Intelligent calculation method of communication Transmission loss based on hybrid neural network

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Abstract. The traditional calculation method of communication transmission loss has the calculation error of communication loss, and the application scope of the calculation method is small. Therefore, this paper proposes an intelligent calculation method of communication transmission loss based on hybrid neural network. Based on the ideal free space transmission loss model, the transmission loss model of outdoor environment is established; the communication obstacles in the transmission process are determined; and the transmission loss calculation area is divided. The calculation of communication transmission loss is completed by using hybrid neural network combined with the specific parameters of the demarcated area. By comparing with the method based on neural network, it is verified that the method using hybrid neural network can improve the calculation accuracy by about 77.1%, and the method has a wider range of application.

1. Introduction

The information source will increase the transmission energy value of loss when transmitting the transmission signal according to the transmission and calculated value, which can not only avoid the deviation of communication content receiving caused by the loss in the communication transmission process, but also evaluate the communication transmission quality according to the calculated results. Traditional communication transmission loss calculation method uses artificial neural network to calculate communication transmission loss through statistical processing of a large number of historical data[1]. However, this method is limited by the influence of various factors in the communication transmission environment, which makes the error of the calculation result unstable and cannot be widely applied to most communication transmission losses.

Hybrid neural network is based on neural network, which integrates different neural networks or neural networks with other technologies. It has the advantages of hybrid neural network, which can further improve the efficiency of neural network solution[2]. In order to clarify the loss of data in the communication process and improve the quality of data transmission communication, this paper will study the intelligent calculation method of communication transmission loss based on the above analysis.

2. Research on intelligent calculation method of communication Transmission loss based on hybrid neural network
2.1 Establish the communication transmission loss model

When communication electromagnetic wave propagates in free space, the phenomenon of transmission path loss will occur. To simplify calculation, the average attenuation value of transmitting and receiving signals at both ends of sending and receiving is used to replace the transmission path loss[3]. Therefore, the definition of transmission path loss can be obtained:

\[
PL(dB) = 10\log_{10}\left(\frac{P_t}{P_r}\right) \\
P_r = (d)\left(\frac{P_GG_r\lambda^2}{(4\pi)^2d^2L}\right)
\]

(1)

In formula (1), \(P_r\) is the signal energy of the communication receiver; \(P_t\) is the signal energy of the transmitting end of communication information source; \(d\) is the straight-line distance between the transmitting end and receiving end of the signal in outdoor communication; \(G_t\) is the gain of the transmitting antenna at the signal transmitting end; \(G_r\) is the gain of the receiving antenna at the signal receiving end; \(L\) is the transmission loss factor; \(\lambda\) is the wavelength of the communication wave. In free transmission, the gain of transmitting antenna at the transmitting end and receiving end can be set as 1. According to relevant theoretical knowledge, the received signal strength is related to the signal propagation distance, and a parameter is introduced to represent the relationship between the signal propagation distance and the received signal strength[4]. Therefore, the transmission path loss model established is as follows:

\[
PL(d) = PL(d_0) + 10\gamma \log(d/d_0) + X_\sigma
\]

(2)

In formula (2), in free transmission, the value of parameter \(\gamma\) is 2; \(X_\sigma\) is a Gaussian random distribution function of the actual received signal strength random fluctuation[5], whose mean value is 0 and variance is \(\sigma\). During outdoor transmission, under the influence of obstacles, meteorological factors and environmental factors in the transmission environment, the loss of outdoor transmission communication is different from that of free space transmission. Some parameters are introduced to obtain the following model of outdoor communication transmission loss.

\[
L = K_1 + K_2 \log d + K_3 \log H_{Txe} + K_4 D_t + K_5 H_{Roe} + PL(d)
\]

(3)

In formula (3), \(K_1\) is the fixed offset in the transmission process, and the unit is dB; \(K_2, K_3, K_4, K_5\) are product factors; \(H_{Txe}\) is the effective height of the transmitting antenna; \(D_t\) refers to the loss caused by avoiding obstacles on the straight-line distance during communication signal transmission, and the unit is dB. \(H_{Roe}\) is the effective height of the receiving antenna. After the transmission loss model is established, the transmission calculation area is divided.

2.2 Hybrid neural network calculates communication transmission loss

In this paper, the transmission loss calculation model established in formula (3) of hybrid neural network combined with genetic algorithm and RBF neural network is selected. Based on the three-layer forward RBF neural network, the center of the hidden layer in the neural network is determined by genetic algorithm, so as to determine the parameters of the hybrid neural network[6].

