Research on Active Disturbance Rejection Method of Mobile Communication Network Nodes Based on Artificial Intelligence

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Abstract. With the increasingly complex network environment and the interference of various other radio waves, the quality of mobile communication network is seriously affected. Aiming at the above problems, this paper studies an auto-disturbance rejection method for mobile communication network nodes based on artificial intelligence. According to artificial intelligence, an interference identification analysis model is constructed, which is used to identify and analyze the interference factors of mobile communication network nodes. Based on the recognition results, the characteristics of different interference types are summarized, and the interference problem is accurately judged. Then, the anti-interference work of mobile communication network nodes is completed by checking and processing the results. The experimental results show that the user is more satisfied with the quality of the mobile communication processed by this method than the traditional method of UAI participating in the identification and analysis of interference factors, which proves that this method is effective in anti-jamming and can meet the needs of users.

Keywords: Artificial intelligence · Mobile communication network · Anti-interference · Feature analysis

1 Introduction

In modern society, remote information exchange plays a key role, and remote information exchange can only be achieved by relying on mobile communication network. With the increasingly complex network environment of mobile communication industry and the interference of various other radio waves, problems such as increasing drop-out rate, reducing base station coverage, and sharply decreasing network indicators emerge one after another, seriously affecting the quality of calls. Under this background, how to reduce the interference in the network and improve network capacity and quality has become a problem that must be solved in the network operation and maintenance of operators [1, 2]. Reasonable and efficient analysis and solution of interference problems has become an important requirement in daily network operation and maintenance work.

Previous methods proposed by experts and scholars focused on the research of interference processing methods in mobile communication networks, but ignored the

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identification and detection of interference factors. Effective identification and detection will make mobile communication network interference processing more effective. Reference [3] proposes an efficient deployment method for optimizing coverage of key nodes in industrial mobile wireless networks. This method considers the industrial characteristics and mobility of wireless networks, and then simplifies the static and mobile node coverage problems into target coverage problems. A new cluster head deployment strategy is proposed based on the improved maximum cluster model and iterative calculation of new candidate cluster head positions. The maximum clique is obtained by double tabu search. Each cluster head updates its new position through an improved virtual force, and moves with full coverage to find the minimum inter cluster interference. The experimental results show that. This method can realize the location between interference nodes, but the anti-jamming effect is not good, and it takes a long time to identify interference nodes. In reference [4], an active interference suppression method for fully distributed communication delay is proposed. In this method, automatic generation controller is used instead of traditional control center, and automatic generation controller is embedded in each participating generating unit to avoid communication delay of control signal. Simulation results show that this method has good performance and robustness in the presence of communication delay, but when the number of attacks is large, the anti-jamming effect is not obvious, and it takes a long time to identify interference nodes.

Aiming at the weakness of traditional methods, this paper proposes an artificial intelligence-based ADRC method for mobile communication network nodes. The greatest advantage of this method is to introduce interference recognition into it. After verification and analysis, the communication quality of this method has been greatly improved, which promotes the development of mobile communication network.

2 Anti-jamming Method of Mobile Communication Network Node Based on AI

Mobile network is an important branch in the research of computer related fields. Nodes in mobile network communication system will enter and exit continuously, and then form a certain rule. Mobile network systems need to strictly request the bandwidth and timeliness of data transmission to ensure high-quality communication results. Through an efficient anti-jamming scheme, it can ensure that the mobile network system has stable information transmission and related functions under strong interference.

2.1 Disturbance Recognition and Analysis

Artificial Intelligence, abbreviated as AI. It is a branch of computer science. It produces an intelligent machine that can respond in a similar way to human intelligence. The research in this field includes robots, language recognition, image recognition, natural language processing and expert systems. Artificial intelligence can simulate the process of human consciousness and thinking. Recognition of interference factors in mobile communication networks is a weak part of traditional interference methods. Traditional methods focus on the research of anti-interference methods, but neglect the role of interference recognition. In this paper, pattern recognition in artificial intelligence is used to analyze the types of interference in order to deal with them pertinently in the future. Effective interference identification will greatly improve the efficiency of anti-interference and the speed of network operation.

