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Fault Diagnosis Expert System Using Object Frame Knowledge Representation Approach

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Abstract—Knowledge representation approach is very important to the development of a fault diagnosis expert system. Inference engine is the other component of fault diagnosis system. Frame knowledge representation is one of the primary technologies used for large scale knowledge representation in artificial intelligence. To simplify the complexity of knowledge representation in fault diagnosis expert system and According to the characteristic of the large complex electromechanical system, a fault diagnosis model in fault space describes the relationship between fault sources, fault symptoms, fault propagation and test sets. In this paper, Fault diagnosis knowledge hierarchical framework is established based on object-frame knowledge representation. A fault diagnosis expert system implemented in the Linux/QT environment is demonstrated, which utilizes My SQL database for storing fault knowledge. This approach is effective and has good compatibility and scalability.

Index Terms—knowledge representation and reasoning knowledge engineering, fault diagnosis expert system.

I. INTRODUCTION

Knowledge becomes a pivotal factor for intelligence to support decision making. Elicitation, representation and use of knowledge are major areas of research in the field of Artificial Intelligence, leading to development of knowledge bases and expert systems [1]. Intelligent system designers can use different elements to represent different kinds of knowledge. Knowledge representation (KR) elements could be primitives such as rules, frames, semantic networks and concept maps, ontology's, and logic expressions [2].Knowledge engineering
Oriented intelligent ES developmentplatform provides a commercial intelligent ESdevelopment platform COSIM-Expert v1.0 which includesKnowledge Acquisition Tool,qualitative and quantitativecollaborative solving engine andreasoning and analysismonitoring Tool. Among them, Knowledge Acquisition Toolis a kind of interactive software for expert knowledgeacquisition and file generation on the platform [3, 4]. Knowledgerepresentation approach is veryimportant to thedevelopment of a fault diagnosis expert system.Traditional Transformer fault diagnosis system has lack of comprehensive consideration and judgment lead to the result of one-sidedness. To eliminate these disadvantages, the expert system is developed that defines a series of representation of knowledge and rules that describe several of problems in the working process of transformer [5]. Domain specific knowledge is the core, and its quality represents the actual level of domain experts in the development of fault diagnosis expert system [6]. In the past few decades AI researchers in knowledge representation have implemented over 50 frame knowledge representation systems. Tools are KEE, ART, SRL and PRED represent facts as frames. A number of frame languages have been developed in recent year to support knowledge-based systems. Protégé is an OKBC compatible knowledge-base-editing environment. The goal of this system is to achieve interoperability with other knowledge representation systems [7, 8].

With the rapid development of modern industry, higher equipment performance requirements, electromechanical systems become increasingly large, improving function, large equipment moving in the direction of the highly automated, integrated and large-scale continuous development. Ensure normal state is a great challenge to equipment maintenance and security. Therefore, there is a need to establish fault reasoning model based on large-scale equipment to improve the accuracy of model representation and reasoningand intelligence to provide effective decision support for equipment maintenance and security. Fault detection & diagnosis expert system plays an important role in fault detection and maintenance. Aiming at the problem of digitalized mechanical and electrical equipment real-time fault detection and diagnosis, this paper proposed a real-time fault diagnosis method which is in the Linux/QT environment utilizes MySQL database. Present the general model of real-time fault diagnosis system using QT C++ and My SQL. Discuss the process of knowledge representation based on object-frame and knowledge storage based on MySQL as well as real-time reasoning.

II. BACKGROUND

Knowledge representation is important in knowledge reasoning. The most frequent methodology used for representing the knowledge is production rules, and frames [1]. Frame is one of the primary technologies used

for large scale knowledge representation in Artificial Intelligence. Frame knowledge technique is used to represent knowledge in many information and experts systems. The elements of a frame are slots, facets and data. A frame can have one or more slots. Each slot contains a particular kind of data [2].Knowledge representation researches how to recognizeand utilize the knowledge by intelligent system. Accordingto the characteristics of the various types of knowledge forthe complex product, uses Fuzzy CDG to representthe expert's knowledge and experience. FuzzyCDG is developed from the belief network, and mergedrepresentation methods for uncertainty and fuzziness [3, 4].

Whether the knowledge representation is good determine the quality and accuracy of the expert system. Designing of the knowledge representation that satisfies needs to accurately describe the characteristics of the working process of transformer is one of the important works in establishment of the fault diagnosis system.The transformer fault diagnosis expert system breaks through the limitation of one-sidedness of traditional transformer fault diagnosis method. The expert system gives a new and effective proposal to improve the feasibility and accuracy of transformer fault diagnosis using Rule-matching method. There are some aspects need to research such as, accumulate and perfect the expertise knowledge database in the certain form, classify the expertise knowledge in the related degree to match the rules more efficiently and adjust and optimize the self-learning mechanism to acquire the new knowledge more effectively [5].

