An Adaptive Enhancement Algorithm for Weak Signals in Communication Networks Based on Wavelet Transform

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Abstract. In order to improve the accuracy of network weak signal prediction, combined with the changing characteristics of network signals, and considering the limitations of the current network signal prediction model, a wavelet transform-based communication network weak signal enhancement adaptive algorithm is proposed. Compressing and decompressing signal data from weak signals in communication networks is essential for the real-time distribution and synchronization of network communications. It is used to evaluate the modulation mode of a weak network signal. This is the content of joint research on weak signal processing and pattern recognition in communication networks. This paper takes wavelet transform as the theoretical basis of the research, uses the adaptive enhancement algorithm as the main research algorithm, and integrates its important contents to analyze and research the optimization of the adaptive enhancement algorithm. This paper takes the classic adaptive enhancement algorithm as the research object, and optimizes and improves the weak signal of the communication network respectively. The adaptive enhancement algorithm in wavelet transform can be regarded as a kind of node sorting algorithm, so it can be used to construct weak signal strategy of communication network. The experimental results show that this research has a better effect on using wavelet transform and adaptive enhancement algorithm parameters to estimate the weak signal prediction value of the communication network and calculate the prediction error. From the prediction error of the adaptive enhancement algorithm, check whether the observed signal contains a weak signal.

Keywords: Wavelet Transform, Communication Network, Weak Signal, Adaptive Enhancement Algorithm

1. Introduction
In simple terms, communication is the fast, efficient, safe and accurate transmission of information between channels. In modern society, as communication network resources become more and more valuable to make full use of channel bandwidth, people have developed various signal modulation techniques [1]. At the same time, due to the rapid development of science and technology, users have put forward higher and higher requirements for information transmission. With the rapid development of network technology and the continuous development of communication technology, various types of communication networks have appeared [2]. The communication network pervades all fields of society, and it is inseparable from the network for people's work, life and study. As the amount of data continues to increase, the types of network signal data sent are also increasing, such as video, image, sound, etc., and because the network signal and network traffic cannot be effectively managed, especially during the peak period of Internet access, the network often appears Congestion [3]. Therefore, it is extremely important to optimize the communication network signal, and there is no efficient algorithm for the detection of weak signals in the communication network. The adaptive enhancement algorithm based on wavelet transform has been successfully applied in the digital signal compression of weak signals in communication networks because of its singularity analysis and feature extraction capabilities [4].

In order to improve the prediction accuracy of weak network signals based on the change characteristics of weak network signals, a prediction model based on wavelet transform weak network signal adaptive enhancement algorithm is established. According to the test results table, the adaptive enhancement algorithm detection through wavelet transform can improve the prediction accuracy of weak network signals, effectively control the lower network signal prediction errors, and improve the detection efficiency [5]. Weak signal prediction The detection technology used to detect communication signals can automatically detect the modulation mode of weak network signals with an adaptive enhancement algorithm, which has very important applications in multi-system communication and soft radio [6]. Establishing feedback between the fundamental frequency power of the signal receiving system and the excitation amplitude of the system can complete the quantitative description of the characteristics of the signal system and the detection mode of weak network signals, and then construct it according to the rules and the quantitative description of the characteristics of the signal system [7].

In order to detect the weak signal in the communication network, the wavelet transform analysis method is used to perform coefficient transformation on the signal samples collected in the same period, and at the same time, the nonlinear relationship between the input signal value and the output value is obtained, and the adaptive enhancement algorithm is set according to the conversion factor. The non-linear function normalization processing is performed through the enhancement algorithm to reduce the noise of the signal samples and retain the data information of the original signal. In theory, weak signal detection technology uses techniques such as information theory, computer science and physics to obtain statistical information about the characteristics of the detected signal [9]. The common weak signal detection method is based on analog settings, amplify the signal through a dedicated channel, and then perform detection calculations based on the channel signal. On this basis, based on the detection principle of weak signals in the communication network, the detection principle of transient signals and periodic signals, this paper discusses the long detection time and low detection accuracy of classical detection methods [10].
2. Adaptive enhancement algorithm

