Design of Fractal Features-Based Partial Discharge Pattern Recognition using Multi Support Vector Machine Method

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Abstract. Partial Discharge (PD) is one of the causes of insulation deteriorisation mode and impacts on the reliability of high voltage equipment. Therefore, PD measurement is used for diagnostic technique of high voltage equipment. Diagnostic output of high voltage equipment contain information about PD type, PD cause, PD location and PD severity. after identification, a proper preventive maintenance pattern can be performed. Therefore PD pattern recognition system is very important on PD diagnostic system to recognize the PD pattern and determine the level of hazard that occurs in specimen object or high voltage equipment.. In this paper, PD pattern recognition system is designed with fractal geometry approach and support vector machine (SVM) algorithm. The coding and programming of graphical user interface of the application is done. Each PD type and hazard level on various insulating materials (solid, liquid and gas) have the dimensions of the fractal and the lacunarity. The type of PD (void, corona) and its danger level (bad, fair and good) can be identified with the support vector machine (SVM)

1 Introduction

Diagnosis of power apparatus based on partial discharge (PD) measurement requires PD pattern recognition and judgement system. PD pattern recognition and judgement are actually analysis and evaluation stages which produce information of insulating qualities or insulation deterioration level or health conditions of power apparatus. At first, the stages of analysis and evaluation is done entirely by human (expert). The PD pattern interpretation relies mainly on the knowledge and the experience of a human expert. However, the development of computer technology and the need for speed and accuracy of analysis require the application of pattern recognition and judgement system without human assistance (expert), which can easily be done by anyone, anytime [1-4].

Meanwhile, SVM has been popular as a method of pattern recognition in the world of bioinformatics, such as fingerprint image recognition, voice recognition in security systems, as well as disease classification automatically based on the diagnosis of the patient medical record [5]. On the other hand, mathematicians often use fractal geometry to describe natural phenomena and complex shapes. PD signal is natural and random occurrence, so that it can be extracted in the form of a unique fractal. The patterns are unique. PD can be further

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identified by the SVM algorithm so that in the end PD source, PD type and the level of danger can be predicted.

The purpose of this paper is to design PD recognition and judgement system. The system recognizes patterns of partial discharge (pattern recognition) and determine the level of hazard that occurs on the object specimen / high voltage equipment under test (judgement system), with fractal geometry approach and SVM algorithm.

2. Partial Discharge, Fractal Geometry and Support Vector Machine (SVM)

2.1 Partial Discharge

Partial Discharge (PD) occurs when the electric field in the void beyond the field strength at the gas permeability of the void. According to Standard IEC 60270: 2000, partial discharge is defined as discharge which only partially connects the insulation between the electrodes [6]

2.2 Fractral Geometry

Fractals are geometric structures with dimensions of fractions [7-10]. To explain the pattern of a natural phenomenon and complex shapes, as well as stochastic. Examples of natural phenomena and other complex forms between clouds, snow crystal, batik and leaves. Fractal is a pattern within a pattern, in a pattern. Some fractal objects can be broken down into several parts that are similar to the original fractal.

An object that has a fractal dimension is something that has the same variation with self-similarity in a variety of scales, so maximum detail will never be achieved by increasing the scale. Lacunarity, first introduced by Mandelbrot (1982) to describe the characteristics of fractals with the same dimensions with different textures. In general, a low value indicates Lacunarity texture similarity, whereas a high value indicates a different texture of lacunarity.

2 .3 Support Vector Machine (SVM)

SVM concepts can be explained simply as an attempt to find the best hyperplane which serves as a separator are two classes in the input space. Hyperplane in the vector space dimension d is affine subspace dimension d-1 which divides the vector space into two parts, each of which corresponds to the different classes.The best separator hyperplane between the two classes can be found by measuring the hyperplane margin.

3. Design of PD Recognition and Judgement System

3 .1 System Block Diagram

Data input in the form of *csv is sample of PD signal and AC voltage signal in 10 cycles. Which is derived from the output of signal processing stage, so that it has been filtered from the noise.

