Data Anti-jamming Method for Ad Hoc Networks Based on Machine Learning Algorithm

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Abstract. The current data anti-jamming methods lack the feature classification process, which leads to poor anti-jamming effect. In order to solve this problem, this paper proposes a data anti-jamming method based on machine learning algorithm for ad hoc networks. First of all, based on machine learning algorithm, the data transmitted in the ad hoc network is processed by feature mining and classification, and the ad hoc network information transmission management platform is constructed. Then optimize the steps of extracting the anti-jamming information features of the ad hoc network data, and combine machine learning algorithm to optimize the anti-jamming evaluation algorithm of the communication data of the internet of things, so as to achieve the identification and protection of the ad hoc network interference data. The experimental results show that this method has high practicability and can meet the research requirements.

Keywords: Machine Learning Algorithm · Ad Hoc Network · Data Anti-Interference · Multichannel Transmission

1 Introduction

The use environment of the ad hoc network is relatively complex. In order to meet the needs of the use, the multi-channel routing of the ad hoc network has become a more popular network form. Among them, the multi-channel transmission technology of the ad hoc network is to transmit the cells belonging to the same virtual connection to the opposite node. Most of today's ad hoc network switching devices regard the different channels of the channel group connected to the same node as separate entities, ignoring the problem of interference between the channel group and the same pair of nodes. Even if the cell-level traffic changes, it will To a certain extent, the problem that some channel cells are overloaded and the remaining channels are basically idle can be avoided. In addition, because the data transmission of the ad hoc network will suffer a certain degree of interference, which limits the application of high-frequency signal scenarios, especially in the absence of anti-interference measures, the false alarm rate will be greatly increased.

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In order to improve the anti-jamming capability of ad hoc network data, relevant experts proposed an anti-jamming avoidance method for ad hoc network sensor data based on adaptive link and inter-symbol interference suppression. This method optimizes the deployment of sensor nodes on the basis of constructing a transmission channel model. According to the baud interval, the sensor sensing channel of the Internet of Things is equalized, and the filtering process is completed through inter-symbol interference suppression to complete data anti-interference. Some scholars have also established a transmission link model to complete interference filtering according to spread spectrum channel modulation, use fractional interval equalization to suppress multipath links in ad hoc networks, achieve load balancing control of ad hoc links through bit error rate feedback modulation, and complete data anti-interference control.

Based on the above research, this paper proposes a new data anti-interference method for ad hoc networks based on machine learning algorithm. The idea is as follows:

① Based on machine learning algorithm, the characteristics of the data transmitted in the ad hoc network are mined, and the mining results are classified;
② Build an ad hoc network information transmission management platform, optimize the data anti-interference evaluation algorithm with machine learning algorithm, and realize the identification and defense of malicious interference data.

2 Anti-interference Method of Ad Hoc Network Data

2.1 Classification of Data Interference Types

Due to the wireless communication environment and its own characteristics, ad hoc networks have weak resistance to interference. The multi-channel transmission platform of ad hoc network mainly consists of three modules: micro control chip, rf chip and sensor. The architecture of the multi-channel transmission platform of the ad hoc network is shown in Fig. 1.

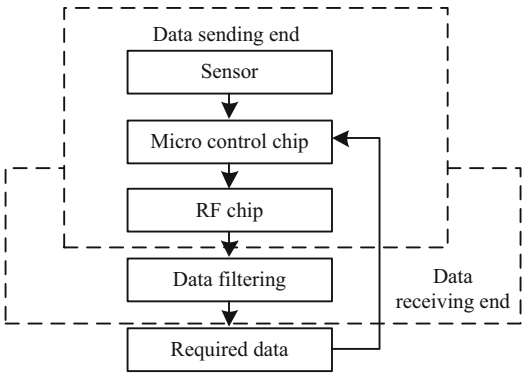

Fig. 1. Schematic diagram of the architecture of the ad hoc network information transmission management platform

It combines the versatility and expansibility in the data processing environment of the ad hoc network, and can normally control the high-confidential data collection process,

so that the technical control effect is better. Therefore, in order to realize the versatility and scalability of machine learning technology, it is necessary to use machine learning as the basic framework to realize the control of massive high-confidential data clients in the ad hoc network, and to complete the control between the client and the server by managing different distributed servers. Therefore, the intelligent control of the collection of high-confidential data in the distributed network in the two-layer mode is realized, and the expandable space of the device application is provided. Therefore, the networked control architecture is designed as shown in Fig. 2.

