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DESCENTRALIZED CONTROL SCHEME FOR SMALL SATELLITE WITH MANIPULATORS

Abstract

The control of small satellites with multiple rigid manipulators can become considerably complex as the movement of every manipulator alters the dynamics of the other manipulators as well as the satellite. The complexity increases when the manipulators are under the forces and moments of the manipulated objects. The study of this type of highly coupled system requires finding a suitable solution in terms of computational cost, precision in the manipulation of the robotic arms, stability in the attitude of the satellite, and robustness against external disturbances and failures.

In most of the previous work, this methodology has been employed in a general way without adding examples of how the manipulators' reduced equivalencies can be calculated. On the other hand, some derivations can be found for the particular case of a two-dof robotic arm in the context of flying multirotor. The solutions can be found under the centralized and decentralized approaches, the latter being the most suitable in terms of complexity and fault tolerance.

This work presents a decentralized control scheme methodology to reduce the complexity of controlling the highly coupled satellite and manipulators without sacrificing performance. The complexity of the multiple manipulators over the satellite is reduced analytically, and the resulting equivalency is demonstrated. Then, a decentralized control scheme is employed. The method can be described as follows. First, we obtain the equivalent manipulator model using the Newton-Euler recursive algorithm methodology. The computation of the forces and moments due to the manipulator's dynamics acting on the flying base, that is, the satellite's main body satellite, is obtained. Under the assumption of systems with full actuation, the control strategy decouples both systems by compensating forces and moments. The decentralized scheme considers that the forces and moments coming from every manipulator are exogenous disturbances to the dynamics of the satellite and the other manipulators and vice versa. For the manipulators, a computed torque control strategy is employed. The methodology's backbone consists of deriving the diffeomorphism between the equivalent and original manipulator models. Then, we implement the computed torque on the equivalent model. This work contributes by extending the analysis previously made for a two-dof manipulator to a three-dof manipulator. To showcase the methodology, a small satellite with two robotic three-dof arms is studied. The numerical simulations validate the results. The control of the coupled small satellite with the manipulators is considerably simplified in terms of the analytical derivations and computational cost.