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ATTITUDE STABILIZATION OF A FLEXIBLE SPACECRAFT USING COMBINED PZT/OPTICAL SENSORS

Abstract

Space structures are generally characterized by the presence of large and light bodies e.g. solar arrays or antennas. Of course the dynamics of the appendages interacts with the attitude dynamics of the system and vice versa, hence the control of large space structures can be seriously affected in terms of accuracy or even of stability, because of the high flexibility and the very low natural frequencies of the involved structures.

The aim of the work is the design and experimentally test a stable satellite control for a fast maneuver in presence of large flexible appendages. The experimental test bed consists on free floating platform, equipped with very flexible appendages able to perform assigned translational and rotational maneuvers. In addition to inertial measurement sensors, piezo-electric (PZT) devices, embedded in the fiberglass composite plates, are used for measuring elastic oscillations. The PZT cannot however be considered as a standalone sensor for measuring the elastic deformation of the plate, since the cure of the PZT inside the autoclave modifies their electro-mechanical properties. A new approach, based on the combined use of optical sensors and PZT will be employed for the estimation of the properties of the PZT sensors, in particular the modified electro-mechanical coupling factor.

The PZT parameters estimated in such a way allows for the direct measurement of the elastic displacement and relevant modal amplitude, a key quantity that definitely enriches the multibody mathematical model that is used to develop the control strategies.

In the present work two different strategies have been implemented in order to prevent an unstable behavior during the maneuver, without decreasing the control gains or slowing down the maneuver. The first strategy is based on the compensation of the delay of the system through the prediction of the state; the second is able to suppress the attitude control actions whenever their application on the amplifies the modal amplitude. The two control strategies are studied numerically and then tested experimentally in order to very their robustness; the experimental and the numerical results will be compared and final conclusions will be reported on the limits and advantages of the proposed approaches.