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Fault Diagnosis Research of Computer Software Based on the Fuzzy Theory

Zhixue Li

Weifang University of Science and Technology, Shouguang,Shandong, CHINA
lzxkong@163.com

With the popularity of computers, all kinds of computer software become indispensable to people's life. The main causes that fault occurs in computer software are that software non-compatibility, illegal operation, error operating, irrational software setup, computer prevention. And there are six symptoms. Using the phase-divided dynamic adjustment weight coefficient method combined with the data inspected by computer software, expert experience, and mechanism analysis to determine the fuzzy diagnosis matrix, the symptoms and causes are established fuzzy corresponding relationship, the fuzzy model of computer software fault diagnosis is established, through the fault symptoms of computer software to judge its fault causes so as to handle faults quickly and ensure the normal operation of computer software.

1. Introduction

With the development of society and the popularity of computers, there appears more and more computer software, which develops rapidly. Computer software has been integrated into every aspect of people's daily life, such as entertainment, work, life, and etc. There are more and more companies of which the development of computer software is taken as the main business. Computer languages become diverse. Program development is classified as the compulsory course of current college students. Therefore, it is very necessary to inspect computer software, collect data and diagnose its faults in order to guarantee the normal safe operation of computer software, make computers compatible with the software, and improve the operation efficiency of computer software.

Computer software refers to the programs and documents set up in computer system. The programs are computing the processing objects of the tasks and dealing with the description of the rules. Documents are interpretation data that is convenient to know about its program. The program couldn't work until they are set up into the computer while documents are generally to show people, not necessarily setting up into the computer.

The fault diagnosis of computer software is to establish an appropriate model (Cui, 2014) using the study of the data relationship between computer software fault and the symptoms, and then according to its model to diagnose the fault. Because the computer system is a very complex system, its running state is inseparable from the computer software. Once there appears faults in computer software, the computer breakdown may occur, which would affect the normal work of the computer.

2. The fault diagnosis theory of computer software

2.1 The fuzziness and complexity of computer software fault

The normal operation of the computer is influenced by computer network, computer environment, computer software and some other conditions. The variation of these factors forms interference to the normal operating computers. At the same time, the normal operation of computer software is also influenced by its running time, load variation, medium variation, and temperature changes. It's running state and fault factors are fuzzy (Bu and Bu, 2012). The possible causes of computer software fault are software non-compatibility, illegal operation, error operating, irrational software setup, computer prevention, which are also uncertain.

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When there are faults in computer software, precursors may appear which are fuzzy as well. It is hard to determine the cause exactly. For the whole computer system is very complex, it is interacted, inter-influenced and inter-restricted by its internal parts.

2.2 The fault diagnosis theory of computer software

The process of computer software fault diagnosis is similar to the process of traditional Chinese medicine (TCM) checking its patients. Through inspection, auscultation-olfaction, interrogation and palpation method and one's own experience to diagnose patient's symptoms, according to the fuzzy relationship between the patient's symptoms and the disease, the patient's disease could be determined. The causes of computer software fault could establish fuzzy relationship with its fault symptoms. When there appear faults in computer software, according to its symptoms, the causes of computer software could be diagnosed, so as to clear troubles and make the normal operation of computer software.

Through the prophase investigation, using principal component analysis, the five main causes of computer software fault and its six corresponding fault symptoms could be determined. The specific details are shown in table 1.

Table 1: the main causes of computer software fault and its corresponding symptoms

Computer software fault		Corresponding indexes	
the causes of computer software fault	y	software non-compatibility	y_1
		illegal operation	y_2
		error operating	y_3
		irrational software setup	y_4
		computer prevention	y_5
Fault symptoms of computer software	x	Software can't be installed.	x_1
		Software can be unable to startup normally.	x_2
		Software icons can't be displayed properly.	X_3
		After turning on the software, it would automatically shut down.	x_4
		During the operation of software, it would suddenlyshut down.	x_5
		Software running results cannot be saved.	x_6

The general process of computer software fault diagnosis is shown in Chart 1.

