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OBSERVER-BASED ROBUST SLIDING MODE CONTROL FOR SPACECRAFT ATTITUDE MANEUVER SUBJECT TO REACTION WHEEL FRICTION

Abstract

Reaction wheels are commonly used actuators that store and exchange angular momentum to generate the torques necessary to control and stabilize the attitude of a spacecraft. Periodic disturbances and perturbations, may lead to speed reversals (zero crossings) which cause an abrupt increase in the error of the spacecraft attitude control system. Furthermore, the attitude dynamics of the spacecraft is coupled and highly nonlinear, and the model parameters of the spacecraft may not always be determined accurately. Additionally, if flexible spacecraft appendages, such as booms or solar arrays, are taken into account and the need for vibration suppression will arise. All of the above issues make it difficult to achieve ideal control performance for spacecraft attitude maneuvers.

To address this, we make use of friction compensation observer and sliding mode control techniques. The influence of wheel zero-crossing on attitude control system is firstly addressed, and the friction model is proposed. A novel friction observer is then developed to compensate the influence of wheel zero-crossing. The convergence of the observation errors is discussed by Lyapunov method. It should be noted that the friction characteristic parameters are unnecessary to design such an observer. A robust controller, based on the observer and sliding mode control approach, is therefore proposed to perform attitude maneuvers. Model uncertainties and disturbances are also addressed in the paper to evaluate the algorithm's robustness. To alleviate the chattering phenomenon, we introduce a function and develop a modified controller. Simulation results are finally provided to illustrate the performance of the proposed controller by comparing with a PID controller. The results will demonstrate that the proposed controller has a higher accuracy and better robustness. Using friction-observer-based sliding mode techniques for spacecraft attitude maneuver appears to provide a promising solution to overcome the inherent influence of reaction wheel friction, as well as tackle model uncertainties and disturbances.