

## Research on Fuzzy Control Method in EDM Machine

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### **Abstract**

*Processing effect is a lot of. In this paper, the research perspective is to improve the machining efficiency and machining quality of the system. Based on the analysis of the characteristics of the edm process as the foundation, proposed a fuzzy control technology. In edm process, using fuzzy neural network control technology. According to the characteristics of the fuzzy controller, combined with the advantages of artificial neural network, to correct the adverse effect of some imperfect rules, improve the fast response ability of the control system in a reliable way.*

**Keywords:** EDM; fuzzy neural control; fuzzy controller; Artificial Neural Networks;

### **1. Introduction**

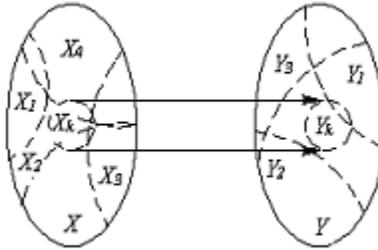
The physical process of electrical discharge machining is very short and complicated, each of the micro process of spark erosion is the electric field force, electromagnetic force, thermodynamic, fluid power, electrochemical and colloid chemistry and so on synthesis process. Now, for this process to establish a precise mathematical model is impossible. For this problem, a better approach is to use the fuzzy control, use of some characteristics of its mathematical model is expressed, establish fuzzy control rules, and expressed in the form of fuzzy language. When the control process is too complex, with a simple fuzzy control system is difficult to establish effective decision rules. Using artificial neural network can just make up for the inadequacy of fuzzy system in this regard. . The combination of fuzzy system and artificial neural network is constituted fuzzy neural control system, this is the one with adaptive system of human sensory and cognitive components, the neural network directly embedded in a full fuzzy and neural network structure, In the structure of fuzzy training data to learn, produce, and highly summarized correction between input and output fuzzy rules. Then, according to the geometric distribution of input fuzzy set and the fuzzy rules produced by past experience, they can get from this reasoning to the correct conclusion.

### **2. The fuzzy control thropy**

Application of fuzzy logic in control field are called fuzzy control. Fuzzy control is one of the biggest characteristics is that it will be the operator or expert control experience and knowledge representation language variables to describe the control rules, and then use these rules to control the system. Therefore, fuzzy control mathematical model is especially suitable for the unknown and complicated nonlinear

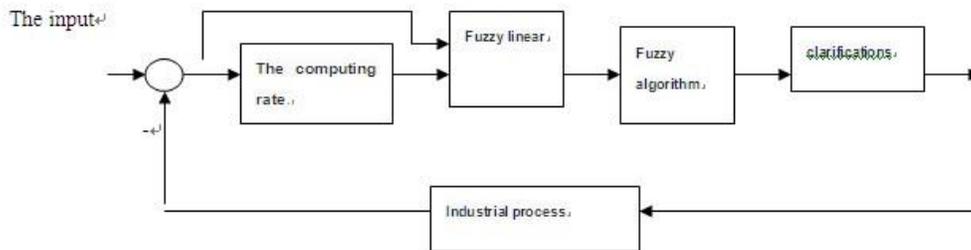
system control. From the perspective of information, fuzzy control is a kind of rule-based expert system, it is also a class of nonlinear controller.

For each language rules in the fuzzy controller, Like: "if A is  $A_k$  and B is  $B_k$ , C as  $C_k$ , Defines a fuzzy relation contains the type  $(A_k, B_k, C_k)$ . the input value to one or more  $A_k$  and  $B_k$  fuzzy rules, which based on fuzzy reasoning to determine output fuzzy subset, real output is obtained by solving fuzzy process again, Real output is obtained by fuzzy process again. On the theory of the specified domain, all rules are defined these vague relationship, form a kind of mapping  $fF$ , as shown in Figure 1. Due to the uncertainties of the mapping relationship itself, difficult to express with mathematics type.



