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Research on Wind Power by a Combination Prediction Method Based on Meteorological Data

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Abstract. The prediction of output wind power is considered as an effective way to increase the wind power capacity and improve the safety and economy of power system. It is one of the hot research topics on wind power. The wind farm output power is related to many factors such as wind speed, temperature, etc., which is difficult to be described by some mathematical expression. In this paper, Back Propagation (BP) neural network algorithm is respectively combined with genetic algorithm (GA) and particle swarm optimization (PSO) to establish the combination prediction model of the short-term wind farm output power based on meteorological data The Meteorological data is used to determine the input variables of the BP neural network. Meanwhile, the GA and the PSO is respectively used to adjust the value of BP's connection weight and threshold dynamically. Then the trained GA-BP and PSO-BP neural network are used to predict the wind power by combination method. The experiment results show that our method has better prediction capability compared with that using BP neural network, GA-BP neural network and PSO-BP neural network alone.

Key words: wind farm, combination prediction, GA, PSO

1 Introduction

Wind power is one of the fastest growing and most mature renewable power generation technologies [1]. However, wind power also has its drawbacks, which is fluctuant and intermittent. When the proportion of wind power in power grid is small, the above characteristics are not able to influence the performance of power grid. However, as the development of wind power, the power generated from wind plays a very important role in power generation. Hence, in order to make a reasonable power generation plan and ensure the steady performance of power system, the prediction model of wind farm output power is required [2]. In this paper, we use the neural network method to research the prediction of wind farm output power.

Recently, the technical of wind power prediction is not mature in China. Previous

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researches by continuous method, time sequence method, and neural network method make some improvement in practical experiment, without prediction accuracy [3-4]. Furthermore, the combination prediction method on the basis of BP neural network respectively using GA and PSO optimization is rarely mentioned. Therefore, in this paper, we design a new wind farm output power combination model, which is based on the meteorological data and BP neural network respectively using GA and PSO optimization to perform the short-term wind power prediction. It is worth noting that short-term prediction can satisfy the requirement of market trade, system maintenance scheme, and safe power supply.

2 Methods

The common method for the training of network connection weights and thresholds is BP neural network algorithm, which is a kind of algorithm based on error back propagation algorithm. Actually, it is a multilayer forward artificial neural network with supervisor training method. Furthermore, the BP neural network can approach nonlinear function with arbitrary accuracy. It has the ability of learning, self-adaption, and fault tolerance. Therefore, the constructed model has good robustness. The neuron of the BP neural network is denoted by a node, and the link vector between nodes is called weights vector. The basic structure of BP neural network contains three parts: the input layer, the hidden layer, and the output layer. The hidden layer includes one layer or multi layers, and neurons of different layer are connected by the connection weights [5-7]. Through the analysis of the previous part, we know that the number of neurons in the output layer is 1, which is the wind power of wind farm, while the input data contains wind speed. However, the number of neurons in the input layer can not be determined easily, because different number of neurons in the input layer can make different prediction result, so does the hidden layer. Hence, according to the experiment requirement the number of neurons in the input layer is determined among 1 to 5, while according to the experiment requirement the number of neurons in the hidden layer is determined among 5 to 12. In this paper, we choose the number of input layer neuron is 4, while the number of hidden layer neuron is 8. Consequently, the basic structure of BP neural network is 4-8-1.

The performance of BP neural network algorithm is very good, but the training speed is slow and the minimum value is sometime a local value. Note that GA and PSO is global searching algorithm compared with the BP algorithm, the searching speed for optimal area of GA and PSO is faster [8-9]. Therefore, in this paper, we respectively choose GA and PSO algorithm to optimize the BP neural network, which is GA-BP and PSO-BP, and then the two methods are combined together to perform prediction.

Combination prediction is a method which its prediction result can be determined by the result of several prediction methods' weighted average. It aims for eliminating the bigger error of single prediction method in order to improve the prediction accuracy. Fig.1 shows the combination method by GA-BP and PSO-BP [10].

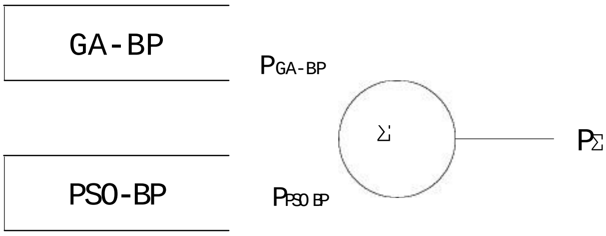

Fig.1 Combination Prediction Model

There are two functions of weighted average. One is equally-weighted average method, which is as follow.

$$P_{\Sigma} = \frac{P_{GA-BP} + P_{PSO-BP}}{2} \quad (1)$$

Where is the total prediction output power, P_{GA-BP} is the prediction output power of GA-BP method, and is the prediction output power of PSO-BP method.

Another function of weighted average is as follow named differently-weighted.

$$P_{\Sigma} = \lambda_1 P_{GA-BP} + \lambda_2 P_{PSO-BP} \quad (2)$$

Where is the weight of GA-BP method, while λ_2 is the weight of PSO-BP method. Note that .We should firstly select the objective function in order to determine the value of weight. There are two common functions to determine the value of weight such as root mean square error (RMSE) and mean relative error (MRE), which is as follow [11].

$$e_{RMSE} = \sqrt{\frac{\sum_1^N (O-P)^2}{N}} \quad (3)$$

$$e_{MRE} = \frac{1}{N}\sum_1^N \left|\frac{O-P}{O}\right| \quad (4)$$

Where is the RMSE, e_{MRE} is the MRE, O is the real output power, is the prediction output power, and N is the number of samples. From the above two functions, we can conclude that the same error will lead to the larger MRE when the real output power is small, while the same error will lead to the smaller MRE when the real output power is large. Hence, in this paper, we choose the RMSE as the objective function. Note that, the best number of evolution about GA and PSO is from 20 to 100. According to the experiment, we can get the best number of GA's evolution is 90, while the best number of PSO's evolution is 50, which the RMSE of GA-BP and PSO-BP reach the smallest. Meanwhile, the value of is set as 0.9 and the value of is set as 0.1.

