COMPUTER-IMPLEMENTED METHOD FOR CLASSIFYING A PARTIAL DISCHARGE TYPE

TECHNICAL FIELD

[0001] Various aspects of this disclosure relate to a method for classifying a partial discharge type.

BACKGROUND

[0002] Electrical insulation plays a vital role in protecting high-voltage equipment and mitigating damage resulting from random and potentially harmful abnormal discharges. These discharges, occurring sporadically, have the potential to cause insulation deterioration, leading to eventual electrical failures. The continuous monitoring of partial discharge (PD) activity stands as a critical practice, aimed at evaluating the condition of electrical insulation and averting unexpected system breakdowns. To capture partial discharge signals, several measurement techniques have been devised, including the analysis of high-frequency voltage signals, electromagnetic waves, light, sound, and the examination of decomposed gases.

[0003] A need therefore exists to provide an improved method for classifying partial discharge types.

SUMMARY

[0004] According to a first aspect of the present disclosure, a computer-implemented method for classifying a partial discharge type, executed by at least one processor, the computer-implemented method comprising: determining a set of parameter values for generating a set of Phase Resolved Partial Discharge (PRPD) patterns from partial discharge signals, a respective PRPD pattern of the set of PRPD patterns being generated based on a respective parameter value of the set of parameter values; extracting a set of features from the set of PRPD patterns, a respective feature of the set of features being extracted from a respective PRPD pattern of the set of PRPD patterns; generating a set of partial discharge scores from the set of extracted features by a pre-trained PRPD classification model, a respective partial discharge score of the set of partial discharge scores being generated for a respective feature of the set of features; and classifying a partial discharge type based on a PRPD pattern

of the set of PRPD patterns corresponding to a maximal partial discharge score of the set of partial discharge scores.

[0005] According to a second aspect of the present disclosure, a data processing system is provided including a communication interface, a memory and a processing unit configured to perform the method described herein.

[0006] According to a third aspect of the present disclosure, a computer program element is provided including program instructions, which, when executed by one or more processors, cause the one or more processors to perform the method described herein.

[0007] According to a fourth aspect of the present disclosure, a computer-readable medium is provided including program instructions, which, when executed by one or more processors, cause the one or more processors to perform the method described herein.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] The invention will be better understood with reference to the detailed description when considered in conjunction with the non-limiting examples and the accompanying drawings, in which:

- FIG. 1 depicts a schematic block diagram of a system for classifying a partial discharge type according to various embodiments of the present disclosure.
- FIG. 2A and 2B depict schematic block diagrams of methods for pre-training a classification model according to various embodiments of the present disclosure.
- FIG. 3 shows a graph of partial discharge signal waveforms according to various embodiments of the present disclosure.
- FIG. 4A and FIG. 4B show graphs of Phase Resolved Partial Discharge (PRPD) patterns according to Data Acquisition System (DAQ) and according to various embodiments of the present disclosure, respectively.
- FIG. 5 depicts a schematic flow diagram of a computer-implemented method for classifying a partial discharge type according to various embodiments of the present disclosure.
- FIG. 6 shows a schematic block diagram of a system for classifying a partial discharge type according to various embodiments of the present disclosure.

DETAILED DESCRIPTION

[0009] The following detailed description refers to the accompanying drawings that show, by way of illustration, specific details and embodiments in which the disclosure may be practiced. These embodiments are described in sufficient detail to enable those skilled in the art to practice the disclosure. Other embodiments may be utilized and structural, and logical changes may be made without departing from the scope of the disclosure. The various embodiments are not necessarily mutually exclusive, as some embodiments can be combined with one or more other embodiments to form new embodiments.

[0010] Embodiments described in the context of one of the devices or methods are analogously valid for the other devices or methods. Similarly, embodiments described in the context of a device are analogously valid for a vehicle or a method, and vice-versa.

[0011] Features that are described in the context of an embodiment may correspondingly be applicable to the same or similar features in the other embodiments. Features that are described in the context of an embodiment may correspondingly be applicable to the other embodiments, even if not explicitly described in these other embodiments. Furthermore, additions and/or combinations and/or alternatives as described for a feature in the context of an embodiment may correspondingly be applicable to the same or similar feature in the other embodiments.

[0012] In the context of various embodiments, the articles "a", "an" and "the" as used with regard to a feature or element include a reference to one or more of the features or elements.

[0013] As used herein, the term "and/or" includes any and all combinations of one or more of the associated listed items.

[0014] It will be further understood that the terms "comprise" (and any form of comprise, such as "comprises" and "comprising"), "have" (and any form of have, such as "has" and "having"), "include" (and any form of include, such as "includes" and "including"), and "contain" (and any form of contain, such as "contains" and "containing") are open-ended linking verbs. As a result, a method or device that "comprises," "has," "includes" or "contains" one or more steps or elements possesses those one or more steps or elements, but is not limited to possessing only those one or more steps or elements. Likewise, a step of a method or an element of a device that "comprises," "has," "includes" or "contains" one or more features possesses those one or more features, but is not limited to possessing only those one or more features. Furthermore, a device or structure that is configured in a certain way is configured in at least that way, but may also be configured in ways that are not listed.

[0015] As used herein, the phrase of the form of "at least one of A or B" may include A or B or both A and B. Correspondingly, the phrase of the form of "at least one of A or B or C", or including further listed items, may include any and all combinations of one or more of the associated listed items.

[0016] The term "exemplary" may be used herein to mean "serving as an example, instance, or illustration". Any aspect or design described herein as "exemplary" is not necessarily to be construed as preferred or advantageous over other aspects or designs.

[0017] The terms "at least one" and "one or more" may be understood to include a numerical quantity greater than or equal to one (e.g., one, two, three, four, [...], etc.). The term "a plurality" may be understood to include a numerical quantity greater than or equal to two (e.g., two, three, four, five, [...], etc.). The phrase "at least one of" with regard to a group of elements may be used herein to mean at least one element from the group consisting of the elements. For example, the phrase "at least one of" with regard to a group of elements may be used herein to mean a selection of: one of the listed elements, a plurality of one of the listed elements, a plurality of individual listed elements, or a plurality of a multiple of listed elements.

[0018] The words "plural" and "multiple" in the description and in the claims expressly refer to a quantity greater than one. Accordingly, any phrases explicitly invoking the aforementioned words (e.g., "a plurality of (objects)", "multiple (objects)") referring to a quantity of objects expressly refer to more than one of the said objects. The terms "group (of)", "set (of)", "collection (of)", "series (of)", "sequence (of)", "grouping (of)", etc., and the like in the description and in the claims, if any, refer to a quantity equal to or greater than one, i.e. one or more.

