Design and Testing Neuro Networks Control System for Direct Current Machine

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الملخص

تقدم الورقة طريقة تحكم ذكية تكيفية للتغلب على تأثيرات بعض العوامل غير المحددة وغير الملموسة التي يعاني منها محرك التيار المستمر. نستخدم شبكات عصبية ثلاثية الطبقات من خلال خوارزمية ((backpropagation (BP) لتحقيق تكتيكات التحكم الضبابي. نستخدم وحدة الخلايا العصبية من خلال التعلم الديناميكي لخوارزمية Hebb لتحقيق آلية التكيف. تعتمد المحاكاة على مجموعة أدوات MATLAB للشبكات العصبية مع simulink. تظهر نتائج المحاكاة أن طريقة التحكم الذكي التكيفية تمكن النظام من الحصول على أداء ديناميكي واستقرار جيد. تعمل الطريقة المقترحة على تطوير استخدام المحاكاة في مجال المحرك الكهربائي للتحكم التكيفي الذكي.

Abstract

The paper presents an adaptive intelligent control method to overcome effects of some indeterminate and undealt factors that a DC. drive is suffered. In the speed loop, we use a three-layer neural networks through a backpropagation (BP) algorithm out of line learning to realize the fuzzy-control tactics. We use unit neuron through Hebb algorithm on-line dynamic learning to realize adaptive mechanism. The simulation is based on a MATLAB neural networks toolbox with simulink. The results of the simulation show that adaptive intelligent control method enables the system to have good dynamic and stability performance. The proposed method develops the use of simulink in the field of electrical drive of adaptive intelligent control.

***Keywords**: DC motor, neural networks, and adaptive control.*

1. Introduction

The performance of a DC drive system is effected by some indeterminate and undeal factors, for example, the changes of moment of inertia, the change of amplificative multiple for controlled object and driving device, etc [1]. How does the Controller automatically change self-parameters to keep good performance of a system? One of many methods is to use adaptive intelligent control. In order to check correctness and effectiveness of the scheme, we use simulation experimentation. The senior languages BC or VC can be used for our simulation. Also, we can use MATLAB directly for simulation. The paper uses MATLAB6.0 to realize Simulation.

2. Scheme Design of Adaptive Intelligent Control

2.1 Adaptive Intelligent Control System

The construction of adaptive intelligent control for a DC drive system is shown in Fig.1.

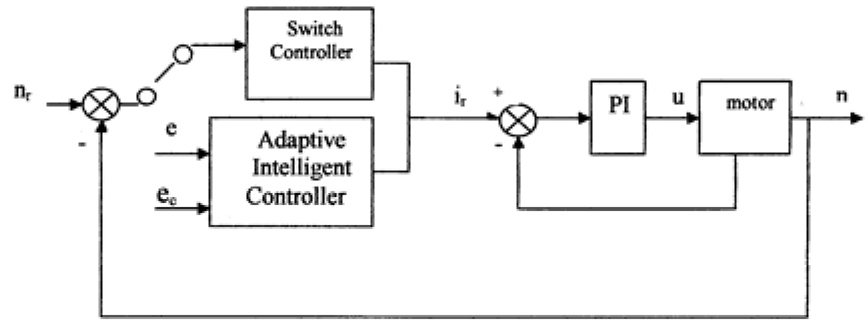

fig.1 DC drive System of adaptive intelligent control

Where, PI is the current regulator controller, the speed regulator is Combined by adaptive intelligent controller with switch controller. When the motor is in starting stage, the switch controller acts on. After the speed reaches a given value, adaptive intelligent controller acts on.

2.2 The Construction of Adaptive Intelligent Controller

The construction of adaptive intelligent controller is shown Fig.2.

