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# Adaptive Finite-Time Neural Control for a Class of Pure-Feedback Nonlinear Time-Delay Systems with Unknown Virtual Control Coefficients

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## Introduction

In recent years, by using neural networks or fuzzy logic systems, approximation-based adaptive control approaches have been developed for uncertain nonlinear systems without satisfying the matching condition. This kind of methods has gradually been considered as a kind of effective way to solve the problem about nonlinear system control and modeling. At the meanwhile, the nonlinear systems with the un-measurable state variables have received more attention both from academic and industrial domains.

Moreover, compared with the classical stability, the finite-time stability has better performances, such as fast transient response, and more strong robustness. Therefore, many works have been widely carried out. These existing works motivate our research.

## Main Contributions

Inspired by the above observation and analysis, our research objective for this article is to further investigate output feedback finite-time adaptive control method for a class of pure-feedback nonlinear systems with time delays and unknown virtual control coefficients. Based on the finite-time stability theory and adaptive techniques, an observer-based adaptive neural finite-time control strategy is proposed, which can ensure the closed-loop system has the desired performance in finite time. In the process of observer design, the solvability of such a nonlinear matrix inequality is difficult to guarantee and is not easy to solve. The results presented in this paper transform the above problem into solving a set of linear matrix inequality. This improves the solvability of the problem and facilitates the use of Matlab toolbox for solving.

## Main Results

The finite-time output-feedback control scheme is proposed for the following systems with time delays.

$$\begin{cases} \dot{x}_i = f(\bar{x}_{i+1}) + d_i x_{i+1} + h_i(\bar{x}_i(\tau_i)) & 1 \le i \le n-1 \\ \dot{x}_n = f_n(\bar{x}) + u + h_n(\bar{x}_n(\tau_n)) \\ y = x_1 \end{cases}$$

Then using the adaptive backstepping, the virtual and real control signals can be expressed as follows:

$$\alpha_i = -\frac{1}{2a_i^2} z_i \hat{\theta}_i \bar{S}_i^T \bar{S}_i - k_i z_i^{2\gamma-1} \quad u(t) = -\frac{1}{2a_n^2} z_n \hat{\theta}_n \bar{S}_n^T \bar{S}_n - k_n z_n^{2\gamma-1}$$

Then the designed real control signal *u* can ensure that all the signals in the close-up systems can converge near the equilibrium point in a finite time.

## Figures

The simulation results are shown in the following figures.

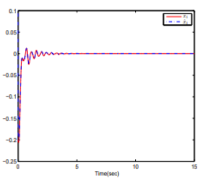

Fig.1: $x_1$ and $\hat{x}_1$.

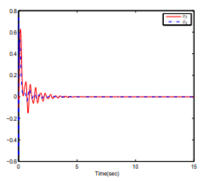

Fig.2: $x_2$ and $\hat{x}_2$.

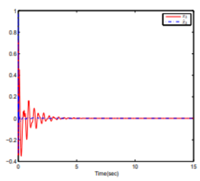

Fig.3: $x_3$ and $\hat{x}_3$.

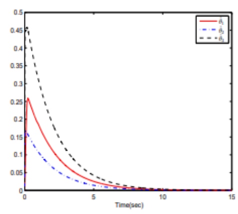

Fig.4: $\hat{\theta}_i$ (i=1,2,3).

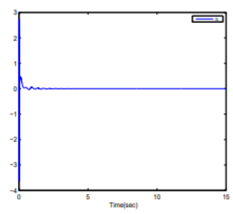

Fig.5: $u$ .

## Conclusion

The problem of adaptive neural finite-time control of pure-feedback nonlinear systems with time delays and unknown virtual control coefficients is discussed in this paper. Under the proposed control scheme, the boundedness of all the closed-loop signals can be guaranteed. Finally, the simulation example verifies the effectiveness of the proposed control method.