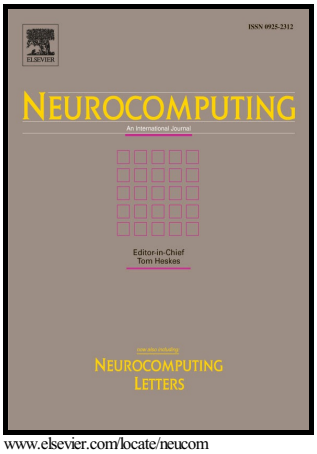

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Decentralized guaranteed cost control of interconnected systems with uncertainties: A learning-based optimal control strategy ☆

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Abstract

A novel learning-based optimal control approach is constructed to attain the decentralized guaranteed cost controller design for a class of continuous-time complex nonlinear systems with dynamical uncertainties and interconnections. This is performed by combining robust decentralized control formulation with adaptive critic learning technique. By expressing the interconnected subsystems as a whole system and introducing a new cost function for the overall plant, the decentralized guaranteed cost control problem is formulated as an optimal control problem for the nominal overall system. Then, a policy iteration based learning control algorithm is employed to solve the modified Hamilton-Jacobi-Bellman equation with respect to the nominal plant iteratively. A critic neural network is constructed to approximate the optimal state feedback control law and then the uniform ultimate boundedness stability issue is analyzed. Meanwhile, a simulation experiment is conducted to verify the good performance of the control approach.

Keywords: Adaptive dynamic programming; Decentralized control; Guaranteed cost control; Interconnected systems; Learning control; Neural networks; Optimal control; Uncertain plant.

1. Introduction

In many application areas, there always exist system uncertainties between mathematical models and real dynamics that may result in instability of the plants. The designed feedback control law should be robust for the dynamical uncertainties. The robustness and optimal control of complex systems have been paid attention by many researchers for a long time [1–10]. Actually, the significance of designing robust control law has been realized by researchers for several decades and many effective strategies have been proposed in literature. Fox example, Chen et al. [2] proposed an advanced robust trajectory tracking control method for multi-input and multi-output uncertain nonlinear systems subject to constrained inputs. Lin et al. [10] provided a novel approach to study the robust stabilization with optimal control framework and also led to a great attention of the optimal feedback control design.

In the past twenty years, the adaptive dynamic programming (ADP) methodology has been considered as one of the key directions for future researches on designing adaptive, learning, and intelligent systems [11]. Generally, it is conducted by nearly and iteratively solving the Hamilton-Jacobi-Bellman (HJB) equation using a function approximation structure (for instance, neural networks [11–17]). In this sense, the ADP method can be also called approximate dynamic programming or neural dynamic programming, so as to emphasize the great function of neural network approximation. Actually, the ADP and related researches, especially, reinforcement learning, have acquired much attention from scholars of many fields; see, e.g., [16, 17] and the numerous related references. Among those, the ADP methodology has

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