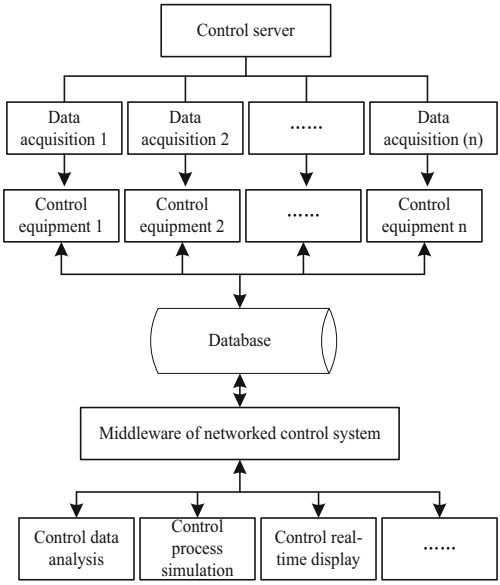

Fig. 2. Data feature classification control architecture

It can be seen from Fig. 2 that the structure mainly includes four layers, namely, data acquisition layer, control layer, communication layer and application layer. Including:

Data acquisition layer realizes data acquisition through different measurement and control equipment.

The control layer accesses the real-time data in the networked database to realize the comprehensive control of the data.

The communication layer is mainly composed of middleware. Good compatibility between different instruments and equipment is achieved through information transmission and interface processing. The returned information status can be obtained by processing the external equipment, and the good status information can be transferred to the database for storage.

The application layer is the outermost basic application in the distributed networked control structure. It realizes the intelligent control of data collection by processing the data information collected by the middle layer.

For the management of different control equipment, it is necessary to analyze one by one according to the distribution in the entire network, and transmit the information to be controlled to the data processing center, and the data processing center analyzes and processes the information to be controlled, and the two-way interactive communication method, to ensure the cooperation between multiple control devices.

Due to the mobility of the ad hoc network, the interfered nodes can frequently change their attack targets and perform malicious acts on other nodes in the network, so it is difficult to track the malicious acts performed by the interfered nodes in the network, especially in large ad hoc networks. The rules are different when sending, so it is necessary to consider all neighbor types to select time slots and channels. The rules for selecting channels and time slots for the four types of nodes are shown in Table 1.

Table 1. Transmission channel and time slot selection rules

Node type	One hop neighbor node type	Channel and slot selection
Normal node	Normal node	The first time slot is sent on the channel
Internal node	External node	The entire time slot is transmitted on the channel
Edge node	Internal node, edge node, connection node	The second time slot is transmitted on the channel
Connection node	Connecting node, normal node, edge node	The first time slot is sent on the channel: the second time slot is sent on the replacement channel

Threats from the interfered nodes inside the network are much more dangerous than attacks from outside the network, and these attacks are difficult to detect because they come from the interfered nodes and perform well before being interfered. It can be seen from this that special attention should be paid to the threat from the interfered nodes in the ad hoc network, and mobile nodes and infrastructure should not easily trust any node in the network, even if they all perform well, because it is likely that they have been infected.

Since the mobile ad hoc network does not have a centralized management mechanism such as a server, this leads to some vulnerable problems. The lack of a centralized management mechanism makes attack detection a very difficult problem because it is not easy to monitor traffic in a highly dynamic and large-scale ad hoc network. The lack of centralized management mechanism will hinder the trust management of nodes in mobile ad hoc networks.

Some algorithms in mobile ad hoc networks depend on the cooperative participation of all nodes and infrastructure. Because there is no centralized permission and the decisions in mobile ad hoc networks are sometimes decentralized, attackers can take advantage of this vulnerability and execute some attacks that undermine the collaboration algorithm. Network data protocols include TCP/IP, MICROSOFT and NOVELL. The specific network protocol selection basis is shown in Table 2.

Table 2. Network data protocol selection basis table

Protocol type	Selection basis
TCP/IP	Directly integrate with data script to avoid untimely data adjustment
MICROSOFT	Promote the rapid progress of identification operation and improve the quality of data transmission
NOVELL	And exists in parallel with the Microsoft protocol

In the process of data anti-interference, the lack of centralized management mechanism will lead to loopholes. This vulnerability may affect many aspects of operations in mobile ad hoc networks. Mobile ad hoc networks are built on open shared media, so interference sources can easily launch interference attacks to reduce network performance, such as directly paralyzing some nodes, increasing packet transmission time, and reducing PDR. The interference source usually attacks the network in the form of sending invalid wireless signals or data packets, causing the channel of network communication to be occupied or the received data packets to be damaged. Interference sources can be divided into basic interference and advanced interference, while basic interference can be further divided into active interference and passive interference, and advanced interference can be further divided into function specific interference and intelligent mixed interference, as shown in Fig. 3.

