Software fault location technology under terminal embedded component

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Abstract: In order to improve the software fault location capability of embedded components of heterogeneous Web server terminals, a software fault location method of embedded components of heterogeneous Web server terminals based on source code fault feature detection is proposed. The original information collection model for software fault detection of embedded components of heterogeneous Web server terminals is constructed, the big data feature quantity of software safety information of embedded components is mined. The spectrum information of software safety information is extracted by adopting a dynamic information fusion method, so as to obtain the fuzzy closeness of software faults. The big data information parameters of embedded component software faults of heterogeneous Web server terminals are adaptively adjusted, and the cross information distribution set of embedded component software faults of heterogeneous Web server terminals is determined. The disturbance of embedded component software faults of heterogeneous Web server terminals is obtained by using the method of limit mining, and the adaptive mining of software faults is realized. Simulation results show that this method is accurate in locating software faults under terminal embedded components, and the software has strong anti-attack ability.

1. Introduction
With the wide application of large-scale heterogeneous Web server terminal embedded component software, the security requirements for heterogeneous Web server terminal embedded component software are getting higher and higher. Under the complex network environment, due to the influence of network attacks and other factors, the embedded component software of heterogeneous Web server terminal fails, so it is necessary to build an optimized fault detection model for embedded component software of heterogeneous Web server terminal. Combining the big data distribution and mining results of software faults, the software fault location can be realized and the software security can be improved. The research on the embedded software fault location method of heterogeneous Web server terminal is of great significance in software development and maintenance[1].

The fault location of software is realized by analyzing the features of embedded software faults of heterogeneous Web server terminals. At present, the methods for detecting software faults of embedded components of heterogeneous Web server terminals mainly include autocorrelation statistical analysis method, software fault mining method of fuzzy feature detection and fault mining method of spectral density feature decomposition, and a fusion filtering detection model for software faults of embedded components of heterogeneous Web server terminals is constructed[2]. Combined with the intrusion feature decomposition results of embedded component software of heterogeneous
Web server terminals, the fault detection and mining of embedded component software of heterogeneous Web server terminals are carried out. However, the traditional method for fault mining of embedded component software of heterogeneous Web server terminals has poor adaptability and low feature detection ability. To solve the above problems, this paper proposes a software fault location method for embedded components of heterogeneous Web server terminals based on source code fault feature detection. The original information collection model of heterogeneous Web server terminal embedded component software fault detection is constructed\[3\], the location mining of heterogeneous Web server terminal embedded component software fault is realized by adopting the dynamic information fusion method, and the cross information distribution set is determined by combining the statistical feature analysis method. According to the spectrum distribution characteristics of software faults, the objective function of software fault detection is established, and the adaptive detection of software faults is realized by combining the methods of big data information scheduling and multivariate cross distributed identification. Finally, the simulation test verifies the superior performance of the proposed method in improving the software fault location capability.

2. Security information detection and fusion analysis of embedded component software of heterogeneous Web server terminal

2.1. heterogeneous Web server terminal embedded component software security information detection

In order to realize fault location of embedded component software of heterogeneous Web server terminal based on fault feature detection of source code, the original information collection model of embedded component software fault detection of heterogeneous Web server terminal is firstly constructed, and the feature decomposition of security dimension of embedded component software of heterogeneous Web server terminal is carried out by using autocorrelation matching detection method[4], and the directional gain of embedded component software fault information of heterogeneous Web server terminal is obtained as follows:

\[
c(v) = \int_0^\pi \cos\left(\frac{\pi}{2} v x\right) dx
\]

(1)

Establishing the channel capacity parameter estimation model of embedded component software fault of heterogeneous Web server terminal, and combining with improved spatial information clustering, the characteristic decomposition results of embedded component software fault of heterogeneous Web server terminal are as follows:

\[
|s(f)| = A \left(\frac{1}{2k}\right) \left[c(v_1) + c(v_2)\right]^2 + \left[s(v_1) + s(v_2)\right]^2
\]

(2)

The statistical feature quantity of software fault information of embedded components of heterogeneous Web server terminals is extracted, and the fusion model of software fault of embedded components of heterogeneous Web server terminals is obtained by combining the fuzzy information scattering cluster clustering method. The feature decomposition function is as follows:

\[
P_1(t) = \sum_{n=1}^{N} A \left(\frac{e^{-j2\pi \frac{n}{r}}}{r} R_{in} e^{-j2\pi \frac{n}{r}}\right)
\]

