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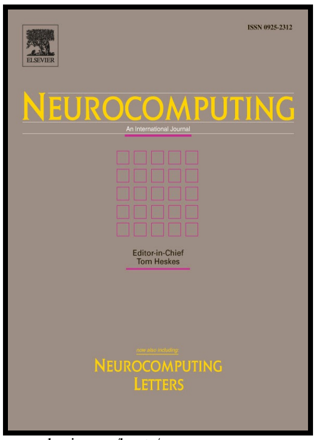

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Adaptive Robust Speed Control Based on Recurrent Elman Neural Network for Sensorless PMSM Servo Drives

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Abstract

In this paper, an adaptive robust control scheme based on recurrent Elman neural network (RENN) is proposed to achieve high-performance speed tracking despite of the existence of system uncertainties for the sensorless permanent magnet synchronous motor (PMSM) servo drive. Firstly, the dynamics of sensorless PMSM operated with the system uncertainties are described in details. Secondly, an adaptive RENN speed controller (ARENNSC) composed of an RENN controller and a compensated controller is developed to achieve the adaptive robust speed control of PMSM drive. The RENN controller is designed to imitate an ideal speed control signal for sensorless PMSM, and the compensated controller is designed to compensate an error between ideal control signal and actual RENN signal, including an RENN reconstruction error. The adaptive laws are derived based on Lyapunov theorem to ensure the stability of ARENNSC. Then, a calculation method of ideal learning rate is also presented to improve the adaptive performance of ARENNSC. The simulation results demonstrate the feasibility, robustness and good dynamic performance of the proposed adaptive RENN speed control scheme.

Keywords: Permanent magnet synchronous motor (PMSM), recurrent Elman neural network (RENN), adaptive, robust, reconstruction error, learning rate.

1. Introduction

Recently, the permanent magnet synchronous motors (PMSMs) have been widely used in a large number of automation control fields such as robots, computer numerically-controlled (CNC) machine tools and elevators due to its advantages of superior power density, maintenance-free operation and high controllability. The conventional PMSM servo drives need sensors such as an incremental encoder and a resolver to achieve the feedback of position and speed of the rotor. These sensors increase the cost and size while decreasing the reliability of drive. Therefore, the control methods without the position and speed sensor for PMSM have become popular research direction [1, 2, 3, 4, 5, 6, 7, 8].

The high-performance digital control of a motor requires the precise values of system parameters in each control cycle, especially in the case of sensorless control. However, the system uncertainties such as mechanical parameter variations, friction force, unmodeled dynamics and load disturbances can result in a considerable decrease about the control performance of PMSM. In order to enhance the dynamic performance and robustness of PMSM control system with uncertainties, many researchers have developed a variety of control methods such as adaptive control [9, 10], predictive functional control [11, 12, 13], disturbance observer based control [14, 15], robust control [16, 17], sliding-mode control [18, 19] and so on. However, these schemes suffer from some limitations. When the schemes are used to design the system controllers, the accuracy of controller output signals is largely influenced by the system uncertainties, thus the nonlinearity could not be achieved.

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