[0019] The term "first", "second", "third" detailed herein are used to distinguish one element from another similar element and may not necessarily denote order or relative importance, unless otherwise stated. For example, a first transaction data, a second transaction data may be used to distinguish two transactions based on two different foreign currency exchange.

[0020] The term "data" as used herein may be understood to include information in any suitable analog or digital form, e.g., provided as a file, a portion of a file, a set of files, a signal or stream, a portion of a signal or stream, a set of signals or streams, and the like. Further, the term "data" may also be used to mean a reference to information, e.g., in form of a pointer. The term "data", however, is not limited to the aforementioned examples and may take various

forms and represent any information as understood in the art. Any type of information, as described herein, may be handled for example via one or more processors in a suitable way, e.g. as data.

[0021] The term "module" detailed herein refers to, or forms part of, or includes an Application Specific Integrated Circuit (ASIC); an electronic circuit; a combinational logic circuit; a field programmable gate array (FPGA); a processor (shared, dedicated, or group) that executes code; other suitable hardware components that provide the described functionality; or a combination of some or all of the above, such as in a system-on-chip. The term module may include memory (shared, dedicated, or group) that stores code executed by the processor.

[0022] Differences between software and hardware implemented data handling may blur. A processor, controller, and/or circuit detailed herein may be implemented in software, hardware, and/or as a hybrid implementation including software and hardware.

[0023] Unless specifically stated otherwise, and as apparent from the following, it will be appreciated that throughout the present specification, description or discussions utilizing terms such as "performing", "extracting", "generating", "determining", "classifying", "identifying" or the like, refer to the actions and processes of a computer system, or similar electronic device, that manipulates and transforms data represented as physical quantities within the computer system into other data similarly represented as physical quantities within the computer system or other information storage, transmission or display devices.

[0024] Some portions of the present disclosure are explicitly or implicitly presented in terms of algorithms and functional or symbolic representations of operations on data within a computer memory. These algorithmic descriptions and functional or symbolic representations are the means used by those skilled in the data processing arts to convey most effectively the substance of their work to others skilled in the art. An algorithm is here, and generally, conceived to be a self-consistent sequence of steps leading to a desired result. The steps are those requiring physical manipulations of physical quantities, such as electrical, magnetic or optical signals capable of being stored, transferred, combined, compared, and otherwise manipulated.

[0025] According to various non-limiting embodiments, the proposed method seeks to explore electromagnetic data to formulate an efficient approach for the detection and identification of partial discharge events.

[0026] Different types of partial discharges may be categorized, including internal partial discharge, surface partial discharge, and corona partial discharge, primarily based on their origins. To detect and classify these partial discharges, pertinent features may be extracted from the recorded partial discharge pulse waveforms. Given that partial discharge events are inherently stochastic in nature, the collection of a sufficient number of partial discharge samples may be imperative to enable accurate statistical analysis and pattern recognition. However, practical partial discharge data may incorporate notable levels of noise, stemming from sensor constraints and data acquisition systems.

[0027] The Phase Resolved Partial Discharge (PRPD) method may represent a pragmatic strategy for feature extraction from partial discharge signals. The PRPD may provide an independent discriminant predictor that remains uninfluenced by the circuit path between the detector and the defect. Due to noise interference, as well as errors and disturbances during the data acquisition (DAQ) process, the PRPD patterns generated from captured signals may occasionally experience polarity confusion. This issue may significantly impact the efficacy of partial discharge detection and type classification.

[0028] According to various non-limiting embodiments, the proposed method seeks to effectively manage these captured signals and establish their correct polarity by introducing an artificial intelligence (AI)-based trigger control strategy aimed at determining an appropriate trigger value for a given set of captured signals. This present method may enable generation of clear and accurate PRPD patterns for partial discharge type classification and employ statistical operators for feature extraction to construct partial discharge classifiers.

[0029] According to various non-limiting embodiments, the proposed method seeks to alleviate the influence of noise on recognition outcomes, thereby distinguishing authentic partial discharge signals from noise. Advantageously, the proposed method may simplify the task of partial discharge type identification, effectively framing it as a matter of recognizing single-source signals.

[0030] The present disclosure seeks to enhance the detection and classification performance of the partial discharge model by the utilization of a well-trained AI model, which is trained on extensive manually labelled PRPD pattern samples, to mitigate interference in the data acquisition system. The proposed method and system seek to acquire reliable and accurate PRPD patterns, where different trigger values correspond to distinct PRPD patterns. The

generation of these newly accurate PRPD patterns may in turn enhance the performance of the partial discharge detection and classification model.

[0031] The following examples pertain to various aspects of the present disclosure.

[0032] Example 1 is a computer-implemented method for classifying a partial discharge type, the method including: determining a set of parameter values for generating a set of Phase Resolved Partial Discharge (PRPD) patterns from partial discharge signals, a respective PRPD pattern of the set of PRPD patterns being generated based on a respective parameter value of the set of parameter values; extracting a set of features from the set of PRPD patterns, a respective feature of the set of features being extracted from a respective PRPD pattern of the set of PRPD patterns; generating a set of partial discharge scores from the set of extracted features by a pre-trained PRPD classification model, a respective partial discharge score of the set of partial discharge scores being generated for a respective feature of the set of features; and classifying a partial discharge type based on a PRPD pattern of the set of PRPD patterns corresponding to a maximal partial discharge score of the set of partial discharge scores.

[0033] In Example 2, the subject matter of Example 1 may optionally include that the pre-trained PRPD classification model includes an Artificial Intelligence (AI) model.

[0034] In Example 3, the subject matter of Example 2 may optionally include that the AI model is pre-trained by manually labelled sample PRPD patterns.

[0035] In Example 4, the subject matter of Example 2 may optionally include that the pre-trained PRPD classification model is based on a convolutional neural network (CNN) and training of the pre-trained PRPD classification model includes: performing a plurality of feature extraction operations on sample PRPD patterns using a plurality of convolution layers of the CNN to produce a plurality of feature maps, wherein a respective feature extraction operation of the plurality of feature extraction operations is performed by a respective convolution layer of the plurality of convolution layers; feeding the plurality of feature maps to a global average pooling layer; feeding pooling outputs of the global average pooling layer to fully connected layers.

[0036] In Example 5, the subject matter of Example 2 may optionally include that the pre-trained PRPD classification model is based on Support Vector Machine (SVM) classification model and training of the pre-trained PRPD classification model includes: performing histogram feature extraction operations on sample PRPD patterns; generating outputs from the histogram features by the Support Vector Machine (SVM) classification model.

