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PERFORMANCE CHARACTERIZATION OF A NON-CONVENTIONAL STAR TRACKER BASED ON A HYPER-HEMISPHERICAL PANORAMIC CAMERA

Abstract

The attitude determination and control system is typically used to enable accurate pointing of payloads, communication antennas and solar arrays, as well as to perform slew maneuvers. Hence, based on the related accuracy and control requirements, it may have a significant impact on the overall mass and power budgets of a space platform. This aspect can be particularly critical when designing small and micro satellites, whose use is significantly increasing in the latest years especially for applications in Low Earth Orbit. In this framework, panoramic cameras have great potential for reducing weight and cost of future missions, since their extremely wide field of view may allow simultaneously imaging the star field, large celestial bodies, as well as other space objects orbiting in proximity. Thus, they can be operated as multifunctional sensors, e.g., suitable for both attitude determination and space situational awareness. This work lies in the framework of the POLIFEMO project, whose goal is to develop a multifunctional sensor which exploits an innovative optical system (based on a hyper-hemispheric lens) to catch a field of view of 360 in azimuth and up to 270 in elevation (hyper-hemisphere) without needing moving parts. This paper focuses on the star tracker mode of this panoramic sensor. Specifically, an innovative, non-conventional approach has been conceived to perform star identification, i.e., to find correct correspondences between imaged stars and the stellar catalogue. Indeed, standard solutions are not applicable since modern star tracker exploit cameras capable of imaging a relatively small field of view (up to 40) with higher resolution and sensitivity than panoramic cameras. Thus, the proposed method is based on template matching and point cloud registration techniques to globally match the full pattern of detected stars with similar sets of stars a-priori stored in an onboard database. To satisfy lost-in-space requirements, the computational effort is limited by creating an ad-hoc database which allows uniformly sampling the space of possible pointing of the camera over the celestial sphere. Performance of the proposed approach is assessed by means of numerical simulations in terms of both star identification and attitude determination, considering the presence of unexpected/lost stars and hot pixels on the detector, as well as partial occlusions of the field of view caused by the Earth or other celestial bodies (e.g., Sun or Moon). Preliminary results show the possibility to get sub-degree accuracy with a success rates above 93