The Research of Station Identification Method based on Multi-feature Fusion Similarity

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Abstract: Line loss rate has always been an important indicator of economic operation for power grid, and the key to ensure accurate calculation of line loss is to establish the correct relationship between households. The problem is that the line loss index is affected by the inaccuracy of the relation between the households in the station area, this paper proposes station identification method based on multi-feature fusion similarity. According to the signal characteristics of different stations, the proposed scheme calculates the similarity coefficient by multi-feature fusion, and distinguishes the membership relationship of stations by the similarity coefficient. Finally, the effectiveness of the proposed method is proved by the field experiment.

1. Introduction

Due to the continuous promotion and improvement of the electricity information acquisition system, as well as the construction requirements of ubiquitous power Internet of things for state grid[1-4], the deepening application of the electricity- acquisition system has been widely valued by the power sector[5]. With the continuous improvement of the reliability, security and efficiency requirements of smart grid, how to ensure the rapid and efficient collection for grid end-user information, it has become the focus of attention[6].A common factor is that the success rate of the acquisition is affected, this problem not only affects the acquisition success rate, but also affects the automatic enter an item of expenditure in the accounts rate and the line loss qualification rate.

The data of household change relation occurs in the process of power supply load adjustment generally. Due to various reasons such as load optimization and building relocation, the load needs to be adjusted. If the household change relation is not updated in time, the household change relation will be wrong. Due to the large amount of maintenance work for low-voltage users' mass information data, the change of operation mode is caused by load balance, abnormal movement of low-voltage equipment is frequent, and the effective checking method is lack, and it leads to manual information entry errors, the problem of inconsistent information data and field is more likely to occur in the household change relation.

At present, there are mainly three ways to sort out the relationship between households. One is manual line inspection, and it can determine the ownership of the user's station area by tracing the direction of the line [7]. The second is the power failure method in the station area, and it can be used to check and judge the ownership of the station area for transformer power failure one by one, or analyze and judge the power failure event of the meter by acquisition equipment, this method is relatively accurate, but power failure will affect users' power consumption and reduce the quality of power supply service, so there are disadvantages [8]. Third, the host and client are used respectively to receive signal, verify and judge through the using station identification instrument in the three-phase output line of the transformer and the user side. This method still relies on manpower, the efficiency is not high and time-consuming. In conclusion, it is difficult to meet the efficient and accurate collection requirements of terminal information and automatic identification. Therefore, for this problem, literature proposed a station identification method based on power information collection and copying system[9]. This scheme carried out the station discrimination through the

caused loads phase shift in different station and the maximum likelihood estimation principle. To solve the problem of incomplete file foundation in the middle station area for power grid: Literature proposes a process method of automatic list search based on carrier chip[10], and it can realize fine management of the station area and ensure the management of line loss. The method of gray level correlation analysis is applied to the phase judgment of station identification in literature[11], and a station identification method based on electricity meter data is proposed to solve the problems of station identification and power theft detection.

In this paper, a new method based on the similarity of multi-feature fusion is proposed to solve the problem, it is that the line loss index is affected by the inaccuracy of the records in the field. Firstly, the paper introduces the principle of station area identification, the characteristic information of various station areas are studied, the similarity coefficient is calculated by means of multi-feature fusion, and the accurate station area membership relation is realized. Then, the identification process of CCO centralized method and STA distributed method are discussed in detail. At the end of this paper, the method is used in Shi Er Pu power supply station of HuLudao power Supply Company through the test results, it is shown that this method can effectively distinguish the station area and improve the line loss qualification rate of the station area.

2. The principle for station area identification realization

The key to the accurate calculation of line loss in the station area is to establish the accurate line loss relationship in the station area. The identification technology of the station area can identify the working area of different HPLC networks, thus the accuracy of the judgment in the station area and economic operation level of the power grid is improved.

The problem for communication crosstalk between stations is serious, intelligent watt-hour meter in field stations may establish communication connections with concentrators in multiple stations. If the watt-hour meter is assigned to the wrong station, the file management of collection system may cause errors or confusion.

