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ADAPTIVE FUZZY CONTROL FOR A CLASS OF UNCERTAIN NONLINEAR SYSTEMS VIA LMI APPROACH

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Abstract. *This paper deals with control design and stability analysis for a class of nonlinear systems with system uncertainties as well as input constraint when using the T-S fuzzy model. As a result, it achieves an adaptive fuzzy controller, which consists of two components: one is corresponding with the regular state feedback controller based on the LMI approach in order to deal with the known part in the T-S fuzzy model; and another one is obtained based on adaptive law in order to deal with the unknown part in the T-S fuzzy model. In the end, the problem of relaxing LMI conservatism is considered.*
Keywords: Uncertainties, LMIs, Input Constraint, Adaptive law, Conservatism

1. **Introduction.** One of the essential elements of the control problem is the model of the dynamical system to be controlled. In many cases, a mathematical model of the system is unavailable or incomplete, or the equations that we believe are adequate to represent the behavior of the system are too complicated for the design purpose. This is the most likely reason why the application of the fuzzy set theory to control problem has been the focus of numerous studies. The reason is that the fuzzy set theory provides an alternative to the traditional modeling and design of control systems, where knowledge of the dynamic model of the system in the traditional sense is uncertain and time-varying. In recent years, there have been significant advances in the study of the stability analysis and controller synthesis for the so-called Takagi-Sugeno (T-S) fuzzy systems [1], which have been used to represent certain complex nonlinear systems. In the T-S fuzzy model, the local dynamics in different state-space regions are represented by linear models such as $\dot{x}(t) = A_i x(t) + B_i u(t)$, where A_i, B_i are certain known matrices with some appropriate dimensions. The overall model of the system is obtained by the fuzzy blending of these local models. The control design is carried out based on the fuzzy model by the so-called parallel distributed compensation (PDC) scheme [2]. For each local linear model, a linear feedback control is designed. The resulting overall controller is again a fuzzy blending of the individual linear controllers. Originally, Tanaka and his colleagues have provided certain conditions that are sufficient for the stability of the T-S fuzzy systems in the sense of Lyapunove [2]-[4]. The conditions for the existence of a common Lyapunov function are obtained by solving Linear Matrix Inequalities (LMIs).

In this paper, we consider a class of nonlinear systems with system uncertainties as well as input constraint (saturation). Actually, the system input constraint can severely degrade the closed-loop system performance, and sometimes even destabilizes the otherwise stable closed-loop system. Recently, considerable attention has been paid to the systems with input constraint [5]-[9]. In general, input constraint problem can be overcome by