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Application of Neural Network and 3D Pattern Matching in Partial Discharge Signal

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<Abstract>

Aging diagnosis system using partial discharge(PD) is being highlighted as a research area. But the application of PD requires complicated analysis method because the PD has complex progressing forms.

In this paper, it has been developed to the PD diagnosis system using neural network(NN). As a result after NN learning, the recognized rate was represented about 85%. The safety area is possible to express the second output of NN in this experiments.

Key words : 3D PD, NN, Aging Diagnosis.

1. Introduction

The aging diagnosis system using PD is being highlighted as a research area for deterioration of power equipment. Many researchers make efforts to develop not only diagnosis of aging state but also detection of defects in the initial stage. But PD research for aging diagnosis is required complicated analysis method because of the complex forms with external noise.

The approach of neural networks has been very successful applied to the various practical problem in a pattern recognition. The important reason is its ability to learn the required input-out mapping information from test examples without mathematical definition. The researchers of 3-d PD for preventive diagnosis have been carried out on the NN application. However, the most serious problem of PD diagnosis is a complicated mechanism between input pattern and unclear teacher group.

In this paper, we have developed the PD measuring system using the 3D pattern matching and the PD diagnosis system using neural network.

By using a 3D pattern matching, the complex form of PD as well as changing in aging condition can be easily expressed and observed real-time measurement, Specially, 3D expression of PD has good possibility to the new classification of unknown PD pattern using conventional technics. The ability of NN to recognize 3D PD pattern has been investigated, Additionally, we have developed the aging diagnosis system using 3D PD pattern for the NN input group and the classification of the NN output.

2. Neural Network (NN)

Most of typically cases, the neural network is 8trained by a learning group of input-output pairs which are examples of the mapping that the network is required to compute in supervised learning method. In supervised learning , an error magnitude is defined to the each output neuron according to the external

'teacher'. For the last couple of years, almost research works on 3-d PD using NN has been concluded by the experienced size of NN construction.

The simplest NN construction of supervised learning is a two-layer feedforward network between an input layer from normalization of 3-d PD signal and an output layer by experienced decision. Each output neuron was calculated to the signal from all input neurons according to connections with modifiable weights. But such two-layer feedforward network can compute only linearly separable functions. However, it has been represented that a feedforward networks with more than one layer called hidden layer of adaptive weights can compute very complicated nonlinear functions.

Our experimental NN construction represents 120-10-3 of a multilayer feedforward network. The neurons in NN construction can be divided into three layer: input layer, hidden layer and output layer. The NN can identify input pattern once the connection weights are adjusted by means of the learning process. Error correction rule called the Back-propagation learning algorithm is most popular method in NN training. The connection weights of the feedforward network are derived from the input-output patterns in the training group by the generalized delta rule. The algorithm is based on minimization of the error function.

In learning data group, the output cell called 'teacher' was derived from the characteristics of electrical tree using image process. For the measurement of tree, a visual method with an optical microscope has been used to explain breakdown mechanism. It is possible to analyze on tree degradation area, progressed direction, tree pattern etc.

3. Experiments

The XLPE specimen was a 12×12×3 mm^3 block type. The sample was preheated at 120℃ in an oven for 15 min, after which the needle was inserted, and was then allowed to cool slowly to room temperature. A metallic need(Ogura treeing electrode) of tip radius 5㎛ was inserted in XLPE. For the testing of SFD, the distance between the needle tip and plate electrode was 2 mm.

For the testing of NN application, the inserted needle after above the processing removed and then another needle of tip radius 250㎛ was inserted. The second inserted needle was fixed by epoxy and silicon adhesive. The distance between the needle type void and plate electrode was 3 mm.

Our experimental system have been measured simultaneous both 3D PD signal and aging prediction. After the reasonable learning cycles, was saved NN parameter such a weight, a offset for 3D pattern recognition.

After saving NN parameter, we tried to the NN recognition from unknown pattern.

Figure 1 shows the experimental process for 3D PD pattern recognition using NN.

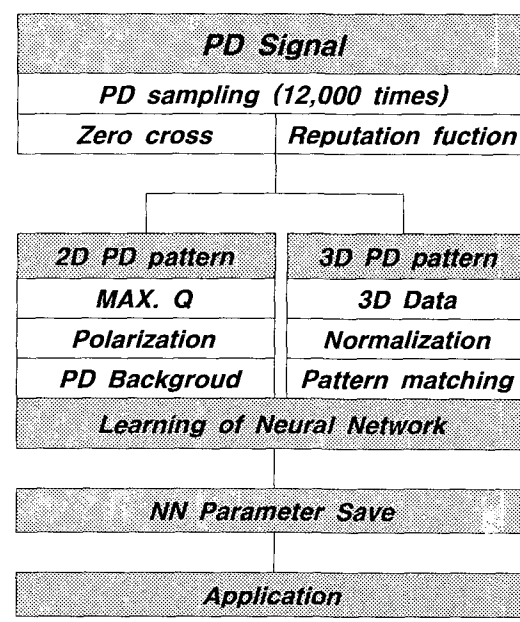


Figure 1. Experimental process for 3D PD pattern recognition using NN.