(1) disturbance recognition analysis model
The interference spectrum data FAS collected by frequency sweeper is taken as the basis of the system, and the location function of interference cell is completed by pattern recognition. On the one hand, similar disturbance patterns are matched and located from the shape angle, on the other hand, from the FAS data feature point of view, and random forest pattern recognition method is used to locate similar disturbance characteristics of the cells, as shown in Fig. 1.

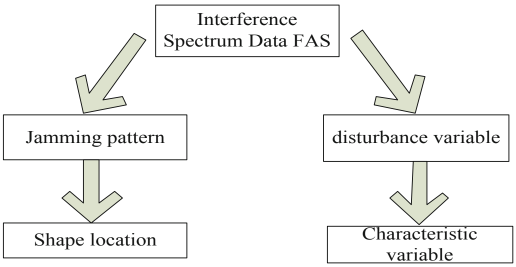


Fig. 1. Disturbance recognition analysis model.

Decision tree is not only a more understandable classifier, but also has advantages in training speed and memory usage. At the same time, considering the recognition of multiple possible classifications of target network elements, the system chooses the stochastic forest learning model based on decision tree. On the one hand, it has the advantages of decision tree, and at the same time, stochastic forest can improve the stability of training. It can count the votes of multiple classifications belonging to a single cell. It is a multi-classifier, i.e., multi-output model, which is the use of the system. The reason of disturbance in machine forest model learning [5].

Pattern recognition describes the characteristics of objects by extracting their features and phenomena. After learning and understanding the features, it establishes a learning rule model from objects to recognition results. The process is shown in Fig. 2.

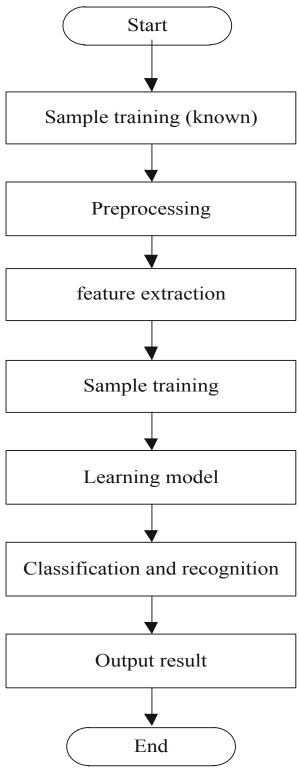


Fig. 2. Patterns recognition process.

As shown in Fig. 2 above, feature extraction and sample training are two key steps in the process of pattern recognition, which have a great impact on the recognition results, so feature extraction should be representative and the data of training set must be reliable. The extracted feature variables constitute the feature dimension of the pattern space, and the feature dimension is better representative for classification; the number of training samples should be enough, and the ratio of the sample number to the model space dimension should be at least greater than or equal to 3, preferably greater than or equal to 10. The main methods of sample training are decision tree, Bayesian classification training, random forest, neural network, support vector machine and so on. Stochastic forest method is used to build learning model and complete the learning process [6].

(2) feature extraction

Assuming that x represents a cluster of random variables consisting of n communication interference signals, y represents the frequency range of each cluster, and m represents a constant threshold of interference energy, the spectrum amplitude corresponding to the same frequency of each random variable in the random process is constituted into a new sequence, which is expressed by formula (1).

$$R = \frac{m \times y}{n \oplus \{p\}} \cdot x \tag{1}$$

In the formula, p represents a sequence of spread spectrum codes.

Assuming that a represents the finite additivity of the probability of communication interference signal, with the increase of random variable T' in the random process T, which consists of the spectrum sequence of communication interference signal, the probability of the corresponding spectrum amplitude also increases. Formula (2) is used to construct the spectrum matrix of communication interference signal.

$$G(f) = \frac{T \pm T'}{a \cdot f} \otimes \frac{E \cdot R}{h(2\pi f)} \tag{2}$$

In the formula, f represents the initial frequency of FM, E represents the linear frequency, R represents the number of time-domain segments, and h represents the sampling period of interference signal.

