APPLICATION OF FAULT DIAGNOSIS EXPERT SYSTEM FOR AIRCRAFT ELECTRIC POWER SYSTEM

ZHU XinYu
(China Civil Aviation Flight College, Guanghan City 618307)
SHEN SongHua
(Beijing University of Aeronautical and Astronautical, Beijing City 100083)

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Abstract

Based on artificial intelligence theory, the authors developed monitoring unit for some aircraft electric power system. The knowledge base in electric system adopts modularization structure according as the styles of fault divided into five modules. This search build a integrated fault tree model for aviation electric power system, and build a rule-based expert system. Inference engine use forward chaining with heusistic rules. Data's pre-management can avoid operating repeatedly. By using expert system, it can carry out sate monitoring and fault diagnosis. It provides experiments for all non-avionics system using expert system to diagnose and has actual applying value.

1 General Introduction

The engines were thought of as aircraft's heart, Electric Power has become aircraft's blood now. With increasing electrical equipment and coming forth the "All Electric Aircraft" concept, the reliability and maintainability and measurability has become important. If any fault existed in electric power system can not be detected and corrected in good time, it could expanded and disturbing operating. It will lead to device's invalidation, even influence aviation safety. Self-contained testing can decrease the frequency of failure which can not be measured [1].

Expert System has been used for a fault diagnosis method widely. Because of the integration of lots of experts in the same field, the intelligence level to put the axe in the helve has overrun single expert in the field. Furthermore, working time and environment can not disturb the system's capability[2].

A lot of problem in electric system must be resolved in expert system because usually[5]:

(1) There are not mathematic mode with intact and precise and including of all restricting qualification in electric power system;

(2) The system or component is complex. Precise numeric answer can't be gotten in time domain.

(3) Some problems cannot be resolved by arithmetic. They need the collecting of intuition.

Expert system is suitable to aircraft electric system's fault diagnosis, because there is orbicular expert's experience and integrated operating rules and technical manual, it is easier to sort out data, scanning space is smaller.

2 System's configuration and function

This system makes use of productive pattern, its architecture can be seen in figure 1. it consists of knowledge base, inference engine, data base, explanatory software, human-machine interface, data interface, pre-managing procedure[2-5]. It is a real-time expert system. Its pivotal subassembly includes:

(1)Knowledge base: It storages special knowledge in full research domain. Because of including of domain expert's experience, it is a key factor to ensure its capability is good or not.

(2)Data base: It is a set of symbol or fact which describes the process disposing object. It consists of initial data, temporary data in

resolving process, real-time data and final result.

(3)Inference engine: it is the core of expert system. Its functions include of controlling and assorting with expert system's operating.

(4)Knowledge acquisition procedure: It is a functional module which can convert factual knowledge in the field and domain expert's sole experiential to some format which can be use by computer.

(5)Explanatory software: It answers question of user about all system. It can explain about the resolving process of conclusion and current disposing status. Users can know expert system's resolving mode. It makes founding and confirming mistakes in data base easier.

(6) Human-machine interface: they translate the inputting information of expert and user into the same mode with the entire system. Then translate the system's outputting information into mode users are easy to understand.

The special real-time data interference in Expert system collects real-time data on the spot from process computer, then they are sent to diagnosis expert system overall data base and the computer sends warning command which produced by expert system to progress computer.

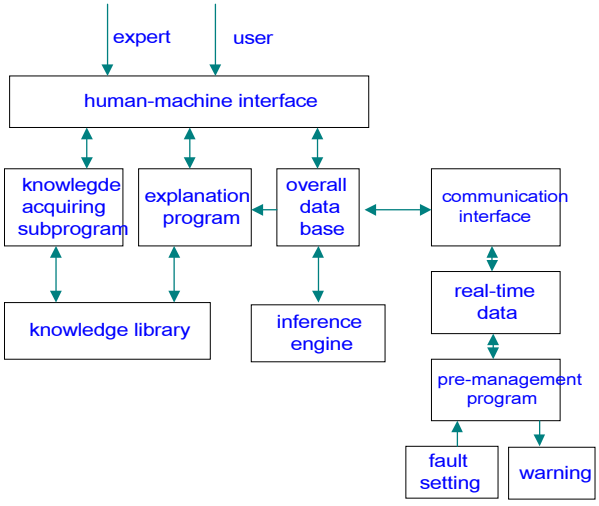

figure 1 real-time diagnosis expert system

3 Real-time diagnosis expert system

The developing environment of real-time fault is: the operating system is windows 98, communication is written by Borland C++ Builder 4.0, progress computer's computer use assemble language. The upper computer's CUP is Pentium II 300. The lower computer's CPU is T320C240.

