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Fast Controlling Induction Motor Speed Estimation Using Neuro-Fuzzy

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ABSTRACT

Speed control performance of induction motors are affected by parameter variations and non linearity in the induction motor. This paper introduces a novel adaptive speed control of induction motor drives using Neuro-Fuzzy. Speed estimation method for control of induction machine drive has gained increasing interest among the research communities. The supremacy of an induction machine drive depends on the speed estimation accuracy. To ensure accurate speed estimation over a wide range, from zero to high levels exceeding the rated speed, accurate values of the machine's parameters, the aim of the simulation proposed control is to improve the performance and robustness of the induction motor drives under non linear loads and parameter variations. Both the design of the fuzzy controller and its integration with neural network in a global control system are discussed. Simulation results shown excellent tracking performance of the proposed control system, and have convincingly demonstrated the usefulness of the neuro-fuzzy controller in high performance drives with uncertainly

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INTRODUCTION

Three phase induction motor is, devices widely used in the industrial world. Induction motor has several parameters that are non-linear, especially the rotor resistance, whose value varies for different operating conditions. This cause the settings on the induction motor is more complex than AC motors. Solution induction motor control has the features of precise and quick torque response. In the mid eighties have been recognized to be a viable solution to achieve these requirements (Miloudi, A, Al radadi, E.A Draou., 2007; A. Miloudi, E.A.A Radadi, A. Draou and Y. Miloud., 2004; P. P. Cruz, J. M. Aquino and M. R. Elizondo., 2004; S. Kaboli, M. R. Zolghadri, E. Vahdati-khajeh, A. Homaifar., 2005; M. N. Uddin and Hao Wen., 2004). In the neural fuzzy scheme (Miloudi, A, Al radadi, E.A Draou., 2007) (Fig. 3), the electromagnetic torque and flux signals are delivered to two hysteresis comparators.

The corresponding output variables and the stator flux position sector are used to select the appropriate voltage vector from a switching table which generates pulses to control the power switches in the inverter (A. Miloudi, E. A. Al Radadi, A. Draou, Y. MI loud., 2006). This scheme presents many disadvantages (variable switching frequency - violence of polarity consistency rules - current and torque distortion caused by sector changes - start and low-speed operation problems - high sampling frequency needed for digital implementation of hysteresis comparators) (M. N. Uddin and H. Wen., 2004; S. Kaboli, M. R. Zolghadri, E. Vahdati-khajeh, A. Homaifar., 2005; Abolfazl Vahedi, Farzan Rashidi., 2008; M.L. Benloucif, and H. Balaska., 2006; M.N. Uddin and Hao Wen., 2004). To eliminate the above difficulties, Neuro Fuzzy Control scheme (NFCS) has been proposed (M. N. Uddin and Hao Wen., 2004).

This scheme uses a controller based on an adaptive NF inference system (B.P. McGrath, D.G., Holmes and T. Meynard., 2006; Rajesh Kumar, R.A. Gupta, 3Rajesh S. Surjuse., 2008; S. Kaboli, M.R. Zolghadri, E. Vahdati-Khajeh., 2007) together with a space voltage modulator to replace both the hysteresis comparators and the switching table.

The Adaptive NF inference system controller combines fuzzy logic and artificial neural networks to evaluate the reference voltage required to drive the flux and torque to the demanded values within a fixed time period [4]. This evaluation is performed using the electromagnetic torque and stator flux magnitude errors together with the stator flux angle. This calculated voltage is then synthesis using Space Vector Modulation (SVM). To generate the desired reference voltage using this scheme, the Adaptive NF inference system controller acts only on the amplitude. A proposed modification of this scheme is to design a Adaptive NF inference system controller to act

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on both the amplitude and the angle of the reference voltage components. All the schemes cited above use a PI controller for speed control.

The use of PI controllers to command a high performance direct torque controlled induction motor drive is often characteristic by an overshoot during start up control. The use of PI controllers to command a high performance direct torque controlled induction motor drive is often characteristic by an overshoot during start up.

