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FEEDFORWARD PLUS FEEDBACK FUZZY ROBUST TRACKING CONTROL FOR A CLASS OF UNCERTAIN NONLINEAR SYSTEMS

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Abstract. *This paper presents a novel fuzzy tracking control method for the tracking problem of uncertain nonlinear systems. Based on T-S (Takagi-Sugeno) fuzzy description of uncertain nonlinear dynamics, the tracking error is studied. Without the need for augmented system, exponential stability of the tracking error can be obtained by a fuzzy feedforward controller. The main advantage lies in eliminating the demand for dimension increase, and reducing the conservativeness of methods involving an augmented disturbance. Another contribution of this work is that good performance of the tracking controller can be achieved by using H_∞ control and disk pole placement. The solutions to the robust fuzzy tracking controller can be obtained by applying linear matrix inequality tool and fuzzy logic theory. Simulation results demonstrate that the fuzzy feedforward control based technique can greatly improve the tracking speed and robust performance.*
Keywords: T-S fuzzy model, Uncertain nonlinear systems, Tracking control, Disk pole, H_∞ index, Feedforward control

1. **Introduction.** To an uncertain nonlinear system, stabilization control plays an important role. A main challenge is that many practical systems are high complex nonlinear dynamics, which requires nonlinear techniques while designing controllers. Fuzzy systems method has been proven to be useful to design controllers for these complex systems [7,14,16-20]. There are two common inference methods: Mamdani fuzzy and T-S fuzzy [9]. T-S fuzzy can compensate some shortcomings of Mamdani fuzzy in aspect of mathematical analysis, and its advantage is that a large class of nonlinear plants can be well represented by local linear models without the need to modify the original nonlinear dynamics in any significant way. In recent years, T-S fuzzy has been successfully applied in stabilization control of nonlinear systems [10-13], some resulting control problems can be easily solved by using LMI (linear matrix inequality) technique [1].

However, stabilization is not the only requirement in practical applications, how to realize the output tracking control for the controlled plants is always another big challenge [2,5,15,17,18]. Though T-S fuzzy tracking method based LMI is effective to nonlinear systems [2,5,15,18], its tracking performance is still hampered by two restrictions. Firstly, an augmented system including the controlled plant and a reference model is required [15,18], which increases the design difficulties and restricts its applications. Actually, in practical applications, a low-order controller is always desired, especially when fuzzy systems are approximating high-order nonlinear systems under a real-time mode. For example, when an nonlinear dynamics with six-state is considered, a twelve or eighteen-order augmented system should be required, then the whole control system may suffer the "curse of dimensionality" and becomes un-controllable. Secondly, in [15] and [18],