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DELAY-DEPENDENT STABILIZATION CONDITIONS OF CONTROLLED POSITIVE T-S FUZZY SYSTEMS WITH TIME VARYING DELAY

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Abstract. *This paper deals with the problem of delay-dependent stability and the stabilization of Takagi-Sugeno (T-S) fuzzy systems with a time-varying delay while imposing positivity in closed-loop. The stabilization conditions are derived using the single Lyapunov-Krasovskii Functional (LKF) combining the introduction of free-single matrices. A memory feedback control is also used in case the delay matrix is not nonnegative. An example of a real plant is studied to show the advantages of the design procedures.*
Keywords: LMI, Parallel distributed compensation, Lyapunov-Krasovskii functional, T-S fuzzy systems, Stabilization, Time-delay, Positive systems

1. **Introduction.** Since the introduction of T-S fuzzy models by Takagi and Sugeno [34] in 1985, fuzzy model control has been extensively studied [3, 7, 8, 10, 15, 17, 30, 31, 32, 33] because T-S fuzzy models can provide an effective representation of complex non linear systems. However, all the aforementioned results are proposed for time-delay free T-S fuzzy systems. In practice, time-delay often occurs in the transmission of information or material between different parts of a system. Transportation systems, communication systems, chemical processing systems, environmental systems and power systems are examples of time-delay systems. Also, it has been shown that the existence of time-delay usually becomes the source of instability and deteriorates the performance of systems. Therefore, the T-S fuzzy model has been extended to deal with nonlinear systems with time-delay. The existing results of stability and stabilization criteria for this class of T-S fuzzy systems can be classified into two types: delay-independent, which is applicable to delays of arbitrary size [12, 24, 36], and delay-dependent, which includes information on the size of delays [9, 13, 22, 23, 25, 28, 29]. It is generally recognized that the delay-dependent results are usually less conservative than delay-independent ones, especially when the size of the delay is small. We notice that all the results concerning the analysis and synthesis of delay-dependent methods cited previously are based on single LKF that bring conservativeness in establishing the stability and stabilization tests. Moreover, the model transformation $x(t-\tau(t)) = x(t) - \int_{t-\tau(t)}^{t} \dot{x}(s)ds$, the conservative inequalities $-2c^T d \leq c^T X c + d^T X^{-1} d$ and the so-called Moon's inequality [30] for bounding cross terms are all used in the derivation processes, which introduce the conservatism of the results. More recently, [38] have used a fuzzy LKF combining the introduction of free