

An Integrated algorithm for Detecting and Classifying the Faults in Power Systems

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Abstract- The power transformer is one of the important components in electric power systems and the continuity of the transformer operation is vital for maintaining the reliability of power system. In order to detect the transformer faults efficiently, some necessities such as high speed, highly sensitive and reliable protective relays are required. For this purpose, different fault detection techniques are proposed in existing works. But, it has some drawbacks such as magnetizing inrush current which always exists during energization of power transformers. In order to overcome these drawbacks, a new fault detection technique, namely, Improved Particle Swarm Optimization (IPSO) – Support Vector Machine (SVM) technique is proposed. It efficiently detects the faults in a transformer by using a Dissolved Gas Analysis (DGA). In order to improve the performance of fault detection and classification, an integration of Evolutionary Particle Swarm Optimization (EPSO), Cuckoo Search Optimization (CSO), Relevance Vector Machine (RVM) and fuzzy logic system are proposed.

Keywords- Improved Particle Swarm Optimization (IPSO), Support Vector Machine (SVM), Dissolved Gas Analysis (DGA), Evolutionary Particle Swarm Optimization (EPSO), Cuckoo Search Optimization (CSO), Relevance Vector Machine (RVM) and fuzzy logic.

1. Literature review

A DGA based intelligent agent for detecting incipient faults in power transformers is proposed in [1]. The authors of [2] designed a power cable fault detection circuits using a bridge method to accurately detect the fault points of single phase open circuit, two-phase short circuit and single-phase grounding. In [3] introduced a novel Conformal Surface Wave (CSW) exciter for power line fault detection and communications.

In [4], the authors proposed a statistical decision tree based fault classification methodology for the protection of power transmission lines based on the wavelet transform of three-phase current and it was measured by classification and regression tree method. In [5] recommended a generalized approach for intelligent fault detection and recovery in power

electronic systems. An intelligent control was used to engage redundant components to fault recovery.

In [6,7] a feature extraction and classification technique based on wavelet PCA and neural networks has been proposed. In [8] a model for fault classification in series compensated transmission line is proposed. This framework was based on the multiclass support vector machine and multiclass extreme learning machine. In [7], introduced a harmonic elimination in the multilevel inverter. This method was based on the usage of GA and PSO algorithms. Total harmonic distortion for output voltage was reduced by maintaining the selected harmonics within allowable limits

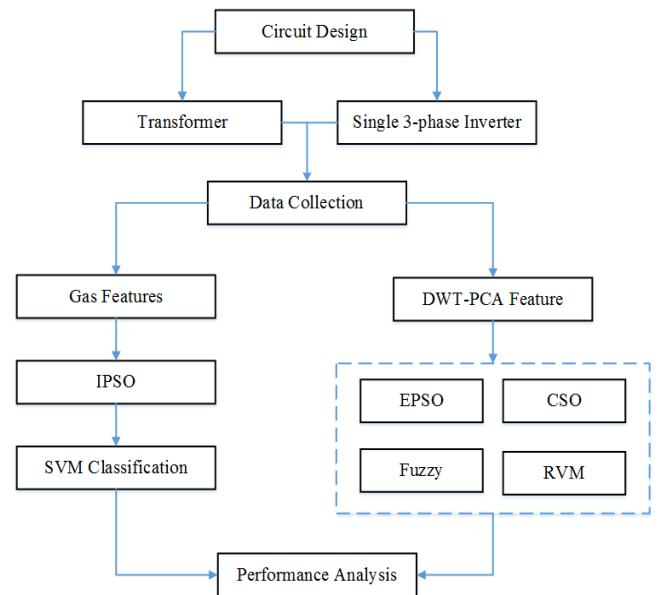


Figure 1. Overall flow of the proposed fault detection and classification system

2. Fault Classification in a Power Transformer using Dissolved Gas Analysis (DGA)

IPSO – SVM hybrid algorithm is proposed to detect and classify the faults in a transformer. The IPSO uses a dynamic inertia weight and acceleration coefficient to avoid the local optimal and make it converge faster. Moreover, it reduces the dimensionality of data space and preserves the features of

DGA. Also, it efficiently predicts the transformer fault state and normal state flow. The proposed fault detection method is based on five different gases such as hydrogen (H₂), methane (CH₄), ethylene (C₂H₄) and ethylene (C₂H₆). These gases occur due to fault present in the transformer and are monitored regularly to determine the degree, pattern and the abnormality conditions [9-13].