3.1 structure and express of knowledge library

3.1.1 structure of knowledge library

The research object is various speed constant frequency(VSCF) AC electric power system. Both IDG is same. They supply power to respective channel independently, and standby for each other. DC power provided by three transformer rectifier unit(TRU). They supply power to two substantive power net. Aircraft's power supplying system is consisted of two same subsystem, so building two independent expert system.

Knowledge is composed of five modules. It has :over-current fault library, over-voltage fault library, under-voltage fault library, frequency abnormity fault library, one-off fault library. When system is working, correlative fault module is sent to memory according as the style of fault. This can avoid scanning full space and saving time and memory space. It makes system expand to be possible.

3.1.2 knowledge expressing

According to the characteristic of fault, the knowledge is divided into: precise knowledge and un-precise knowledge.

Precise knowledge associate the set of fault symptom with target directly. Where the fault is in the system can be got by fault symptom. Then locate line replaceable unit(RLU).

Conclusion can not be got through un-precise knowledge which is related to fault symptom. Furthermore, system can not provide assistant information. So judge device is fault or not must depend on its invalidation rate.

Fault tree is a qualitative cause and effect module which reflects on structure and function and action relation of diagnosis object.

It embodies hiberarchy and consequence between super-node and sub-node of fault spreading.

Sub-node is a fault source of super node in fault tree. Because of this characteristic, the cause of fault can be confirmed by building a fault diagnosis tree[6]. A under-voltage diagnosis tree is given in figure 2.

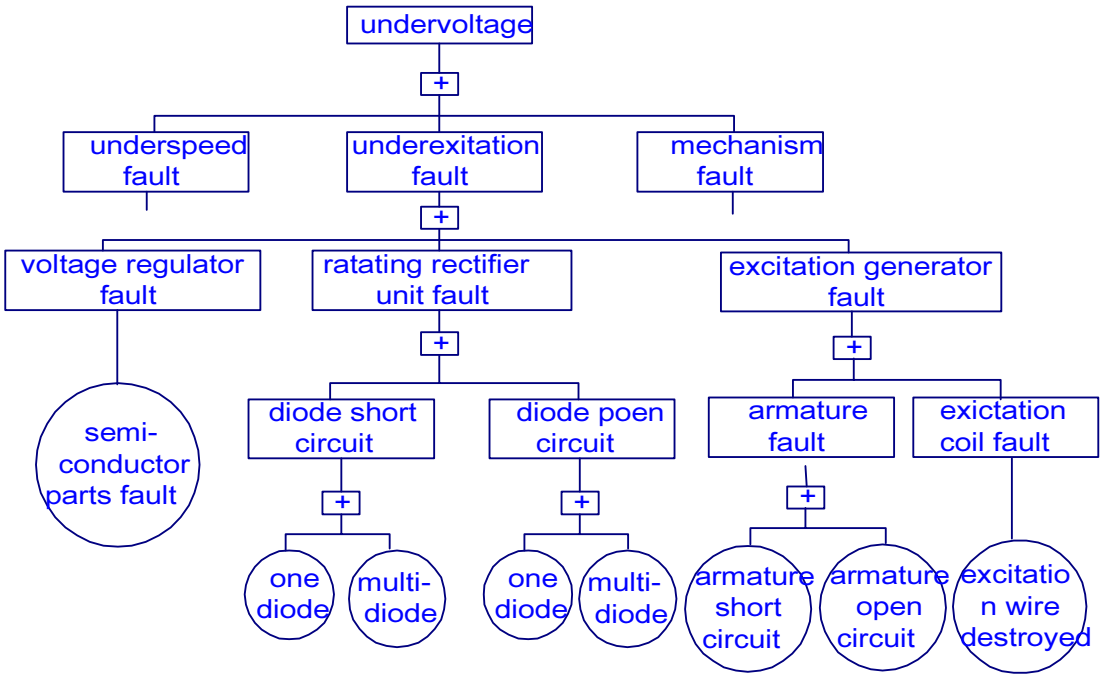

Figure 2 ac generator under-voltage fault tree

Generator's under-voltage is a fault even in the tree. Middle events include rotating rectifier unit fault, voltage-regulator fault, etc. Fault conclusion comprises armature coil turnoff, a diode shortcut, etc.(see fig 2). The relations between fault and fault symptoms is obvious in the tree. It's suitable to precise knowledge and un-precise knowledge.

This system is a rule-based Expert system. Rules describe as:

If A1 and A2 and … An Then B with confidence CF

In the description, A1,A2,…,An are the precondition of rules, B is the conclusion of rules, CF is certainty factors.

