International Journal of Innovative Computing, Information and Control
Volume **4**, Number **8**, August **2008**

ICIC International ©2008 ISSN 1349-4198
pp. 2079–2086

ROBUST FUZZY CONTROL OF NONLINEAR SINGULARLY PERTURBED SYSTEMS WITH PARAMETRIC UNCERTAINTIES

Ping Mei, Chenxiao Cai and Yun Zou

School of Automation
Nanjing University of Science and Technology
200 Xiao Ling Wei, Xuan Wu District, Nanjing 210094, P. R. China
meiping1007@163.com; zouyun@vip.163.com

Received June 2007; revised December 2007

Abstract. *This paper examines the problem of robust fuzzy control for nonlinear singularly perturbed systems described by a T-S fuzzy model. Two cases of the T-S fuzzy system with parametric uncertainties, both continuous-time and discrete-time cases are considered. Based on a linear matrix inequality (LMI) approach, some LMI-based sufficient conditions are proposed for stabilization of the controlled systems via fuzzy state feedback controllers. In order to eliminate the ill-conditioned problem caused by the interaction of fast and slow modes, solutions to the above problem are transformed to a group of well-conditioned -independent LMIs. The proposed approach does not involve the decomposition of the systems into fast and slow subsystems and hence is applicable to standard and non-standard singularly perturbed nonlinear systems. Two examples are included to demonstrate the effectiveness of the proposed methods.*

Keywords: T-S fuzzy model, Singularly perturbed systems, Linear matrix inequality (LMI), Fuzzy control, Parametric uncertainties.

1. **Introduction.** Singularly perturbed (SP) systems often occurred at the physical systems in engineering field, such as motor control system, electronic circuits, and so on. The methodology of singular perturbation has been a popular tool for system analysis and controller synthesis [1]. Recently, many researchers have focused on stability analysis and design of SP systems, see, for instance, [2-4] and references therein.

But nonlinear singularly perturbed systems remain an open research area. This is because, in general, nonlinear singularly perturbed systems cannot be easily separated into slow and fast subsystems. In [5], E. Fridman decomposed the optimal control of the nonlinear singularly perturbed systems into slow and fast subsystems by invariant manifold. In fact, current various approaches to control nonlinear singularly perturbed systems are rather complicated and difficult to use. The systematic and general method has not been proposed.

Recently, nonlinear control approaches based on the T-S fuzzy model have been successfully developed in the framework of LMI designs [6-9], essentially because it can provide an effective solution to the control of plants that are complex, uncertain, and ill-defined. The mainly design methods of fuzzy control system consist of three steps. The first step is modeling the nonlinear plant by a Takagi-Sugeno type fuzzy model. In this type of fuzzy model, the local dynamics in different state space regions are represented by different linear models. The overall model of the system is achieved by fuzzy "blending" of these linear models [6-8] . Then the second step is the controller design. The controller is carried out based on the fuzzy model via the so-called parallel-distributed compensation scheme. The idea is that for each local linear model, a linear feedback control is designed. The resulting overall controller, which is nonlinear in general, is again a fuzzy blending of