When two or more concentrators read the same watt-hour meter, some concentrators will fail to read: if the watt-hour meter really belongs to reading failure, the success rate of reading has a greater impact.

Two or more "back-to-back" area, due to the different load, the differences in alternating current phase shift and voltage fluctuation are different. For the characteristics, synchronization for alternating current zero phase offset and voltage fluctuation get quantity huge amounts of data, the concentrators for power supply area are accurately judged, the area belongs to provide accurate and reliable，it is shown in Fig. 1.

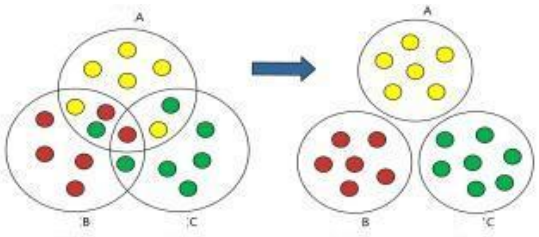

Fig. 1 The station division

In accordance with the HPLC technology handbook, station identification is used by Power frequency periodic sequence, its principle is that the same area of passing zero change has good consistency, because of the different load. At least, different area of passing zero has the obvious gap on some time inevitably, zero element of watt-hour meter communication cycle and concentrator local communication unit passing zero periodic sequence are judged similarly,the same station similarity is higher.

This scheme records the power frequency crossing zero sequence of station table and household table, and correlation between power frequency crossing zero sequence of station table and household table are compared and analyzed. The data of successive zero crossing moments are

collected periodically and synchronously, and the correlation between zero crossing sequence moments on the transformer side and zero crossing sequence moments on each household table is compared.

The similarity calculation formula is as follows:

$$r = \frac{\sum_{n=1}^{N} x_1(n)x_2(n)}{\sqrt{\sum_{n=1}^{N} x_1^2(n)\sum_{n=1}^{N} x_2^2(n)}}$$

X_1 is the zero-crossing periodic sequence of watt-hour meter communication unit, X_2 is the zero-crossing periodic sequence of concentrator local communication unit, N is the number of the zero-crossing data sequence used to calculate the similarity, and r is the similarity between the zero-crossing periodic sequence of watt-hour meter communication unit and concentrator communication unit.

However, the power load of the adjacent stations is very light, the interval characteristic difference of power frequency stations is small. If the harmonic content of power frequency is too large, it will directly affect timing sequence of the zero-crossing signal and station feature consistency. Station identification will lead to the problem of insufficient resolution only by using zero-crossing sequence correlation.

Therefore, this paper introduces the idea of multi-feature fusion, including power frequency voltage curve, power frequency and other features, and the characteristics of watt-hour meter is calculated through the fusion of multidimensional data independent each other, so the recognition success rate is improved.

The core idea of the household variable relation identification in this paper is that: User-side nodes (communication units of watt-hour meter) continuously collect data from neighboring nodes, including zero-crossing sequence, voltage, frequency and so on. Through statistics and calculation, the final similarity coefficient is obtained by integrating various characteristic parameters. If the similarity between node A and node B is the highest, it is judged that nodes A and B belong to the same station area. Similarly, all nodes can adopt the same similarity recognition model to obtain the similarity relationship between nodes. Initialization time to transformer side node C (concentrator local communications unit) benchmark trusted node, through similarity judgment, node A identification and C belong to the same area, so the node A upgraded to the trusted node, and release the information broadcasting, node B identification and node A is the highest similarity, the process is judged to the same area, and node B also upgraded to the trusted node, and release the information broadcasting. By analogy, the transformer side node C (concentrator local communication unit) will be taken as the center, it will be spread out from near to far, finally the similarity- discrimination of the whole network will be completed. Voltage similarity r_v: For the voltage deviation between any two nodes, data from multiple time points can be collected for comprehensive calculation. The weight of voltage similarity in the whole similarity model is w_v.

Frequency similarity r_f: For frequency deviation between any two nodes, data from multiple time points can be collected for comprehensive calculation. The weight of frequency similarity in the whole similarity model is w_f.

Zero crossing sequence similarity r_p, and weights w_p.

