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Study on Shearer Control System based on Fuzzy RBF Neural Network

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Abstract

Through the analysis of the electrical characteristics of the shearer motor, the shearer motor is constructed as the transfer function of the controlled object. The performance of fuzzy RBF neural network control is verified by simulation experiments. The results show that the control method has a good effect on the adjustment of the shearer control system, and the system response time is greatly reduced.

Keywords

Shearer; Fuzzy RBF Neural Network; Simulink.

1. Preface

Because of the complexity of geological conditions and coal rock conditions when the shearer is working underground, it is very difficult to control the shearer motor speed at an appropriate value. Under the current technical conditions, the control of the shearer is mainly realized by manual control or automatic control system, but the system's feedback of the random quantity of the collected coal and rock characteristics cannot form a specific corresponding relationship, which leads to the automatic control system is not reliable enough in the field operation, or largely depends on manual control. The advantage of the fuzzy RBF neural network control system is that it can realize the accurate control of the nonlinear controlled object when it is unable to build a certain mathematical model of the controlled object. This paper designs a control system based on fuzzy RBF neural network to improve the control effect and response speed of shearer.

2. Build the Shearer Motor Model

If the coal and rock conditions, cutting power, mining technology and other conditions are certain during the operation of the shearer, the driving speed of the shearer and the power of the motor will maintain a linear relationship. At this time, we can adjust the speed of the motor to achieve the goal of the shearer. In the actual control process of the shearer, the speed of the shearer is controlled by controlling the input current, and the working state of the shearer can be judged by the actual current of the shearer. If the shearer operates at a fixed power when cutting, it needs to adjust its speed frequently to adapt to different coal and rock conditions, so the accuracy and stability of cutting cannot be guaranteed. In order to solve this problem, we changed the power of the shearer motor from a fixed value to 0.8~1.2 times of its rated power, and the system will automatically control the motor speed according to the actual situation.

In the design of shearer motor control system, the difficulty is that the load, input and feedback signals are variable, which determines that the requirements for motor control accuracy and speed are very high. Therefore, on the basis of traditional PI control, this paper designs a fuzzy RBF neural network control system, and compares its control effect with that of PI control.

3. Design of Fuzzy RBF Neural Network Control System

The structure of fuzzy RBF neural network is shown in Figure 1.

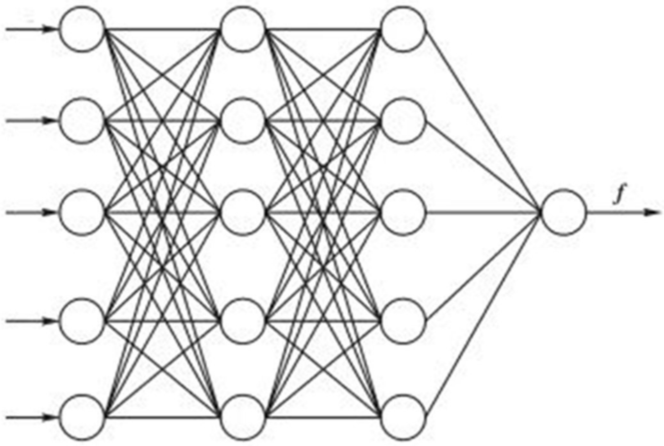

Figure 1. Structure diagram of fuzzy RBF neural network

The first layer is the input layer. Input signals are shearer motor current e and feedback current e_c and all interference signals, the input signals are:

$$f_1(i) = x_i . i = 1,2,\cdots \tag{1}$$

The second layer is the blur layer. The input is the input signal transmitted by the previous layer. The input signal is fuzzified and Gaussian function is used as the membership function. At this time, the output of the second layer are:

$$f_2(i,j) = \exp(\frac{\|f_i(i)-c_{ij}\|^2}{2b_{ij}^2}) \tag{2}$$

Where: c_{ij} represents the mean value of the Gaussian function of the ith input signal and the jth ambiguity set; b_{ij}represents the standard deviation of the Gaussian function of the ith input signal and the jth ambiguity set.

The third layer is fuzzy inference layer. The fuzzy rules are set in advance and placed in the third layer. When the output signal of the current layer is transmitted to this point, its ignition intensity can be obtained by matching the output signal of the previous layer with its corresponding rules for operation. The output signal of this layer is the product of all signals before the output node, that is:

$$f_3(i) = \prod_{j=1}^{N} f_2(i,j) \tag{3}$$

Where: $\mathrm{N} = \prod_{i=1}^{n} N_i$,$N_i$ is the number of fuzzy partitions of the ith input.