This is mainly caused by the fact that the high value of the PI gains needed for rapid load disturbance rejection generates a positive high torque error (S. Kaboli, M. R. Zolghadri, E. Vahdati-khajeh, A. Homaifar., 2005). This will let the DTC scheme take control of the motor speed driving it to a value corresponding to the reference stator flux. At start up, the PI controller acts only on the error torque value by driving it to the zero borders. When this border is crossed, the PI controller takes control of the motor speed and drives it to the reference value. To overcome this problem, we propose the use of a variable gains PI controller (VGPI) (M.L. Benloucif, and L. Mehenaoui., 2005). A VGPI controller is a generalization of a classical PI controller where the proportional and integrator gains vary along a tuning curve. In this paper, a variable gain PI controller is used to replace the classical PI controller in the speed control of a modified direct torque neural fuzzy controlled induction machine drive where the ANFIS of the DTNFC acts on both the amplitude and the angle of space vector components (Mohamed-Lamine Benloucif., 2009).

Proposed Neuro-Fuzzy Controller:

Fuzzy logic and artificial neural networks can be combined to design a direct torque neural fuzzy controller. Human expert knowledge builds an initial artificial neural network structure whose parameters could be obtained using online or offline learning processes. The adaptive NF inference system (ANFIS) (M. Zerikat, M. Bendjebbar and N. Benouzza., 2005; B.P. McGrath, D.G. Holmes and T. Meynard., 2006; M.N. Uddin and H. Wen., 2004) is one of the proposed methods to combine fuzzy logic and artificial neural networks. The use of PI controllers to command a high performance direct torque controlled induction motor drive is often characterized by an overshoot during start up. This is mainly caused by the fact that the high value of the PI gains needed for rapid load disturbance rejection generates a positive high torque error which will cause the speed to go beyond its reference value. When the torque error value crosses the zero borders due to the action of the PI controller, the speed of the motor begins to decrease towards its reference value. Which is rotating at the synchronously speed, can be simply described by the following nonlinear differential (S. Kaboli, M. R. Zolghadri, E. Vahdati-khajeh, A. Homaifar., 2005).

$$\frac{d}{dt} \begin{bmatrix} i_{ds} \\ i_{qs} \\ \psi_{rd} \\ \psi_{rq} \\ \omega_r \end{bmatrix} = \begin{bmatrix} \frac{-R_s L_r^2 - R_r L_m^2}{\sigma L_s^2 L_r} & \omega_r & \frac{R_r L_m}{\sigma L_s^2 L_r} & \omega_r & \frac{L_m}{\sigma L_s^2 L_r} \\ \frac{-R_s L_r^2 - R_r L_m^2}{\sigma L_s^2 L_r} & -\omega_r & \frac{R_r L_m}{\sigma L_s^2 L_r} & -\omega_r & \frac{L_m L_m}{\sigma L_s L_r \sigma L_s L_r} \\ -\frac{R_r L_m}{L_r} & 0 & -\frac{R_r}{L_r} & -(\omega_s - \omega_r) & 0 \\ 0 & \frac{R_r L_m}{L_r} & -(\omega_s - \omega_r) & -\frac{R_r}{L_r} & 0 \\ \omega_r & 0 & \frac{L_m}{p J L_r} (\psi_{rd}^2 - \psi_{rq}^2) - \frac{1}{3} T_l & 0 & 0 \end{bmatrix} + \begin{bmatrix} \frac{L_s V_{sd}}{\sigma L_s L_r} \\ \frac{L_s V_{sq}}{\sigma L_s L_r} \\ 0 \\ 0 \\ 0 \end{bmatrix} \quad (1)$$