3 Result Analysis

In this section, we use the prediction samples and the trained combination prediction model to perform the analyzing of 12 hours in advance for wind power prediction. First, we analyze the prediction result of the three simple methods, which are simple BP method, GA-BP method, and PSO-BP method. Fig.2 presents the comparison between the real value of wind power and the predicated value of wind power from the above three methods.

From the Fig.2, it shows that the method of simple BP is the worst one, because the difference between the real value and the predicated value from simple BP is the largest, compared with the difference between the real value and the predicated value from GA-BP and PSO-BP.

Secondly, we analyze the prediction result of the two combination prediction methods, which are equally-weighted combination method, and differently-weighted combination method. Fig.3 presents the comparison between the real value of wind power and the predicated value of wind power from the above two methods.

Fig.4 shows the absolute errors calculated by the two combination methods. From the observation of Fig.4, we can get the average absolute error is 74.1053, and the RMSE is 90.9773 by differently-weighted combination method, while the average absolute error is 80.9015, and the RMSE is 95.1119 by equally-weighted combination method.

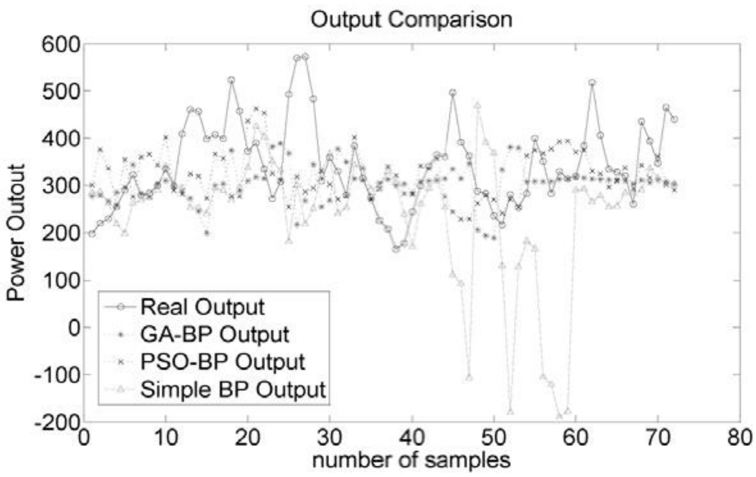

Fig.2 Output Comparison of Three Methods

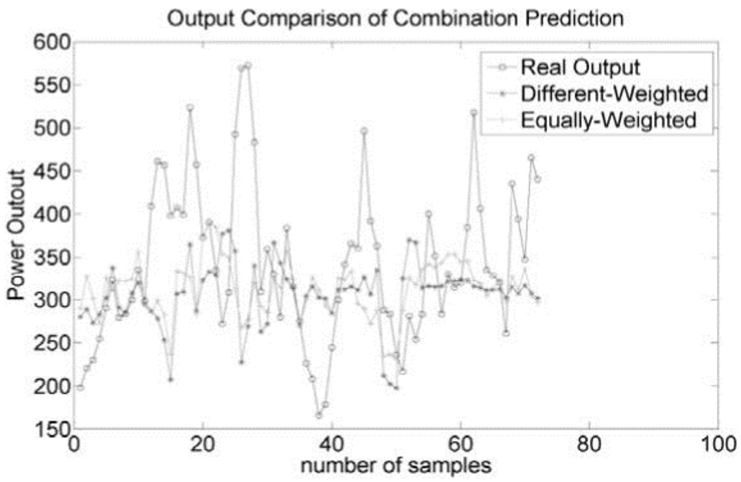

Fig.3 Output Comparison of Combination Prediction

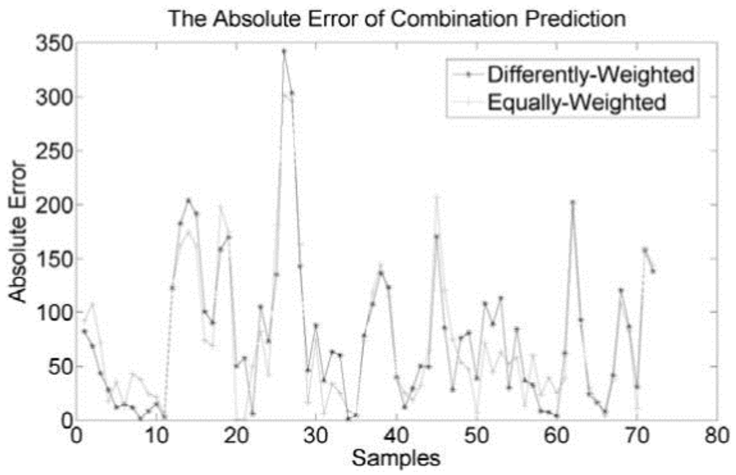

Fig.4 Absolute Error of Combination Prediction

4 Conclusions

The experiment results show that the GA-BP and PSO-BP is better than the simple BP. By the way, they avoid the fact that simple BP neural network fall in down local minimum value. In addition, they also revolve the slow convergence speed in simple BP. In this paper, the combination prediction method is better than any another methods. There are two kinds of combination prediction, which are differently-weighted method and equally-weighted method. In accordance with the experiment result, the differently-weighted method is better than the equally-weighted method. Consequently, the differently-weighted combination method can be used to predict the real wind power. It plays an important role in management of power grid system.

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