The fourth layer is the output layer. The output signal is the weighted sum of the input signals transmitted previously, that is:

$$f_4(l) = W^T \cdot f_3(i) = \sum_{j=1}^{N} w(l,j) \cdot f_3(j) \tag{4}$$

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Where: l is the number of nodes in the output layer, and W is the weight matrix between the output node and the node in the third layer.

4. Control System Design and Simulation

4.1 Design of Traditional PI Control System

According to the reference documents and the actual parameters of the shearer, the controlled function is constructed as $\frac{160.235s+4639\ .160}{s^2+430.800s+4639\ .160}$, according to this, the control system is designed and the parameters are adjusted, as shown in Figure 2.

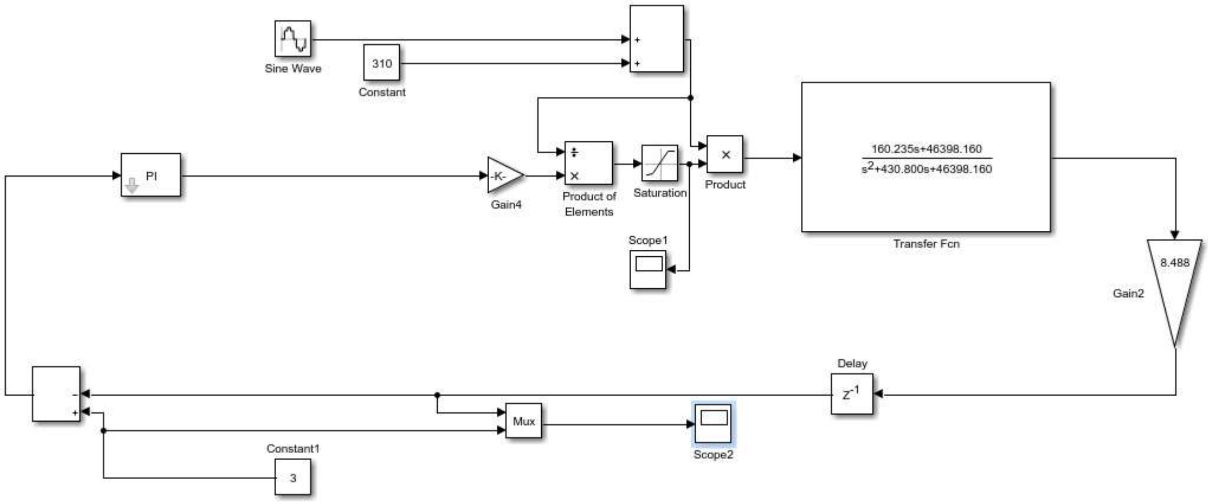

Figure 2. PI controlled shearer control system

4.2 Design of Fuzzy RBF Neural Network Control System

Redesign the controller and use the fuzzy RBF neural network to control the shearer. The principle diagram of the control system is shown in Figure 3.

