Research Article
Researching on Distribution Network Fault Location System

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Abstract: In this study, we propose the method using rough set theory to realize the distribution network fault positioning in WEBGIS environment. According to the distribution network tree structure, using of the area user s' fault complain information as condition attributes, fault elements as decision attribute, form the decision table automatically. By using rough set method reduce the decision table, the minimal reduction of decision table for fault diagnosis is derived, the minimal diagnostic rules are obtained, guarantee the objectivity of the rule. When the fault complain call information is imperfect, it can still achieve rapid, accurate fault location on purpose, has good fault tolerance performance. In this study the use of C# language programming to achieve the reduction process for distribution network fault diagnosis decision table, combined with the WEBGIS platform, make full use of internal network database resources, to realize fault diagnosis simple and rapid operation and fault location visualization. The results show that the method is feasible and effective.

Keywords: Distribution network, fault complain information, fault location, non-supervise area, rough set, WEBGIS

INTRODUCTION

With the city-net and farming-net improving further and people's life level rising make electric power develop fast. Power distribution network expands constantly. The power quality and reliability of power supply in increasingly high demand. To power outages caused by self reason, Supply department should be able to immediate position fault location, isolate and restore power supply, to reduce the outage time. After distribution network faults, it's important to get the location and isolation fast and accurate. An approach is the use of feeder terminal unit (Feeder Terminal Unit, FTU), supervisory control and data acquisition (Supervisory Control and Dated Acquisition, SCADA) system to realize fault location. The demand of communication system and computer is higher, investment is large. Devices only are installed in the main feeder of the distribution network and a Long Branch line. Zhang and Wu (2001) analyze the rough set theory and method. Xu (2001) study the distribution network software development and system integration. Sood *et al*. (2009) develop a communication infrastructure for the smart grid. Purucker *et al*. (2007) have a research of the feeder automation designs for installing an integrated distribution control system. Jen-Hao and Chan-Nan (2006) study the value-based distribution feeder automation planning. Keiji *et al*. (2006) have a research of the considerations of a shunt active filter based on voltage detection for installation on a long distribution feeder.

For the short branch line or subdivision line, no remote information switches such as switch and fuse are heavily used. Further more rural power distribution network only installed remote terminal unit (Remote Terminal Unit, RTU)in the substation, a large portion of the line belongs to the distribution network non-supervise area. For this part of the region, since there is no configuration column FTU, impossible to obtain the real time fault information; therefore, rely on the SCADA system provides fault information for fault location of distribution network is not feasible. By using the fault complain management (TCM) cannot solve the reason of power failure and power supply recovery time or other issues, the establishment of electric power department and the good relationship. But use the fault complain call (TC) and easy access to the calling telephone or user code, the user of the transformer and the connection, use the TC information

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for fault location in distribution network is a feasible way, can separate the application, as the use of SCADA system for fault location in power distribution network supplementary. In the distribution network non-supervise area, according to the different regions' large number of users' complaint information to determine the fault location, is to say when the regions where complaint phone call can be inferred to the fault point. In fact because the user's subjective reason, knowledge level and other factors, these complaints information in part does not necessarily represent certain things to happen, which is likely to contain some uncertainty and error factors? The complaint information is a rough set. Such use of rough set theory to distribution network fault location problem mathematical description will be more consistent with the actual situation.

Based on the above, the author uses rough set theory and based on fault complaint information to find the method for distribution network fault positioning. The method according to the topological structure of distribution network, the user area fault complain call as condition attributes, fault element as decision attribute, form a fault decision table and then use rough set theory to simplify the fault location, derived the minimum reduction form, so as to achieve rapid, accurate fault location of distribution network. At the same time the WEBGIS into the electrical fault management system, sharing the enterprise network database resources, the use of WEBGIS excellent space management and spatial orientation function, providing a visual query policy environment, realize the fault diagnosis and location.

