# ABSTRACT

The onboard satellite attitude control system relies on attitude information for designing efficient control algorithms to guarantee precise control of maneuvers. The modified Rodriguez parameters (MRPs) are the preferred choice for attitude representation owing to their simple three-parameter representation with a maximum rotation range. However, redundancy in the attitude representation using the MRPs pair leads to the unwinding phenomenon. This dissertation introduces a novel approach to unwinding-free control in the framework of the body and the shadow MRPs pair, effectively mitigating the kinematic singularity faced in satellite attitude control problems. The effectiveness of the proposed unwinding-free controls is validated through simulation for rigid and flexible satellites. A double-gimbal variable-speed control moment gyro (DGVSCMG) is considered for attitude control of a rigid satellite. The DGVSCMG is susceptible to control singularity named gimbal-lock. To circumvent this, a nonlinear constrained optimization approach is proposed. The DGVSCMG, consisting of a flywheel and two gimbals, may face potential faults in its electrical and mechanical components making it dysfunctional. To address this problem, this work presents the first-ever detailed fault model of the DGVSCMG considering all possible faults. First, a novel unwinding-free non-singular fast finite-time sliding mode controller (SMC) is designed for attitude control of a rigid satellite equipped with a single DGVSCMG. Following that, an unwinding-free smart fault-tolerant non-singular fast fixed-time SMC is proposed and designed for attitude control of a rigid satellite with faulty DGVSCMG. The unwinding-free global stability of the DGVSCMG-satellite system is established using the hybrid control in the framework of the MRPs pair. The results show that the unwinding-free motion of a rigid satellite ensures energy-efficient fast convergence for rest-to-rest maneuvers and tracking maneuvers with small initial angular velocity. However, this may not lead to an optimal solution while doing tracking maneuvers in the presence of induced vibration due to onboard flexible appendages. Therefore, finally, a novel predefined-time hybrid SMC with conditional anti-unwinding is proposed for attitude control of a tracking satellite with flexible appendages, which ensures energy-efficient fast convergence with least vibration. In contrast to conventional switching methods, a novel sliding manifold is proposed for designing the non-singular predefined-time SMC based on a state-dependent variable exponent coefficient. The issues of vibration, rotational displacement, and energy are addressed through a set of switching conditions between the body and the shadow MRPs using the proposed hybrid control. Extensive simulation results are presented and compared with the existing fast finite-time, fixed-time, and predefined-time sliding control approaches. The results show superiority of the proposed predefined-time controller with conditional anti-unwinding for tracking maneuvers in terms of convergence time, energy, and vibration of flexible appendages.

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