Assuming that v represents the symbol rate of the source, s represents the direct sequence pseudo-random code rate, b represents the corresponding amplitude of the same frequency, W represents the total probability of all amplitudes under each frequency, and z represents the spectrum distribution law of instantaneous interference of the fixed frequency signal, W is calculated by formula (3):

$$W = \frac{b \otimes z}{s} \otimes [v \oplus j] \tag{3}$$

In the formula, j represents the analysis window length of Fourier transform.

Assuming that d represents the spectrum statistical characteristics of full-time communication interference signal and k represents the change of signal position, formula (4) is used to calculate d:

$$d = \frac{R \oplus x(f)}{W \otimes r} \cdot ok \tag{4}$$

In the formulas, r and o represent the transformation parameters of the time domain and frequency domain of the communication interference signal.

In summary, in the process of optimum detection of communication interference signals in mobile networks, a new sequence of spectrum amplitudes corresponding to the same frequency of each random variable in the random process is formed by using probability and statistics method, and the spectrum matrix of communication interference signals is formed. The spectrum distribution law of instantaneous interference of fixed frequency signals is obtained, and the characteristic spectrum of communication interference signals is extracted to realize the shift. Optimal detection of communication interference signals in mobile networks lays the foundation [7].

(3) sample training

The Stochastic Forest method is to build a forest consisting of a decision tree, and there is no correlation between each decision tree. The basic component of random forest is decision tree. In the process of building multiple trees, feature subsets are selected randomly to make each decision tree different. Selecting subsets from the extracted feature variables to decide how to split the data is the best. It has proxy splitting with missing values and can judge the closeness (i.e. similarity) of two samples. The number of variables to be split and the number of trees in random forest are two important parameters in the training process. The number of training samples is represented by N, the number of characteristic variables by M and the number of trees by K. The steps are as follows:

1) The k-group training subset is formed by repeated sampling from training sample N, and each training subset is the training sample set of each classification tree.
2) Each classification decision tree is trained, and m (m < M) feature variables are randomly selected at each node of the tree. One or more of the M feature variables are selected to split according to the minimum impurity of the nodes, so that the tree can grow continuously without pruning in the process of growth.
3) According to the generated random forest, the target data are predicted and the classification results of each tree are counted.

The specific steps of sample training are shown in Fig. 3.

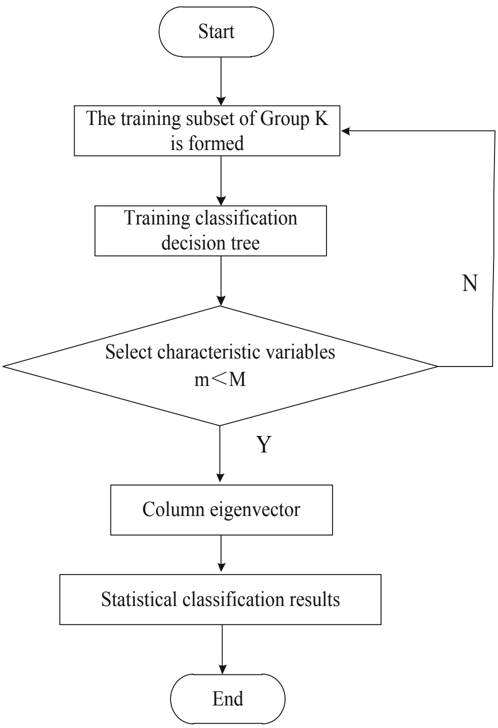


Fig. 3. sample training process.

2.2 Anti-jamming Processing of Mobile Communication Network Nodes

By summarizing the characteristics of different interference types, can distinguish the interference types from the spectrum performance of the received signals, make a rough judgment on the interference problems, and then make a survey and processing according to the results. The main interference in mobile communication system includes co-frequency interference, adjacent-frequency interference, inter modulation interference, repeater interference and other interference [8].