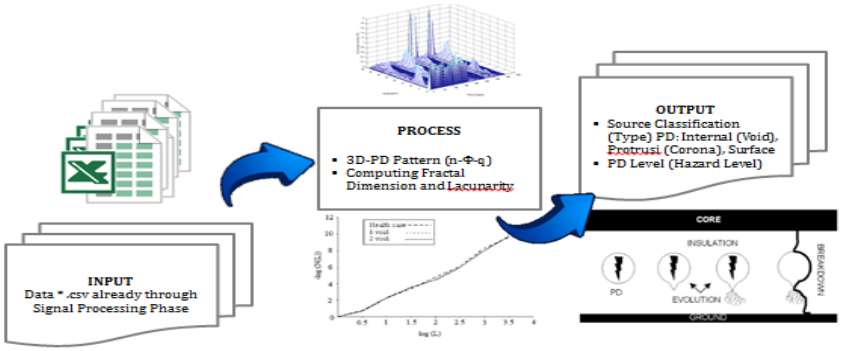

Fig. 1. Block Diagram of PD Pattern Recognition and Judgement System

3.2 Flowchart of the Application

In performing its function as partial discharge pattern recognition application, this application requires a database with known data, to be used as a reference or benchmark for identifying unknown data. Thus, the workings of this application, consists of 2 pieces flowchart, which consists of building database and pattern recognition.

3.2.1 Flowcharts Database Creation

To build a database of pattern recognition, it takes the known test data. The data form * csv file, which consists of two pieces of data, namely data of applied voltage, hereinafter referred to as an AC signal and partial discharge measurement data from sensors, hereinafter referred to as the signal PD.

Both of these data will have normalized, so that the value in conformity with the actual conditions. In addition, the normalization phase, is also used to retrieve the required data. Fig. 2 shows the flowchart of the database creation process. At signal processing stage, each data will experience different processing. In the AC signal data, the data has a lot of noise, visible from the non-smooth waveform. The AC signal data will pass through low pass filter with frequency passed by 50 Hz. So the output of this stage, the fundamental sine wave is smooth and less noise amount.

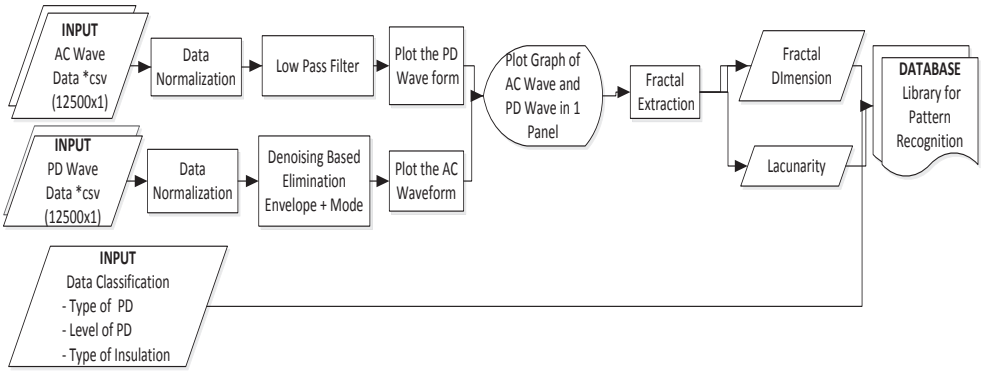

Fig. 2. Flowchart Database Creation

After going through the stages of signal processing, the data is then plotted into a graph, and then combined in a single panel. The graph is then converted into image data. Data conversion chart into image data, aiming to facilitate the extraction process to form a fractal.

The image data, and then will be fractal extraction resulting data in the form fractal dimension and lacunarity. This data was to be used as database applications partial discharge pattern recognition.

3.2.2 Flowchart Pattern Recognition

Basically, the pattern recognition process is similar to the process of making the database. To perform pattern recognition, must be prepared the test data that want classified its type and its PD level. The data should be a * csv file, which consists of two pieces of data, namely : Data source voltage injection, hereinafter referred to as an AC signal and PD measurement data from sensors, hereinafter referred to as the signal PD.

