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Research and implementation of intelligent processing system for grid monitoring signals

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Abstract. Grid monitoring signals form an effective basis for regulators to judge and analyze the grid. In this paper, the method and implementation of intelligent processing of grid monitoring signals, and the implementation scheme of intelligent processing system for grid monitoring signals are introduced. Based on the expert knowledge base, an intelligent deduction is performed for monitoring signals, to form fault conclusions and decision-making advices on the basis of signal compression. Intelligent semantic parsing is used to automatically form a secondary model, which, with satisfactory universality and maintenance-free feature, can achieve good results in engineering practice.

Keywords. Grid monitoring signals, signal analysis, knowledge base.

With the deepening of integrated regulation, the regulators should handle larger grids with much more signals. Therefore, scholars and experts at home and abroad have carried out in-depth research and preliminary practice with respect to the signal intelligent alarm technology. There are mainly two types of research achievements at present: 1. Online diagnosis of device faults through analyzing and processing alarm information at the dispatching end with AI analysis algorithms such as the expert system, genetic algorithm and fuzzy set; 2. Hierarchical classification, inference analysis, and comprehensive display of alarm information in combination with the characteristics of monitoring service. The above research plays an important role in improving the intelligence level of the processing of dispatch automation alarm information, but further research should be conducted to support large grid operation.

The increasing interconnection scale and operational complexity of modern grids have made grid operation approach the limit. Traditional research mainly relies on the network topology model, as a result, the changes in system structure and parameters due to malfunction may result in the change of system load flow. Based on the changes determined by load flow calculation, the faults can be judged. The traditional mathematical methods are generally used for single centralized solution, which, due to the limitations of system scale, complexity and uncertainties, cannot meet the requirements for fault determination of modern power systems, and the system fault diagnosis cannot achieve the desired effect. At present, the methods for the research on fault identification and auxiliary decision making involving power systems tend to be intelligentized based on expert knowledge base.

The signal analysis and auxiliary decision-making method based on expert knowledge base mainly involves the expert system fault diagnosis method, extension theory, and fuzzy fault diagnosis method. The main advantage is that such a method does not rely on the specific mathematical model. With the rich and flexible knowledge expression and problem solving ability, it can give full play to the ability of experts to perform reasoning judgments based on their senses, knowledge, and experience in the process of diagnosis, and it can also be used in fault discrimination on various occasions [1].

In this paper, an expert knowledge base derivation method based on extension theory was proposed, which can improve the accuracy and performance of signal analysis and fault diagnosis reasoning based on the primary and secondary equipment models of the power system, and can better meet the demands of engineering practice.

1. System scheme

1.1. Software architecture of the system

In term of the functional system, the system consists of the general extensible service bus, signal analysis and auxiliary decision-making related services, expert knowledge base, various auxiliary modeling tools, and human-machine session layer.

Data model layer: It consists of primary equipment modeling, secondary equipment modeling, primary and secondary equipment relationship model, and expert knowledge base.

Application layer of signal analysis and auxiliary decision-making service: Based on the modeling of primary and secondary equipment, and according to the data of interface between the expert knowledge base and real-time base, it can give play to the functions of signal compression processing, fault diagnosis, topology analysis, and auxiliary decision-making and general alarm.

Real-time interface service: It is adaptive to the real-time data interface of SCADA system, including full remote signaling, and full remote sensing.

General extensible service bus NetX: It can standardize the communication modes between modules of the system, and ensure that each software module can be installed and flexibly configured on any node machine of the system, so as to reduce the coupling between modules, improve the robustness and enhance the operational efficiency of the system.

Human-machine session layer: It can provide a user-friendly manual interface.

