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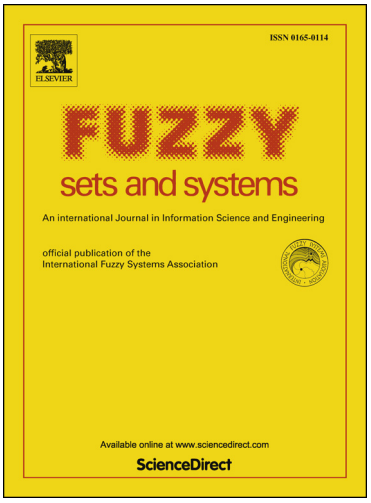

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Delay-Estimation-Based Adaptive Fuzzy Memory Control for a Class of Uncertain Nonlinear Time-Delay Systems

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Abstract

This paper is concerned with the problem of adaptive fuzzy memory control for a class of uncertain nonlinear systems with unknown time delays. Compared with the existing results, the restrictions on the time-delayed functions are overcome, and the unknown delay parameters are estimated by establishing the piecewise adaptive laws. Based on the delay estimations and the backstepping technique, a novel adaptive fuzzy memory output feedback controller is designed. For the analysis of stability, the cubic Lyapunov functions with absolute value are constructed. It is proved that the proposed control scheme can guarantee that all the signals in the closed-loop system are bounded and the tracking error converges to a small neighborhood of the origin. Two practical simulation examples are given to demonstrate the effectiveness of the proposed control scheme.

Keywords: adaptive fuzzy control, uncertain nonlinear systems, piecewise adaptive laws, the backstepping technique

1 Introduction

During the past few decades, adaptive control for nonlinear systems has become a mature and well established research area within control systems society. In the early stage, the key requirement for the analysis of the global stability is that the controlled nonlinear systems must satisfy the matching conditions [1], extended matching conditions [2], or growth conditions [3]. In order to overcome these restrictions, the adaptive backstepping control technique is developed. Subsequently, the adaptive backstepping control technique as a powerful tool has received considerable attention for controlling strict-feedback nonlinear systems, and various significant results on adaptive backstepping control for nonlinear systems have been reported in [4]-[14], and the references therein. Among them, [4, 5] are for single-input and single-out (SISO) nonlinear systems, [6, 7] are for multiple-input and multiple-output (MIMO) nonlinear systems. Recently, approximation-based adaptive fuzzy control has been developed to deal with the control problem of nonlinear systems with unknown nonlinear functions [8, 9, 10]. [8] investigated adaptive fuzzy control for a class of stochastic pure-feedback nonlinear systems with unknown hysteresis. [10] proposed a fuzzy adaptive control approach for nonlinear systems with unknown control gain sign. The backstepping control technique has become one of the most popular design methods for a large class of nonlinear systems [11, 12, 13, 14]. In [12, 14], the adaptive fuzzy backstepping control method is applied to deal with switched nonlinear systems. Although the backstepping-based adaptive technique has been used widely and developed extensively, there exists the issue of explosion of complexity in the design process. To avoid the problem, dynamic surface control (DSC) technique was proposed in [15]. The DSC technique was developed to eliminate the problem of explosion of complexity by introducing a first-order filter at each step of the traditional backstepping approach [16, 17, 18]. Among them, [16] developed a neural network-based adaptive backstepping control scheme for a class of nonlinear systems in strict-feedback form with arbitrary uncertainty. [17] proposed adaptive dynamic surface control of nonlinear systems with unknown dead zone in pure feedback

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