

Chapter 24

Fuzzy Neural Network Control for Robot Manipulator Directly Driven by Switched Reluctance Motor

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ABSTRACT

Applications of switched reluctance motor (SRM) to direct drive robot are increasingly popular because of its valuable advantages. However, the greatest potential defect is its torque ripple owing to the significant nonlinearities. In this paper, a fuzzy neural network (FNN) is applied to control the SRM torque at the goal of the torque-ripple minimization. The desired current provided by FNN model compensates the nonlinearities and uncertainties of SRM. On the basis of FNN-based current closed-loop system, the trajectory tracking controller is designed by using the dynamic model of the manipulator, where the torque control method cancels the nonlinearities and cross-coupling terms. A single link robot manipulator directly driven by a four-phase 8/6-pole SRM operates in a sinusoidal trajectory tracking rotation. The simulated results verify the proposed control method and a fast convergence that the robot manipulator follows the desired trajectory in a 0.9-s time interval.

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INTRODUCTION

There has recently been a considerable interest in developing efficient direct drive robot manipulator, because the elimination of gear boxes simplifies the construction of manipulators and removes sources of flexibility and nonlinearities, such as friction and backlash, which are known to cause difficulties in designing high-quality controls. Many motors, like conventional dc motor (Mohamed et al., 2004), brushless dc motor (Park et al., 2003), induction motor (Hsu et al., 2005), and switched reluctance motor (SRM) (Wallace et al., 1991; Spong et al., 1987; Chen et al., 2003; Amor et al., 1993; Bortoff et al., 1998; Milman et al., 1999), have been investigated in applications to direct drive manipulator, where the SRM is increasingly popular due to its simple structure, low cost and reliability in harsh environments. Moreover, the SRM can produce high torque at low speed, which is compatible with direct drive manipulator specifications.

SRM model, however, exhibits significant coupled nonlinear, multivariable, and uncertainty. Hence the classical linear control schemes cannot provide the required performances for high-precision position control.

The latest advances and engineering applications of cognitive informatics have gotten blooming achievements (Wang et al., 2010; Wang, 2009a, 2009b; Zhong, 2008). Artificial neural networks have been adopted extensively due to their abilities to achieve nonlinear mappings and fast autonomous learning, in a wide variety of domains, from modeling and simulation (Cai et al., 2011), rotor position estimation (Beno et al., 2011), classification of musical chords (Yaremchuk et al., 2008), sensorless control for a switched reluctance wind generator (Echenique et al., 2009), to robot control (Bu et al., 2009; Bugeja et al., 2009; Dierks et al., 2009, 2010; Ferreira et al., 2009; Hong et al., 2009; Hou et al., 2010; Tan et al., 2009; Wai et al., 2010; Wei et al., 2009; Zhao et al., 2009).

It can be seen that the neural network provides an effective approach to wide range of complex practical issues. Of course, the SRM control gets a big benefit of the neural network. Nevertheless, the conventional neural network may produce a degraded control performances when the existence of uncertainties. The fuzzy neural network (FNN) will overcome this disadvantage, because it possesses the merits of both fuzzy systems (e.g., humanlike rules thinking and ease of incorporating expert knowledge) and neural networks (e.g., learning and optimization abilities, and connectionist structures) (Wai, 2002). In this way, one can bring the low-level learning and computational power of neural networks into fuzzy systems and also high-level, humanlike rule thinking and reasoning of fuzzy systems into neural networks. Thus, the FNN-based control techniques have represented an alternative method to deal with uncertainties of the control system in recent years (Hu et al., 2006; Liu et al., 2006; Lachman et al., 2004). Reference Liu et al. (2006) employed a fuzzy logic-based neural network to establish the dynamic inversion of biped robots to compensate the complex nonlinearity. The neuro-fuzzy model of SRM in Lachman et al. (2004) used the adaptive neuro-fuzzy inference system techniques, which provided a method for the fuzzy modeling procedure to learn information about a data set, in order to compute the membership function parameters that best allow the associates fuzzy inference system to track the given input/output data. Reference Hu et al. (2006) combined the sliding mode control and the neural-network control with different weights, which were determined by a fuzzy supervisory controller, in its application to two-link manipulator with the presence of both structured and unstructured uncertainties.

The contribution of this paper is to present a FNN control method for robot manipulator directly driven by an SRM. The organization of the paper is as follows. In *Section Robot Manipulator*, we establish the model of robot manipulator directly driven by an SRM. In *Section FNN-based Torque*

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