(3)

The multipath transmission channel model of embedded component software of heterogeneous Web server terminal is constructed, and the sampling component of fault characteristic information is obtained by combining fuzzy parameter fusion:

\[
P_1(t) = \sum_{n=1}^{N} e^{-j2\pi \frac{n}{r}} a_m e^{j2\pi \frac{n}{r}}
\]

(4)

Wherein, \(A(t)\) is the amplitude of software fault fusion of embedded components of heterogeneous Web server terminals, \(f_0\) is the initial frequency of information sampling, \(k = B/T\) is the jumping frequency of software fault detection of embedded components of heterogeneous Web server terminals,
and b is the basis function set. Therefore, the software security information detection model of embedded components of heterogeneous Web server terminals is constructed, as shown in Figure 1.

Fig. 1 Software security information detection model for embedded components of heterogeneous Web server terminals

According to the security information detection model of heterogeneous Web server terminal embedded component software shown in figure 1, the spectrum information of security information of heterogeneous Web server terminal embedded component software is extracted [5], and the channel carrier component of heterogeneous Web server terminal embedded component software is obtained by random functional analysis:

\[ H(z) = \frac{N(z)}{D(z)} \]

In the above formula, \( N(z) \) is the molecular polynomial of heterogeneous Web server terminal embedded component software information transmission, and its zero point is at \( z = e^{\omega_0} \), which is the statistical feature quantity of big data mining of heterogeneous Web server terminal embedded component software faults. Analyze the fuzzy feature matching set of heterogeneous Web server terminal embedded component software fault information output to obtain the residual component of fault distribution, and determine the amplitude-frequency response of heterogeneous Web server terminal embedded component software situational awareness [6]. The reference frequency of heterogeneous Web server terminal embedded component software fault mining is:

\[ \omega_0 = \frac{a}{2} \]

The fuzzy closeness degree of software faults is obtained, and the big data information parameters of software faults of embedded components of heterogeneous Web server terminals are adaptively adjusted [8], and the frequency response of software faults mining of embedded components of heterogeneous Web server terminals is obtained as follows:

\[ e^{j\omega} = V(e^{j\omega}) = \frac{\sin \theta_1 + \sin \theta_2 (1 + \sin \theta_1) e^{j\omega_0} + e^{j2\omega_0}}{1 + \sin \theta_1 (1 + \sin \theta_2) e^{j\omega_0} + \sin \theta_2 e^{j2\omega_0}} \]

With the method of spread spectrum sequence analysis, the distributed structure reorganization of software fault information of embedded components of heterogeneous Web server terminals is carried out, and the perception transfer function of software fault information of embedded components of heterogeneous Web server terminals is obtained as follows:

\[ H(z) = \frac{1}{2} \left[ 1 + V(z) \right] V(e^{j\omega}) + e^{j\Phi(e)} \]

Selecting different matched filter characteristic parameters and bandwidth parameters, fault information detection and big data mining models are established.

2.2. Software fault information fusion

Mining the big data features of security information of embedded component software of heterogeneous Web server terminals, and using the method of dynamic information fusion, the fault location mining of embedded component software of heterogeneous Web server terminals is realized.
The optimized output coefficient of the coupling model of fault information of embedded component software of heterogeneous Web server terminals is:

\[
\begin{align*}
    a_1 &= \sqrt{\frac{\lambda^2}{4} + \alpha^4 + \frac{\lambda^2}{2} b_1} = \sqrt{\frac{\lambda^2}{4} + \alpha^4 - \frac{\lambda^2}{2}} \\
    a_2 &= \sqrt{\frac{\lambda^2}{4} + \alpha^4 + \frac{\lambda^2}{2} b_2} = \sqrt{\frac{\lambda^2}{4} + \alpha^4 - \frac{\lambda^2}{2}}
\end{align*}
\]  

(9)

