LOAD CONTROL COST PREDICTION MODEL OF POWER DISPATCHING SYSTEM UNDER THE BACKGROUND OF BIG DATA

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Abstract: Aiming at the low accuracy of load control cost prediction model for traditional power dispatching system, a load control cost prediction model for power dispatching system is designed. Taking the neural network algorithm as the core, the load control cost data of the dispatching system is preprocessed to generate the sequence. Neural network algorithm is used to discretize the generated sequence and output the preliminary prediction result sequence. The forecasting result sequence is corrected and the cost forecasting of load control is finally completed to realize the model construction. In order to verify the predictive effect of the model, a comparative experiment was designed by comparing the traditional predictive models. The experimental result show that the designed load control cost prediction results are obviously better than the traditional models in accuracy.

1. Introduction
With the rapid development of national economy and technology and the diversification of people's life style, electricity and people's work and life become inseparable, and people's demand for power load is growing. More and more huge power system makes power dispatching enter the era of big data. Electric power dispatching is very important for the control and management of power grid in a region. Load cost prediction is a traditional research topic in the field of power system. It refers to studying or utilizing a set of mathematic methods which can deal with past and future loads systematically under the full consideration of some important system operation characteristics, capacity-increasing decision-making, natural conditions and social influences, and determining the load value at a specific time in the future on the premise of meeting certain accuracy requirements.[1]. The load control cost of electric power dispatching system is time-varying, and this change presents some characteristics such as continuity, periodicity, non-linearity, and at the same time contains certain randomness. It is affected not only by its own internal factors, but also by a variety of complex and uncertain external factors, which makes the load control cost prediction of power system not only according to the inherent regularity of load changes, but also taking into account various random factors that affect the load control cost changes. Load control cost prediction of power dispatching system is an important part of energy management system and distribution management system. It is the premise of automatic generation control and economic dispatching control. It involves power system planning and design, economy, security, reliability and stability of power system operation. At the same time, with the continuous development of power system and the modernization and complexity of power grid management, the research on load forecasting of power dispatching system has attracted wide
attention. Accurate power load control cost prediction can reasonably arrange the operation of power grid internal generator set and maintain the safety and stability of power grid operation. The maintenance plan can be reasonably arranged to ensure the normal production of the society and the normal life of the people; It can determine the size of new installed capacity and the dispatch and control of power grid, effectively reduce the cost of power generation and improve economic and social benefits [2].

Due to the rapid development of social economy, the emergence of diversified power sources and micro-grid makes it more difficult to improve the accuracy of load control cost prediction in power system. Traditional load control cost forecasting models of power dispatching system are usually time series model, grey forecasting model and regression analysis model. The basic modeling steps of grey prediction model are: accumulating the original sequence to generate the sequence. According to the form of solution of linear differential equation, matrix and vector are calculated by least square method. The parameters of grey model are calculated: development coefficient and grey coefficient; the grey prediction model is established, and the time response sequence is obtained and generated accurately. Predict and test the accuracy of the model [3].

Deficiencies: because the modeling process is an approximate process, the parameter estimation is discrete and the prediction solution is continuous, and the solution of the model depends on the choice of the initial point, which may deviate from the optimal effect of the modeling itself. Especially when the smoothness of modeling data is poor, the prediction deviation may be large. Correct decision-making needs scientific prediction. Nowadays, the degree of modernization and scientificalization is getting higher and higher. It is also an urgent need to improve methods and techniques for power load control cost prediction. Therefore, this paper will build a load control cost prediction model for power dispatching system.

2. Establishment of load control cost prediction model for electric power dispatching system

In power dispatching system, it is very important to predict the cost of load control. As shown in Figure 1, it is a schematic diagram of load control cost modeling steps.

