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Attitude tracking with an adaptive sliding mode response to reaction wheel failure

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Abstract

This paper proposes an attitude tracking control for a rigid spacecraft that adapts to two types of faults that commonly occur in reaction wheels: a gain fault and a deviation fault. In its normal operating mode the tracking controller replicates that of a continuous quaternion feedback controller. When a fault occurs in the system the attitude of the spacecraft will deviate from the reference trajectory and will consequently trigger a sliding mode response of the control which introduces robustness. For the proposed control law, we construct a suitable Lyapunov function to prove the closed-loop system is asymptotically stable in the presence of such faults. However, the proposed control is not practically suitable over long periods as the gain on the sliding mode component will always increase unless the sliding surface is exactly zero (in practise this is never the case because of sensor noise). To address this problem a simple adaptive parameter is defined such that it converges to an appropriate upper-limit. Simulations of the attitude dynamics of a spacecraft are undertaken which compares the tracking performance in the presence of a fault with and without the adaptive sliding mode component.

Keywords: Unknown external disturbances, Actuator limited output torques, Actuator failures, Robust gain control, Sliding surface, Adaptive control

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