Let the resonance component and impedance factor of embedded component software fault information of heterogeneous Web server terminal be \( v = r \omega_c \), the dynamic suppression coefficient of embedded component software fault information of heterogeneous Web server terminal be \( r = r_c + l_s \), and the low frequency modulation coefficient of fault information be, and construct an adaptive inversion control model to obtain the fusion function of embedded component software fault information of heterogeneous Web server terminal:

\[
f_c(X) = w_c f_c(X) + w_v V(X) + w_C C(X)
\]

(10)

The damping coefficient of software fault information detection of embedded components of heterogeneous Web server terminals is obtained, and the statistical characteristic quantity of software fault detection is as follows:

\[ S = \pi (r^2 - MB^2) \]

(11)

The gradient space model of embedded component software fault of heterogeneous Web server terminal is established, and the fault analysis of embedded component software of heterogeneous Web server terminal is carried out through cascade feature matching, which is expressed as. After the "screening" process, the fuzzy probability density function of embedded component software of heterogeneous Web server terminal is obtained as follows:

\[
f(V) = \frac{1}{\sqrt{2\pi\sigma_v}} \exp\left(-\frac{V^2}{2\sigma_v^2}\right)
\]

(12)

Wherein, \( \sigma_v \) is the channel difference function of embedded component software of heterogeneous Web server terminal, and the detection coefficient is obtained by using tap delay filter detection method. In a fixed frequency range, the Doppler frequency shift of fault mining of embedded component software of heterogeneous Web server terminal is obtained and recorded as \( \omega_d \), and the vulnerability information space cluster distribution of embedded component software of heterogeneous Web server terminal is as follows:

\[
s = \frac{v - \nu}{c + v} = (1 - \frac{v}{c})(1 - \frac{\nu}{c} + (\frac{\nu}{c})^2 - \cdots) = 1 - \frac{2\nu}{c} + 2(\frac{\nu}{c})^2 + \cdots
\]

(13)

The frequency spectrum characteristic quantity of fault detection of embedded component software of heterogeneous Web server terminal is obtained by using the method of basis function set stability analysis, and the recursive characteristic quantity of fault information of embedded component software of heterogeneous Web server terminal is as follows:

\[
\int \left[ \|g, U(x)g\| \right] d\mu(x) < \infty
\]

(14)

Using the method of limit mining, the disturbance feature decomposition result of the fault of embedded component software of heterogeneous Web server terminal is obtained as follows:

\[
S_x(x, x') = S_x(x, x')^*_x \cdots S_x(x, x')^*_x S_x(x, x')
\]

(15)

In which \( ^*_x \) represents convolution coefficient of fault detection of embedded component software of heterogeneous Web server terminal, and the safety limit distribution obtained at time \( k+1 \) is as follows:

\[
x_i(k+1) = x_i(k) + x_i(k) - x_i(k)
\]

(16)
Combined with statistical feature analysis method, the cross information distribution set of embedded component software faults of heterogeneous Web server terminals is determined, and the ability of self-adaptive fault mining is improved [7-9].

3. Software fault location optimization

3.1. heterogeneous Web server terminal embedded component software fault information extraction

Using the big data mining method, the transmission information collection and node deployment of embedded component software of heterogeneous Web server terminals are carried out [10]. The spread spectrum bandwidth of fault mining of embedded component software of heterogeneous Web server terminals is:

\[
\begin{align*}
\hat{w}_j^k & = \begin{cases} 
    w_j^k, & \text{if } |w_j^k| \geq T_j, j=1,2,...,J+1 \\
    0, & \text{else}
\end{cases} \\
\end{align*}
\]

The iterative function of fault mining for embedded component software of heterogeneous Web server terminal is as follows:

\[
\hat{w}_j^k = \begin{cases} 
    \text{sign}(w_j^k)(|w_j^k| - T_j), & \text{if } |w_j^k| \geq T_j, j=1,2,...,J+1 \\
    0, & \text{else}
\end{cases}
\]

According to the fuzzy decision model, the distribution model of software failure information of embedded components of heterogeneous Web server terminals is established, and the channel switching control for software failure mining of embedded components of heterogeneous Web server terminals is established. The evaluation index set of software failure of embedded components of heterogeneous Web server terminals is set as \( E_k \in E(1,2,...,t) \), and the adaptive switching control function is defined as \( v_{a,m} \in [1,n] \). The time domain distribution information of software fault information is expressed as:

\[
\tilde{y}(t) = \int \int b(\tau,\phi) \exp[j2\pi\phi]\tilde{f}(t-\tau)d\tau d\phi
\]

Wherein, \( b(\tau,\phi) \) is the scale solution value of vulnerability information of embedded component software of heterogeneous Web server terminal, \( \tilde{f}(t) \) is the frequency component of big data sampling of software fault mining, \( \tau \) is the delay of ambiguity extension, and \( \phi \) is the multipath feature component of software. According to this, the feature quantity of big data of security information of embedded component software of heterogeneous Web server terminal is mined, and fault tracking and identification are realized according to the result of big data mining [11].

