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HOMOCLINIC/HETEROCLINIC ORBITS IN FOMATION CONTROLLED BY ARTIFICIAL POTENTIAL FUNCTION

Abstract

Multi spacecraft in proximity controlled by artificial potential fields (APF) present high flexibility, reliability and precision compared to traditional monolithic spacecraft. A typical application of such formation is the distributed antenna arrays, which can produce complex patters and group plenty of antenna elements into a cooperative structure. This paper discusses the nonlinear dynamics of the formation in the control of the APF, and investigates how the APF mediates interactions between spacecraft. We consider a formation that consists of 5 identical particles for example. The spacecraft are controlled through APFs operating on a pairwise basis; that is, attraction among the particles in the formation is achieved through a weak long-range attractive potential which is parameterized by Ca and la, while collisions between neighboring particles are prevented through a strong short-range repulsive potential parameterized by Cr and lr. The total effective energy of the formation is defined through a summation to evaluate each pairwise potential interaction and a summation of each kinetic energy. Then the nonlinear dynamical behavior of a 5-agent formation system is investigated with the assist of nonlinear theory in astrodynamics. The influence of the four coefficients of APF on the geometry and topology is discussed. There exist three types of equilibria for the system yielded by APF, including the center, saddle and unstable focus. For some hyperbolic equilibria, an iterative procedure is employed to correct periodic orbits numerically, i.e., the so-called Lyapunov orbits. The invariant manifolds originating from Lyapunov orbits are plotted and selected by Poincaré mapping to create the heteroclinic or homoclinic trajectories. Similarly, the heteroclinic or homoclinic connections of the unstable focus can be illustrated. As for the heteroclinic connections between equilibrium points of different types, the coefficients of APF can be used as the control factors to keep the energy of different equilibria the same, and then to find intersections of different curves. These transfer orbits between different equilibria are significant in enlarging the observed area for more high-resolution measurements.