

The prediction of the impact of climatic factors on short-term electric power load based on the big data of smart city

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Abstract. The climate changes have great impact on the residents' electricity consumption, so the study on the impact of climatic factors on electric power load is of significance. In this paper, the effects of the data of temperature, rainfall and wind of smart city on short-term power load is studied to predict power load. The authors studied the relation between power load and daily temperature, rainfall and wind in the 31 days of January of one year. In the research, the authors used the Matlab neural network toolbox to establish the combinational forecasting model. The authors trained the original input data continuously to get the internal rules inside the data and used the rules to predict the daily power load in the next January. The prediction method relies on the accuracy of weather forecasting. If the weather forecasting is different from the actual weather, we need to correct the climatic factors to ensure accurate prediction.

1. Introduction

With the continuous development of China's economy, people rapidly increase their demand for electric power. The electric power system is the foundation of a country. Saving electric power is of great significance for the country. The climate changes have great impact on the residents' electricity consumption [1], so the study on the impact of climatic factors on electric power load is important. It is the power sector's job to predict power load. Different prediction method has different effect. Effective forecasting method can greatly improve the electricity efficiency.

At present, there are regression analysis method, chaotic forecasting method and time series method for the prediction of climatic factors to power load. But these methods cannot meet the needs of modern society, especially unsuitable for China [2] [3] [4]. With the continuous efforts of many scholars, the researches on neural network have drawn people's attention. Due to the late research on neural network to power load prediction in China, the techniques are not mature. At present, more scholars use Error Back Propagation Algorithm for power load prediction. It takes the effects of the historical load as input, the interrelation among neural cells form the functional relations from input to output and from output to input. The difference between output and actual data meeting requirements determines the cycle to terminate or not [5].

With the continuous construction of smart cities, the corresponding big data, such as the population data, legal data, economic data and other big data of people's daily lives are open and shared



nowadays. Because the power load has some certain periodicity and similarity, we can forecast the power load in a future period of time based on climatic factors of the big data of smart city. The continuous changing of the climate makes climatic factors and future power load uncertain to some degree. People's living environment is composed of the humidity, temperature, wind, rainfall, sunshine and a series of other factors. As we know that the temperature of human body is constant. So, in order to keep their body's temperature constant, people need to exchange of energy with the around the surrounding to balance the needed energy and the absorbed energy [6]. Among the climatic factors, the temperature, rainfall, and wind have obvious impact on human being, so they are the major factors causing the short-term fluctuation of power load. So, it is of significant to study the effects of temperature, rainfall and wind on the short-term load.

In this paper, the authors predict the impact of climatic factors on short-term electric power load based on the big data of smart city. Power load forecasting with big data is a very important task, it is important for residents to save power and improve power supply efficiency. Effective forecasting can be helpful for balancing power supply and saving resource consumption, to provide good foundation for reasonable power supply among industries and construction of power grid. With the continuous development of China's economy, people's quality of life is getting better and better, and people are using more and more household electrical appliances, such as air conditioners, heaters, refrigerators and other high-power appliances. These appliances take great proportion of the total electricity consumption [5]. The usage of the appliances is due to the climatic changing. People are paying more and more attention to the impact of climatic changing to the electric power load. Because climatic changing is uncertain, it is difficult to have a concrete way to establish the relation between climate and power load. While Matlab neural network has obvious advantages in dealing with this problem, because it doesn't need concrete model but some input and output data as samples, which the neural network will train the samples to approximate a function to set up a model. The trained model can effectively forecast the short-term power load in the future.

2. Prediction Algorithm

Please follow these instructions as carefully as possible so all articles within a conference have the same style to the title page. This paragraph follows a section title so it should not be indented. In this paper, the effects of the data of temperature, rainfall and wind of smart city on short-term power load is studied to predict power load. The authors studied the relation between power load and daily temperature, rainfall and wind in the 31 days of January of one year. In the research, the authors used the Matlab neural network toolbox to establish the combinational forecasting model [7]. The authors trained the original input data continuously to get the internal rules inside the data and used the rules to predict the daily power load in the next January. The prediction method relies on the accuracy of weather forecasting. If the weather forecasting is different from the actual weather, we need to correct the climatic factors to ensure accurate prediction.