[0037] In Example 6, the subject matter of Example 3 may optionally include that the AI model is pre-trained to generate partial discharge scores based on classification losses calculated from the manually labelled sample PRPD patterns.

[0038] In Example 7, the subject matter of Example 1 may optionally include that classifying a partial discharge type includes classifying a partial discharge type into one of three types of partial charges and noise, three types of partial charges including corona partial discharge, internal partial discharge and surface partial discharge.

[0039] In Example 8, the subject matter of Example 1 may optionally include that the set of parameter values include percentages of an initial trigger value.

[0040] In Example 9, the subject matter of Example 8 may optionally include that the set of parameter values include 10%, 20%, 30%, ..., 100% of the initial trigger value.

[0041] In Example 10, the subject matter of Example 8 may optionally include that the set of parameter values include the percentages of the initial trigger value, adjacent two percentages with an equal increment.

[0042] In Example 11, the subject matter of Example 1 may optionally include that the set of parameter values includes a set of trigger values and wherein the set of PDPR patterns are generated from partial discharge signals having values greater than the set of trigger values.

[0043] In Example 12, the subject matter of Example 11 may optionally include that the partial discharge signals having values greater than the set of trigger values are activated and recorded by a Data Acquisition System.

[0044] In Example 13, the subject matter of Example 12 may optionally include that the partial discharge signals having values greater than the set of trigger values are recorded with a magnitude and polarity.

[0045] In Example 14, the subject matter of Example 1 may optionally include that the set of partial discharge scores includes a set of confidence levels of partial discharge.

[0046] In Example 15, the subject matter of Example 1 may optionally include that the maximal partial discharge score corresponds to a confidence level of the set of confidence levels, indicating a highest probability of partial discharge.

[0047] In Example 16, the subject matter of Example 1 may optionally include that the partial discharge signals are presented in pulse waveforms.

[0048] In Example 17, the subject matter of Example 1 may optionally include that the partial discharge signals are obtained at a predetermined sampling rate.

[0049] Example 18 is a data processing system including a communication interface, a memory and a processing unit configured to perform the method of any one of Examples 1 to 17.

[0050] Example 19 is a computer program element including program instructions, which, when executed by one or more processors, cause the one or more processors to perform the method of any one of Examples 1 to 17.

[0051] Example 20 is a computer-readable medium including program instructions, which, when executed by one or more processors, cause the one or more processors to perform the method of any one of Examples 1 to 17.

[0052] In the following, embodiments will be described in detail.

[0053] FIG. 1 depicts a schematic block diagram of a system 100 for classifying a partial discharge type according to various embodiments of the present disclosure. The system 100 may include a parameter values input module 102, a features extraction module 103, a data processing module 105 (e.g. including a pre-trained classification model) and a results output module 107. The system may optionally include a Phase Resolved Partial Discharge (PRPD) database module 101.

[0054] According to various non-limiting embodiments, the parameter values input module 102 may be configured to determine a set of parameter values for generating a set of PRPD patterns from partial discharge signals. In the context of various embodiments, "determine" may refer to determining the set of parameter values based on external inputs (e.g. from a user of the system 100) or determining the set of parameter values based on a software program (e.g. a machine-learning program embedded therein).

[0055] According to various non-limiting embodiments, the partial discharge signals generated by a target equipment may be captured/recorded (e.g. at a predetermined sampling rate) in pulse waveforms with a magnitude and polarity by a Data Acquisition System (DAQ) (e.g. included in a partial discharge detector or any other capable measurement system) or by a signal acquisition module (not shown) of the system 100 during a partial discharge testing (e.g. to assess electrical insulation health of a gas pipe). In the DAQ system, a trigger condition may be a mechanism that initiates the start of data acquisition based on certain predefined conditions or events. Once the trigger condition is detected (e.g. the magnitudes of the signals is higher than an initial trigger value (e.g. a predefined value)), the DAQ system may begin sampling and recording data from input channels. The DAQ system continuously monitors the

input signal from the sensors or sources. The DAQ system may compare real-time signal values against the initial trigger value. When input signal reaches or exceeds the initial trigger value, it may indicate that the desired event or condition has occurred. The trigger condition may ensure that the relevant portion of the signals, corresponding to the trigger event, is captured accurately.

[0056] The DAQ may be set to generate PRPD patterns based on a trigger condition, that is, generate the PRPD patterns based on partial discharge signals if they surpass (e.g. exceed) a (fixed) trigger point (i.e. an initial trigger value). The partial discharge detector or any other capable measurement system may input (e.g. transfer) the captured/recorded partial discharge signals to the parameter values input module 102 of the system 100. Alternatively or additionally, the system 100 may be included in the partial discharge detector or any other capable measurement system (e.g. communicate with the DAQ). The partial discharge signals may be used to generate a set of PRPD patterns by the parameter values input module 102.

[0057] According to various non-limiting embodiments, a set of parameter values may include percentages. In some embodiments, the set of parameter values may include 10%, 20%, 30%, ..., 100% of an initial trigger value, that is, increasing from 10% by an increment of 10% to 100% (i.e. adjacent two percentages with an equal increment) of the initial trigger value. It should be appreciated that the percentages are not limited as shown herein but include any percentages that are suitable. According to various non-limiting embodiments, a set of parameter values may include ratios.

[0058] According to various non-limiting embodiments, a set of parameter values may include a set of trigger values for generating a set of PRPD patterns from partial discharge signals by the parameter values input module 102. The partial discharge signals may have values (e.g. magnitudes) greater than the set of trigger values. PRPD patterns generated based on a fixed trigger point (e.g. an initial trigger value) of the Data Acquisition System (DAQ) may cause waveform polarity discrepancies. A trigger point may be so determined that a partial discharge occurs when values (e.g. magnitudes) of the partial discharge signals are above a value of the trigger point. In various embodiments, the set of trigger values (e.g. various trigger values) may be utilized to generate the set of PRPD patterns, that is, to multiply re-trigger the partial discharge signals so as to obtain the set of PRPD patterns (i.e. multiple PRPD patterns). In the context that the set of parameter values include percentages, the partial discharge signals may be re-triggered by a sequence of percentages (e.g. a percentage of an initial trigger value).

That may mean the set of parameter values are lower than the initial trigger value. More details will be described with reference to FIG. 3 below.

