Research on Interactive Fault Reasoning of Complex Agricultural Equipment by IETM

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Abstract. As the equipment of modern agriculture becomes more and more complex, fault reasoning and fault maintenance support have turned into two important core functions. And how to improve the fault reasoning task success rate is an unavoidable problem for Interactive Electronic Technical Manual (IETM) that has been used in modern agriculture support information. Aiming to solve the poor interactive, inaccurate location, one-sided guidance problems in fault reasoning and fault maintenance of complex agricultural equipment, we use process data module and fault data module to describe the fault and full process for fault diagnose, fault reasoning and fault maintenance, and then according to interactive fault reasoning principle based on process data module and fault data module to guide fault maintenance staff complete fault reasoning, isolation and maintenance in shorter time. As a result, this is a new approach to improve the accuracy and efficiency of fault remedy and maintenance, and it also improves the efficiency of fault reasoning of complex agricultural equipment by IETM in an interactive way.

1. Introduction

Interactive Electronic Technical Manual (IETM) refers to the integrated application of computer multimedia, database and network technology advantages, organizing the operation manual, maintenance manual and other information in accordance with relevant standards, and will be in the form of optimal text, tables, graphics, engineering graphics, sound, video, animation, and other information displayed on the electronic screen, consulting interactively, and will accurately show the information that maintenance technicians or system operator need to speed up the implementation of the equipment use and support activities[1]. As one key element of equipment integrated support, the widespread use of IETM is important to reduce the cost of equipment support, and it can improve the efficiency of equipment integrated support. IETM has been used in complex equipment domain, such as agriculture domain that contain lots of complex equipment. At the same time, it has a significant advantage of shortening the time of fault maintenance and improving maintenance efficiency, which has become a hot spot in the research of equipment information technology support.

In all functions of IETM, an important function in the process of fault reasoning and maintenance is to provide reasoning and maintenance support, interactively guide the breakdown maintenance technical personnel in a relatively short time for fault reasoning, maintenance and show the fault isolation path for user, so as to improve the accuracy of troubleshooting and maintenance, efficiency, maximize the efficiency of equipment integrated support. Process data module is the foundation of interactive fault reasoning and maintenance, and how process data module and fault data module play the role of fault reasoning and maintenance is the main content of this article research.
2. Progress Data Module and Fault Data Module
There are two important data module types in IETM which are called progress data module and fault data module. They can collaborate to handle with fault reasoning base on IETM.

2.1 Function of Process Data Module and Fault Data Module
IETM technology standard that named S1000D defines a process data with special interaction function module is used to represent the program flow consisting of data modules and steps, such as maintenance process, fault finding program and fault isolation path to realize the complex interaction process of IETM technology information [2]. The "interactive" is an important interaction aspects of IETM, so it is mainly used to describe the interactive program structure information. According to the static or dynamic state information, it is the core and key to the realization of IETM interactivity to build a structured program with multiple interactive functions, consisting of multiple data modules or steps in a special order. Furthermore, S1000D also defines a type of data module called fault data module which contains the equipment’s fault phenomenon, fault detection and other information of fault.

The purpose of the data process module design is to realize the interaction process of IETM, acquisition, storage, and operation status information ability. It can fully describe a complete fault diagnosis, isolation and maintenance process. The interaction functions of process data module can achieve are mainly [3,4] as following:

- Fault diagnosis, especially dynamic diagnosis and system simulation.
- Implement external procedures to achieve IETM interaction with external programs.
- Interactive functions such as navigation, tracking and dialog driving.
- Information filtering, which presents the information needed to match the current situation of the user.
- Order traversal, especially for test and platoon, the next step is to decide based on current dynamic state information or external input.

2.2 Structure of Process Data Module and Fault Data Module
The process data module uses the element <process> tag. The content organization takes the node as the basic element. And the execution sequence of the data module can be constructed by using sequence, branch, condition, and loop 4 node types. According to the S1000D standard, the pattern structure of the entire process data module is shown in figure 1.
It contains the following child elements in the main elements <process>: variable declaration <variableDeclarations>, common information <commonInfo>, preliminary requirements <preliminaryRqmts>, data module sequence <dmSeq> and close requirements <closeRqmts>. Two important sub-elements are the <variableDeclarations> and <dmSeq>, and then the former is used to declare variables and initial values, while the latter is the elements of aggregation sequence information.

<variableDeclarations> element can contain one or more variable element <variable>, which is used to define and initialize all of the global variables used in the process data module, including the variable name, description, configuration, type, accuracy and the range of use attributes, and a dialog box or dialog box branch, variable initialization and three other sub elements. The dialog <dialog> element provides 5 kinds of interaction, such as the blanks, menus, buttons, message boxes, and dialog boxes to receive the user's input and assign the variables, so as to realize information interaction between user and logic engine.

<dmSeq> element is the main content of the data process module which determines the steps, dialogue, external application request, and the order of conditions in the data module. At the same time, it defines the logical order of sub elements <dmNode>, <dmNode>, <dmIf> and <dmLoop>.

