Method for Selecting Healthy Nodes in Communication Networks under Background of Multi-Mode Noise

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Abstract: In the strong interference environment of wireless communication network, the communication nodes are affected by interference and multi-path restriction, which leads to the poor balance of transmission links between nodes, so it is necessary to make healthy selection of communication nodes in wireless communication networks, and improve the accurate transmission and adaptive control ability of network communication. The traditional method of selecting healthy nodes in communication networks adopts the inter-node baud interval balanced scheduling routing and distribution protocol. Because of the random link distribution of forwarding nodes, the anti-interference ability to the nodes communication is not strong. A healthy node selection model for communication networks with multi-mode noise based on fractional interval sampling and load balancing scheduling is proposed. The optimal deployment and location model of healthy nodes in wireless communication network is constructed, and then the optimal array network distribution design of communication nodes is carried out. Based on fractional interval sampling and load balancing scheduling method, an improved healthy node selection model for communication networks under the background of multi-mode noise is implemented. The simulation results show that the optimal deployment and selection of the healthy nodes in the communication network under the background of multi-mode noise can reduce the packet loss rate and delay of the output of the communication signal and reduce the computation overhead. The channel equalization and modulation ability of the network are improved, and the bit error rate of communication output is low.

1. Introduction

With the development of network communication technology, wireless communication network, as an application direction of network communication, has the characteristics of self-organization and simple flexibility of routing nodes, and it is widely used in civil and military fields. The research on channel equalization and data communication in wireless sensor networks is based on the optimal design of the deployment of communication nodes[1]. Under the strong interference environment, the communication nodes are affected by interference and multi-path constraints. Due to the poor balance of transmission links between nodes, it is necessary to make healthy selection of wireless communication nodes to improve the accurate transmission and adaptive control ability of network communication. Therefore, it has great significance to study the selection of robust communication nodes in wireless communication networks[2].

Traditionally, there are connection graph, routing protocol method, support vector machine (SVM) method and grid coverage method to select healthy nodes in communication networks. All of the above methods cover the communication nodes evenly in wireless communication networks, and they can be used to select healthy nodes in wireless communication networks, such as connection graph, routing protocol method, support vector machine (SVM) method and grid coverage method[3]. Then the Boolean model is used for data forwarding and channel model setting to realize the communication node selection and routing design for wireless communication network. However, under the background of multi-mode noise, the traditional methods lead to the

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poor balance of transmission links between sensor nodes, and so on. For this reason, the improved algorithm is designed in the related literature[4]. In reference [5], a communication coverage algorithm based on WSN two-layer robust network data fusion is proposed to optimize the routing of WSN, which can effectively improve the correct rate of location detection of leakage sources and reduce the detection errors of communication nodes. Improve the network life cycle, but the algorithm has the delay, cannot effectively realize the network sensor data fusion. In reference [6], it presents a robust design and channel equalization for wireless communication network nodes based on quadratic data fusion algorithm (TFA), and uses regression analysis interpolation to realize maximum likelihood estimation of data transmitted by communication nodes. The improvement of data fault tolerance mechanism is beneficial to prolong the life cycle of the network. However, the algorithm does not consider the presence of robust communication nodes and noise in sensor networks, and its applicable value is not high. In order to solve these problems, this paper proposes a healthy node selection model for communication networks with multi-mode noise based on fractional interval sampling and load balancing scheduling. Firstly, the optimal deployment and location model of healthy nodes in wireless communication network is constructed, and then the optimal array network distribution design of communication nodes is carried out. Based on the method of fractional interval sampling and load balancing, the healthy node selection model of communication network under the background of multi-mode noise is improved. The performance of the simulation experiment is verified, and the healthy selection of the communication node in this paper is demonstrated. The advantages of improving the communication performance of WSN nodes.

