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Wind Speed Prediction based on Neural Network Algorithm of Mapreduce

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Abstract

In order to solve the relatively lack of research on the wind speed prediction of domestic transmission lines. In this paper, the time series analysis method is used to predict the wind speed of the transmission line, and the prediction accuracy is not high. By consulting related references, this paper proposes a combination of BP neural network algorithm and genetic algorithm GA-BP neural network algorithm combined with time series analysis method to obtain high-precision wind speed prediction algorithm. Finally, using the advantages of MapReduce distributed operation mechanism, the GA-BP neural network algorithm is implemented on MapReduce. The simulation results show that the algorithm has a great improvement in prediction accuracy compared with the time series analysis method.

Keywords

Transmission line; BP neural network algorithm; Genetic algorithm; MapReduce.

1. Introduction

The vibration of transmission line caused by strong wind is one of the main meteorological disasters affecting the safety of electric energy transmission. High voltage transmission tower lines have the characteristics of towering structure and long span structure, which makes them very sensitive to wind load, and because transmission tower lines are usually distributed in the field, Therefore, it is difficult to monitor the wind speed around transmission tower line for a long time [1]. The wind speed prediction model for the transmission tower system can provide a reference for the structural design of the transmission tower line, and can also set aside sufficient time for the power maintenance personnel to determine reasonable countermeasures to deal with the strong wind situation.

One of the key techniques of wind speed prediction is to select a suitable prediction method to establish a reasonable mathematical model for the measured wind speed around the transmission tower line, and to realize the advance prediction of wind speed. Many scholars at home and abroad put forward various wind speed prediction methods based on the research of wind speed prediction. literature combining the meteorological model with the neural network algorithm, the parameters such as wind speed, wind direction, temperature and air pressure in the meteorological model are used as the input of the neural network to realize the prediction of wind speed [2]. The FIR filter and IIR filter are used to predict the wind speed literature, and the state space model represented by discrete Markov chain is used to realize the wind speed Optimal prediction. Literature use time series analysis to establish ARMA model to prove that the length of prediction time directly determines the accuracy of wind speed prediction [3]. Document Kalman filter is used to predict wind speed under stable wind speed. Based on time series analysis and BP neural network algorithm, a wind speed prediction model is established [4]. Moreover, BP neural network algorithm can be integrated into the

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MapReduce programming model to predict the wind speed information quickly by processing the massive wind speed data [5-6].

The paper is organized as follows. Section 2 presents the processed wind speed data. Section 3 proposed the GA-BP neural network of MapReduce predict the wind speed. GA-BP algorithm based on MapReduce in Section 4. Conclusion of the present research work is given in Section 6.

2. Processing of Wind Speed Data

Because the wind speed time series package is nonstationary and nonlinear, it is necessary to test the measured wind speed series when establishing the wind speed prediction model. If the wind speed sequence is not stationary, it is necessary to smooth the wind speed sequence. In this paper, autocorrelation coefficient and partial correlation number are used to test the stationarity of wind speed series. According to mathematical statistics theory, the autocorrelation coefficient of stationary sequence is trailing or truncated. If the autocorrelation coefficient or partial correlation coefficient of a time series is neither trailing nor closing, then the sequence can be judged to be nonstationary, if the self-correlation number and partial correlation number of the sequence decay slowly or show a Now periodic attenuation, then the sequence is called stable.

In this work, the data originated from a wind measuring point in Guangdong Province of China, the wind speed data is measured every 3 minutes, the first 500 sample data $\{X_t\}$is shown in Fig.1.

