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Author: Mr. Qing Li
China, qing-li05@mails.tsinghua.edu.cn

Prof. Tianshu Wang
China, tswang@tsinghua.edu.cn
Prof. Xingrui Ma
China Aerospace Science and Technology Corporation (CASC), China, maxr@spcechian.com

REDUCED MODEL OF FLEXIBLE SAIL-BOOM INTERACTION FOR SOLAR SAIL DYNAMICS

Abstract

As potential propulsion for further space exploration, solar sail spacecraft is powered by the pressure of sunlight which is sustainable other than fuels. However, to obtain enough acceleration, a solar sail must be large scale but light weight. Consequently, flexibilities of the sail and the boom as well as their interaction must be considered properly during dynamics and control design. Though finite element (FE) model is high-fidelity, it is quite time-intensive for the design process. A reduced model with satisfactory accuracy and efficiency is actually required. In this paper, a reduced model of flexible sail-boom interaction is proposed in the floating frame of reference. Geometric nonlinear effects of the sail and the boom are formulated according to foreshortening deformation. For instance, a five-point connected square solar sail is simulated using this reduced model. Dynamic responses of the solar sail during translational and rotational maneuver are investigated, respectively. The high efficiency of the methodology is obtained by using a modal reduction technique. The accuracy of simulation is verified with a high-fidelity ABAQUS FE model. It is illustrated that the reduced model can be both efficient and accurate for engineering applications. Improvement of the proposed model and its application prospects on the dynamics and control design for solar sail spacecrafts are to be discussed. It is declared that, this material is new and original, which has neither been presented at a previous meeting nor been appeared in previous literature.