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Academia/Industry collaboration for the development of PD recognition tool

Context and objectives

In the objective of increasing the reliability of high voltage substation equipment, diagnostic methods are continuously improved and more and more widespread. These methods often require the study of data by an expert, making their applicability expensive and time consuming. In order to reduce these drawbacks, efforts are being made on automatization of defect's recognition and risk estimation (TB 525 and TB 674). There is still need of improvement of recognition efficiency and systems are mainly design for AC signals (left part of Figure 1), because mostly based on phase information: Phase Resolved Partial Discharge (PRPD).
Nevertheless, with the integration of renewable energy, HVDC lines and MTDC grids are currently under development, requiring the development of new diagnostic methods, as no phase exists under HVDC (right part of Figure 1). These methods are only at early stages.
A collaboration with Artificial Intelligence & Electrical engineering academic researchers has been launch in that purpose. The aim is the development of new diagnostic methods and of a diagnostic tool compatible with both HVAC and HVDC systems, such as methods based on density map on parameters from sequences (Figure 2).

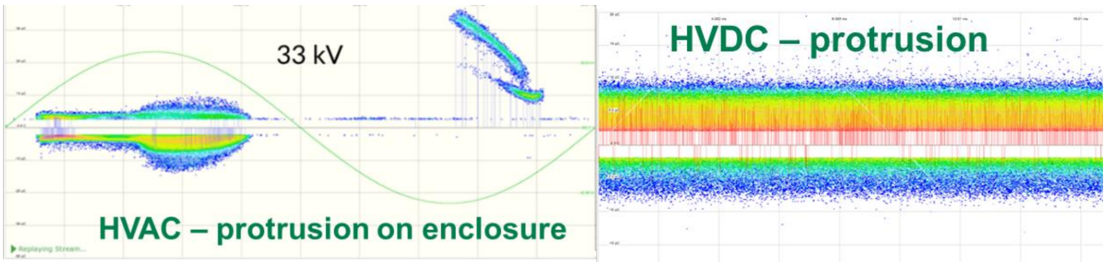

Figure 1: Left, PRPD pattern for a protrusion on enclosure under HVAC; right, PRPD pattern for a protrusion under HVDC

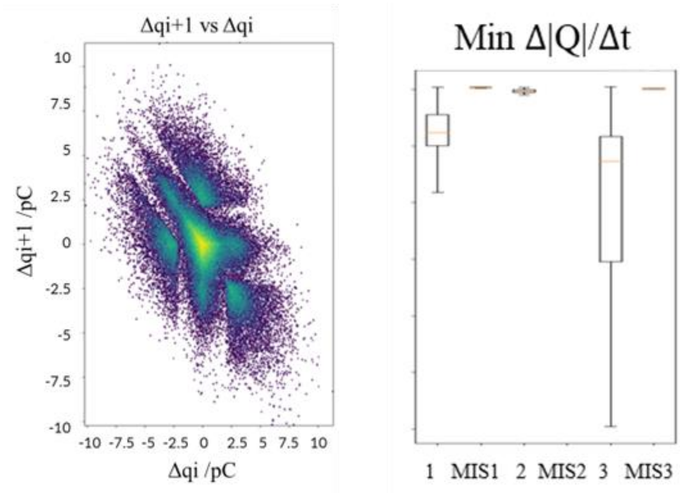

Figure 2: Examples of sequences analyses from HVDC measurement

Developed tool

The collaboration led to an Artificial Intelligence software (Figure 3). It takes as input sequences, called samples, of discharge events (time, charge and voltage) from any type of sensor. There is the possibility to use redundance to get most probable defect. Then the software processes the sequences to get derived quantities (time difference, charge difference …). Finally, sequences are reduced to a statistical pattern vector.

If the defect is known, data can be used to train a classifier, a wide range of possibilities are proposed: k-nearest neighbours, support vectors, random forest …. The software also allows to optimize the data selected and the hyperparameters of classifier by estimating the accuracy and time of processing (Figure 4).
If the defect is unknown, classifier is applied to data and gives an estimated defect's type.

