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# Transformer equipment fault detection based on multiple machine learning algorithms

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**Abstract.** Transformer is an indispensable equipment in the power system, and its normal operation plays a vital role in the stable operation of the power system and power quality. However, due to the complexity of the working environment of the transformer, its internal structure is also more complex, so the transformer failure frequency is higher. Therefore, timely detection and early warning of transformer failure is of great importance. In this paper, a machine learning algorithm is introduced to automatically discover the laws and patterns in the data by learning and analysing a large amount of data, and use these laws and patterns to make predictions and decisions. In this paper, the winding temperature indicator, oil temperature indicator alarm, oil temperature indicator trip and magnetic oil level indicator are taken as the target variables, and the current and voltage parameters are taken as the input variables, and the dataset is divided into training set, validation set and test set according to the ratio of 6:2: 2. The dataset is divided into training set, validation set and test set, and 12 kinds of machine learning models are introduced to predict the winding temperature indicator, the oil temperature indicator alarm, the oil temperature indicator trip, and the magnetic oil level indicator, respectively. indicator alarm, oil temperature indicator trip, and magnetic oil level indicator values, respectively, to observe the operating status of the transformer in real time by predicting the transformer state parameters. The results show that the machine learning model has high application value in transformer condition monitoring. Through the input of current and voltage parameters, the machine learning model can accurately predict and monitor the important indicators of the transformer, and discover the abnormal state of the transformer in time, so as to ensure the safe operation of the transformer. In the prediction of winding temperature, oil temperature and oil temperature indicator tripping, the prediction accuracy of the 12 machine learning models reaches more than 85%, and the prediction accuracy of some models even reaches 100%. For magnetic oil level prediction, the prediction accuracy of the 12 machine learning models is more than 90%. These results show that the machine learning models have high accuracy and stability and can provide reliable technical support for transformer fault detection. In summary, machine learning algorithms have high application value in transformer fault detection, which can automatically discover the laws and patterns in the data by learning and analysing a large amount of data, and use these laws and patterns to make predictions and decisions.

**Keywords:** Transformer equipment fault detection, Machine learning algorithms, Prediction accuracy.

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## 1. Introduction

Transformer is an important power equipment in the power system, and its stable operation is crucial to the normal operation of the power system [1]. However, transformers may have various faults in long-term operation, such as winding short-circuit, insulation aging, etc. These faults will affect the performance of the transformer and may even lead to the destruction of the transformer [2,3]. Therefore, timely and accurate detection of transformer faults is an important measure to ensure the safe and stable operation of the power system [4].

Traditional transformer fault detection methods mainly rely on manual inspection and laboratory testing, and these methods have problems such as low efficiency, high cost, and susceptibility to subjective factors [5]. With the development of machine learning technology, more and more researchers began to explore the application of machine learning in transformer fault detection [6]. Machine learning can automatically learn the characteristics of transformer under normal operation and fault state by training and learning from the data, so as to achieve the automatic detection of transformer faults [7,8]. In recent years, more and more researchers have begun to use machine learning methods for transformer fault detection, and certain research progress has been made [9].

Among them, the commonly used machine learning methods include neural networks, support vector machines, decision trees and so on. These methods can learn the characteristics of transformer faults by training on a large amount of transformer operation data, so as to achieve accurate detection and diagnosis of transformer faults [10]. The research of machine learning in transformer fault detection provides new ideas and methods to improve the accuracy and efficiency of transformer fault detection, which has a broad application prospect.

## 2. Introduction to data set parameters

In this paper, the public dataset of transformer fault detection from UCL database is selected, the current and voltage information is shown in Table 1, and the transformer state information is shown in Table 2.

**Table 1.** Current and voltage parameters.

| Parameter name | Hidden meaning |
|---|---|
| VL1 | phase line 1 |
| VL2 | phase line 2 |
| VL3 | phase line 3 |
| IL1 | current line 1 |
| IL2 | current line 2 |
| IL3 | power line 3 |
| VL12 | voltage line 1 2 |
| VL23 | voltage line 2 3 |
| VL31 | voltage line 3 1 |
| INUT | neutral current |

**Table 2.** Transformer status parameters.

| Parameter name | Hidden meaning |
|---|---|
| OTI | Oil Temperature Indicator |
| WTI | Winding Temperature Indicator |
| ATI | Ambient temperature indicator |
| OLI | Oil level indicator |
| OTI A | Oil temperature indicator alarm |
| OTI T | Oil temperature indicator tripped |
| MOG A | Magnetic Oil Level Indicator |

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Winding temperature indicator, oil temperature indicator alarm, oil temperature indicator trip and magnetic oil level indicator are four very important indicators reflecting the working status of the transformer, and we can take these four indicators as target variables to judge the working status of the transformer by whether these four indicators are abnormal.