Furthermore, the formula for calculating the final similarity is as follows:

$$r = r_v \times w_v + r_f \times w_f + r_p \times w_p$$

The station area identification is divided into CCO centralized mode and STA distributed mode.

CCO centralized identification mode means that CCO collects the characteristic information of each station area of STA sand compares it with its own station area characteristic information. Through similarity analysis of station area membership, the identification process is shown in the figure 2.

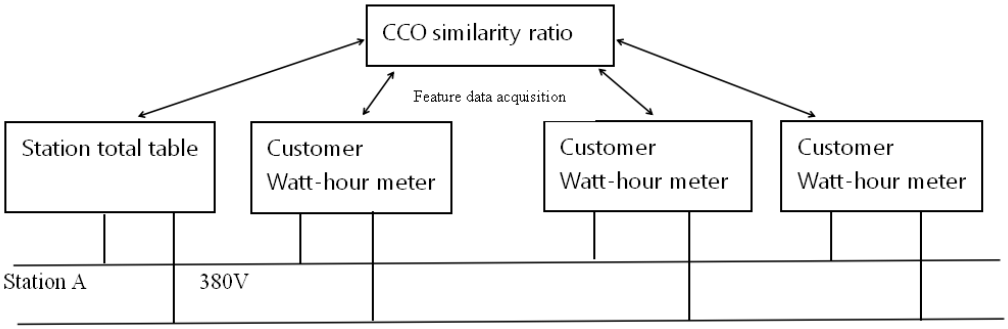

Fig. 2 CCO centralized identification pattern

STA distributed identification mode is to compare and analyze the characteristic information of the station area in each CCO, and compare with the characteristic information of its local station area to form the correct station area membership relationship. The identification process is shown in figure 3.

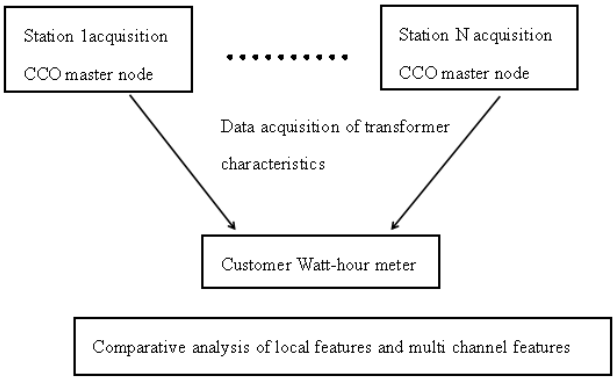

Fig. 3 the STA distributed identification

3. The realization process of station identification

According to the requirements of HPLC technology application manual, STA distributed identification mode is used by default. Therefore, this paper mainly introduces the process of STA distributed identification mode, it is shown in figure 4.

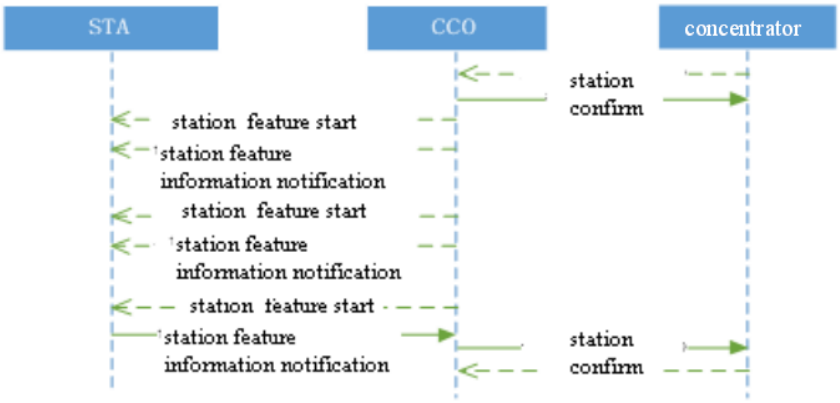

Fig.4 STA distributed identification process

4. CCO main processes

(1) It needs to start up the identification tasks of the remote station area, it is generally necessary to start the simultaneous identification of adjacent station areas. The CCO and STA will carry out the station area identification according to the characteristic information of the station area.

