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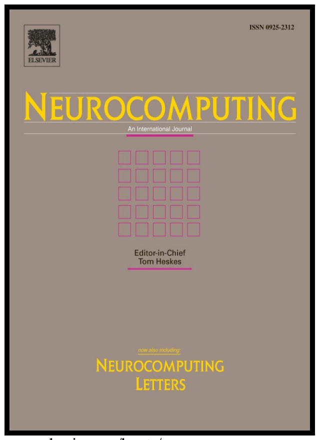


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# Discrete-time Optimal Adaptive RBFNN Control for Robot Manipulators with Uncertain Dynamics

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**Abstract**

In this paper, a novel optimal adaptive radial basis function neural network (RBFNN) control has been investigated for a class of multiple-input-multiple-output (MIMO) nonlinear robot manipulators with uncertain dynamics in discrete time. To facilitate digital implementations of the robot controller, a robot model in discrete time has been employed. The high order discrete-time robot model is transformed to a predictor form, and a feedback control system has been then developed without noncausal problem. The controller has been designed by an adaptive neural network (NN) based on the feedback system. The adaptive neural control system has been proposed by a critic RBFNN and an actor RBFNN to approximate a desired control and a strategic utility function based on the tracking error, respectively. To guarantee stability of the closed-loop robot system and obtain high-quality dynamic performance, rigorous Lyapunov analysis has been performed to establish uniformly ultimate boundedness (UUB) of closed-loop signals. Simulation studies indicate that the proposed control scheme performs better than other available schemes currently, for robot manipulators.

*Keywords:* Discrete-time system; Neural networks; Robot manipulator; Adaptive control; Dynamics uncertainties



## 1. Introduction

Robot manipulators are typically modelled as MIMO systems with high nonliearity, and they are usually subject to unmodelled dynamics and uncertainty [1, 2, 3]. Control signals of nonaffine nonlinear robot manipulators have nonlinear inputs with coupling effect,uncertain parameters and unknown nonlinear functions, and thus, it is still a challenging problem to design reliable control for general uncertain robot manipulators. With advances of robot technologies, application of manipulators in industry and other fields become increasingly popular, and the researches on control design for robot manipulators have attracted much attention, e.g., feedback linearization method [4, 5], sliding mode and other methods [6, 7, 8, 9], have all been extensively investigated for robot control systems. Furthermore, intelligent control methods have been well applied in robot control, e.g., adaptive control [10, 11], adaptive-fuzzy control [12], adaptive-sliding control [13], and adaptive-fuzzy-sliding mode control [14] for robot manipulators. In order to compensate for uncertainties caused by robot dynamics, adaptive neural network (ANN) researches have been extensively exploited, due to its capacity of online learning and universal approximation of smooth nonlinear functions in [15, 16, 17].

In recent years, adaptive RBFNN methods have been developed to be more powerful to deal with dynamics uncertainties that are more complex in practical application, In [18], an adaptive RBFNN algorithm based control guaranteeing stability of closed-loop system online, has been proposed for a robot manipulator system. In [19, 20], novel RBFNN estimator has been designed to compensate for the effects caused by dynamics uncertainties. These approaches are able to guarantee UUB stability of the closed-loop robot control systems, and their stability analysis has been well established in continuous time. At the same juncture, the digital implementation of robot controllers and network communication of high-speed computers are becoming increas-

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