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Author: Mrs. Amirah Algethami
University of Glasgow, United Kingdom

Prof. Colin R. McInnes
University of Glasgow, United Kingdom
Dr. Matteo Ceriotti
University of Glasgow, United Kingdom

GUIDING ASTEROIDS TO FORM AN ARTIFICIAL BOUND BINARY PAIR USING CONTINUOUS CONTROL ACCELERATION

Abstract

Asteroids are being considered for future scientific missions and for creating resources. For example, asteroids that could be injected into periodic orbits around the collinear Lagrange points of the Sun-Earth or Earth-Moon systems have been identified and transfer orbits examined. This paper investigates the ability to control one of two asteroids with a constant low-thrust acceleration to capture the asteroids in a bound pair within their zero-velocity curve. An analytical method is introduced to determine the constant control acceleration as a function of the transverse position between the two asteroids, moving on neighbouring circular orbits. This is achieved by ensuring that the Jacobi constant of the asteroid pair linearly increases until a critical value is reached required for capture. The constant control acceleration is then added to Hill's equations, then tested over a grid of initial conditions representing a uniform drift of one asteroid relative to the other. The control acceleration is then switched off when the approaching asteroid trajectory crosses the radial axis directed away from the Earth and is between the two collinear Lagrange equilibrium points. By integrating the augmented equations of motion and monitoring the Jacobi constant, it was established that the resulting trajectory can be controlled. Successful initial conditions for capture trajectories were found when the Jacobi constant of the asteroids reaches a critical value, with the arrival of the asteroids in a closed zero velocity curve to create a bound pair. Operationally, two spherical asteroids of the same size in a circular orbit are assumed to encounter each other in the Earth-Moon system. The results of numerical simulations show the ability to produce a bound pair of asteroids within the zero-velocity curve. Again, this is achieved by applying a constant transverse acceleration for a chosen period of time prior to the relative transverse position of the asteroids vanishing. The performance of case studies is also considered to select only initial conditions for non-colliding trajectories in the two stages; specifically the initial relative drift motion and the accelerated motion. The behaviour of capture trajectories after switching off the control acceleration demonstrates numerically that they are bound within the zero-velocity curve for a period of time until the asteroids contact. The total force applied for the proposed continuous acceleration control design in the near-Earth scenario is evaluated for typically small near-Earth asteroids.