14TH IAA SYMPOSIUM ON BUILDING BLOCKS FOR FUTURE SPACE EXPLORATION AND DEVELOPMENT (D3)
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Author: Dr. Silvio Cocuzza
Space Mechatronic Systems Technology Laboratory, University of Strathclyde, United Kingdom, silvio.cocuzza@strath.ac.uk

Mr. Alessandro Tringali
Space Mechatronic Systems Technology Laboratory, University of Strathclyde, United Kingdom, alessandro.tringali@strath.ac.uk
Prof. Xiu-Tian Yan
University of Strathclyde, United Kingdom, x.yan@strath.ac.uk

ENERGY-EFFICIENT MOTION OF A SPACE MANIPULATOR

Abstract

In this paper the performance of a novel reaction control method recently introduced the author is analyzed in the case of multi-degrees-of-freedom space manipulators. The proposed method locally minimizes the reactions transferred by redundant manipulators to the base spacecraft by using simple least-squares real-time routines, thus reducing the energy required by the Reaction Control System. The interesting performances that can be achieved with a high level of redundancy are analyzed in this paper in case of minimizing the base reaction torques, forces, or weighted combinations of them. The Zero Reaction Workspace in which a null reaction torque is possible has been computed for different space manipulators with increasing degrees of freedom, showing that it can be significantly increased by increasing the available degree of redundancy. This study has been carried out for free-floating and fixed-based manipulators, which are used as a reference, and both considering the robot physical joint limits or not. In addition, a study on the peak joint angles, velocities, and accelerations required to perform an end-effector trajectory inside the Zero Reaction Workspace by robot with increasing degrees of freedom has been carried out, using the classical pseudoinverse solution as a reference. Then, the Zero Reaction Workspaces in case of minimizing the base reaction torques, forces, or weighted combinations of them are compared for different robot degrees of freedom, with particular attention to their shape and area, both in the case of free-floating base and fixed-based robots. Finally, the study of the Zero Reaction Workspace for an increasing number of desired null reaction components has been carried out for a 5-degrees-of-freedom space manipulator.