[0059] According to various non-limiting embodiments, a respective PRPD pattern of the set of PRPD patterns may be generated based on a respective parameter value of the set of parameter values. In other words, a respective parameter value of the set of parameter values may be used to re-trigger the partial discharge signals to obtain a respective PRPD pattern of the set of PRPD patterns. That is, a set of PRPD patterns may be generated from the (same) partial discharge signals by the set of parameter values.

[0060] According to various non-limiting embodiments, the set of parameter values may be used to generate a set of PRPD patterns from partial discharge signals by the parameter values input module 102. The set of PRPD patterns generated may be transferred (e.g. communicated) to the feature extraction module 103 for extracting a set of features from the set of PRPD patterns. In various embodiments, a respective feature of the set of features may be extracted from a respective PRPD pattern of the set of PRPD patterns. Accordingly, the respective feature of the set of features may correspond to the respective PRPD pattern of the set of PRPD patterns and in turn correspond to the respective parameter value of the set of parameter values based on which the respective PRPD pattern of the set of PRPD patterns is generated.

[0061] According to various non-limiting embodiments, the data processing module 105 may include a pre-trained PRPD classification model which will be descried below in more details. The extracted set of features may be transferred (e.g. communicated) to the data processing module 105 and the data processing module 105 may be configured to generate a set of partial discharge scores from the extracted set of features by the pre-trained PRPD classification model included therein. In other words, by taking the extracted set of features from the set of PRPD patterns as input, the data processing module 105 may output the set of partial discharge scores for the set of PRPD patterns. The set of partial discharge scores may represent partial discharge probabilities for the corresponding set of PRPD patterns from which the set of features are extracted, for example, the higher the partial discharge score the greater probability that a partial discharge occurs. In various embodiments, a respective partial discharge score of the set of partial discharge scores may be generated for a respective feature of the set of features. Accordingly, the respective partial discharge score of the set of partial discharge scores may correspond to the respective feature of the set of features, and correspond to the respective PRPD pattern of the set of PRPD patterns from which the respective feature

of the set of features is extracted, and in turn correspond to the respective parameter value of the set of parameter values based on which the respective PRPD pattern of the set of PRPD patterns is generated.

[0062] According to various non-limiting embodiments, the pre-trained PRPD classification model included in the data processing module 105 may be per-trained by sample PRPD patterns stored in the PRPD pattern database module 101. In some embodiments, the pre-trained PRPD classification model may include an Artificial Intelligence (AI) model. The AI model may be pre-trained by manually labelled sample PRPD patterns. That is, the sample PRPD patterns may be labelled manually by types of partial discharge which the sample PRPD patterns show. The sample PRPD patterns may include PRPD patterns showing noise, corona partial discharge, internal partial discharge and surface partial discharge. The pre-trained PRPD classification model may be consequently trained to generate partial discharge scores (e.g. prediction scores) corresponding to noise, corona partial discharge, internal partial discharge and surface partial discharge categories. The PRPD classification model's prediction score for each category may be normalized (e.g. 0.01, 0.74, 0.15, 0.1), that is, the sum of all category scores is 1. The category with the largest score may be selected as the predicted category. For example, when the PRPD classification model obtains a maximal partial discharge score on the noise category, it may be judged as noise; when it obtains a maximal partial discharge score on the corona partial discharge category, it may be judged as corona partial discharge.

[0063] According to various non-limiting embodiments, the set of partial discharge scores may be transferred (e.g. communicated) to the results output module 107 and the results output module 107 may be configured to classify a partial discharge type based on a PRPD pattern of the set of PRPD patterns corresponding to a maximal partial discharge score of the set of partial discharge scores. Classifying a partial discharge type may include classifying a partial discharge type into one of three types of partial charges and noise, three types of partial charges including corona partial discharge, internal partial discharge and surface partial discharge.

[0064] According to various non-limiting embodiments, prior to classifying the partial discharge type, the results output module 107 may be configured to identify a parameter value from the set of parameter values, the identified parameter value corresponding to the maximal partial discharge score of the set of partial discharge scores. That may mean the maximum of the set of partial discharge scores represents a maximum partial discharge probability, and the

corresponding parameter value based on which the corresponding PRPD pattern is generated is identified.

[0065] FIG. 2A and 2B depict schematic block diagrams of exemplary methods 302, 304, respectively, for pre-training a classification model according to various embodiments of the present disclosure. It should be appreciated that the pre-trained classification model (e.g. as included in the data processing module 105) may be trained by other methods (e.g. algorithms, programs) than the ones shown in FIG. 2A and FIG. 2B.

[0066] According to various non-limiting embodiments, in FIG. 2A, the pre-trained PRPD classification model may be based on a convolutional neural network (CNN). The training method 302 of the pre-trained PRPD classification model may include: performing a plurality of feature extraction operations on sample PRPD patterns using a plurality of convolution layers of the CNN to produce a plurality of feature maps. A respective feature extraction operation of the plurality of feature extraction operations may be performed by a respective convolution layer of the plurality of convolution layers. The sample PRPD patterns may be stored in a database (e.g. the PRPD pattern database module 101). In some embodiments, the pre-trained PRPD classification model may be pre-trained by manually labelled sample PRPD patterns. That is, types of partial discharge shown by the sample PRPD patterns may be manually identified (i.e. identified by a human) and input as known parameters to the pre-trained PRPD classification model so as to train the pre-trained PRPD classification model. The sample PRPD patterns may be regarded as images to train the CNN-based PRPD classification model and the classification loss (e.g. softmax loss) may be relayed on. The CNN model may automatically learn features from the input data.

[0067] According to various non-limiting embodiments, the training method 302 of the pre-trained PRPD classification model may further include: feeding the plurality of feature maps to a global average pooling layer (GAP), and feeding pooling outputs of the global average pooling layer to fully connected layers (FC). Partial discharge scores of the sample PRPD patterns may be generated from outputs of the fully connected layers based on classification losses calculated from the sample PRPD patterns. The classification losses may include dielectric-based classification losses. The classification losses may be calculated by classification loss function. The classification loss function, also referred to as the softmax loss function which now is commonly used as the Cross-Entropy classification loss function, may be represented as

$$-\frac{1}{c}\sum_{i=1}^{c} y_i \log p_i,$$

where p_i and y_i are the predicted result and ground truth value for class i, c is the class number.

