Study on partial discharge pattern classification of GIS by adaptive neuro-fuzzy inference system

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Abstract. In this study, a PD defect identification system based on linear discriminant analysis and adaptive neural fuzzy inference system is developed. In this study, the partial discharge signs of typical defects of the GIS measurement were measured with a measuring device. The corresponding characteristic parameters extracted from the GIS measurement were filtered according to the optimization algorithm and stored in the form of three-dimensional discharge mode (q-φ-t). On this basis, the 3d discharge mode is converted into statistical parameters. Statistical PD features can be used for defect classification purposes, but it is clear that for this goal, the treatment of sovolume data base will be inefficient. Therefore, it would be very helpful to select those features that are more effective and more efficient to identify and distinguish potential PD defects through their relevant statistical parameters. Select feature extraction techniques for dimensionality reduction. In solving pattern classification problems, feature extraction methods are usually used as preprocessing techniques, which cannot only reduce the computational complexity, but also achieve better classification performance by reducing irrelevant and redundant information in the data.

1. Introduction

Partial discharge (PD) is an omen and the main reason for the deterioration of insulation of gas insulated switchgear (GIS) [1]. In this study, a new method to identify discharge power using adaptive neural fuzzy inference system (ANFIS) is proposed. ANFIS identifies PD defects using discharge fingerprints containing 74 statistical parameters. Moreover, the contribution of each feature to classification is analyzed by linear 1-resolution analysis (LDA). It shows not all the characteristics and the same discriminatory forces. In other words, the original feature is transformed into a new feature without loss of accuracy, thus an an classifier with a simplified structure can be obtained. In this way, the total number of input features after linear discriminant analysis is reduced to 5. Then use samples to train and test PD recognition. Finally, the performance of ANFIS classifier was evaluated [2]. Failure of power equipment, such as power transformers, can cause disruption of power supply and cause considerable loss of profits. Therefore, early detection of insulation defects in power equipment is a priority for power equipment users. PD pattern recognition is an important tool for insulation diagnosis of power equipment. More than half of power equipment failure accidents are due to deterioration of insulation [3].

The existence of insulation defects has a great influence on the reliability of power devices. Partial discharge pattern recognition has been considered as an important diagnostic method to prevent fault of insulation defects in power equipment [4]. PD phenomenon usually originates from Insulation
defect is an important symptom to detect the initial failure of gas insulation system (GIS). the classification of different types of pd modes is important for gas insulation systems .

2. Partial discharge introduction

The feature extraction process uses a linear combination of all measured values. Select the Method of the selinear combinations determined by used Dimensionality Reduction algorithm and the the number of to be used combination determined according to dividence numbers of new feature. In the research process, the success of the classification method is to reduce the dimension through LDA. ANFIS-based classification methods have been considered where features are extracted from statistical parameters, first using LDA and then blurring if then classification rules, which are obtained from experts for the training process of the ANFIS model. finally, the classification of pd defects is automatically completed by the trained system. the performance of the identification system was verified using test samples. the results were concentrated on the classification three pd defect type 3[5].

Partial discharge occurring inside the system. The discharge in the cavity belongs to the partial discharge type and is necessary for the PD measurement system. The partial discharge measurement system provides the performance information of 9 kinds of insulation materials for high voltage power supply equipment. the measurement of pd using different methods. The principle of measuring PD is to produce / dissipate the energy associated with discharge, generate electromagnetic waves, dissipate heat energy, light and form noise, etc. PD phenomena include several discharge types, namely, surface discharge, cavity discharge, corona discharge, and Treeing channel [6].

3. Partial Discharge Data Acquisition

PD measurements of GIS were generated and recorded through laboratory tests. When we were testing the rated voltage of the circuit, the PD detector began to measure and record the PD signal through the measuring device. During the experiment, all the measured analog data are converted to digital data in order to store them in a computer. after storing the partial discharge measurement data, these data need to be converted to q-φ-t format (discharge evaluation mode). This data matiscallas Phase solve partial release data [7].

This PRPD data analysis can serve as a good indicator to diagnose fuzzy pd patterns because it presents unique features for each pd defect pattern, and it has accumulated longer than PD real-time data. To facilitate statistical analysis, the 3D pattern is decomposed into two 2D distributions, which are projected to two axis phases and magnitudes. statistical analysis of the two distributions respectively. in addition, statistical analysis of the phase angles from 0 to 180°, and the difference between positive and negative PDS were performed, respectively. For each distribution, calculate two types of statistics, name amplitude statistics, and shape statistics. Statistical descriptors have mean, standard deviation, skewness, and keratosis. In addition, global maxim sizes of positive and negative PD sandrelied phase region PD patterns are also calculate DAS features [8].

Using this form of data, knowledge-based systems provide an automated defect classification method and provide an explanation for their conclusions. this ability provides a physical explanation for the automatic classification set. for further statistical analysis, the 3d pattern is decomposed into two 2d distributions, which are projected to the two axes-phase and amplitude. Figure 1 shows the three-dimensional q-φ-t mode decomposition, which is transformed into a two-dimensional distribution mode, including two-axis phase and size.
Figure 1 3-D $q$-$\varphi$-$t$ decomposition

The feature extraction stage is one of the most important parts in the field of pattern recognition because it can directly affect the diagnosis results. Even if the same number of features are extracted, the feature vectors extracted from good features reflect the unique features of each PD pattern, and better diagnostic results can be obtained. As previously mentioned, three types of partial discharge are considered in this study. These defect samples were manually generated in the laboratory and the relevant basic PD quantities related to the test voltage, such as PD size, starting 30 voltage, cycle number, and phase position, were recorded for feature extraction. 74 statistical features (positive and negative) were extracted from the four major PD quantities by statistical operators with basic PD quantities on hand. These 74 statistical features are also called PD fingerprints.

4. Performance Analysis

The PD fingerprint in this work is a histogram combination of PD signal statistical features. The shape of the histogram provides information about the nature of PD signal. The features of the histogram are statistical features, where the histogram serves as a model for the probability distribution. These statistical features provide the characteristics of a PD pattern. The discharge phase region is illustrated by two distributions: and negative half of the negative cycle in Figure 2 for the positive half cycle of the voltage.

Figure 2 DPR (Discharge phase region)

Dimensionality reduction is to transform high-dimensional data into meaningful dimensionality reduction representation. Ideally, induction representation has a dimension. Corresponding to the intrinsic dimension of the data, the intrinsic dimension of the data is the minimum number of features
required to explain the observed characteristics of the data. Dimensionality reduction is important in many fields because it promotes classification, visualization, and compression of high-dimensional data by mitigating the curse of other unwanted properties of dimensionality and high-dimensional space [9].

5. Conclusion

Using the LDA feature and ANFIS combined with the least square method, the back propagation gradient descent method was used to classify the PD defects. The hybrid algorithm consists of a pre-transmission and a post-transmission. The least square method (Progresspass) is used to optimize the subsequent parameters when the precondition parameters are fixed. Once the optimal subsequent parameters are found, the backward transfer starts immediately. The gradient descent method is used to optimize the precondition parameters and the fuzzy set is optimized in the input domain. The output of ANFIS is calculated by using the subsequent parameters found in the forward channel. The output error is used to fit the prerequisite parameters of the standard back propagation algorithm. In classification, the purpose is to denote input pattern stone of three classes, usually by output restricted to lie in the range, so that they represent the probability of the class membership. While classifying, assigning specific patterns to specific classes according to the characteristics that represent PD defects.

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