3d-PD의 통계적 고찰과 신경망 응용기술

The Application Technique on AI and Statistical Analysis of 3d-PD

임장섭, 박용식, 최병하, 한석균

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Abstract

The partial discharge testing is widely used in diagnostic measuring technology because it gives low stress to power equipment which is undertaken tests. Therefore it is very useful method compare to previous destructive methods and effective diagnosis method in power system that requires on-line/on-site diagnosis. But partial discharges have very complex characteristics of discharge pattern ,so it is required continuous research to development of precise analysis method.

In recent, the study of partial discharge is carrying out discover of initial defect of power equipment through condition diagnosis and system development of degradation diagnosis using HFPD(High Frequency Partial Discharge) detection.

In this study, simulated system is manufactured and HFPD occurred from those simulator is measured with broad-band antenna in real time, the degradation grade of system is analyzed through produced patterns in simulated target according to the AI/statistics processing.

1. INTRODUCTION

Despite of the growing number of applications and development of PD test systems, the question how the measured partial discharge quantities relate to the residual lifetime of a specific test object still remains open.

The complexity and fuzziness of measured discharge signal patterns in the real noisy world, such as acoustically, chemically, electrically, thermally or any other methods, can be interpreted as a type of imprecision that stems from grouping elements into classes that do not have sharply defined boundaries. For recognition of our ambiguous, vague measured information of their pattern features from high voltage system, fuzzy set can be a better or effective representation model of measured human data than ideal crip set information.

The characteristics of intuition, prediction and statistical discharge pattern recognition of uncertain information in power system allows a neural network to deal with situation or may have some corrupted data.

ANN has the ability to learn the desired 3D mapping without knowledge of mathematical relationships. Complex relationships between inputs/outputs on noise corrupted chaotic or stochastic PD pattern are distributed on the connection weight of ANN.

In this respects, this paper presents a new ANN recognizing system concerning analysis of measured PD pattern performed on different power apparatus and models of power systems using ANN principles. The advantages provided by this ANN pattern recognizing analyzer are the possibilities to perform more reliable identification of aging process and to predict the lifetime of the tested power systems.

2. ANN based PD Model

The aim of PD pattern recognition or classification is to assign a level to a PD pattern of unknown original information from previously collected patterns with know levels.

Discharge recognition is also possible by feeling other types of information to the ANN, e.g. the combination of many integrated chemo-physical signal quantities and statistical moments or the parameters which characterize the PD pulse shape measured or by measuring the charge displacement in electro-magnetic waves, acoustic waves, light etc.

Among the studies found in the literature the back-propagation(BP) network has the best learning ability when tested to the different models of PD sources. However, BP learning algorithm has shown some problems to find global optimum in parameter space. If those differences can be included in a knowledge base, inference of the defect type from the observed PD pattern may be possible(i.e. an expert system). In the literature the discharge patterns associated with a number of typical discharges sources were investigated.

3. Training 3D PD pattern: (F, dB, s) pattern

The important parameters to characterize partial discharges are measurement Frequency, electro-radiation magnitude dB and statistical sorting S. The 3d-mapping(F, dB, s) distribution consists of the Frequency, dB and S using the information group with repetition rate as a function of data structures.

The distribution contains the most of other PD characteristics and therefore the distribution was selected as a PD characteristics to recognized the electrode systems. As neural networks require tremendous calculation time to learn patterns. the phase window and magnitude window number in the 3d-mapping(F, dB, s) distribution pattern must be minimized. Recently, fractal features have been also introduced to describe 3d-mapping(F, dB, s) patterns. For the last couple of years, almost research works on 3-D PD using ANN has been concluded by the experience size of ANN construction. Our experimental ANN construction represents 500-50-3 of a multilayer feedforward network. The neurons in ANN construction can be divided into three layer: input layer, hidden layer and output layer. The ANN can identify input pattern once the connection weights are adjusted by means of the learning process. The connection weights of the feedforward network are derived from the input-output patterns in the training group bye the generalized delta rule. The algorithm is based on minimization of the error function.

4. The approach of ANN

The approach of ANN 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 information mapping from testing examples without mathematical definition as a physics-based modeling.