3. The fuzzy modelof computer software fault diagnosis

The method of computer software fault diagnosis is according to the membership function of fuzzy theory and the fuzzy relationship matrix to carry on the fuzzy correspondence between the fault causes of computer software and its fault symptoms so as to realize the computer software fault diagnosis.

(1) According to table 1 and Figure 1, the cause set of computer software fault is determined as follows:

$N=\{y_1, y_2, y_3, y_4, y_5\}$,

The fault symptom set induced by the five computer software fault causes is as follows:$M=\{x_1, x_2, x_3, x_4, x_5, x_6\}$.

(2) Using the method of ranking by dual comparison, the membership function of computer software fault symptoms is determined as μ_i, according to the membership function to calculate the corresponding membership degree of symptom x_i as $\mu_i(x_i)$, the fuzzy vector of computer software fault symptoms could be obtained as follows: $X=\{\mu_1(x_1), \mu_2(x_2), \mu_3(x_3), \mu_4(x_4), \mu_5(x_5), \mu_6(x_6)\}$;

Let fault symptom sample of computer software M bring about by fault cause N and the membership degree be $v_i(y_i)$, the fuzzy vector of computer software is: $Y=\{v_1(y_1), v_2(y_2), v_3(y_3), v_4(y_4), v_5(y_5), v_6(y_6)\}$.

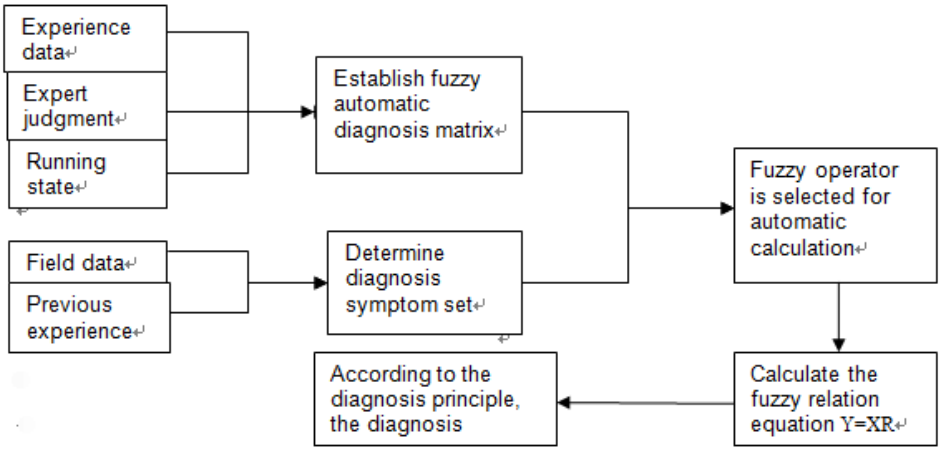

Figure 1: The flow chart of computer software fault diagnosis

(3) Using the phase-divided dynamic adjustment weight coefficient method combined with the data inspected by computer software, expert experience, and mechanism analysis to determine the fuzzy diagnosis matrix (Armando et al., 2012), the detailed process is as follows:

First, according to the monitoring data of computer software fault, the membership degree could be determined as a_{ij}. According to the expert experience, the membership degree could be determined as b_{ij}. According to the mechanism analysis of computer software fault, the membership degree could be determined as c_{ij}. (DavoodSamari et al., 2011)

Second, according to the running time, working state, fault times of computer software, the weight coefficient of each membership degree is $\lambda_1, \lambda_2, \lambda_3$, and when $\lambda_1, \lambda_2, \lambda_3 \geq 0$, $\lambda_1+\lambda_2+\lambda_3=1$;

Finally, the elements of fuzzy diagnosis matrix could be obtained, that is, the final membership degree:

$r_{ij}=\lambda_1 a_{ij}+\lambda_2 b_{ij}+\lambda_3 c_{ij}$,

The fuzzy diagnosis matrix of computer software fault could be obtained as follows:

$$R=(r_{ij})_{6\times 5}=\begin{bmatrix} r_{11} & r_{12} & \cdots & r_{15} \\ r_{21} & r_{22} & \cdots & r_{25} \\ \vdots & \vdots & & \vdots \\ r_{61} & r_{62} & \cdots & r_{65} \end{bmatrix},$$

And $r_{ij} \in [0,1], i=1,2,\ldots,6; j=1,2,\ldots,5$.

(4) With the aid of the fuzzy vector of computer software fault symptom, the fuzzy vector of fault cause and the fuzzy diagnosis matrix, the fuzzy relation equation could be established as follows:

$Y'=XR$,

After solving the equation, based on the maximum membership principle, the causes of computer software fault could be determined.

4. The simulation application of computer software fault diagnosis

4.1 Using the method of ranking by dual comparison, the membership function of computer software fault cause could be determined

The common method of determining the membership function is the method of ranking by dual comparison. When there appear fault symptoms of computer software, it could determine the sequence of fault causes. In this paper, the alternative optima relative method is chosen, that is, when n fault causes of computer software

induce the same fault symptom, enough computer professionals carry on the multiple comparisons to these n fault causes at a time, evaluating which one is the most probable cause bringing about the computer software fault symptoms. And according to the results of the multiple records, the sequence of fault causes under this symptom could be determined.

Using the alternative optima relative method, 100 professionals carry on the multiple comparisons to five fault causes of certain software. Record the most probable cause that each professional thinks inducing the computer software fault as an experiment. Every one repeats twice, and the experiment is carried on 60 times. At last, sort out the experiment results of these 100 professionals' 3000-time experiments. The results are shown in table 2.

Table 2: the preferred time data results of five computer software fault causes

Y	y_1	y_2	y_3	y_4	y_5	Σy_i	Ranking	$v_i(y_i)$
y_1	0	193	111	104	90	498	4	0.599
y_2	74	0	81	93	104	352	5	0.424
y_3	228	175	0	100	151	654	3	0.787
y_4	261	178	136	0	90	665	2	0.800
y_5	352	189	115	175	0	831	1	1

From table 2 we could get that through the alternative optima relative method, the fuzzy vector of membership function the fault symptom x_j of computer software to the fault cause y_i could be determined as follows:
Y=(0.599, 0.424, 0.787, 0.800, 1)

4.2 Construct the fuzzy diagnosis matrix of computer software fault

According to the monitoring data of computer software fault, the membership degree could be determined as:

$$A=(a_{ij})_{6\times5}=\begin{bmatrix}0.4 & 0.7 & 0 & 0.28 & 0\\ 0.5 & 0.45 & 0.35 & 0 & 0\\ 0.44 & 0 & 0.48 & 0.45 & 0.39\\ 0 & 0 & 0.6 & 0 & 0\\ 0 & 0 & 0.5 & 0 & 0\\ 0.35 & 0.4 & 0.5 & 0.48 & 0.55\end{bmatrix};$$

According to the expert experience, the membership degree could be determined as

$$B=(b_{ij})_{6\times5}=\begin{bmatrix}0.6 & 0.8 & 0 & 0.72 & 0\\ 0.5 & 0.55 & 0.4 & 0 & 0\\ 0.56 & 0 & 0.52 & 0.3 & 0.61\\ 0 & 0 & 0.4 & 0 & 0\\ 0 & 0 & 0.5 & 0 & 0\\ 0.4 & 0.6 & 0.5 & 0.52 & 0.45\end{bmatrix};$$