Library and soft are separated in rule-based expert system. Knowledge library can be self-existent and can be made up together according to demand. Only one library is used which make it easier to reasoning and manage.

3.2 Design of inference engine

Inference engine confirms which rules to start according as the fact in overall data library. When a fault reason can be caused by several faults, more than one rule is sprung. Then conflict clear-up tactic must be used to determine which rule is suitable.

For example, TRU's outputting waveform including too many ac quantity is caused by TRU itself or by generator in the same channel. The fault relation is given in figure 3. In this system conflict clear-up tactic consist of: organization sequence of knowledge library, classifying in module, time-relaying, etc.

From the fault diagnosis tree, diagnosis's hiberarchy can be gotten. But in the actual reasoning process, "over-level diagnosis" uses more frequently in stead of level diagnosis. Because fault diagnosis tree has a few levels in electric power system, "over-level diagnosis" can be used according to acquaintance with level diagnosis and combining with expert's knowledge. This can enhance the efficiency of diagnosis reasoning.

When abnormal data is found in overall data base, reasoning use forward chaining with heuristic rules. This can avoid having no

matching rules. By making use of heuristic method scanning can be finished quickly.

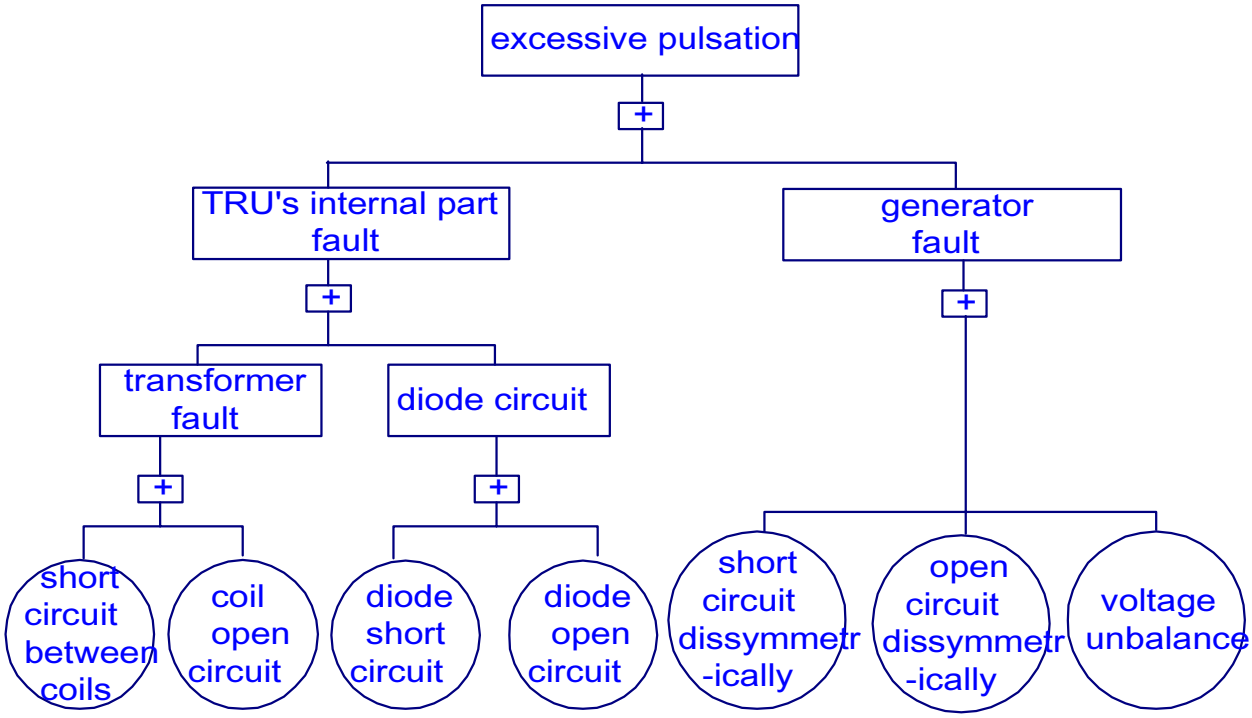

figure 3 Consequence of TRU's excessive pulsation

3.3 Realization of real-time diagnosis

Because of the limiting of sampling-spacing, fault diagnosis expert system must give diagnosis conclusion in prescriptive time. In this system data is pre-processed which can avoid repeated data operation. The combination of deep and shallow inference can optimize inference process. Classifying the data base can reduce scanning step. Multithreading running can avoid executing command unnecessarily.

4. Conclusion

Setting a lot of fault in running, the system simulated collection, process and fault location. Its validity is validated. The setting fault can be detected and located after time delaying. Its conclusion can reach the level of domain expert.

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