are used to maximise performance metrics, including attitude determination accuracy and RSO detectability. System parameters, including exposure time and gain, and algorithm variables, such as filter characteristics, are chosen for optimisation. The best performing configuration had an average attitude error of 22.5 ± 26.7 " and detected 286 RSOs in a single orbit. The datasets generated were also used to explore the system's sensitivity to both intrinsic and extrinsic parameters. It was found that the responses to intrinsic parameters (such as exposure time or gain) for both functions of attitude determination and RSO detection were well coupled. The responses to extrinsic parameters such as RSO size, apparent brightness, distance, and speed are also discussed.

The results demonstrate that, for the optimised configuration, star trackers can be used for enhanced space situational awareness without significantly reducing their primary task performance. This will be strengthened by future work that extends the RSO pipeline to include initial orbit determination and tracking. The findings of this work support the growing trend of considering star trackers for RSO detection.