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GNC AND FDIR DATA FUSION TECHNIQUES FOR THE ASTEROID IMPACT MISSION

Abstract

The Asteroid Impact Mission (AIM) is a proposed technology demonstration mission of the European Space Agency to explore a binary asteroid system and test planetary defence techniques. In the frame of AIM, an activity has been initiated with the goal of developing the GNC (Guidance, Navigation and Control) and FDIR (Failure Detection, Isolation and Recovery) data fusion algorithms needed to support the scientific characterization of a binary asteroid and the deployment of a passive lander on the surface of the secondary asteroid of the binary system. Developing the GNC and FDIR data fusion algorithms of AIM is a difficult task because of the large uncertainties in the geological and shape characteristics of the binary asteroid system (for instance mass, shape, size, surface properties). As a consequence, any proposed data-fusion algorithm must be robust to the mentioned uncertainties. The AIM mission has demanding proximity operations that include high and low altitude observations for asteroid characterization (below 10 km). In order to safely operate the spacecraft to achieve the science and technology objectives of the mission under the constraint of limited on-board equipment, novel GNC and FDIR data-fusion algorithms need to be designed and implemented that exploit payload instruments as well as GNC units. This paper is focused on the data fusion solutions employed for the main phases of the proximity operations as follows: early characterization phase (ECP), detailed characterization phase (DCP) and final descent (FD) trajectory to the target body for the lander deployment. For all the mentioned phases, the relative visual navigation is used, with inputs from VIS (Visual) camera, TIR (Thermal infrared) camera and altimeter. The following types of image processing are performed on VIS and TIR captured images: limb fitting image processing technique is used to determine the centre of the primary asteroid during ECP with data from the VIS camera, while centre of brightness is used to determine the centre of the primary asteroid with images from the TIR camera. During DCP and FD unknown landmark tracking is performed (the principle is to detect features in the first image taken by the camera and then to search for the same features in the following images). The performance and robustness to modelling uncertainties of the selected data fusion algorithm is analysed and important conclusions are drawn.