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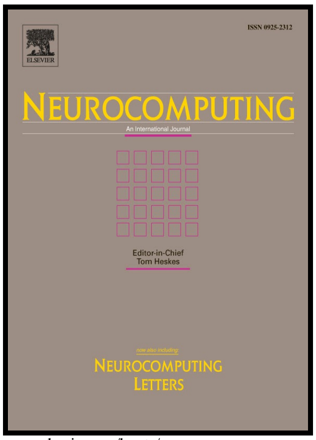

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Iterative GDHP-based Approximate Optimal Tracking Control for a Class of Discrete-time Nonlinear Systems ⋆

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Abstract

In this paper, an iterative globalized dual heuristic programming (GDHP) method is developed to deal with the approximate optimal tracking control for a class of discrete-time nonlinear systems. The optimal tracking control problem is formulated by solving the discrete-time Hamilton-Jacobi-Bellman (DTHJB) equation. Then, it is approximately solved by the developed iterative GDHP-based algorithm with convergence analysis. The iterative GDHP algorithm is implemented by constructing three neural networks to approximate the error system dynamics, the cost function with its derivative, and the control policy in each iteration, respectively. The information of the cost function and its derivative is provided during iteration calculation. Two simulation examples are investigated to verify the performance of the proposed approximate optimal tracking control approach.

Key words: Adaptive dynamic programming (ADP); approximate optimal tracking control; globalized dual heuristic programming (GDHP); neural networks; nonlinear systems.

1 Introduction

The tracking control problem aims to make system states follow specific reference trajectories, rather than stabilize system states at the origin. It is another significantly important topic in the control field, and has attracted more and more attention in recent years as it is often encouraged in the industrial applications [1–4]. Many classical control strategies have been investigated on this field based on the accurate system model, such as feedback control, variable structure control, back-stepping control and finite-time control [5–8]. However, the classical control approach requires that the system dynamics can be known and the relevant tracking controller is designed in terms of the system model. With the increased complexity of the systems, it is difficult to accurately model nonlinear systems. Based on this situation, the intelligent control becomes very promising and gradually promotes the control technology to a new stage.

In the scope of intelligent control, several methods, such as neural network control, support-vector-regression-based control, and fuzzy logic control, are utilized to deal with the control problem of nonlinear systems [9–16]. Although the intelligent control methods have been effectively applied to the control of nonlinear systems, most of these methods do not consider to product an optimal control policy. The optimal control of nonlinear systems is to solve the nonlinear Hamilton-Jacobi-Bellman (HJB) equation instead of the Riccati equation for the optimal control of linear systems [17–19]. Generally speaking, due to involve nonlinear partial difference equations, it is more difficult to obtain the solution of HJB equation than to obtain the solution of Riccati equation. The dynamic programming (DP) technology has been an admired technique to deal with optimal control problems for many years, however, due to the “curse of dimensionality”, it is often difficult to obtain optimal solutions by directly operating the DP method. In recent years, great attention has been paid to obtain approximate solutions of HJB equation. The approximate dynamic programming (ADP) approach has become one of popular methods [20–24].

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