2. Wireless communication network model and optimal deployment and location of healthy nodes

2.1. Wireless communication network model

In this paper, the healthy node selection model of communication network under the background of multi-mode noise is studied. Firstly, the wireless communication network model and the communication node distribution model are analyzed[7], and a bivariate directed graph is used to represent the WSN. The distribution structure model of wireless communication network is obtained as shown in figure 1.

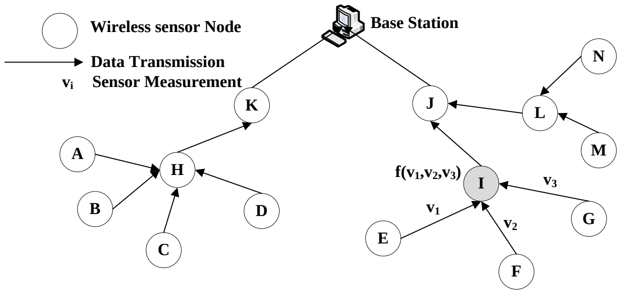


Fig. 1 Model of wireless communication network structure

Wherein, V is the set of WSN vertices deployed in the monitoring area; E is a collection of all edges in the communication node covering area G. M_1, $M_2 \dots M_N$ are a sensor node and uses 802.15.3A and 802.15.4 special short-range communication protocol to construct the WSN data receiving and transmitting and communication routing model. The routing and forwarding protocol of WSN is constructed by using the most commonly used Boolean model (0/1 model). The communication radius between the communication node (x_s, y_s) and the relay node s is obtained as the communication radius between the nodes using Euclidean distance calculation (Euclidean distance calculation), which is the communication radius of the wireless communication network communication node $d(s, p)$. When the relay node, the sink node and the hop number of (x_s, y_s) are fixed, the system state equation of selecting the individual proportion of the robust trust node of the wireless communication network is obtained.

$$F(x_1)=\frac{[x_1\cdot(mu(s_1,\boldsymbol{x})+np)+x_2\cdot(mu(s_2,\boldsymbol{x})+np)]}{(u(s_1,\boldsymbol{x})+g)x_1+(u(s_2,\boldsymbol{x})+g)x_2}\cdot(u(s_1,\boldsymbol{x})+g)\cdot x_1-x_1\cdot(mu(s_1,\boldsymbol{x})+np) \quad (1)$$

Where x_1 and x_2 respectively represent the optimal deployment of two-layer robust healthy nodes to locate the individual ratio of trust and distrust, and satisfy the $x_1+x_2=1$.

Definition 1: In the robustness game of communication nodes in wireless communication networks, the nodes covering efficiency $i\in S$ are selected to carry out channel equalization, assuming that $K\{r_i\}$ is the detection coefficient of wireless sensor nodes within the range of communication radius in the area, and $mu(i,\boldsymbol{x})+np$ is $mu(i,\boldsymbol{x})+np$, in which $mu(i,\boldsymbol{x})+np>0$, $n<0$ $m<0$, $u(i,\boldsymbol{x})$ is the node detection coefficient. p indicates that the fitness of the characteristic quantity is the throughput of the communication transmission in the case of $u(i,\boldsymbol{x})$. The adaptive equalization strategy is selected. The total revenue expectation of the communication node TE is covered by the node s, and the $\boldsymbol{x}$ indicates the success rate of the packet transmission[8].

According to the above analysis, it can be seen that most of the existing robust deployment and selection algorithms of communication nodes in wireless communication networks are carried out under the premise of $R_c\geq 2R_s$, and the priority P_c is non-uniform, which can easily lead to node interruption and communication imbalance. It is necessary to improve communication performance through healthy selection of nodes.

