ROBUST NONLINEAR CONTROL OF ROBOT MANIPULATOR WITH UNCERTAINTIES IN KINEMATICS, DYNAMICS AND ACTUATOR MODELS

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ABSTRACT. This paper, according to practical method in robot manipulator control, introduces a novel robust control approach for trajectory tracking of electrically-driven robotic manipulators in task space. A new task space control scheme is proposed to overcome uncertainties of actuator dynamics, robot dynamics and kinematics. A robust controller is designed based on Lyapunov method, using dynamic delay, backstepping method and unknown bounds of uncertainties. It is proven that the closed loop system has global uniform ultimate boundedness stability. Although, for overcoming the uncertainties in actuator dynamics, robot dynamics and kinematics is a major advantage, the proposed control cannot pass the singular points in task space and there will be malfunctions when it is applied on the practical implementation. Modifications are used to derive a control law which is free of velocity terms and can pass the singular points into task space. The control approach is applied on a two-link elbow robotic manipulator which is driven by permanent magnet dc motors and can be applied on up to n-links robotic manipulators, too. The performance of proposed control laws is confirmed by simulations.

Keywords: Robot manipulators, Uncertain kinematics, Uncertain dynamics, Actuator dynamics, Backstepping method, Task space, Practical implementation

1. Introduction. It is well known that the kinematics and dynamics of robots are highly nonlinear with coupling existing between joints. There is a problem in the compatibility of the nonlinearity and uncertainty of the robot dynamics, and to cope with this, it has been shown in [1,2] that a simple joint space controller such as the PD or PID feedback is effective for setpoint control.

A great many control schemes for robotic manipulators have been developed in the literature during the past few decades. In most of the control methods [1-5], the controllers are designed at the torque input level and the actuator dynamics has not been considered. As shown by Good et al. [6], the actuator dynamics constitutes an important part of the whole robot system and may cause detrimental effects when neglected in the design procedure, especially, in the cases of highly varying loads. Recently, the actuator dynamics has been explicitly applied in some joint space control schemes, and especially, it has been developed to deal with this problem at rigid-link robots, as can be found in [7-9].