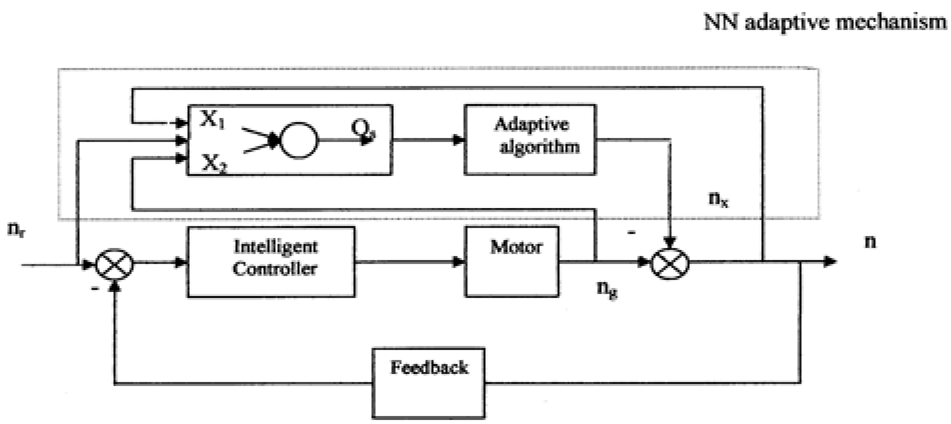

fig.2 Construction of adaptive intelligent controller

Where, intelligent controller is realized by fuzzy-neural networks controller (FNC),the adaptive mechanism consists of the neuron predictor, model-distinguish and adaptive algorithm.

2.3 Design of Adaptive Intelligent Controller

2.3.1 *intelligent controller*

Intelligent controller uses a three-layer front neural networks of 3-4-1 construction. Two inputs are the speed deviation (e) and the rate of the deviation (e_c). The output is current-giving value i_r. The neural networks determine their weight values through the BP algorithm out-line learning. The training data of neural networks are determinated by the system specifications of following performance and resist-disturbance performance through fuzzy control rules.

2.3.2 *Adaptive Mechanism*

Adaptive mechanism is the most characteristic part of all links for a DC drive system. Its main function is that the system can automatically change self-parameters and control rules to maintain high performance [2]. For example, if moment of inertia is changed in a large scope, or mathematical models of controlled object is changed, output speed keeps unchanged. This function is not able to realize if only depends on the control of front-series controller (intelligent controller). Because the summarization and inference of mankind experience, dividing language variables into group, selecting membership function of language variables, learning of neural networks, etc. Cannot avoid having large or small errors, during design and realization of intelligent controller. Therefore, control rules of intelligent controller cannot suit controlled object. After introduced neuron adaptive mechanism, as the system operates, the models-distinguish is more and more approximative controlled object. Control rules are also modified more and more suitale to controlled object. So that, the system itself is able to regulate to satisfactory working condition [3].

Since adaptive mechanism uninterruptedly distinguishes controlled object on-line during system operating, selecting the construction of neural networks is required to suit working performance on line learning and to learn fast. Therefore, the system uses the neuron dynamic learning to realize distinguishing function on line. The construction of neuron predictor and model-distinguish is shown in Fig.3.

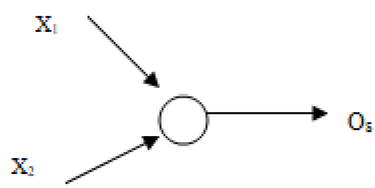

Fig.3. Neuron of adaptive mechanism

Where:

x_1, x_2: are the inputs of the neuron

O_s: is the output of the neuron.

We use linear simulative function. Its slope equals 0.1; its characteristic can be represented as:

$$\left.\begin{aligned} &O_s=0.1(w_1x_1+w_2x_2) \\ &\text{if } O_s>1 \text{ then } O_s=1 \\ &O_s<-1 \text{ then } O_s=-1 \end{aligned}\right\} \quad (1)$$

Because the neuron of adaptive mechanism needs uninterruptedly learn on-line during system operation. The Hebb algorithm was selectd as a learning supervisory algorithm.

$$\left.\begin{aligned} \Delta w_2 &= \eta_2(d-O_s)x_2O_s \\ \Delta w_1 &= \eta_1(d-O_s)x_1O_s \\ w_1 &= w_1+\Delta w_1 \\ w_2 &= w_2+\Delta w_2 \end{aligned}\right\} \quad (2)$$

Where: d is ideal output of the neuron i.e. teaching signal;η_1,η_2 are learning factor.