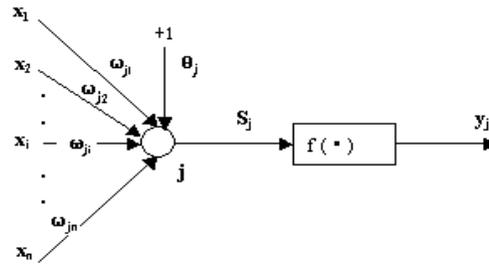
**Figure 1. The fuzzy mapping relation graph**

Schematic is shown in Figure 2 is the fuzzy control system, the control system of the input and output are exact value, and the control algorithm is the fuzzy algorithm. The basic component of the fuzzy controller mainly contains fuzzification interface, rules library, fuzzy reasoning, narrated the interface section. Process the input of the fuzzy control system is difference of the measured variables and system Settings (e), and the deviation of the rate of change (ec). Output is a system of real-time control variables (u), the input of precise quantity through fuzzy sets are into E and C. Fuzzy multiplier is the core of fuzzy controller, it will be the person's experiences, thinking process, summarized into fuzzy relation and fuzzy reasoning rules, fuzzy reasoning is a kind of fuzzy transformation, it will transform input variable fuzzy sets for the output variable fuzzy sets, and realize the transformation of domain, U get output fuzzy sets, fuzzy judgment after fuzzy clear into a precise amount, to control the controlled object.



**Figure 2. Fuzzy control system diagram**

### 3. The structure of the artificial neuron



**Figure 3. The structure of the artificial neuron**

Shown in figure 3 are modelled on the basic characteristics of biological neuron structure of typical artificial neuron model.

$x_1, x_2, \dots, x_i, \dots, x_n$  representing the input from other neurons.

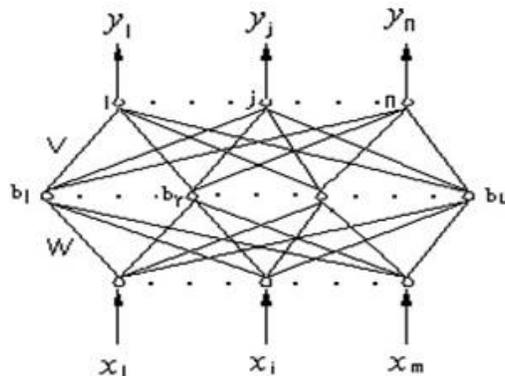
$\omega_{j1}, \omega_{j2}, \dots, \omega_{ji}, \dots, \omega_{jn}$  respectively according to neurons 1, 2, ..., i, ..., n With the first j neurons of the connection strength, namely the weights.  $\theta_j$  Is called the threshold also known as the threshold, generally it is a fixed offset + 1.

Net input of neurons  $S_j$  through the transfer function  $f(\bullet)$ , output of the neuron is:

$$y_j = f[S_j] = f\left[\sum_{i=1}^n \omega_{ji} x_i + \theta_j\right] \quad (1)$$

### 4. BP algorithm

Neural network to spread the information stored in the form of weight matrix in the training process of neural networks is the right of matrix modification process, make it comply with the needs of the research problem. As a result of the single layer neural network can only solve linearly separable problems, even the simple "xor problem can not solve, in this paper, in order to have a hidden layer of three layer feed forward network as an example, analyzes its Error backward Propagation algorithm (the Error Back Propagation, BP algorithm) modify the principle of weight matrix. A single hidden layer feed forward network topology structure as shown in Figure 4:



**Figure 4. A single hidden layer feed forward network topology**

Set input layer nodes  $x_i$  to the hidden layer nodes  $b_r$  connection has a weight of  $\omega_{ir}$ , of hidden layer nodes  $b_r$  to the output layer nodes  $y_j$  connection has a weight of  $v_{jr}$ ,  $T_r$  as the input layer node threshold,  $\theta_j$  for the output layer node threshold, Is the BP algorithm training rule is as follows:

- (1) The preset a small random weight matrix  $W, V$ .
- (2) For an input mode:  $x_1, x_2, \dots, x_i, \dots, x_n$ , according to the formula (1), the output layer nodes in turn forward calculation:

$$b_r = f\left(\sum_{i=1}^m \omega_{ir} \cdot x_i + T_r\right) \quad (r = 1, \dots, u)$$

$$y_j = f\left(\sum_{r=1}^u v_{jr} \cdot b_r + \theta_j\right) \quad (j = 1, \dots, n)$$

