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Novel Concepts and Technologies to Enable Future Building Blocks in Space Exploration and Development (3)

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VISUAL NAVIGATION TECHNOLOGY COMBINING STAR TRACKERS AND PROXIMITY CAMERAS

Abstract

Space probes increasingly explore the solar system, up to faraway planets. Orbit determination of these probes, based on radio tracking from Earth, becomes clearly less accurate as the distance from Earth increases. Above all, the time required for telemetry/navigation data downlink and telecommand uplink also increases with distance from Earth and therefore real-time manoeuvres and operations become impossible. When a spacecraft is close to a planetary target (or celestial body, including comets and asteroids), optical navigation ensures accurate estimates of the relative kinematics and allows to conceive manoeuvres computed on board, autonomously and in real time. This technique, based on imaging and on the comparison with already known data as previously captured images, celestial catalogues or ephemerides, helps with the determination of the complete kinematic state (position, velocity, attitude) of the spacecraft, relative to the target. Indeed, it is similar to attitude determination traditionally carried out by means of star trackers, where the spacecraft's orientation with respect to inertially fixed stars is evaluated. The similarity in concept, with imaging process and comparison to stored information, introduces the question if star trackers' and proximity cameras' functions can be exploited by the same on board hardware. The availability of a universal optical navigation sensor, sharing a large part of its expensive components, could really be an enabling technology for a more effective space exploration. The aim of the proposed paper is to investigate and analyse this possibility, which is collecting more and more interest. The main issue is the identification of the sensors' configurations - as an example beginning with multi-head star trackers with different optics and focal lengths - and algorithms allowing to exploit this twin use. This identification moves through a correct modelling of the sensor behaviour depending on the various phases of a mission (cruise, approach, fly-by or descent to the target, and so on). The combination between star trackers and proximity cameras as position/attitude sensors could obviously allow a reduction in costs, and – probably more important at the current, preliminary status of this approach – provide a back-up in case of failures thanks to a possible, even non-optimal redundancy. Furthermore, the interest of the study is not limited to deep space missions, and can be extended to other vehicles currently using star trackers and cameras as the planetary rovers.