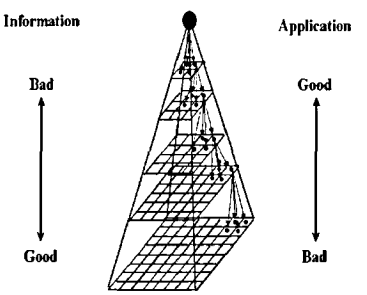


Fig. 1. Pyramid data structure

Our results, the ANN application of reasonable size is powerful tool for preventive diagnosis of power system and has a possibility

to adapt in different stress as acceleration test. However, the ANN system also remains many problems for actual application.

- How many the reasonable 3D Mapping of PD window for application.
- Data accumulation for actual system or GIS.
- Random process technique between a lab and an actual test.

Figure 1 shows the pyramid data structure to be connected with input mapping size. For the last couple of years, almost research works on 3D PD using ANN has been concluded by the experienced size of input mapping construction. Typical types of input cell magnitude represent 320, 512, and 1024 etc. But data distribution of laboratory testing represented to be probably so 50%. Furthermore, external noise with extremely large pulse has a effect to change total input data because all data transfer to relative recalculation in normalized process. We have a careful attention about reasonable size and reduced input magnitude, because economic selection of ANN input mapping determines the discrimination speed, data accumulation, learning time, ANN parameter approach, compact system and low cost diagnosis system etc. In out experiment, the construction of ANN consisting of 500 input cell has an abundant possibility to be diagnosis structure.

5. Results and discussion

The most significant advances made in the area of PD pattern recognition primarily concern the discrimination between single discharge signal of different types. For example, in the papers of the reference it was demonstrated that neural networks using the multi-layer perceptron technique can readily distinguish between the discharge pulse shapes that are due to charges in void size and void surface layer characteristics when comparing single discharge sources on a one to one basis.

The first important step is to select a type of HFPD patterns that has good discrimination power.

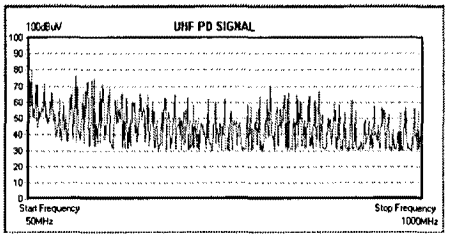
Especially 3d-mapping(F, dB, s) distribution and its derivatives such as frequency, electro-magnetic dB measuring distribution have been extensively used for recognition. Due to lack of "a priori knowledge or information" of concerned problems, there is no unique way to do this. Statistical parameters(skew, kurtosis) are just few examples of such features. The trade-off between the number of features, time for the calculation of the features, discrimination power of the features and the final speed of classification should be considered when designing the features.

Mapping techniques and cluster analysis methods can be used for this purpose but it should be realized that there is no 'best' method. The present works in reference have demonstrated that even with the most simple of PD pattern and sources the recognition capabilities of the ANN evaluated are not always perfect and reliable.

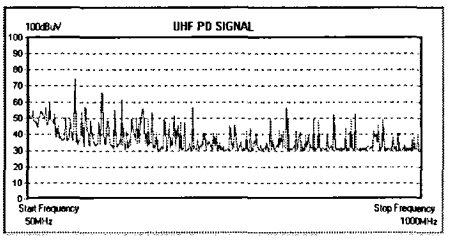
a) Case Study 1 (Statistical reformation)

The 3-d HFPD normalization process was carried out the computer programing using 400,000 data of 100 cycles during the sweep time frequency. The ANN data group must be exchanged the normalized cell from 0 to 1 because of translated function as sigmoid function for multi-layer feedforward network. Connection weights are trained by means of the learning process called the back-propagation learning algorithm. The calculation was done by borland C++ on a IBM-PC.

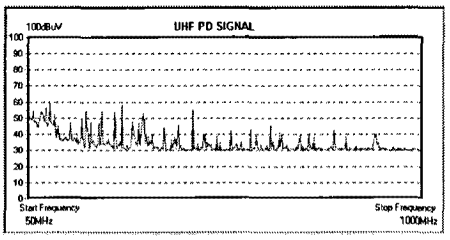
Figure 2. shows the statistical distribution result of HFPD signal during simulated testing. After 2-d PD measurement from on-lime testing, the random properties of aging processing easily find the complicated variances, the corrected result of normalization was decided on reappearance of logarithm value of unit reformation as measurement period. Therefore, statistical processing by computer programing has a aquirement characteristics to get the more precise reappearance.