Where $\sigma = 1 - \frac{L_m^2}{L_s L_r}$ (2)

i_s, v_s, s, y, R, L denote the stator current and voltage vector components, the rotor flux linkage, resistance and inductance respectively. The subscripts s and r stand for stator and rotor, d and q are the components of a vector with respect to a synchronously rotating frame. ω_e, ω_r are the angular speed of coordinate system and the angular speed of rotor shaft respectively. σ is the dispersion coefficient, p denotes the number of pole pairs, J is the total

rotor inertia and T1 is the load torque. The induction motor space vector model is derived from the basic electrical equations describing each of the stator windings and each of the rotor windings. The stator windings equations are given in (3) where u_{as} , u_{bs} and u_{cs} are the phase voltages, i_{as} , i_{bs} and i_{cs} are the phase currents,

$$U_{as} = R_s i_{as} + \frac{d \psi_{as}}{dt} \tag{3}$$

$$U_{bs} = R_s i_{bs} + \frac{d \psi_{bs}}{dt} \tag{4}$$

$$U_{cs} = R_s i_{cs} + \frac{d \psi_{cs}}{dt} \tag{5}$$

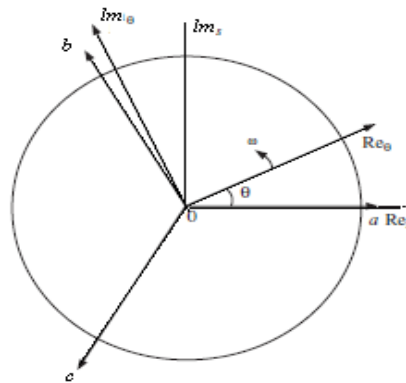


Fig. 1 : Stator reference frame Induction

Neural network controllers are designed using Multilayer Perception Neural network error Back propagation type. Neural network structure used in as shown in Figure 3. Network has the two layers namely the output of the set point input and output of the system response, a single layer as output control signals and one or more hidden layers. The number of layers, which are used as much as two layers by using two types of neurons, is 20 neurons and 50 neurons. Activation function used for input and hidden layer is sigmoid logarithmic whereas the output neurons use linear activation functions.

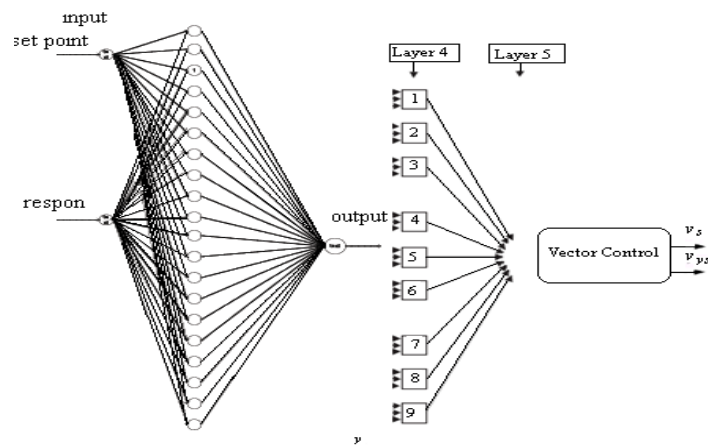


Fig. 2: Structure Controller Neural Network

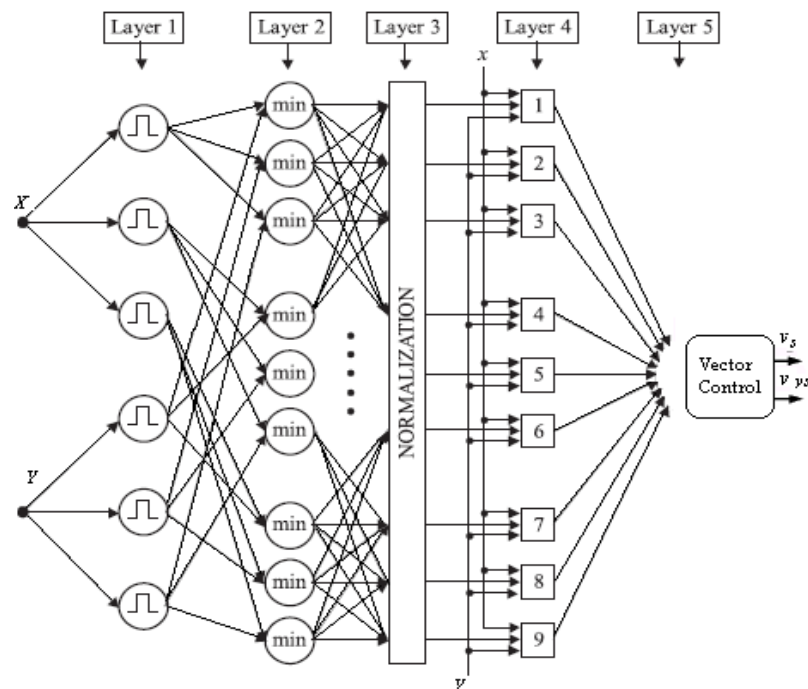


Fig. 3: Neuro - Fuzzy Structure Controller

Parameter of Induction Motor in Neuro – Fuzzy:

