Fault Cause Description Model: For Training Simulation

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Abstract. Fault diagnosis model is the core of virtual simulation and hardware-in-loop simulation training, which has become a hot spot in current research. Construction of the fault description model of the virtual simulation training and hardware-in-loop simulation training is an important theoretical support for fault diagnosis description model. The XML as the description language, with S1000D as the reference standard, the description requirement of fault cause was analyzed to establish computer sensible fault-cause description model that for training simulation. The model can be used in fault diagnosis model for mechanical, electronic and mechanical and electrical equipment. This model is used to describe the LRU fault in the diagnosis tree, and the rationality and validity of the model are verified.

1. Introduction

In fault diagnosis training, real equipment training is the most effective training pattern of traditional training mode, but there is many limits when it is applied such as the high cost, many complex factors, the training time and even the damage. The application of simulation technology in fault diagnosis can provide a good solution for the problems in the practical training so as to its economy, security and restrictions and other advantages. On the base of the simulation technology of virtual training simulation and semi-physical simulation training as an effective supplementary measure of practical training, can effectively improve the knowledge and ability level of fault diagnosis for maintenance personnel.

Fault diagnosis simulation training is a train for the trainees in the case of basic maintenance knowledge to complete the fault state recognition, analysis and diagnosis training by interacting with the prototype[1]. Fault diagnosis model is the core of virtual simulation and hardware-in-loop simulation training, which has become a hot spot in current research. The description model of fault diagnosis process, fault phenomenon and fault cause constitute the main part of the fault diagnosis model, the fault cause description model is used to describe the main factors that determine the cause of the failure in the process of fault diagnosis, and is one of the main purposes of fault diagnosis[2].

There is different fault diagnosis model for different researchers, thus the cause description model of the fault diagnosis is various [3][4]. As a fundamental basis for the guidance of troubleshooting, it is important for realizing the integrated fault diagnosis training system to establish a fault cause description model that support virtual simulation training and semi physical simulation training. The XML as the description language, with S1000D as the reference standard, analyzes and builds the fault cause description model. The application of LRU fault diagnosis tree as an example to verify the feasibility of the model.

2. Fault cause description model analysis

According to the possible fault causes division of the S1000D, the possible fault causes are divided into LRU, wiringPossibleCause, otherPossibleCause and sru[5]. Although there are essential

differences between the fault causes and the possible causes, the classification method can follow the division principle of S1000D, so the fault causes have the same description elements as the possible fault causes.

For reference the possibleCauseGroup in S1000D, according to the relationship between the fault diagnosis model and mechanism model, The fault cause description model not only should contain a description of the reasons for different types, should also describe each of the cause of the fault t state and fault phenomenon etc. Therefore, on the basis of possibleCauseGroup elements, it need to add the fault state element of faultState and fault phenomenon elements of faultPhenomenonDescr for different types of fault causes. PossibleCauseGroup is also used as a description element of the fault cause, so as the same change to add faultState and faultPhenomenonDescr elements. Although the description of the fault cause and possible fault cause of possibleCauseGroup is basically the same, but there are essential differences between them. PossibleCauseGroup is used to represent the conclusions after diagnostic reasoning that is the possible fault causes of the conflict between the observed value and the predicted value, and fault causes are used to indicate the real cause of the failure caused by fault detection and fault isolation. Due to the different nature of the fault causes and possible fault causes, so the naming method is also different, the fault causeis named faultCause. At the same time according to the describe rules of XML schema, in order to solve the problem of conflict, the naming of elements in the faultCause also need to make corresponding changes, the four kinds of fault cause are renamed as lruCause, wiringCause, otherCause and sruCause.

For each fault cause corresponding to the fault state, the analysis from the angle of different needs is shown in Table 1

Table1 The demand analysis of the fault state description

angle of different needs	Required elements / attributes
From the diversity of fault condition	Different types of fault status
From fault state coding	Code identification
From the description of the fault cause	Text type description
From the relationship with mechanism model	Normal state space
From the state value corresponding to the fault reason	Actual state value

As the state space description of product related elements, each fault state (faultState) needs to have the corresponding fault state encoding and the attribute is ID. The mainly description method of the fault state includes three kinds, which are the character description, the state space description and the reference model corresponding to the elements descr, normalStateRange and refs respectively. For state space domain is mainly described by interval and value, so the expected value, single limit, limit pair and fuzzy value four ways in which a state representation and corresponding element were expected, singleLimit, limitPair and mask. The real value of the state can be described by three types of data type, set type and index matrix., so with the element datum, collection and indexedArray to represent the type of the value. A character type descr element is used to describe the status of a state that cannot be described by numerical value.

To sum up, the elements of fault cause description model include fault reason, LRU fault, wiring faults, SRU fault, other faults, fault state, and fault phenomenon, identification and reference type description, text type description, normal state space and the real value. The S1000D standard contains a part of elements required, some of the elements can be directly used, some of the elements need to be renamed. The lack elements need to be built. Specific correspondence and description schemes between describe elements of fault phenomenon and S1000D such as table 2 shows, including "√" said with this description elements, "×" said does not have this description elements.

