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MODEL ESTIMATION USING HOVERING SATELLITES ABOUT ASTEROIDS

Abstract

In this thriving era for small body exploration, several tools and techniques have been explored for flying spacecraft in strongly perturbed environments such as in the vicinity of asteroids and comets. One of the most interesting approaches is hovering above points of interest in either the body-fixed (BCF) or the body-centered inertial (BCI) frames. Either way, hovering above the surface of a small body would allow for the collection of high resolution measurements that could shed some light on the formation and evolution of our Solar System.

Unfortunately, hovering above small bodies requires frequent control actuations that might prevent standard filtering techniques from extracting all of the scientific information out of the measurements. In many cases, standard filters may even diverge from the true solution and fail to correctly estimate the state vector parameters. However, Lubey and Scheeres (Paper AAC, 2014, Paper AAS-15-251, 2015) have recently developed a new estimation algorithm that applies functional optimization to include estimates of the control policies required to evolve between states at consecutive measurement epochs. By analyzing the control policies estimated by the so-called Optimal Control Based Estimator (OCBE), it is possible to account for unknown and mismodelled dynamics without needing to reinitialize the filter after each control maneuver. Accordingly, the OCBE manages to keep track of previously acquired information, meaning that accurate estimates of physical quantities of interest, e.g., asteroid gravity spherical harmonics coefficients, can theoretically be achieved.

In the proposed paper, the OCBE will be applied for the first time to a scenario where a cubesat is hovering 100-meters above the surface of asteroid 25143 Itokawa. The altitude of the spacecraft is maintained with a dead-band controller based on the work of Broschart and Scheeres (JGCD 30(2), 2007) that allows the vehicle to naturally explore different regions around the central body. Furthermore, range and optical measurements of the small satellite are taken from a mothercraft hovering in the BCI frame at 10 km from the surface of the asteroid. Simulation results show that the OCBE manages to detect and reconstruct all the maneuvers occurring within the observation window while producing accurate estimates of both the state of the cubesat and the gravity field of the asteroid.