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MATHEMATICAL MODELING OF MULTIPLE-ARM FREE-FLOATING SPACE ROBOT FOR SPACE TARGET DETUMBLING

Abstract

The development of orbital space robotics in recent decades has been aimed at meeting the demand for extra-vehicular missions, such as supply, maintenance, inspection, rescue and transportation of materials. A space manipulator can be defined as one or more arms coupled to a floating base developed for operation in orbit. The distinguishing feature of these systems is the dynamic coupling between the base and the manipulators, which makes it difficult to formulate a mathematical model of the robot, especially when external forces are involved.

In detumbling applications, a set of end-effectors is subjected to external torques by fast rotating targets, whose angular momentum must be attenuated by the robot joint actuators. Therefore, mathematical modeling of the joint dynamics and the inertial motion of the end-effectors, with non-zero angular momentum, is of great importance to support the design of the stabilization control system.

In this work, we propose a detumbling formulation for a multi-arm floating base robot based on the Extended Generalized Jacobian Matrix, which represents a generalization of the GJM for systems with more than one arm and non-zero moment. The proposed model calculates the joint dynamics required to mitigate the rotation of multiple end-effectors in post-capture conditions.

Computer simulations based on the Computed Torque control architecture reveal that this detumbling formulation is capable of stabilizing multiple targets with optimal inertial performance under nominal conditions. The model in question, being sufficiently modular to adapt to different controller architectures in the task space, such as robust and adaptive, can become an important tool in future work in the area of space robotics and detumbling.