

## A Fuzzy Neural Control System for EDM

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**Abstract.** Electrical Discharge Machining technological law is very complex, and many factors influence machining process. From the point of improving process efficiency and process quality, this paper analyses the characteristic in the process course of EDM first. Based on the analyses, a fuzzy neural control system for EDM was achieved. Utilizing the characteristic of fuzzy controller and combining with the excellency of Artificial Neural Networks, the disadvantageous impacts of some imperfect rules were corrected indeed and the ability to respond quickly of control system was improved dependably.

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

### 1 Introduction

Physical process of electrical discharge machining is a very brief and complex, with 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. At present, for the edm process to establish a precise mathematical model is impossible. For this problem, a better approach is to use the fuzzy control, using the mathematical model showed some of the features, 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, it is a with human cognitive component and the feel of the adaptive system, neural network is directly embedded in the structure of a whole fuzzy, in the structure of the fuzzy learning from training data, produce, correction and generalize fuzzy rules between input and output. 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 theory

Application of fuzzy logic in control field are called fuzzy control. Fuzzy control is one of the biggest characteristics is that it can control of the operator's or expert experience and knowledge as variables to describe the control rules of language, 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, such as "if A is  $A_k$  and B is  $B_k$ , C for  $C_k$ , defines A fuzzy relation contains the type  $(A_k, B_k \rightarrow C_k)$ . The input value to one or more  $A_k$  and  $B_k$  fuzzy rules, which based on fuzzy reasoning to determine output fuzzy subset, and then the real output is obtained by fuzzy process. On the theory of the specified domain, all rules are defined these fuzzy relations constitute a fuzzy mapping, as shown in figure 1. Due to the uncertainties of the mapping relationship itself, difficult to express with mathematics type.

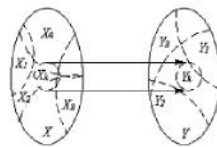


Fig.1. The fuzzy mapping relation graph

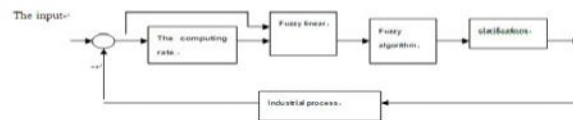


Fig. 2. Fuzzy control system diagram

As shown in figure 2 is the fuzzy control system schematic diagram, the input and output of the control system are accurate value, but its control algorithm is the fuzzy algorithm. The basic parts of a fuzzy controller is mainly 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). The output of the fuzzy control system is the 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, the operation experience, the thought process is summarized into fuzzy relation and fuzzy inference rules. Fuzzy reasoning is a kind of fuzzy transformation. It will transform the input variable fuzzy sets for the output variable fuzzy sets, realize the transformation of domain, and finally can be get U output fuzzy sets, it is to control the controlled object, through fuzzy judgment fuzzy clear into a precise amount.

## 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.  $W_{j1}, W_{j2}, \dots, W_{ji}, \dots, W_{jn}$  is said

neurons respectively 1, 2,... And  $i, \dots, n$  with the first  $j$  neurons of the connection strength and the right values. Called Threshold (Threshold), also known as the Threshold, it is commonly a fixed offset + 1. Net input through the Transfer Function of neurons (Transfer Function) ( $f$ ), is the neuron output:

$$y_j = f\left(\sum_{i=1}^n w_{ji} x_i + b_j\right) \quad (1)$$

Neural networks information is stored in the form of scattered in the weight matrix. The training process of neural networks is the right of matrix modification process, to make it comply with the needs of the research problem. Because of the single layer neural network can only solve linearly separable problems, even the simple "exclusive or" problem can not solve, so this article is based on feedforward network with a hidden layer three layer 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:

Suppose  $x_i$  to input layer nodes connection weights between the hidden layer node  $b_r$  is  $w_{ir}$ , Hidden layer nodes  $b_r$  to output layer connection weights between  $y_j$  is  $v_{rj}$ ,  $T_r$  is input layer node threshold,  $\theta_j$  threshold for the output layer nodes, the rules of the training of the BP algorithm is as follows:

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

## 4 BP algorithm

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. The average current, with the spark gap represents the size of the gap between electrodes, through the setting of the servo motor control parameters, determine the distance between the poles

$$b_r^m = \left( \bigoplus_{i=1}^m w_{ri} x_i + T_r(r=1, \dots, n, u) \right);$$

$$y_j^u = \bigwedge_{r=1}^n v_{rj} b_r^m \quad (j=1, \dots, n)$$

## 5 The fuzzy neural controller

First through the input state detection circuit current accurately detect clearance on machining process, Then it compared with best gap average current, get two input variables--- gap of current deviation and deviation rate of change, The amount of output is the adjustment of the drive system change, and then to the three precise quantity into fuzzy quantity. Accurate quantity and set the deviation change rate as  $[-6 + 6]$  change between continuous quantity, setting of  $[-6 + 6]$  between the continuous amount of change, can draw their membership curve:

$$U = \{PL, PM, PS, ZE, NS, NM, NL\}$$

Fuzzy control and neural network combining fuzzy neural control system, it is one of research directions in the current popular attention. The advantage of both is not

$$I = \{PL, PM, PS, ZE, NS, NM, NL\}$$

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

entirely dependent on the model of the 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, is the imitation process uncertainty indecision-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, It to make the fuzzy neural control system in the process of edm in-depth research and extensive application, provides a great possibility.

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