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Predictive Control of Enterprise Energy Management System

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Abstract. Industries and large-scale public building are one of the main power Energy consumers in China, where they consume about 70% of all the energy in the country. Different types of industrial processing techniques, equipment, product types, ways of energy management can have different influences on energy consumption. This paper suggests using BP Neural Network to scientifically predict business energy consumption, and models and analyzes consumption amount, enable the business energy manager to predict business energy consumption trend, advise business producing, fixing, and balancing, thus guarantee a balance between energy supply and demand.

Keywords: Energy Management System; Predictive; Neural Network.

1. Introduction

Without affecting production, the energy management system is an information-based control system for improving economic efficiency. It can help enterprises plan and use energy rationally and reduce the energy consumption of individual products. The main roles are as follows: [37]

(1) Through the collection of energy data, the data can be analyzed, processed and processed to facilitate management and scheduling personnel to understand the status of the system in a timely manner. Through the collection of energy data, data can be analyzed, processed and processed. it is convenient for managers and scheduling staff to know the status of the system in a timely manner.

(2) Through the analysis of the company's basic energy needs, energy can be decentralized and centralized management, in order to achieve the intelligent and automation of energy equipment operation management.

(3) Saves manpower cost, reduces management input, raises labor productivity. Improve the response ability of the accident, observe the operating condition of the whole plant from a global perspective, and effectively restore the normal operation of the system.

(4) Real-time understanding of energy demand and consumption in enterprises, optimize energy dispatch and use to make energy reasonable. To solve the problem of energy balance management and monitoring management, to create conditions for equipment process optimization.

The energy regulatory system should solve many problems that have arisen in the energy monitoring and management system, such as real-time data links, safety infrastructure, communication channels, resource sharing, access to information, common and personalized services, and optimization of technology. It is an important support framework for energy consumption monitoring and enterprises management system.

2. Structural Design of Predictive Model

The input problem is the first consideration of predictive model. The BP neural network prediction input of enterprises energy consumption needs to consider the decisive factor that can have a great influence on the output energy consumption. The number of decisive factors determines the number of neurons in the input layer. However, it should be noted that if there are more neurons in the BP neural network input layer, the weight between the connecting input layer and the implicit layer will also increase exponentially. On a field trip, there are many factors that affect energy consumption in energy management systems, such as electricity consumption, water consumption, energy prices, integrated energy consumption, Steam use, industrial output value, temperature, and climate, all of which have an impact on total energy consumption. As a sample data is limited, only the data from

January 2014 to December 2016, so if it wants to have a good prediction effect, it must reduce the number of input layers, that is, reduce the dimension of the sample. Otherwise, the BP neural network will have too many input layers and too few sample data and will not receive sufficient learning training. Normally, if it needs to reduce the number of input neurons in the BP neural network, two criteria should be strictly followed:

(1) The input section should select variables that are easy to detect as far as possible, such as power consumption, output value, etc. And for the output of the small amount, such as temperature, climate, etc. Because the distribution of the factory area is relatively large, it is not easy to detect, and the impact on the output is very small, such variables must be eliminated as much as possible;

(2) Enter variables as little relationship as possible, for example, select power consumption as an input, there is no practical significance in selecting the standard tons of coal for energy consumption. During the selection process, it is often encountered that a variable cannot determine whether it has a large impact on the output. At this time, a BP neural network can be added. One contains the variable as input, the other removes the variable, compare the training results and select the good ones.

With reference to the above two criteria, and after repeated comparisons of the training process, the three inputs that has a large impact on the enterprises energy consumption and easy to detect are: industrial output value, comprehensive energy consumption and electricity consumption. Therefore, the input of the BP neural network is determined to be 3 and the output is 1. The number of input nodes of the structure is 3 and the number of output nodes is 1.

2.1 Data Normalization

Data normalization treats the data transformation of the input and output of the BP neural network as a dimensionless form, also known as scale transformation. The input and output data are strictly limited to the [0,1] range. The main reasons for data normalization are as follows:

(1) The input data of the input layer of the BP network, such as the selected unit of electricity consumption Kwh, the total industrial output value Rmb, etc., usually have different dimensions. So, the primary purpose of normalization is to allow each input variable data to be in the same position at the time of network training, allowing the data to change between [0,1];

(2) If the net input absolute value of the neuron exceeds the range, it is easy to saturate the output of the neuron. In order to avoid this situation, the BP neural network often uses the Sigmoid transfer function as a neuron. The advantage is that after data normalization, it can avoid weight adjustment into the flat area of the error surface;

(3) The role of normalization is to put the output data in the same data range, and the output range of the Sigmoid transfer function is between [0,1]. The absolute error of the large output component is large, and the absolute error of the small output component is small. After the data is normalized, the output data is strictly controlled between [0,1].

2.2 Training and Test Sample Division

Dividing the sample data into training samples and test samples can test the predictive ability of the trained BP neural network, also known as the generalization ability of the network. The test sample data does not participate in the training of BP neural network.

2.3 Identification of Predictive Models

Through the above analysis, the steps for designing a multi-layer BP feedforward network are as follows:

(1) Determine the number of hidden layers. According to the sample data analysis, an implicit layer can be set up temporarily. After training and learning, if the training process is found to be relatively slow and the desired output is relatively large, the number of hidden layers can be considered. The research energy consumption prediction, after analysis, BP neural network uses an implicit layer of BP neural network, that is, three layers of BP neural network structure.

