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# ENERGY-BASED AUTONOMOUS CONTROL LAWS FOR BODY-FIXED HOVERING AND ORBITAL MAINTENANCE IN PROXIMITY OF UNIFORMLY ROTATING ASTEROIDS

**Abstract**

Maintaining spacecraft in proximity of asteroids and comets requires extensive orbit determination campaigns and relies on a concept of operations with the ground in the loop. Apart from some autonomy planned for the very last legs of landing and touch-and-go trajectories, nowadays all the orbital manoeuvres have to be carefully planned in advance thanks to a model of the gravitational potential that becomes more and more detailed along the mission but whose knowledge remains on the ground. Recent developments in on-board navigation pave the way for autonomous proximity operations. Thanks to navigation packages like the OBIRON (On-board Image Registration and Optical Navigation) by JPL and the DSAC (Deep Space Atomic Clock) by NASA, future spacecraft will have, directly on-board, the knowledge of their relative position and velocity with respect to the small body. Simple gravity models are then required in order to be easily stored and handled on board. In this work we use a class of models whose creation ensures that they represent well some characteristics of the dynamical environment around the asteroid. In particular we chose to fit the positions and Jacobi energies of the equilibrium points generated by the balance of gravity and centrifugal acceleration in the body fixed frame. In this way these models give also a good estimate of the condition of stability against impact for orbital trajectories. In this paper we present autonomous guidance laws for achieving body fixed hovering and orbit maintenance in proximity of the asteroid while ensuring that no impact will occur with the body. We control separately in the directions parallel and normal to the instantaneous velocity. The parallel component is used to achieve the target energy level thanks to a Lyapunov controller. The normal component is used to direct the motion towards the target position (or direction) and to compensate the deviations caused by the components of gravitational, centrifugal and Coriolis forces which are normal to the velocity. Assuming relative navigation data as an input and considering the associated uncertainties of the autonomous navigation systems previously mentioned, we discuss the performance of the proposed control laws in various scenarios.