Research on Evaluation Method of Failure Probability of Communication Equipment

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Keywords: communication equipment; failure probability; big data; Evaluation

Abstract: By detecting the failure probability of communication equipment in real time and improving the ability of performance detection and real time estimation of communication equipment, a failure probability evaluation technology of communication equipment based on statistical feature analysis is proposed. The real time data acquisition of failure probability of communication equipment is carried out by using wireless sensor technology, and the information fusion processing of the failure probability of communication equipment is carried out. Combined with big data's statistical feature analysis method, the failure probability of communication equipment is counted in real time, the spectral characteristic quantity of failure probability of communication equipment is extracted, and the time-frequency analysis and wavelet scale decomposition method are used to evaluate the failure probability of communication equipment. The simulation results show that the real-time performance of communication equipment failure probability detection is better, the failure probability is high, and the anti-interference property is good.

1. Introduction

With the automation level of communication equipment getting higher and higher, the parameter energy requirement of communication equipment is getting higher and higher. It is necessary to detect the failure probability of communication equipment in real time. Combined with the method of wireless sensing information fusion and feature extraction, the failure probability performance of communication equipment is analyzed, the statistical analysis of failure probability of communication equipment and big data mining model are constructed, and the artificial intelligence technology is used to realize the failure probability detection of communication equipment[1]. It has great significance to improve the performance of communication equipment and study the real-time detection method of failure probability of communication equipment in improving the combat capability of individual soldiers and the intelligent level of communication equipment.

In the traditional methods, the failure probability evaluation methods of communication equipment mainly include joint mean square error estimation method, spectrum feature detection method, fuzzy detection method and statistical feature detection method[2]. The failure probability evaluation model of communication equipment is constructed, big data information fusion technology is used to realize the failure probability evaluation of communication equipment, and the real-time and intelligence of communication equipment failure probability detection are improved. However, there are some problems in the evaluation of communication equipment failure probability, such as poor anti-interference and high computational complexity. In order to solve the above problems, this paper proposes a communication equipment failure probability evaluation technology based on statistical feature analysis[3]. Firstly, wireless sensor technology is used to collect the real-time data of communication equipment failure probability, and the information fusion processing of the collected communication equipment failure probability is carried out. Combined with big data's statistical feature analysis method, the failure probability of communication equipment is counted in real time, and then the spectral characteristic quantity of failure probability of communication equipment is extracted, and the time-frequency analysis and

  DOI: 10.25236/aisct.2019.075

wavelet scale decomposition method are used to evaluate the failure probability of communication equipment. Finally, the simulation results show the superior performance of the proposed method in improving the failure probability evaluation ability of communication equipment.

2. Parameter acquisition and information fusion processing

2.1. Failure probability acquisition model for communication equipment

In order to evaluate the failure probability of communication equipment, it is necessary to construct the data acquisition model of failure probability evaluation of communication equipment. The information collection and node deployment of failure probability evaluation of communication equipment are carried out by using array signal analysis and distributed sensor networking method[4]. The performance characteristics of failure probability of communication equipment are analyzed, and the failure probability of communication equipment is detected by feature extraction and big data fusion technology. The time domain characteristic components of failure probability acquisition of communication equipment are described as follows:

$$X = \left[\overrightarrow{a_1}, \overrightarrow{a_2}\right] \begin{pmatrix} s_1 & 0 \\ 0 & s_2 \end{pmatrix} \begin{pmatrix} \vec{c}_1 \\ \vec{c}_2 \end{pmatrix} \tag{1}$$

Wherein, a_2 and $\vec{c}_1$ are the characteristic distribution bandwidth and spectrum component of communication equipment failure probability real-time data acquisition, the high-order statistical feature analysis method is used to design the wave beam element domain of communication equipment failure probability, the fourth-order joint feature estimation method is used to construct the cumulant joint estimation model of communication equipment failure probability detection[5], and the signal feature distribution vector set of communication equipment failure probability sampling is $\{x_1, x_2, \cdots x_n\}$,. In the two-dimensional subspace, the distribution set of operational effectiveness characteristics of the failure probability of communication equipment is expressed as follows:

$$span\{x_1, x_2, \cdots x_n\} = \left\{\sum_{i=1}^{n} a_i x_i \middle| a_i \in C\right\} \tag{2}$$