In this study, we propose the method using rough set theory to realize the distribution network fault positioning in WEBGIS environment. According to the distribution network tree structure, using of the area user s' fault complain information as condition attributes, fault elements as decision attribute, form the decision table automatically. By using rough set method reduce the decision table, the minimal reduction of decision table for fault diagnosis is derived, the minimal diagnostic rules are obtained, guarantee the objectivity of the rule. When the fault complain call information is imperfect, it can still achieve rapid, accurate fault location on purpose, has good fault tolerance performance. In this study the use of C# language programming to achieve the reduction process for distribution network fault diagnosis decision table, combined with the WEBGIS platform, make full use of internal network database resources, to realize fault diagnosis simple and rapid operation and fault location visualization. The results show that the method is feasible and effective.

ROUGH SET THEORY

The extension rule is defined as follows. Rough Set (RS) theory is proved by the Poland scholars (Pawlak, 1982), is a kind of new characterizations incompleteness and uncertainty of the mathematical tools. Compared with the probability statistics, fuzzy set to deal with vagueness and uncertainty of mathematical tools, rough set theory is the theory has the superiority. Statistics require a priori probability, fuzzy set theory need the membership function. The main advantage is that rough set theory does not need to provide needed data collection in addition to any a priori information, can effectively analyze and deal with the imprecise, inconsistent, incomplete data and find hidden knowledge, revealing potential rule.

RS using a decision table to describe the domain object in U, decision table (information table) is a kind of special and important knowledge expression system. It indicates that if certain conditions are met (behavior) how to carry out the decision. Decision table is a two-dimensional table; each row in the table describes an object, called the decision rules, each column of token object an attribute. Attribute points as condition attributes and decision attributes.

In a decision system, the attribute often has a certain degree of dependence or association. Reduction can be understood without affecting the classification under the premise, the most simple decision table decision attribute collection. Using rough set theory from the decision table is the process of extracting rules for decision table reduction process, that the condition can be the least amount.

Decision table reduction has two steps: removal the invalid attributes not in decision table to get on decision table reduction; the simplification of decision rules in each condition attribute, to get a minimal reduction.

DISTRIBUTION NETWORK FAULT LOCATION ALGORITHM DESIGN

The whole process includes three key elements: form the original decision table, the original attribute reduction of decision table, attribute value reduction Distribution network has a generally complex loop structure, according to the need of protection and the use of the radial power supply open loop operation mode, the level of the structure is quite obvious. Therefore, the distribution network divided into sections, while considering the variability of distribution network, according to the distribution network topology automatic formation based on fault complain call information of distribution network fault location decision table, first the raw information for simplification, find the original information equivalent reduction, decision rules are extracted, so as to achieve
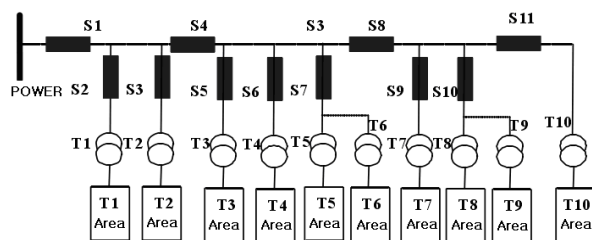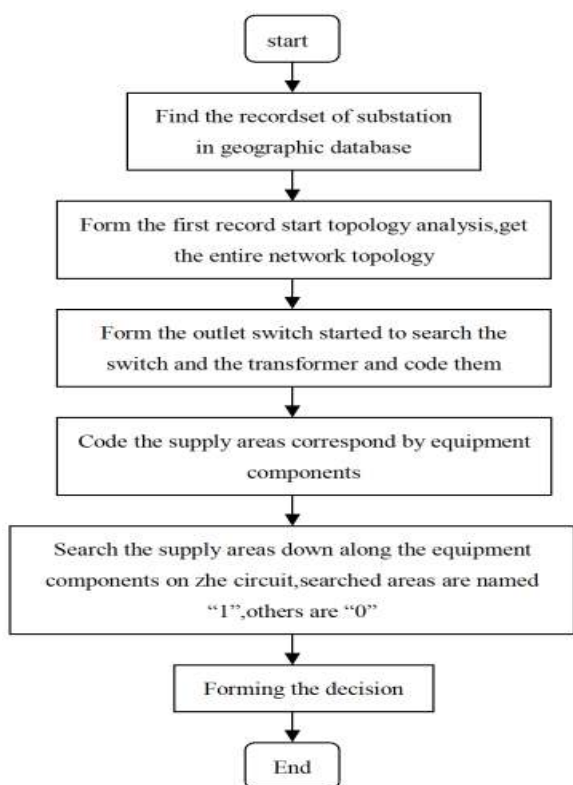
Fig. 1: Simple model of distribution network

Fig. 2: Distribution network dynamic encoding flowchart

rapid, accurate fault location of distribution network for the purpose.