A method of using neural fuzzy to interpret current of induction motor for its stator condition monitoring was presented. Correctly processing these current signals and inputting them to a neuro - fuzzy decision system achieved high diagnosis accuracy. There is most likely still room for improvement by using an intelligent means of optimization. We can see parameter the induction motor in table 1.

Table 1: Parameter Of Induction Motor

Rated Parameters of the Induction Motor Under Test		
Rated Values	Power	4 kW
	Frequency	50 Hz
	Voltage	220/380 V
	Current	15/8.6 A
	Speed	1440 rpm
	Pole Pair	2
	Resistance stator (Rs)	7.13 ohm
	Resistance rotor (Rr)	8.18 ohm
	Reactance stator	9.45 ohm
	Reactance rotor	9.45 ohm
	Reactance together	189.65 hm

Result Of Experimental Simulation:

Simulations made using Simulink and m-file from MATLAB 7. Based on the results modeling of an induction motor with the dq model has done so for the model simulation induction motor in Simulink as shown in Figure 3. Motor parameters obtained from the measurement of induction motor carried out into MATLAB with the induction using m-files.

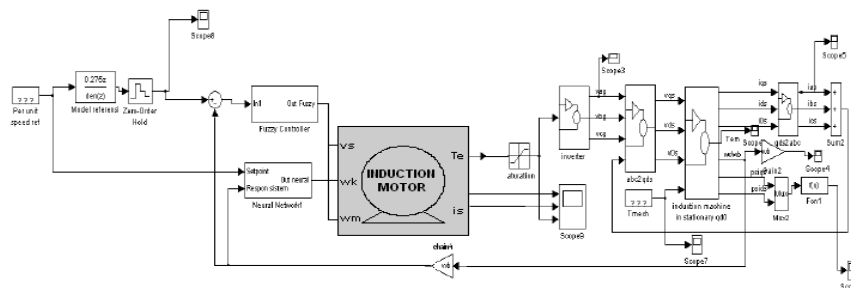


Fig. 4: Control Induction Motor Based Neuro-Fuzzy

In this simulation scenario the Induction motor follow parameter from that motor. The estimated values of direct rotor flux and load torque also track their measured values more closely throughout the operation range.

