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BINARY ASTEROID LANDING TRAJECTORY DESIGN FROM A SELF-STABILIZED TERMINATOR ORBIT CONSIDERING PARAMETRIC UNCERTAINTIES.

Abstract

The Asteroid Impact and Deflection Assessment (AIDA) collaboration, consisting of NASA's DART mission and ESA's Hera mission, will test the capability of a kinetic impactor to deflect an asteroid. The specific target of these missions is the binary asteroid Didymos, where the DART spacecraft will impact the smaller secondary body called Dimorphos. The payload of Hera partly consists of two CubeSats which plan to orbit the system and land on the surface of the secondary. Due to the mass and power constraints of these CubeSats, a ballistic landing, i.e. without active control during decent, is desirable as it does not require a dedicated guidance, navigation, and control system. In this research, a method to design robust ballistic landing trajectories is introduced and applied to the case of Didymos. Specifically, the landing trajectory considered starts from a self-stabilized terminator orbit (SSTO) and lands on the secondary body Dimorphos. The SSTO is often used in minor body scenarios due to its stability against large radiation pressure forces. Due to the long descent time and highly non-linear environment, a minor body landing trajectory can be highly sensitive to uncertainties in the deployment state and environment parameters. Thus, when designing these trajectories it is important to take into account the effect of uncertainties. This is done using the Generalised Intrusive Polynomial Algebra (GIPA) technique, which is able to propagate the uncertainties along the trajectory using a polynomial approximation. Starting from a range of allowable landing conditions (i.e. latitude, longitude, and impact direction) and uncertainties in the non-spherical gravitational fields of the two bodies, a set of trajectories is propagated backwards using GIPA until it intersect with the SSTO. A bisection algorithm is then used to repeat this procedure and find the minimal impact velocity for the complete set of trajectories. Furthermore, using Hermite polynomials, an approximation of the distribution of deployment location, speeds, and directions from the SSTO to initiate the landing trajectory is made. The calculation of the distributions allows for a connection between the landing and dynamical uncertainties and the constraints on the deployment maneuver. The method developed in this work allows for the design of ballistic trajectories under uncertainties, and increases the safety and feasibility of these types of missions.