- (3) Calculate the output layer, and the first  $j$  a node connected weights  $v_{jr}$  modifier  $\Delta v_{jr}$ , set  $y_j$  the ideal output for  $t_j$ , a transfer function for single polarity Sigmoidfunction:

$$y = f(s) = \frac{1}{1 + e^{-s}}, \text{ then}$$

$$f'(s) = (1 - y)y$$

$$\Delta v_{jr} = -\alpha \frac{\partial E_p}{\partial v_{jr}} = \alpha(t_j - y_j) f'(s) b_r = \alpha(t_j - y_j) y_j (1 - y_j) b_r = \alpha \delta_{yj} b_r$$

In the formula:  $\alpha$  as the vector  $0 < \alpha < 1$ ,  $E_p$  is to define the error function

$$E_p = \frac{1}{2} \sum_{j=1}^n (t_j - y_j)^2$$

- (4) Back to the hidden layer nodes distribution error:

$$\begin{aligned} \Delta \omega_{ri} &= -\beta \frac{\partial E_p}{\partial \omega_{ri}} = -\beta \frac{\partial E_p}{\partial b_r} \frac{\partial b_r}{\partial s_r} = \beta \left[ \sum_{j=1}^n (t_j - y_j) \frac{\partial y_j}{\partial s_j} \frac{\partial s_j}{\partial b_r} \right] \frac{\partial b_r}{\partial s_r} \frac{\partial s_r}{\partial \omega_{ri}} \\ &= \beta \left[ \sum_{j=1}^n \delta_{yj} v_{jr} \right] b_r (1 - b_r) x_i = \beta \delta_{br} x_i \end{aligned}$$

In the formula:  $\beta$  vector hidden layer  $0 < \beta < 1$ ;  $\delta_{br}$  hidden layer error signal

$$\delta_{br} = \left[ \sum_{j=1}^n \delta_{yj} v_{jr} \right] b_r (1 - b_r)$$

- (5) Adjust the connection weights between nodes in each layer and node threshold:

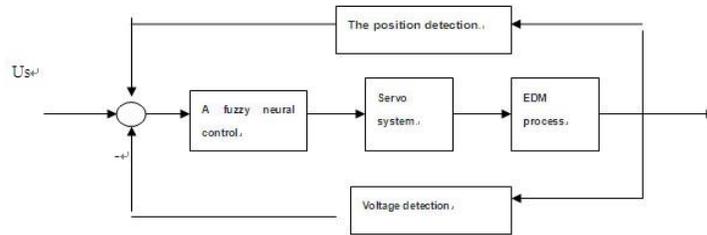
$$\begin{aligned} v_{jr} &= v_{jr} + \alpha \delta_{jr} b_r & ; & \quad \theta_j = \theta_j + \alpha \cdot \delta_{jr} \\ \omega_{ri} &= \omega_{ri} + \beta \delta_{br} x_i & ; & \quad T_r = T_r + \beta \cdot \delta_{br} \end{aligned}$$

- (6) Enter the next mode, continue to train the network, until the error function  $E_p < E_{\max}$  so far, end of the study.

### 5. The fuzzy neural controller

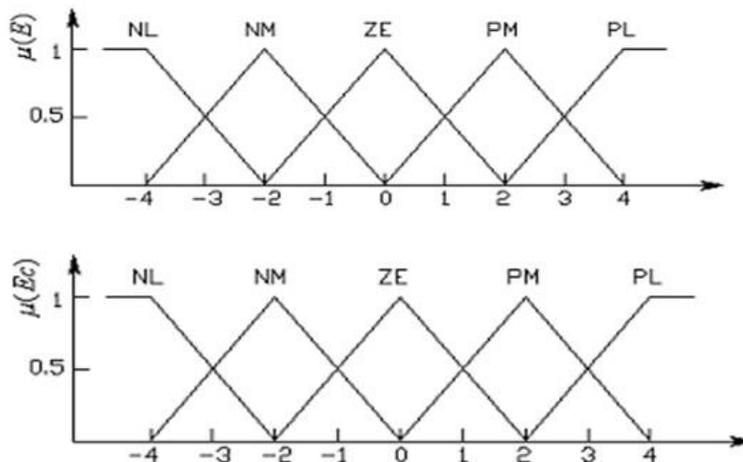
In edm process, the introduction of fuzzy neural controller, can greatly improve the machining quality and efficiency of machine tool. EDM machine servo control system, mainly by the current feedback, fuzzy neural controller, servo system and EDM machine tool.