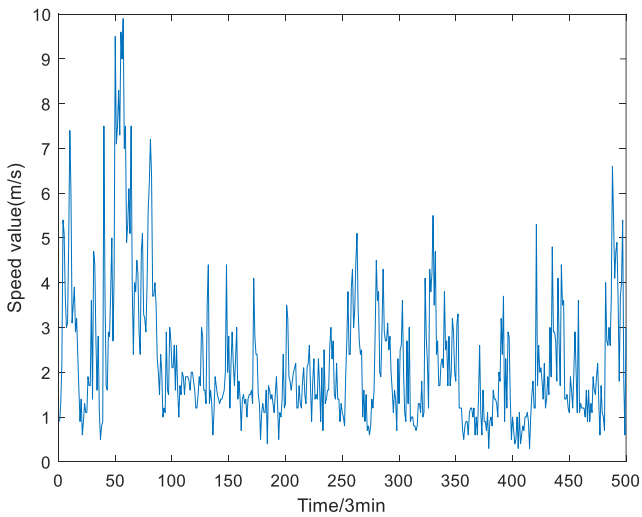

Fig 1. The sequence of wind speed

3. Wind Speed Prediction based on Neural Network of MapReduce

3.1. The Theory of GA-BP

The BP neural network has a variety of mapping ability and strong learning ability, it can predict the state of complex system without relying on mathematical modeling, but because BP neural network is a gradient-based method, It has the defect of slow convergence and easy to fall into local solution. Therefore, in the design of this paper, BP neural network is combined with genetic algorithm, because of the robustness of genetic algorithm, it can be used for large-scale parallel processing calculation. Therefore, the optimization process is carried out in the whole solution space and does not depend on the selection of population initial values. and thus

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overcome the shortcomings of the BP neural network algorithm. The combination of genetic algorithm and BP neural network algorithm is called GA-BP algorithm.

BP neural network is a multi-layer feedback network, including input layer, hidden layer, output layer, BP neural network model is shown in Fig.2. Fig .2 is a three-layer BP neural network diagram.

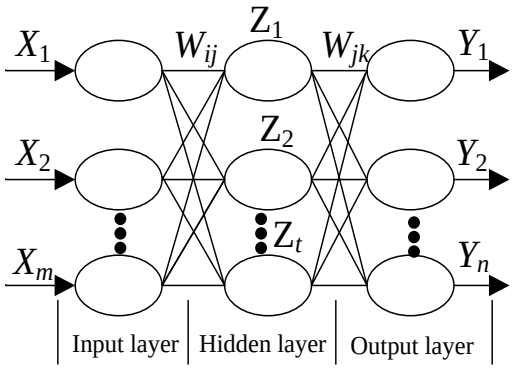

Fig 2. The model of BP neural network

The network structure is m-t-n, in which there are m neurons in the input layer, t neurons in the hidden layer and n neurons in the output layer. The relationship between input layer vector X, hidden layer vector Z and output layer vector Y is as follows:

$$Z_j = f\left(\sum_{i=1}^{m} W_{ij} \cdot X_i + \theta_{ij}\right) \tag{1}$$

$$Y_k = f\left(\sum_{j=1}^{t} W_{jk} \cdot Z_j + \theta_{jk}\right) \tag{2}$$

Where f(*) is the activation function of neurons, usually taking the $f(x) = \frac{1}{(1+e^{-x})}$. The learning process of BP neural network has two processes: signal forward propagation and error back propagation. When the signal is forward propagation, the input vector X input from the input layer, map in the hidden layer, get the vector Z enter the output layer. If the output vector Y does not match the expected output, the error back-propagation phase. The back propagation of error is to input the error vector into the output layer, then adjust the weight of the network according to the gradient descent method in the hidden layer through the hidden layer, and then return it to the input layer. Forward propagation of signals and back propagation of errors to complete a given number of cycles or errors to meet the requirements.

The genetic algorithm is used to adjust the weights of the BP neural network in this paper because of the defects of gradient descent in the learning process of the BP neural network. Genetic algorithm is an adaptive optimization method based on the principle of biological evolution. Genetic algorithm represents the solution of the problem as a string expressed by coding. From the initial gene individual population, according to the fitness function, High fitness individuals are selected to cross and mutate to produce the next generation of individual populations. After many iterative operations, the excellent genes in individuals are retained and combined to obtain better gene individuals. Thus From the point of view of algorithm, the optimal solution is carried out continuously. The improved GA-BP algorithm is shown.

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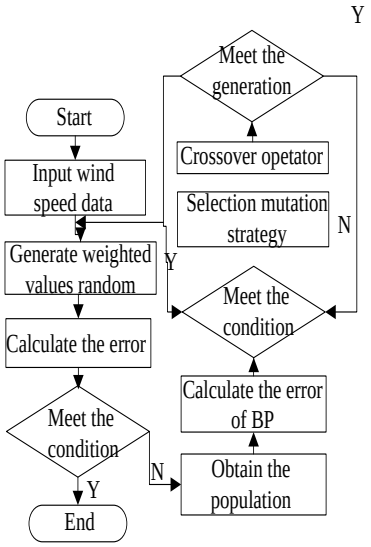

Fig 3. The framework of GA-BP algorithm

Input preprocessed wind speed data and let the neural network randomly generate a set of weights and thresholds to complete the initialization of the neural network; Find out the actual output of the neural network forward propagation, and judge whether the training times meet the requirements and whether the error between the actual output value and the expected output value meets the requirements; Generate the initial population of the genetic algorithm. The weights and thresholds of the neural network are connected in a certain order to form an individual, and then N-1 other weights and thresholds are generated according to the method of initializing the neural network, and then the same connection generates N-1 individuals. Finally, the weights and thresholds are expanded and binary coded. Then output the best weight values based on the GA.