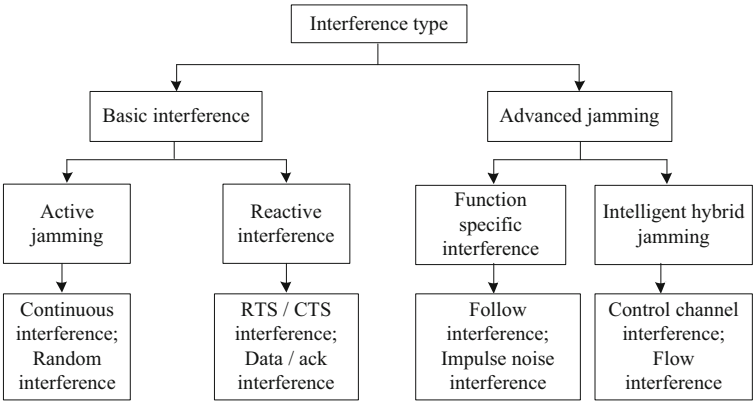

Fig. 3. Schematic diagram of the division of data interference types

Because of its wireless environment and its own characteristics, the mobile ad hoc network has weak resistance to interference. Therefore, many anti-interference technologies and schemes have been studied in the academic circles to improve the communication reliability of the mobile ad hoc network. For the multi-channel transmission platform of the Internet of Things, due to the integrity of the sensor, the micro control chip and the self-organized network structure, the data of the platform can be in and out. Among them, the micro control chip will use various algorithms to compare the collected

data with the received data, and then realize data processing and fusion. Based on the anti-interference problem of Internet of Things communication data, the point-to-point model should be used for the transmission platform.

2.2 Design of Anti-jamming Algorithm for Ad Hoc Network Data

Machine learning algorithms establish mathematical models based on sample data or training data, or interact with the environment so that they can predict or make decisions to perform tasks without explicit programming. Existing machine learning algorithms can be classified by the expected structure of the model, mainly including supervised learning, unsupervised learning, and reinforcement learning. In supervised learning, the machine learning algorithm has a labeled training data set, which is used to build a model representing the learning relationship between input, output and parameters. Unlike supervised learning, unsupervised learning does not need labeled data sets. Its goal is to classify the sample sets into different groups or clusters by obtaining the similarity between input samples. Reinforcement learning algorithms learn through the interaction between agents and the environment, that is, online learning. Finally, since some algorithms share characteristics of supervised and unsupervised learning methods, they do not fit into these three categories, these hybrid algorithms are often referred to as semi-supervised learning and aim to inherit the advantages of these main categories while maximizing the reduce their weaknesses.

Machine learning is a research area of artificial intelligence that aims to make computers learn autonomously like humans, thereby speeding up the speed at which computers process data. The ultimate goal of machine learning is to gain knowledge from data. The machine learning model design generally consists of four parts: environment, learning element, knowledge base and execution element, as shown in Fig. 4.

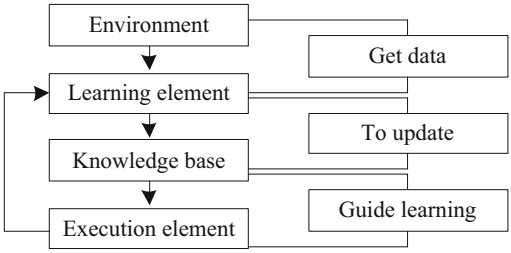

Fig. 4. Machine learning model design diagram

The machine learning model is used to process the big data of the ad hoc network. First, the machine learning based link node clustering of the ad hoc network uses iterative calculation theory as the core processing basis. l center point is determined from all the operating state data of the ad hoc network equipment to minimize the sum of the distances from other data points to the cluster center point. The selection of cluster center point l has strong randomness. With the increasing initialization effect of machine learning theory, these center points will gradually move in a unified direction. In order to reduce

the number of clustering iterations of the link nodes in the ad hoc network, all operation data can be allocated to the range of classes contained in the nearest center point one by one, and the clustering processing can be completed once by accumulating the distance between the data points and the center point for many times.

