Research on Application of Neural Networks to Wind Power Prediction

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Abstract. In this paper, a wind power prediction method based on deep neural network is proposed, which fully considers several factors that influence wind power, such as wind speed, wind direction, air density and season, and gives the best power prediction value through deep neural network training and learning. The results show that the neural network method improves the robustness of wind power prediction.

Keywords: Wind Power, Power Prediction, Neural Network

1. Introduction

Wind power is a renewable and clean energy source. Traditional wind power prediction methods are mainly divided into two categories: one of them is based on wind speed time series[1], and the typical methods include continuous prediction method Auto-Regression and Moving Average Model[2]; the other is a statistical model, Artificial neural networks[3]. Compared with traditional shallow neural networks, deep networks have stronger data learning capabilities[4] .Because of its strong data learning ability, neural networks are used for wind power prediction[5]. Wind power is influenced not only by wind speed, but also by local climate, such as wind direction and air density. In addition, wind power can be analyzed from the perspective of time. For example, in different seasons or months of a year, the average power of wind power tends to be quite different. The influence of different characteristics on wind power is studied.

2. Feature selection

Wind speed is considered in the traditional wind power forecasting method. In fact, wind power is also related to factors such as wind speed, wind direction and time[6]. The combination of these factors is conducive to more accurate prediction of wind power. For this reason, the following typical characteristics are selected for the wind power prediction in this paper.
2.1. Wind speed
Wind speed is the most important factor affecting wind power. In the traditional method, wind speed is an important feature of wind power prediction, which is of great significance for accurate prediction of wind power. The relationship between output power and wind speed can be obtained through training samples to investigate the impact of wind speed on wind power. In this paper, wind speed is substituted into the designed network as a continuous variable, and a more effective feature description is obtained through learning.

2.2. Air density
Air density also has an important effect on wind power. The space density will affect the torque of the motor, resulting in changes in the output wind power. At the same time, the air density will directly affect the rotation of the power generation fan caused by the wind speed.

2.3. Wind direction
The normal operation of the wind motor depends on the wind vane, which is adjusted according to the direction to achieve the maximum output power. In fact, due to the estimation error of the wind vane and the alignment error of the wind turbine, the final output often does not reach the ideal value. For this reason, the influence of wind direction needs to be considered in wind power prediction. This paper uses wind direction as a discrete feature in the neural network.

2.4. Month
There is a big difference in wind power output in different months. This is mainly because the climate change brought by different months has affected the performance of wind power. Different months actually reflect the combined effects of climate, humidity, light and other factors in different seasons. Month as a typical discrete variable is also examined in the deep neural network designed in this paper.

The features selected in this paper can more effectively reflect the characteristics of wind power data, and by effectively discovering these contained information, the wind power can be estimated more accurately.

3. Modeling
The wind power prediction neural network designed in this paper is shown in Figure 1. The input parameters are wind speed, air density, wind direction and month. The predicted value of wind power

![Wind power prediction model](image)

**Figure 1.** Construction of wind power prediction model
The process of wind power prediction includes the following key steps:
Step 1: Collect a large amount of historical data for a specific wind farm to build a training sample;
Step 2: The characteristics of the training sample such as wind speed, air density, wind direction and month, and the measured wind power are extracted.

Step 3: Obtain the estimated wind power under the current conditions.

4. Results analysis

There are 30,000 pieces of data in the data set, and the correlation between output wind power and wind speed, air density, wind direction, and wind direction is established. Figure 2 shows the average power in different months, which directly reflects the effect of the month on the output power.

![Figure 2. Monthly average wind power output](image)

In order to evaluate the performance of the method, this paper also chooses a classic wind power prediction method for comparison. Specifically, it includes Auto-regressive Moving Average Method (ARMA), shallow BP network and RBF neural network method.

Table 1 and Table 2 show the statistical results of different methods. Table 1 shows three indexes: average relative error, average root mean square error, and elapsed time. It can be seen that the average error of the two methods is significantly smaller than other methods, which fully proves its effectiveness. At the same time, the prediction time of the method in this paper is much lower than other methods, which highlights the efficiency of the proposed method.

The probability, which the prediction error of different methods is less than 10% and 30%, is shown in Table 2. The method in this paper has achieved accuracy of 95.4% and 98.8%, which is the highest level in all methods, fully verifying its effectiveness. According to the comparison results, the method in this paper can achieve the highest efficiency, so the method in this paper is more conducive to real-time wind power estimation.

In summary, the prediction method based on deep neural network designed in this paper can efficiently complete the wind power prediction work based on the measured data.
Table 1. Comparison of prediction errors of different methods

| Methods     | MRE  | MSE  | Time(ms) |
|-------------|------|------|----------|
| ARMA        | 10.5 | 12.6 | 60.3     |
| BP          | 13.2 | 15.3 | 104.2    |
| RBF         | 11.5 | 13.7 | 89.3     |
| Method of this article | 4.6  | 6.3  | 41.4     |

Table 2. Comparison of prediction accuracy of different methods

| Methods     | Less than 10% probability | Less than 30% probability |
|-------------|----------------------------|---------------------------|
| ARMA        | 86.5%                      | 91.4%                     |
| BP          | 88.2%                      | 92.5%                     |
| RBF         | 90.5%                      | 93.7%                     |
| Method of this article | 95.4%                      | 98.8%                     |

5. Conclusion

For wind power prediction, a neural network-based method is proposed. The neural network can simultaneously accept multiple continuous and discrete features as outputs, making it possible to comprehensively examine the factors affecting wind power. In the specific implementation, the influence of the four factors of wind speed, air density, wind direction and time are investigated. The prediction results are output with high accuracy through the training of the designed neural network. The results show the superiority of this method over some typical traditional methods. In subsequent studies, the output of the network can be enriched and improved according to other factors encountered in wind power prediction.

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