(2) After the open station area identification, CCO periodically issues the "station area feature

acquisition start up message" and "station area feature information notification message".

(3) CCO sends "station discrimination result query" message to inquire the STA information on 1-hour cycle.

(4) CCO and STA cooperate with each other in the station area, and form relatively correct station area identification results. Generally, the identification cycle is 1 day, and the identification results are reported to the concentrator, it continues to report to the main station.

(5) When the identification task of the station area is completed, the identification task of the station area is closed remotely.

5. STA main procedures

According to the message "station feature acquisition start" received by STA, zero cycle was collected at the corresponding time.

STA calculated the similarity between the collected local zero-crossing sequence and CCO reference zero-crossing sequence broadcast.

STA identified the highest similarity station and reported the results to CCO through multi-network optimization.

After identification, STA actively report the identification results; a message of "checking the result of the station" is received at any time, the message of"checking the result of the station" should be replied.

6. The specific implementation process debugging log is as follows

After the station area identification is opened remotely, CCO periodically releases messages of "station area feature acquisition start" and "station area feature information notification", it is shown in Fig.5.

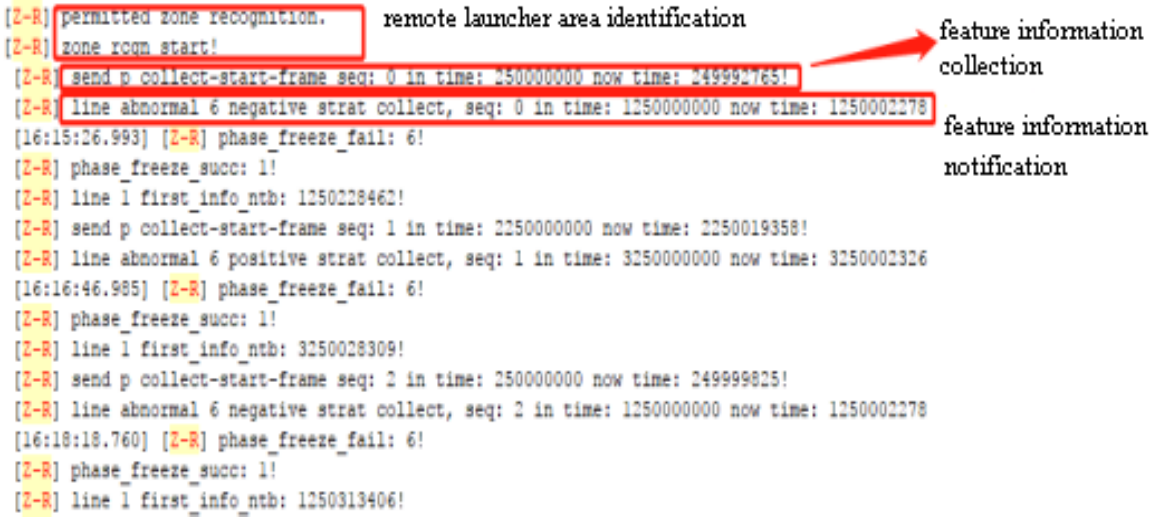

Fig.5 CCO periodic release message

STA will send the identification result to CCO every time, it is shown in Fig.6.

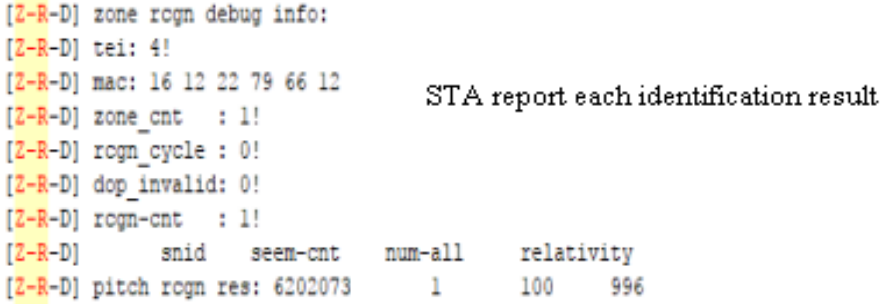

Fig.6 STA report identification results

After identification, it will report the identification result to CCO with the message of "discrimination result notification", it is shown in Fig.7.

