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DESIGN OF THE VISION-BASED GNC SUBSYSTEM OF HERA'S MILANI MISSION

Abstract

AIDA is an ESA-NASA collaboration aimed at sending two spacecraft to the binary asteroid 65803 Didymos to assess the deflection capability of a kinetic impactor on hazardous near-Earth objects. First, NASA's DART will impact the secondary asteroid, Dimorphos, to alter its orbit. Then, ESA's Hera will rendezvous with the binary system to characterize it following DART's impact. In proximity of the target, Hera will release the first CubeSats to perform long-term operations around a binary asteroid: Milani and Juventas. Milani is a 6U CubeSat with 6-DOF maneuvering capability that will perform hyperspectral imaging of the asteroids' surface and characterize the dust environment around the system. Milani will communicate with ground via Hera through an Inter-Satellite-Link making the CubeSat a unique opportunity for technological demonstration in deep space. The project is led by Tyvak International and it is currently in Phase C. Politecnico di Milano is responsible for the mission analysis and GNC subsystem design.

This work focuses on the vision-based GNC of Milani, which is characterized by semi-autonomous capabilities enabled by innovative image processing (IP) and autonomous navigation components, paired with traditional guidance and control methods. The main task of the GNC subsystem is to produce a primary pointing to the desired target, with the capability to switch between Didymos, Dimorphos and Hera. Even if the orbit determination of the spacecraft will be performed on-ground, the GNC includes an on-board Extended Kalman Filter (EKF) to autonomously estimate the spacecraft trajectory using IP and LIDAR observables, which will be employed both for pointing purposes and as part of an autonomous optical navigation experiment. To generate a reliable and robust guidance solution throughout the mission, three main pointing strategies have been designed: reference, tracking and predicted. In reference, guidance is obtained from ground-provided information, either following a specified pointing profile or interpolating ephemerides data. Tracking uses IP data to bring the target to the centre of

the navigation camera's field of view. Finally, predicted employs the position estimated by the on-board EKF and the ephemerides of the target to compute the guidance solution. The GNC can automatically transition between different pointing strategies depending on the available data and the EKF state. Extensive analyses have been performed and the main results are reported and discussed in this paper. The proposed design proved to be compliant with mission constraint enhancing the autonomous capability for deep-space CubeSats.