SPACE EXPLORATION SYMPOSIUM (A3)
Small Bodies Missions and Technologies (4)

Author: Ms. Noela Despre
Astrium Satellites, France, noela.despre@airbus.com

Mr. Marc Chapuy
Astrium Satellites, France, marc.chapuy@airbus.com
Mr. Gregory Jonniaux
Astrium Satellites, France, gregory.jonniaux@airbus.com
Dr. Keyvan Kanani
Astrium Satellites, France, keyvan.kanani@airbus.com
Mr. Erwan Kervendal
Astrium Satellites, France, erwan.kervendal@airbus.com

ASTEROID 3D RECONSTRUCTION FOR THE NEOSHIELD STUDY

Abstract

For more than a decade, the possibility of an asteroid impact on Earth has been identified as a potential hazard, and observation campaigns aiming at detecting potentially threatening Near Earth Objects (NEO) have been undertaken. In this context, the next step is to prepare mission able to divert the NEO from its trajectory: a reconnaissance Orbiter, followed by a Kinetic Impactor. This is one of the end goals of the NEOShield project, initiated this year by a large consortium of science laboratories and industrial partners and funded by the European Union (FP7 project). In the team, Astrium France is in charge of designing the GNC of the Kinetic Impactor concept, and provides the image processing algorithms for the Orbiter proximity operations.

Past and current missions to asteroids (Rosetta, Dawn, Hayabusa...) have demonstrated the wide variety of shapes and characteristics of NEO. For NEOShield, Astrium proposes to reconstruct the NEO shape using the on-board camera images. The purpose of this reconstruction is twofold: first, characterization of the asteroid is necessary to determine the best impact strategy (velocity, impact area); secondly, the 3D model of the object is of prime interest for the absolute navigation techniques used on-board the Orbiter.

There are two main classes of 3D reconstruction methods with passive sensors: stereo and shape from shading. The two classes have usually been considered separately, although it has long been recognised that they have mutual advantages: stereo is powerful when object surfaces have sufficient texture or intensity variations but performs poorly for homogeneous surface regions or under illumination changes. Shape from shading on the contrary is well adapted to the latter case, although requiring assumptions on surface material, which are at least approximately verified for asteroids. In this paper, we present an approach combining stereo and shading methods, and taking benefit of multi-view monocular imaging of asteroids. This approach is based on mesh evolution: starting from an initial 3D shape, this surface (mesh) evolves via a gradient descent procedure, taking into account criteria from both methods.

After an introduction to the mission context, the main principles of this method are presented. A previous study has contributed to assess the sensitivity of the algorithms to environmental and measurement conditions. The NEOShield study takes these results one step further, taking into account realistic interactions with the GNC subsystem, and in particular the Navigation, and the constraints of an actual NEO mission.