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IAF SPACE EXPLORATION SYMPOSIUM (A3)
Small Bodies Missions and Technologies (Part 1) (4A)

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AIM AUTONOMOUS ASTEROID NAVIGATION

Abstract

The Asteroid Impact Mission (AIM) was a small ESA mission of opportunity which objective is to perform scientific observations of a binary asteroid (Didymos) while demonstrating technologies for future missions and addressing planetary defence. It was presented to the ministerial council in December 2016 but it did not receive the funding necessary for its implementation.

Despite the outcome of the CM2016, the mission concept has not been put aside and it will be used as baseline for the new HERA mission. At the moment of the preparation of this paper, details on HERA are not available yet, but the GNC baseline will most likely be the one designed and tested in AIM. GMV has been the GNC responsible for AIM and it decided to continue the algorithms development and testing running internal activities.

The purpose of the paper is to present the new design of the Unscented Kalman Filter (UKF) adopted for the autonomous navigation during the characterization phases of the mission. During such phases, the spacecraft will perform fail-safe hyperbolic arcs at a distance of 35 km (Early Characterization Phase) and at 10 km (Detailed Characterization Phase), slowly getting closer to the binary asteroid system Didymos while improving the knowledge of the dynamic environment. It has been demonstrated in the frame of the AIM system study that to perform the characterization phases with low level of autonomy (ground authority for both the manoeuvre application and the reference attitude) might lead to partial or complete loss of the asteroids from the Field of View of the camera. For this reason, GMV developed an autonomous attitude mode that is able to always point to the centre of the main asteroid thanks to an on-board relative state estimator. In the paper, details about the design of the selected navigation filter will be given together with the trade-off that leads to its implementation.

The AIM Framing Camera (qualification model developed by Max Planck Institute and used in the NASA DAWN mission) is available and currently set-up in the optical laboratory of GMV. This allowed an intensive test campaign of the new navigation design, including also the Image Processing (GMV implementation of a centroiding algorithm, based on the correlation with the Lambertian Sphere) in a Hardware-In-the-Loop architecture.