III. RELATED WORK

Knowledge base system (KBS) development is complex, expensive, and time consuming process that needs to be applied in an organized manner. There are powerful tools for eliciting and representing KBSs. Using these tools becomes a very difficult task for users without specific knowledge in Artificial Intelligence. The aim research is to use a normative approach to elicit and represent the knowledge. To achieve thisNevienet. al. [1] proposed an elicitation and representation tool NormEST which allows the domain experts and the non-technical users are able to build their own KBSs. NormEST can be considering as a new approach in eliciting and representing the knowledge. Emil et. al. [2] states that a successful intelligent system employs its knowledge to become more self-aware. To achieve this self-awareness, system designers are developing more sophisticated KR models and reasoning capabilities, drawing on research in ontology's, data mining, intelligent agents, autonomic computing, knowledge processing, and many other areas.

In recent years, R&D evolves to be knowledge-based and intelligent increasingly. Enterprises and research institutions are more and more concerned about using platform to accumulate, refine and reuse the knowledge and experience. Therefore, Tripathi [3] state that the traditional ES which has the characteristics of single-disciplinary, single-function, dedicated and small is becoming enterprise level network collaborative platform which has the characteristics of multi-disciplinary, multifunctional, integrated and large. Based on the requirement of large-scale applications in enterprise groups,SongTi, et al. [4] proposes an ES development platform which provides development specifications and key technologies for developing ES.The expert system defines a series of representation of knowledge and rules that describe several of problems in the working process of transformer. Though cumulating and storing the expert knowledge and experience in real work situation, set up a diagnosis rules expert database. This expert system synthesizes a variety of method and experience in the relevant fields thus can achieve a relatively accurate and good diagnosis result. To the standard of judgment of knowledge, Keheet. al. [5], Uses the fuzzy evaluation theory and define a membership grade for every certain circumstance of rules. The expert system based on the fuzzy evaluation open up a new methods and thoughts for transformer fault diagnosis, and is the effective complement and sublimation to present diagnosis method. To a large extent, it greatly improves the accuracy and efficiency of transformer diagnosis, and provides assistance for the security and reliability of power system. Ying et. al. [6] introduces that a diagnostic expert system requires prior knowledge representation in the use of knowledge for the exchange of information or intelligence problem solving to realize knowledge implementation and the purpose of solving the problem.

Bailinet. al. [7] Knowledge quality and usability is core to a fault diagnosis system. Frame knowledge technique has been used to represent knowledge in many information and expert systems.Kesarwaniet. al. [8]Aframe is a data structure that includes all the knowledge about a particular object. This knowledge is organized in a special hierarchical structure that permits a diagnosis of knowledge independence. Frames are basically an application of object-oriented programming for artificial intelligence and Expert System. Frames provide a concise structural representation of knowledge in a natural manner. The knowledge in a frame is partitioned into slots. A slot can describe declarative knowledge (e.g., the color of a car) or procedural knowledge. A frame includes two basic elements: slots and facets. A slot is a set of attributes that describe the object represented by the frame. Each slot contains one or more facets. The facets (subslots) describe some knowledge or procedural information about the attribute in the slot. Most artificial intelligence systems use a collection of frames linked together in a certain manner to show their relationship. This is called a hierarchy of frames. The hierarchical arrangement of frames permits inheritance frames.

IV. EXISTING METHODOLOGY

A. On-line diagnostic expert systems

On-line diagnostic expert systems [4] usually use a combination of quantitative and qualitative methods for fault detection that allows interaction and evaluation of all available information sources and knowledge about the technical process.

B. Rule-Based Diagnostic Expert Systems

In the rule-based systems, [5] knowledge is represented in the form of production rules. A rule describes the action that should be taken if a symptom is observed. The empirical association between premises and conclusions in

the knowledge base is their main characteristic. These associations describe because effect relationships to determine logical event chains that were used to represent the propagation ofcomplex phenomena.

C.*Model-based diagnostic expert systems*

Model-based reasoning is a broad category that describes the use of variety of engineering models and techniques for fault diagnosis. Model-based diagnostic expert systems have eliminated some limitations of the early expert systems. In these systems expert knowledge is contained primarily in a model of the expert domain. Model based diagnosis uses knowledge about structure, function and behavior and provides device independent Diagnostic procedures. The use of models enables the estimation of variables and parameters which are influenced by the fault. In addition model-based methods have the potential of early detection of slowly developing faults in complex processes.

IV. ANALYSIS AND DISCUSSIONS

A variety of fault detection and diagnosis techniques have been developed for the diagnostic problem solving process. These techniques include model based approaches, knowledge based approaches, qualitative simulation based approaches, and neural network based approaches and classical multivariate statistical techniques. Expert systems found broad application in fault diagnosis from their early stages because an expert system simulates human reasoning about a problem domain, performs reasoning over representations of human knowledge and solves problems using heuristic knowledge rather than precisely formulated relationships, in forms that reflect more accurately the nature of most human knowledge.

