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EFFICIENT MODELLING OF SMALL BODIES GRAVITATIONAL POTENTIAL FOR AUTONOMOUS APPROACH

Abstract

One of the main challenges of proximity operations about asteroids is their small and non-uniform gravitational attraction. Knowledge of relative distance and velocity, from optical navigation and LIDAR measurements, has been proven sufficient to control the last leg of landing and touch-and-go trajectories. However, a spacecraft in orbit about an asteroid needs also a model of the gravitational potential in order to achieve autonomous guidance and control. Given the limited computational resources available, the on-board gravity model has to be governed by a small number of parameters and the calculation of the effect of each of its elements has to be straightforward. Reviewing the main characteristics of the dynamical environment about asteroids, we show how the approximate model is not required to be globally accurate but rather to represent well those features that can be exploited for control purposes. In particular we are interested in modelling the position, the behaviour and the energy level of the equilibrium points, generated by the balance of the gravitational and centrifugal forces, close to asteroids in uniform rotation. We present guidance laws that take advantage of natural dynamics, and of the properties of the equilibrium points, for achieving station keeping while eliminating the risk of an unwanted impact with the small body. During the initial phases of each asteroid mission, a fairly accurate shape model is created and good estimates of the total mass of the body and its rotation rate are also available. In this paper we also discuss how to derive, from these high accuracy data, a simple three point mass model of the asteroid to be used in combination with the devised control strategy.