International Journal of Innovative
Computing, Information and Control
Volume 7, Number 7(B), July 2011
 ISSN 1349-4198
pp. 4363–4376

A SWITCHING CONTROLLER DESIGN VIA SUM-OF-SQUARES APPROACH FOR A CLASS OF POLYNOMIAL T-S FUZZY MODEL

Shun-Hung Chen and Jyh-Ching Juang

Department of Electrical Engineering
National Cheng Kung University
No. 1, University Road, Tainan, Taiwan
juang@mail.ncku.edu.tw

Received April 2010; revised October 2010

Abstract. *This paper presents a switch methodology together with a sum of squares (SOS) techniques to synthesize a nonlinear controller for a polynomial Takagi-Sugeno (T-S) fuzzy model. A polynomial T-S fuzzy model adopts a polynomial representation of the nonlinear dynamics in its consequent part, which make it less susceptible to linearization errors. With respect to polynomial T-S fuzzy models, a fuzzy switching control mechanism instead of fuzzy blending mechanism is developed to provide stability and performance. The switching control mechanism is synthesized by using the SOS technique which is capable of rendering an estimate of the region of convergence and, accordingly, leading to the partitioning of the fuzzy model. Computer simulations for two representative nonlinear systems are provided to demonstrate the effectiveness and robustness of the proposed nonlinear fuzzy control.*
Keywords: Polynomial T-S fuzzy, Switch controller, Sum of squares programming

1. **Introduction.** In the paper, a design procedure for nonlinear systems is proposed without resorting to model linearization. The proposed method adopts a polynomial Takagi-Sugeno (T-S) fuzzy model to represent the nonlinear system to be controlled and utilizes a fuzzy switching mechanism to evoke appropriate control rules. Natural systems are subject to nonlinear effects. In general, the controller of a nonlinear system is synthesized by linearizing the nonlinear model, designing a linear controller against the linearized plant, and tailoring different linear controllers through scheduling [9,11,18] or switching [2,7,10]. The design procedure of gain-scheduling controller design typically comprises the following steps [9]: selecting operating points that could cover the range of the dynamics of nonlinear plant, constructing linear time-invariant (LTI) plants, designing a linear controller for each linearized plant, and scheduling or interpolating the compensators to lead to a controller for the nonlinear system. A drawback of gain-scheduling method is that the change of the scheduling variable may be rather abrupt across the boundaries of the region, which may result in unacceptable or even unstable performance [11,18]. For a class of "multi-modal" system, the switching strategies have also been investigated; see [10] for a review of the stability and control of switched systems. In [2], the multiple Lyapunov function method has been proposed for the analysis and design of switching control systems. The effectiveness of fuzzy control which is designed via knowledge eliciting from human operators in accounting for nonlinearities and uncertainties has been reported in several textbooks. Takagi and Sugeno modeled a nonlinear system in terms of a set of fuzzy IF-THEN rules which describe the local linear input-output relationships of a nonlinear system [19]. They then offered a systematic procedure to design controllers of nonlinear systems. More precisely, the nonlinear system is approximated by a T-S fuzzy