[0068] According to various non-limiting embodiments, the sample PRPD patterns may include PRPD patterns showing noise, corona partial discharge, internal partial discharge and surface partial discharge. The pre-trained PRPD classification model may be consequently trained to generate partial discharge scores corresponding to noise, corona partial discharge, internal partial discharge and surface partial discharge. The set of partial discharge scores may include a set of confidence levels of partial discharge. The confidence level may represent a probability of partial discharge, that is, a higher confidence level represents a high probability that a partial discharge occurs. Accordingly, the set of partial discharge scores may represent the probability of partial discharge. The maximal partial discharge score may correspond to a confidence level of the set of confidence levels, indicating a highest probability of partial discharge. The highest probability of partial discharge may be optimal.

[0069] According to various non-limiting embodiments, in FIG. 2B, the pre-trained PRPD classification model 304 may be based on Support Vector Machine (SVM) classification model. The training method 304 of the pre-trained PRPD classification model may include performing histogram feature extraction operations on sample PRPD patterns and generating outputs from the histogram features by the Support Vector Machine (SVM) classification model. The sample PRPD patterns may be stored in a database (e.g. the PRPD pattern database module 101). In some embodiments, the pre-trained PRPD classification model may be pre-trained by manually labelled sample PRPD patterns. That is, types of partial discharge shown by the sample PRPD patterns may be manually identified (i.e. identified by a human) and input as known parameters to the pre-trained PRPD classification model so as to train the pre-trained PRPD classification model. In the SVM model, the features extracted from the sample PRPD patterns may be based on the row and column statistical features of the sample PRPD patterns, that is, the two-dimensional directions of the sample PRPD pattern images are summed, and the two obtained feature vectors are concatenated together as input to the SVM classification model.

[0070] Similarly as shown in FIG. 2A, partial discharge scores of the sample PRPD patterns may be generated from the outputs of the SVM classification model based on classification losses calculated from the sample PRPD patterns. The classification losses may include

dielectric-based classification losses. The classification losses may be calculated by classification loss function. The process of training the SVM classification model may involve optimization of minimizing the classification loss function as represented

$$\frac{1}{2}\mathbf{w}^2 + CF\left(\sum_{i=1}^{\ell}\xi_i^{\sigma}\right),$$

where C is a constant and σ is a hyper parameter. F is a monotonic convex function. $\mathbf{w}$ is the weight matrix to be optimized. ξ is the deviations item.

[0071] According to various non-limiting embodiments, the sample PRPD patterns may include PRPD patterns showing noise, corona partial discharge, internal partial discharge and surface partial discharge. The pre-trained PRPD classification model may be consequently trained to generate partial discharge scores corresponding to noise, corona partial discharge, internal partial discharge and surface partial discharge. The set of partial discharge scores may include a set of confidence levels of partial discharge. The confidence level may represent a probability of partial discharge, that is, a higher confidence level represents a high probability that a partial discharge occurs. Accordingly, the set of partial discharge scores may represent the probability of partial discharge. The maximal partial discharge score may correspond to a (optimal) confidence level of the set of confidence levels, indicating a highest probability of partial discharge.

[0072] FIG. 3 shows a graph 300 of partial discharge signal waveforms according to various embodiments of the present disclosure.

[0073] The partial discharge signals waveforms 301, 302 may be captured/recorded (e.g. at a predetermined sampling rate) with a magnitude and polarity by a Data Acquisition System (DAQ) (e.g. included in a partial discharge detector or any other capable measurement system) or by a signal acquisition module (not shown) of the system 100 during a partial discharge testing (e.g. to assess electrical insulation health of a gas pipe). The partial discharge signals waveforms 301, 302 may be obtained by the same DAQ system during one data acquisition. The DAQ may be set to generate PRPD patterns based on a trigger condition, that is, generate the PRPD patterns based on partial discharge signals if they surpass (e.g. exceed) a fixed trigger point (e.g. an initial trigger value). The initial trigger value is denoted as dashed lines 309 and intersects with the partial discharge signals waveforms 301, 302 at trigger points 302a, 302b. This shows the fixed trigger point of DAQ resulting erroneous polarities (i.e. the trigger point 302a with an opposite (down) polarity to an (up) polarity of the trigger point 302b) as the

trigger points 302a, 302b should have the same (up) polarity. Thus, PRPD patterns generated based on a fixed trigger point (e.g. an initial trigger value) of the DAQ may cause waveform polarity discrepancies. This may be due to the difference in peak values of the timing signals, when the DAQ system judges the polarity according to the fixed trigger point position. The polarity of the trigger points may be determined (on-site) by a technician staff with professional background knowledge based on the waveform change trend (e.g. first rises sharply and then decays).

[0074] According to various non-limiting embodiments, a set of trigger values may be determined to generating a set of PRPD patterns from partial discharge signals (e.g. by the parameter values input module 102). In some embodiments, the set of trigger values may include percentages and/or ratios. Accordingly, the set of trigger values may be less than the fixed trigger value (i.e. the initial trigger value) of DAQ. One of the set of trigger values is denoted as dashed lines 308 (i.e. with less magnitude than the fixed trigger value denoted as dashed lines 309 as described above) and intersects with the partial discharge signals waveforms 301, 302 at trigger points 301a, 301b. This shows, the set of trigger values according to various embodiments, resulting right polarities (i.e. the trigger point 301a with a same (up) polarity to the (up) polarity of the trigger point 301b). Advantageously, PRPD patterns generated based on the set of trigger values according to various embodiments may show right waveform polarity, whereby more accurate PRPD patterns may be obtained by the present disclosure. The other(s) of the set of trigger values may similarly be utilized to generate the set of PRPD patterns, that is, to multiply re-trigger the partial discharge signals (e.g. with correct polarity determination) so as to obtain the set of PRPD patterns (e.g. more accurate).

[0075] FIG. 4A and FIG. 4B show graphs 410, 420 of Phase Resolved Partial Discharge (PRPD) patterns according to Data Acquisition System (DAQ) and according to various embodiments of the present disclosure, respectively.

[0076] Experiments have been performed to assess the efficacy of the present AI-aided trigger control strategy for partial discharge detection. As depicted in FIG. 4A, PRPD patterns were initially entangled with noise patterns, making it challenging to achieve precise predictions based on PRPD patterns using the fixed trigger values from the DAQ. However, after applying the proposed method, the trigger values adapted dynamically to the current captured signals. Prediction results were then obtained by employing the present well-trained AI model, which effectively measured the trigger values and selected the optimal settings for

each signal set. This process corrected the polarity of the captured waveforms, as denoted 412 and 422, resulting in clear and accurate PRPD patterns. These refined patterns may be readily used by the partial discharge classification model to yield accurate partial discharge detection and classification results.