2.2. Design of optimal array network distribution for communication nodes

Based on the above-mentioned WSN network model construction and basic definition description, the optimal node density design for robust communication of sensor networks is carried out[9]. Assuming that the coverage contribution of two adjacent nodes in a wireless communication network is strongly correlated, the correlation of active nodes is expressed as:

$$E\left[x\left(\eta_p\right)x\left(\eta_q\right)\right]=\rho^{\left\|\eta_p-\eta_q\right\|} \quad (2)$$

Wherein, δ is used to represent the energy coefficient between the two nodes, $\rho\in(0,1)$. In the strong interference environment, the cluster head node adopts adaptive tracking quantization analysis method for data fusion in order to avoid information collision. The number interference characteristic signals of the n cluster head received by the fusion center are as follows:

$$y_n=\sqrt{P_n}x\left(\eta_n\right)+z_n \quad (3)$$

Where, P_n is the timer to control the cluster head to transmit energy, and z_n is the strong interference Gaussian noise with the variance of σ_z^2. Assuming that the energy density of the Sink relay node is P_0, candidate cluster head node density in the unit region under multipath attenuation, in order to ensure the channel equilibrium between the SN node and the sink, the sensor node v_i, far away from the sink is selected for the sake of ensuring the channel equilibrium between the SN node and the sink. The distance between them is calculated and the estimated value of sensor position $x_s=\left[x\left(\eta_1\right),...,x\left(\eta_N\right)\right]^T$ in interference environment is obtained.

$$\hat{x}_s=W_s^T y \quad (4)$$

Where, $\hat{x}_s=\left[\hat{x}\left(\eta_1\right),...,\hat{x}\left(\eta_N\right)\right]^T$, when the number of wireless communication network nodes per unit area is the same, the energy of each node is $P_n = \frac{P_0}{\delta}$. The effect of node density on the spatial correlation of data fusion centers is expressed as:

$$\begin{cases} E\{\mathbf{w}(k)\mathbf{u}_i^T(k)\} = \mathbf{B}_i(k), \quad i = 1, 2, \cdots, N \\ E\{\mathbf{u}_i(k)\mathbf{u}_j^T(k)\} = \mathbf{D}_{ij}(k), \quad i, j = 1, 2, \cdots N, i \neq j \end{cases} \tag{5}$$

The problem of optimal array network distribution of communication nodes is expressed as follows:

$$\boldsymbol{x}(k+1) = \boldsymbol{A}(k)\boldsymbol{x}(k) + \boldsymbol{\Gamma}(k)\boldsymbol{w}(k) \tag{6}$$

$$\boldsymbol{z}_i(k) = \boldsymbol{H}_i(k)\boldsymbol{x}(k) + \boldsymbol{u}_i(k), \quad i = 1, 2, \cdots, N \tag{7}$$

Where, $\boldsymbol{x}(k) \in \boldsymbol{R}^{n\times 1}$ is the target state of the optimal array network distribution of the communication nodes, $\boldsymbol{A}(k) \in \boldsymbol{R}^{n\times n}$ is the state transition matrix, and the process noise of the optimal array network distribution of the communication nodes is the Gaussian white noise with the mean value of zero and the variance of $\boldsymbol{A}(k) \in \boldsymbol{R}^{n\times n}$, and the process noise of the optimal array network distribution of the communication node is the state transition matrix. $\boldsymbol{Q}(k)$ is the energy bandwidth matrix. $\boldsymbol{z}_i(k) \in \boldsymbol{R}^{p\times 1}$ is the robustness coefficient of the first sensor. Based on the above processing, the optimal array network distribution design model of the communication nodes is obtained, as shown in figure 2.

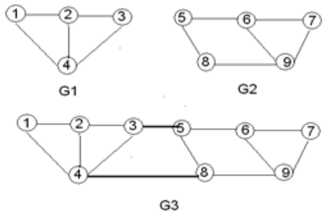


Fig. 2 Design model of optimal array network distribution for communication nodes