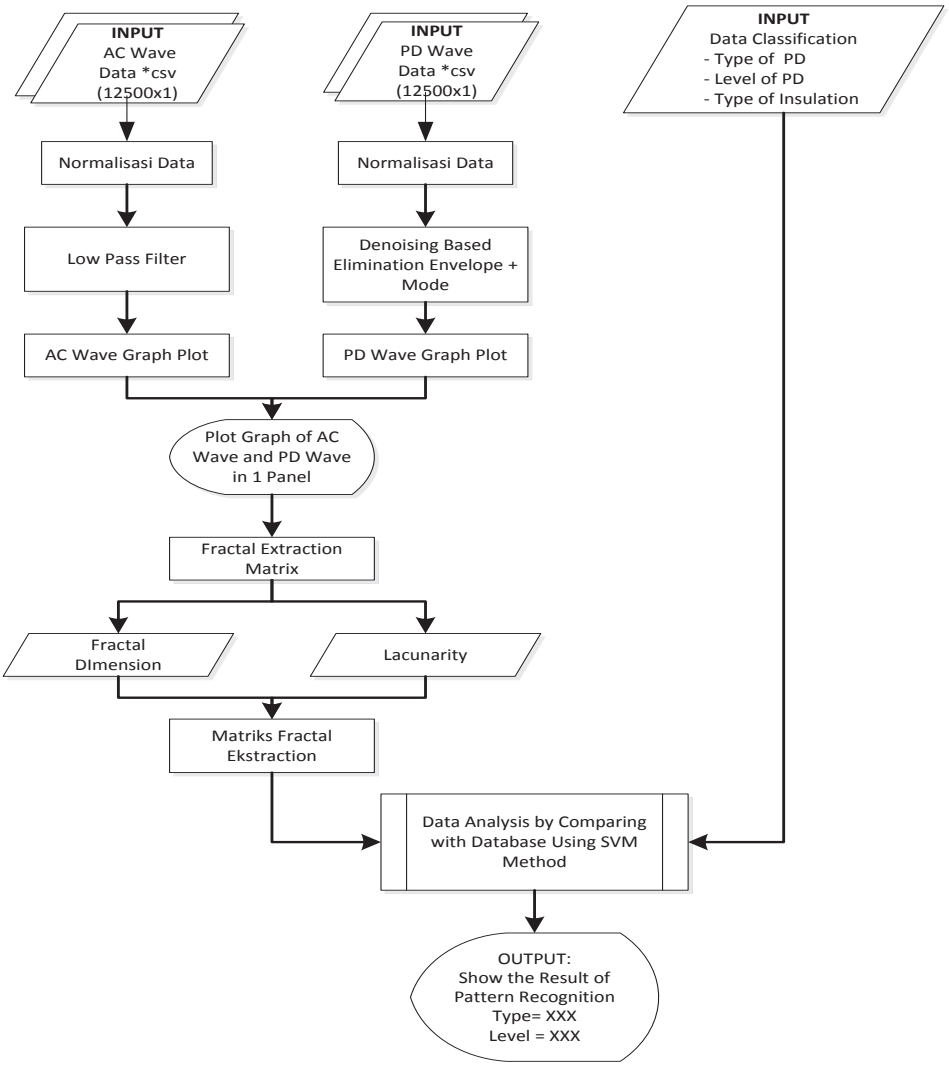

Fig 3. Flowchart Pattern Recognition Applications

In the signal processing stages, each data will undergo a different treatment. In the AC signal data, the data of crude has a lot of noise, seen from the waveform is not smooth. AC signal data going through the Low Pass Filter with a frequency of 50 Hz are bypassed. So

that the output of this stage, the fundamental sine wave that is smooth and less noise amount.

While the PD signal data, the data of crude has a lot of noise complicates the introduction of actual PD signals. In this research, PD signal will pass through the stages of denoising. Stages denoising is done by our group, slightly different from the denoising in general (wavelet or high pass filter with a reference Background Noise). Stages of our denoising, performed by eliminating the reference value of the mode value (value with the highest frequency of occurrence) and the maximum value of the data.