The fitness function of the genetic algorithm is determined according to the extremum evaluation process of the objective function in the training process of the neural network, then the fitness function of the hybrid neural network is as follows:
fitness = \frac{1}{N} \sum_{i=1}^{N} \sum_{j=1}^{K} (Y_j(i) - \bar{Y}_j(i))^2 \quad (4)

In formula (4), \( Y_j(i) \) is the actual output of training data \( i \) at the output node \( j \) during mixed neural network training; \( \bar{Y}_j(i) \) is the expected output of training data \( i \) at the output node \( j \); \( K \) is the number of output nodes of hybrid neural network; \( N \) is the number of samples. The calculation process of communication transmission loss model using hybrid neural network is as follows:

(1) Set the initial population size as 20, calculate the path loss parameter value according to the given antenna height and electromagnetic frequency of transmission signal, and convert the parameter value into binary code. Set the number of iterations and extract the pre-processed values to calculate the fitness function. (2) The calculated fitness function value is used as the initial parameter of the hybrid neural network to calculate the transmission loss. According to the evolution, variation and genetic process of genetic algorithm, the calculated value is obtained once. (3) Use historical data to correct the model and verify the square value of data error as the termination condition of hybrid neural network solution. When the hybrid neural network reaches the termination condition, the calculation is stopped. The data output by the hybrid neural network is the communication transmission loss value. Set the parameter to zero and wait for the next calculation. The research on the intelligent calculation method of communication transmission loss based on hybrid neural network is completed above.

3. Verification simulation

3.1 Simulation process

The transmission loss in the wireless communication network shown in the figure below is calculated using the experimental group and the comparison group method.

![Wireless network structure diagram](image)

Figure 1 Wireless network structure diagram

The communication parameters between various communication endpoints in the wireless communication network in the figure above are shown in the following table.

| Serial number | Communication nodes | Communication path | Communication data volume/MB | Intensity of communication/Hz |
|---------------|---------------------|--------------------|-----------------------------|-----------------------------|
| 1             | 1→4                 | 1→2→13→4          | 15                          | 300                         |
| 2             | 2→6                 | 2→11→12→7→6       | 20                          | 300                         |
| 3             | 3→8                 | 3→4→5→6→7→8       | 25                          | 400                         |
| 4             | 2→5                 | 2→13→4→5          | 18                          | 500                         |
| 5             | 5→9                 | 5→6→7→8→9         | 14                          | 500                         |
| 6             | 6→11                | 6→7→12→11         | 16                          | 400                         |
3.2 Simulation results

Artificial neural network and hybrid neural network calculate the communication transmission loss between nodes in the wireless network. The number of iterations of the two neural networks in the calculation process is shown in the figure below.

![Figure 2 Comparison of iteration times of neural network](image)

By analyzing the figure above, it can be seen that both neural networks can complete the iterative calculation of communication loss within a limited time, while hybrid neural networks can achieve the iterative target value in a shorter time with a smaller number of iterations. It shows that the number of iterations is less when using hybrid neural network, which can save the time of calculating communication loss to a great extent.

According to the communication parameters in Table 1, the measurement of communication transmission loss is taken as the reference value, and the calculation error of the two methods is obtained through calculation. The experimental group and the comparison group method calculate the error of transmission loss of each node in the wireless communication network as shown in the table below, analyze the data in the table, and draw the corresponding experimental conclusion.

| Serial number | Experimental group | Control group |
|---------------|--------------------|---------------|
| 1             | 1.53               | 6.13          |
| 2             | 1.96               | 9.54          |
| 3             | 1.69               | 6.51          |
| 4             | 2.09               | 6.86          |
| 5             | 1.69               | 9.11          |
| 6             | 1.81               | 6.44          |
| 7             | 1.63               | 6.92          |
| 8             | 1.83               | 9.42          |
| 9             | 1.90               | 8.96          |
| 10            | 1.46               | 6.82          |

By analyzing the data in the above table, it can be seen that there is a large difference between the two calculation methods in calculating the communication transmission loss with the measurement value of the detection instrument at the network receiver as the standard reference. The error between the communication loss calculated by the experimental group method and the standard value is much smaller than that calculated by the comparison group method. The average error of the two groups in the above table was calculated. The average error of the experimental group was 1.759dB, and that of
the comparison group was 7.671dB. Further calculation shows that in this test, compared with the comparison group method, the experimental group method has improved the calculation accuracy by about 77.1%. It is shown that the calculation accuracy of communication transmission loss can be improved effectively by using the calculation method studied in this paper.

4. Conclusion
Communication transmission loss refers to the energy loss per unit length in the propagation of electromagnetic wave transmission signal along the signal transmission guide structure. Due to the influence of communication transmission environment and transmitted signal energy, excessively high transmission loss will cause the receiving end unable to receive information or incomplete received signal. In this paper, the hybrid neural network is used to optimize the communication loss calculation method. The reliability of the intelligent calculation method of communication transmission loss based on hybrid neural network is verified by experiments. In the future research, it is necessary to further optimize the hybrid neural network in order to expand the application scope and calculation accuracy of the method.

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