3. Communication node optimization selection model

On the basis of the optimal array network distribution design mentioned above, the robust communication node distribution design of the network is carried out. Under the strong interference environment, the communication nodes are affected by interference and multi-path restriction. Due to the poor balance of transmission links between nodes[10], it is necessary to make healthy selection of wireless communication nodes to improve the accurate transmission and adaptive control ability of network communication. In this paper, a healthy node selection model for communication networks with multi-mode noise based on fractional interval sampling and load balancing scheduling is proposed[11]. Using fractional interval sampling and load balancing scheduling method, the fractional interval sampling and load balancing scheduling relay node vector set of wireless communication network fusion center is obtained as $y = [y_1, y_2, ..., y_N]^T$. The node optimal coverage can be used to obtain the consistent unbiased estimation of the data fusion center of the node in the effective coverage area where the data fusion center of the node is $x(\eta), \forall \eta \in \Omega_\eta$ and the estimation is consistent and unbiased. The σ_η^2 estimation of the communication node N at any location can be expressed as:

$$\sigma_\eta^2 = E\left[\hat{x}(\eta) - x(\eta)\right]^2, \eta \in \Omega_\eta \tag{8}$$

Where, $\hat{x}(\eta)$ is an adaptive hierarchical state combination for sensor networks, and $x(\eta)$ is an unbiased estimation. Assuming that the energy equalization system of the wireless communication network is an n-order multi-input multi-output (MIMO) system, the description is expressed as follows:

$$y^{(n)} = f(y^{(n-1)},\cdots,\dot{y},t)+\Delta f(y^{(n-1)},\cdots,\dot{y},t) \\ +d(t)+b(y^{(n-1)},\cdots,\dot{y},t)u \tag{9}$$

Where, $y \in \mathrm{R}^{\mathrm{m}}$ is the initialization state vector; $f \in \mathrm{R}^{\mathrm{m}}$ is a known radial distribution function of fractional interval sampling and load balancing scheduling. $u \in \mathrm{R}^{\mathrm{m}}$, it filters the strong interference by adaptive energy equalization, and obtains that the variance of the measurement residual of the robust node of the $\boldsymbol{V}(k)=[\boldsymbol{v}_1^T(k),\boldsymbol{v}_2^T(k),\cdots,\boldsymbol{v}_N^T(k)]^T$, WSN robust node of the strong interference measurement noise satisfies the variance:

$$E[\mathbf{V}(k)\mathbf{V}^T(k)]=\begin{bmatrix} \mathbf{R}_v^1(k) & \mathbf{D}_{12}(k) & \cdots & \mathbf{D}_{1N}(k) \\ \mathbf{D}_{21}(k) & \mathbf{R}_v^2(k) & \cdots & \mathbf{D}_{2N}(k) \\ \vdots & \vdots & \ddots & \vdots \\ \mathbf{D}_{N1}(k) & \mathbf{D}_{N2}(k) & \cdots & \mathbf{R}_v^N(k) \end{bmatrix} := \mathbf{R}_{\mathbf{V}}(k) \tag{10}$$

Combined with the expansion measurement equation of WSN fusion center, the state fusion cluster center vector at k time is obtained by selecting $\rho=0.95$, $\beta=1.2$,. The correlation between noise $\boldsymbol{w}(k)$ and $\boldsymbol{V}(k)$ in hierarchical energy equalization process of communication node clustering network channel is as follows:

$$E[\boldsymbol{w}(k)\boldsymbol{V}^T(k)]=\begin{bmatrix}\boldsymbol{B}_1(k) & \boldsymbol{B}_2(k) & \cdots & \boldsymbol{B}_N(k)\end{bmatrix}:=\boldsymbol{B}(k) \tag{11}$$

Because the interference $\boldsymbol{R}_V(k)$ of communication node clustering network channel is a positive definite real symmetric matrix, according to the equation of state of information fusion, $\boldsymbol{R}_V(k)$ can be decomposed into:

$$\boldsymbol{R}_V(k)=\boldsymbol{L}(k)\boldsymbol{R}(k)\boldsymbol{L}^T(k) \tag{12}$$

Using fractional interval sampling and load balancing scheduling for noise filtering, the interference vector σ_η^2 of robust communication nodes in wireless communication network is minimized, and the estimation of communication state space spectrum can be expressed as follows:

$$\hat{x}(\eta)=\sqrt{P_n}\,r_\eta^T\left(P_nR_{ss}+\sigma_z^2I_N\right)^{-1}y \tag{13}$$

