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REACTIONLESS WORKSPACE OF A MULTI-DEGREES-OF-FREEDOM SPACE MANIPULATOR

Abstract

The problem of controlling the reactions transferred to the spacecraft during manipulator manoeuvres is of particular interest in space robotics because reduced reactions result in reduced energy consumption and longer operating life of the Attitude Control System. In this paper the performance of a novel reaction control method recently introduced by the authors is analyzed in the case of hyper-redundant space manipulators. The proposed method locally minimizes the base reactions transferred by the manipulator to the base spacecraft by exploiting its redundancy, and has some important advantages with respect to the previous ones presented in the literature: a simple mathematical formulation, the possibility to use simple least-squares real-time routines for the solution, and the possibility to take into account the joint limits and the joint velocity and acceleration limits of the manipulator. Different test cases are analyzed in order to evidence the interesting performances that can be achieved with a high level of redundancy. The first test case is set up in order to show that a higher minimization performance can be obtained by increasing the degrees of freedom of the manipulator, in the case that the redundant degrees of freedom are less than the reaction components to be minimized. On the other hand, if the redundant degrees of freedom are equal to the reaction components to be minimized, a zero reaction solution is possible, and the number of reaction components that can be controlled increases as the redundant degrees of freedom increase. The Zero Reaction Workspace of different space manipulators with increasing degrees of freedom has been computed, showing that the workspace in which a zero reaction is possible is significantly increased by increasing the available degree of redundancy. Other test cases are used to show that if a reaction control task is performed by exploiting more redundant degrees of freedom than those strictly necessary, it is possible to utilize the additional redundancy in order to obtain other zero reaction components, to minimize other performance criteria, and/or to perform a given trajectory with a higher mean velocity, without exceeding the given maximum acceleration limit.