In the operational effectiveness evaluation of communication equipment failure probability, the density spectrum of big data sampling of communication equipment failure probability is taken as the input feature set, and the single peak value of communication equipment failure probability acquisition is obtained.

$$y_i = tr\left[W_i^H X\right] = g_{i1}s_1 + g_{i2}s_2 \tag{3}$$

In any $m \times n$ dimension matrix A, the range of failure probability detection for communication equipment is defined as:

$$g_{ij} = tr\left[W_i^j \overrightarrow{a_j}\overrightarrow{c_j}\right] \tag{4}$$

The $A \in C^{n \times n}$ is used to represent the statistical distribution of the failure probability of the collected communication equipment and $v \in C^n$, big data fusion of the failure probability of the communication equipment on the array model of the failure probability of the communication equipment shown in Fig. 1.

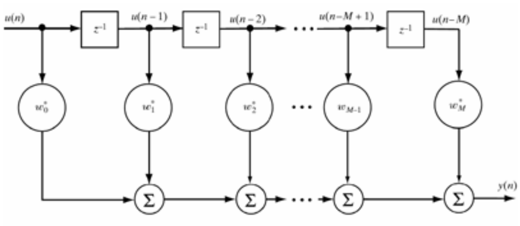

Fig. 1 An array element model for the probability of failure of communication equipment

According to the element model of communication equipment failure probability acquisition shown in figure 1, the collected communication equipment failure probability can be described as a dimensional vector representation, that is:

$$\begin{bmatrix} x_1(t) \\ x_2(t) \\ \vdots \\ x_M(t) \end{bmatrix} = \begin{bmatrix} \sum_{i=1}^{d} g_1(\theta_i)s_i[t-\tau_1(\theta_i)] \\ \sum_{i=1}^{d} g_2(\theta_i)s_i[t-\tau_2(\theta_i)] \\ \vdots \\ \sum_{i=1}^{d} g_M(\theta_i)s_i[t-\tau_M(\theta_i)] \end{bmatrix} + \begin{bmatrix} n_1(t) \\ n_2(t) \\ \vdots \\ n_M(t) \end{bmatrix} \quad (5)$$

In the near field condition, the information source of the failure probability acquisition of the communication equipment is distributed into a finite vector set, and when the set number of iterations is less than the threshold, the information sampling is carried out[6], and the fusion filtering and the characteristic detection of the failure probability of the communication equipment are carried out according to the sampling result[7].

2.2. Communication equipment failure probability information fusion process

The invention adopts a wireless sensor technology to carry out real-time data acquisition of failure probability of communication equipment, carries out information fusion processing on the failure probability of the collected communication equipment, adopts a k-order invariant moment as the detection statistic[8], and obtains the sparse recovery information as follows:

$$s_i(\theta,\psi_i;t) = s_i(\theta,\psi_i), \forall t \in R \quad (6)$$

Under the background of color noise, IIR filtering method is used to detect the failure probability of communication equipment. The covariance matrix expression of failure probability detection of communication equipment is obtained as follows:

$$R_z = E\left[z(t)z(t)^H\right] = R_s(\psi) + R_n \quad (7)$$

In the above formula, $R_s(\psi)$ is a self-correlation function of the failure probability observation sample of the communication equipment, and is expressed as a cross-correlation angle measurement error.

$$R_s(\psi) = \sum_{i=1}^{p}\sum_{j=1}^{p}\int_{-\pi/2}^{\pi/2}\int_{-\pi/2}^{\pi/2} a(\theta)p_{ij}\left(\theta,\theta^{'};\psi_i,\psi_j\right)a^H\left(\theta^{'}\right)d\theta d\theta^{'} \quad (8)$$

