IAF ASTRODYNAMICS SYMPOSIUM (C1)
Interactive Presentations - IAF ASTRODYNAMICS SYMPOSIUM (IP)

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EXTENDED REACTIONLESS WORKSPACE OF A SPACE MANIPULATOR THROUGH REACTION WHEELS

Abstract

Spacecraft mounted manipulators need to be carefully manoeuvred in order not to alter the base spacecraft attitude, since the loss of orientation could have a negative impact on the communication with the ground station and on solar panels efficiency. This is usually obtained through minimum reaction control strategies, which minimize the dynamic disturbances transferred to the base spacecraft by the robotic arm. However, this impacts the robot workspace extension, which in turn implies more fuel consumption to approach out-of-reach targets. In this paper, the authors propose an inverse kinematic solution for redundant space manipulators which uses reaction wheels in order to extend the workspace in which zero base reactions are possible. The performance of the proposed solution has been evaluated through dynamic simulations and compared both to a solution that minimizes the torque transferred to the base spacecraft and to a minimum energy solution for a 3-DOF planar manipulator. The workspaces have been compared by computing the maximum distance achievable by the robot end-effector along radial linear trajectories, starting from the same robot initial configuration. A great workspace extension has been obtained with the proposed method, which is due to the fact that - thanks to the inclusion of the reaction wheel dynamic model in the manipulator Jacobian - manipulability retains a positive minimum value in robot configurations that would otherwise correspond to dynamic singularities. As a conclusion, the proposed method demonstrates that the reactionless workspace of a redundant space manipulator can be significantly extended by exploiting the coupled manipulator-reaction wheel dynamics.