2.1 Data preprocessing of load control cost

For load control cost prediction model, the cost of load control in power dispatching process is input data. For different scale power dispatching system, the cost of load control in dispatching process is different. If the input data are different in dimension and magnitude, some data will be automatically
regarded as interfering data by the processing program in the prediction process, which will result in unfavorable phenomena such as submergence, prematurity and lag of data, seriously affecting the efficiency and accuracy of data processing, and then affecting the prediction results of the prediction model [7]. Therefore, when selecting the original sample data, the data should be preprocessed first. In engineering practice, normalization or normalization preprocessing technology is usually used to transform all data into corresponding dimension level, which ensures that the input and output vector data matrix of the prediction model are valid, that is, all data are converted into characteristic data in [-1,1] interval.

The following formula is used to normalize the sample data.

\[
P_n = \frac{2(P - P_{\text{min}})}{P_{\text{max}} - P_{\text{min}}} - 1 \quad (1)
\]

\[
T_n = \frac{2(T - T_{\text{min}})}{T_{\text{max}} - T_{\text{min}}} - 1 \quad (2)
\]

In formula P, the original sample data matrix vector is input to the model. \(P_{\text{max}}\) is the maximum value of the matrix vector of the original sample data input by the model. \(P_{\text{min}}\) is the minimum value in the matrix vector of the original sample data input by the model. \(P_n\) is the matrix vector of the input original sample data processed by the normalization technology. T is the original target data matrix vector expected by the model. \(T_{\text{max}}\) is the maximum value of the original target data matrix vector expected by the model. \(T_{\text{min}}\) is the minimum value of the vector of the original target data matrix expected by the model. \(T_n\) is the original target data vector matrix expected by the model after normalization technology processing [8].

Because the load control cost data volume of the power dispatching system is very large, in order to facilitate the processing of a large number of data and speed up the processing process, MATLAB software was used to write the program for the normalization processing. The following are some main procedures of data preprocessing:

\[
P=[0 1 0 1, \ldots, 1 1 1 1];
\]
\[
T=[425, \ldots 538];
\]
\[
s1=28; \quad s2=28;
\]
\[
[W1, bl, W2, b2, W3, b3]=initff(P, SI, 'tansig', S2, 'tansig', T, 'Purelin')
\]
\[
\text{Disp}\_\text{freq}=15;
\]
\[
\text{max}\_\text{epoch}=800;
\]
\[
\text{err}\_\text{goal}=0.03;
\]
\[
\text{tp}=[\text{disp}\_\text{freq} \max\_\text{epoch} \text{err}\_\text{goal}] ;
\]
\[
[w1, bl, W2, h2, W3, b3, te, tr]=trainlm(W1, bl, 'tansig', W2, b2, 'tansig', W3, b3, 'Purelin', P, T, tp);
\]

The normalized data can eliminate the data errors caused by various factors in the process of data collection and will not affect the subsequent processing. The processed data can be predicted by neural network algorithm.

2.2 Data discrete processing

The normalized data is a generating sequence, marked as \(X^{(i)}\). Neural network algorithm is used to discretize the generated sequence. For generating sequence \(X^{(i)}\), there are: let 1 \(\{X^{(m)}\}\) be a sequence
of M times, i-times cumulative reduction of \( \{X^{(m)}\} \), defined as \( \alpha^{(i)} \), and its formula is as follows:

\[
\alpha^{(i)}(X^{(m)}(t)) = X^{(m)}(t)
\]  

(3)

Since the generating sequence \( X^{(i)} \) has exponential growth law, and the solution of the first order differential equation is exactly the solution of exponential growth form, the sequence \( X^{(i)} \) satisfies the formula.

\[
\frac{dx}{dt} + \alpha x = u
\]  

(4)

Rewrite the above formula according to the definition of derivative.

\[
\frac{dx}{dt} = \lim_{\Delta t \to 0} \frac{x^{(i)}(t + \Delta t) - x^{(i)}(t)}{\Delta t}
\]  

(5)

In terms of discrete equation, the differential term can be written as follows.

\[
\frac{dx}{dt} = \frac{x^{(i)}(k + 1) - x^{(i)}(k)}{k + 1 - k} = x^{(i)}(k + 1) - x^{(i)}(k)
\]  

(6)

If the value of \( x^{(i)} \) can only be taken at a time, there is the formula (7).

\[
\frac{1}{2} \left[ x^{(i)}(k + 1) - x^{(i)}(k) \right]
\]  

(7)

Therefore, formula (7) is introduced into formula (3) and formula (6) to obtain formulas (8).

\[
x^{(0)}(k + 1) + \frac{1}{2} \alpha \left[ x^{(i)}(k + 1) - x^{(i)}(k) \right] = u
\]  

(8)

\( \alpha \) and \( u \) are preset parameters, which are set according to the scale of the power dispatching system used in the model[9].

