International Journal of Innovative Computing, Information and Control
Volume **4**, Number **9**, September **2008**

ICIC International ©2008 ISSN 1349-4198
pp. 2235–2242

NEURAL NETWORK BASED ROBUST NONLINEAR CONTROL FOR A MAGNETIC LEVITATION SYSTEM

Chun-sheng Liu, Shao-jie Zhang, Shou-song Hu and Qing-xian Wu

College of Automation Engineering
Nanjing University of Aeronautics and Astronautics
29 Yudao Street, Nanjing, Jiangsu 210016, P. R. China
liuchsh@nuaa.edu.cn

Received June 2007; revised December 2007

Abstract. *In this paper, a robust nonlinear control approach is presented for a magnetic levitated ball system with uncertain parameters and external disturbance. Gaussian basis RBF neural networks are used to approximate the nonlinear uncertainties, a high-gain observer is used to estimate the ball velocity which cannot be measured. A fixed controller and an adaptive robust controller derived can guarantee that the closed-loop system is stable and robust; the desired position tracking performance is achieved when the system parameters change. Simulation results are provided to demonstrate the utility of the proposed method.*

Keywords: RBF neural networks, Magnetic levitation, Nonlinear system, Robust control, High-gain observer

1. **Introduction.** Because of their various uses such as frictionless bearings, high-speed maglev passenger trains, and vibration isolation of sensitive machinery, magnetic levitation control systems are receiving increasing attention in [1-3]. Based on a backstepping manner, a robust controller for a magnetic levitation system is proposed in [4]. Feedback linearization in combination with robust control technique is employed for the regulation of active magnetic bearings in [5]. Sliding mode control and dynamic surface control [6,7] are just a few examples of nonlinear control for magnetic levitation systems. But in these papers, the controllers require all the model parameters and the states are known. However, these conditions are too restrictive to be obtained in practical applications

In recent years, a considerable amount of effort has been made in the area of nonlinear systems, see [8-10,15] and references therein. Owing to their universal approximation, learning and adaptation abilities to handle our inexact knowledge about real world systems, neural networks are widely used, and revealed several improvements in many nonlinear control systems [11-13]. To the authors' knowledge, few neural networks control schemes have been done on nonlinear magnetic levitation systems.

Motivated by these considerations, a neural network-based robust nonlinear controller for a magnetic levitation system with uncertain model parameters as well as disturbance is proposed in this paper, and the measurability of the states is not required. RBF neural networks are used to approximate the nonlinear uncertainties; a high-gain observer is used to estimate the ball velocity. A fixed control law and an adaptive law are derived from Lyapunov stability analysis. Both system robustness and position tracking performance are achieved.

The organization of this paper is as follows. In Section 2, the nonlinear model for magnetic levitated ball system is presented. In Section 3, the control scheme based on the estimation states is derived, and the controller is composed of two parts, i.e. a fixed