On inverse kinematics and kinetics of redundant space manipulator simulation

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Redundant manipulators are nowadays favoured in several future space mission scenarios in order to enhance the skill and flexibility of the entire system. DLR, since many years, has been engaged in the development of light-weight robotic systems in modular design. Typical tasks for space applied robotics are to define robot kinematics and to calculate joint kinetics very rapidly in order to support the whole space mission design from the very beginning. Redundant manipulators then require the solution of the inverse kinematics problem for more than 6 degrees of freedom. Equivalently, the respective joint torques and forces are to be calculated by forward and backward recursions. Rather than applying conventional schemes based on pseudo-inverse matrix methods, we favour optimization with equality constraints, based upon the well-known Lagrange formalism. The optimization criteria are chosen to represent the underlying physical meaning, such as minimization of joint velocities, accelerations, torques or power, or even an optimization criterion that maintains the entire robot configuration during motion very close to a reference configuration. Simultaneously, this procedure also takes care that the joint loads and stresses in structural arm links do not exceed upper bounds. Two examples of light-weight robot design for space applications are presented that very clearly show the efficiency of the underlying algorithms.

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