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CONFINEMENT OF SPACECRAFT SWARMS IN J2-PERTURBED ORBITS ABOUT THE EARTH

Abstract

Within the spacecraft swarm concept one considers a large number of small spacecraft confined in a region but without strict requirements in terms of distances and geometry between the agents. The main applications of this concept aims to interferometry and communications.

As opposite to formation flight, the dynamics of spacecraft swarms allow for more freedom and less requirements on constraints leading to a lower cost associated for maneuvering. However this cost is not neglegible: without maneuvers, the natural motion of the satellites tend to diverge their orbits, the desired swarm configuration degradates and it will be finally lost. In addition, keeping a large number of spacecraft in close orbits (the swarms are thought to have hundreds, or even thousands, of satellites) can lead to collisions hazards that must be attended.

This work focuses on the strategies and costs for maintainig a swarm of a large number of spacecraft in a close neighborhood (in our case represented by an sphere but any other confining geometry could be considerd) for long periods of time.

One of the main issues that one encounters when optimizing the sequence of control maneuvers for a large group of spacecraft is the huge number of variables and constraints. Our methodology considers a hierarchical structure that accounts both for collision avoidance and degradation of the confinement region of the spacecraft swarm. In an strobe way, usually counted in one or few orbital periods, a few spacecraft of the set are selected and a suitable and efficient control procedure is applied to them, assuring this way comptutational efficiency.

A main objective of the paper is also to give a broad information for this class of problems in terms of the parameters that define it, like: number of spacecraft in the swarm, size of the confinement region, security distance between agents..., and also attending to the selected orbit (semi-major axis, eccentricy, inclination).