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ADAPTIVE NEURAL NETWORK STATE PREDICTOR AND TRACKING CONTROL FOR NONLINEAR TIME-DELAY SYSTEMS

Jing Na, Xuemei Ren, Yan Gao

Department of Automatic Control
Education Ministry Key Laboratory of Complex System Intelligent Control and Decision
Beijing Institute of Technology
Beijing 100081, P. R. China
najing25@163.com; { xmren, gaoyan }@bit.edu.cn

Griñó Robert and Costa-Castelló Ramon

Instituto de Organización y Control de Sistemas Industriales
Universitat Politècnica de Catalunya
Barcelona, Spain
{ roberto.grino, ramon.costa }@upc.edu

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Abstract. *A new adaptive nonlinear state predictor (ANSP) is presented for a class of unknown nonlinear systems with input time-delay. A dynamical identification with neural network (NN) is constructed to obtain NN weights and their derivatives. The future NN weights are deduced for the nonlinear state predictor design without iterative calculations. The time-delay and unknown nonlinearity are compensated by a feedback control using the predicted states. Rigorous stability analysis for the identification, predictor and feedback control are provided by means of Lyapunov criterion. Simulations and practical experiments of a temperature control system are included to verify the effectiveness of the proposed scheme.*

Keywords: Time-delay system, Neural network, State predictor, Feedback control

1. **Introduction.** Substantial time-delays and unknown nonlinearities are always unavoidable in control systems such as process control, network systems and so on [1]. The stability and stabilization of time-delay systems have been attracting considerable attention during the past decades [2,3] and references therein. However, the tracking control design is more general and difficult than stabilization, especially for systems with input-delay [1]. Due to the unknown nonlinear dynamics, the Smith-based control [4], Internal Model Control [5] and other model-based time-delay compensators [6] are invalid for nonlinear time-delay systems. To overcome this problem, Huang and Lewis [7] established a NN-based control for a class of uncertain nonlinear systems with communication delays. We also developed a time-delay positive controller with NN compensation [8] for more general cases. However, the employed local linearization can not be implemented where the time-delay is an inherent phenomenon of the plant such as temperature control and fluid control.

As known, if system states (or output) at the future time instants are available for feedback control, the effect of input time-delays can be compensated. This usually receives the name of predictive control [6,9]. In [10], a modified predictive control for networked control systems was presented. Nonlinear state predictors [11,12] were developed based on the extended Kalman filter (EKF). However, these predictors require an exact model of the plant. For systems with unknown nonlinearities, there have been increasing interests