The fault data module uses the main element <faultReporting> or <faultIsolation> tag[5]. This two tag can only exist one or another at one time, so it means that there two subclasses of fault data module. <faultReporting> is used for reporting a isolated fault, detected fault, observed fault or correlated fault. on the other hand, <faultIsolation> is used to describe a fault's isolation procedure. According to the S1000D standard, the pattern structure of the entire fault data module is shown in figure 2.
In the IETM browsing platform, the interactive logic structure is described by the process data module, and the implementation of interactive functions requires a logic engine, and the fault reasoning result will direct to fault data module. Logic engine is the software part that performs the data module process. It is the interpreter of program script flow, which is completed by the Schema based on the process data module. For example, the element <dmSeq> is processed, and the contents are sorted by the result of processing. The function of logic engine in the interaction and fault diagnosis of IETM mainly contain the following 4 aspects: The traversal of process data module maintains the variable status table, evaluates the expression, and the dialog box appears, as shown in Figure 3.

Logic engine gets the input from the human-computer interaction interface, traverses the data process module, evaluates the expressions of the obtained variables. At the same time, it makes the dialog box render, and then the result calculations are used for logical judgment and maintenance of variable expressions. If the output result of logical judgment is not a clear equipment failure, the next test task will continue according to human-computer interaction. And at the same time, logic engine
will output fault isolation path real time, then the path picture gives a visual representation of the fault isolation state for the maintenance staff.

3. Interactive Fault Reasoning

The interactive fault reasoning based on IETM need to be combined with the feature of fault, the test results and user experience. Those composition formed a comprehensive systematic analysis flow by using process data module, and then guide the maintenance man by what they input interactively. The process data module get test jump conditions step by step, and gradually reasoning, detect, locate the fault until fault has been isolated thoroughly.

Fault reasoning in IETM mainly use fault reasoning unit for equipment troubleshooting. The fault reasoning unit is a large data module composed of description, fault and procedure data modules, which is the data module of fault reasoning process, and is the process data module essentially. The model diagram of interactive fault reasoning based on process data module is shown in figure 4.

The fault reasoning process data module contains the precondition, link unit, test unit and the troubleshooting unit. The precondition gives the expression of variables that must be satisfied in the fault reasoning process data module. The test unit is a description of the inspection task and the status of the test results, which is used to match the diagnostic reasoning rules to locate the fault. The link unit provides information about fault reasoning, maintenance related text, images, multimedia, etc.[7,8]

The interactive fault reasoning is the process of the user input an fault phenomenon through the dialog of interactive interface, and then it will convert to the variable assignment inside of the IETM system. In IETM system’ back end, there is a fault state variable expression table which is maintained by logic engine. By matching the expression of fault reasoning process data module and the preconditions in the system, the match result will decide to activate the corresponding fault reasoning process, and then the logical process of reasoning will according to the test results and the operation result to make a decision of whether fault diagnosis have completed or the next test task is needed. All
diagnostic rules include an end request that contain an assignment statement, and when the fault has not been located, it will enter the queue of test unit.

After the troubleshooting unit, if the troubleshooting can not be ruled out, the maintenance staff can ask the remote support of domain expert for help to troubleshoot. Domain experts, according to the fault information, propose a solution to guide the troubleshooting staff to fault reasoning interactively by IETM[9,10]. After troubleshooting unit successfully troubleshooting, users can feedback in the IETM platform interactive diagnosis reasoning process, and at the same time if the IETM platform integrate with fault knowledge database, maintenance knowledge database and tool instrument database, depending on the fault reasoning and maintenance process, we can update the corresponding knowledge database, and the rules of the domain experts to form unified analysis case can also be stored into the knowledge management database, the updated knowledge base for the next fault reasoning constantly optimize the logical process of reasoning, thereby improving the success rate of fault reasoning.

4. An Instance of Interactive Fault Reasoning
In a certain kind of complex agriculture equipment’s IETM browsing platform, interactive fault reasoning based on process data module and fault data module is as follows: in the platform’s full-text retrieval interface, the user input "right pump" keyword, then select and start the right pump fault reasoning process in the search result list. The progress will guide user to answer a series of questions until find the fault bottom event. Finally, the cause of the fault has been found and output the fault isolation path that is created by the fault tree create algorithm set. After finding the cause of fault, the process data module will invoke the troubleshooting unit and guide the user to carry out the maintenance, thus complete the whole process of fault reasoning and maintenance.

5. Discussion and Conclusion
As the development of agricultural equipment’s integrated level, it has become more and more difficult to do fault reasoning and fault maintenance for complex agricultural equipment. With the continuous application of IETM in modern agriculture support information, especially the use of process data module and fault data module, fault reasoning and maintenance’s interactivity and accuracy are greatly improved. At the same time, the reasoning mechanism based on process data module and fault data module does not need frequent access to the database in the actual reasoning process, so it can show fault isolation path for real time in addition, and therefore it also has a good independence to make the reasoning process relatively concise and clear. As has been said above, maintenance staff have improved the efficiency of complex agricultural equipment by IETM.

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