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NEURAL NETWORK SLIDING-MODE-PID CONTROLLER DESIGN FOR ELECTRICALLY DRIVEN ROBOT MANIPULATORS

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Abstract. *This paper addresses a neural-network-based chattering free sliding mode control (SMC) for robot manipulators including structured and unstructured uncertainties in both manipulator and actuator dynamics by incorporating a PID outer loop. The main idea is that the robustness property of SMC and good response characteristics of PID are combined to achieve more acceptable performance. Uncertainties in the robot dynamics and actuator models are compensated by a two-layer neural network. External disturbance and approximation error are counteracted by robust signal with adaptive gain. The stability of closed-loop system is guaranteed by developed control scheme. Finally, the proposed methodology is applied to a two-link elbow robot as a case of study. The simulation results show the effectiveness of the method and its robustness to uncertainties and disturbances.*
Keywords: Robot manipulators, Sliding mode control, Neural networks, PID control, Uncertainties

1. **Introduction.** Robot manipulators are well-known as nonlinear systems including high coupling between their dynamics. These characteristics, in company with structured uncertainties caused by model imprecision of link parameters, payload variation, etc., and unstructured uncertainties produced by un-modeled dynamics, such as nonlinear friction and external disturbances, make the motion control of rigid-link manipulators a complicated problem [1]. Additionally, one constraint in the robot controller designs is saturation nonlinearity of actuators which is less considered in control design of robot manipulators.

A well improved control method for coping with mentioned difficulties is sliding mode control which is capable in controlling a wide range of different systems, such as nonlinear uncertain systems, MIMO systems and even, discrete time systems [2,3]. Moreover, it has a good deal of advantages such as insensitivity to parameter variations, disturbance rejection, and fast dynamic responses [4]. A good survey on this topic has been provided by Hung et al. [5]. Despite these merits, SMC suffers from some disadvantages. Actually, the sliding mode control law consists of two main parts [6]. The first part is the equivalent control law which involves inverse dynamics of model nonlinearities that demonstrates the dependency of SMC on the dynamical model of the plant. The second part is the robustifying term which has discontinuous nature and may employ unnecessary high control gain to overcome uncertainties and disturbances. However, this discontinuity may lead to