IAF ASTRODYNAMICS SYMPOSIUM (C1)
Virtual Presentations - IAF ASTRODYNAMICS SYMPOSIUM (VP)

Author: Mr. Aurelio Kaluthantrige
International Space University, France

DEVELOPMENT OF AN UNSCENTED KALMAN FILTER FOR THE VALIDATION OF THE EUROPEAN SPACE AGENCY CANDIDATE MISSION ASTEROID IMPACT MISSION'S OPTICAL NAVIGATION STRATEGY UP TO HARDWARE IN THE LOOP

Abstract

Asteroid exploration mission is a booming field for planetary sciences and space engineering. Most asteroids are irregular shaped, though a few are near spherical, and they are often pitted or cratered. As they revolve around the Sun in elliptical orbits, the asteroids also rotate, sometimes erratically, tumbling as they go. Several missions have flown by and observed asteroids, retrieving information regarding the origins of the Solar System and analyzing their trajectories for potential critical collisions with the Earth.

The European Space Agency (ESA) together with the National Aeronautics and Space Administration (NASA) planned to test if a technique called Kinetic Impact would work to deflect an asteroid from its original orbit. The overall mission is called Asteroid Impact Deflection Assessment (AIDA) and is made of two spacecrafts, the American Double Asteroid Redirection Test (DART) and the European Asteroid Impact Mission (AIM).

The latter will leverage an optical navigation system to determine its position, velocity and attitude during its journey to the target asteroid. This method has always been a cornerstone for the majority of terrestrial navigation and still represents one of the most used and reliable techniques for space exploration. Imaging and computing have been improving during the years, offering the opportunity to obtain more autonomous spacecraft, enhancing onboard computing and processing. The demand of independent spacecraft arises considering mission scenarios that includes proximity operations with small-bodies, which features such as shape and mass distribution are quite irregular, as for the asteroids. These irregularities are often completely unknown and remain so until the spacecraft approaches this kind of bodies. This time also corresponds with the time when the knowledge on these characteristics is needed the most. Thus, this uncertain environment has a heavy impact on the mission design, which must deal with these uncertainties. Obtaining an autonomous optical navigation system requires sophisticated analysis, in order to ensure the feasibility of the operations.

This paper aims to define and to portrait the autonomous optical navigation of AIM by employing an Unscented Kalman Filter for the proximity operations with the asteroid. The validation and implementation are conducted with the Guidance Navigation and Control tool developed by Grupo Mecanica del Vuelo (GMV) in Madrid. The tests aim to optimize the navigation filter, starting from feeding it with computed measurements up to Hardware in the Loop, consisting in the Qualification Model of the spacecraft's optical camera.