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SIX DOF ANALYSIS FOR ASTEROID AUTONOMOUS EXPLORATION

Abstract

The autonomy in asteroid missions has gained particular attention in the last years. Reference [1] shows that a bolder approach, taking full advantage of the spacecraft autonomy, is possible by using a robust guidance to deal with the uncertain asteroid environment, with no need to maintain the same conservative approach applied in other works. Although the time constants in an asteroid environment are usually large, allowing the spacecraft to make sparse measurements in hours, with plenty of time to execute other required maneuvers, it is worth investigating the coupling between attitude and guidance to assess if any undesired behavior derives from it. That investigation is especially needed in an operational profile such as the proposed by Reference [1], which might present frequent control activity for trajectory correction and orbital maintenance. This work makes a six degree of freedom (DOF) analysis for the GNC approach proposed in Reference [1]. For that sake, we consider a spacecraft equipped with a LIDAR and two optical navigation cameras on its -z body-fixed frame panel, twelve thrusters are used for attitude control and guidance (similar to Hayabusa 2), and four reaction wheels. A fixed solar panel is considered, which simplifies the spacecraft design and removes points for failure, increasing the robustness of the mission. Uncertainties in the attitude are modeled accordingly to the noise level of the IMU LN-200S of the Northrop Grumman, the same used in the OSIRIS-REx mission. The attitude control algorithm aims to point the solar panels towards the Sun to recharge the batteries while executing the required guidance maneuvers. The orbital maintenance in close proximity to the asteroid is made using the control proposed by Reference [2]. The spacecraft also needs to point its LIDAR and optical cameras to the asteroid once every hour for the measurement used in the trajectory estimation. Preliminary considerations and specificities in operating about binary asteroids are also made. Reaction wheels desaturation maneuvers are planned and investigated. The results draw guidelines for further developments in the autonomous exploration of the challenging environments of small bodies.

[1] Negri, R.B.; Prado, A.F.B.A; Chagas, R.A.J.. Autonomous Rapid Exploration of an Asteroid. Submitted to Journal of Guidance, Control, and Dynamics, 2022 [2] Negri, R.B.; Prado, A.F.B.A.. Autonomous and Robust Orbit-keeping for Small-body Missions. Journal of Guidance, Control, and Dynamics, p.1-12, 2022