(1) anti-co-frequency interference
At present, mobile communication systems adopt cell structure to improve frequency utilization by using the same frequency multiplexing method, and the same frequency can be reused every certain distance. Under the condition of certain distance interval, the co-frequency interference in the system will not affect the normal communication too much. However, with the cell splitting and the increase of co-frequency multiplexing coefficient, a large number of co-frequency interference will seriously affect the normal operation of the system. When the carrier-to-interference ratio of the same frequency interference is less than a certain value, it will directly affect the communication quality of the mobile phone. Serious calls will be dropped or users can not establish normal calls.

Spread spectrum technology is used as information transmission mode. Spread spectrum code is used to modulate the transmitted information at the transmitter. The bandwidth of the original signal is broadened. The received information is decomposed coherently with the same spread spectrum code at the receiver to recover the information data. Through this process, the intensity of interference signal is reduced. In spread spectrum communication, the wider the spread spectrum, the stronger the anti-jamming ability.

(2) anti-adjacent frequency interference
Due to frequency planning and other reasons, there may be unreasonable design of adjacent frequency or coverage in adjacent cells, which will lead to adjacent frequency signals falling into the passband of adjacent frequency receivers and causing adjacent frequency interference. In addition, due to the near-far effect, the influence of adjacent frequency interference is also increased. When the adjacent carrier-to-interference ratio is less than a certain value, it will also affect the quality of communication, resulting in dropped calls or the inability to establish normal calls.

Aiming at the problem of adjacent frequency interference, power control technology is mainly used for anti-interference. Power control is to change the transmission power of mobile station or base station by radio within a certain range [9]. Power control can minimize transmission power and improve interference to other calls under the condition of good reception. Power control includes forward power control and reverse power control. Reverse power control is divided into open-loop power control which is only participated by mobile station and closed-loop power control which is jointly participated by mobile station and base station. For the adjacent frequency interference caused by far-near effect, the power control technology can be used to improve it. When the distance between the mobile station and the base station is closer, reducing the transmitting power of the mobile station can reduce the interference to other users. When the distance is longer, the transmitting power of the mobile station can be increased to overcome the increased path attenuation, so that the signal transmitted by the mobile station has the same signal strength as possible when it reaches the base station.

(3) anti-inter modulation interference
Because a large number of non-linear circuits are used in the communication system, when two or more different frequency signals enter at the same time, there will be inter modulation. If the frequency of modulated signal falls into the receiving frequency band, there will be inter modulation interference, and the direct consequence of interference is the waste of base station resources, but also the drop of words [10]. Frequency hopping is the main measure to solve intermodulation interference. Frequency hopping is to hop the carrier frequency of communication at several frequency points. Frequency hopping can play the role of frequency diversity and improve the error code characteristics caused by fading, but frequency hopping can also play the role of interference source diversity. Slow frequency hopping technology is adopted in mobile communication network. The frequency hopping rate is 217 hops. Frequency hopping is carried out between two slots. Fixed frequency is used in one slot and another frequency is used in the next slot to reduce the influence of interference.

(4) anti-repeater interference
The main reason for repeater interference is that the broadband repeater amplifies the useful upstream signal, and at the same time amplifies the noise, resulting in wideband interference. Mobile communication networks are gradually replacing existing broadband repeaters by using optical fiber frequency selective repeaters or by stretching RRU. However, due to the relative lag of station construction and site selection, many owners in weak coverage areas will install illegal broadband repeaters by themselves to solve their own coverage problems, while introducing a source of interference [11, 12].

The way to solve the interference of repeater is to start from two aspects: using optical fiber frequency selective repeater or stretching RRU to gradually replace the existing broadband repeater; Follow up the pace of urban construction, solve the problem of weak coverage through network planning and construction, and coordinate the elimination of private installed illegal repeaters through the radio management committee [13, 14]. In other words, to fundamentally solve the problem of repeater interference, it is necessary to solve the problem of user coverage through continuous network planning and construction, in order to suppress the emergence of repeater interference sources.