Aiming at the problems of traditional algorithms in weak signals in communication networks, an adaptive enhancement algorithm for weak signals in communication networks based on wavelet transform is proposed. By replacing the average weight with adaptive enhancement weights, the signal components are algorithmically enhanced in space. Wavelet transform represents a signal through a series of wavelet function families. The wavelet function family can be defined as:

\[ f(x) = \sum_{k} c_{j}(k) \psi_{j}(x) + \sum_{j,k} d_{j}(k) \phi_{j,k}(x) \]  

(1)

In the formula, \( j \) is the starting scale; \( c \) is the scale coefficient; \( k \) is the wavelet coefficient. The approximate component obtained by using the discrete wavelet transform can be understood as an approximation of the signal image. After wavelet transform, the signal components are decomposed to obtain approximate components, and then the adaptive enhancement algorithm is used to improve:

\[ L_{\text{approx}} = \frac{1}{N} \sum \log [p_i p*(1-p)(1-p)] \]  

(2)

Among them, \( P_i \) is the target in the i-th node; \( \bar{P}_i \) is the non-target in the i-th node. \( L_{\text{approx}} \) is the regression function of the detection signal frame, which is mainly used to modify the node coordinates of the signal parameters to obtain the best weak signal detection frame.

\[ L_{\text{approx}} = \lambda \frac{1}{N} \sum P_i L_{\text{approx}}(t_i) \]  

(3)

Based on the calculation results, it proved the existence of transient signals and periodic signals, and based on them, established a weak network signal detection model based on the adaptive enhancement algorithm, and identified the weak network transmission signal prediction error formula based on the noise layer:

\[ L_{\text{approx}} = R(t_i - \hat{t}_i) + \sigma |t_i - \hat{t}_i|^{0.5} \]  

(4)

Among them, \( t \) is the predicted target signal detection frame coordinates; \( \hat{t} \) is the real weak signal detection frame coordinates; \( \sigma = 0.3 \), used to control the smooth area of the loss function. \( L_{\text{approx}} \) In order to enter the weak signal of the communication network, the decomposed wavelet transform coefficient containing signal noise, the final terminal loss function is:

\[ f(p_x) = \min_{p_x} \frac{1}{2} ||p||^2 + \frac{1}{m} \sum \lambda_1 l(p_x, y) \]  

(5)

3. Modeling method

This model mainly combines the wavelet transform with the weak signal of the communication network to extract the waveform of the weak signal, thereby constructing the algorithm model. Mainly use the multi-resolution characteristics of wavelet analysis and the ability of network weak signal restoration and feature extraction. The model of this algorithm is:
\[ P(x \mid c(z), o) = h^w(x - z) \] (6)

\[ PR(p) = (1 - d) + d \sum_{i=1}^{n} \frac{PR(T) \times W(t_i)}{C(T)} \] (7)

The wavelet transform coefficient theory at different scales is obtained by wavelet decomposition, and the reconstructed signal after the wavelet transform coefficients of each scale are processed, and the target trust mapping model is as follows:

\[ m(x) = P(x \mid o) = be^{- \frac{X - x}{a}} \] (8)

After a period of automatic learning, the error signal meets the corresponding weak signal accuracy requirements. At this time, the scale and weight of the wavelet transform are the best values under this accuracy. The update equation for the weight of the weak signal of the communication network is:

\[ m(x) = \sum_{i \in \chi} P(x \mid c(z), o)P(c(z) \mid o) \] (9)

It can be seen from the model that after decomposing the weak signal immersed in noise into wavelets, it is equivalent to using a multi-sample filter bank to filter the signal, thus obtaining:

\[ H(x) = P(x \mid o) = be^{- \frac{X - x}{a}} \] (10)

\[ H(x) = \sum_{i \in \chi} P(x \mid c(z), o)P(c(z) \mid o) \] (11)

Therefore, for the weak signal in any communication network, the impulse response of the sub-band filter is shorter than that of the broadband filter, thus creating a more accurate weak signal detection model. The prediction accuracy and prediction error of this model are compared with other models, as shown in Table 1:

| Model name    | Forecast accuracy/% | Forecast error/% |
|---------------|---------------------|-----------------|
| ELM           | 88.54               | 9.34            |
| WA-BPNN       | 90.25               | 7.58            |
| Paper model   | 95.36               | 3.42            |

In the process of adaptive update and learning of the weights of the weak signal sub-bands of each communication network, different degrees of adaptive enhancement algorithms can be used, which will obtain a faster convergence rate than the full-band adaptive weak signal filter.