[0077] FIG. 5 depicts a schematic flow diagram of a computer-implemented method 500 for classifying a partial discharge type according to various embodiments of the present disclosure

[0078] The computer-implemented method 500 for classifying a partial discharge type may include:

at step 502, determining a set of parameter values for generating a set of Phase Resolved Partial Discharge (PRPD) patterns from partial discharge signals, a respective PRPD pattern of the set of PRPD patterns being generated based on a respective parameter value of the set of parameter values;

at step 504, extracting a set of features from the set of PRPD patterns, a respective feature of the set of features being extracted from a respective PRPD pattern of the set of PRPD patterns;

at step 506, generating a set of partial discharge scores from the set of extracted features by a pre-trained PRPD classification model, a respective partial discharge score of the set of partial discharge scores being generated for a respective feature of the set of features; and

at step 508, classifying a partial discharge type based on a PRPD pattern of the set of PRPD patterns corresponding to a maximal partial discharge score of the set of partial discharge scores.

[0079] The method 500 may be performed by the system 100 as described hereinbefore. Accordingly, embodiments described in the context of the system 100 are analogously valid for the method 500.

[0080] In the context of various embodiments, "determining" may refer to determining the set of parameter values based on external inputs (e.g. from a user) or determining the set of parameter values based on a software program (e.g. a machine-learning program embedded therein). The set of parameter values may be determined in a manner that the generated PRPD patterns reflect correct polarities as described hereinbefore (e.g. with reference to FIGS. 3, 4A and 4B). The partial discharge signals may be used to generate a set of PRPD patterns based on the set of parameter values as parameter inputs.

[0081] According to various non-limiting embodiments, a set of parameter values may include percentages. In some embodiments, the set of parameter values may include 10%, 20%, 30%, ..., 100%, that is, increasing from 10% by an increment of 10% to 100% (i.e. adjacent two percentages with an equal increment). It should be appreciated that the percentages are not limited as shown herein but include any percentages that are suitable. According to various non-limiting embodiments, a set of parameter values may include ratios.

[0082] According to various non-limiting embodiments, a set of parameter values may include a set of trigger values for generating a set of PRPD patterns from partial discharge signals (e.g. by the parameter values input module 102). In various embodiments, the set of trigger values (e.g. various trigger values) may be utilized to generate the set of PRPD patterns, that is, to multiply re-trigger the partial discharge signals so as to obtain the set of PRPD patterns (i.e. multiple PRPD patterns). In the context that the set of parameter values include percentages, the partial discharge signals may be re-triggered by a sequence of percentages (e.g. a percentage of a fixed trigger point). That may mean the set of parameter values are lower than the fixed trigger point (i.e. the initial trigger value).

[0083] According to various non-limiting embodiments, a respective PRPD pattern of the set of PRPD patterns may be generated based on a respective parameter value of the set of parameter values. In other words, a respective parameter value of the set of parameter values may be used to re-trigger the partial discharge signals to obtain a respective PRPD pattern of the set of PRPD patterns. That is, a set of PRPD patterns may be generated from the (same) partial discharge signals by the set of parameter values.

[0084] According to various non-limiting embodiments, the set of parameter values may be used to generate a set of PRPD patterns from partial discharge signals (e.g. by the parameter values input module 102). A set of features may be extracted (e.g. by the feature extraction module 103) from the set of PRPD patterns. In various embodiments, a respective feature of the set of features may be extracted from a respective PRPD pattern of the set of PRPD patterns. Accordingly, the respective feature of the set of features may correspond to the respective PRPD pattern of the set of PRPD patterns and in turn correspond to the respective parameter value of the set of parameter values based on which the respective PRPD pattern of the set of PRPD patterns is generated.

[0085] According to various non-limiting embodiments, a set of partial discharge scores may be generated (e.g. by the data processing module 105) from the extracted set of features

by a pre-trained PRPD classification model (e.g. trained by the methods 302, 304 as described with reference to FIGS. 2A and 2B). In other words, by taking the extracted set of features from the set of PRPD patterns as input, the set of partial discharge scores for the set of PRPD patterns may be output of the pre-trained PRPD classification model (e.g. by the data processing module 105). The set of partial discharge scores may represent partial discharge probabilities for the corresponding set of PRPD patterns from which the set of features are extracted, for example, the higher the partial discharge score the greater probability that a partial discharge occurs. In various embodiments, a respective partial discharge score of the set of partial discharge scores may be generated for a respective feature of the set of features. Accordingly, the respective partial discharge score of the set of partial discharge scores may correspond to the respective feature of the set of features, and correspond to the respective PRPD pattern of the set of PRPD patterns from which the respective feature of the set of features is extracted, and in turn correspond to the respective parameter value of the set of parameter values based on which the respective PRPD pattern of the set of PRPD patterns is generated.

[0086] According to various non-limiting embodiments, the pre-trained PRPD classification model may be per-trained (e.g. trained by the methods 302, 304 as described with reference to FIGS. 2A and 2B). In some embodiments, the pre-trained PRPD classification model may include an Artificial Intelligence (AI) model. The AI model may be pre-trained by manually labelled sample PRPD patterns. That is, the sample PRPD patterns may be labelled manually by types of partial discharge which the sample PRPD patterns show. The sample PRPD patterns may include PRPD patterns showing noise, corona partial discharge, internal partial discharge and surface partial discharge. The pre-trained PRPD classification model may be consequently trained to generate partial discharge scores corresponding to noise, corona partial discharge, internal partial discharge and surface partial discharge. For example, a partial discharge score of may represent noise, and a partial discharge score of may represent corona partial discharge.

[0087] According to various non-limiting embodiments, a partial discharge type may be classified (e.g. by the results output module 107) based on a PRPD pattern of the set of PRPD patterns corresponding to a maximal partial discharge score of the set of partial discharge scores. A maximal partial discharge score of the set of partial discharge scores may represent a maximum partial discharge probability. A corresponding parameter value based on which a

corresponding PRPD pattern is generated from which a corresponding feature is extracted based on which the maximal partial discharge score is generated may be identified (e.g. by the results output module 107) prior to classifying the partial discharge type. Classifying a partial discharge type may include classifying a partial discharge type into one of three types of partial charges and noise, three types of partial charges including corona partial discharge, internal partial discharge and surface partial discharge.

[0088] While the methods 302, 304, 500 described above is illustrated and described as a series of steps or events, it will be appreciated that any ordering of such steps or events are not to be interpreted in a limiting sense. For example, some steps may occur in different orders and/or concurrently with other steps or events apart from those illustrated and/or described herein. In addition, not all illustrated steps may be required to implement one or more aspects or embodiments described herein. Also, one or more of the steps depicted herein may be carried out in one or more separate acts and/or phases.

