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INDEX-INTEGRATED MPC FRAMEWORK FOR MULTI-DEBRIS RENDEZVOUS AND CAPTURE

Abstract

The growing congestion in Low Earth Orbit (LEO) due to space debris necessitates innovative solutions for effective debris mitigation. This paper presents an Index-Integrated Model Predictive Control (MPC) framework tailored for multi-target debris rendezvous missions. The proposed approach integrates debris prioritisation indices into the MPC path planning process, enabling the selection and removal of high-risk debris objects based on dynamic environmental factors. The debris index considers key metrics such as collision risk, debris size, orbit lifetime, and proximity, influencing both target selection and trajectory optimisation. The MPC formulation incorporates state and control constraints, ensuring safe and fuel-efficient maneuvers during approach, capture, and departure phases. The architecture incorporates both long-horizon planning for multi-target sequencing and short-horizon control for precise terminal guidance, utilizing a receding horizon approach that maintains computational efficiency. Safety assessments are embedded across mission phases to safeguard against collision risks. Simulation results will demonstrate how index-integrated MPC framework achieves efficient multi-debris rendezvous while prioritising critical debris, contributing to the long-term sustainability of space operations.