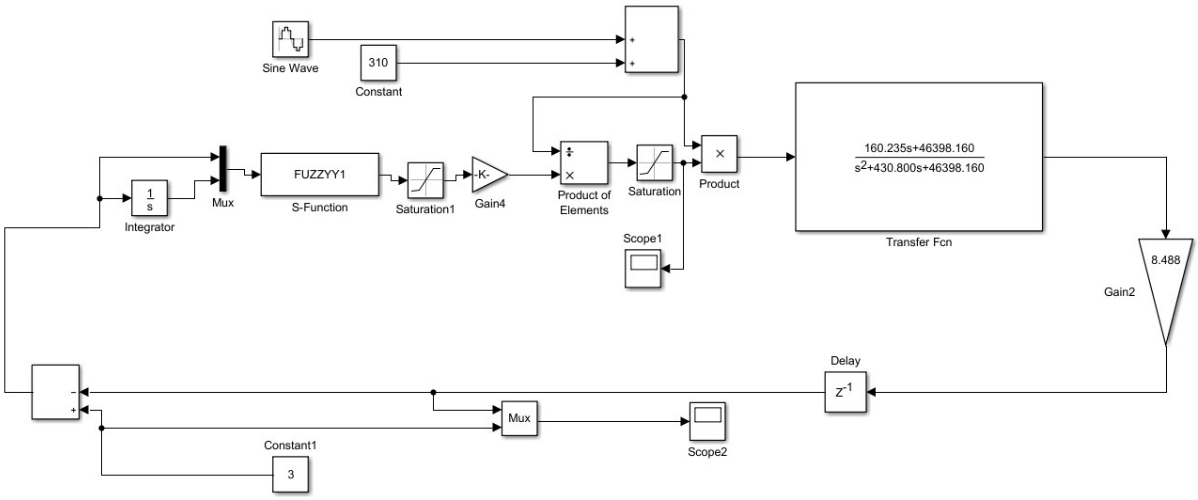

Figure 3. Shearer control system based on fuzzy RBF neural network control

4.3 Simulation Results and Analysis

The simulation results of the above two control methods are as follows:

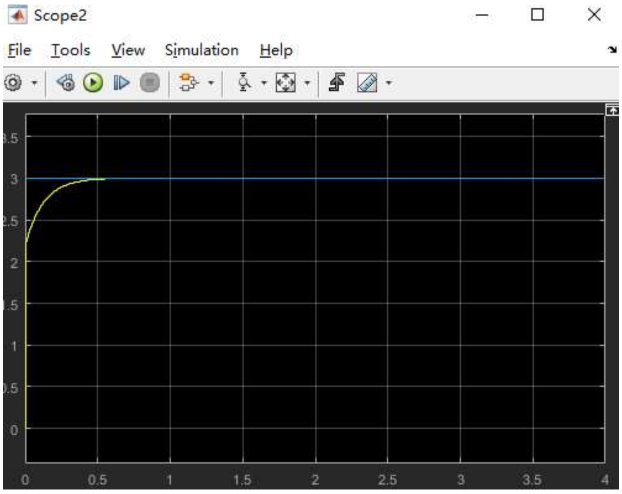

Figure 4. Simulation results of traditional PI control

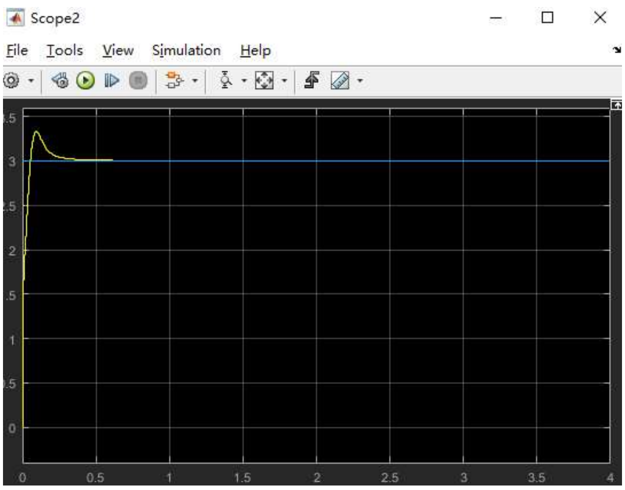

Figure 5. Simulation result diagram of fuzzy RBF control system

The blue line in the figure represents the value of shearer speed given by the system, and the yellow line represents the curve of actual shearer speed change. After the traditional PI control, the system will become stable after 0.69ms, achieving the effect of regulating the system stability; After the fuzzy RBF neural network control, the system will become stable after 0.45ms, achieving the effect of regulating the system stability.

In terms of the control time of the system, the control effect of fuzzy RBF neural network control is reduced by 34.8% compared with the traditional PI control, and the overshoot of the system is 10.5%, which significantly improves the adaptability of the whole system. The system response diagram under the control of fuzzy RBF neural network is more suitable for the shearer, which is a very complex working environment, and the coal and rock conditions, periodic weighting and support pressure are constantly changing. The smaller the response time of the shearer control system, the more timely adjustment and response measures can be made after the underground situation changes, which can effectively protect the life safety of underground workers and the property safety of equipment.

5. Conclusion

The shearer control system based on fuzzy RBF neural network is constructed through simulink and its simulation analysis is carried out. It is concluded that the control image of the shearer motor after adopting this control method is more consistent with the requirements of engineering practice, and

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the control time of the system is greatly reduced compared with the traditional PI control, which improves the response rate of the control system. And because of the adaptability and learning ability of neural network, it is more suitable for processing some fuzzy information, and is very suitable for intelligent control of shearers.

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