

RESEARCH ARTICLE

Practical finite-time fuzzy control of uncertain nonstrict-feedback systems with actuator saturation and output constraints

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Summary

This article investigates the devise issue of a practical finite-time output-tracking control for uncertain nonlinear nonstrict-feedback systems subject simultaneously to time-varying output constraints (TVOC), actuator saturation, and bounded unmatched disturbances. An adaptive fuzzy approximator-based control system is devised using the dynamic surface control (DSC) concept. System output constraints are addressed by employing an appropriate barrier Lyapunov function. Adaptive fuzzy disturbance observers are constructed to practically deal with time-varying unmatched but bounded disturbances. It is verified via Lyapunov stability analysis and simulation experiments that all closed-loop signals remain bounded, the output tracking error practically converges in finite time to a tiny but adjustable neighborhood around the origin, and the system output stays within its required time-varying bounds.

KEYWORDS

fuzzy adaptive controller, fuzzy disturbance observer, input and output constraints, uncertain nonstrict-feedback system

1 | INTRODUCTION

Uncertainties commonly exist in real-world systems owing to modeling precision, parameter variations, and external disturbances. So, it is very important that they should be considered during the design of the control systems. As universal approximators, fuzzy logic systems (FLSs) and neural networks (NNs) have been widely employed to efficiently estimate unknown nonlinear functions and uncertainties.^{1,2} For some classes of unknown nonlinear systems with unmatched uncertainties, many fruitful results on the adaptive backstepping control problem based on FLSs or NNs have been obtained in recent years, for example, references 3–7. The closed-loop system stability has been carefully analyzed in these works via a Lyapunov method. In a different way from the works cited above, some scholars use nonlinear disturbance observers (NDOs) rather than universal approximators to deal with system uncertainties.^{8–13} Such observers make it possible to provide accurate disturbance (external perturbations + uncertain functions) estimates, which will be subsequently used in the control law.