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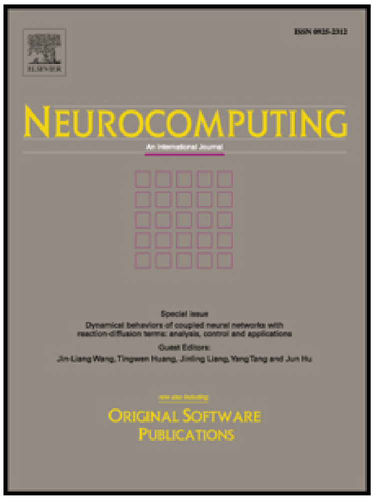

A novel neural optimal control framework with nonlinear dynamics: Closed-loop stability and simulation verification

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A novel neural optimal control framework with nonlinear dynamics: Closed-loop stability and simulation verification

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Abstract

In this paper, we focus on developing adaptive optimal regulators for a class of continuous-time nonlinear dynamical systems through an improved neural learning mechanism. The main objective lies in that establishing an additional stabilizing term to reinforce the traditional training process of the critic neural network, so that to reduce the requirement with respect to the initial stabilizing control, and therefore, bring in an obvious convenience to the adaptive-critic-based learning control implementation. It is exhibited that by employing the novel updating rule, the adaptive optimal control law can be obtained with an excellent approximation property. The closed-loop system is constructed and its stability issue is handled by considering the improved learning criterion. Experimental simulations are also conducted to verify the efficient performance of the present design method, especially the major role that the stabilizing term performed.

Keywords: Adaptive dynamic programming, adaptive system, learning control, neural network, optimal regulator, stability.

1. Introduction

As is known, linear optimal regulator design has been studied by control scientists and engineers for many years. For nonlinear systems, the optimal control problem always leads to cope with the nonlinear Hamilton-Jacobi-Bellman (HJB) equation, which is intractable to solve in general cases. Fortunately, a series of iterative methods have been established to tackle the optimal control problems approximately [1–3]. For adaptive/approximate dynamic programming (ADP) [3–9], the adaptive critic is taken as the basic structure and neural networks are often involved to serve as the function approximator. Generally speaking, employing the ADP method always results in approximate or adaptive optimal feedback controllers. Note that optimality and adaptivity are two important criteria of control theory and also possess great significance to control engineering, such as [10–16]. Hence, this kind of adaptive-critic-based optimal control design has great potentials in various control applications.

In the last decade, the methodology of ADP has been widely used for optimal control of discrete-time systems, such as [17–24] and continuous-time systems, like [25–32]. Heydari and Balakrishnan [18] investigated finite-horizon nonlinear optimal control with input constraints by adopting single network adaptive critic designs. Song et al. [19] proposed a novel ADP algorithm to solve the nearly optimal finite-horizon control problem for a class of deterministic nonaffine nonlinear time-delay systems. Mu et al. [21] studied the approximate optimal tracking control design for a class of discrete-time nonlinear systems based on the iterative globalized dual heuristic programming technique. Zhao et al. [22] gave a model-free optimal control method for optimal

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