Research on Ship Electronic Power System Fault Diagnosis Based on Expert System

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Abstract. Aiming at the difficulty in locating the fault point quickly and accurately after the ship electronic power system fault. In this paper, fault diagnosis expert system is used to diagnose the fault occurred to ensure stability of power supply of ship power system. The possible faults are divided into four categories on the base of analysis of ship electrical system fault characteristics. Frame structure is used to describe the connections between the various parts of the ship power system in knowledge presentation. Expert system uses production rules to describe the specific fault and combine the ideal of fuzzy inference to dealing with the uncertainty in fault diagnosis at the same time. The expert system designed in this paper can find fault points and provide solutions quickly and accurately and improves the reliability of the ship power system by test.

1. Introduction
With the continuous development of China's shipbuilding industry, marine power system is more and more tend to be more and more complicated, the hair of the ship power grid power distribution module and the complexity of the load also constantly improve, once the failure occurs somewhere, largely caused the secondary faults, which makes the engineer's work has greatly increased, it is often difficult to rapidly and accurately locating the fault point and troubleshooting, seriously affected the stability of the vessel operation[1-3]. And ship power equipment along with the development of the shipbuilding industry are also constantly upgrading, and the original utility engineer is very difficult to cope with the new equipment failure, therefore, it is necessary to construct a set of can integrate the expert knowledge and can constantly update the knowledge base in the field of fault diagnosis expert system[4-5], improving the work efficiency and the accuracy of the engineer, ensure the continuity of vessel operation. Traditional power system fault diagnosis is based on the research of the characteristics of the power system network topology model is established, and the expansion of system correlation matrix, vary according to the trend of the event of a failure to fault location, the method based on mathematical calculation due to the complexity of the electric power system and increasingly expanded scale, at the same time under the influence of various aspects of uncertainty is difficult to achieve an ideal effect [6]. At present, intelligent methods are mainly adopted for fault diagnosis of power system, including those based on signal processing, analytical model and knowledge. Among them, literature [7] adopted an analytical model-based approach, first analyzing the characteristics of the diagnosed object, and then Establish the corresponding mathematical model, an observer is constructed to estimate the output of the system, and then each sensor measurement value compared with the estimate, so as to extract the fault information, this method because of the difficulty of modeling and the event of a failure may cause the change of the model structure or
parameters, affect the accuracy of the conclusion. Literature [8] adopts the method based on signal processing. The advantage of this method is that it can avoid modeling complex models and directly adopt models such as wavelet transform, correlation function, autoregressive sliding average and frequency spectrum. This method is relatively simple to implement, but it is not sensitive to the detection of minor faults. Only when the faults develop to a certain degree can it have a better detection effect. Literature [9] used the method based on knowledge, the method not only inherits the advantages of the signal processing does not need to build mathematical model, while avoiding the defect insufficient sensitivity of the signal processing method, the method introduces expert diagnosis knowledge, can give full play to human experts in the process of diagnosis and subjective experience, improve The efficiency and accuracy of fault diagnosis, which is based on knowledge, has become the focus of many researchers. On the basis of above research, combining with the characteristics of ship power system, through the analysis of power system, the possibility of failure and its causes, to produce the fault classification, frame type knowledge are used to indicate the structure of the whole power system, at the same time use the production rule knowledge of specific faults are described, the fuzzy reasoning to solve the uncertainty in the process of reasoning, designed a fault diagnosis expert system. This system combines the reasoning knowledge and diagnosis experience of several experts, and the diagnosis ability of some faults can even surpass that of a single expert. Through tests, this expert system can make rapid and accurate diagnosis of various faults.

2. The overall structure of expert system and fault classification of Marine power system

2.1. overall design of fault diagnosis expert system

Fault diagnosis expert system of Marine power system can be divided into five parts, including comprehensive database, knowledge base, inference machine, explanation machine and human-computer interaction interface, as shown in figure 1. Its working principle is as follows: the user inputs fault features into the expert system by human-computer interaction interface, the inference machine loads rules and matches them with the knowledge in the knowledge base, sends the matched information into the comprehensive database, and feeds back to the user through the interpretation machine [10]. Experts can also upgrade and maintain the information in the knowledge base through human-computer interaction interface, so that the expert system can constantly adapt to the updating of equipment. Through the above operations can achieve the output. Enter the fault to judge, so as to get the diagnosis results.
2.2. Classification of Marine power system faults
Ship power system due to its special working environment and the layout of the intensive, under the influence of environmental factors is more, fault phenomenon and the cause of the problem has a certain randomness and disruptive, based on the relay protection knowledge and ship electric experts experience, common fault of Marine power system are classified and summarized. In this paper, the faults of Marine power system studied can be divided into four categories, namely generator fault, distribution device fault, power grid fault and power load fault. The cable wiring of ship power system is very close and the working environment is bad, and the external insulation layer of cable is vulnerable to corrosion. Therefore, the power grid fault is the most frequent place for the fault of ship power system, and the power grid fault often leads to the damage of other parts and causes secondary fault[11-12]. Therefore, power grid faults should be given priority in fault diagnosis.

3. Knowledge base construction of expert system
Knowledge base and reasoning machine separate is marked characteristics from the traditional application of expert system, knowledge base is used to store all kinds of diagnosis expert system rules, fault reasoning machine is used for the input and the knowledge base of knowledge is compared to diagnosis conclusion, the separation of knowledge base and reasoning machine makes it to expert system knowledge to upgrade the need to modify the contents of the knowledge base without having to modify the reasoning machine, which greatly reduce the cost of the expert system upgrade, this expert system USES Microsoft Access 2008 for the construction of knowledge base, To realize the characteristics of the knowledge base that is easy to modify and input [13].