Under the given sidelobe stage, the statistical characteristic quantity of the failure probability of the communication equipment is constructed, and the fourth order cumulant of the failure probability of the communication equipment is output[9]. If the value is constant, the joint estimation value of the two target sources is as follows:

$$cum\{a+x_1,x_2,\cdots,x_n\} = cum\{x_1,x_2,\cdots x_n\} \quad (9)$$

For M array elements, the statistical characteristic distribution model of the failure probability sampling source i of the communication equipment in the signal correlation distribution source is as follows:

$$z(t)=\sum_{i=1}^{p}s_i(t)b_i(\theta_i)+n(t) \tag{10}$$

In the formula, the statistical eigenvector $a(\theta_i,r_i)$ of the interference signal and the measurement signal in the I column is represented as follows:

$$s(t)=\left[s_1(t),s_2(t),...,s_q(t)\right]^T \tag{11}$$

Based on the accurate azimuth estimation of the two target sources, combined with the technical performance of the communication equipment[10], the filtering characteristic information of the communication equipment failure probability detection is obtained as follows:

$$E\left[s_t s_k^H\right]=P_s\delta(t,k),E\left[n_t n_k^H\right]=\sigma_n^2 I_M\delta(t,k) \tag{12}$$

In the above formula, $\delta(t,k)$ is a polarization vector function and σ_n^2 is a noise variance. Based on the maximum expected estimation method, the information fusion covariance matrix of communication equipment failure probability detection is obtained as follows:

$$R=E\left[z(t)z^H(t)\right]=BP_sB^H+\sigma_n^2 I_M \tag{13}$$

Wherein, $B=\left[b_1(\theta_1),b_2(\theta_2),...,b_q(\theta_q)\right]^T$, $U_n^H b_i(\theta_i)=0$, according to the results of information fusion, the feature extraction and azimuth estimation of communication equipment failure probability detection are realized, and the spatial beamforming processing is carried out according to the azimuth estimation results to improve the failure probability detection ability of communication equipment[11].

3. Real time detection optimization of failure probability of communication equipment.

3.1. Feature extraction

In this paper, a communication equipment failure probability evaluation technology based on statistical feature analysis is proposed. The wireless sensor technology is used to collect the real-time data of communication equipment failure probability, and the information fusion processing of the collected communication equipment failure probability is carried out[12]. The failure probability of communication equipment estimated by DOA is taken as input, and the failure probability of communication equipment is assumed to collect array element spacing d and array element number N. The output corresponding communication equipment failure probability near-field source array popular vector satisfies:

$$b_i(\theta_i)=\Phi(\theta_i)h_i \tag{14}$$

The spectral peak estimation of the failure probability of the communication equipment is carried out by using the MUSIC algorithm, which comprises the following steps:

$$f_1(\theta)=-\log 10\left(\lambda_{\min}\left[Q_1(\theta)\right]\right) \tag{15}$$

In the above formula, Q_1 represents the direction vector of the failure probability of the communication equipment sampling wave up to the direction θ_{ik}, and the statistical spectrum special amount for calculating the failure probability of the communication equipment is calculated by the following formula:

$$f(\phi)=\frac{1}{b^H(\varphi)\hat{U}_n\hat{U}_n^H b(\varphi)} \tag{16}$$

The self-adaptive beam forming algorithm is adopted to obtain the measurement error distribution matrix of the failure probability sampling of the communication equipment:

$$\begin{bmatrix} x_1(t) \\ x_2(t) \\ \vdots \\ x_M(t) \end{bmatrix} = \begin{bmatrix} \sum_{i=1}^{d} g_1(\theta_i)s_i(t) \\ \sum_{i=1}^{d} g_2(\theta_i)s_i(t-\frac{\Delta}{c}\sin\theta_i) \\ \vdots \\ \sum_{i=1}^{d} g_M(\theta_i)s_i(t-(M-1)\frac{\Delta}{c}\sin\theta_i) \end{bmatrix} + \begin{bmatrix} n_1(t) \\ n_2(t) \\ \vdots \\ n_M(t) \end{bmatrix} \tag{17}$$

The higher the signal-to-noise ratio, the smaller the angle-measuring error, and the spatial gain of each array element is:

$$\begin{bmatrix} x_1(t) \\ x_2(t) \\ \vdots \\ x_M(t) \end{bmatrix} = \begin{bmatrix} \sum_{i=1}^{d} s_i(t) \\ \sum_{i=1}^{d} s_i(t-\frac{\Delta}{c}\sin\theta_i) \\ \vdots \\ \sum_{i=1}^{d} s_i(t-(M-1)\frac{\Delta}{c}\sin\theta_i) \end{bmatrix} + \begin{bmatrix} n_1(t) \\ n_2(t) \\ \vdots \\ n_M(t) \end{bmatrix} \tag{18}$$

Based on 7 element uniform linear array beamforming processing, combined with spectral feature extraction technology, the maximum likelihood estimation and spectral feature extraction of failure probability of communication equipment are realized[13].