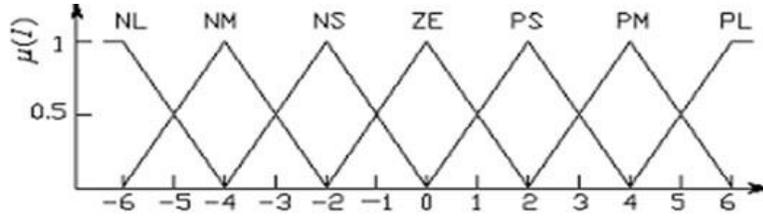
By adjusting the servo motor forward or backward, causes the gap distance between electrodes; according to the discharge electrodes and adjusting servo reference voltage, get the best discharge gap. System control block diagram as shown in figure 5. Use discharge gap average current,



**Figure 5. Edm machine servo control system block diagram**

Represents the size of the gap between the electrode, through the setting of servo motor control parameter, to determine the distance between the poles. First through the input state detection circuit current accurately detect clearance on machining process, then compares it with best gap average current  $i_r$ , Get two input variables, clearance of current deviation  $e(t)$  and the deviation change rate,  $e_c(t)$ , the output is the adjustment of the drive system variation  $\Delta i(t)$ , then the three precise amount into fuzzy quantity. Accurate quantity  $e(t)$  and the deviation change rate  $e_c(t)$  set to  $[- 4 + 4]$  change between continuous quantities,  $\Delta i(t)$  set to  $[- 6 + 6]$  change between continuous quantities, can draw their membership degree curve :





Determine  $E(t)$ ,  $E_c(t)$  and  $I(t)$  the fuzzy subsets are:

$$\begin{aligned} \tilde{E} &= \{ PL, PM, ZE, NM, NL \} \\ \tilde{E}_c &= \{ PL, PM, ZE, NM, NL \} \\ \tilde{I} &= \{ PL, PM, PS, ZE, NS, NM, NL \} \end{aligned}$$

In the neural network is shown in figure 4, each input unit corresponding to the input variable  $E(t)$ ,  $E_c(t)$ , a fuzzy subset, Network of the input signal format as follows, including  $m = 10$  nodes: as shown in figure 6, shown in Figure 7.

$$[\mu_{NL}(e), \mu_{NM}(e), \mu_0(e), \dots, \mu_0(ec), \mu_{PM}(ec), \mu_{PL}(ec)]$$

Network output variable corresponding to each unit of output is a quantitative value of the theory of spatial domain, because the theory of servo reference current change quantity to  $\Delta I$  domain is divided into 13 files, that is  $\{-6, -5, -4, -3, -2, -1, 0, +1, +2, +3, +4, +5, +6\}$ , The network output node number  $n = 13$ , and its output signal format for: as shown in figure 8.

$$[\mu_Y(\Delta U_{s1}), \mu_Y(\Delta U_{s2}), \mu_Y(\Delta U_{s3}), \dots, \mu_Y(\Delta U_{sm-2}), \mu_Y(\Delta U_{sm-1}), \mu_Y(\Delta U_{sm})]$$

Before using the neural network, and it is initialized to the learning and training, and input or adjust the fuzzy rules, and the introduction of fuzzy neural network controller.

## 6. Conclusion

Fuzzy neural control system is the combination of fuzzy control and neural network, and the research direction caught the attention of people. Fuzzy control and neural network does not need precise model of controlled object, a fuzzy neural network controller is usually composed of a neural network and fuzzy algorithm. Among them, the fuzzy controller using fuzzy inference rules, to simulate the processing of uncertainty in the process of decision-making behavior, but to automatically generate rules from experience, and modify the self-learning function of the control decision making is also imperfect. The introduction of the neural network performance index in the process of fuzzy control is better, to make the fuzzy neural control system in the edm process in-depth research and extensive application, provides a great possibility

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