Fault Diagnosis and Forecast of Substation Equipment Temperature Based on Fuzzy C Means Clustering Algorithm

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Abstract: The normal operation of power equipment is directly related to the normal life of people in the relevant areas and the normal operation of the enterprise. Regardless of the quality factor of equipment, the most important factor affecting the normal operation of the equipment is the working temperature of the equipment.The traditional temperature measurement of electric power equipment is relying on manual inspection. This method not only has a large workload, high cost, but also low efficiency. The most important is that it cannot predict the temperature of the equipment in a timely manner. After considering the above factors, the fuzzy C means clustering algorithm is used to diagnose and forecast the substation equipment.

Introduction

Substation is an important part of the smart grid transmission and distribution system, and it has important significance to the implementation of the state monitoring of various electrical appliances, and to make early warning, to prolong the service life of the equipment and reduce the accident rate.[1]

There are two main methods for the temperature test of electrical equipment: One is placed at the critical point of the device to test temperature wax film, and then people regularly go to check the device's wax tablets; the other is the use of thermal imaging. But the two methods have obvious shortcomings, when the temperature is too high, the wax to melt dripping, so that the former cannot discover the device temperature is too high, on the other hand prediction effect is poor, and labor costs are high; the biggest drawback of the latter is the cost is very high. (At present ,the price of a thermal imager is about 150000.)Secondly, some of the details of the device's temperature cannot be accurately detected, resulting in a safety hazard.

After considering the above factors, the fault diagnosis and prediction model of substation equipment temperature based on fuzzy C means clustering algorithm is proposed. By installing the passive sensor in the key points of the substation electrical equipment, the sensor can collect the temperature of the device and transmit the temperature data to the base station, the base station will receive the data to be processed. This can not only diagnose the abnormal temperature of the electrical equipment, but also can predict the trend of the change of the equipment temperature.

Fuzzy C means clustering algorithm

Clustering algorithm is an important tool in data mining, which is based on the similarity between the data clustering, that is, the similarity between the two classes is minimal, and the

similarity of the data in the class is the largest. The fuzzy C means clustering algorithm is one of the important clustering algorithms. Fuzzy C means clustering is also called soft C means clustering, and soft clustering is relatively hard clustering. C means clustering algorithm is to determine the membership degree of each data belongs to which category, the general understanding of the degree of membership is a data belongs to a collection of degree. In the hard C means clustering algorithm, the membership degree is only 0 and 1, while the membership function of the soft C means clustering algorithm is [0,1].C mean, just as the name implies is that the N data set $X=\{x_1, x_2,... X_N\}$ is divided into C class, and then the clustering center of each class is calculated , The optimal value is achieved by the iteration of the non similarity value function (that is, the function value is the smallest).

The value function and membership function of fuzzy C means clustering are respectively (1) and (2).

$$J(u,v)=\sum_{i=1}^{N}\sum_{j=1}^{C}(u_{ij})^{m}\, d_{ij}^{2}(x_i-v_j) \qquad (1)$$

$$\sum_{j=1}^{C}u_{ij}=1 \qquad \forall\ i=1,2\,\mathbf{L}\,N; \qquad (2)$$

Among them, v_j represents the center vector of the cluster, and $V=\{v_1, v_2, ... , vc\}$indicates clustering center matrix. u_{ij} represent the membership degree that the element x_i of data set X belongs to class j, and the membership degree must satisfy the constraint condition (2).That is, the degree of membership must meet the principle of normalization. $U=(u_{ij})_{C\times N}$ Indicates membership matrix. M represents the fuzzy weight, the size of m determines the size of the fuzzy degree, and appropriate size of the m has a smooth membership function .Usually, the value of M is 2. $d_{ij}^{2}(x_i-v_j)=d_{ij}=\|x_i-v_j\|^2$ Represents the Euclidean distance of the element x_i to the cluster center v_j.

The membership degree u_{ij} and clustering center v_j can be derived by Lagrange multiplier , and Lagrange constructors are as Eq.3

$$F=\sum_{i=1}^{N}\sum_{j=1}^{C}u_{ij}^{m}d_{ij}^{2}-\sum_{i=1}^{N}l_i(\sum_{i=1}^{C}u_{ij}-1) \qquad (3)$$

Eq.3 respectively make the partial differential of u_{ij} and v_j, then we can obtain Eq.4 and Eq.5.

$$\frac{\partial F}{\partial u_{ij}}=mu_{ij}^{m-1}d_{ij}^{2}-l_i=0 \qquad (4)$$

$$\frac{\partial F}{\partial l_i}=-\sum_{j=1}^{C}u_{ij}+1=0 \qquad (5)$$

Through Eq.4 and Eq.5,we can get Eq.6

$$(\frac{l_i}{m})^{\frac{1}{m-1}} = \frac{1}{\sum_{j=1}^{C}(\frac{1}{d_{ij}^{\ 2}})^{\frac{1}{m-1}}} = \frac{1}{\sum_{k=1}^{C}(\frac{1}{d_{ik}^{\ 2}})^{\frac{1}{m-1}}} \quad (6)$$

Combine with Eq.4 and Eq.6,we can get Eq.7and Eq.8

$$u_{ij} = \frac{1}{\sum_{k=1}^{C}(\frac{d_{ij}}{d_{ik}})^{\frac{2}{m-1}}} \quad (7)$$

$$v_j = \frac{\sum_{i=1}^{N} u_{ij}^{\ m} x_i}{\sum_{i=1}^{N} u_{ij}^{\ m}} \quad (8)$$