Table2 The relations with S1000D and the solutions to describe of required descriptive elements

Required description elements	S1000D		Description scheme
	Existing elements	Correspondent node	
Fault cause	√	possibleCause Group	Renamed as faultCause
LRU fault	√	lru	Renamed as lruCause, and expand
wiring faults	√	wiringPossible Cause	Renamed as wiringCause, and expand
SRU fault	√	sru	Renamed as sruCause, and expand
other faults	√	otherPossibleC ause	Renamed as otherCause, and expand
fault state	×	×	Newly build faultState
fault phenomenon	×	×	Newly build faultPhenomenonDescr
Text type description	√	descr	Directly using
Reference typedescription	√	refs	Directly using
Normal state space	×	×	Newly build normalStateRange
Real value	×	×	Newly build realValue
identification	√	id	Directly using

After defining the elements of the fault cause description model, the relationship between the elements must be defined. Because the new elements faultState and faultPhenomenonDescr belong to a part of the different types of fault cause, so add the faultState and faultPhenomenonDescr respectively as sub elements of lruCause, wiringCause and sruCause elements, as parallel relationship with name elements. The connection is performed by sequential connection. As a result, the XML Schema of the fault cause description model is shown in figure 1.

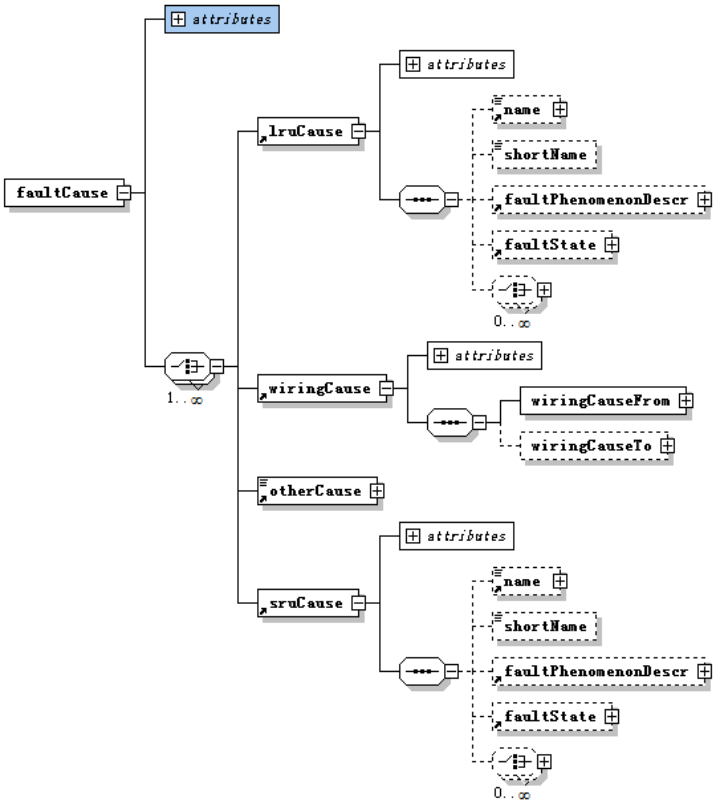

Figure1 The XML Schema of fault cause description model

3. Construction of fault cause description model

In the fault cause description model, there is four replicates required sub elements for the element of faultCause, they are lruCause、wiringCause、sruCause、otherCause and respectively used to describe the LRU fault causes, line fault causes, SRU fault causes and other causes of failure. These four kinds of fault cause elements all have attribute ID, attribute ID indicates the fault reason corresponding to the fault state code. LruCause and sruCause elements have the same sub elements that is name, shortName, faultPhenomenonDescr, faultState and identNumber, etc. The sub elements of wiringCause are divided into wiringCauseFrom and wiringCauseTo. WiringCauseFrom and wiringCauseTo also have the same sub elements that is name, shortName, faultPhenomenonDescr and faultState, etc. OtherCause is a character type element, without any sub elements. FaultPhenomenonDescr of these sub elements is used to describe fault phenomenon that corresponding to the fault cause, the specifics of sub node that fault phenomena described reference the phenomenon description model.

FaultState is used to describe the fault status information, the XML Schema of the element is shown in Figure 2. FaultState contains elements such as descr, normalStateRange, realValue, refs and so on. The descr node is used to describe the fault state briefly. The normalStateRange nodes is used to describe the normal state space range of the corresponding fault unit. The realValue node is used to describe the real state value. Normal state space domain mainly is represented by four ways such as the expectation value, single limit, limit pair and fuzzy value, which corresponding to the sub node of normalStateRange node as expected, singleLimit, limitPair and the mask. The state that unable to describe by interval and numeric is described by character type element descr. The types of value are mainly divided into three types: data type, set type and index matrix, which correspond to datum, collection and indexedArray. The state that unable to describe by numeric is described by character type element descr.