In each clustering process, the position of the next center point l is determined by counting the average value of the ad-hoc network link nodes. When the coordinates of all center points remain unchanged or within the class range of each center point l After the blank positions are no longer included, the iterative processing is stopped, and the clustering processing of the ad hoc network link nodes based on machine learning is completed. The specific processing principle and operation formula are as follows:

$$F = \frac{\sqrt{l \cdot h\Delta t}}{3k + g} \cdot \int (s + p)d \tag{1}$$

Among them, F represents the clustering processing result of the link nodes in the ad hoc network based on machine learning, h represents the cumulative times of the distance between data points and center points, Δt represents the change interval of the class range, k represents the average value of the link nodes in the ad hoc network, g represents the average value of the clustering weight, s represents the iteration constant of the link data in the ad hoc network, represents the p-term coefficient of the node processing constant, and d represents the node parameters of the clustering processing. The principle of link node clustering in an ad hoc network based on machine learning is shown in Fig. 5.

Build the random matrix structure of the communication data of the ad hoc network, analyze the reception of the communication data, deduce the acquisition matrix of the received communication data as the autocorrelation moment library of the noise, analyze the characteristics of the matrix, solve the optimal anti-interference judgment threshold expression, and complete the multi-channel Design of anti-jamming algorithm for ad hoc network communication data under transmission. The machine learning channel hopping strategy takes into account the channel selection and time slot division rules for each type of node in broadcast mode. The time slot and channel selection rules of nodes when receiving are the same as in unicast mode.

Set the random variable of independent and identically distributed ad hoc network communication data as m, and the random variable matrix is n. Then the following formulas are used to describe the definition center and calibration constant respectively:

$$\mu = (\sqrt{n-1} + \sqrt{m})^2 \tag{2}$$

In order to improve the success rate of data transmission, the basic idea of this strategy is to replace the disturbed channel with the corresponding replacement channel. Before enabling this strategy, the node will switch to the channel indicated by the frequency hopping pattern every time slot to send and receive data. After this policy is enabled, when the frequency hopping pattern indicates the need to switch to the disturbed channel v, the internal nodes and edge nodes will switch to the alternative channel v, while the connecting nodes and normal nodes will still switch to the channel v. However, only channel replacement will prevents the adjoining node from receiving packets from certain

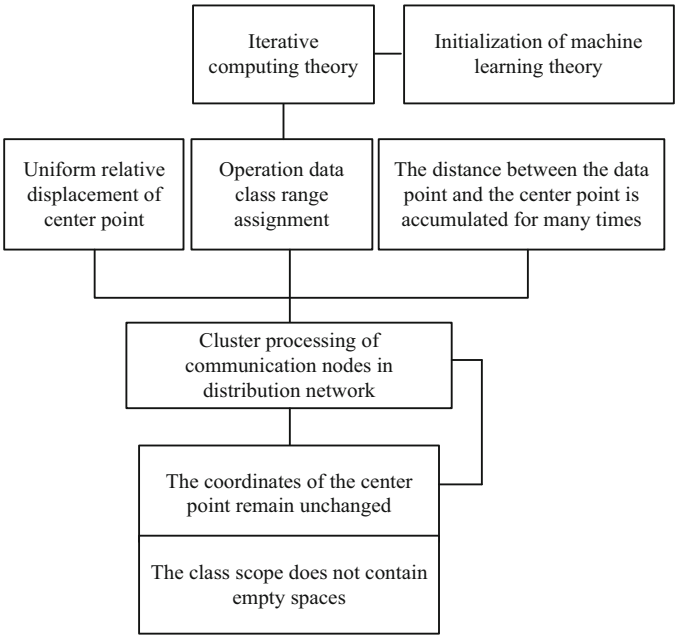

Fig. 5. Principle of clustering of ad hoc network link nodes based on machine learning

types of neighbors. The cumulative distribution function of the first-order du distribution is expressed as F_1, and the defining formula of this function is as follows:

$$F_1(t) = \exp\left(-\frac{1}{2}\int_1^{\infty}(\mu + v)\mathrm{d}u\right) \tag{3}$$