The ratio of emission gasses due to overheating that is closely related to the fault types. A periodic monitoring of the transformer is necessary to avoid the transformer fault and to keep gas discharge in the lowest level. DGA is an efficient fault detection technique that is mainly used to find the internal faults in a transformer. So, it is necessary to integrate the advantages of various methods for realizing the comprehensive diagnosis of the transformer faults with improved reliability and accuracy. Thus, this paper proposes a combination of IPSO-SVM techniques for transformer fault detection and classification.

3. Fault Detection and Classification for Three Phase Single Inverter Circuit

The proposed fault diagnosis method is classified into the following steps:

1. The system is formulated based on the Circuit under Test (CUT) that is a three-phase single level inverter in this instance.
2. The DWT and PCA techniques are utilized for various fault conditions as well as non-faulty conditions.
3. Hence, the transform coefficients are extracted by constructing the fault dictionary.

Table 1. Comparative analysis between PSO-SVM and IPSO-SVM for transformer fault detection and classification

<i>Techniques</i>	<i>Training + Validation accuracy (%)</i>	<i>Testing accuracy (%)</i>	<i>Testing time (s)</i>	<i>Classifier mean accuracy (%)</i>
PSO-SVM	98.25	97.89	15.21	96.4
IPSO-SVM	99.01	98.01	13.01	98.28

Table 2. Comparative results of inverter circuit fault analysis without optimization for training (30%) and testing (70%)

<i>Techniques</i>	<i>Training</i>	<i>Testing</i>		
	<i>Time (s)</i>	<i>Accuracy %</i>	<i>S.D</i>	<i>Time (s)</i>
RVM	1.46	92.5000	176.83	0.43
FUZZY	1.6337	87.0228	169.97	0.46

4. Then, the fault types are identified based on the parameters of CUT in fuzzy logic and RVM classifiers.

4. Optimization techniques

Fault classification results are optimized and compared based on EPSO and CSO techniques. The EPSO algorithm includes the following steps such as replication, mutation, reproduction, evaluation and selection. Cuckoo search is a type of optimization algorithm that provides better quality solutions than the existing technique. A cuckoo egg indicates a new solution, whereas every host bird egg in a nest denotes a solution. The main objective of this optimization is to replace the worst solution with the possible better solution. This algorithm includes the following steps: population initialization, cuckoo generation, replacement, new nest generation and termination.

5. Performance analysis

This section presents the performance and comparative analysis of the proposed fault detection and classification system. The classification rate of IPSO-SVM for 30% training and 70% testing samples gives 92.78% and 91.25%, whereas, the primary SVM gives a classification rate of 87% and 90.13% for the same number of sample sets. Table 1 shows the overall results of classification accuracy for both PSO-SVM and IPSO-SVM in terms of trial time and error rate. From this analysis, it is observed that the proposed IPSO-SVM gives better performance results in terms of accuracy, training time and standard deviation when compared to the primary SVM.

Table 2 describes the comparative results of the inverter circuit for fault without the optimization techniques. Table 3 defines the values observed for the optimization techniques with the classification techniques. From this

analysis, it is observed that the combination of CSO-RVM attains better accuracy, standard deviation and time than the other combinations such as EPSO-RVM, EPSO-Fuzzy and CSO-Fuzzy.

Table 3. Comparative results of inverter circuit fault analysis without optimization for training (30%) and testing (70%)

<i>Techniques</i>	<i>Training</i>	<i>Testing</i>		
	<i>Time (s)</i>	<i>Accuracy %</i>	<i>S.D</i>	<i>Time (s)</i>
EPSO-RVM	14.28	84.18	172.62	2.20
EPSO-FUZZY	16.22	85.66	181.27	2.20
CSO-RVM	12.51	88.78	296.32	0.57
CSO-FUZZY	8.4	82.53	177.19	1.16

6. Conclusion

The main contribution of this phase is to provide the integration of optimization with the classification technique to detect the fault in a three-phase single inverter circuit. IPSO-SVM is proposed to detect the faults in a transformer. The main intention of this technique is to detect different types of fault based on the DGA method. Here, four different types of gases such as H₂, CH₄, C₂H₂, C₂H₄ and C₂H₆ are used. Moreover, an optimized SVM technique is implemented for the power transformer under the fault condition and it has been experimented and compared with various types of classifiers using DGA dataset. Combination of EPSO, CSO, fuzzy and RVM techniques are developed for detecting and classifying the faults in a single three-phase inverter circuit. Here, various numbers of faulty components are included in the proposed fault dictionary to describe the fault and its corresponding conditions. Here, the combination of optimization techniques is analyzed with the classification techniques. From this analysis, it is evaluated that the combination of CSO-RVM provides the better results than the other techniques.

In future, the fault can be detected in a transmission line based on the classification and optimization techniques. Hence, the main aim of the future work is to improve the size of the fault dictionary.

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