When BP neural network is taken for learning and training, input data should be the 31 days' climatic factors, e.g. temperature, rainfall and wind, from the big data of a smart city. But the factors cannot be input just directly, they must be quantified. For example, as for rainfall, it can be classified as sunny, cloudy, overcast, drizzle, snow and other weather conditions, and sunny is set as 1, cloudy is set as 0.9, overcast is set as 0.8 and so on. Thus, climatic factors can be qualified to better use BP neural network. In BP neural network, the output represents the daily electric power load of the 31 days. A model is set up via BP neural network, and is configured with the daily climatic factors of the next January to predict the daily electric power load of the month.

2.1. BP Neural Network Structure

In general, neural network is composed of input layer, hidden layer, and output layer. Hidden layer can be one-layered or multi-layered. Input layer and output layer is determined by given data, most of them are one-layered. BP neural network is an error corrective learning algorithm composed of forward propagation and back propagation. Signals are input from the input layer, processed in the hidden layer and transferred to the output layer. The states of each layer's neural cells effect only those of the next layer. If the expected output cannot be got from the output layer, the back propagation of the error signal is input, the correlation weight among the neural cells of each layer is modified to

minimize the error [8]. Researches proved that 3-layered BP neural network can realize complex non-linear mapping. BP neural network is shown as Figure 1.

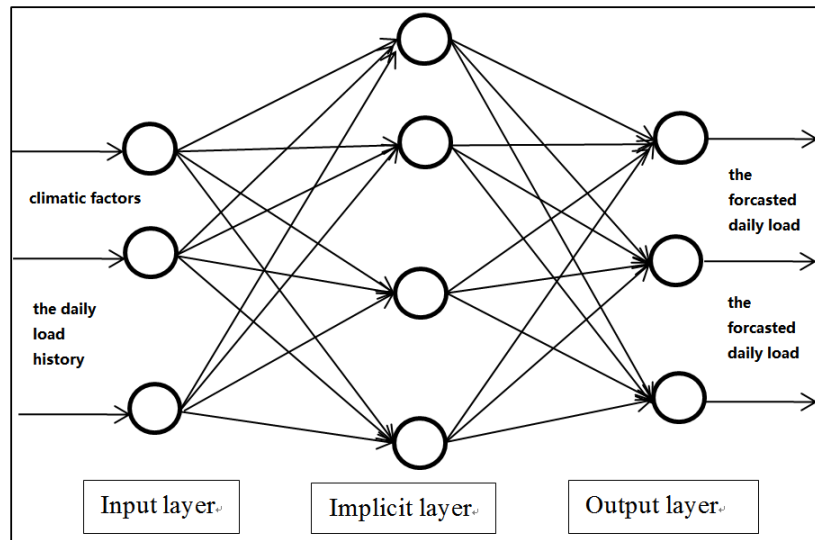


Figure 1. The structure of BP neural network.

The algorithm flow of BP neural network is described as follows.

begin

 given data of training samples

 initialize weight and threshold

 given input and expected output

 calculate the output of hidden layer and output layer

 calculate the error E between the actual output and the expected output

 if (the error E meets the condition) then

 if (all of the errors meet the conditions) then

 go to end

 end if

 else

 calculate the error of hidden layer

 calculate error gradient

 learn and correct weight and threshold

 end if

end

2.2. Qualify Climatic Factors

2.2.1. Qualify Temperature. The temperature in January usually varies between -10 and 10 degree. The qualified average daily temperature is set between 0 and 1. The qualified temperature is shown in Table 1.

Table 1. The qualified temperature

Temperature	-10	-8	-6	-4	-2	0	2	4	6	8	10
Qualified temperature	0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1

2.2.2. *Qualify Rainfall.* Normally, rainfall is classified as sunny, cloudy, overcast, drizzle, snow and so on. The qualified rainfall is shown in table 2.

Table 2. The qualified Rainfall

Rainfall	Qualified Rainfall	Rainfall	Qualified Rainfall	Rainfall	Qualified Rainfall
sunny	0	cloudy	0.1	overcast	0.2
drizzle	0.4	light rain	0.3	moderate rain	0.4
heavy rain	0.5	rain and snow mixed	0.6	light snow	0.7
moderate snow	0.8	heavy snow	0.9	blizzard	1

2.2.3. *Qualify Wind.* Wind can be classified into calm, light air, light breeze and so on. The qualified wind to be the input is listed as in table 3.

