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SOLARELASTIC STABILITY MODELING AND STRUCTURAL CONTROL OF A HELIOGYRO SOLAR SAIL

Abstract

Recent advances in NASA-sponsored research have produced several methods to characterize the fully-coupled nonlinear structural and attitude dynamics of heliogyro solar sails, including finite-element techniques, discrete-mass approaches, and analytical models based on continuous beam mode shapes. A unifying aim of these methods is the modeling of the flutter phenomenon in the sail blades, which is a major feature in identifying the stability boundaries of the heliogyro system under varying orbital conditions. This paper reports the methods and results of current efforts to find consistency among the modeling approaches with respect to sail blade stability as a function of solar radiation pressure. In particular, the study demonstrates a convergent solution for instances of divergence instability, as well as the model size-dependance in the search for a solution for the flutter condition. The results from the analytical model are compared to similar investigations using an equivalent discrete-mass approach. As a complement to these developments on the structural and attitude dynamics of the heliogyro, this paper presents the formulation of model-based control design in order to impose uniformity on the sail blades, and therefore enable attitude-changing maneuvers. Specifically, generalized predictive control is investigated as an adaptive method to provide identified linear models for controller design on specific time-intervals, which can then be applied onto the full nonlinear system. Additionally, the paper discusses the issue of adding robustness to the control scheme by way of achieving asymptotic stability in the controller and closed-loop system.