FURTHER RESULTS ON ADVANCED MODELING AND CONTROL OF COMPLEX MECHANICAL SYSTEMS

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Keywords: Calculus of General Order, Robot Manipulator, Exoskeleton Robotic System, Robust Control, Iterative Learning Control.

ABSTRACT (Invited Lecture)

The investigation into the dynamics and control of robotic and complex (bio)mechanical systems has been an active topic of research for many years. The science of robotics/adaptronics has grown tremendously over the past twenty years, fueled by rapid advances in computer and sensor technology, as well as theoretical advances in control theory. Recently, calculus of general order $\alpha \in R$ has attracted an increased attention of scientific society where fractional operators are often used for control issues and for modelling dynamic of complex systems,[1].The modelling complex rigid multibody systems using symbolic equations can provide many advantages over the more widely-used numerical methods of modelling these systems.

In this presentation, we propose using procedure for symbolic form computation of the complete dynamics of (exoskeleton) robotic systems with kinematic chain structures using the Rodriquez approach, [2]. Dynamic equations are given as Lagrange equations of the second kind in the covariant form with external generalized forces of the gravity, motor-torque, viscous and spring. Mathematical model of the proposed NeuroArm robotic system due to a high gear ratio between the actuators and robot joints, can be reduced to a linear model. Robust control of general order with no overshoot can be obtained using fractional order compensator which is designed according to the symmetrical optimum principle, [3].The effectiveness of the proposed method will be illustrated through the control simulation of three degrees of freedom robot manipulator. Also, some attention will be devoted to problem the viscous friction in robotic joints. The calculus of general order and the calculus of variations are utilized to modelling the viscous friction which is extended to the fractional derivative of the angular displacement. This model is introduced into dynamic equations via generalized forces which are derived by using the principle of virtual work.

Also, it is presented the tracking problem of exoskeleton robotic system for rehabilitation with three DOFs with revolute joints via intelligent control which includes advanced iterative learning control (ILC), [4]. First, a feedback linearization control technique based on computed torque method is applied on a given robotic system. Then, the proposed intelligent ILC algorithm takes the advantages offered by closed-loop control PD type and open-loop control *sgn*PDD2 type of ILC. Suggested robust ILC algorithm is applied to the linearized system to further enhance tracking performance for repetitive tasks and deal with the model uncertainties. Finally, a simulation example is presented to illustrate the effectiveness of the proposed robust ILC scheme for a proposed exoskeleton robot arm.

Acknowledgement Authors gratefully acknowledge the support of the Ministry of Education, Science and Technological Development of the Republic of Serbia under the projects TR 35006, III 41006 (M.P.L.) and TR 33047 (P.D.M.).

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