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DUAL QUATERNION BASED AUTONOMOUS RENDEZVOUS AND DOCKING VIA MODEL PREDICTIVE CONTROL

Abstract

This paper presents a Guidance and Control (G&C) strategy to address 6-Degrees-Of-Freedom (6-DOF) spacecraft attitude and position control for future Rendezvous and Docking (RVD) missions. Future RVD missions, specifically when the target is uncooperative, are challenging as geometric constraints and parameter uncertainties are both present. In addition, due to close proximity and potential angular motion of the target satellite, the point mass approach is no longer sufficient to represent the relative motion dynamics. Hence, throughout this paper, the coupling between translational and rotational motion of spacecraft relative motion is addressed via Dual Quaternions and Piece-wise Model Predictive Control framework. The algorithm is developed such that the relative position of interest is no longer Centre-Of-Mass (COM) position of the target satellite but can be docking port or a predefined grasping feature. Secondly, physical and geometric constraints are explicitly formulated and respected by formulating a constrained optimization problem. The proposed framework is real-time implementable because the control problem is formulated as a convex optimization problem. The computational time requirements and results are discussed accordingly with respect to the current and future trends of space processors capabilities. Subsequently, to demonstrate the efficiency of the proposed framework, a decoupled controller is considered and compared. The relative translational motion is formulated via Yamanaka-Ankersen (Y-A) Equations based on Linear Time-Varying (LTV) MPC framework whereas rotational motion is controlled via Euler's Equations based MPC framework in a cascade system. Both frameworks are tested on the High Fidelity Engineering Model (HFEM) provided by an industrial partner. Eventually, Monte-Carlo simulations are run to evaluate the performance in the presence of parametric uncertainties. Simulation results show that the proposed algorithm is promising because it can respect the physical and geometric constraints and minimize the propellant consumption while coupling translational and rotational motion

and still being real-time implementable.