According to the random matrix characteristics of machine learning, we can fully understand the channel characteristics of the current communication, and its covariance matrix can verify the parameter attributes of the channel received data. The node can select channels by referring to the historical channel selection and the observation of its real state. Some scholars have shown that the optimal channel decision under multi-channel is based on the statistical data of all historical decisions and observations. The reasonable application of computer and network management can increase the transmission speed of engineering information, improve the work efficiency of intelligent engineering management and construction management personnel, improve the work efficiency of various departments of the project, and enhance the coordination, communication and coordination among various personnel of the project.The long-distance wireless ad hoc network preferentially selects nodes with farther distances as data packets, which can greatly increase the number of hops in the network transmission process, thereby reducing the delay of packet distribution, reducing redundant information in the network, and effectively improving data. Distribution Control Efficiency. By calculating the transmission distance of the data packet, the signal strength of the receiving node and the location information transmitted by the node can be obtained. To this end, the forwarding delay protocol is set using the distance, so that the distribution delay of

the receiving node is inversely proportional to the distance of the sending node. The calculation formula of node distribution delay is:

$$d = MDT \times \frac{S^e - X^{\mathrm{e}}}{S^e} \tag{4}$$

Where, MDT is the maximum waiting time of the node; S is the node signal transmission range; X is the distance between the data sending node and the receiving node, and e is a constant. Under this protocol, as the node density increases, the number of nodes actually distributed will also increase. In order to solve the problem of continuous increase of nodes, a forwarding probability that is inversely proportional to the node density is added to keep the number of distribution nodes constant, thus realizing the design of data distribution control for wireless ad hoc networks with no time delay and long distance. When the model is initialized, if there is no historical data to reference, the confidence vector will be initialized. Each element in the vector can be obtained from the Markov chain. The process is as follows:

$$\omega_o^i = \frac{p_{01}^i}{p_{01}^i + p_{10}^i} \tag{5}$$

The anti-interference function of multiple channels can be realized through the Myopic channel selection scheme. However, this method has a disadvantage. Only when the channel state transition is positive correlation, this method can achieve the performance that almost the optimal strategy can achieve in any number of channels. When the channel state transition is negatively correlated, that is $p_1 < p_0$. This method can match the performance of the optimal strategy only when the number of channels is 2 or 3.

2.3 Realization of Anti-interference of Ad Hoc Network Data

Due to the data transmission of the ad hoc network, the following two situations will occur: the existence of the main user data and the existence of the noise data. The former indicates that the channel is occupied, and the latter is in an idle state. If $s(k)$ is the directional received data energy in the ad hoc network, l is the energy information of the data, $n(k)$ is the energy information of white Gaussian noise, the channel occupancy is set to H_1, and the idle state is H_0, the data receiving expression is as follows

$$x(k) = \begin{cases} l_{\max} \cdot (s(k) + n(k)) & H_1 \\ l_{\min} \cdot n(k) & H_0 \end{cases} \tag{6}$$

Assuming that there are $A(\theta)$ directional channels at the receiving end of the ad hoc network, the data $A(\theta)$ collected at the receiving end at time k is described by the following expression

$$x(k) = A(\theta)s(k) + n(k) \tag{7}$$

In the formula, the direction matrix of $k = 1, 2, \ldots, M$ and M directional channels to collect user data is denoted as $A(\theta)$, the energy of main user data at a certain moment

in the collected data is $s(k)$; the energy of noise data is $n(k)$. Because the communication data is more or less disturbed by noise, based on the premise that γ is established, the false alarm probability is used to distinguish 0 of the communication data types, and the description formula is as follows

$$\frac{\rho_{\max} - \rho_{\min}}{E_*(N)} > \gamma \tag{8}$$

Based on the characteristic analysis results of mean value M, the expression of false alarm probability p is established as follows:

$$P_f = \phi\left(\frac{4M}{\sqrt{2}\gamma} - \sqrt{\frac{NM}{2}}\right) \tag{9}$$

In the formula, the probability integral function is $\phi(*)$, and the delay mainly occurs in the information collection process between the master and the slave clock. The slave clock sends a delay information request packet to the master clock, unlike the synchronous data packet with a period of 2 m. The information data packets sent are sent only when the delay request data packets occur, and the specific process is shown in Fig. 6.