4. Evaluation results and research
4.1. Filtering of Weak Network Signals by Wavelet Transform

As shown in Figure 1, the data statistics of the weak network signal filter can be obtained by analyzing the true value and estimated value of the wavelet transform. By analyzing the frequency domain of various typical weak grid signals, the following conclusions can be drawn: the weak network signal is an extremely low frequency signal, the frequency range is usually 0 to 4.0 Hz, and the upper limit frequency is usually about 0.1 Hz. For the weaker main signal, the upper frequency limit is usually less than 4 Hz. The peak frequency of weak and medium network signals is usually 0.025 Hz. As the frequency increases, the bandwidth increases, and the peak frequency of the spectrum increases to higher frequencies. Weak short-distance network signals have more frequency components, wider bandwidth, and sometimes more peak spectral frequencies. As the distance increases, the high frequency components gradually become weaker, the bandwidth becomes narrower, and the number of spectral peaks decreases and shifts to the low frequency. The longitudinal response of a weak network is a characteristic of a weak network in the time domain, but in practical applications, the target signal is often suppressed by external magnetic interference. The signal-to-noise ratio of the measured signal is usually less than 1, which determines the frequency domain characteristics of the weak network. The frequency domain function to analyze and process the target signal. Weak network signal detection is a new modulation detection method. The detection rate of weak network signals is low, the signal-to-noise ratio is low, but the amount of calculation is large, the real-time performance is poor, and the learning rate is low; wavelet transform has the characteristic part of the signal in both the time domain and the frequency domain. Functional detection characteristics with high frequency resolution and low time resolution in the low frequency range, high time resolution and low frequency resolution in the high frequency range, and high transient detection level. It can accurately describe the changing moments of digital signals, and the ability to recognize weak network signals is better under low SNR.

4.2. Adaptive enhancement algorithm detection advantages
As shown in Figure 2, in the process of using the game model to analyze the optimal offensive and defensive decision-making of network security, we must pay attention to grasping the network reachability and vulnerabilities, and generate a state offense and defense map. In this process, we must pay attention to grasping the probability of success and the damage of the attack path, so as to ensure that the focus of the defense process can be grasped, so that the optimal offensive and defensive decision can meet actual needs. The mechanism of the offensive and defensive game model is to comprehensively consider the predicted behavior and actual behavior of the individual in the research target, so as to study the optimization strategy of prediction and actual behavior. The offensive and defensive game model is applied to specific network evaluation and real-time protection, and its mechanism of action is mainly manifested in four aspects. First, through game theory, the defender can find malicious nodes and normal nodes in the computer system, so as to comprehensively analyze the vulnerable links and possible security threats in the system, and prepare for possible threats in advance. Based on random game theory, it can not only analyze the Nash equilibrium of both offense and defense, but also effectively analyze the offense and defense strategies of both parties. Finally, applying the theory of offensive and defensive game model to the computer real-time active defense system can analyze the attacker's attack intention and establish the system's offensive and defensive game model, thereby ensuring the effectiveness of network information security evaluation and system protection.

5. Conclusion

On the current basis, network signal recognition technology is developing rapidly, and traditional communication network signal detection methods have many limitations. It is imperfect to process the received signal and evaluate the corresponding modulation parameters in the modulation detection of the weak signal of the communication network without the corresponding technical conditions, and it will often cause loss or neglect of the weak signal of the network. On this basis, by combining the activation conditions of the adaptive enhancement algorithm, an adaptive enhancement algorithm design on the weak signal detection of the communication network is created, and by adjusting the signal model parameters, the weak signal that meets the weak signal detection requirements is obtained from the communication network. This paper presents an effective method to detect weak communication network signals under wavelet transform technology. Experimental results show that the adaptive enhancement algorithm under wavelet transform used for weak network signal detection can greatly improve the signal-to-noise ratio and the detection ability.
of weak network signals, thereby responding to the network signal, so the weak signal of the communication network based on wavelet transform is adaptively enhanced. The algorithm can detect weak signals in the communication network more effectively.

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