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Small Bodies Missions and Technologies (Part 2) (4B)

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OPTIMIZATION OF HOPPING TRAJECTORIES FOR ASTEROIDS SURFACE EXPLORATION

Abstract

In recent years, there has been a renewed interest in exploring small bodies, such as asteroids and comets, because they can reveal important information about planetary formation and evolution and the origin of life and water on the Earth. Therefore, it is extremely important to design accurate space missions to analyse and characterise asteroids surfaces and eventually bring samples back to the Earth. When dealing with small bodies, such as asteroids, new concepts of spacecraft have been developed so that to explore the surface by exploiting the so-called hopping trajectories. Hopping trajectories exploit the low gravity of asteroids to make the spacecraft jump from one location to the other, which means that it is possible to visit multiple regions of the asteroid without consuming much propellant. In this paper, different optimizations of hopping trajectories are analysed considering the bouncing 6DOF dynamics of the spacecraft and the morphology of the asteroids surface. As for the optimization, the metaheuristic PSO is exploited. In particular, the proposed approach considers different initial conditions in terms of position and velocity that can allow to achieve the objective of the optimization. Constraints can also be added as additional penalty terms in the cost function of PSO, which can allow, for example, to avoid those trajectories escaping from the gravitational field of the asteroid or having dangerous impacts with the surfaces. For what concerns the proposed contact model, the asteroid and the bouncing spacecraft are assumed to have polyhedron shapes. During the contact, elastic-damping force and frictional force, acting along the local normal and tangential direction, respectively, are considered. These forces depend on some parameters that are empirically chosen: K and , which are constants coefficients related to the bodies geometry and material; n, which is a parameter due to the non-linearity; static and dynamic friction coefficients. Preliminary results have been focused on the maximization of asteroid surface coverage and the exploration of a percentage of the asteroid surface with minimum time of flight. For the final work, hopping trajectories among binary asteroids system, such as the 1999 KW4 system, will also be presented. In particular, a strategy to maximise both the asteroids surface coverage with the same hopping trajectory will be considered by fixing the number of jumps related to each asteroid and adding one jump to connect the two bodies. In this case, an additional force will be added to allow for the connecting trajectory.