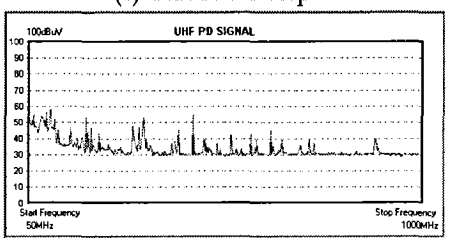
(a) Original signal pattern



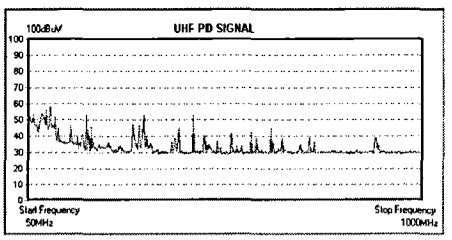
(b) Statistical step 1



(c) Statistical step 2



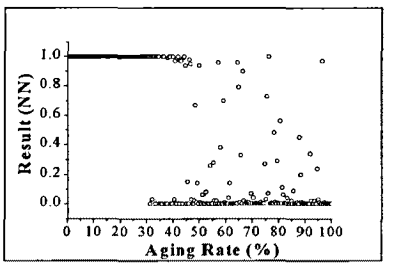
(d) Statistical step 3



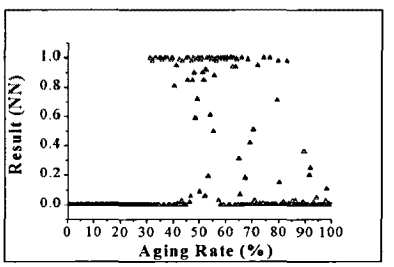
(e) Statistical step 4

Fig. 2. 2-d expression of HFPD signal pattern

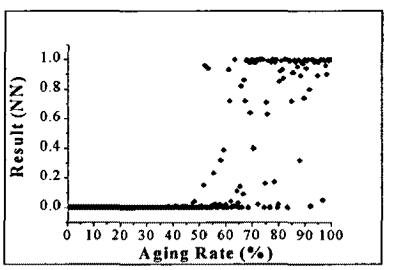
The measured HFPD value of the Figure 2(a) has a excellent sensitivities compared to the another measurement technique. However, some measured data was shown the random/chaotic characteristics, Specially, the field testing in actual system was easily measured to the unknown data with external noise. But otherwise those measurement reduced reappearance.



(a) Safty region



(b) Middle region



(c) Dangerous region

Fig. 3. AI pattern recognition of 3-d HFPD

b) Case Study 2 (3-d progressing)

Almost of aging experiment depends upon acceleration test for analysis of aging processing. In this paper, we have investigated the availability applying different stress,

One example of recognition results represents Fig. 3. In this case, the ration of aging recognition can not be calculated like above section, because results have many unknown points as the complex damping characteristics. But result of ANN output cell can be used for the decision on above classification : safety area, middle area and dangerous area. Those area was supposed unknown area. Especially, field test was easily calculated to the unknown area. Those characteristics were predicted on the unclear pattern between 0 and 1 for ANN discrimination, those results of the field test ecome widely more than learning data of lab test because of linear progress character of PD development. At the first, the ambiguous results group both two output cell except other cell carry out some special region, those output is clear different error of area above section. Unstable area above the section called damping was discontinuous valve between the safety and dangerous area, this result was estimated on the ANN characteristics as possibilities of identification of medium state. At the second, the dangerous area was easily found to the recurrent phenomena of ANN output. However, such area is very difficult to analysis of mechanism and to predict the lifetime in present state, it is possible to discriminate by means of learning data accumulation.

6. Conclusion

In this paper a general outline of the development of neural technique based HFPD diagnostics using normalization and statistics is given with emphasis on problems of the validity of underlying models and the interpretation of results. After a discussion of primary 3-d HFPD resulting degradation, some basic matters regarding measurement employing neural techniques and testing are described and their problems are discussed. The new method called normalization/statistics has been introduced and it has shown both a good recognition characteristic and the capability of higher speed calculation comparing with the case of the conventional diagnostic system. Future automated recognition systems should also be able to recognize field HFPD signals and to pinpoint the most dangerous one. Possibilities inspired bye the random engineering for monitoring the aging of insulation by means of PD recognition should also be further investigated. Currently on-going projects related Research and Development works on this special subject is continuing accompanied with R&D works of ANN technologies and random processing Engineering methodologies.

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