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Author: Ms. Dayung Koh
University of Southern California, United States, dayungko@usc.edu

Dr. Rodney Anderson
Caltech/JPL, United States, Rodney.L.Anderson@jpl.nasa.gov

COMPUTATION OF PERIODIC ORBITS IN MULTI-BODY MODELS USING CELL MAPPING

Abstract

In this study, a new computational approach for understanding the global behavior of multibody models in astrodynamics is introduced. A typical approach to search for a periodic solution is to parametrically continue a known solution using a continuation method in combination with differential correctors. In contrast to the existing method, the proposed method does not require a guess for the initial conditions that are close to the actual solution. Moreover, no symmetric constraints are imposed in the approach. Thus, the method is applicable to a broad search in a great variety of models which include the circular restricted three-body problem (CRTBP), the bicircular problem (BCP), and the elliptic restricted three-body problem (ERTBP).

For this study, an approach combining analytical and numerical methods, or cell mapping and point mapping methods, is used. In the cell mapping approach, the state variables are thought of as a collection of intervals. The cell state space S we are interested in is constructed by dividing each state variable component into uniformly sized cells. In the cell state space S, a cell-to-cell mapping C is created. Then, an unraveling algorithm is used to find the periodic solutions and regions of attraction. When a cell repeats after applying the map K-times, multiple-period periodic solutions are determined. A point mapping method is used for analyzing the stability of periodic solutions and bifurcation conditions.

The initial orbit search was applied to computing periodic orbits around L2 and L4 in the CRTBP to understand the computational issues associated with this type of problem and to aid in selecting an appropriate mesh for the algorithm in both stable and unstable regions at different libration points. Beyond the well known solutions such as Halo orbits, Lyapunov orbits, and figure eight solutions, families of asymmetric three-dimensional solutions and some bifurcations are discovered. Moreover, multiple-period periodic solutions and the bifurcation conditions as a function of the Sun's perturbation for planar cases are verified for the BCP.