Dynamics of Continuous, Discrete and Impulsive Systems
Series **B:** *Applications & Algorithms* **8 (2001)** 339-358
Copyright ©2001 Watam Press

REAL-TIME FINE MOTION CONTROL OF ROBOT MANIPULATORS WITH UNKNOWN DYNAMICS

Simon X. Yang[1] and Max Meng[2]

[1]ARIS (Advanced Robotics and Intelligent Systems) Lab
School of Engineering
University of Guelph, Guelph, Ontario N1G 2W1
[2]ART (Advanced Robotics and Teleoperation) Lab
Department of Electrical Engineering and Computer Science
University of Alberta, Edmonton, Alberta, T6G 2G7

Abstract. A novel neural network based approach is proposed for real-time fine motion control of robot manipulators without any knowledge of the robot dynamics and subject to significant dynamics uncertainties. The controller structure consists of a simple feed-forward neural network and a PD feedback loop, which inherits advantages from both the neural network based controllers and the traditional PD-type controllers. By taking advantage of the robot regressor dynamics, the neural network assumes a single-layer structure, and the learning algorithm is computationally efficient. The real-time fine motion control of robot manipulators is achieved through the on-line learning of the neural network without any off-line training procedures. The PD control loop guarantees the global stability during the learning period of the neural network. In addition, the proposed controller does not require any knowledge of the robot dynamics and is capable of quickly compensating sudden changes in the robot dynamics. The global system stability and convergence are proved using a Lyapunov stability theory. The proposed controller is applied to track an elliptic trajectory and to compensate a sudden change in the robot dynamics in real-time. The effectiveness and the efficiency of the proposed controller are demonstrated through simulation and comparison studies.
Keywords. Fine motion control, neural networks, dynamics uncertainty, robot regressor dynamics, real-time control, Lyapunov stability

1 Introduction

Fine control of robot manipulators in real-time is a very important but also difficult issue in robotics, especially when there is no knowledge of the robot dynamics and when sudden changes in the robot dynamics occur. There are many studies on manipulation robot control using various approaches (e.g., [1]-[26]). The traditional proportional and derivative (PD) controller is very simple and does not require any knowledge of the robot dynamics. However it requires very large actuation to achieve fine control, which is not practical but highly demanded in many cases [14, 15, 16]. The computed torque control approach is capable of achieving fine control. Nevertheless it requires the exact model of the robot dynamics, which is almost impossible in practice [14, 16]. Adaptive controllers (e.g., [20, 21, 14, 12, 3, 6]) can achieve fine control and compensate partially unknown manipulator dynamics. But,