Where, $r_\eta = E\left[x[\eta]x_s\right], x_s=\left[x(\eta_1),...,x(\eta_N)\right]^T$, $R_{ss}=E\left[x_sx_s^T\right]\in R^{N\times N}$. Assuming that V_a and C_a are independent of each other, according to the statistical characteristics of the measurement robustness of communication nodes[12], the expression of σ_η^2 can be obtained as follows:

$$\sigma_\eta^2 = 1-r_\eta^T\left(R_{ss}+\frac{\delta}{\gamma_0}I_N\right)^{-1}r_\eta \tag{14}$$

Wherein, γ_0 represents the robust state estimation of the communication nodes in the k-time wireless communication network. Using the robustness fusion results of the sensors, the information matrix $\boldsymbol{Y}(k\,|\,k)=\boldsymbol{P}^{-1}(k\,|\,k)$ and $\boldsymbol{Y}(k\,|\,k-1)=\boldsymbol{P}^{-1}(k\,|\,k-1)$ are introduced to optimize the selection of robust nodes in the network under the background of multi-mode noise, by means of the connectivity graph of the measure information and the hierarchical equalization of the energy. To improve the output performance of communication signals of communication nodes[13], the design objectives of the improved model are expressed as follows:

(1) $C \subset S$

(2) Min $\|C\|$

(3) $\forall p \in A, \text{cov}_p \geq k$

(4) Robust node C in Wireless communication networks to achieve multiple connectivity

(5) Max $(t_{end} - t_0)$, t_{end}, t_0 represent the end and start time of the network respectively, when the energy of the wireless communication network is balanced, the throughput of the data is improved and the packet loss rate is reduced[14,15].

In comprehensive analysis, the communication network health node selection is realized, the implementation process is shown in figure 3.

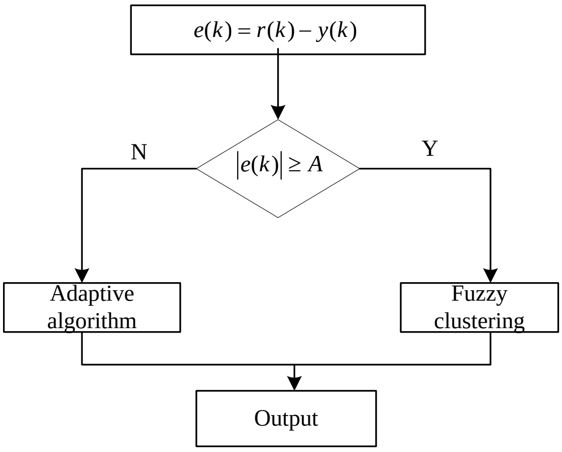


Fig. 3 Improved Model implementation proc

4. Simulation experiment and result analysis

Aiming to test the performance of the algorithm in selecting and optimizing the communication network health node under the background of multi-mode noise, the simulation experiment is carried out. In the experiment, a wireless communication network structure model is first established, the monitoring area of the wireless communication network is a square structure of 400m * 400m, the information communication coverage radius of the relay transmission node is R = 15m, the maximum number of iterations of the communication transmission is selected to be N = 300, The sink node of the sensor network is located in a two-dimensional space, the SNR of the strong interference noise is -13dB, and the other simulation scenes and parameters are set in Table 1.

Table 1 Scene of simulation and parameters setting

Simulation scene and parameters	Value	Simulation scene and parameters	Value
Network coverage	500×500	Total number of network nod *N*	400
Base station location	(140, 400)	Node initial energy	0.56J
E_{elec}	50n J/bit	d_0	65 m
P	0.45	R_c^0	76 m
E_{DF}	56 n J/bit	Packet siz	7000 bits
ε_{fs}	13 pJ/(bit·m^2)	ε_{mp}	0.45 pJ/(bit·m^4)

According to the above simulation environment and parameter setting, the algorithm is designed and realized by Matlab programming, and the optimal selection model of robust nodes in wireless communication network is simulated. First, the original node distribution model is given as shown in figure 3.

