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SWITCHING T-S FUZZY MODEL-BASED GUARANTEED COST CONTROL FOR TWO-WHEELED MOBILE ROBOTS

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Abstract. *Based on the switching Takagi-Sugeno (T-S) fuzzy control theorem, this study investigates the position control for a developed differential-drive two-wheeled mobile robot (TWMR). The developed TWMR is introduced, followed by a description of the kinematic equations of the TWMR, which are represented by exact T-S fuzzy systems. The uncontrollable problem of the derived T-S fuzzy model is avoided by considering the switching section mechanism. The switching T-S fuzzy model is synthesized by a switching parallel distributed compensation. Moreover, a guaranteed cost control issue is considered to obtain proper control signals and improve state responses for the developed TWMR. A feasible controller is obtained by solving the derived linear matrix inequalities (LMIs). Finally, the proposed control law is implemented on the developed TWMR, demonstrating the effectiveness of the control design.*

Keywords: Two-wheeled mobile robot, Switching T-S fuzzy system, Guaranteed cost control

1. **Introduction.** Mobile robots have received considerable attention for academic and industrial applications, including such as security, home services, medical care, industrial manufacturing, transportation and business services. Wheeled mobile robots are characterized by their ability to move rapidly on flat surfaces. Therefore, this work investigates the position control in a differential-drive two-wheeled mobile robot (TWMR). Nonlinear controller design for TWMR has been extensively studied [1-8]. Recent efforts have attempted to control TWMR by using fuzzy control [9-14].

As an effective and simple control method, linguistic fuzzy control is often designed based on the experience of designers without considering the system model. However, the stability of a traditional linguistic fuzzy control system cannot be guaranteed by mathematical analysis. T-S fuzzy control is a reliable scheme to ensure the stability of a system. T-S fuzzy model-based control has been extensively explored in recent decades [15]. Tanaka and Sugeno verified the stability of a T-S fuzzy system by using a quadratic Lyapunov function $V(k) = \mathbf{X}^T(k)\mathbf{P}\mathbf{X}(k)$ [15]. System stability is guaranteed if a common positive definite matrix $\mathbf{P}$ can satisfy the Lyapunov inequalities with respect to the T-S fuzzy system. Lyapunov inequalities can be converted into linear matrix inequalities (LMIs), and then be solved efficiently by LMI tools. Parallel distributed compensation (PDC) is conventionally adopted control design for T-S fuzzy model-based stabilization. The corresponding Lyapunov inequalities for PDC design can also be converted into LMIs. LMI-based fuzzy control design and common matrix $\mathbf{P}$ can be solved simultaneously by LMI tools. Hence, LMI-based T-S fuzzy control is applied to numerous applications, such as inverted pendulum, truck, overhead crane, networks and TWMR [15-21].