

Diagnosis of Transformer Condition based on Dissolved Gas Analysis Data Using Multivariate Analysis

Background

In general, Japanese electric power companies adopt a diagnosis criterion * 1, which was established in 1999 by Electric Technology Research Association, as a standard diagnosis criterion of transformer condition based on dissolved gas analysis data * 2. However, an accurate dissolved gas analysis recently has been achieved and accurate dissolved gas analysis data is accumulated. The measurement constraint, which should be satisfied to use the traditional diagnosis criterion, has been changed, now. Therefore, electric power companies need to upgrade the diagnosis criterion of transformer condition using accumulated dissolved gas analysis data.

Objectives

Typical multivariate analysis methods will be applied to accumulated dissolved gas analysis data and the upgrading the diagnosis criterion of transformer condition will be realized.

Principal Results

1. Diagnosis results of transformer condition based on dissolved gas analysis data using typical multivariate analysis

Our experimental data were taken from 15 defective transformers and 100 normal transformers. These data were analyzed by multivariate linear discriminate analysis, Maharanobis distance and Support Vector Machine with a linear kernel (hereafter linear SVM) (see Figure 1) and the following diagnosis results were obtained.

- (1) In the case of diagnosis of transformer condition based on dissolved gas analysis data, the linear SVM achieved 0% misdiagnosis rate in the experimental data (see Table 1).
- (2) Leave-One-Out Cross Validation (see Figure 2) was carried out to evaluate the statistical performance of the linear SVM. The linear SVM achieved 0% averaged misdiagnosis rate.

2. Effective dissolved gas analysis data for the linear SVM

The linear SVM can evaluate the influence of each dissolved gas for the discriminant function of the diagnosis of transformer condition. This evaluation is realized by comparing each coefficient of dissolved gas in the discriminant function. Accordingly, we could discover it is possible to diagnose transformer condition correctly using the dissolved gas analysis data of just C₂H₂ (acetylene) and C₂H₄ (ethylene).

Future Developments

We will plan to collect the dissolved gas analysis data of oil-immersed transformers sufficiently and improve the diagnosis accuracy of the linear SVM.

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Reference

T. ONoda, et.al., 2007, "Transformer condition classification using multivariate analysis of dissolved gas analysis data", CRIEPI Report R07001 (in Japanese)

* 1 : The diagnosis criterion was established by using the chemical knowledge and the maintenance data of transformers. The diagnosis criterion consists of some rules. An example of these rules is that if C₂H₂ (acetylene) is bigger than 5 ppm, the transformer will be abnormal.

* 2 : The dissolved gas analysis data consist of H₂ (hydrogen), CH₄ (methane), C₂H₆ (ethane), C₂H₄ (ethylene), C₂H₂ (acetylene), CO (carbon monoxide) and CO₂ (carbon dioxide).

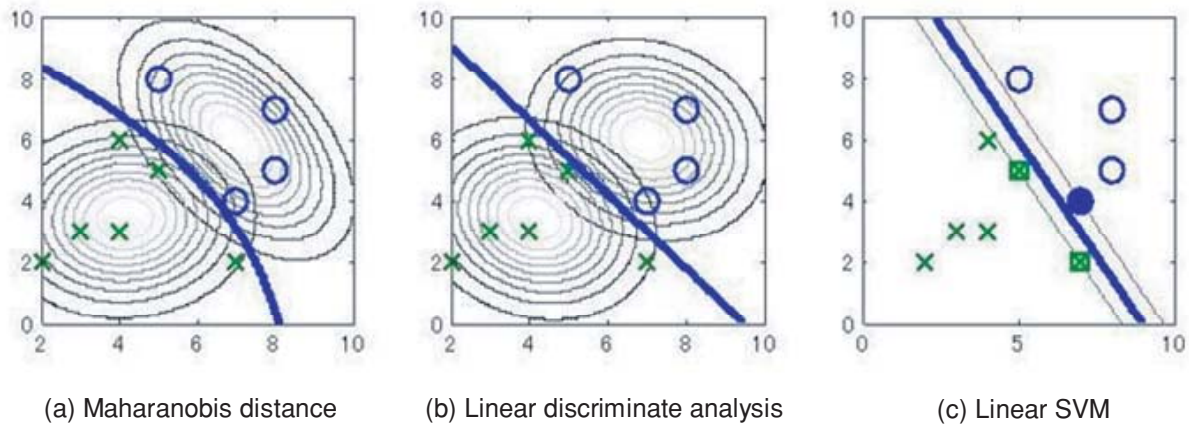
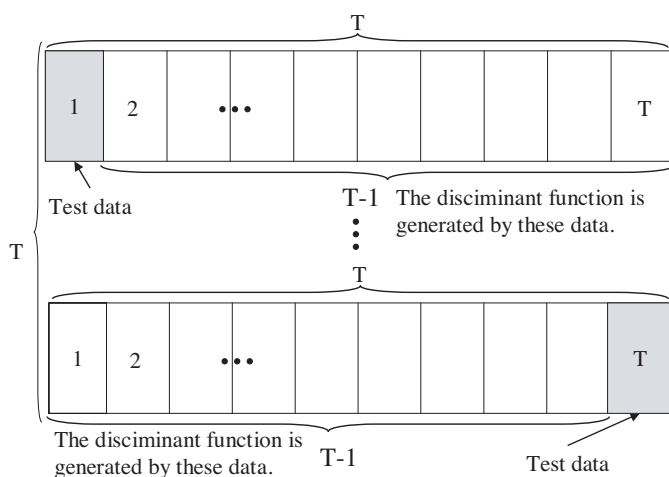


Fig.1 Typical multivariate analysis methods

(a) The maharanobis distance assumes that data distribution is normal distribution. (b) The linear discriminate analysis assumes that data distribution is normal distribution and all data distributions have same variance and covariance. (c) The linear SVM assumes that the observed data can be classified definitely.

Table 1 Misclassification rate for each multivariate analysis method

		Normal condition	Abnormal condition
The number of data		100	15
Misclassification rate	Maharanobis distance	50(50%)	0(0%)
	Linear discriminate analysis	0(0%)	6(40%)
	Linear SVM	0(0%)	0(0%)



Leave-one-out cross-validation involves using a single sample from the original samples as the validation data, and the remaining samples as the training data. In our case, a single sample is extracted from 115 samples as the validation data, and the remaining samples are used as the training data. This process is iterated 115 times.

Fig.2 Leave-One-Out Cross Validation