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Proceedings of the ASME 2014 International Mechanical Engineering Congress & Exposition
IMECE2014
November 14-20, 2014, Montreal, Quebec, Canada

IMECE2014-37791

ADAPTIVE CONTROL OF ELECTRICALLY-DRIVEN ROBOT MANIPULATORS WITHOUT VELOCITY/CURRENT MEASUREMENTS

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ABSTRACT

An adaptive output feedback controller for electrically-driven robot manipulators is developed in this paper. The proposed controller can compensate for parametric uncertainties while only requiring link position measurements. To eliminate the need for measuring link velocity and electrical winding current, two individual observers are used as a surrogate for unmeasurable quantities: one for joint velocity estimation, and another for motor current estimation. Based on these observers, a modified adaptive integrator backstepping procedure is utilized to design input voltage which guarantees semiglobal asymptotic link position/velocity tracking in spite of the mechanical parametric uncertainties and lack of link velocity and rotor current measurements. The main novelty of our presented work lies in simultaneous estimation of joint velocities, rotor currents, and mechanical uncertainties to produce a controller which provides a system level input, the voltage to an electric actuator, to control the link position/velocity of electrically-driven robot manipulators.

1. INTRODUCTION

Adaptive control of robotic systems has been studied for many years and so far a great number of globally stable algorithms have been developed [1-5]. In the majority of these methods, the controller is developed at torque level and the adaptation and control laws are generated by measurements of both the position and velocity tracking errors. In fact the control and adaptation signals are linear combination of the joint position and velocity error vectors.

The joint positions are measured by encoders which can provide extreme accuracy; however, link velocities are mostly targeted for elimination because of the noisy nature of tachometer based velocity measurements. High precision velocity sensors are frequently eliminated due to cost, volume, and weight savings [6]. As a result, the controller should be driven by the estimated velocity as a surrogate for the velocity measurements by tachometers. Hence, the problem of control of robotic systems by sole measurements of joint position, of output feedback control fame, has been a topic of great enthusiasm for almost two past decades.

One approach to output feedback control problem is the design of an observer which mimics the physical behavior of the system and estimates the joint velocities. For instance, in [7-10] model based observers are utilized and in [11,13] filtering techniques and/or variable structure type algorithms [14] are used to estimate the joint velocities. Adaptive observer-based tracking controllers for robotic systems have been considered in [15,16].

In the conventional design methods, the robot is driven by the torques input to each link; however, the mechanism that

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