[0089] According to various non-limiting embodiments, a data processing system including a communication interface, a memory and a processing unit configured to perform the method 500 as described herein.

[0090] According to various non-limiting embodiments, a computer program element including program instructions, which, when executed by one or more processors, cause the one or more processors to perform the method 500 as described herein.

[0091] According to various non-limiting embodiments, a computer-readable medium including program instructions, which, when executed by one or more processors, cause the one or more processors to perform the method 500 as described herein.

[0092] FIG. 6 depicts a schematic block diagram of a system 600 for classifying a partial discharge type according to various embodiments of the present disclosure. The system 600 includes: at least one memory 602; and at least one processor 604 communicatively coupled to the at least one memory 602 and configured to perform the method 500 for classifying a partial discharge as described hereinbefore according to various embodiments of the present disclosure. Accordingly, the at least one processor 604 is configured to: (at step 502) determining a set of parameter values for generating a set of Phase Resolved Partial Discharge (PRPD) patterns from partial discharge signals, a respective PRPD pattern of the set of PRPD patterns being generated based on a respective parameter value of the set of parameter values; (at step 504) extracting a set of features from the set of PRPD patterns, a respective feature of

the set of features being extracted from a respective PRPD pattern of the set of PRPD patterns; (at step 506) generating a set of partial discharge scores from the set of extracted features by a pre-trained PRPD classification model, a respective partial discharge score of the set of partial discharge scores being generated for a respective feature of the set of features; and (at step 508) classifying a partial discharge type based on a PRPD pattern of the set of PRPD patterns corresponding to a maximal partial discharge score of the set of partial discharge scores.

[0093] It will be appreciated by a person skilled in the art that the at least one processor 604 may be configured to perform various functions or operations through set(s) of instructions (e.g., software modules) executable by the at least one processor 604 to perform various functions or operations. Accordingly, as shown in FIG. 6, the system 600 may include: an input module (or an input circuit) 612 configured to determine a set of parameter values for generating a set of Phase Resolved Partial Discharge (PRPD) patterns from partial discharge signals; a data processing module (or a data processing circuit) 614 configured to perform the above-mentioned extracting (at step 504) a set of features from the set of PRPD patterns and the above-mentioned generating (at step 506) a set of partial discharge scores from the set of extracted features by a pre-trained PRPD classification model; and an output module (or an output circuit) 616 configured to classify a partial discharge type based on a PRPD pattern of the set of PRPD patterns corresponding to a maximal partial discharge score of the set of partial discharge scores.

[0094] It will be appreciated by a person skilled in the art that various modules of a system are not necessarily separate modules, and two or more modules may be realized by or implemented as one functional module (e.g., a circuit or a software program) as desired or as appropriate without deviating from the scope of the present disclosure. For example, two or more modules of the system 600 for classifying a partial discharge type (e.g., the input module 612, the data processing module 614, and the output module 616) may be realized (e.g., compiled together) as one executable software program (e.g., software application or simply referred to as an "app"), which for example may be stored in the at least one memory 602 and executable by the at least one processor 604 to perform various functions/operations as described herein according to various embodiments of the present disclosure.

[0095] It will be appreciated by a person skilled in the art that a system may include further modules, for example, the system 600 may include a display module (not shown) configured

to displaying the PRPD patterns in accordance with the set of parameter values according to the steps as described therein.

[0096] In various embodiments, the system 600 for classifying a partial discharge type may correspond to the method 500 for classifying a partial discharge type as described hereinbefore with reference to FIG. 5 according to various embodiments, therefore, various functions or operations configured to be performed by the least one processor 604 may correspond to various steps or operations of the method 500 for classifying a partial discharge type as described hereinbefore according to various embodiments, and thus need not be repeated with respect to the system 600 for classifying a partial discharge type for clarity and conciseness. In other words, various embodiments described herein in context of the methods are analogously valid for the corresponding systems, and vice versa.

[0097] For example, in various embodiments, the at least one memory 602 of the system 600 for classifying a partial discharge type may have stored therein the input module 612, the data processing module 614, and/or the output module 616, which correspond to one or more steps (or operation(s) or function(s)) of the method 500 for classifying a partial discharge type as described herein according to various embodiments, which are executable by the at least one processor 604 to perform the corresponding function(s) or operation(s) as described herein.

[0098] A computing system, a controller, a microcontroller or any other system providing a processing capability may be provided according to various embodiments in the present disclosure. Such a system may be taken to include one or more processors and one or more computer-readable storage mediums. For example, the system 600 for classifying a partial discharge type described hereinbefore may include at least one processor (or controller) 604 and at least one computer-readable storage medium (or memory) 602 which are for example used in various processing carried out therein as described herein. A memory or computer-readable storage medium used in various embodiments may be a volatile memory, for example a DRAM (Dynamic Random Access Memory) or a non-volatile memory, for example a PROM (Programmable Read Only Memory), an EPROM (Erasable PROM), EEPROM (Electrically Erasable PROM), or a flash memory, e.g., a floating gate memory, a charge trapping memory, an MRAM (Magnetoresistive Random Access Memory) or a PCRAM (Phase Change Random Access Memory).

[0099] In various embodiments, a "circuit" may be understood as any kind of a logic implementing entity, which may be special purpose circuitry or a processor executing software

stored in a memory, firmware, or any combination thereof. Thus, in an embodiment, a "circuit" may be a hard-wired logic circuit or a programmable logic circuit such as a programmable processor, e.g., a microprocessor (e.g., a Complex Instruction Set Computer (CISC) processor or a Reduced Instruction Set Computer (RISC) processor). A "circuit" may also be a processor executing software, e.g., any kind of computer program, e.g., a computer program using a virtual machine code, e.g., Java. Any other kind of implementation of the respective functions may also be understood as a "circuit" in accordance with various embodiments. Similarly, a "module" may be a portion of a system according to various embodiments and may encompass a "circuit" as described above, or may be understood to be any kind of a logic-implementing entity.

[00100] The present disclosure also discloses various systems (e.g., each may also be embodied as a device or an apparatus), such as the system 600 for classifying a partial discharge type, for performing various operations/functions of various methods described herein. Such systems may be specially constructed for the required purposes, or may include a general purpose computer or other device selectively activated or reconfigured by a computer program stored in the computer. The algorithms presented herein are not inherently related to any particular computer or other apparatus. Various general-purpose machines may be used with computer programs in accordance with the teachings herein. Alternatively, the construction of more specialized apparatus to perform various method steps may be appropriate.

