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ORIGINAL PAPER

Improved intelligent methods for power transformer fault diagnosis based on tree ensemble learning and multiple feature vector analysis

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Abstract

This paper discusses the impact of the feature input vector on the performance of dissolved gas analysis-based intelligent power transformer fault diagnosis methods. For this purpose, 22 feature vectors from traditional diagnostic methods were used as feature input vectors for four tree-based ensemble algorithms, namely random forest, tree ensemble, gradient boosted tree, and extreme gradient tree. To build the proposed diagnostics models, 407 samples were used for training and testing. For validation and comparison with the existing methods of literature, 89 samples were used. Based on the results obtained on the training and testing datasets, the best performance was achieved with feature vector 16, which consists of the gas ratios of Rogers' four ratios method and the three ratios technique. The test accuracies based on these vectors are 98.37, 96.75, 95.93, and 97.56% for the namely random forest, tree ensemble, gradient boosted tree, and extreme gradient tree algorithms, respectively. Furthermore, the performance of the methods based on best input feature was evaluated and compared with other methods of literature such as Duval triangle, modified Rogers' four ratios method, combined technique, three ratios technique, Gouda triangle, IEC 60599, NBR 7274, the clustering method, and key gases with gas ratio methods. These methods suffer from unreliability, and this is the motivation behind the current work to develop a new technique that enhances the diagnostic accuracy of transformer faults to avoid unwanted faults and outages from the network. On validating dataset, diagnostic accuracies of 92.13, 91.01, 89.89, and 91.01% were achieved by the namely random forest, tree ensemble, gradient boosted tree, and extreme gradient tree models, respectively. These diagnostic accuracies are higher than 83.15% for the clustering method, 82.02% for the combined technique, 80.90% for the modified IEC 60599, and 79.78% for key gases with gas ratios, which are the best existing methods. Even if the performance of dissolved gas analysis-based intelligent methods depends strongly on the shape of the feature vector used, this study provides scholars with a tool for choosing the feature vector to use when implementing these methods.

Keywords Dissolved gas analysis · Gradient boosted tree · Power transformer · Random forest · Tree ensemble · XGBoost model

1 Introduction

Power transformers are major pieces of equipment in electrical energy transmission and distribution networks [1]. Condition-based maintenance plays a crucial role in prolonging the operational lifespan of equipment [2]. In the

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