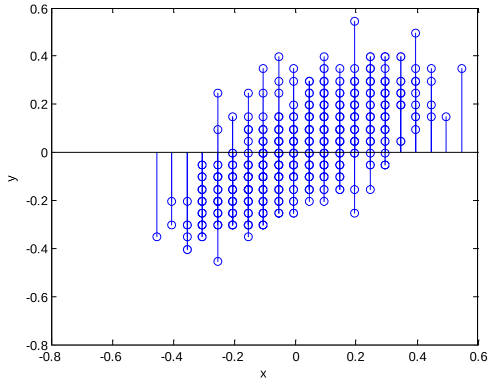
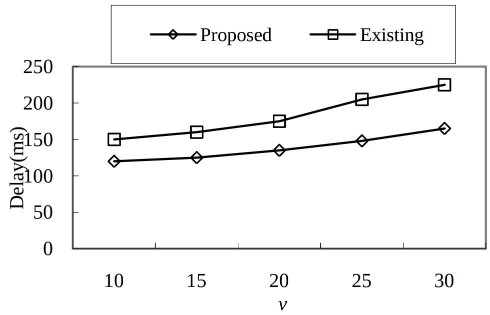
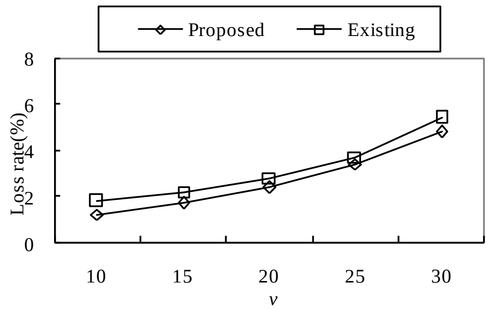


Fig. 4 Node distribution model of wireless communication network

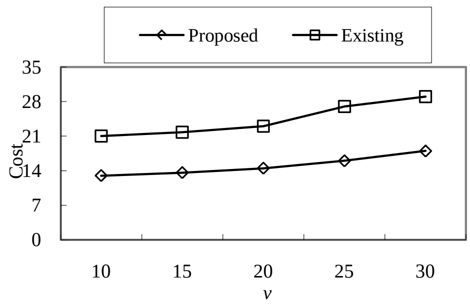
In the above-mentioned node distribution model, the optimal array network distribution design of communication nodes is carried out. The data information fusion and robust communication node selection of sensor networks are carried out by using fractional interval sampling and load balancing scheduling methods. Taking the communication signal output delay, packet loss rate and calculation overhead as the test indexes, the simulation results are shown in figure 5 using the proposed model and the traditional model.



(a) Transmission delay of communication node



(b) Packet loss rate



(c) Computational overhead

Fig. 5. Performance test

By analyzing the above results, it can be seen that using this algorithm to select healthy nodes in the communication network under the background of multi-mode noise can reduce the output delay of communication signals and the packet loss rate of communication transmission at the same time. Reduce the computation overhead, improve the stability and robustness of the wireless communication network, test the bit error rate of the output, the results are shown in Table 2, and the analysis Table 2 shows that In this paper, the optimal selection of healthy nodes in wireless communication network has a low bit error rate (BER), which has a good application value in the optimal deployment design and communication of wireless communication network nodes.