(2) Determines the number of implicit layer nodes. At present, BP neural networks often use trial method to determine hidden layer nodes. For example, the prediction of energy consumption studied

in this paper. First, set the number of implicit layer nodes to 3. After many trainings, the number of implicit layer nodes gradually increases. When it is increased to 5 layers, it is found that the network error is minimized. Therefore, it is determined that the number of implicit nodes is 5 in the BP neural network predictive control.

In summary, the BP neural network prediction model for determining the enterprise energy consumption is a three-layer BP neural network. The BP network is trained using the increased momentum term method. The input layer uses 3 neurons (input is industrial output value, comprehensive energy consumption, and electricity consumption), the implicit layer uses 5 neurons, and the output layer uses 1 neuron (energy consumption), as shown in Figure 1. The transfer function of the network is a unipolar Sigmoid function.

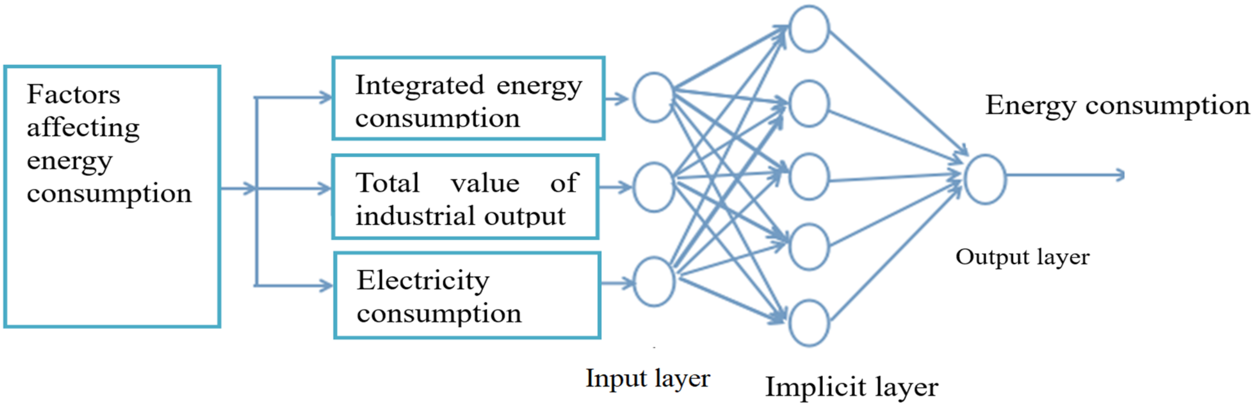

Fig. 1 BP neural network prediction model

3. Analysis of BP Neural Network Prediction Results

Using the BP neural network prediction model above, the programming simulation analysis is conducted using Matlab language. Fig. 2 is a comparison of the predicted value and actual value of the BP neural network prediction model.

The neural network was simulated using data from January 2013 to December 2015, the results of which are shown in table 1. The unit of actual and simulated values is tons of standard coal. From Table 1, it can be seen that the relative error of BP neural network prediction model is less than 1 %, and the similarity is better. However, it needs more comprehensive sample data that can represent various situations, otherwise the BP neural network generalization ability trained is poor.

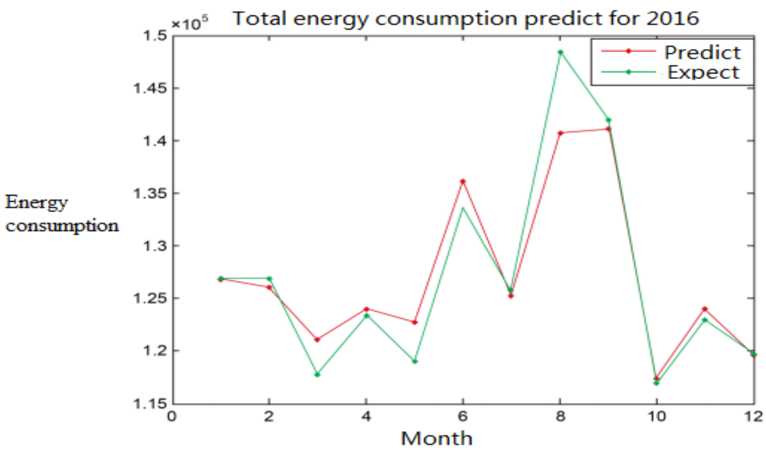

Fig. 2 Comparison of the prediction of BP neural networks with the actual values for 2016

Table 1. actual value, simulation value and relative error of BP neural network prediction model

Year Month	Actual	simulation value	Relative error(%)
2016.01	126848.769	126417.4	0.34%
2016.02	126903.080	127264.5	0.28%
2016.03	117798.023	116846.3	0.81%
2016.04	123385.371	123771.8	0.31%
2016.05	118991.618	118661.7	0.28%
2016.06	133543.256	133820.4	0.21%
2016.07	125762.661	126265.7	0.40%
2016.08	148414.558	149165.3	0.51%
2016.09	141967.106	142846.9	0.62%
2016.10	116959.443	115958.9	0.86%
2016.11	122953.972	123564.6	0.50%
2016.12	119691.042	120465.3	0.65%

4. Summary

The paper collects energy data from the enterprise's spare parts workshops, applies BP neural networks to the predicting of enterprise energy consumption, and uses a three-layer BP neural network to input total energy consumption, electricity consumption, and industrial output value as an input, with an implicit layer and energy consumption as output. Through data normalization, increased momentum item training, and division of test samples, the prediction of energy consumption was successfully achieved. Experimental results show that BP neural network has better similarity and more accurate prediction.

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