Table 3. The Qualified Wind

Wind	calm	light air	light breeze	gentle breeze	moderate breeze	
Qualified Wind	0	1	2	3	4	

2.3. The Transfer Function of BP Neural Network

The temperature in January usually varies between -10 and 10 degree. The qualified average daily

In the BP neural network, the output is the daily total power load. Hyperbolic tangent function is used for the transfer layer as shown in (1). In the hyperbolic tangent function, the input scope is mapped into (-1, 1) from real number range. The input of the to-be-trained samples is mapped into (-1, 1), which can reflect the accurate relation of the neural network.

$$y = f(x) = \tan \operatorname{sig}(x) = \frac{e^x - e^{-x}}{e^x + e^{-x}} \quad (1)$$

2.4. Set up Neural Network

2.4.1. *Input & Output.* An approximate model is got by simulated training with the daily weather, temperature and wind of last January as the input of the neural network and the daily output as the output. Current month's power load is predicted via the trained neural network taking the daily weather, temperature and wind as the input.

For the simulation, a 3-layered BP neural network is constructed with 3 nodes of input and 1 node of output.

2.4.2. *Determine the number of the nodes of hidden layer.* When neural network is used to predict electric power load, the determination of the number of the nodes of the hidden layer can be made based on the below formula.

$$\begin{aligned} h &= \sqrt{n+m+a^*} \quad 1 < a^* < 10 \\ 0.02m < h < 4m \\ h &= \log_2 n \end{aligned} \quad (2)$$

Therein, h is the number of the nodes in the hidden layer, m is the number of nodes in the input layer, n is the number of the nodes in the output layer.

From the aforementioned neural network, we can get that m=3, n=1. So, h can be between 3-12, let's say h=8, i.e., the number of hidden layers is 8. S-shaped tangent function tansig is taken as the

activation function of the neural cells of hidden layer, and linear function purelin is taken as the activation function of the neural cells of the output layer.

2.4.3. Set Training Parameters. Our testing showed that we can get the best output when the learning rate is 0.035. The period of showing intermediate result is 50; the maximum iteration is 2000; the target error is $1e-3$.

3. Prediction Result Analysis

The climatic factors and daily electric power load of last January from the database of smart city are taken as input and output data. Network error training curve is predicted via BP neural network shown as Figure 2. The curve proves that BP neural network not only reaches the set objective error, but also reaches the set training steps.

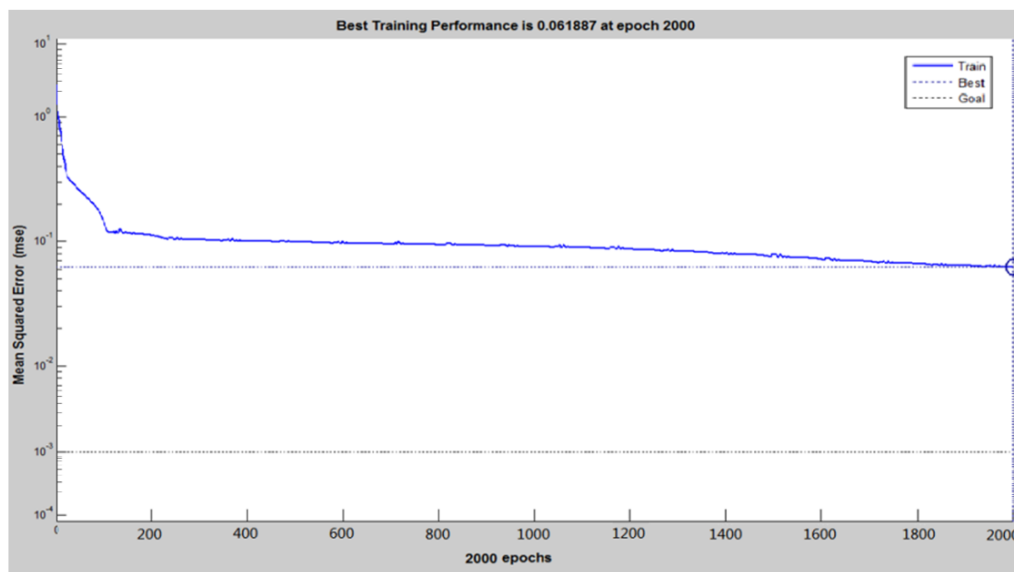


Figure 2. Network Training Error Curve

Figure 3 presents the power load output by the neural network and the actual power load, and shows that the errors between the training output and the actual data is not big and acceptable. Once a neural network is trained, the trained model can take the qualified climatic factors of the 31 days of the next January to get the daily power load of the 31 days of the next January, like shown in Figure 4.

