Paper ID: 84710
oral

IAF SPACE SYSTEMS SYMPOSIUM (D1)
Cooperative Systems (4)

Author: Dr. Marco Sabatini
Sapienza University of Rome, Italy

SATELLITE SWARM MAINTENANCE VIA BEHAVIORAL CONTROL BASED ON SIMPLE VISUAL INFORMATION

Abstract

In recent years, there has been a significant push towards miniaturizing spacecraft, with micro and nano-satellites gaining popularity due to their cost-effectiveness and ease of launch. The deployment of fleets, or "swarms," of nanosatellites is a possible solution to mitigate individual limitations by distributing the payload among multiple satellites. For such a kind of large systems, an interesting guidance and control architecture solution are the so-called "behavioral" strategies. They are inspired by the behavioral of natural swarms, which reach a high level of global survivability with individual simple actions based on very limited information and no centralized control. The present paper specifically investigates the feasibility of a swarm keeping in the framework of the limited sensor and computation capabilities of the nanosatellites. It is supposed that each satellite is equipped with a camera pointing in the along-track direction. With respect to one observer agent, the other agents are in one of these conditions: (a) not visible (too far); (b) visible; (c) not visible (out of the field of view). Even the small number of visible satellites are not fully characterized: even though an angles-only navigation could be implemented, the goal is to relieve the on-board computer from an advanced object detection and tracking. A proper relative navigation task is in some sense skipped, and the control action of each agent is based on simple visual information: number and dimension of "blobs" (after image processing the nanosatellite are transformed in white areas, or blobs) and their path between two successive frames, without a satellite-to-blob deterministic assignment. This simple measurements are sufficient to perform the main behavioral control laws: collision avoidance (from the blobs position and direction it is possible to retrieve the information to parallelize the differential eccentricity and inclination vectors, necessary condition for collision free trajectories), alignment and attraction (from the blob dimensions it is possible to cancel the differential semimajor axis and keep the differential mean anomaly bounded); the effective control of the single agent is determined by the sum of the basic control actions with respect to all visible satellites. The results suggest that, with very simple control logic, the integrity of a swarm composed by a very large number of agents can be globally preserved without the use of an impractical human intervention from ground. This qualitative study paves the way to future investigations including the technical challenges relevant to the use of vision sensors.