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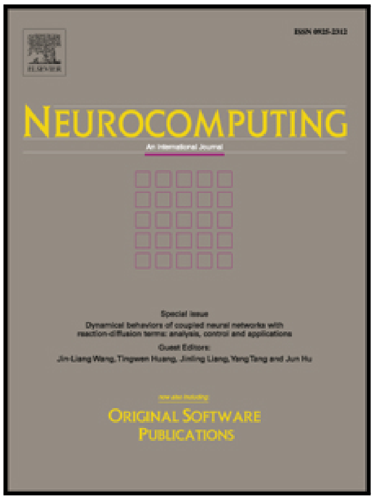

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Disturbance observer based adaptive neural control of uncertain MIMO nonlinear systems with unmodeled dynamics

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Abstract

This paper investigates the disturbance observer-based adaptive neural tracking control of a class of multiple-input multiple-output (MIMO) systems in the presence of unmodeled dynamics, system uncertainties, time varying disturbance and input dead-zone. An adaptive neural control method combined with backstepping technique and the radial basis function neural networks (RBFNNs) is proposed for the systems under consideration. In recursive backstepping designs, neural network (NN) is employed for uncertainty approximation. The disturbance observer is developed to provide efficient learning of the compounded disturbance which includes the effect of time varying disturbance, neural network approximation error. It is shown that by using Lyapunov methods, the developed control scheme can ensure semi-globally uniformly ultimately bounded (SGUUB) of all signals within the closed-loop systems. Simulation results are presented to illustrate the validity of the approach. This paper is novel at least in the two aspects: (1) disturbance observer based tracking control method is developed for MIMO nonlinear systems with unmodeled dynamics and (2) the strong coupled terms is considered in this paper where the interconnections are functions of all states, which is a more general form than existing related results.

Keywords: Adaptive backstepping control, Disturbance observer, Unmodeled dynamics, Input dead-zone, Radial basis function neural networks(RBFNNs)

1. Introduction

The problem of nonlinear is commonly resides in almost all real systems since many systems cannot be simplified into a linear model. Therefore, tremendous attention has paid on the control design of nonlinear systems during the past few decades. A variety of remarkable control approaches have been presented in the literature, including adaptive control[1–3], fuzzy control [4–6], fault tolerant control [7, 8] and intelligent control [9–11]. Among them, the adaptive backstepping technique as an effective control approach has undergone rapid development and played an important role in the control of nonlinear systems [1–3]. For a class of complex nonlinear systems with unknown functions, many control schemes were explored by combining adaptive control and functional approximators. It is konwn that neural networks and fuzzy-logic systems are proved to be effective approaches for controlling the highly uncertain nonlinear systems [12–23]. In general, neural networks or fuzzy systems are employed to estimate uncertain continuous nonlinear functions, to list a few, in [24, 25], the adaptive control based neural networks was developed for nonlinear systems with unknown virtual control coefficient functions. In [26], an effective neural network control is developed for Bimanual Robots systems with unknown uncertainties. In [20, 27], the research is extended to multiinput multioutput (MIMO) nonlinear systems. Alternatively, many researchers have been actively working on the fuzzy systems-based control design of uncertain nonlinear systems containing unknown functions [4, 28–31].

Input dead-zone problem exists in many real systems, their existences frequently deteriorates control performances and even result in the instability of the system. Therefore, the consideration on the control of nonlinear systems affected by input dead-zone has accepted increasing attention, and a variety of effective control methods have been proposed in [32–36]. In [33], the robust adaptive control is presented for a class of uncertain pure-feedback nonlinear systems with actuator dead-zones by using fuzzy methods. A class of nonlinear uncertain systems with dead-zone has been solved in the work [34], and the basic idea was to treat dead-zone as disturbance in a same way. Moreover, the author in [35] solved the chattering problems by proposing a smooth adaptive dead-zone inverse algorithm and a different adaptive compensation scheme for unknown dead-zone is derived in [36]. However, it is observed that the unmodeled dynamics is not seriously considered based on the aforementioned results.

On the other hand, the unmodeled dynamics and unknown external disturbance often exist in actual engineering, since the practical systems are almost impossible to describe precise mathematical models. Therefore, the consideration on the control of nonlinear systems with unmodeled dynamics has gained

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