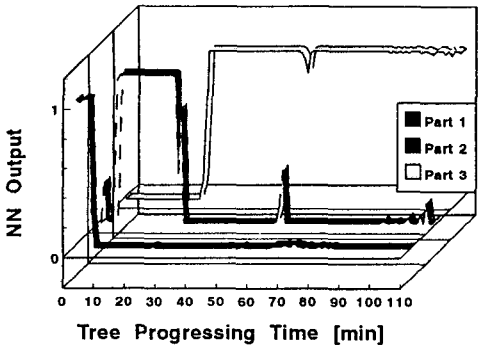
4. Results and Discussion.

To aging diagnosis, the unknown PD patterns were applicated into the NN which had finished the learning from data group. The variation of tree area using image process can define the 3 area : safety area, initial area, dangerous area.

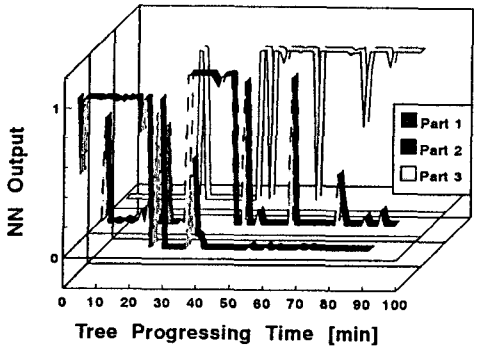
The learning process was carried out using 60 data of 3D pattern from 5 kind of SFD during the treeing test.

The NN construction consists of 120-10-3 of a multilayer feedforward network. Connection weights are trained by means of the learning process called the back-propagation learning algorithm.

The calculation was done by Turbo-c on a IBM-PC.



(a) example 1.



(b) eample 2.

Figure 2. The NN result of unknown PD signal.

After NN learning from data group, the ratio of aging recognition is about 85 % in case of similar applied voltage, the corrected result of NN output cell was decided on above the 0.8 value of predicted output. The first and the second output cell was supposed to the safety area, the third cell was decided on dangerous area that has a possibility to breakdown. However, some area was shown the damping characteristics. Those area supposed unknown area. Specially, those characteristics was predicted the unclear pattern between 0 and 1 for NN discrimination, The summary of test result represents table 1.

Table 1. Aging Diagnosis of Same Testing Voltage.

No.		Tree progressing time [min]							
①	Time	-	20	40	60	80	100	120	140
	NN output	1	1	2	2	2	3	3	3
	Safety area								
	Unknown								
	Dangerous								
②	Time	-	15	30	45	60	75	90	105
	NN output	1	1,2	2	2	2,3	2,3	2,3	
	Safety area								
	Unknown								
	Dangerous								
③	Time	-	25	50	75	100	125	150	175
	NN output	1	2	2	2	2	1,2	2,3	3
	Safety area								
	Unknown								
	Dangerous								
④	Time	-	15	30	45	60	75	90	105
	NN output	1	2	2	3	3	3	3	3
	Safety area								
	Unknown								
	Dangerous								
⑤	Time	-	15	30	45	60	75	90	105
	NN output	1	1,2	2	2	3	3	3	
	Safety area								
	Unknown								
	Dangerous								

At the second, the dangerous area was easily found to the recurrent phenomena of NN output. However, such area is very difficult to analysis of mechanism and to predict the lifetime in present state, it is possibile to discriminate via learning data accumulation.

In case of high stress, the safety area is possible to express until second output of NN. The summary of test result represents table 2.

Table 2. Aging Diagnosis of Different SFD Testing Using Neural Network.

No.		Tree progressing time [min]							
⑥	Time	-	100	200	300	400	500	600	700
	NN output	1	1,2	2,3	2,3	3	3	3	1,2,3
	Safety								
	Unknown								
	Dangerous								
⑦	Time	-	100	200	300	400	500		
	NN output	1	2	1,2,3	1,3	1,3	1,3		
	Safety								
	Unknown								
	Dangerous								
⑧	Time	-	100	200	300	400			
	NN output	1	2	1,2,3	1,2,3	1,2,3			
	Safety								
	Unknown								
	Dangerous								

5. Conclusions.

The neural network was applicated to aging diagnosis of 3D PD patterns. After the learning processing, we tried to examine unknown partial discharge pattern into the neural network.

It was found that

1. The new method called 3D PD pattern matching has a good expression characteristics and an ability of high recognotion more than conventional 2D PD.
2. In our experiment, the construction of NN consisting of 120 input cell for 3-d partial discharge has a possibility to compact size for PC or 1-chip process.
3. After NN learning, the recognized rate in case of same sress was represented about 85%.

Above results show that the NN of compact size is powerful tool for preventive diagnosis of insulation system, has a possibility to adapt in different stress as acceleration test. However, many problem are remain for application to the actual power equipment; accumulation, modeling of system, learning method, PD sensitivity etc.

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