ASTRODYNAMICS SYMPOSIUM (C1)
Multibody Dynamics (8)

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A CONSTRAINED LEAST SQUARES APPROACH FOR ATTITUDE DISTURBANCE CONTROL IN SPACECRAFT/MANIPULATOR SYSTEMS

Abstract

The minimization of the dynamic disturbances transferred to the spacecraft during a manipulator manoeuvre is an important issue in order to maintain the antennas communication link, keep the orientation of pointing instrumentation, scanning devices, and solar panels. Reduced dynamic disturbances result in reduced energy consumption and longer operating life of the Reaction Control System. Several inverse kinematic redundancy resolution schemes have been proposed in literature according to a kinematic approach, for the local minimization of the spacecraft attitude disturbance exploiting the momentum and angular momentum conservation laws, and according to a dynamic approach, whose aim is to minimize the reaction forces and torques transferred to the base spacecraft. In this paper a novel constrained least squares solution for the attitude disturbance minimization problem is presented, both according to a kinematic approach and a dynamic approach. Closed form solutions have been developed, and a constrained Jacobian matrix of least attitude disturbance, which can be used in the control loop, has been defined in the first case. In the kinematic approach the inverse kinematics at the velocity level is considered, and the cost function to be minimized is related to the spacecraft angular velocity. In the dynamic approach the inverse kinematics at the acceleration level is considered and the cost function is related to the reaction, comprising forces and torques, transferred to the spacecraft center of mass. Two characteristics make the proposed inverse kinematics solutions very appealing. The first is that the solution can be extended in order to take into account the robot physical/mechanical constraints in the form of joint angle, velocity and acceleration limits directly inside the solution algorithms, and this may be also useful for avoiding algorithmic instabilities and dynamic singularities. The second one is that the presented solutions, and their extension which takes into account the joint limits, result to be suitable for real-time implementation by means of recursive algorithms, by means of solution techniques used for the more general constrained Quadratic Programming problem, or by means of neural networks algorithms. The presented methods have been implemented in a software simulator of a four degrees-of-freedom robotic arm mounted on a free-floating base, which has been previously tested in an ESA Parabolic Flight Campaign. The numerical simulations allowed to validate the presented methods and compare their performances with previous solutions presented in literature for a set of selected test cases.