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VIS-TIR CAMERAS DATA FUSION TO ENHANCE RELATIVE NAVIGATION DURING IN ORBIT SERVICING OPERATIONS

Abstract

The paper proposes an effective and robust approach to cope with operating in proximity of non cooperative orbiting objects for In Orbit Servicing, Debris Removal included. The novelty of the here proposed approach, stays in exploiting visible (VIS) and thermal infrared (TIR) images fusion to improve the vision-based relative navigation systems. Indeed, solutions related to VIS cameras strongly depend on illumination conditions, which constrain operations planning since it may lead to limited opportunities to properly detect and track the target itself with unacceptable either mission length or risk increase. Illumination bottlenecks are particularly significant for targets in LEO orbit, which experience long eclipses. A further complexity on objects and dynamics reconstruction through imaging raises, whenever target bodies have axial-simmetry such is the case for launchers' adapters. To get rid of the illumination constraints, the paper proposes to integrate TIR images into VIS, being the former insensitive to illumination conditions. However, the lower resolution and poorer texture of TIR images make the VIS-TIR image fusion a challenge to solve. The lack of datasets for VIS and TIR images acquired on orbit under proximity maneuvering scenarios, drove towards an in-house developed simulator. In particular, the target object TIR synthetic images are obtained by first computing its temperature distribution from its thermophysical properties and flux sources and then converting it into its equivalent gray-values, by modeling the behaviour of uncooled microbolometer sensors [Piccinin2021].

The TIR-VIS image fusion might be then solved by considering the typical pixel-level fusion methods [Ma2019]; however, they would require source images of equal resolution and strictly geometrically aligned to efficiently operate. Those requirements are not usually met by state-of-art VIS-TIR cameras here considered, differing in Field of View (FOV), resolution and by being mounted in different positions and orientations on board. In general, the image registration problem is tackled through either area-based or featured-based methods [Ma2019] and its computation can be relieved if the two cameras relative parameters are known. The current work adopts an affine transformation, applied to the TIR image to overlap it to the VIS camera output. The paper shows obtained results with the the VEga Secondary Payload Adapter (VESPA) target case study, as it is supposed to be the target for the first Active Debris removal European Mission [Silvestrini2020]. In fact, from the image processing perspective, VESPA represents a representative case as it offers the axial-symmetry challenge together with the material homogeneity in terms of optical properties as well. The paper will also report about results obtained testing different

fusion methods, compared in terms of quality metrics [Jagalingam2015] which take into account the computational load too.

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