MODEL BASED FUZZY CONTROL WITH AFFINE T-S DELAYED MODELS APPLIED TO NONLINEAR SYSTEMS

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ABSTRACT. This paper mainly investigates fuzzy control with affine T-S delayed models, which can be applied to some nonlinear systems. Motivated from performing the linearization process associated with distinct operating points for nonlinear systems, an affine T-S fuzzy model with delayed state is addressed. The overall control then can be performed by the fuzzy inference mechanism, in which the consequent parts are represented by the locally linear affine subsystems with delayed state. Sufficient stability conditions for the unforced T-S affine models with delayed state are first derived. By involving the parallel distributed compensator (PDC), design conditions for the resulting closed-loop systems are further investigated. Since all the proposed criteria are formulated by the linear matrix inequalities (LMIs), we thus can perform the stability analysis or the PDC synthesis via current LMI solvers. A nonlinear numerical example and an applicable physical model with TCP/RED flowing control mechanism are given to demonstrate the validity and effectiveness of the proposed approach.

Keywords: T-S fuzzy model, Delayed state, Affine systems, Linear matrix inequality (LMI)

1. Introduction. Model based fuzzy control has been successfully applied to miscellaneous systems, which are mathematically poorly modeled and where the knowledge and the experience of operators can achieve the control object well. It can approximately represent the states’ behaviors of nonlinear systems or uncertain systems by appropriate transformation [1-4]. To date, Tanaka and Sugeno [5,6] first proposed a T-S fuzzy model and discussed its stability issue, where the consequent parts presented the locally linear models. By performing the fuzzy control, the model can be associated with the so-called “parallel distributed compensation (PDC)” [3]. Thereafter, the stability analysis and the controller synthesis for the T-S fuzzy model have attracted a great deal of research (e.g., [7-10] and the references therein). Recently, the linear matrix inequality (LMI) technique [11] was involved for deriving some explicit stability analysis and design criteria [12-16], and they could be readily evaluated by some commercial software [17].

In most physical and engineering systems, such as circuit systems, chemical processes, and long transmission lines in network systems, delay states cannot be neglected [18-21]. Since they in industrial plant are main sources of instability, oscillations, or degraded performances, the stability analysis and the PDC synthesis are extended to tackle the T-S fuzzy models with delayed state [22-30]. Moreover, for nonlinear system control, we can perform the linearization process on some distinct operating points and consequently obtain a set of the locally linear affine subsystems. Then, the overall control law can be implemented by the fuzzy inference system [31,32]. However, to the best of our knowledge, the stability analysis and the PDC synthesis for the T-S fuzzy affine model subjected to