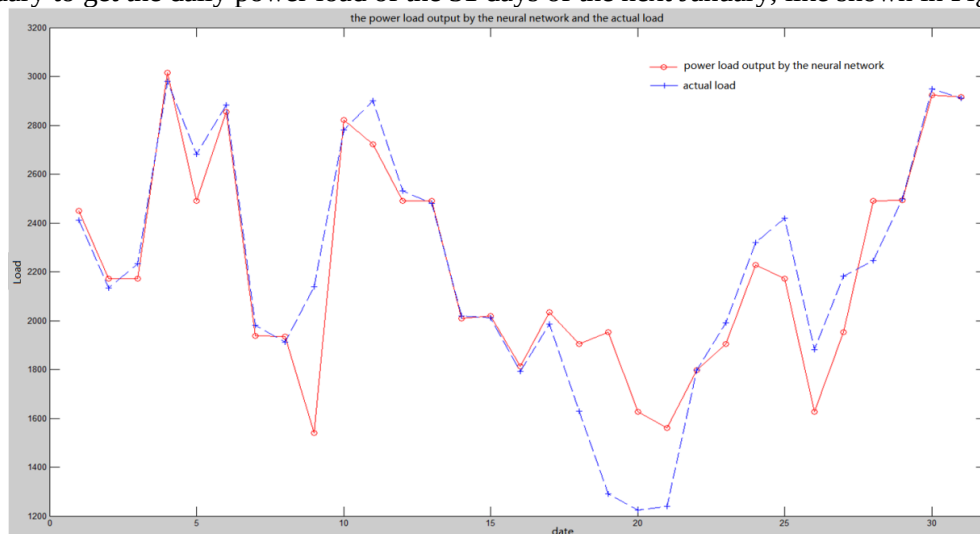


Figure 3. The curve of the power load output by the neural network and the actual load

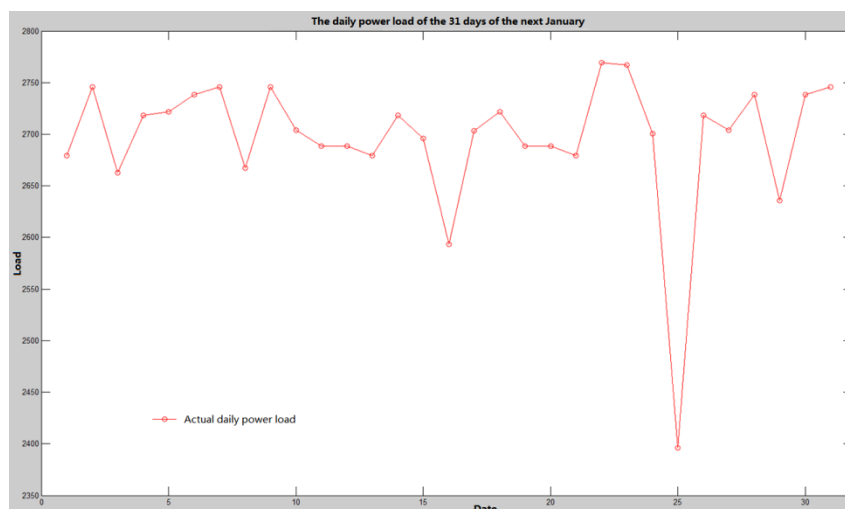


Figure 4. The daily power load of the 31 days of the next January

4. Conclusion

The prediction of the impact of climatic factors on short-term electric power load based on the big data of smart city is the foundation of electric power system. Accurate and effective prediction is of great significance for national power sector. With the increasing of people's quality of life and development of smart cities, the power load by household electrical appliances takes more and more proportion of total load. Climatic changes influence the variation of power load. Different areas have different climate and geographic factors. And the fitness of persons to the climate also impacts power load indirectly. So, when the neural network is designed, the local climatic factors and the actual power load must be considered to predict the impact of climatic factors on electric power load.

In the paper, BP neural network is adopted to set up a prediction model; and the climatic variation and daily electric power load from the big data of a smart city of the last January is used to accurately train the relationship between temperature, rain, wind and power load. Experiment data proves that the BP neural network based prediction model is an effective prediction method.

5. References

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