After calculating and processing the above steps, the output data sequence is the result of load control cost prediction. There will be some errors in the output of the prediction model, so it is necessary to correct the output data.

2.3 Correction of prediction results

The forecasting result of load control cost of power dispatching system can be regarded as a sample. The variance of a sample is the sum of squares of the difference between the data in the sample and the average of the sample, and the standard deviation of the sample is further squared. Variance is the most commonly used and important indicator to describe the fluctuation trend of discrete sequence. The larger the variance, the greater the fluctuation trend of the sample data. Conversely, the smaller the variance of the sample, the smaller the fluctuation trend of the sample data. It is usually required that the fluctuation energy of the sample sequence studied be as small as possible, so in general, the smaller the variance of a sample, the better [10]. According to the flow chart of Figure 2 below, the prediction results are corrected.
After calculating the variance of multi-group data of model prediction, the normalized data is processed again. The normalized data is used as the original data sequence, and the model is used to re-advance the prediction. A posterior error test is carried out to check whether the data is qualified or not, and the unqualified data is reconstructed; a residual test is carried out to check the sequence of qualified output results; an initial value of the unqualified model is reset, and the above steps are repeated until the correction of the predicted results is completed. So far, the design of load control cost prediction model for power dispatching system has been completed.

3. Experiment

3.1 Experimental equipment
Two computers with 32G system running memory, 400 MHz operating frequency, 64-bit I8 processor and win 8.1 running environment are configured.

3.2 Experimental steps
The power dispatching system in a certain area is selected as the experimental object, and the traditional negative mode load control cost prediction model is used as the control group. The load control cost prediction model is designed as the experimental group. The actual load control cost of the power dispatching system is collected as the reference data, and the accuracy of the two models is verified by comparative experiments. Because the power consumption is different in different areas and at different times, the load of power dispatching system is different when it carries out relevant regulation and dispatch, which will make the cost of load control different. Therefore, according to the time period, the power dispatch in the selected experimental area is divided, and 24 hours of a certain day is chosen as the experimental time to predict the load control cost of the power dispatching system within an hour.
Table 1 Comparison of experimental results

| group | actual control cost /MW | experimental group /MW | control group /MW |
|-------|-------------------------|------------------------|-------------------|
| 1     | 2.78                    | 2.62                   | 3.57              |
| 2     | 2.88                    | 2.77                   | 3.49              |
| 3     | 2.81                    | 2.52                   | 3.77              |
| 4     | 2.75                    | 2.74                   | 3.85              |
| 5     | 2.66                    | 2.62                   | 3.15              |
| 6     | 2.63                    | 2.67                   | 3.24              |
| 7     | 2.73                    | 2.72                   | 3.75              |
| 8     | 2.98                    | 2.94                   | 3.65              |
| 9     | 2.62                    | 2.61                   | 3.83              |
| 10    | 2.71                    | 2.68                   | 3.32              |
| 11    | 2.81                    | 2.78                   | 4.01              |
| 12    | 2.55                    | 2.51                   | 3.22              |
| 13    | 2.64                    | 2.58                   | 3.73              |
| 14    | 2.87                    | 2.73                   | 3.68              |
| 15    | 2.93                    | 2.91                   | 3.41              |
| 16    | 2.68                    | 2.61                   | 3.83              |
| 17    | 2.73                    | 2.83                   | 3.77              |
| 18    | 2.75                    | 2.68                   | 3.61              |
| 19    | 2.79                    | 2.76                   | 3.47              |
| 20    | 2.77                    | 2.75                   | 3.13              |
| 21    | 2.81                    | 2.78                   | 3.86              |
| 22    | 2.97                    | 2.93                   | 3.34              |
| 23    | 2.95                    | 2.87                   | 3.99              |
| 24    | 2.85                    | 2.89                   | 3.53              |