3.2. Big Data Mining for Faults

Assuming that the fuzzy dynamic constraint parameter model of heterogeneous Web server terminal embedded component software fault information transmission is described as \( x_j = \{x_{ij},x_{j2},...,x_{jm}\}^T \), the convergence constraint conditions of heterogeneous Web server terminal embedded component software fault mining are as follows:

\[
TW << \frac{c}{2|\varepsilon|}, \quad \left| \frac{2\nu}{c} \right| << 1
\]

In the above formula, \(|\varepsilon|\) represents the complex envelope of software fault distribution of embedded components of heterogeneous Web server terminals, assuming that \( \alpha_\theta \) is the transmission data on the information transmission channel \( e \) of embedded components of heterogeneous Web server terminals, heterogeneous directed graph analysis method is adopted to reorganize the software fault information
structure of embedded components of heterogeneous Web server terminals, and the fuzzy matrix $R = (r_{ij}, a_{ij})_{mn}$ is adaptively allocated for software fault mining, and the reliability feature set of fault distribution is expressed as follows:

$$x_{\min,j} = \max \left\{ x_{\min,j}, x_{g,j} - \rho (x_{\max,j} - x_{\min,j}) \right\}$$  \hspace{1cm} (21)

$$x_{\max,j} = \min \left\{ x_{\max,j}, x_{g,j} + \rho (x_{\max,j} - x_{\min,j}) \right\}$$  \hspace{1cm} (22)

In the above formula, the interval $[x_{\min,j}, x_{\max,j}]$ constitutes the big data distribution time window SW of embedded component software fault mining of heterogeneous Web server terminals, and $\rho$ is the adaptive adjustment coefficient of embedded component software fault mining of heterogeneous Web server terminals, which is defined as:

$$\rho = \frac{\sum_{p=0}^{N_k-d>}(o)lrd_{k}(o)}{\mid N_k-d>lrd_{k}(p)\mid}$$  \hspace{1cm} (23)

Determine the cross information distribution set of embedded component software faults of heterogeneous Web server terminals, and combine the spectrum distribution characteristics of software faults to obtain the fusion feature solution of embedded component software fault mining output of heterogeneous Web server terminals as follows:

$$Y_k = [y_{k1}, y_{k2}, \cdots, y_{k2}, \cdots, y_{ke}] \hspace{1cm} (k = 1, 2, \cdots, N)$$  \hspace{1cm} (24)

Establish an information clustering model for fault mining of embedded component software of heterogeneous Web server terminals, and carry out fault detection and intrusion detection of embedded component software of heterogeneous Web server terminals. The output detection statistics are as follows:

$$f_j(n) = \left\| \ln[\lambda_j(n)] \right\| / 2\pi\Delta t$$  \hspace{1cm} (25)

In the formula, $\Delta t$ represents the time interval of software fault mining for embedded components of heterogeneous Web server terminals. Combined with the spectrum distribution characteristics of software faults, the objective function of software fault detection is established[12], and the fault location is realized by using the methods of big data information scheduling and multivariate cross-distributed identification. The implementation process is shown in Figure 2.
4. Simulation test analysis
In the simulation experiment of software fault mining, the maximum load of software fault information test is set at 240Kbps, the data sample size of fault information sampling is 2000, the template data matching degree of test set is 0.35, the training sample data size is 120, the order of software fault information mining is 5, and the spatial distribution dimension is 14. According to the above parameter settings, a big data collection model of fixed software fault information is constructed, and the distribution of big data is shown in Figure 3.
Taking the data in Figure 3 as the test object, the software fault mining is realized, and the feature extraction result of fault location is shown in Figure 4.

