IAF ASTRODYNAMICS SYMPOSIUM (C1)
Attitude Dynamics (2) (4)

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SYNERGETIC APPROACH IN ATTITUDE CONTROL OF VERY FLEXIBLE SATELLITES BY MEANS OF THRUSTERS AND PZT DEVICES

Abstract

The limited volume available even in the largest launchers usually calls for a folded design of structures like antennas, solar wings or payloads, which once in orbit are deployed up to very large dimensions. As the performance requirements of these systems become more and more demanding, their elastic dynamics starts to be a serious concern, in particular for satellites in which attitude maneuvers are required. The interaction between angular motion and flexible vibrations can heavily disturb the stability of the system. Many control strategies have been developed for solving this issue. Some of them are focused on the attitude dynamics, building on robust controllers that consider flexibility as a disturbance, as well as on model-based controllers in which an effort is done to include a dynamic model both for the rigid and the elastic dynamics. A different approach is also frequently studied, consisting in facing the problem from the structural point of view, trying to actively damp the vibrations induced by the attitude control, using smart material (like PZT) devices. In this research, an approach unifying the two aspects is proposed. The satellite is modeled as a flexible multibody system, in which the two sets of actuators (attitude and structural devices) are commanded by means of a single model-based control law. In such a way, the two systems are not considered as competitors (trying each one to cancel the disturbing effects caused by the other one), but they are cooperating for the common goal of acquiring a desired attitude in a given time without residual oscillations. This synergetic approach is first developed in a high fidelity numerical environment, then it is tested by means of a free floating platform (with eight on-off thrusters for attitude control) equipped with flexible appendages, designed and built as a multilayer composite material with a net of embedded PZT patches. These PZT patches work both as sensors and as actuators. The overall navigation and control loop is based on the information coming from the Inertial Measurement Unit and from the PZT sensors, which are filtered and sent to the synergetic controller; this one outputs both the thrusters firing sequence and the PZT actuators voltage difference required to reach the goal. The experimental results are compared with the ones obtained by more classic approaches (separate attitude and structural control), commenting both advantages and drawbacks of the different approaches.