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COUPLED ORBITAL AND ATTITUDE CONTROL OF SPACECRAFT IN FORMATION

Abstract

Formation flying has become an area of great interest for the design of Earth-observation missions. Future formations will exploit very low inter-satellite range, requiring coordinated coupled control and tracking of both orbital and attitude relative motions. Autonomous control is so the most important field that must be developed for enhance in-space maneuvers and operations. In this paper a completely coupled system for the control of both orbital and attitude relative dynamics of a spacecraft flying in formation will be proposed. Despite a coupled control system does not improve the total fuel consumption, since attitude dedicated devices would allow better performances, the choice of a coupling configuration simplifies the propulsion system architecture and allows to optimize its design. With the minimal number of thrusters required, the resulting integrated control system exploits the naturally coupled behavior of the two dynamics (provided by environmental actions and misalignment of thrust direction) to provide the necessary robustness from failures and desired high-frequency modulation to satisfy the requests of relative maneuver tracking. This entails the use of a more complicated control algorithm: the State-Dependent Riccati Equation (SDRE) technique is proposed to derive both a linear-like proportional controller and a Kalman-like filter, and it is implemented with a timing strategy to reduce the computational load on the GNC computer. The proposed approach will be applied to an up-to-date test-bed, which is the Proba-3 mission. The mission is constituted by a pair of spacecraft, the Coronagraph (CS) and the Occulter (OS), flying at small range in High Elliptical Orbit (HEO). The control system has been designed for the relative orbital and attitude control of the OS. Numerical simulations (conducted with mission data available on ESA web-site and in Phase-A Summary Report) considering a tracking signal for both orbital and attitude relative maneuvers during an operative orbit of the mission are presented. Results obtained prove that coupling control applied with SDRE technique can provide the high performance and safety levels required for modern Formations, which exploit very close coordinated relative maneuvers between theirs members. In particular, the adoption of a timing strategy, here in the limit case of HEO, is definitely the complement that SDRE methodology needs to become the most performing technique to control modern nonlinear systems.