Short-term Load Forecasting Considering Meteorological Factors and Electric Vehicles

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Abstract. A short-term load forecasting method considering meteorological factors and electric vehicles is essential to the successful operation of the power system. This paper proposes a unique short-term load forecasting method based on neural network. First, through the analysis of typical daily load data, it is demonstrated that the short-term load data changes with the daily, weekly, weather type and the charging of electric vehicles. Then, the load forecasting model based on the neural network is set up with historical data, meteorological data and electric vehicle charging data as input. Finally, the prediction model is simulated to improve the accuracy of load forecasting.

1. Introduction

Short term load forecasting is an important work of power dispatching and power trading departments. With the development of the operation and scheduling of modern power grid, especially the construction and operation of the power market, the high precision short-term load forecasting is becoming more and more important, which is directly related to the safe and stable economic operation of the power grid and the economic benefits of the enterprise itself. With high precision prediction demand, short term load forecasting is developed from classical linear model to intelligent model algorithm stage, and many forecasting methods have emerged.

There are many methods for short-term load forecasting, such as regression analysis, trend prediction and time series prediction. With the development of load forecasting technology, artificial neural network, wavelet analysis, support vector machine and so on appear in recent years. However, no matter what prediction method is adopted, it is necessary to set up a prediction model. To establish prediction models, we need to find input and output. For the daily load forecasting, the output is the load of the next 24 hours, and the input needs to be selected according to the characteristics of the load. The correct of the input is directly related to the accuracy of the forecast.

The daily periodicity of power load is the starting point and the point of view for many short-term load forecasting studies, but because of the natural growth of power load and the influence of the external factors such as weather, holidays and electric vehicles. The key to solving the problem of short-term load forecasting is how to organize and process historically relevant data, how to dig the similarity of the daily load curve under the similar conditions of external factors and find the changes in the daily load caused by changes in external factors. This article is based on this key issue.
2. Characteristics analysis of short-term load forecasting

The characteristics of power load are mainly periodicity, trend, randomness and particularity. The daily periodicity of load refers to the regularity of load changes in a period of 24 hours per day. The external factors that affect the daily load characteristics are people's production and life. Due to the important influence of weather conditions on daily production and life, the weather conditions are associated with the daily load characteristics, and sometimes it has strong correlation. In addition, the number of electric vehicles has increased year by year. More and more electric vehicles need to be connected to the grid for charging. At present, both are important external factors affecting daily load characteristics. Figure 1 shows a typical daily load curve for a city, which shows two peaks of electricity consumption in one day, which are composed of industrial power and household electricity.

![Figure 1. Typical daily load curve of a city.](image1)

From the point of view of load balance, the time characteristics of the use and charging of electric vehicles have the function of cutting peak and filling the valley, so it has little influence on the transmission network, and the agglomeration effect of electric vehicle charging will have a great influence on the part of the distribution network. Figure 2 shows the disordered charging load of electric cars. It can be seen from the picture that the charging load of electric vehicles is mainly concentrated from evening till early in the morning. From 17:00, the charging load of electric vehicles is increasing as users come home from work, until the peak of charging in the 19:00-21:00 period, and the charging period has obvious aggregation. Afterwards, as part of the car was charged, the charging load gradually decreased.

![Figure 2. Discharging of EVs.](image2)

Meteorological factors is an important factor affecting the characteristics of power load, and it is also a key part of this paper. Meteorological changes have great randomness and uncertainty, so they also affect the uncertainty and volatility of power load.
As shown in Fig. 3, there is a certain positive relationship between the size of the power load and the meteorological conditions. In a period of high temperature, the power load also increases accordingly. Therefore, meteorological factors should also be included in the power load forecasting model.

![Figure 3. Curve of annual load and maximum temperature.](image)

3. Formatting the text

3.1. Introduction to neural networks

BP neural network is a multilayer feedforward network trained by the error back propagation algorithm. It is one of the most widely used neural network models. BP network can learn and store a large number of input output pattern mapping without revealing the mathematical equation describing the mapping. Its learning rule is to use the steepest descent method to continuously adjust the weights and thresholds of the network through backpropagation so as to minimize the squared error of the network. Figure 4 shows the structure diagram of the three layer neural network. As shown in the figure, the neural network is composed of input layer, hidden layer and output layer.

![Figure 4. Neural network structure diagram.](image)

The training of BP neural network is achieved by updating the weights according to the error between the output and the expected values of the output neurons of the neural network.

3.2. The establishment of prediction model
From the above analysis, we can see that the short-term power load has a great relationship with meteorological factors and electric vehicles. Before the prediction model is established, it is necessary to select the input required for the prediction. From the analysis of the load characteristics, it can be known that the input quantity is determined as historical load data, meteorological data and electric vehicle charging load data. The structure of the forecast model is shown in Figure 5.

Using IBM SPSS Modeler software to build a load forecasting model, the training set data is read from the excel table obtained from data processing to learn, assign variables, define count ID variables, input variables and output variables, add artificial neural networks and set parameters. After running the neural network, the processed historical data can be learned. After a certain period of time, the neural network is completed after training. After neural network training is completed, the prediction of the next moment can be completed by inputting data to the neural network. Figure 6 shows the construction of the model.

3.3. Neural network training
The training input is historical load data, meteorological data, and electric vehicle charging load data. In the training process, it is compared with the actual output of the training set by comparing the expected value generated by the connection weight and the actual output of the training set, and updating the weight according to its error. In the continuous training process, the weight value is constantly increased by an incremental update, the weight increment will be reduced each time, the final model tends to be stable, and the maximum approximation is a certain algorithm or function or
the optimal expression of some logical strategy. When the training error is no longer changed, the training ends.

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After the neural network training was completed, the load value of the city in July 2016, the charging load of electric vehicle and the weather condition of the forecast day were taken as input, and the prediction results were calculated by the neural network calculation.

In order to verify the accuracy of the two factors, a control group was set up, which did not take into account the influence of electric vehicle charging load and meteorological data, and used only historical data to predict.

The prediction results of the two methods are compared with the actual load data, and the comparison results are shown in Figure 7.

![Figure 7. Load forecasting results.](image)

It can be seen from the diagram that the prediction results of this method is very close to the actual load curve and the method of not considering the meteorological factors and the charging load of the electric vehicle has large error with the actual load.

5. Conclusions
Using the BP neural network to predict the short-term power load can reflect the inherent law of the natural load growth. In the short term load forecasting, the influence of the meteorological factors and the increasing charging load of the electric vehicle should be fully considered. When the structure of the neural network is designed, it should be combined with the actual load situation in the area. Taking the most important meteorological factors into consideration, the artificial neural network (ANN) technology is used to determine the BP neural network model considering the charging load of the meteorological factors and electric vehicles. The model is used to predict the short-term load. The prediction results show that the load forecasting precision has been considerably improved after the full consideration of the meteorological factors and the charging load of the electric vehicle, and the results can be extended and deserve further research.

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