The following equations describe the learning factors:

Working process is divided into distinguishing and modifying processes. For example, during the k order distinguishing process, input sample of the neuron is the speed $n_g(k-1)$ without adaptive control and the speed n(k-1), expectance output is the speed n(k). We use [n_g (k-1), n(k-1), n(k)] as training samples and use supervisory Hebb learning algorithm to realize dynamic study. In equations (1) and (2), we use $x_1=n_g(k-1)$, $x_2=n(k-1)$, d=n(k) instead. After dynamic learning, we can get modified weight values w_1 and w_2. Thus, the information of mathematic a models about controlled object are kept in these weight values.

Modifying process is divided into two stages. Thus are predictive stage and error reverse-transfer stage, (or adaptive algorithm stage). For example, in predictive stage of the k order the neuron is in positive calculating condition

$n(k+1) = 0.1[w_1 n_g(k) + w_2 n(k)]$ (3)

Where: $n_g(k)$ is output of front intelligent controller; $n(k)$ is the k-order speed output of the system.

In error-reverse transfer stage the output of adaptive mechanism is determinated according to predictive error between predictive speed $n(k+1)$ and speed giving value n_r.

$n_x = -0.1(O_s - d)\, w_1$ (4)

Where: $O_s = n(k+1)$, it is predictive value,

$d = n_r$, it is speed giving value.

The final output of the K-order for adaptive intelligent controller is the sum of the k-order control value for front intelligent controller and the k-order output of adaptive mechanism.

$n(k) = n_g(k) + n_x$ (5)

In summary, neural networks adaptive mechanism regulates control rules according to modifying the output of front intelligent controller. Thus, the design of adaptive intelligent controller is completed well.

3. Simulation for realizing control tactics

The requirement of dynamic performance for a DC drive system is to be as high as the development of science and technology. Thus, modern control technology is widely used in the field [4]. Consequently, the paper uses adaptive intelligent control. The Simulink and neural networks toolbox based on MATLAB6.0 plat form provide better environment for building models and simulation of complex and high-performance dynamic system.

3.1 Simulation Construction Drawing

A block diagram of the system simulation construction drawing of adaptive intelligent control in simulink is shown in Fig.4.

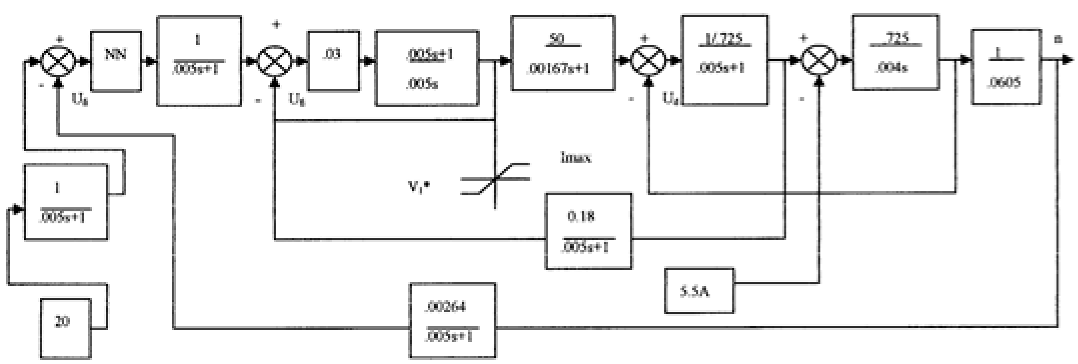

Fig.4 System simulation construction drawing

Building adaptive intelligent controller needs to design through neural networks toolbox and transfers into the model block in simulink environment [5]. First, we use net= newff function to build three-layers front Bp networks of an intelligent controller, then we sequentially need to use net. train Parma. goal to establish training objective error, to use net=init (net), net=train (net, p, t) (where p,t is input and output sample vector data) to train neural networks. After finishing training,

we use sim function and sample data to simulate trained neural networks. Finally, we use gensim function to transfer designed object of neural networks into simulink type.
In the same way, we can build the neuron of adaptive mechanism and transfer it into simulink type. Then, we take simulink types of intelligent controller and adaptive mechanism to build subsystem in simulink , as neural networks model unit in Fig.4.