According to the mechanism analysis of computer software fault, the membership degree could be determined as

$$C=(c_{ij})_{6\times5}=\begin{bmatrix}1 & 0 & 0 & 1 & 0\\ 1 & 1 & 0 & 0 & 0\\ 1 & 0 & 1 & 0 & 1\\ 0 & 0 & 1 & 0 & 0\\ 0 & 0 & 1 & 0 & 0\\ 0 & 1 & 1 & 1 & 1\end{bmatrix};$$

According to the running time, working state, fault times of computer software(Geng and Xu, 2011), the weight coefficient of each membership degree is as follows: λ_1=0.4,λ_2=0.4, λ_3=0.2;

Finally, according to the formula $r_{ij}=\lambda_1 a_{ij}+\lambda_2 b_{ij}+\lambda_3 c_{ij}$, the fuzzy diagnosis matrix of computer software fault could be obtained as follows:

$$R=(r_{ij})_{6\times 5}=\begin{bmatrix} 0.6 & 0.4 & 0 & 0.98 & 0 \\ 0.8 & 0.98 & 0.3 & 0 & 0 \\ 0.95 & 0 & 0.8 & 0.3 & 0.98 \\ 0 & 0 & 0.98 & 0 & 0 \\ 0 & 0 & 0.9 & 0 & 0 \\ 0.3 & 0.6 & 0.9 & 0.98 & 0.95 \end{bmatrix}.$$

Details are shown in table 3.

Table 3: the fuzzy diagnosis matrix of computer software fault

fault causes / fault symptoms	software non-compatibility y_1	illegal operation y_2	error operating y_3	irrational software setup y_4	computer prevention y_5
Software can't be installed.x_1	0.6	0.4	0	0.98	0
Software can be unable to startup normally. X_2	0.8	0.98	0.3	0	0
Software icons can't be displayed properly. X_3	0.95	0	0.8	0.3	0.98
After turning on the software, it would automatically shut down. X_4	0	0	0.98	0	0
During the operation of software, it would suddenlyshut down. X_5	0	0	0.9	0	0
Software running results cannot be saved. X_6	0.3	0.6	0.9	0.98	0.95

4.3 The maximum membership degree principle is used to determine the fault causes of computer software

When there are 4 symptoms of computer software fault, that is, software can't be installed x_1, software icons can't be displayed properly x_3, after turning on the software, it would automatically shut down x_4, during the operation of software, it would suddenly shut down x_5, use number 1 to express that there appear computer software fault symptoms, use number 0 to express that computer software fault symptoms don't appear. The fault symptom vector could be obtained as follows:

X= (1, 0, 1, 1, 1,0).

Fuzzy relation equation is established as follows:

$$Y'=X\bullet R=(1,0,1,1,1,0)\begin{bmatrix} 0.6 & 0.4 & 0 & 0.98 & 0 \\ 0.8 & 0.98 & 0.3 & 0 & 0 \\ 0.95 & 0 & 0.8 & 0.3 & 0.98 \\ 0 & 0 & 0.98 & 0 & 0 \\ 0 & 0 & 0.9 & 0 & 0 \\ 0.3 & 0.6 & 0.9 & 0.98 & 0.95 \end{bmatrix}=(0.95,0.4,0.98,0.98,0.98).$$

According to the known fuzzy vector of fault cause Y and the solved Y', the possibility vector of corresponding fault causes could be calculated as follows:

(0.599×0.95, 0.424×0.4, 0.787×0.98, 0.800×0.98, 1×0.98) = (0.569,0.169,0.771,0.784,0.98)

Based on themaximum membership principle, the fault cause of computer software could be determined as computer prevention y_5.

5. Conclusion

According to the fuzzy theory to establish the fault diagnosis model of computer software(Robin, 2004), it is crucial to query the fault causes of computer software quickly, and ensure the normal operation of computer software and computer itself. The model is fast, accurate and timesaving while the deficiency of this model is that the determination of fuzzy diagnosis matrix needs the real-time data and the expert experience so as to ensure more accurate determination of fault causes.

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