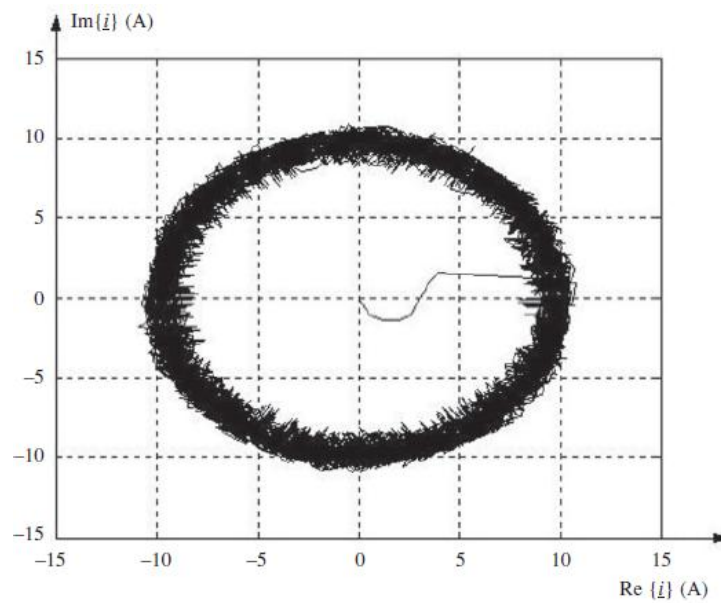


Fig. 5: Space Vector Induction Motor

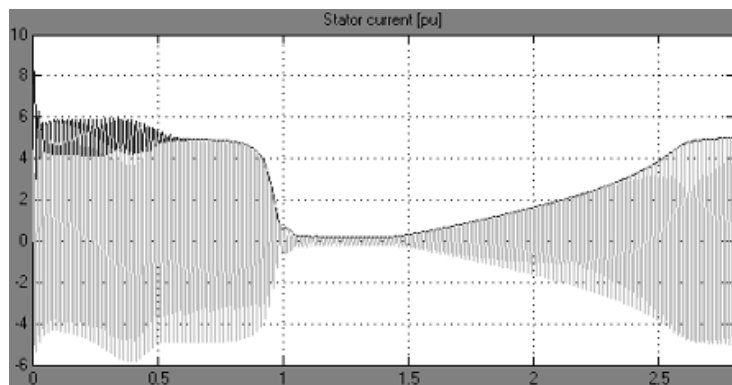


Fig. 6: Stator Current from Induction Motor Based Neuro-Fuzzy

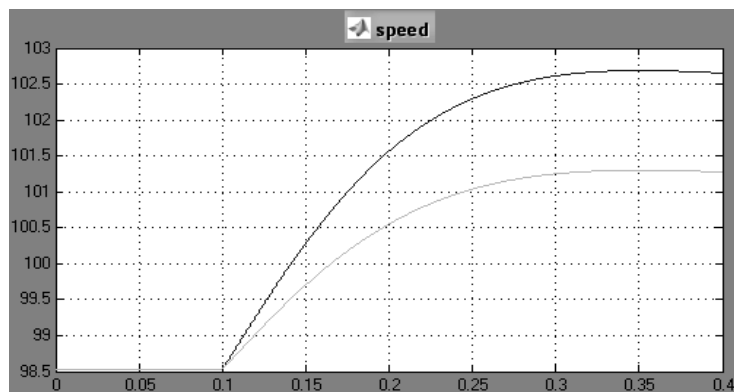


Fig. 7: Speed control Using Neuro-Fuzzy

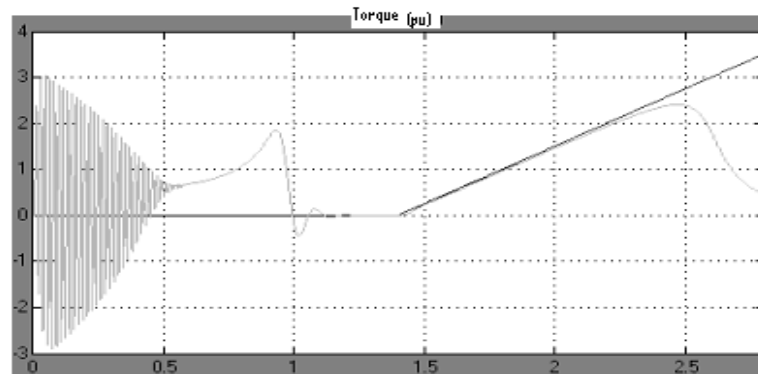


Fig. 8: Torque from Performance Induction Motor

In the Figure 6, 7, and 8, showed the stator current, speed, and torque currents of induction motors using system Neural Fuzzy, where everything is quite stable when compared to using other systems.

Conclusion:

Based on the results of simulation and analysis of induction motor speed control system in a centrifugal machine using neuro-fuzzy controller, it can be concluded:

- a. In the simulation of neuro-fuzzy controller without the expense that generated the response speed depends on the number of neurons used.
- b. At no-load conditions, controller with 50 neurons produce the most rapid settling time that is equal to 2.48 seconds, while the steady state error by using the smallest controller with 20 neurons by 0.3%. Application of neuro-fuzzy controller does not cause the maximum overshoot in the system.
- c. In the simulation of neuro-fuzzy controller by providing the load change to maintain exact speed controller set point. In the controller 50 neurons have faster recovery time with the smallest steady state error of 0.13%.

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