3.2. Communication equipment failure probability detection output

With the increase of the number of sources to be measured[14], the distributed signal model to obtain the failure probability of communication equipment is expressed as follows:

$$\begin{bmatrix} x_1(t) \\ x_2(t) \\ \vdots \\ x_M(t) \end{bmatrix} = \begin{bmatrix} \sum_{i=1}^{d} g_1(\theta_i)s_i(t) \\ \sum_{i=1}^{d} g_2(\theta_i)s_i(t-\frac{\Delta}{c}\sin\theta_i) \\ \vdots \\ \sum_{i=1}^{d} g_M(\theta_i)s_i(t-(M-1)\frac{\Delta}{c}\sin\theta_i) \end{bmatrix} + \begin{bmatrix} n_1(t) \\ n_2(t) \\ \vdots \\ n_M(t) \end{bmatrix} \tag{19}$$

The observed communication equipment failure probability distribution covariance matrix R_x is characterized in that the sparse Bayesian model is represented as an $R_xV=\Lambda V$, and the time-frequency parameter joint estimation is carried out on the communication equipment parameters under the sparse Bayesian model among different array elements, The initial probability of the near-field source is estimated to be satisfied:

$$\hat{\theta}_i=\sin^{-1}\left[\frac{\hat{\lambda}_i}{4\pi d}angle(\rho_F(i))\right] \tag{20}$$

$$\hat{\upsilon}=\frac{2c}{\sqrt{\frac{k}{k_0}+1}}-c \tag{21}$$

In the above formula, the $\rho_G(i)$ is the probability density function of the likelihood function, d is the element width, θ is a SMV model representing a sparse characteristic, and a fuzzy constraint control method is combined to obtain the statistical feature quantity as follows:

$$\Phi(\theta_i) = diag(a(\theta_i)) \tag{22}$$

The spectral features of the failure probability of communication equipment are extracted, and the joint feature estimates are obtained by using time-frequency analysis and wavelet scale decomposition:

$$m_{kx}(\tau_1, \cdots, \tau_{k-1}) = mom[x(n), x(n+\tau_1), \cdots, x(n+\tau_{n-1})] \tag{23}$$

$$c_{kx}(\tau_1, \cdots, \tau_{k-1}) = cum[x(n), x(n+\tau_1), \cdots, x(n+\tau_{k-1})] \tag{24}$$

in that sparse matrix to be recovered, the optimal receive polarization characteristic quantity of the antenna is obtain, and the obtained angle estimate error value is expressed as follows:

$$z(t) = \sum_{i=1}^{p} \int_{-\pi}^{\pi} a(\theta) s_i(\theta - \theta_i, t) d\theta + n(t) \tag{25}$$

Wherein, $n(t)$ is the interference characteristic quantity. According to the above analysis, combined with big data's statistical feature analysis method, the failure probability of communication equipment is counted and detected in real time[15,16].

4. Simulation experiment and result analysis

The performance analysis of the failure probability of the communication equipment is carried out by the simulation experiment. The experiment is designed with Matlab 7, and the algorithm is designed with C ++. The interval of the failure probability sampling of the communication equipment is 0.14 s, the large data sample set is 2000, the average joint error is 0.124 and 0.146, respectively. The SNR is -12dB, the number of fast beats is 20, the position and cosine of the operational performance of the communication equipment is 2.98, and the failure probability evaluation of the communication equipment is carried out according to the above simulation parameters, and the real-time acquisition result of the failure probability of the communication equipment is shown in Fig.2.