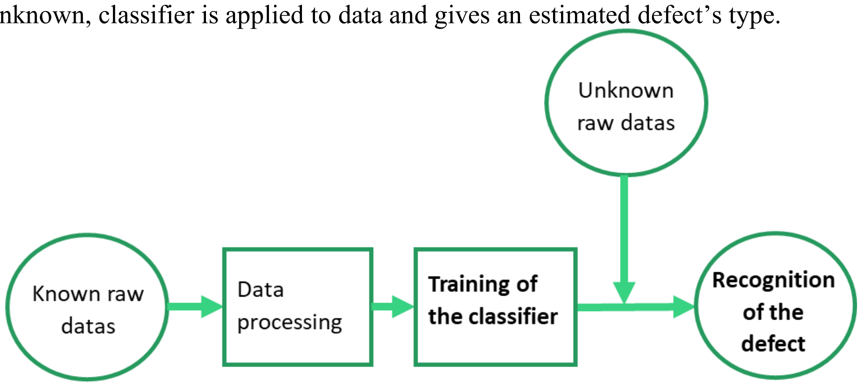

Figure 3: Simplified schematics of Partial Discharges recognition tool functioning

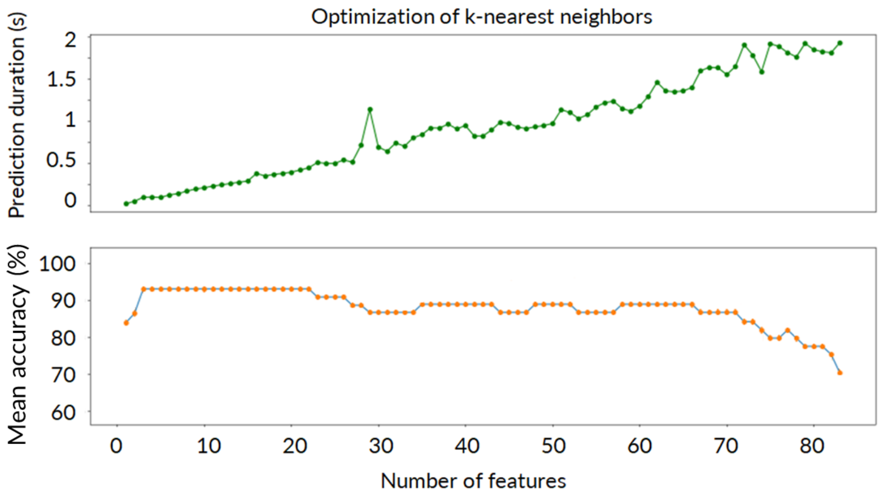

Figure 4: Example of optimization of selected features showing time of prediction and mean accuracy with a fixed number of features (it depends on selected features)

Application to HVDC defects

The developed diagnostic method has been applied to data from a real size GIS with SF6 insulation under HVDC (Figure 5) but could be applied to HVAC or other gases insulation. 3 different defects were compared: floating-moving particle, particle on insulator and protrusion.

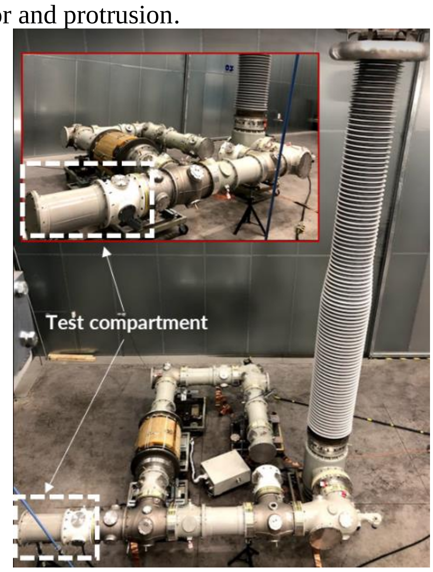

Figure 5:Pictures of GIS loop under test

The results show a very high accuracy (>98 %) using 40 % of the database for learning and 60% for validation with more than 8000 samples (Figure 6).

True \ Predicted	floating-moving particle	Particle on insulator	Protrusion	Accuracy
floating-moving particle	3551	6	2	99,8%
Particle on insulator	2	167	1	98,2%
Protrusion	1	3	1346	99,7%

Defect type/class	Samples
floating-moving particle	5924
Particle on insulator	291
Protrusion	2249

Figure 6:Results of validation database after training and repartition of overall samples

Conclusion

Would industry and academia working together more closely lead to new or improved algorithms?

Yes, academic/industry collaboration can lead to improved algorithm for instance, for new diagnostic methods. These collaborations allow:

- Academics to access testing platform and on-site measurement
- Manufacturers to get insight of state-of-the-art findings of research in this case on algorithms