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INVARIANT MANIFOLD DYNAMICS VIA POLYHEDRAL REPRESENTATION

Abstract

In the last decades invariant manifold dynamics has assumed an increasing relevance for analysis and design of low-energy missions, both in the Earth-Moon system and in alternative multibody environments. This is testified also by a number of low-energy missions that employ invariant manifold dynamics, thus demonstrating its doubtless utility. Recent efforts have been devoted to developing a suitable representation for the manifolds, which are composed of the trajectories asymptotically emanating from or converging into unstable periodic orbits. This work illustrates and describes an original, intuitive polyhedral interpolative approach for each state component associated with manifold trajectories, both in two and in three dimensions. A suitable grid of data, coming from the numerical propagation of a finite number of manifold trajectories, is employed. Invariant manifolds are topologically two-dimensional, because each state (identified by position and velocity) belonging to the manifold depends on two parameters, related to the departing (or arriving) point along the periodic orbit and to the time of flight on the manifold. Polyhedral interpolation allows expressing each state component as a linear function of these two parameters. With regard to the planar manifold associated with the Lyapunov orbit at the interior collinear libration point L1, accuracy of this representation is evaluated, and is proven to be satisfactory, with the exclusion of limited regions of the manifold. The polyhedral interpolation technique has several applications, and some of them are illustrated in this paper. First, orbits transiting from the Earth to the Moon are identified in the phase space, at different locations in the synodic reference system. Second, for a specified propagation time, the set of homoclinic trajectories connected with the Lyapunov orbits at the collinear libration points are detected. Third, the set of heteroclinic connections is determined between the same terminal periodic orbits. In general, homoclinic connections for the manifolds emanating from a Halo orbit exist only at certain energy values. In this context, the polyhedral representation can be profitably employed for the purpose of finding near-homoclinic trajectories emanating from a Halo orbit and associated with modest propellant consumption. In the end, the polyhedral representation has the desirable features of simplicity, reliability, as well as numerical accuracy, as confirmed through numerical refinement for all of the cases described in this work.