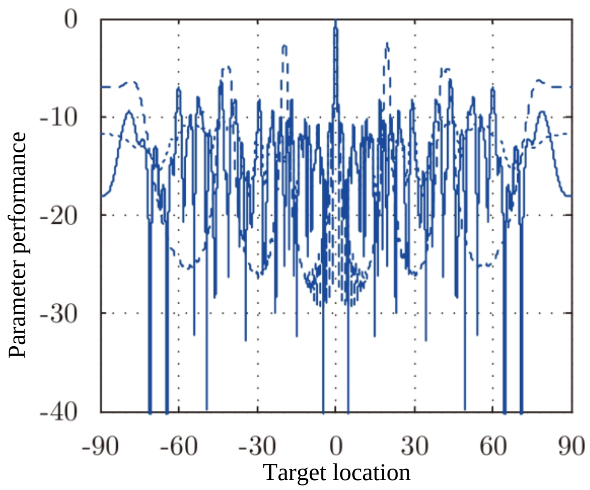

Fig. 2 Real - time acquisition of communication equipment failure information.

Fig. 2 shows the failure probability efficiency distribution of communication equipment. Taking the data of Fig. 2 as input, the failure probability of communication equipment is evaluated, and the detection performance curve is shown in Fig. 3.

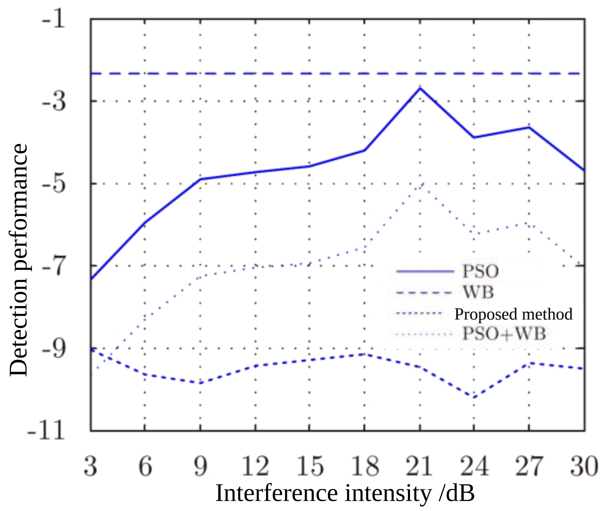

Fig. 3 Comparison of failure probability detection performance curves for communication equipment

The analysis of Fig.3 shows that the accuracy of the failure probability evaluation of the communication equipment is high, the stability convergence is good, and the test detection error is obtained by adopting the method, and the result is shown in Fig.4.

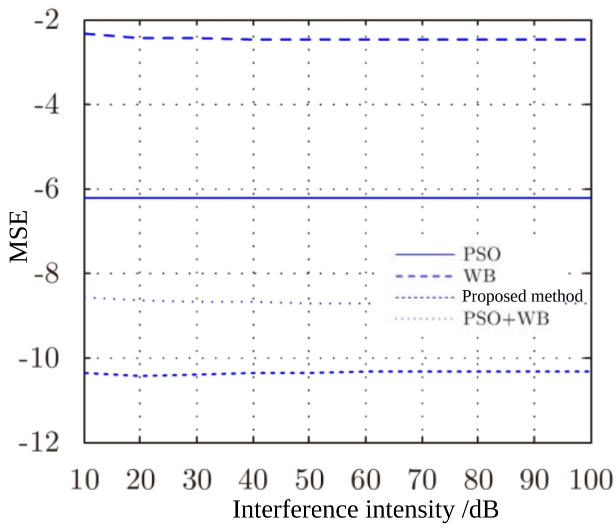

Fig. 4 Detection error for failure probability of communication equipment

The analysis figure 4 shows that the error of the failure probability evaluation of communication equipment is small and the failure probability is high, which improves the anti-interference ability of communication equipment failure probability evaluation.

5. Conclusions

In this paper, the failure probability evaluation method of communication equipment is studied, so as to improve the performance detection and real-time estimation ability of communication equipment. A communication equipment failure probability evaluation technology based on statistical feature analysis is proposed. Wireless sensor technology is used to collect the real-time data of communication equipment failure probability, and the performance characteristics of communication equipment failure probability are analyzed. Through feature extraction and big data fusion technology, The failure probability detection of communication equipment is carried out, the cumulant joint estimation model of communication equipment failure probability detection is constructed, the statistical characteristic quantity of communication equipment failure probability is constructed under the given sidelobe level, the multi-path interference suppression is carried out, and the failure probability evaluation of communication equipment is realized. It is found that the accurate probability of failure probability evaluation of communication equipment is high and the error is small.