[00101] In addition, the present disclosure also at least implicitly discloses a computer program or software/functional module, in that it would be apparent to the person skilled in the art that individual steps of various methods described herein may be put into effect by computer code. The computer program is not intended to be limited to any particular programming language and implementation thereof. It will be appreciated that a variety of programming languages and coding thereof may be used to implement the teachings of the disclosure contained herein. Moreover, the computer program is not intended to be limited to any particular control flow. There are many other variants of the computer program, which can use different control flows without departing from the scope of the disclosure. It will be appreciated by a person skilled in the art that various modules described herein (e.g. the input module 612, the data processing module 614, the output module 616) may be software module(s) realized by computer program(s) or set(s) of instructions executable by a computer processor to perform the required functions, or may be hardware module(s) being functional

hardware unit(s) designed to perform the required functions. It will also be appreciated that a combination of hardware and software modules may be implemented.

[00102] Furthermore, two or more of the steps of a computer program/module or method described herein may be performed in parallel rather than sequentially. Such a computer program may be stored on any computer readable medium. The computer readable medium may include storage devices such as magnetic or optical disks, memory chips, or other storage devices suitable for interfacing with a computer. The computer program when loaded and executed on such the computer effectively results in a system or an apparatus that implements various steps of methods described herein.

[00103] In various embodiments, there is provided a computer program product, embodied in one or more computer-readable storage mediums (non-transitory computer-readable storage medium(s)), including instructions (e.g., the input module 612, the data processing module 614, the output module 616) executable by one or more computer processors to perform the method 500 for classifying a partial discharge type, as described herein with reference to FIG. 5 according to various embodiments. Accordingly, various computer programs or modules described herein may be stored in a computer program product receivable by a system therein, such as the system 600 for classifying a partial discharge type as shown in FIG. 6, for execution by at least one processor 604 to perform various functions.

[00104] In various embodiments, the system 500 may be realized by any computer system (e.g., desktop or portable computer system (e.g., mobile device)) including at least one processor and at least one memory. Various methods/steps or functional modules may be implemented as software, such as a computer program being executed within the computer system, and instructing the computer system (in particular, one or more processors therein) to conduct various functions or operations as described herein according to various embodiments.

[00105] While the disclosure has been particularly shown and described with reference to specific embodiments, it should be understood by those skilled in the art that various changes in form and detail may be made therein without departing from the spirit and scope of the invention as defined by the appended claims. The scope of the invention is thus indicated by the appended claims and all changes which come within the meaning and range of equivalency of the claims are therefore intended to be embraced.

CLAIMS

1. A computer-implemented method for classifying a partial discharge type, executed by at least one processor, the computer-implemented method comprising:

determining a set of parameter values for generating a set of Phase Resolved Partial Discharge (PRPD) patterns from partial discharge signals, a respective PRPD pattern of the set of PRPD patterns being generated based on a respective parameter value of the set of parameter values;

extracting a set of features from the set of PRPD patterns, a respective feature of the set of features being extracted from a respective PRPD pattern of the set of PRPD patterns;

generating a set of partial discharge scores from the set of extracted features by a pre-trained PRPD classification model, a respective partial discharge score of the set of partial discharge scores being generated for a respective feature of the set of features; and

classifying a partial discharge type based on a PRPD pattern of the set of PRPD patterns corresponding to a maximal partial discharge score of the set of partial discharge scores.

2. The computer-implemented method of claim 1, wherein the pre-trained PRPD classification model comprises an Artificial Intelligence (AI) model.

3. The computer-implemented method of claim 2, wherein the AI model is pre-trained by manually labelled sample PRPD patterns.

4. The computer-implemented method of claim 2, wherein the pre-trained PRPD classification model is based on a convolutional neural network (CNN) and training of the pre-trained PRPD classification model comprises:

performing a plurality of feature extraction operations on sample PRPD patterns using a plurality of convolution layers of the CNN to produce a plurality of feature maps, wherein a respective feature extraction operation of the plurality of feature extraction operations is performed by a respective convolution layer of the plurality of convolution layers;

feeding the plurality of feature maps to a global average pooling layer;

feeding pooling outputs of the global average pooling layer to fully connected layers.

5. The computer-implemented method of claim 2, wherein the pre-trained PRPD classification model is based on Support Vector Machine (SVM) classification model and training of the pre-trained PRPD classification model comprises:

performing histogram feature extraction operations on sample PRPD patterns;

generating outputs from the histogram features by the Support Vector Machine (SVM) classification model.

6. The computer-implemented method of claim 3, wherein the AI model is pre-trained to generate partial discharge scores based on classification losses calculated from the manually labelled sample PRPD patterns.

7. The computer-implemented method of claim 1, wherein classifying a partial discharge type comprises classifying a partial discharge type into one of three types of partial charges and noise, three types of partial charges including corona partial discharge, internal partial discharge and surface partial discharge.

8. The computer-implemented method of claim 1, wherein the set of parameter values comprise percentages of an initial trigger value.

9. The computer-implemented method of claim 8, wherein the set of parameter values comprise 10%, 20%, 30%, ..., 100% of the initial trigger value.

10. The computer-implemented method of claim 8, wherein the set of parameter values comprise the percentages of the initial trigger value, adjacent two percentages with an equal increment.

11. The computer-implemented method of claim 1, wherein the set of parameter values comprises a set of trigger values and wherein the set of PDPR patterns are generated from partial discharge signals having values greater than the set of trigger values.

12. The computer-implemented method of claim 11, wherein the partial discharge signals having values greater than the set of trigger values are activated and recorded by a Data Acquisition System.

13. The computer-implemented method of claim 12, wherein the partial discharge signals having values greater than the set of trigger values are recorded with a magnitude and polarity.

14. The computer-implemented method of claim 1, wherein the set of partial discharge scores comprises a set of confidence levels of partial discharge.

15. The computer-implemented method of claim 14, wherein the maximal partial discharge score corresponds to a confidence level of the set of confidence levels, indicating a highest probability of partial discharge.

16. The computer-implemented method of claim 1, wherein the partial discharge signals are presented in pulse waveforms.

17. The computer-implemented method of claim 1, wherein the partial discharge signals are obtained at a predetermined sampling rate.

18. A data processing system comprising a communication interface, a memory and a processing unit configured to perform the method of any one of claims 1 to 17.

19. A computer program element comprising program instructions, which, when executed by one or more processors, cause the one or more processors to perform the method of claims 1 to 17.

20. A computer-readable medium comprising program instructions, which, when executed by one or more processors, cause the one or more processors to perform the method of any one of claims 1 to 17.