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CONTROL-ORIENTED MODELLING OF AN ACTIVE SUPPRESSION SYSTEM FOR LARGE SPACE SMART STRUCTURES

Abstract

The standard approach of controlling in-orbit large flexible structures only by adopting actuators and sensors located at platform level is currently being challenged by new missions' stringent requirements in terms of demanding guidance profiles and instrument performance. Most of modern Earth Observation (EO) missions, as BIOMASS, SMAP or OSCM, are required to host large antenna payloads, thus leading to issues related to high flexibility and low damping. At the same time, such satellites call for the capacity of performing high resolution geospatial services without incurring in geometric distortions or communication issues related to undesired elastic vibrations. Nowadays, the standard control strategies consist in tuning a platform PID controller, enlarged with higher order filters allowing the avoidance of the first flexible modes, and in passively rigidizing the structure, thus involving more mass at design level. In this perspective, smart materials offer a different solution to improve the performance of space systems by controlling the vibrations of such lightweight structures. In this paper, the problem of designing an end-to-end architecture for active control of large in-orbit structures is addressed. First, a FE model of a large space antenna is derived by using commercial software. The instrument is designed to be supported by an active deployable frame hosting an optimal minimum set of collocated smart actuators and sensors. To this purpose, a comparison among different placement techniques, as Gramian and Modal Strain Energy (MSE) based methods, is proposed to find the final configuration for both actuators and sensors. A trade-off among different types of smart devices is carried out to find the best solution in terms of actuating/sensing capabilities. The impact of their mechanical and inertial properties on the dynamic behaviour of the system is investigated as well. The model is then reduced to obtain a system to be easily handled by control systems algorithms. Attention is paid to create a GNC strategy combining collocated control on flexible appendages with platform control, while minimizing the relative displacements among the most critical points of the antenna. To achieve high performance, Linear Fractional Transformation (LFT) modelling and advanced multivariable techniques are implemented. Furthermore, as the properties of smart devices may be affected by slight changes due to launch loads or orbit aging, robustness to uncertainties of both passive structure and actuators is also analysed. Finally, to validate the proposed controller, the control system is tested by simulating typical spacecraft manoeuvre profiles.