IAF ASTRODYNAMICS SYMPOSIUM (C1)
Attitude Dynamics (2) (6)

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COORDINATED ATTITUDE DETERMINATION AND CONTROL IN A SWARM OF CUBESATS

Abstract

This work delineates the ADCS design for a technology demonstration mission involving a swarm of Cubesats. Each of the Cubesats is equipped with several gamma-ray detectors to register gamma-ray bursts (GRB) accompanying such events as mergers of neutron stars. The swarm comprising four spacecraft simultaneously observing the sky from different positions should allow precise determination of the detected GRB direction. The CubeSats have identical ADCS which are to make use of the neighbors' sensor information obtained via inter-satellite link.

The swarm is to be deployed from the ISS, which defines the orbit and the environmental conditions used in the simulations. The mission requirements drive the choice of sensors (gyroscope, sun sensors, magnetometers) and actuators (magnetorquers).

After the swarm deployment, the Bdot algorithm is employed for each individual satellite to perform detumbling and slow down the rotation of the spacecraft to angular velocities comparable to the mean motion. The three-axis magnetic attitude control algorithm is then applied to achieve and maintain the attitude of each spacecraft defined by the scientific objectives. Apart from operating in these two modes, the ADCS has the capability to perform a special 'thermal' maneuver (controlled slow rotation about the local vertical) whose main goal is to balance the thermal loads on the spacecraft exposed to the Sun. Thus, a complete set of solely magnetic attitude control algorithms is developed, implemented and tested by numerical experiments.

The principal goal of our work is the study of the attitude determination algorithms using the sensor data exchange between the swarm neighbors. This distributed attitude determination estimator is integrated into the ADCS, which is to implement all the control algorithms specified earlier. The approach appears to enhance the overall performance of each individual ADCS. We show that with the proper tuning of the Kalman filter employed to fuse all the measurements data, the determination accuracy of one degree and the pointing accuracy of ten degrees can be achieved. In certain LEO orbits such performance can be maintained even in the case of a fully magnetic ADCS that relies only on magnetometers data for attitude determination. We also analyze possible optimization of the communication topology between satellites in larger swarms that use a modification of the distributed attitude determination estimator.