3 Mobile Communication Quality Testing and Analysis

In the above chapters, the quality of mobile communication will be affected after interference, so this simulation experiment analyses the quality of mobile communication with the participation of artificial intelligence, in order to judge the performance of the auto-disturbance rejection method of mobile communication network node based on artificial intelligence.

In the experiment, 200 users were selected for a one-month communication quality experience, and 100 mobile communication networks with artificial intelligence for anti-interference processing were selected as group A. Another 100 mobile communication networks using unattended artificial intelligence to participate in anti-interference processing, this group is group B. A month later, the communication satisfaction of 200 users (mainly in drop-off, connection, interference noise and other three aspects) was investigated. With the above data as an indicator, a mobile communication quality evaluation model was constructed, as shown in Fig. 4 below.

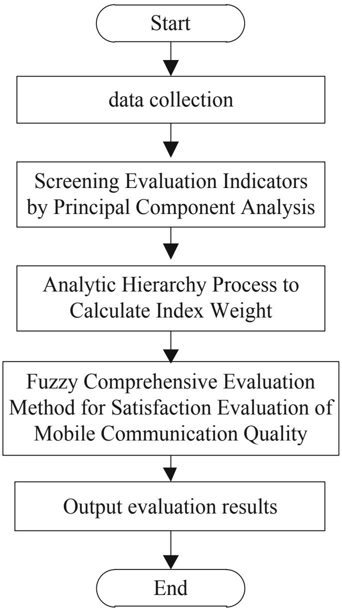


Fig. 4. Mobile communication quality assessment model.

After the establishment of the model, the model is used to evaluate the call quality. The evaluation results are shown in Table 1.

Table 1. Evaluation results (bits).

Name	Group A	Group B
Very satisfied	34	5
Satisfied	64	32
Commonly	2	45
Dissatisfied	0	10
Very dissatisfied	0	8

As can be seen from Table 1, 34 of the evaluations given by group A users are very satisfactory, 64 of them are satisfactory, and 2 of them are general. In the evaluation given by group B users, 5 are very satisfied, 32 are satisfied, 45 are general, 10 are unsatisfactory, and 8 are very unsatisfactory. Compared with group B, group A users are more satisfied with the quality of mobile communication than group B, which proves that the communication quality is higher after the anti-jamming treatment of this method.

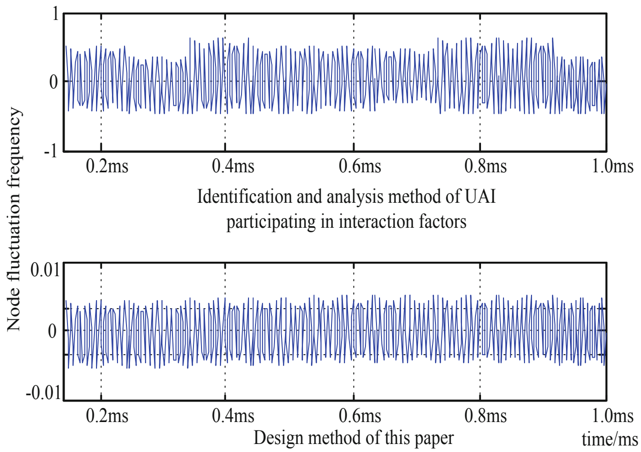
On the basis of the above experiments, in order to further verify the performance of the mobile communication network node anti-interference method under this method, the attack data in KDD cup-99 data set is selected to test the anti-interference effect of different methods. Table 2 shows the test data set.

Table 2. Test data set.

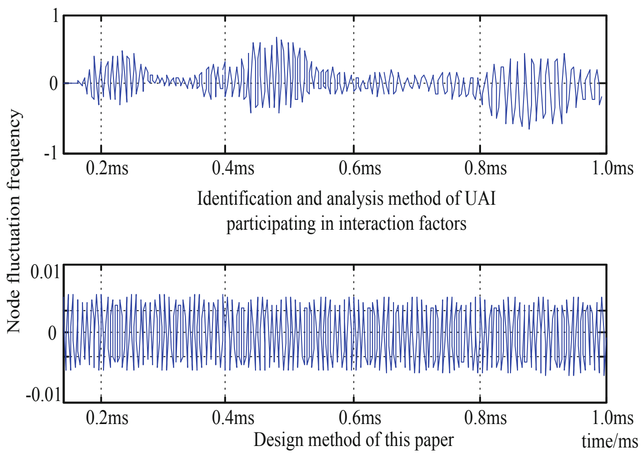
Attack categories	Dataset type	Benign sample	Malicious samples
Dos	1	2157	2254
Probing	2	3965	3647
	3	2954	3015
U2L	4	3654	3519
R2L	5	1987	2024