Figure 1 shows a typical distribution network; illustrate the decision-making table generation steps. In this network, the circuit breaker or switch as element S, a total of 11. The 10 power supply area (T1-T10), 10 T transformers. If a fault occurs in the component S is the element of the line fault occurs, if it occurs in T, description of the transformer is out of order.

Decision table formed a distribution network topology analysis based on. First from to get the geographic database in substation records set, in the GIS system using breadth-first algorithm from the first record and start the cycle, in accordance with the topology analysis algorithm to obtain the distribution network topology[2]. A line switch in the substation as a power supply, its only correspond to a line, using the topology analysis algorithm from the outgoing switch search, get along at the end of the line switch, transformer and corresponding power supply area, carrying on the number, as shown in Fig. 2 distribution network coding for S1, S2, switch, ... , S11, transformer properties in the running number to the T1, T2, ... , T10 is identified, corresponding to the area of power supply for T1 area, T2 area, ... , T10 area, then the line all equipment element search power supply area, to search for the power supply area code" 1", the other power supply region coding is credited as " 0", that the formation of Table 1 of the original decision table for fault diagnosis. The data in the Table 1 indicates the user call fault complain calls, data" 0" indicates not play fault complain call. Distribution network dynamic encoding processes as shown in Fig. 2.

By using the reduction method of the decision table provided by reference[3], Table 1 is simplified to get a minimal reduction, as shown in Table 2. " *" indicates whether the user dials the telephone complaints,

Table 1: Original decision table for fault diagnosis in power distribution network

Specimen	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	Fault element
1	1	1	1	1	1	1	1	1	1	1	S1
2	1	0	0	0	0	0	0	0	0	0	S2, T1
3	0	1	0	0	0	0	0	0	0	0	S3, T2
4	0	0	1	1	1	1	1	1	1	1	S4
5	0	0	1	0	0	0	0	0	0	0	S5, T3
6	0	0	1	1	1	1	0	0	0	0	S6, T4
7	0	0	0	0	1	1	0	0	0	0	S7
8	0	0	0	0	1	0	0	0	0	0	T5
9	0	0	0	0	0	1	0	0	0	0	T6
10	0	0	0	0	0	0	1	1	1	1	S8
11	0	0	0	0	0	0	1	0	0	0	S9, T7
12	0	0	0	0	0	0	0	1	1	0	S10
13	0	0	0	0	0	0	0	1	0	0	T8
14	0	0	0	0	0	0	0	0	1	0	T9
15	0	0	0	0	0	0	0	0	0	1	S11, T10
16	0	0	0	0	0	0	0	0	0	0	No

Table 2: Fault localization improvement value reduction results

Specimen	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	Fault element
1	*	1	*	*	*	1	*	*	1	1	S1
2	1	0	0	0	0	0	0	0	0	0	S2, T1
3	*	1	0	0	0	0	0	0	0	0	S3, T2
4	*	0	*	*	*	1	*	*	1	1	S4
5	*	*	1	0	0	0	0	0	0	0	S5, T3
6	*	*	*	1	1	1	0	0	0	0	S6, T4
7	*	*	*	*	1	1	0	0	0	0	S7
8	*	*	*	*	1	0	0	0	0	0	T5
9	*	*	*	*	0	1	0	0	0	0	T6
10	*	*	*	*	*	0	*	*	1	1	S8
11	*	*	*	*	*	*	1	0	0	0	S9, T7
12	*	*	*	*	*	*	*	1	1	0	S10
13	*	*	*	*	*	*	*	1	0	0	T8
14	*	*	*	*	*	*	*	0	1	0	T9
15	*	*	*	*	*	*	*	*	0	1	S1, T10
16	0	0	0	0	0	0	0	0	0	0	No

no influence on fault location of distribution network. From Table 2 extracting decision rules, formation of fault diagnosis expert knowledge base. Such as rule 4, just that as long as the T6 section, T9 section, T10 section 3 power supply area to call the telephone complaints, regardless of other power supply section whether the dialed telephone complaints, can be inferred from S4 fault has occurred. The original decision Table 2, simplification of the rules was reduced in the 5 redundant condition attributes information still got the same result. Table 2 the location ability and the original decision table with the same.