## 3. Pearson correlation analysis

Current and voltage parameters and transformer state parameters may have some intrinsic correlations and laws, correlation analysis of each parameter and drawing correlation heat map, the results are shown in Figure 1.

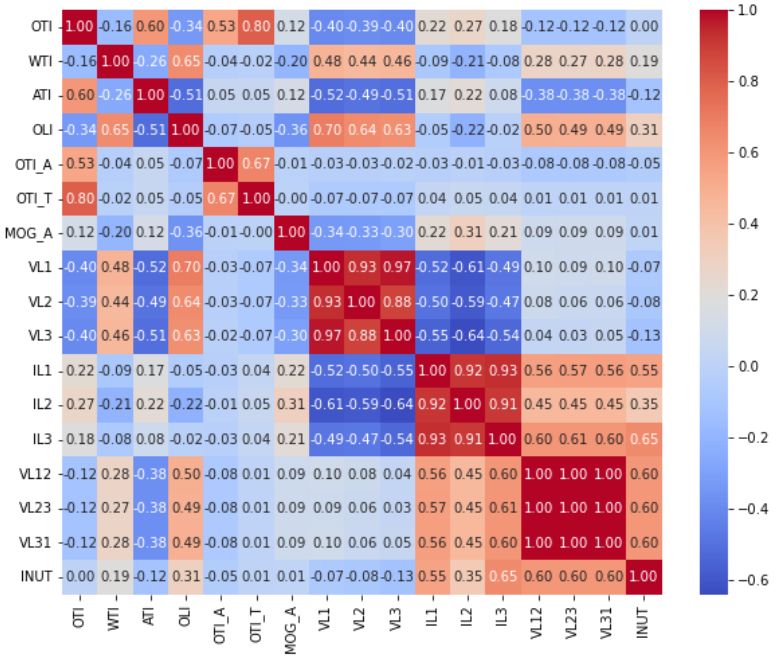


**Figure 1.** Correlation heat map. (Photo credit: Original)

The closer the correlation coefficient is to 1, the stronger the positive correlation is; the closer the correlation coefficient is to -1, the stronger the negative correlation is. From the correlation heat map, it can be seen that there is a strong positive correlation between each parameter, which can be carried out later machine learning research to further explore the intrinsic relationship and the law that exists between the parameters.

## 4. Machine learning model

Machine learning algorithms are a kind of artificial intelligence technology, the principle of which is to automatically discover the laws and patterns in the data by learning and analysing a large amount of data, and use these laws and patterns to make predictions and decisions.

Specifically, machine learning algorithms can be divided into three types: supervised learning, unsupervised learning and reinforcement learning. Among them, supervised learning refers to training a model with existing labelled data (i.e., data with known inputs and outputs) to enable it to predict and classify new input data. Unsupervised learning, on the other hand, refers to the discovery of patterns and structures in data through operations such as clustering and dimensionality reduction of the data in the absence of labelled data. Reinforcement learning, on the other hand, enables the model to learn and make optimal decisions on its own by interacting with the environment.Regardless of the type of machine learning algorithm, the basic principle is to continuously optimise the parameters and structure