1.2. Signal analysis expert knowledge base

Generally, in the case of any fault or abnormality in the substation, the event alarm window of the SCADA system will only receive the information related to protection action and switch breaking, but the specific fault should be analyzed by the operator in combination with the wiring method, the current operation mode, the position of the switch blade and the monitoring signals of the substation. This fault analysis and processing process may ask the man on duty to be familiar with the operating requirements of the primary and secondary equipment, circuits of the substation, scheduling operation procedures and various operating procedures and specifications of the substation; in addition, it also requires a longer period of time for judgment. Therefore, it is necessary to establish a fault reasoning model in the knowledge base, and use an inference engine to complete fault analysis and judgment automatically. The model summarizes the main types and conditions of faults, and uses a separate fault inference plan to resolve each fault.

(1) Types of faults. Common substation faults include line fault, bus fault, main transformer fault, capacitor fault, reactor fault, switch rejection fault, unsuccessful re-switching on, PT faults, CT fault, substation transformer fault, and DC system fault. These faults can be subdivided and combined based on the mode of wiring, to form multiple types of faults, such as “line fault trip, unsuccessful re-switching on”, “line fault trip, switch rejection, failure protection starts busbar differential protection, and trips off other switches on the busbar”, “The side switch rejects, and trips off the switches on the busbar and the connected switches”. The model summarizes common fault types of the substation, and they can be easily expanded.

(2) Time window. To accurately identify a fault, it is necessary to collect the data of a time interval in the cache of monitoring signals received by the system as the reasoning basis, and this time interval is called a “time window”. If the “time window” is too short, it would miss the reasoning conditions, resulting in missed judgments; however, it is not necessarily too long, for it would affect the reasoning efficiency. It can be set as 3-10s, and flexibly adjusted according to the field time operation.

(3) Signal classification. In the case of each type of fault, there should be a key signal serving as the condition for starting the corresponding fault reasoning plan. In order to distinguish these signals, the model should classify the signals into line protection action signal, busbar protection action signal, failure protection action signal, total accident signal, and exit tripping signal.

(4) Establishment method of the knowledge base. The performance of the knowledge base directly determines the advantages and disadvantages of the expert system. Knowledge acquisition is the core issue in the establishment of a knowledge base, and it refers to the extracting of knowledge for solving problems from the knowledge source. This system, based on the extension theory, establishes the ontology knowledge base and signal analysis knowledge base in the field of power regulation and control. On this basis, the system can achieve intelligent analysis and judgment of signals. The system includes power regulation and control principles, dispatching rules and specifications, operation-related training materials and books, and experience of substation operators in the knowledge base. It can be extended to resolve the changes and emerging issues of the rules and specifications.

1.3. Extension event deduction based on the expert knowledge base

In the actual operation of the power grid, due to the integrity of the grid, the alarms are often given in clusters round multiple hotspots. In addition to the multi-event oriented reasoning mechanism, the grid structure and topology information should also be combined, to track and summarize the event information across remote signaling, interval and even substations. Aid decision making should be provided in combination with the actual operation of the current grid, so as to help the dispatchers understand the real causes of the alarm.

2. Characteristics and prospect of the system

2.1. Characteristics

(1) Event presentation of a signal. It changes the current mode of presenting grid monitoring signals in a chronological order only. According to the customizable dynamic rules, it can present the signals by “events”. It can resolve the problems of excessive monitoring signals and interference signals, and the difficulty in distinguishing the abnormal signals.

(2) Improvement of the reliability and safety of grid operation. Through analyzing the internal logic of monitoring information in the case of a grid event, the system can improve the analysis and processing capability of the grid monitoring and alarm information, and ensure the reliability and safety of operation.

(3) Intelligence. The system can automatically adapt to the changes in grid wiring, without the need of configuring new analysis rules by the user.

2.2. Prospect

The intelligent generation of the extended defense system in substation relies on the support of the expert base. With certain intelligence, it can replace the current manual establishment of the microcomputer defense system in substation, and it can even be used in interval-based anti-error locking device combined with the modern defense devices, thus play a greater role of error proofing in substation.

3. Conclusion

The research and implementation of intelligent processing of grid monitoring signals can effectively analyze the signals of the grid, and automatically form the primary and secondary models. By virtue of the satisfactory universality and maintenance-free feature, the system can be of practical significance to quick identification and solution of the faults of the grid.

References

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