References

[1] DOU Q, CHEN H, YU L Q, et al. Automatic detection of cerebral microbleeds from MR images via 3D convolutional neural networks[J]. IEEE Transactions on Medical Imaging, 2016, 35(5):1182-1195.

[2] CHEN H, DOU Q, YU L Q, et al. VoxResNet:deep voxelwise residual networks for brain segmentation from 3D MR images[J]. NeuroImage, 2018, 170:446-455.

[3] RONNEBERGER O, FISCHER P, BROX T. U-Net:convolutional networks for biomedical image segmentation[C]//Proceedings of the 2015 International Conference on Medical Computing and Computer-Assisted Intervention. Berlin:Springer, 2015:234-241.

[4] LI Cheng,MAGLAND J F,SEIFERT A C,et al.Correction of excitation profile in zero echo time imaging using quadratic phase-modulated RF pulse excitation and iterative reconstruction[J].IEEE Transactions on Medical Imaging,2014,33(4):961-969.

[5] HSU S H,CAO Yue,HUANG Ke,et al.Investigation of a method for generating synthetic CT models from MRI scans of the head and neck for radiation therapy[J].Physics in Medicine and Biology,2013,58(23):8419.

[6] LI Chaofan, CHEN Qingkui. GPU Cluster Power Consumption Collection and Monitoring System Based on Sensor[J]. Computer Engineering, 2019, 45(3): 65-72.

[7] PAN Chengsheng, JIA Yaru,CAI Ruiyan,YANG Li. Routing Strategy for Spatial Information Network Based on MPLS[J]. Computer Engineering, 2019, 45(3): 85-90.

[8] LEE G M, LEE J H. On nonsmooth optimality theorems for robust multiobjective optimization problems [J]. Journal of Nonlinear and Convex Analysis, 2015, 16(10): 2039-2052.

[9] SUN X K, PENG Z Y, GUO X L. Some characterizations of robust optimal solutions for uncertain convex optimization problems [J]. Optimization Letters, 2016, 10(7): 1463-1478.

[10] FAKHAR M, MAHYARINIA M R, ZAFARANI J. On nonsmooth robust multiobjective optimization under generalized convexity with applications to portfolio optimization [J]. European Journal of Operational Research, 2018, 265(1): 39-48.

[11] SUN X K, LI X B, LONG X J, et al. On robust approximate optimal solutions for uncertain convex optimization and applications to multi-objective optimization [J]. Pacific Journal of Optimization, 2017, 13(4): 621-643.

[12] CAI Hua, CHEN Guangqiu, LIU Guangwen, et al. Design and implementation of variable Point FFT processor based on FPGA Architecture [J]. Journal of Jilin University (Science Edition), 2018, 56(01):151-158.

[13] Ma Rui, Huang Fu Yigeng, Zhao Dongdong, et al. Modeling Simulation and Experimental Test of Proton Exchange Membrane Fuel Cells in Multiphysical Domain[J]. Journal of Power Supply, 2019, 17(2):3-11.

[14] Gao Z W, Cecati C, Ding S X. A survey of fault diagnosis and fault-tolerant techniques-part I: Fault diagnosis with model-based and signal-based approaches [J]. IEEE Transactions on Industrial Electronics, 2015, 6(62):3757-3767.

[15] Huang X, Wang Z, Li Y, et al. Design of fuzzy state feedback controller for robust stabilization of uncertain fractional-order chaotic systems [J]. Journal of the Franklin Institute, 2015, 351(12): 5480-5493.

[16] Zhong F, Li H, Zhong S, et al. An SOC estimation approach based on adaptive sliding mode observer and fractional order equivalent circuit model for lithium-ion batteries[J]. Communications in Nonlinear Science and numerical Simulation, 2015, 24(1/2/3): 127-144