As can be seen from Table 1, compared with the predicted results of the control group model, the predicted results of the experimental group model are closer to the actual cost of load control, that is, the predicted accuracy of the model designed in this paper is higher than that of the traditional model. The cost of load control predicted by the experimental group is lower than that predicted by the control group model. For electric power dispatching system, the lower the cost of load control, the less the consumption, the higher the efficiency and the less the energy consumption. By analyzing the data, the data predicted by the model in the experimental group fluctuated less than that predicted by the traditional prediction model in the control group. In terms of the stability of the predicted results, the predicted results of the model in the experimental group were better than those of the control group.

4. Peroration

With the rapid development of China's large industry, the technology level is also constantly improving. With the increasing complexity of smart grid, the factors affecting the cost of load control in power dispatching system are greatly increased, and show the characteristics of complexity, hybridity and uncertainty. Therefore, in view of the inaccuracy of traditional load control cost prediction model, the load control cost forecasting model of power system is further discussed and studied by using a variety of mathematical theories and related machine and equipment tools. Power system load control cost prediction is one of the most important basic work in power sector. People have already put its importance in a pivotal position. Because the accuracy of load control cost prediction not only affects the direction of power system planning, but also may affect the economic development of the entire power enterprise. Nowadays, many scholars are devoting themselves to the research of power system load forecasting. Based on this point of view, this paper also does some research work on power system load control cost forecasting, hoping to make some contribution to the work of power system load control cost forecasting through their own efforts. After deeply studying the load control cost prediction model of power dispatching system under the background of large data, this paper puts forward some dynamic reference data which can provide real-time and accurate planning and strategy for power dispatching operators, and provides a new research perspective for power science, economy and energy management and system research.
Reference

[1] Sun Yuan, Zang Tingting, Jiang Feng. Load characteristics analysis of enterprise power users in the context of large data [J]. Statistics and decision-making, 2018 (8): 186-188.

[2] Anonymous. Power load analysis and forecasting based on time series decomposition [J]. Computer Engineering and Application, 2018, 54 (20): 235-241.

[3] Anonymous. Model predictive control of three-phase Z-source inverters [J]. Journal of Power Systems and Automation, 2018, 30 (12)

[4] Wang Guoxu [1, Xu Zhibin. Design of Predictive Controller for PWR Load Tracking Model [J]. Nuclear Power Engineering, 2018, 39 (2): 46-49.

[5] Anonymous. Application of Model Predictive Control in AGC Coordination Control and Main Steam Temperature Control of Ultra Supercritical Units [J]. China Electric Power, 2018, 51 (7): 68-77.

[6] Tang Yi, Li Feng, Wang Qi, et al. Quantitative evaluation method of influence of communication system faults on real-time load control of power system [J]. Power automation equipment, 2017, 37 (2): 90-96.

[7] Sun Dayan, Zhou Haiqiang and Ju Equity Coordination Economics and Voltage Stability of Receiver System Emergency Load Control Optimization Method [J]. Power System Automation, 2017, 41 (17): 106-112.

[8] Zhou Wenhui, Zhong Weifeng, Wu Jie, et al. Adaptive Energy Storage System Control for Smart Grid Load Regulation [J]. Journal of Beijing University of Posts and Telecommunications, 2017, 40 (1): 32-35.

[9] Yu Daolin, Zhang Zhisheng, Han Shaoxiao, et al. Elman-NN short-term load forecasting model considering demand response [J]. New Electrical and Electrical Technology, 2017 (4): 59-65

[10] Anonymous. Short-term load forecasting model for power system based on generalized demand-side resource aggregation [J]. Power system protection and control, 2018, v.46; No.513 (15): 51-57.