3.1. Representation of knowledge
The expert system knowledge representation of adopts frame type and the method of combination of production, first set up the research of power system network topology structure, framework representation is used to describe the topology structure, again to play to the frame type is easy to describe attributes of objects and the advantage of internal relations, the same type of power components with similar groove include: inheritance framework name, type, description, and fault description, certainty and default values, as shown in figure 2. Through the failure phenomenon to diagnose the cause of the problem in the process, this system USES production rules of fault diagnosis knowledge, production rule is usually can be expressed as an IF P THENQ < CF >, in which P and Q respectively correspond to rules and conclusions, the premise of CF said confidence, a rule generally includes rules number, premise, rules, conclusion and confidence, for example: rule 11 IF the generator start-up failure, and the excitation current is close to zero THEN Reason for failure: loss of excitation power source confidence: 0.7, where confidence is used for inexact reasoning.
3.2. Fuzzy rules

Based on past experience, the ship power system fault occurred most frequently in grid part, so need to focus on the grid fault analysis, usually when transmission line grounding or short circuit fault occur, tend to appear increase with the decrease of or current voltage, voltage and current value and the load characteristic and fault points are closely associated with power distance, and often use a certain threshold to determine whether the increase of current and voltage reduce method does not apply here, here, using the fuzzy rules are used to diagnose the faults of transmission lines [14-16]. Since there is generally no condition that voltage increases while current decreases in the case of transmission line fault, the linear membership function in FIG. 3 is used to conduct the paste treatment on the voltage and current values.

When the current is high, the membership function is

$$u(x) = \begin{cases} 
1.0 & x < 10 \\
1.25 - 0.025x & 10 \leq x \leq 30 
\end{cases}$$

When the current is high, the membership function is

$$u(x) = \begin{cases} 
0.05x - 1 & 30 < x < 40 \\
1.0 & 40 \leq x 
\end{cases}$$

For example, when the current value is 20A, u(x)=0.75. When Ix=20A, the reliability of normal current is 0.75. When the voltage is low, the membership function is

$$u(x) = \begin{cases} 
1.0 & x < 320 \\
(380 - x) / 60 & 320 \leq x \leq 350 
\end{cases}$$

That is Vx=360, when the reliability of the normal voltage is 0.75, the voltage and current reliability obtained is the reliability of the fuzzy rule, and the preprocessed voltage and current value can be matched with the fuzzy rule shown in table 1 to get the diagnosis result.

4. Reasoning mechanism of expert system

4.1. reasoning mechanism of power grid module

The inference machine is responsible for how the expert system invokes rules in the process of fault diagnosis. The perfection of the inference machine design will directly affect the inference accuracy and efficiency of the expert system. According to the characteristics of the ship power system, compared with other types of fault, fault module [17], the highest frequency of failure, therefore, preferred fault diagnosis module of power grids will greatly improve the working efficiency of the expert system, in order to improve the reasoning speed, module for power grid fault reasoning using the forward reasoning method, expert system will be known the fault feature information of loaded into comprehensive database, and then one by one with the diagnosis rules knowledge base pairing [18-20], will successfully matching rule conclusion as a new fact is added to the comprehensive database, using the updated database to match again, Until a conclusion is reached or no new knowledge is added.
| Rule number | Ia  | Ib  | Ic  | Ua  | Ub  | Uc  | The fault types               |
|------------|-----|-----|-----|-----|-----|-----|------------------------------|
| F1         | Normal | Normal | Normal | Normal | Normal | Normal | Normal                      |
| F2         | High  | Normal | Normal | Low  | Normal | Normal | A phase short circuit        |
| F3         | Normal | High  | Normal | Low  | Normal | Low   | B phase short circuit        |
| F4         | Normal | Normal | High  | Normal | Normal | Low   | C phase short circuit        |
| F5         | High  | High  | Low   | Low  | Normal | Low   | AB phase short circuit       |
| F6         | Normal | High  | High  | Low  | Normal | Low   | BC phase short circuit       |
| F7         | High  | Normal | High  | Low  | Normal | Low   | AC phase short circuit       |
| F8         | High  | High  | High  | Low  | Low   | Low   | ABC phase short circuit      |

4.2. Reasoning mechanism of other modules
When the expert system of fault diagnosis module is not found after finishing point, fault happened in other modules, because the level of the rest of the equipment failure point is less, can be relatively easy to find fault point, at this time can use the forward reasoning and reverse reasoning methods at the same time, to further improve the accuracy of reasoning, the first use of forward reasoning to put forward the hypothesis of fault point, and then prove the existence of the hypothesis, through a reverse reasoning to find fault point [21].

5. Conclusion
This paper USES the expert system method to diagnose the fault of the Marine electric power system. According to the characteristics of the Marine electric power system, the fault is divided into four modules. The frame structure is used to describe the overall structure of the ship's power grid and the relationship between the modules. The specific diagnostic knowledge is described by production rules. At the same time, fuzzy rules are adopted to solve the uncertainty problems in fault diagnosis. After power system simulation, the fault diagnosis expert system of Marine power system designed in this paper can accurately diagnose the fault and put forward the solution.

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