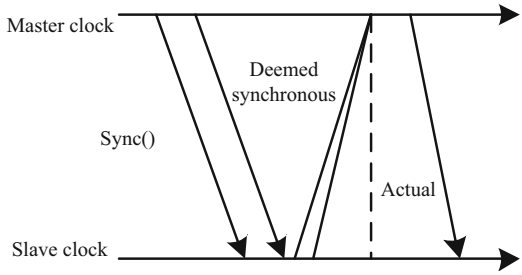

Fig. 6. Data packet sending situation

In case of network delay in sending data packets from the slave clock, the current delay time shall be recorded in time, the time of data packet transmission from the slave clock to the master clock shall be calculated, and the delay request data packet shall be sent. The current time T_1 shall be recorded while transmitting. When the master clock receives the delay request data packet, the time T_2 shall be recorded immediately. Since time T_2 is required for data transmission delay calculation at slave clock, a delay request response packet needs to be sent from master clock to slave clock. The overall delay is:

$$T = T_1 - T_2 \tag{10}$$

Since the transmission between data packets has a symmetrical property, the transmission time of the data packets from the master clock to the slave clock is consistent with the transmission time of the data packets from the slave clock to the master clock. Therefore, the network transmission delay can be calculated. When the slave clock

receives the time stamp T_1, the offset error *offset* between the master-slave clock can be estimated by using the formula, which is:

$$offset = T_1 - T_0 - delay \tag{11}$$

In the formula, T_0 is the time of receiving synchronization packets from the clock; *delay* is delay error between master and slave clocks.

The adaptive connection of the ad hoc network equipment integrates and processes the relevant operation status data according to the development requirements of machine learning theory. On the premise of meeting the automatic maintenance requirements, these data are arranged according to the current network status requirements of the ad hoc network equipment, so as to improve the detection efficiency of the operation data.

In the self-adaptive connection method of the ad hoc network equipment, the direct access method, the network access method, and the private line access method are three common communication methods. Among them, the direct access of the ad hoc network equipment can fully connect each communication node, and strictly limit the maintenance access mode of the running status data.

The private line access of the ad hoc network equipment needs to occupy one or more data transmission channels, and change the original state of these data. The machine learning theory is applied to break up the state data of the equipment in the ad hoc network, and these scattered data are combined into a new state maintenance ring of the equipment in the ad hoc network in the way of connecting the first and last in order. See Fig. 7 for the detailed adaptive connection principle of MANET data.

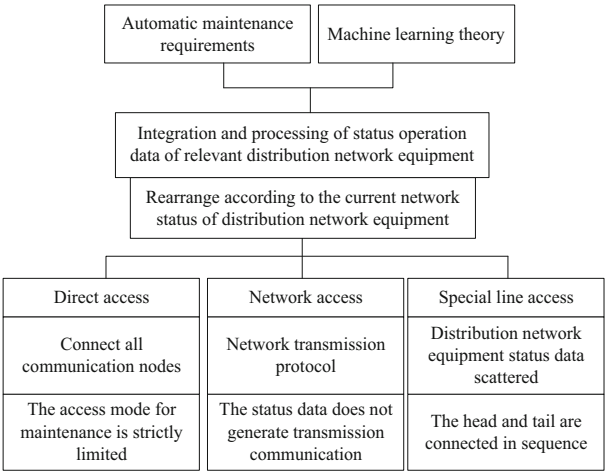

Fig. 7. Detailed diagram of the principle of self-organizing network data adaptive connection

On the basis of the adaptive connection, the data anti-interference implementation process is designed, as shown in Fig. 8.

The specific implementation process of the algorithm is as follows: Assuming that there are K convolution cores and N kinds of output layers, then the weight parameter

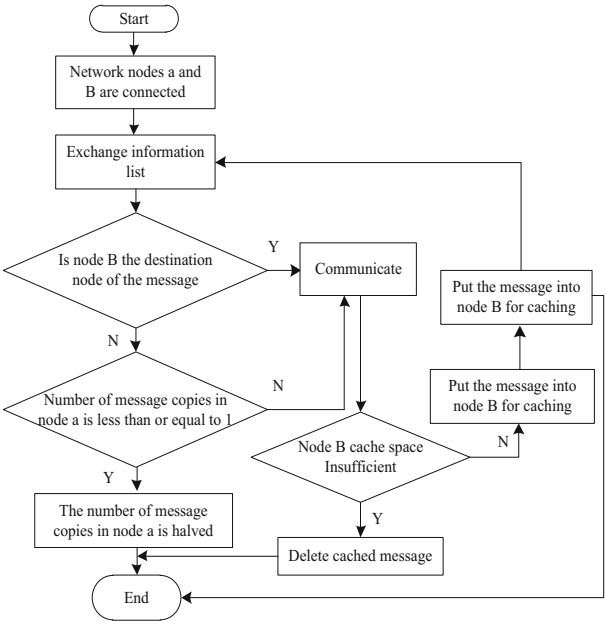

Fig. 8. Data anti-jamming implementation process

θ of the output layer is a $A \times B$ matrix, which can be expressed as $\theta \in C^{A\times B}$, and the feature of the pooled sample X is a K dimension vector, that is, $f \in C^K$. The probability that sample X is divided into the Y category is:

