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Space Structures II - Development and Verification (Deployable and Dimensionally Stable Structures) (2)

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A TWO-ARM FLEXIBLE SPACE MANIPULATOR SYSTEM FOR POST-GRASPING MANIPULATION OPERATIONS OF A PASSIVE TARGET OBJECT

Abstract

Space Manipulator Systems (SMSs) are complex systems made of a platform equipped with one or more deployable robotic arms. They will be playing a major role in future autonomous on-orbit missions such as building large space structures, servicing satellites which ran out of propellant or need repair, and disposal of spacecraft which reached end-of-life conditions and might not be capable of autonomously shift themselves onto "graveyard" orbits. These missions may as well involve manipulation operations of the target object which needs to be moved from an initial configuration to a final one suitable for the specific task under consideration. In the present study, the mission being analyzed concerns the manipulation of a passive body (which could consist of a module of a large space structure, a spent launcher stage or a satellite in need of maintenance) by means of a fully flexible SMS after grasping operations have been performed. The dynamics model is derived in a three-dimensional context (non-linear formulation for the rigid-body motions and linear for the elastic dynamics). The SMS involved in the investigation has two seven-degree of freedom arms. More specifically, each of them consists of seven links: the first six are connected by means of revolute joints (with each rotation axis oriented at 90° with respect to the previous one) and the last two use a prismatic joint. A motor is present at each revolute joint, while a translational actuator is placed along the prismatic joint axis. All the links are characterized by distributed structural flexibility features. Two elastic solar panels are also clamped to the base platform. The calculation of the dynamic properties of the flexible components is carried out by means of a Finite Elements software (MSC Nastran) and the relevant variables are imported into an in-house developed Matlab code for the entire SMS dynamics and control simulation (the adopted modeling technique is based on Kane's approach). The modeling of the grasp constraint existing between the SMS end-effectors and the target object is a critical issue which is addressed in the present paper. Furthermore, the controller design takes into consideration aspects such as the different characteristic time scales of the rigid-body and flexible dynamics (as well as their mutual interaction), the frequency content of the manipulation task and the robustness against external disturbances, non-modeled dynamics and uncertainties regarding the manipulated object inertial properties.