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ADAPTIVE PRESCRIBED PERFORMANCE ATTITUDE CONTROL FOR FLEXIBLE SPACECRAFT USING OBSERVER

Abstract

Recently, modern spacecraft has encountered increasingly strict mission requirements, particularly in terms of the precise pointing accuracy and agile maneuverability needed for communication and observation purposes. However, achieving such precision is challenging due to disturbances from various sources experienced by spacecraft in orbit. These challenges lead to performance degradation and a diminished accuracy of the Attitude Control System (ACS). Especially, the influence of perturbations from flexible structures, which not only contributes to performance degradation but also yields complexity in predicting system behavior. This complexity often necessitates conservative controller design and requires engineers to repeatedly tune controller parameters to meet requirements under harsh conditions. To effectively address these challenges, a novel approach known as the Prescribed Performance Control (PPC) scheme has been proposed. This scheme aims to enforce attitude errors smaller than user-defined performance functions, ensuring strict adherence to prescribed requirements even in the presence of disturbances. By tailoring performance functions to specific missions, both transient and steady-state responses can be constrained. Furthermore, the integration of disturbance observer and modal observer techniques enables the mitigation of external disturbances and flexible vibrations, thereby enhancing the overall stability and accuracy of the ACS. However, both the controller and observer may not play a role in the presence of model uncertainties. To deal with this problem, adaptive laws have been integrated into the control framework to estimate and compensate for model uncertainties such as the moment of inertia and modal participation factor in real-time, ensuring robust performance. In this paper, we present simulations conducted in a Finite Element Method (FEM) environment combined with the controller to showcase the effectiveness of the proposed methodology. Additionally, a comparative analysis with a PD controller will be conducted to highlight its superior performance in strictly meeting the requirements for modern spacecraft missions.