$$P = (\mathrm{Y}|X, C) = \frac{\mathrm{e}^{(c_y \cdot f + q_y)}}{\sum_{h=1}^{N} \mathrm{e}^{(c_y \cdot f + q_\mathrm{h})}} \tag{12}$$

In the formula: q_h represents the h bias term of the fully connected layer, and the loss function can be obtained by maximizing the likelihood probability:

$$\mathrm{W} = -\sum_{\mathrm{y}}^{R} \log\left(p\left(g_y|x_y, \theta\right)\right) \tag{13}$$

In the formula, R is the training data set, and g_y is the real data type of the y sample. In order to prevent over fitting, it is necessary to simplify the ad hoc network structure according to a certain probability to ensure that the weight does not work. After feature compression, the internal state and behavior control of the data can operate freely on the basis of stable database storage space.

Through the above process, parallel recommendation for diversity key data is realized. According to the networked control architecture, the data acquisition layer, control layer, communication layer and application layer are analyzed. According to the distribution of different test equipment in the whole network, the purpose of controlling the comprehensive ability of data acquisition is to study the data acquisition and control. The

pin function of the LPC2292 controller is configured as a GPIO bus expander to design the data acquisition process, store the collected data in the database for comprehensive control, and complete the timing read and write according to the ARM static storage control mechanism. The specific implementation process is as follows:

Step 1: divide the control program into three parts, namely, data acquisition module, control read-write module and bus communication module. The bus communication module is located at the top layer, the data acquisition module and the control read/write module are located at the bottom layer, and the data transmitted through the bottom layer module is used for integrated digital signal processing.
Step 2: For the data acquisition module, the parallel clock drive ADC_CLK needs to be controlled. In the process of writing it, the data collected along the reading is required to have stable and reliable properties. The FPGA field programmable gate array is the driver of the photo for the two channels. The collected data is preprocessed to filter out the 50 Hz interference frequency interference before the data can be written into the memory.
Step 3: The signal CE selected for the control read-write module is relatively low. When using the ARM static memory of CY7C1021DV33 model to read, pay attention to the OE signal, pull it down first and then raise it, and complete the data writing along the signal direction.

According to the above process, realize the intelligent control of the data in the ad hoc network without delay.

3 Analysis of Experimental Results

In order to verify the practical application performance of the data anti-interference method based on the machine learning algorithm, the following experiments are designed.

The simulation experiment environment is Intel Pentium i5-2520M processor, the running memory is 6GB, the operation is Windows XP, and MATLAB2013 software is used as the experimental platform. The experiment adopts the multi-channel transmission parameters of the ad hoc network as shown in Table 3. The data size used in the experiment is 1000 Mb.

Table 3. Multi-channel transmission parameters

Parameter name	Selection range
Primary carrier frequency	20000 Hz
Load wave frequency	1600 Hz
Data signal symbol rate	1300 Baud
FSK adjustment index	0.6
Channel environment	white Gaussian noise

In order to avoid too single experimental results, the method in this paper is compared with the traditional anti-interference avoidance method based on adaptive link and inter-symbol interference suppression for sensor data in ad hoc networks.

First, verify the distribution of data by different methods, and the results are shown in Fig. 9.

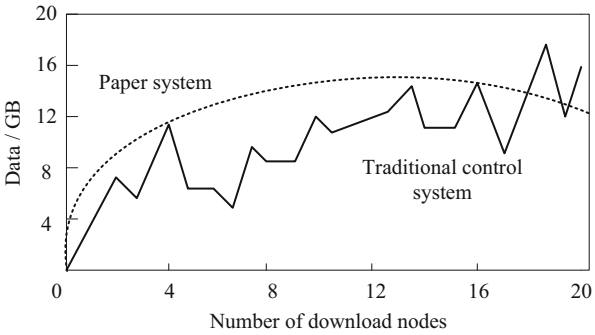

Fig. 9. Comparison results of two distribution data quantities

According to the results of Fig. 9, the method in this paper has a better effect on the distribution of data in ad hoc networks, and the distribution process is more stable. However, the distribution process of traditional methods is not stable enough, and the distribution data volume fluctuates greatly.