It is worth noting that u_{ij} is equal to positive infinity, when d_{ij} is equal to zero, now we do the following instructions: For any i, I_i and $\overline{I_i}$ are defined. $I_i = \{j \mid d_{ij} = 0\}$;$\overline{I_i} = \{1,2...C\} - I_i$,if I_i is empty, then $u_{ij} = \frac{1}{\sum_{k=1}^{C}(\frac{d_{ij}}{d_{ik}})^{\frac{2}{m-1}}}$;if I_i is not empty, then u_{ij} equals zero(j belong to $\overline{I_i}$) and $\sum_{j=1}^{C} u_{ij} = 1$.

Application of fuzzy C means clustering

Setting basic parameters

The working temperature of the electrical equipment in substations is an important parameter to characterize the equipment.The author considers that the fuzzy C means clustering algorithm is applied to the substation electrical equipment temperature processing, which not only can diagnose the equipment failure in time, but also can predict the changing trend of the equipment temperature. Because of the many types of electrical equipment in substation, the normal operating temperature range of different equipment is different, so the base station can receive and process the temperature of the corresponding equipment sensor.

In this paper, taking transformer as an example to analyze the temperature trend of the transformer by fuzzy C means clustering algorithm. Transformer substation is one of the most important equipment, and the main role of transformer oil is heat and insulation. The working temperature of the transformer is obtained by collecting the temperature of the top of the hydraulic oil, and the general situation, and the transformer normal working temperature in 55 degrees to 80 degrees, through access to relevant information.

In fuzzy C means clustering algorithm, the appropriate C is very important. Based on the normal operating temperature range, the C is determined to be 7.Because large historical data are stored in transformer substation, so we can select some data as a training set, without loss of generality, the value of m is 2 in this paper. The clustering center matrix and the membership matrix are calculated by Eq.7 and Eq.8.In this paper, we have selected 140 historical data for simulation, and obtained 7 clustering centers. The clustering center table is shown in Table 1, and the simulation map is shown in Figure 1.

In many cases, the membership functions are often determined, then gradually modified and improved by the learning and the practical test, and the practical effect is the basis of the test and adjustment of the membership function.

x	51.0733	57.0359	61.7828	66.3374	71.9276	76.9428	82.1418
y	51.9031	56.9795	61.7062	66.8479	71.9125	77.2581	81.8866

Table 1

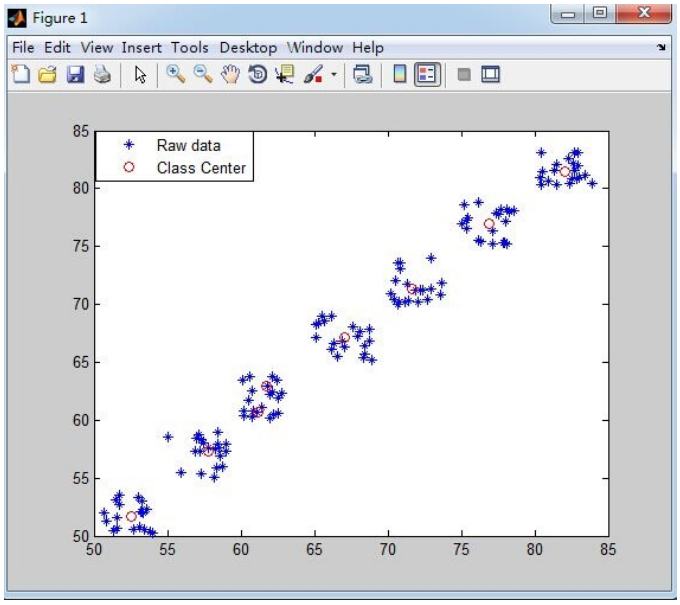

Fig.1

Temperature prediction and diagnosis

After setting the basic parameters of the fuzzy C means clustering algorithm, we can use the fuzzy C means clustering algorithm to deal with the temperature data collected from the wireless sensor, so that the transformer can be obtained from the working temperature of which kind of. When the detection of a device's operating temperature has continued to rise or fall trend, the system will issue a warning to remind the relevant staff to repair the desired equipment.

According to the requirements of the substation, we can collect the temperature of a device every other day, and then compare the operating temperature of the device for several days, judging the trend of the temperature, so as to predict the operating temperature of the next few days. If it is found that some of the device temperature is suddenly close or already in abnormal temperature, then the relevant personnel to check the appropriate equipment in time.

Because of the variety and quantity of substation equipment, so the base station processing data need to establish different temperature processing module according to the different types of electrical equipment and equipment.

Conclusion

This paper is based on the fuzzy C means clustering algorithm to determine the temperature of different substation electrical equipment. By judging the classification of the equipment temperature, it can be found that the electrical equipment's working temperature is abnormal, and can predict the development trend of the temperature. Compared with the traditional method, the fuzzy C means clustering has several advantages, such as high real-time, high efficiency, low cost and high accuracy.

In this paper, the fuzzy C means clustering algorithm is used to study the fault diagnosis and prediction of transformer temperature, and many factors affecting the clustering results are also discussed in the practical application.

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