Table 2 Output bit error rate Test

SNR/dB	Proposed method	Reference[4]	Reference[5]
-20	0.12	0.21	0.32
-10	0.09	0.15	0.26
0	1	0.13	0.13
10	1	0.06	0.05
20	1	0	0.02

5. Conclusions

In this paper, a healthy node selection model for communication networks with multi-mode noise based on fractional interval sampling and load balancing scheduling is proposed. The optimal deployment and location model of healthy nodes in wireless communication network is constructed, and then the optimal array network distribution design of communication nodes is carried out. Based on fractional interval sampling and load balancing scheduling method, an improved healthy node selection model for communication networks under the background of multi-mode noise is implemented. The simulation results show that the optimal deployment and selection of the healthy nodes in the communication network under the background of multi-mode noise can reduce the packet loss rate and delay of the output of the communication signal and reduce the computation overhead. The channel equalization and modulation ability of the network are improved, and the bit error rate of communication output is low. This method has good application value in improving the quality of communication network.

References

[1] WANG Youcheng, ZHANG Feng, FANG Guangyou, et al. A novel ultrawideband exponentially tapered slot antenna of combined electric-magnetic type [J]. IEEE Antennas and Wireless Propagation Letters, 2016, 15: 1226-1229.

[2] SHI En, LI Qian, GU Daquan, ZHAO Zhangming. Weather radar echo extrapolation method based on convolutional neural networks [J]. Journal of Computer Applications, 2018, 38(3): 661-665.

[3] TU Binbin, CHUAI Rongyan, XU Hui. Outlier Detection Based on K-mean Distance Outlier Factor for Gait Signal. Information and control, 2019, 48(1): 16-21.

[4] LIU Na, YANG Suhui, CHENG Lijun, et al. Study on anti-atmospheric turbulence interference of light borne microwave signal [J]. LASER TECHNOLOGY, 2018, 42(5): 611-616.

[5] Lun TANG, Xixi YANG, Yingjie SHI, Qianbin CHEN. ARMA-prediction Based Online Adaptive Dynamic Resource Allocation in Wireless Virtualized Networks [J]. dianziyuxinxixuebao, 2019, 41(1): 16-23.

[6] SU Hongtao, LIU Hongwei, SHUI Penglang, et al. Adaptive beamforming for nonstationary HF interference cancellation in skywave over-the-horizon radar[J]. IEEE Transactions on Aerospace and Electronic Systems, 2013, 49(1): 312-324.

[7] HOU F, TAN J, FAN X, et al. A novel method for sparse channel estimation using super-resolution dictionary [J]. EURASIP Journal on Advances in Signal Processing, 2014(1):

1-11.

[8] HELMY A, HEDAYAT A, and AL-DHAHIR N. Robust weighted sum-rate maximization for the multi-stream MIMO interference channel with sparse equalization [J]. IEEE Transactions on Communications, 2015, 60(10): 3645-3659.

[9] ZHANG Min, JIN Long-xu, LI Guo-ning, WU Yi-nan, ZHANG Ran-feng, HAN Shuang-li. Design of image simulation system of TDICCD space camera [J]. Chinese Journal of Liquid Crystals and Displays, 2016, 31(2): 208-214.

[10] ZHAO Z M, WANG X D. The state-of-the-art and the future trends of electromagnetic energy harvesting [J]. Transactions of China Electrotechnical Society, 2015, 30(13): 1-11.

[11] LI H, HUANG C, CUI S. Multiuser gain in energy harvesting wireless communications [J]. IEEE Access, 2017(5): 10052-10061.

[12] SEO D W, LEE J H, LEE H S. Optimal coupling to achieve maximum output power in a WPT system[J]. IEEE Transactions on Power Electronics, 2016, 31(6): 3994-3998.

[13] WANG W, WANG R, MEHRPOUYAN H, et al. Beamforming for simultaneous wireless information and power transfer in two-way relay channels [J]. IEEE Access, 2017(5): 9235-9250.

[14] ZENG Y, ZHANG R. Full-duplex wireless-powered relay with self-energy recycling [J]. IEEE Wireless Communications Letters, 2015, 4(2): 201-204.

[15] HU S, DING Z, NI Q. Beamforming optimisation in energy harvesting cooperative full-duplex networks with self-energy recycling protocol [J]. IET Communications, 2016, 10(7): 848-853.