SYMPOSIUM ON BUILDING BLOCKS FOR FUTURE SPACE EXPLORATION AND DEVELOPMENT (D3)
Systems and Infrastructures to Implement Future Building Blocks in Space Exploration and Development (2)

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NOVEL REACTION CONTROL OF SPACE MANIPULATORS WITH INCREASED ROBUSTNESS AGAINST SINGULARITIES AND PHYSICAL JOINT LIMITS

Abstract

The minimization of the dynamic disturbances transferred to the base spacecraft by a redundant manipulator during operations is an important issue in space robotic missions, because it leads to reduced energy consumption of the Attitude Control System and, therefore, to an increased system operating life. The use of redundant manipulators makes it possible to perform the required tasks and in the meantime minimize the reactions transferred to the base spacecraft and possibly other additional performance criteria, which can be used to increase the robustness of the solution. A robust solution should at least take into account the joint limits, the joint velocity and acceleration limits, and the avoidance of algorithmic and dynamic singularities. In this paper, two different strategies for obtaining a robust reaction control solution are analyzed in detail, evaluating their pros and cons, in the framework of the least squares reaction control solution recently developed by the authors. The first method is based on the possibility of time scaling the desired trajectories, which gives the possibility to perform the given task with reduced joint velocities and accelerations. An additional advantage of this method is that reduced joint torques are necessary and, therefore, the error in the control due to joint flexibility is reduced or, from another point of view, lighter robot structures can be used. The second method consists in using the recently developed least squares reaction control solution, which can take into account the joint limits and the joint velocity and acceleration limits, and modifying it in order to change the path in the joint space in the proximity of a singularity, in order to avoid it. Simulations are carried out in order to demonstrate the proposed concepts, and then the experimental validation of the proposed solutions is carried out by means of a planar three degrees of freedom manipulator, which is fixed to ground by means of a dynamometer in order to measure the reactions, and suspended by means of air-bearings on a granite plane in order to perform tests in simulated microgravity without time constraints.