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NEW RELAXED STABILIZATION CONDITIONS FOR FUZZY CONTROL SYSTEMS

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Abstract. *The purpose of this paper is to study the stability of discrete-time and continuous-time fuzzy systems with Takagi–Sugeno's models. First, a homogeneous polynomial matrix function is proposed, then by applying the homogeneous polynomial matrix function to the controller and Lyapunov function, some new conditions are obtained. It is shown that as the degree of the the homogeneous polynomial matrix function increases the conditions become less conservative. Numerical examples are included for illustration and comparison.*
Keywords: Takagi–Sugeno's fuzzy model, Polynomial matrix function, Nonquadratic Lyapunov function, Feedback controller, Linear matrix inequality

1. **Introduction.** Since the well-known Takagi–Sugeno (T–S) fuzzy model was established in 1980's [1,2], there are significant research efforts devoted to the stabilization analysis and controller design of this kind of system [3-8]. The range of the solution of the stability condition is one of the most important issue of the fuzzy control. By representing the interactions among the subsystems in a single matrix, reference [9] relaxed the results in [6]. Recently, the conditions proposed in [10,11] further relaxed the results in [9]. These conditions admit more freedom in guaranteeing the stability of fuzzy systems and are found to be very valuable in designing the controllers. In [12], a new stabilization condition was obtained which relaxed the results in [10]. The main difference between [10] and [12] is that the conditions in [10] explored the quadratic combination in $h_i(z(t))$ (the weight functions of the subsystems derived by the memberships of the fuzzy set rules) while the conditions in [12] explored the cubic combination in $h_i(z(t))$ and contain [10] as special case.

On the other hand, how to set the controller and Lyapunov function is another important issue in the stability analysis of fuzzy systems. Most of the works utilize a quadratic Lyapunov function while there are also some papers focusing on non-quadratic Lyapunov functions such as [13,14]. Using the non-quadratic Lyapunov functions and non-parallel distributed compensation (non-PDC) control law design method, some new conditions were proposed in [13] which relaxed the results in [9]. Based on an extended non-quadratic Lyapunov function with more variables, some new conditions were developed in [14], which were less conservative than those in [13].

In this paper both the discrete-time and continuous-time fuzzy systems are all considered. For discrete-time fuzzy system, by applying our proposed homogeneous polynomial matrix function to the non-quadratic Lyapunov functions and non-PDC control law, we further relaxed the conditions in [14]. For continuous-time fuzzy system, due to the reason