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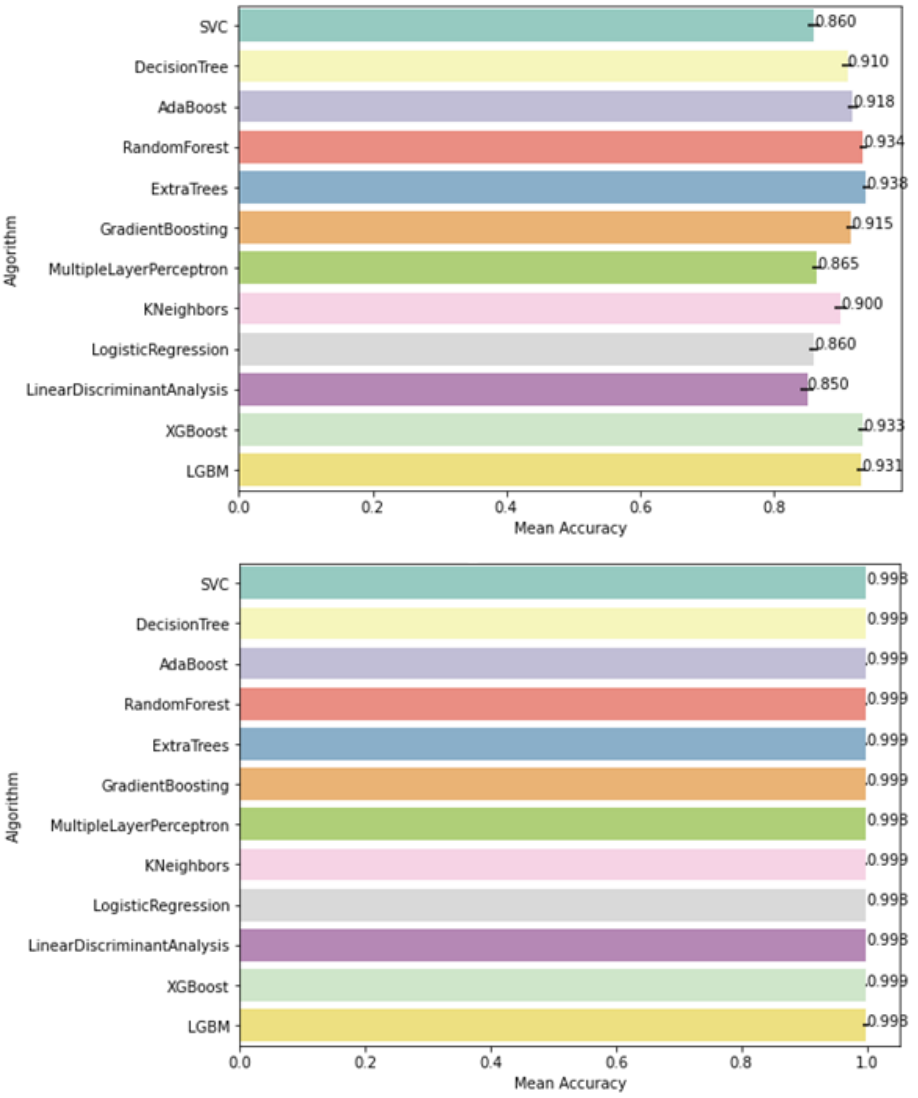
of the model by learning and analysing the data so that it can make more accurate predictions and decisions.

Winding temperature indicator, oil temperature indicator alarm, oil temperature indicator trip and magnetic oil level indicator are four very important indicators reflecting the working status of the transformer, we can take these four indicators as the target variables, take the current and voltage parameters as the input variables, divide the dataset into a training set, a validation set and a test set according to the ratio of 6:2:2, and introduce 12 kinds of machine learning models, respectively, for the winding temperature indicator, the oil temperature indicator alarm, the oil temperature indicator trip and the magnetic oil level indicator. indicator, oil temperature indicator alarm, oil temperature indicator trip and magnetic oil level indicator values are predicted, and the working status of the transformer is observed in real time by predicting the transformer state parameters, and the prediction accuracies of each model for the winding temperature indicator, oil temperature indicator alarm, oil temperature indicator trip and magnetic oil level indicator are shown in Fig. 2.



