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CONSTRAINED ATTITUDE CONTROL OF SPACECRAFT UNDER ANGULAR VELOCITY CONSTRAINTS AND INPUT SATURATION

Abstract

On-orbit spacecraft encounter different constraints when maneuvering, which can be broadly divided into attitude constraints and dynamic constraints. For the former, some sensitive instruments are vulnerable to the strong light, therefore attitude forbidden regions are set up to avoid direct exposure to bright celestial objects. Concerning the latter, it includes the angular velocity limitation owing to the gyro rate saturation and the actuator saturation due to physical limit. Motivated by the aforementioned observation, an attitude maneuver controller is proposed for spacecraft in the presence of attitude forbidden regions, angular velocity limits, actuator saturation, and disturbance torque. The spacecraft dynamics are directly developed on the 3-dimensional Special Orthogonal Group (SO(3)) to avoid singularity and ambiguity caused by other attitude parameters. Then, barrier Lyapunov functions (BLFs) based on SO(3) are introduced to ensure that the attitude constraints are obeyed when the values of BLFs are bounded. In addition, another BLFs are also designed to limit the magnitude of the angular velocity. Finally, input saturation is handled with a dead zone model. Combining these BLFs and sliding mode control technique, a dead zone-based attitude control law is obtained, and the stability of the closed-loop system is proved. Numerical simulation results indicate that using the proposed control method, the spacecraft converges to the desired attitude without entering the attitude forbidden region, and angular velocity limits and actuator saturation are satisfied.