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NEURO-FUZZY CONTROL WITH TIME DELAY ESTIMATION FOR NONLINEAR NETWORKED CONTROL SYSTEMS

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Abstract. *This paper presents a neuro-fuzzy control strategy with online estimation of Round Trip Time delay for nonlinear Networked Control Systems. First, a fuzzy model is identified offline through inputs-states data with delay measurement also the parameters for the estimation of Round Trip Time delay are obtained. The fuzzy control is designed by Linear Quadratic Regulation and a stability analysis is presented. A Real-Life hardware-in-the-loop Magnetic Levitation System is used as case study to show the effectiveness of control and robustness to traffic.*
Keywords: Networked control systems, Neuro fuzzy control, Delay estimation

1. **Introduction.** A feedback control system in which control loops are closed via a communication network is called networked control system (NCS), so, sensors, actuators, controllers and others (monitors, etc.) are interconnected via communication networks. The main advantages of this kind of systems are their low cost, small volume of wiring, distributed processing, simple installation, maintenance and reliability.

Recently, much attention has been paid to control design and stability analysis of NCSs [1-8], where the key problems to resolve are network-induced delays and packet loss that degrade the system performance. Time-delay is considered constants, time varying, or even random. Time-delay as well as loss packet depends on the scheduler, network type, architecture, operating systems, etc. [9,10]. When time delay is less than the sampling period of NCS, results indicate that time-delay has degradation effects in system performance but is possible to correct or eliminate this [11]. However, when time-delay is greater than sampling period with a varying o random behavior, the performance in an NCS is reduced considerably. Whereby, it is necessary to analyze time delays and packet loss to develop an efficient approach to reduce its effect into NCS.

Nilsson analyzes important facets of NCSs [10]. It introduces models for the delays in NCS, first as a fixed delay, after as an independently random, and finally like a Markov process. The author introduces optimal stochastic control theorems for NCSs based upon the independently random and Markovian delay models, but he considers just time delays less than a sampling period. In [12], Walsh et al. introduce static and dynamic scheduling policies but just for transmission from sensor to controller in a continuous-time LTI system. They introduce the notion of the Maximum Allowable Transfer Interval (MATI), which is the longest time in which a sensor should transmit a datum. Therefore, Walsh derived Try-Once-Discarded (TOD) scheduling where the MATI constraint ensures at least one such transmission every τ seconds. However, TOD does not guarantee that