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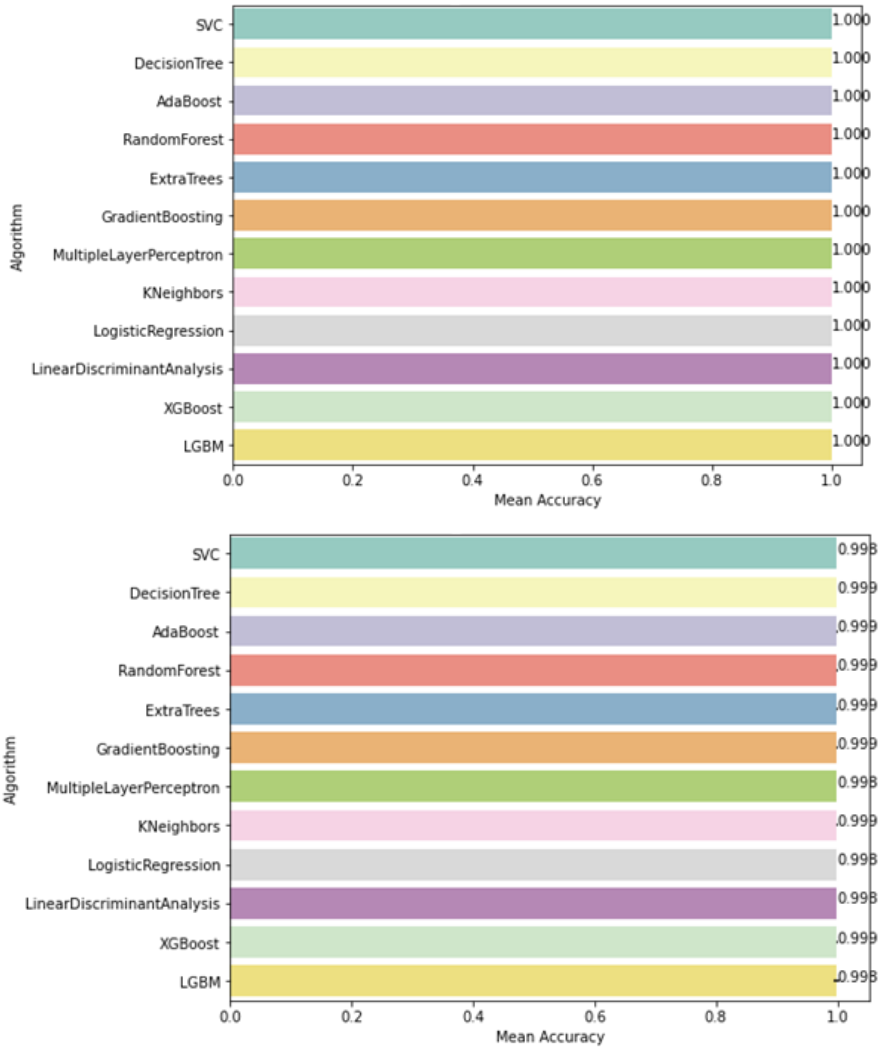


**Figure 2.** Predictive accuracy of group temperature indicators, oil temperature indicator alarms, oil temperature indicator trips and magnetic oil level indicators. (Photo credit: Original)

As can be seen from the results, the accuracy of the 12 machine learning models in the prediction of winding temperature reaches more than 85%, especially the accuracy of the Extratrees model reaches 93.8%, which can accurately monitor the winding temperature in real time and judge the abnormal state of the winding; in the prediction of the oil temperature, the prediction accuracy of the 12 machine learning models reaches more than 99%, which can predict the oil temperature very accurately. In terms of oil temperature, the prediction accuracy of all 12 machine learning models reaches more than 99%, which can predict the oil temperature very accurately; in terms of the prediction of tripping of the oil temperature indicator, the prediction accuracy of all 12 machine learning models reaches 100%, which indicates that the machine learning models are very accurate in predicting the oil temperature; in terms of the prediction of magnetic oil level, the prediction accuracy of all 12 machine learning models reaches more than 90%, which indicates that the machine learning models can predict the magnetic oil level very well.

## 5. Conclusion

In this paper, four important indicators of transformers are predicted by introducing 12 machine learning models to monitor the operating status of transformers in real time. Among them, the target variables are winding temperature indicator, oil temperature indicator alarm, oil temperature indicator trip and

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magnetic oil level indicator, the input variables are current and voltage parameters, and the dataset is divided into training set, validation set and test set according to the ratio of 6:2:2.

For the prediction of winding temperature, all the 12 machine learning models achieved an accuracy of more than 85%, with the Extratrees model achieving an accuracy of 93.8%. This indicates that the machine learning models can accurately monitor the winding temperature in real time and determine whether the working condition of the winding is abnormal.

In the prediction of oil temperature, the prediction accuracy of all 12 machine learning models reached more than 99%. This shows that the machine learning models can predict the oil temperature very accurately, so that the abnormal state of the transformer can be detected in time.

On the prediction of tripping of the oil temperature indicator, the prediction accuracy of all 12 machine learning models reaches 100%. This indicates that the machine learning models have very high accuracy in predicting the oil temperature, which can warn the abnormal state of the transformer in time.

On the prediction of magnetic oil level, the prediction accuracy of all 12 machine learning models reaches more than 90%. This indicates that the machine learning models can predict the magnetic oil level very well, so as to detect the abnormal state of the transformer in time.

Taking the above conclusions together, it can be seen that the machine learning model has high application value in transformer condition monitoring. Through the input of current and voltage parameters, the machine learning model can accurately predict and monitor the important indexes of the transformer, and discover the abnormal state of the transformer in time, so as to ensure the safe operation of the transformer.

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