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FRACTIONAL-ORDER FAST FINITE-TIME SLIDING MODE ATTITUDE CONTROL OF A TRACKING SATELLITE

Abstract

Satellites are often used to track targets. Tracking a continuously moving target of interest requires track-to-track maneuver with great precision in many cases. The dynamics of a track-to-track maneuvering satellite is complex as compared to that of a rest-to-rest maneuvering one, and therefore requires robust controller to ensure precision tracking and acquisition of target within a short time. In the present work, the attitude control system of a rigid satellite is designed using a fractional-order fast finite-time sliding mode control for the track-to-track maneuver while avoiding kinematic singularity and the rotational unwinding. The main objective of the present work is to use the robustness property of the sliding mode controller and enhance its performance by incorporating fractional order integration and differentiation. In this paper, a single double-gimbal variable speed control moment gyro (DGVSCMG) is used as the onboard actuator. The Modified Rodrigues parameters (MRPs) are used for the attitude kinematics along with their counter shadow part and together they provide singularity free rotational description. The MRPs and shadow MRPs are together used for ensuring a unwinding free track to tack maneuver also. A sliding surface and control is designed for achieving the track-to-track maneuver. System stability is proved using Lyapunov stability theorem and it is shown that the proposed controller makes the system convergence not only in a fast finite time manner but also ensures global stability of the system due to unwinding free convergence during the sliding and reaching phases. It is proved that indeed the sling and reaching phases are unwinding free. The proposed fractional-order fast finite-time sliding mode controller has faster convergence and better robust performance than an integer-order fast finite-time sliding controller. The fractional-order derivative and integration add an extra degree of freedom to the sliding controller in comparison to the integer-order controller. The proposed fractional-order sliding mode controller outperforms the integer-order controller with less or the same control torque requirement for the track-to-track maneuver. A thorough assessment of the closed-loop system with different parameter values of the fractional-order controller is carried out. Simulation results for the track-to-track maneuver are presented to support the claims made.