The High-fidelity Asteroid Deflection Evaluation Software (HADES): Assessing the Impact of Environmental and System Uncertainties on Autonomous Proximity Operations

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Keywords: GNC, Inertial Hovering, Body Fixed Hovering, Irregular Objects, Uncertainties

The environment near asteroids, comets and small moons is highly complex because of the general lack of target body's precise data, where simplifications regarding the shape and the composition of the small bodies can drive to a completely incorrect picture of the dynamics of its surroundings. This deeply affects the space missions design, because the performance of the whole GNC system can be strongly affected by the a-priori knowledge of the operative environment, both in terms of sensors/actuators assembly and due to the simplifications implemented for the on-board computers. To tackle this problem the current paper is then dedicated to analyse the effects of the modelling assumptions on the control and navigation of an autonomous spacecraft in the close proximity of irregular minor celestial objects.

The proposed analysis will be performed by means of the High-fidelity Asteroid Deflection Evaluation Software (HADES), which deals with the high-fidelity modelling of spacecraft operations at irregular shape asteroids. The software can handle any operational orbit, with particular care paid to inertial and body fixed hovering. Different control techniques based on both continuous and discrete methods have been considered and implemented. The spacecraft orbit determination is performed through a performance model or by on-board measurements, a navigation camera and a LIDAR, which are processed by an Unscented H-infinity Filter (UHF).

Several cases applied to the proximity operations around the asteroid Didymos and the Comet 67P-CG will be analysed and discussed in the paper. This paper will show that estimation performance strongly depends on available characterisation of operating environment which, as a consequence, can lead to quite diverse results in the control budget. For instance, Figure 1 shows how the estimate for the position can differ depending on the assumption used to model the real world and the navigation system. The spacecraft hovers at 5 km from the asteroid Didymos in an inertial configuration. The effect on the control budget is in the range of 1% different depending on the assumption as shown in Table 1.

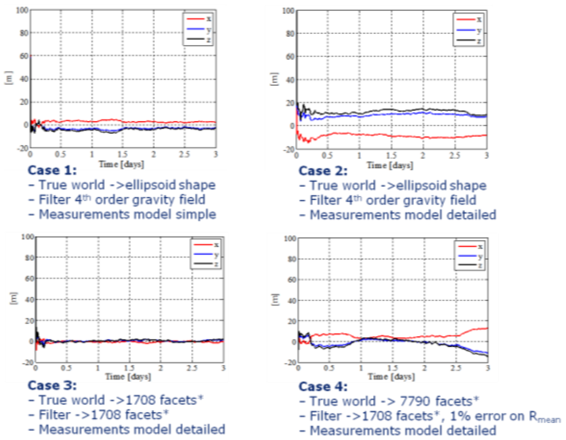

Figure 1. Position estimation trend using different modelling assumptions.

Table 1. Control budget for 3 days. In Case 1 the shape of the asteroid is an ellipsoid and the LIDAR is taken as a linear distance from the spacecraft and the identified centre of brightness of the asteroid (CoB). Case 2-4 sees the image as a product of the actual shape of the asteroid and the LIDAR is taken from a footprint around CoB.

	Δv [cm/s]
Case 1	9.18
Case 2	9.14
Case 3	9.25
Case 4	9.18

References

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