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Pattern Recognition of Corona Discharge based on T-S Fuzzy Neural Network

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Abstract: T-S fuzzy neural network (T-S FNN) is presented to recognize the types of corona discharge. Three types of corona discharge model are made, the maximum, minimum, mean and fractal dimension are extracted from sampling corona discharge signals and then used as the input vectors of neural network. T-S FNN topological structure is investigated in accordance with the number of input vectors, membership functions and the number of membership functions. The T-S FNN, with 4 input neurons and 3 Gaussian functions, is confirmed as the pattern recognition network, Then the network are trained and tested with the extracted features. Results indicate that the method is effective.

Keywords: T-S fuzzy neural network; membership function; corona discharge; pattern recognition

1 Introduction

In the electrical insulation system, operational experience shows that insulation destruction of high-voltage electrical apparatus is related to their partial discharge. Therefore, it is important to detect and identify corona discharge defect, offering important data for high-voltage electrical apparatus state monitoring and forecast prediction. By this time, much effort has been made in applying neural networks to the recognition of corona discharge defect. Many intelligent methods such as fuzzy diagnosis system and neural network diagnosis system as well as expert diagnosis system are applied to monitor electrical insulation systems [1-5]. In reference [1], a time-series approach has been employed to devise neural-network topologies for time-dependent corona discharge pulse pattern recognition applications. Automated recognition of PRPD patterns using a novel complex probabilistic neural network system for the actual classification task [2]. A three-layer artificial neural system with feed forward connections is used for pattern recognition of partial discharge, using BP algorithm as the learning method [4]. The Probabilistic Neural Network (PNN) method has the advantage over multi-layer Neural Network in that it gives rapid training speed and guarantees convergence to a Bayes classifier [5]. In this

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paper, the fuzzy neural network based on T-S model is presented, and the topology is investigated and designed, then the T-S FNN algorithm is also studied. As the input vector of the network, original characteristic and fractal characteristic are extracted from the corona discharge signal.

2 Signal Process

2.1 Corona Discharge Signal

In order to simulate corona discharge in the laboratory, 3 types of defect model are made in accordance with corona discharge patterns, applying a voltage of 25KV between the electrodes and sampling corona discharge signals. Fig.1 shows 3 types corona discharge signal.

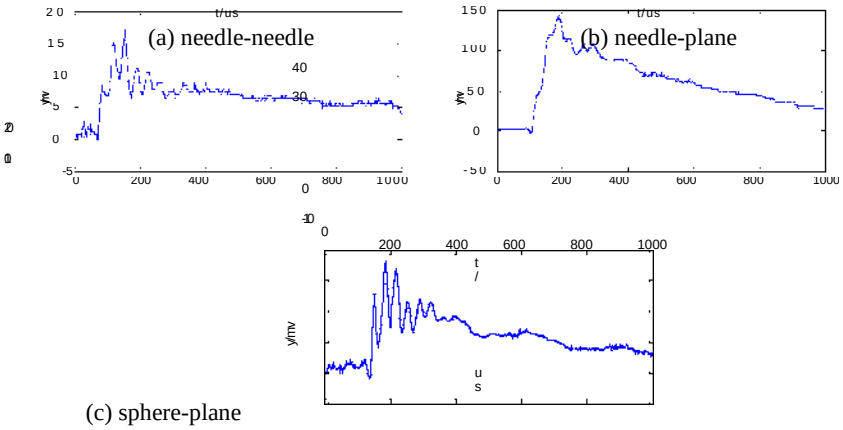

Fig.1. Corona discharge signals

2.2 Feature Extraction

The original features, which include maximum, minimum and mean, are extracted from the corona discharge signal. Thus original feature can act as the input vector of the network. Original feature and fractal dimension are shown in Table.1

Table 1. Original and fractal features

type	maximum	minimum	mean	fractal
needle-plane1	132	-5	54.406 0	1.633 0
needle-plane2	129	-6	54.886 0	1.655 8

needle-needle1	17	-0.4	6.7276 0	1.529 9
needle-needle2	16	-1	6.5578 0	1.584 9
sphere-plane1	36	-2	11.414 0	1.703 6
sphere-plane2	35	-2	11.153 2	1.709 2

3 T-S Fuzzy Neural Network

3.1 T-S Type Fuzzy Model

The T-S type fuzzy model, proposed by Takagi and Sugeno**,** is described by fuzzy IF-THEN rules. The fuzzy neural network based on the T-S model, which make the fuzzy neural network have a better performance to recognize defect model.

3.2 Parameter Update

Network parameters, which include network connection weight, central and width of Gaussian function, should be updated under the condition of ensuring fuzzy partition.

3.3 Membership Function and Topology

According to the learning rule, the number of membership function should be at least 2. However, while the number is more than or equal to 4, the topology structure of network is quite complex. We only analyze the number of membership function is 2 and 3.

4 Recognition Results

Testing samples are randomly selected, and the classification results are shown in Table.2**.**

Table 2. Recognition results of T-S FNN

type	needle-needle	needle-plane	sphere-plane
N	65	70	65
T	59	70	61
Rate(%)	91	100	94

It is obvious that T-S FNN shows an excellent performance in classifying corona discharges.

5 Conclusions

Based on research of topological and algorithm, T-S FNN proposed in this study showed good performance.

(a).T-S fuzzy neural network has the following characteristics: fast convergence speed, simple structure and good reliability.

(b).As the membership function of FNN, Gaussian-type membership function possesses optimum performance when make the partition of input space.

(c). All the defect models can be classified correctly, and all the features are effective to a certain extent.

(d).Based on the results in this paper, the proposed T-S FNN is needed to confirm its performance in the case of the on-site application.

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