On this basis, the application performance of this method is verified. LRT channel is used to conduct the test, and the anti-interference process simulation diagram of this method is obtained. The results are shown in Fig. 10.

In Fig. 10, the upper graph is the successful packet sending rate curve of each cycle of the method in this paper, the lower graph is the cumulative reward curve, and the abscissa is the training time step. Figure 10 illustrates the effectiveness and practicability of our method in the multi-channel state. On this basis, keep the interference frequency of the receiver and transmitter unchanged, and the network data of the transmitter will change with the change of the interference frequency. In this process, the network data of the transmitter is recorded as the maximum value. Under three different coupling coefficients (0.004, 0.005, 0.018), after analyzing and applying the method in this paper, the relationship between the ad hoc network data and the interference frequency change, the results are shown in Fig. 11.

It can be seen from Fig. 11 that the interference frequency is uniformly distributed around 202 kHz, and is relatively small due to the change of interference data. According to the above changes in the network data of the transmitting end, the operating interference frequency of the transmitting end is adjusted according to the minimum value to ensure that the transmitting end and the receiving end are in a matching state, so that the experimental results are more accurate.

Based on the comprehensive analysis of the above experiments, it can be seen that the data anti-interference method proposed in this paper based on machine learning

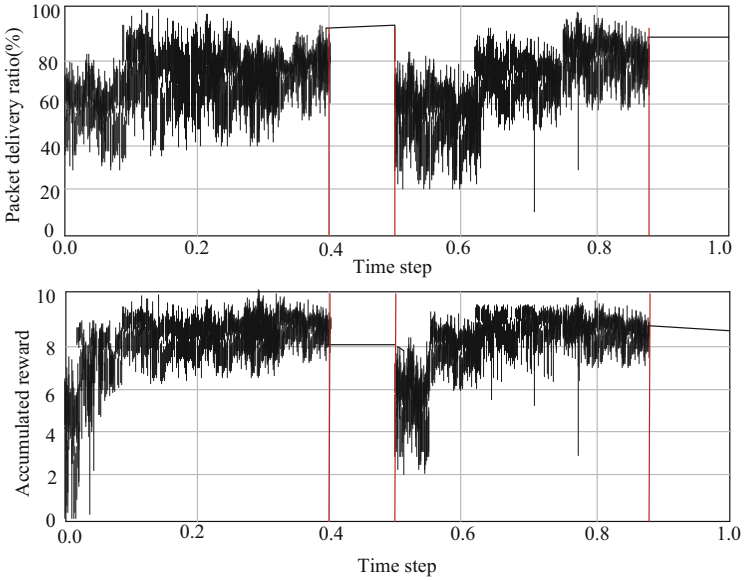

Fig. 10. Simulation diagram of interference perception and anti-interference of ad hoc network under multi-channel

algorithm has high practicability and effectiveness in the practical application process, and repeatedly meets the research requirements.

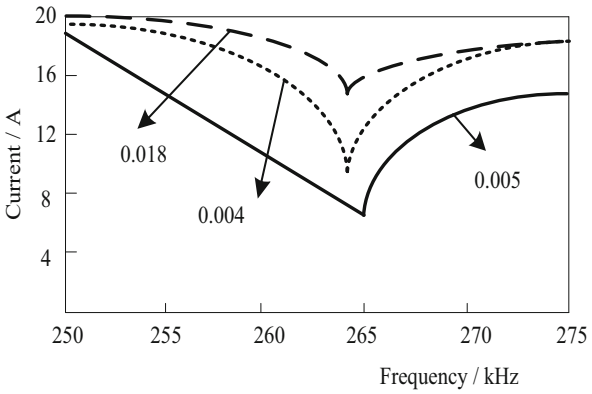

Fig. 11. The relationship between data and interference frequency under different coupling states

4 Conclusion

Due to the increasing support policies of ad hoc networks, more and more multi-channel network environment fields are favored, and the interference generated during communication is generally artificial and non-artificial.

In order to make the communication effect of ad hoc network more ideal, this paper proposes a method of communication data anti-jamming based on machine learning algorithm. This method can effectively suppress data interference and optimize data transmission performance.

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