Figure 2 shows the distribution network as an example to illustrate the availability of the method for fault locating.

Example 1: one power supply departments received T5 and T6 users call the telephone complaints for power failure, fault location system input fault information has been generated. The system use the expert knowledge base of Table 2 for diagnosis, results for the S7 fault, i.e., switch 7 is line failure. This is the actual match. Because sometimes the Super's report does not necessarily indicate fault occurred on the repair user direct power supply branch, which might occur in the branches of a Long Branch line or the main feeder line.

Example 2: one power supply departments received T4 and T5 users' telephone complaints; input fault information system based on expert knowledge database, Table 2 is for T5 fault diagnosis. After the detection, T4 users are due to the time of the overload fuse is burnt by the entire building power failure, not line or transformer fault, belonging to the user mistaken telephone complaints. Visible, for similar reasons caused by false complaints or malfunctioning users dial telephone fault complain call is imperfect, the present method has good fault tolerance.

The above example shows that the method is simple, rapid, effective, when the error is not the key information on complaints, will not affect the positioning results, it has strong fault tolerant ability. The algorithm can be applied in complex radiation distribution network.

DISTRIBUTION NETWORK FAULT LOCATION SYSTEM DESIGN

This study uses the C# language programming to achieve the distribution network fault diagnosis decision table reduction process and introduction it to the development of distribution network fault location system. The distribution network fault location system with X county company of power supply distribution automation combined, using 1: 50000X county topography and distribution electric power equipment related geographic information layer, database using SQL SERVER 2000, WEBGIS foundation to build information platform, provide the basic function of the GIS, at the same time sharing internal database resources, to establish a set of B/S model for incomplete fault information for fault location network edition positioning system. When a customer power fault repair telephone access, with the help of the generated rough set knowledge base can be realized based on the WEBGIS on-line fault diagnosis and location function, as the use of SCADA system for fault location in power distribution network support and complement. In the diagnosis of localization process, will repair telephone information and a fault diagnosis knowledge base of rules matching, through the search, if the repair information and knowledge base a rule in the match, then stop the search, the output results and in the distribution line diagram highlights out, thus can improve the diagnosis rate, for fault recovery the
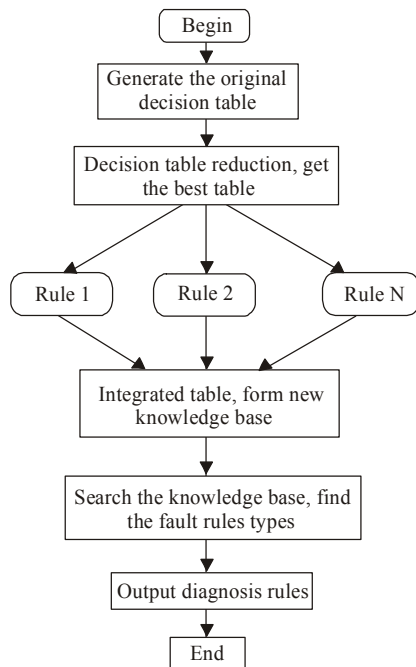
Fig. 3: Distribution network fault locating system flow chart

winning time. Distribution network fault locating system flow diagram is shown in Fig. 3.

CONCLUSION

Combined with the actual condition of rural distribution network area, proposes based on the rough set theory to the fault location method. According to distribution network tree structure, forming the decision table then simplification, getting the most simple fault location rules, compared with the previous results (Zhang and Wu, 2001; Xu, 2001), we ensure the objectivity of the rule, without the need for cumbersome calculations (such as distribution network power flow calculation), greatly shortens the time for fault location and isolation. In the practical application of distribution network, with the WEBGIS platform, it able to objectively compare the fault location. When information is incomplete, this method can realize quick, accurate fault location and has good fault tolerance.

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