3.2. GA-BP based on the MapReduce

The key point of combining GA-BP neural network algorithm with MapReduce is to let the Map function train the sample data of the node, output the neural network weight after a certain amount of training, and collect the output value of each map function Reduce the function. These neural network weights are averaged as new neural network weights. The process of the algorithm is shown in Fig.4.

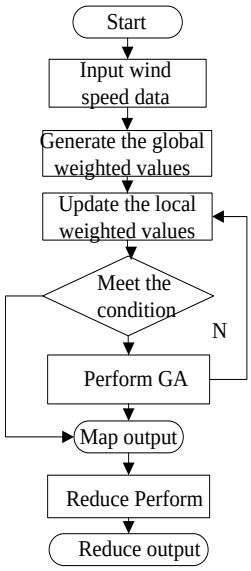

Fig 4. The framework of MapReduce

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4. The Experimental Result

The BP neural network algorithm is improved by genetic algorithm, and the training and learning process of the sample set is optimized based on the parallel distributed operation mechanism of the MapReduce model. The wind speed prediction results obtained by using MapReduce time series analysis and GA-BP neural network algorithm are shown in Fig.5.

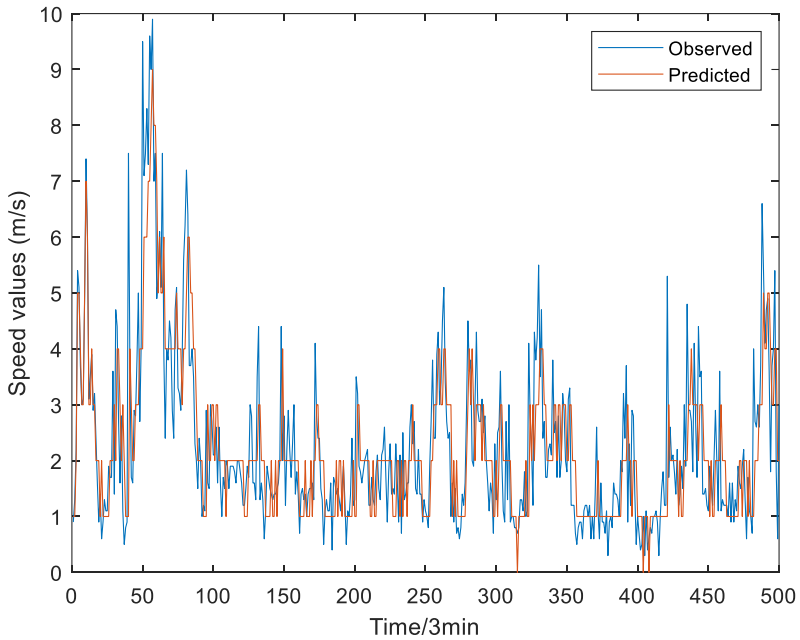

Fig 5. The predicted results

we can see from Fig.5 that the wind speed prediction sequence obtained by the MapReduce based GA-BP neural network algorithm has high prediction accuracy. But we can also see that there is a big deviation between the prediction of wind speed and the actual situation at the inflection point of wind speed change. Generally, the processing method of sampling is to process the wind speed data by sliding average first, and to find out the correlation coefficient between the wind speed data after sliding average processing and the actual maximum wind speed data. Finally, the correlation coefficient of wind speed prediction data set obtained by GA-BP algorithm is weighted to correct the predicted wind speed data. This process can be more accurate The wind speed prediction value also solves the situation that the wind speed prediction at the inflection point is not accurate enough.

5. Conclusions

Wind speed prediction is of great significance to the structural design of transmission lines and towers, to ensure the stable operation of power systems and to improve their economic benefits. The wind speed prediction algorithm based on MapReduce time series analysis and GA-BP neural network algorithm is sampled in this paper. The prediction results show that the design of this paper can obtain satisfactory results and has certain practical application value. At the same time, it is found that wind speed prediction can be further optimized and accuracy can be further improved.

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