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PROXIMITY RELATIVE NAVIGATION SENSORS FOR SMALL-SCALE SPACECRAFT AND DRONES

Abstract

The exploitation of autonomous miniature spacecraft could enable several unprecedented missions in the near future, including on-orbit automated inspection and servicing of larger satellites, on-orbit assembly of low-cost large modular structures and many other operations, including active debris removal. On the other hand, advanced Micro Aerial Vehicles (MAVs) could be employed in several applications from remote observation to inspection of dangerous environments such as damaged buildings or blazing woods, or exploration of planetary environment. In this context, proximity relative navigation systems for autonomous small spacecraft and MAVs are under continuous investigation, aiming to obtain low-cost and low-resources miniaturized sensors. As it concerns large cooperative spacecraft, some relevant examples of proximity navigation sensors can be found, which are usually based on LIDAR, radio or imaging systems; however, they all imply considerable mass budget and high resources consumption, both in terms of power and computational burden. Thus, further developments are needed to realize small and low-power-consuming navigation sensors. In this paper, after a review on the state of the art of relative navigation systems for cooperative and non-cooperative miniature space and aerial vehicles, two simple, low cost devices for proximity navigation are presented. The first one is conceived for operation between cooperative vehicles, and exploits a dual system comprising a small camera imaging an array of LEDs and a LED-photodiode couple for precise range estimation based on intensity measurements. The second sensor is designed to perform proximity ranging and attitude determination with respect to non-cooperative objects in space, air or ground. It is based on a miniature camera that detects the light spots on the target surface generated by three lasers mounted on the chaser vehicle. Theoretical models have been developed for both sensors, as well as simple prototypes; outcomes from numerical simulations are compared to laboratory test results for model validation and preliminary assessment of performance.