By analyzing Figure 4, we know that this method can effectively mine and detect software faults, and improve the feature clustering of software fault information mining. The accuracy of software fault mining is tested, and the comparison results are shown in Table 1. By analyzing Table 1, we know that this method has higher accuracy and better convergence in software fault mining.

| Sample number | This method | Spectral detection method | FCM | Fuzzy detection method |
|---------------|-------------|---------------------------|-----|------------------------|
| 60            | 0.934       | 0.867                     | 0.854 | 0.854                 |
| 120           | 0.967       | 0.934                     | 0.914 | 0.901                 |
| 180           | 0.978       | 0.957                     | 0.924 | 0.913                 |
| 240           | 1           | 0.976                     | 0.956 | 0.945                 |

5. Conclusions
In this paper, an optimized software fault detection model for embedded components of heterogeneous Web server terminals is constructed, and the software fault location is realized by combining the software fault big data distribution and mining results. This paper proposes a software fault location method for embedded components of heterogeneous Web server terminals based on source code fault feature detection. The method of spread spectrum sequence analysis is used to reorganize the distributed structure of embedded component software fault information of heterogeneous Web server terminals, and to mine the big data feature quantity of embedded component software security information of heterogeneous Web server terminals. Through cascade feature matching, the fault analysis of embedded component software of heterogeneous Web server terminals is carried out, and the spectrum feature quantity of fault detection of embedded component software of heterogeneous Web server terminals is obtained by using the method of basis function set stability analysis. The method of big data information scheduling and multivariate cross distributed identification is used to realize fault location. The research shows that the method in this paper has better convergence, higher accuracy and improved anti-attack ability for software fault mining of embedded components of heterogeneous Web server terminals.

References
[1] HE P, YU G, ZHANG Y F, et al. Survey on blockchain technology and its application prospects[J]. Computer Science, 2016, 44(4), pp 1-7,15.
[2] YUAN Y, WANG F Y. Blockchain, the state of the art and future trends[J]. Acta Automatica Sinica, 2016, 42(4), pp 481-494.
[3] ZHAO Dan,SUN Xiangkai. Some Robust Approximate Optimality Conditions for Nonconvex Multi-Objective Optimization Problems[J]. Applied Mathematics and Mechanics, 2019, 40(6), pp 694-700.
[4] KARABADJI N E I,BELDJOUDI S,SERIDI H,et al. Improving memory-based user collaborative filtering with evolutionary multi-objective optimization[J]. Expert Systems with Applications,2018, 98:pp 153-165.
[5] AL-SAFFFAR A A M, TAO H, TALAB M A. Review of deep convolution neural network in image classification[C]//Proceedings of the 2017 International Conference on Radar, Antenna, Microwave, Electronics, and Telecommunications. Piscataway:IEEE, 2017: pp 26-31.
[6] GHIFARY M, BALDUZZI D, KLEIJIN W B, et al. Scatter component analysis:a unified framework for domain adaptation and domain generalization[J]. IEEE Transactions on Pattern Analysis and Machine Intelligence, 2017, 39(7):pp 1414-1430.
[7] SHU J, SHEN X, LIU H, et al. A content-based recommendation algorithm for learning resources[J]. Multimedia Systems, 2018, 24(2): pp 163-173.

[8] KARABADJI N E I, BELDJ OUDI S, SERIDI H, et al. Improving memory-based user collaborative filtering with evolutionary multi-objective optimization[J]. Expert Systems with Applications, 2018, 98: pp 153-165.

[9] SHU W, QIAN W, XIE Y, et al. An efficient uncertainty measure-based attribute reduction approach for interval-valued data with missing values[J]. International Journal of Uncertainty, Fuzziness and Knowledge-Based Systems, 2019, 27(6): pp 931-947.

[10] YUAN Chi. Identity-based dynamic clustering authentication algorithm for wireless sensor networks[J]. Journal of Computer Applications, 2020, 40(11): pp 3236-3241.

[11] XUAN X, YU Q. Video foreground-background separation based on truncated nuclear norm[J]. Computer Engineering and Design, 2018, 39(5): pp 1415-1421.

[12] YIN Chunyong, ZHANG Sun. End-to-end adversarial variational Bayes method for short text sentiment classification[J]. Journal of Computer Applications, 2020, 40(9): pp 2536-2542.