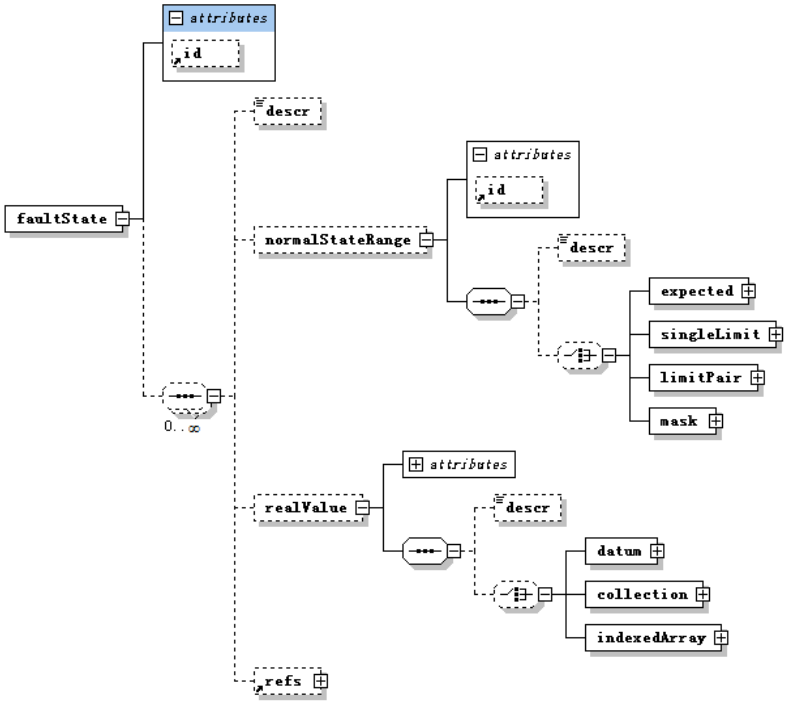

Figure2 The XML Schema of faultState element

4. Example application of the model

Diagnostic tree analysis method is a kind of optimized fault diagnosis method based on fault tree. When use this method to process fault diagnosis, each test node is asked, according to different test results to determine the analysis, and in accordance with the analysis of the results select the different fault diagnosis respectively. Since the establishment of diagnosis tree integrated fault tree, testing and

judgment and optimal search strategy and so on, so it avoided blind search, greatly improved the diagnostic efficiency[6]. In order to verify the validity of the fault description model, this paper takes the LRU fault in the diagnosis tree as an example, and describes the reason of the fault.

```
<faultCause>  // Describe the cause of failure
  <lruCause>  // Description LRU failure
    <name> running out rod </name>  // Name of LRU
    <faultPhenomenonDescr> The running out rod is curved </faultPhenomenonDescr>  // Describe the failure phenomenon
    <faultState>  // Description LRU fault status
      <descr> The running out rod is curved</descr>
    </faultState>
  </lruCause>
</faultCause>
```

The description of the faultState is as follows:

```
<faultPhenomenonDescr>
  <faultState>  // Description of fault phenomena in the form of state
    <normalStateRange>  // Describe the normal state space
      <LimitPair booleanOperation="and">  // Description of boundary pair
        <Limit numberOperation="greatThan">  // Indicates that the boundary is greater than 11.8V
          <Datum type="double" standardUnit="V" value="11.8"/>
        </Limit>
        <Limit numberOperation="lessThan">  // That the boundary is less than 12.2V
          <Datum type="double" standardUnit="V" value="12.2"/>
        </Limit>
      </LimitPair>
    </normalStateRange>
    <realValue numberOperation="equal">  // Describe the true value of the state
      <Datum type="double" standardUnit="V" value="13.5"/>  // Indicates that the true value is 13.5V
    </realValue>
  </faultState>
</faultPhenomenonDescr>
```

5. Summary

In this paper, the construction requirements of the fault cause description model were analyzed in detail, the essential factors to construct the model were determined. On the basis of S1000D standard, the XML as the description language, the fault cause description model that can be identified by computer and for training simulation was established. Combined with the RLU fault in the fault diagnosis tree, the rationality and validity of the model is explained. The model may provide an important theoretical support for the realization of integrated fault diagnosis simulation training system.

References

[1]. Zhao Chunyu, Hao Jianping, Li Xingxin etc. Design of Fault Diagnosis Training Based on Electronic Equipment Virtual Prototyping[J]. Computer Engineering, 2010, 36(11):226-228.

[2]. Li Xingxin. A Study of Virtual Maintenance Training Model and a Platform Development[D]. Ordnance Engineering College, Shi JiaZhuang, 2010.

[3]. P. Santos, L. F. Villa, Aníbal Reñones,et al. Wind turbines fault diagnosis using ensemble classifiers[C]. ICDM 2012, 2012:67-76.

[4]. A. Mahapatro, P. M. Khilar. Online distributed fault diagnosis in wireless sensor networks[J]. Wireless Pers Commun, 2013(71):1931-1960.

[5]. S1000D. International specification for technical publications utilizing a common source database（Issue 4.1）[S]. ASD&AIA&ATA, 2012.

[6]. Zhu Yaxiong, Li Xingxin, Hao Jianping ect. Descriptive Model Research for Fault Diagnosis Virtual Training Based on XML[J]. Computer Measurement&Control. 2015,23(6):1875-1877.