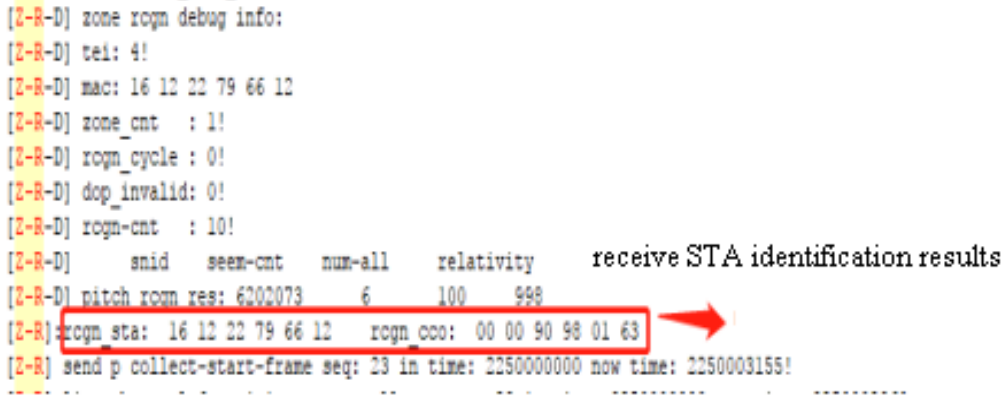

Fig.7 Identification results report CCO

After CCO receives the message of "notification of discrimination result" from STA, it will not report the identification result to the concentrator. If the identification result is in the local area, it will report the identification result to the concentrator. The reported identification result can be checked by monitoring 372.6 with debugging software.

7. Implementation cases

The station area identification function is experimentally implemented at the level of small area in Shi Er Pu power supply station of HuLudao power supply company in this paper, and the station area identification function is realized. The test found that this method can effectively distinguish the station area:the line loss qualification rate is improved, the intelligent management of the power supply station is supported effectively , and the whole business and process is integrated.

ShanHe peninsula no. 4 box transformer is located in XingGong street LianShan district HuLudao city. It belongs to the opening and closing station of line 21401 of ShiErpu power supply station. For the design of dual transformers, there may be inaccurate load attribution due to the existence of zero carrier signal copy. In the files, there are 157 low-voltage power users in the no. 1 transformer platform area, with daily loss of 12% (high loss) on August 12, 2019, and daily loss of -15% (negative loss) for 295 low-voltage users in the no. 2 transformer platform area. On August 18, 2019, the station division method proposed was used to transform the station in this paper. The results are shown in table 1.

Table 1 The station area line losses before and after modification

	number	Line loss rate (%)
1#before modification	157	12
1# after modification	135	2.15
2# before modification	273	-15
2# after modification	295	3.69
total number	430	3.2

Before modification, the influence of the area load belonging inaccurate 1# and 2# transformer, station area line loss is too high. After modification, the line loss rate of 1# transformer and 2# transformer will decrease obviously, total line loss rate is 3.2%, the data meets line loss index requirements for state grid.

In addition, before the transformation, the success rate of low-voltage acquisition was 99.77%, and line loss qualified rate was 67.5%. After the transformation, the station distinguishing function

is adjusted for "back to back" station load in this paper.The line loss qualification rate has reached 98% on October 22, 2019. This data shows the table division function proposed has the great effect of improving line loss index.

8. Conclusions

In order to solve the problem of line loss rate calculation caused by the attribution error of household change in the station area, a station area identification scheme based on multi-feature fusion similarity is proposed in this paper. This scheme uses the principle of similarity coefficient to analyze the feature similarity of the station area, and carries out comparative analysis on the zero-crossing, voltage and frequency characteristics of all metering nodes in the station area, and similar features are considered to belong to the same station area. Finally, this method effectiveness is proved by the field experiment.

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