3.2 Simulation Results

We carried out the simulation corresponding to general PI control and adaptive intelligent control for speed controller under the following situations: Motor parameter (as the resistance) changes from Ra to (1+10%) Ra, supply voltage changes from rated value U_N to 50% U_N, the load of the motor suddly changes from zero to rated value, speed giving value equals 3800rpm.
One Part of simulation curves are shown in Fig.5 and Fig.6

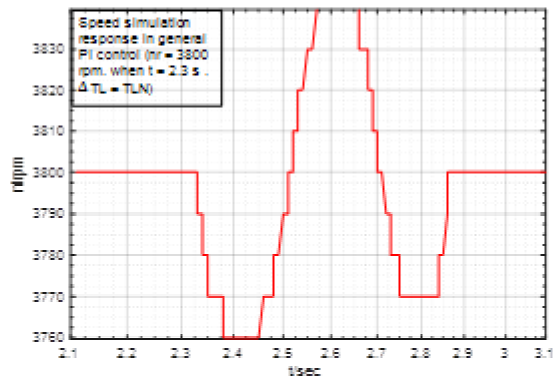

Fig.5. Speed simulation response in general PI control (n_r = 3800 rpm, when t = 2.3 s , $\Delta T_L = T_{LN}$)

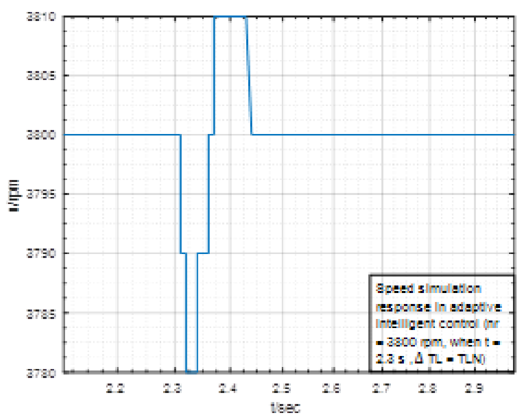

Fig.6. Speed simulation response in adaptive intelligent control (n_r = 3800 rpm, when t = 2.3 s , ΔT_L = T_{LN})

Table 1 shows a comparison between PI control and adaptive intelligent control

Table 1. Anti-interference Performance Comparison

	PI control		**Adaptiv Intelligent control**	
	ΔCmax(rpm)	**t_f (s)**	**ΔCmax(rpm)**	**t_f (s)**
ΔTL = TLN	**28 rpm**	**0.49**	**9**	**0.19**
ΔUd = ½UN	**10.36 rpm**	**0.49**	**4**	**0.1**

Where: ΔC_{max} is maximum dynamic speed drop, t_f is recovery time

The results of the simulation show that the speed of the motor can be kept in stability level when operating conditions of the motor change. After, we use adaptive intelligent control. The system has better adaptive stability.

The reason behind that is in PI control the parameters of speed regulator cannot be changed with the changes of operating condition. While, in adaptive control they can automatically change. Because neural network has this function which were trained before they are used as speed regulator. Except for this reason, attached component nx (refer to fig.2) can compensate the change of the speed deeply.

4 Conclusion

In this paper, neural networks toolbox and a simulink are combined to successfully carry out the simulation of an adaptive intelligent control method for a DC motor drive system.

The results of the experiments conducted in this research show that the adaptive intelligent control method used in a DC motor drive system has a high performance and the system keeps in a steady-state.

5 Reference

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