

ROBUST ADAPTIVE CONTROL OF TIME DELAY UNCERTAIN SYSTEMS WITH FLS

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ABSTRACT. *This paper deals with the problem of robust adaptive controller design for a class of Multi-Input and Multi-Output (MIMO) time delay uncertain systems based on backstepping method and fuzzy logical system (FLS). This problem aims at designing robust adaptive controller for all parameter uncertainties and time delay of MIMO system with backstepping method. This studied system consists of some subsystems which are cascade MIMO uncertain systems, and the time delays of these subsystems are unknown. In each step, the control scheme is derived in terms of linear matrix inequalities (LMI's). With the output of FLS, a robust adaptive controller is given using backstepping and LMI method. Finally, a numerical example is given to illustrate our theoretical results.*

Keywords: Time delay uncertain systems, Fuzzy logical system, Backstepping control, Robust adaptive control

1. **Introduction.** In recent years, backstepping control of uncertain system has been studied by many researches and there have been tremendous successes in the design of control systems[1-2]. Now, the backstepping design can also be extended to handle uncertain system by integrating intelligent control technology such as neural network and fuzzy logical system. Li and Qiang et al [3] studied two different backstepping neural network control approaches for a class of affine nonlinear systems. However, only single-input-single-output (SISO) nonlinear systems without time delay were considered. A robust adaptive control scheme was proposed for a class of uncertain MIMO time delay systems with backstepping method and radical basis function neural network in [4]. But the system parameter uncertainties have not been considered.

Recently, the FLS has been successfully used in the control of uncertain nonlinear systems. Combining backstepping control with FLS to control uncertain systems has received increasing attention for its advantage. A direct adaptive output-feedback controller for highly nonlinear systems was proposed by employing a static FLS in [5]. Yang and Zhou [6] proposed a novel adaptive fuzzy controller with performance for a wide class of strict-feedback canonical nonlinear systems. A robust adaptive tracking control problem was discussed for a class of strict-feedback uncertain systems in [7]. But most of these research results did not considered the nonlinear system with time delays. In modern control area, stabilization of uncertain systems with time delays is receiving much attention [8-10]. Tong and Wang et al [8] studied decentralized robust control scheme for uncertain T-S fuzzy large-scale systems with time-delay. Robust adaptive controllers were designed for neutral delay systems [9], delay-dependent singular linear systems [10] and time delay nonlinear systems. But without MIMO characteristics were considered using backstepping method in these studied results.