Dynamics of flexible-link and flexible-joint manipulator carrying a payload with rotary inertia

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Abstract: A dynamic model of a flexible-arm and flexible-joint manipulator carrying a payload with rotary inertia is presented. The Lagrangian approach in conjunction with the finite element method is employed in deriving the equations of motion, within the assumption of a small deformation theory. All the dynamic coupling terms between the system reference rotational motion, joint torsional deformations and arm bending deformations are accounted for. The dynamics of a payload with rotary inertia are incorporated in the model in a consistent manner. Furthermore, the effects of axial shortening due to beam and bending deformations and motions induced inertial forces as well as the effects of gravity are included in the model. The resulting model and simulation results have shown that the joint flexibility has a pronounced effect on the dynamic behavior of rotating flexible arms that should not be simply neglected. The effect is shown to be due to the nonlinear dynamic interaction between the joint torsional deformations, the arm bending deformations and the system reference rotational motion. Simulation results of the nonlinear and the linearized models are compared and the results are discussed. The effects of the payload are shown to be increasing the elastic deformations' amplitudes and reducing the frequency of oscillations. Due to the model nonlinearity, different combinations of system parameters are expected to develop different effects. This makes the proposed model valid in the design process as well as in the performance evaluation.