The KDD CUP-99 data set contains real data sets generated by various user types, different network traffic and attack means. The whole data set contains about 5 million data records. The data exception types are divided into four categories, including DOS denial of service, R2L unauthorized remote host access, U2R unauthorized local super user privilege access, and probing port monitoring or scanning. Under normal access, the whole data set should contain 5 types, which are labeled as 1,2,3,4,5 respectively. Each data record contains 41 features, including 32 continuous features and 9 discrete features. Because the whole data set is very large, only 10% of the data are selected for experiment.

Based on the above data, the anti-interference effect of the traditional method of UAI participating in the identification and analysis of interaction factors is compared with that of the method in this paper. The results are shown in Fig. 5. Among them, Fig. 5(a) shows the anti-jamming effect comparison when the amount of attack data is small, and Fig. 5(b) shows the anti-jamming effect comparison when the amount of attack data is large.



(a) Less attack data



(b) Large amount of attack data

Fig. 5. Comparison of anti-jamming effect under different methods.

According to Fig. 5(a), in the case of less attack data, the anti-interference effect advantage of the design method in this paper is not obvious, which shows that in this case, both the traditional method and the design method in this paper have better anti-interference effect.

According to Fig. 5(b), when there are many attack data, the anti-interference effect of the design method in this paper is obviously better than that of UAI participating in interaction factor identification and analysis method, which shows that the design method in this paper can adapt to different attack data amount, and the anti-interference effect is better. This is because the method in this paper constructs an interference identification analysis model based on artificial intelligence technology. Using this model to identify and analyze the interference factors of mobile communication network nodes, can summarize the characteristics of different interference types, and accurately judge the interference types, so as to improve the anti-interference effect.

In order to further verify the effectiveness of the proposed method, the anti-jamming effect of different methods is compared with the interference node identification time. The comparison results are shown in Fig. 6.

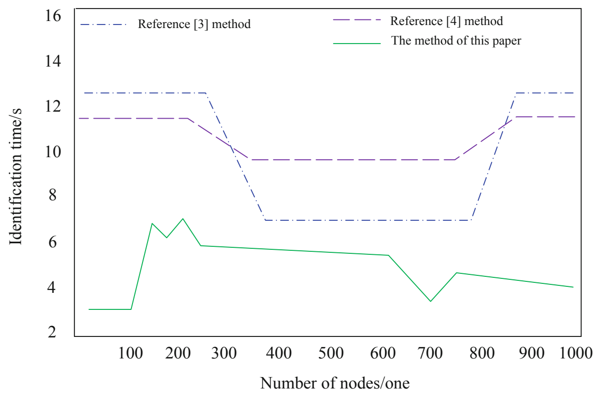


Fig. 6. Comparison of jamming node identification time.

It can be seen from Fig. 6 that the time consumed by the method of reference [3] and the method of reference [4] is much longer than that of the method in this paper, and the longest time of this method is 7S. It shows that the recognition efficiency of this method is higher, and it can realize the identification of interference nodes in a short time.

4 Conclusion

In summary, the mobile communication network is the carrier of modern people's long-distance communication and plays a key role in production and life, so it has important practical significance to ensure the quality of mobile communication. People are disturbed by various factors in the process of communication, such as dropping calls, switching, congestion, murmur and so on. Aiming at this phenomenon, an artificial intelligence based ADRC method for mobile communication network nodes is proposed. The innovation of this method and the application of artificial intelligence in interference recognition make up for the shortcomings of traditional anti-jamming methods.

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