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STABILITY ANALYSIS OF FUZZY CONTROL SYSTEMS USING POLYNOMIAL METHODS

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Abstract. *Stability analysis of fuzzy control systems using polynomial methods is proposed. First, a new approach is introduced to search for poles of a T-S fuzzy system in any mixed weighting case. Next, through the technique of the pole placement, a controller can be designed to achieve the desired response. Then, using the following methods, such as the Kharitonov polynomials, Edge Theorem, Routh stability criterion, and root locus the stability analysis can be made. The proposed method is much more relaxed than that based on the common quadratic Lyapunov functions. Finally, numerical examples are given to demonstrate the feasibility and effectiveness of the proposed method.*
Keywords: Polynomial, Stability, T-S fuzzy system, Uncertain model

1. **Introduction.** Up to the present, fuzzy control has widely been used in a variety of practical industrial applications in the past decades. However, further analysis and discussion are still worth exploring in other aspects for continued development. Tanaka and Sugeno [1] showed that stability problem of a T-S model could be handled by finding a common positive definite matrix $\boldsymbol{P}$ from the quadratic Lyapunov equation. It is realized that this is a very important result, and a new milestone has been built. Subsequently, a lot of refinements and developments have been made [2-6]. In recent years, the stability of a T-S fuzzy system is discussed thoroughly, such as the report of Lian *et al.* [7]. They developed a guideline for the solvability of stabilization problem using LMI-based design by virtue of Kharitonov's theorem. Wang [8] proposed a stability condition by checking the maximum distance of two successive states according to the idea of the firing rule group. Tanaka [9] proposed a polynomial fuzzy model that is a more general representation of the well-known Takagi-Sugeno fuzzy model. They then derived stability conditions based on polynomial Lyapunov functions that contain quadratic Lyapunov functions as a special case. In a sense, the central issue lies in the search for a *common positive definite matrix* $\boldsymbol{P}$ *for multiple matrix equations*. The matrix $\boldsymbol{P}$ provides a sufficient condition based on the Lyapunov function for the stability of T-S fuzzy systems, but it is not a necessary condition for the stability of T-S fuzzy systems.

Thus, the major motivation is to explore the absolute stability of T-S fuzzy systems deeply. The method is enlightened by Lo [10], he provided a systematic stability analysis technique for fuzzy systems using well-established results from robust stability of a family of polynomials. Recently, some results of insight into a T-S fuzzy model were proposed [11]. Therefore, the present work is developed by a Routh test stability criterion as well as the root locus method to determine the stability of the nonlinear system approximated by a T-S fuzzy model.