In On-line diagnostic systems, basic diagnostic procedures are very satisfactory, real-time issue such as sensors drift can lead to problems with nuisance alarms in a system.On-line diagnostic approach provides real time diagnosis and ability to handle noise. This system is domain dependent and inability to explain the reasoning process. It requires good models and considerable data.An on-line diagnostic system is fast in computation but it is expensive.Rule-based expert systemshave a wide range of applications for diagnostic tasks where expertise and experience are available but deep understanding of the physical properties of the system is either unavailable or too costly to obtain. The rule-based approach has weaknesses such as lack of generality and poor handling of novel situations. Induction and Deduction process is easy in rule based approach. A process model is not required in this system. It is not able to learn from their errors, to represent time-varying and spatiallyvarying phenomena. Rule-based approach is efficient and effectiveness in fault detection. This system has difficulties in acquiring knowledge from expertsreliably. Development and maintenance is costly.

Difficulties with model based fault detection methods arise from the fact that the accuracy of the measurements needed to calculate, the evolution of faults should be of high quality.This system is Flexible in the cases of design changes and provides dynamic fault detection. Model-based diagnostic expert systemsare device independent but domain dependant. No need of Knowledge acquisition. It is able to diagnose incipient faults but difficulties in isolation of faults. Knowledge bases are very demanding in this system.

V. PROPOSED METHODOLOGY

Appling object-frame to represent fault diagnosis expert system knowledge is a practical and simple method, which is based on fault layering and fault isolation tree. With regard to leaf node,there is no test and rule knowledge item. The cause of fault can't be divided, it can be set as full; thenon-leaf node, however, fault extent need to be invoked by detection and rule, resolve, so there is no maintain knowledgeitem.

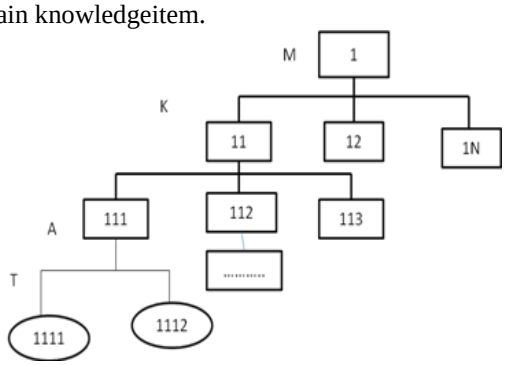

Fig. 1 Object-frame knowledge layer expression

Method of Object-frame knowledge representation is a comprehensive way of knowledge representation; it combines framework technology of expert system and production rule. Object-frame knowledge indicates a node of fault isolation tree. Knowledge representation adopts reasonable doubly linked list as data structure, establishes the foundation of implement of reasoning strategy. Adopted accurate reasoning method as object reasoning machine, adopted forward reasoning strategy as control strategy, adopted rules numbers preferred method strategy as conflict resolution. Reasoning begins with node in abstraction layer of diagnosis model, acquires evidence through detection, executes and extends new fact using rules which match the fact, narrow the extent. Acquiring evidence through detection including 3 methods, one points at M type knowledge nodes, detects or observe consequence through observing manual input; another one points at K type nodes, matches detection consequence directly from routing detection consequence; the last one points A type nodes, launches real-time communication, sends real-time order and communicates with detection progress, isolate detection consequence after receiving. Fig.1 is the layer figure of Object-frame knowledge determining isolation tree, there into, Object-frame type is M, user typed in detection consequence; Object-frame 111 is K type, using routing detection consequence node; Object-frame 1111 and 1112 are A type, using real-time obtaining knowledge and node divided automatically.This process repeats till fault tree leaf node is isolated and the fault source is found. Therefore, the process of object reasoning is a recursive procedure.

This paper uses object-oriented technique to package the access to QT/MySQL database, constructclass object of store and access of fault diagnosis expert system knowledge base. MySQL in Linuxenvironment is adopted

as database, 6 tables are created, state knowledge item table, test knowledge item table, rule knowledge item table, repair knowledge item table and diagram knowledge item table, each table is used for storing knowledge item.

VI. POSSIBLE OUTCOME

In this paper, developed a real-time fault detection and diagnosis & inquire system of an electromechanical system in Linux Redhat 9.0 Operating System with core of 2.4 and MySQL database, based on QT C++. In view of characteristics of the mechanical and electrical equipment, fault diagnosis knowledge hierarchical framework is established based on object-frame knowledge representation. A fault diagnosis expert system implemented in the Linux/QT environment is demonstrated, which utilizes MySQL database for storing fault knowledge.

VII.CONCLUSION

This paper introduces a method of Object-frame knowledge representation. It's a comprehensive way of knowledge representation; it combines framework technology of expert system and production rule.The advantage of this method isno need of knowledge representation language support. This method is efficient and has good compatibility and expandability.The knowledge consistency is an important performancefactor for an expert system. It determines the inferencebehavior of an expert system. In order to access freely toknowledge base, there must be consistencychecking.TheFuture research will focus onknowledge consistency.

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