After going through the stages of signal processing, the data is then plotted into a graph, and then combined in a single panel. The graph is then converted into image data. Data conversion chart into image data, aiming to facilitate the extraction process to form a fractal.

The image data, and then will be fractal extraction resulting data in the form fractal dimension and lacunarity. This data was to be compared with the existing database, using Support Vector Multi Macchine, which will be the output of this process is the classification of the types and levels of PD.

3.3 GUI Design

In making the application of pattern recognition, we use MATLAB software with GUIDE (Graphical User Interface Design Environment) and assisted with the syntax of programming. This application is to get input in the form of 2 pieces * csv file.

GUI application designed into 4 main modules, namely : Display module for displaying graphs and PD parameters, database creation module to add a database of patterns of PD, Processing module to ensure the process is running normally as well as to know its not a database, pattern recognition module, to perform a partial discharge pattern recognition, as well as featuring level and its type.

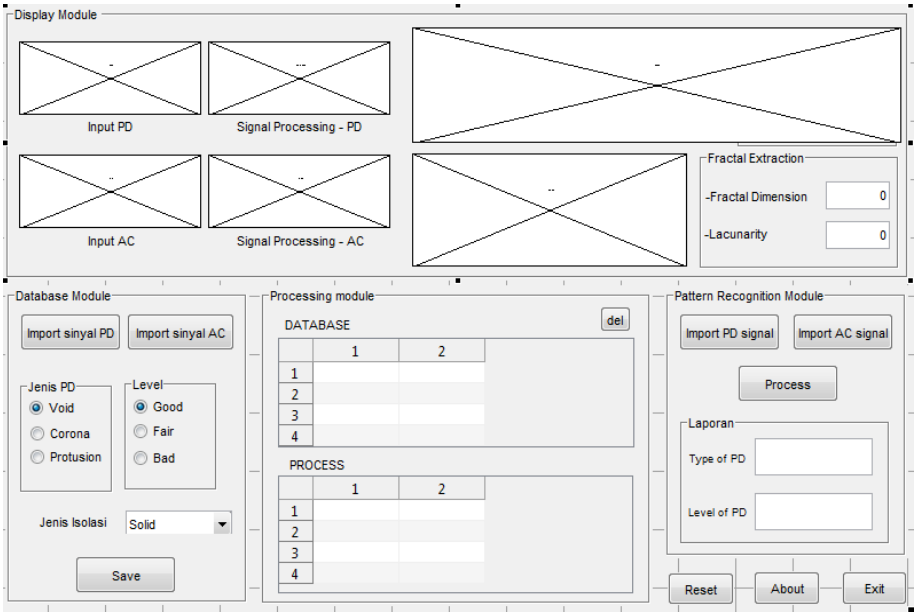

Fig. 4. The Concept of the GUI

4. Conclusion

Applications with the pattern and judgement of PD systems with fractal extraction and SVM methods have been designed. In performing its function, then this application requires database with known data. The workings of this application, consists of 2 pieces of flowchart, which consists of database creation and pattern recognition. To build a pattern recognition database, it takes the data of a known test result. The data is a csv * file, consisting of 2 pieces of data, ie data source injection voltage (AC signal) and PD measurement data from the sensor (PD signal). Both of these data will be normalized, so the inside is in accordance with the actual conditions. In addition, the normalization stage, also used to retrieve the required data.

Next in the signal processing stage, each data will experience different processing. In the AC signal data, the raw data has a lot of noise, visible from the non-smooth waveform. The AC signal data will pass through low pass filter with frequency passed by 50 Hz. From this result, the fundamental sine wave is smooth and the amount of noise is less. While in the PD signal data, data has a lot of noise that complicates the introduction of actual PD signals. The PD signal will pass through the denoising stage. After going through the Signal Processing step, the data is then plotted into the graph, then merged into one panel. The graph then becomes the image data.

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