Research on transmission line project cost forecast method based on BP neural network

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Abstract: It is very important to predict the cost of transmission line project quickly and accurately for reducing the cost of project investment and improving the level of lean management. Based on the characteristics and construction process of transmission line construction, this paper first delves into the main influencing factors of transmission line construction cost. Then the BP neural network is used to realize the complex nonlinear mapping between the power transmission and transformation project cost and the main influencing factors. And then, a prediction model of engineering cost based on BP neural network is established. Finally, the accuracy of the model is verified by selecting practical projects for prediction and analysis.

1. Introduction
With the development of China's social economy and the growth of electricity demand, the investment scale of transmission line construction is increasing day by day [1]. However, with the continuous progress of China's electric power system reform, the government has increased the investment management and control of power grid enterprises, and the power grid enterprises are facing great operating pressure. Therefore, it is urgent to comprehensively improve the investment management level of power transmission and transformation projects. In the project investment management, cost prediction, as the core work in the early decision-making stage of the project, is the key means of investment control. Therefore, it is of great practical significance to study the forecasting method of transmission line project cost[2]. Transmission line engineering has the characteristics of large investment scale and long construction period, etc. and there are many influencing factors of its cost, and each factor is interrelated, which forms a mutual overlapping network, leads to the difficulty of cost prediction [3]. Therefore, it is necessary to deeply explore the correlation between transmission line engineering cost and its influencing factors based on the characteristics and construction process of transmission line engineering construction. On this basis, a scientific and reasonable project cost forecasting method is constructed to improve the cost control level and investment efficiency level of power grid enterprises [4].
2. The basic principle of BP neural network prediction mode

Artificial Neural Networks (abbreviated as ANNs), also known as neural network (NNs) or Connectionist Model, is an abstraction and simulation of some basic characteristics of human brain or natural neural network. Its inspiration comes from the animal neural network, which relies on the complexity of the system and adjusts the inter-connection between a large number of internal nodes to achieve the purpose of processing information. The advantage of artificial neural network is that it has the ability of self-adaptation and self-learning. It can analyze the rule between input and output by a given amount of historical data (input-output data), and apply this rule to predict the result, that is, to predict the project cost by using the key influencing factors of the project cost.

The basic principle of BP neural network model is that the network hierarchy of neural network includes input layer, output layer, single or multiple hidden layers. The upper and lower layers are fully connected, but each layer of neurons is independent of each other and does not produce connections. The input signal \( x_i \) enters from the input layer and acts on the output node through the node of the middle hidden layer. After nonlinear transformation, the output signal \( y_i \) is generated. Each sample of network training includes the input vector \( x_i \) and the expected output \( Y \). Network output value \( y_i \) and the desired output \( Y \), adjust the connection value \( w_{ij} \) between the input layer node and the hidden layer node according to the error, and the connection \( t_j \) and the threshold between the hidden layer node and the output node, to make the error descend in a gradient direction. Repeated learning and training to determine the network parameters corresponding to the minimum error (weights and thresholds), training stops immediately. At this time, the trained neural network can process the input information of similar samples, by itself, process Minimum output error the non-linear transformation information.

3. Methodological steps

3.1 Identification of influencing factors of transmission line engineering cost

Take the final accounting data of transmission line project completion as the research object. In transmission line project completion final accounts data as the research object, transmission line engineering cost is mainly composed of earth and stone work, foundation engineering, pole and tower and wire project, plus other fees, starting from the five aspects, through the systematic analysis of influencing factors, the cost of its using Visio drawing fishbone diagram, the result is shown in figure 1.
3.2 Construction of BP Neural Network Prediction Model

(1) Establish BP network model, the input layer nodes of BP network are selected as 9 nodes, and the input variables are loop number, topographic condition, geological condition, single kilometer tower base, single kilometer tower material weight, conductor type, tensile ratio, tower material unit price, conductor wire unit price, respectively set as \( x_1 \sim x_9 \). The need for a literal description of the influencing factors to be translated into quantifiable criteria (e.g., grades). The output layer of the network is selected as 1 node. The output variable is the folded cost of transmission line engineering under corresponding input conditions (Line folding cost); The number of hidden layer nodes is generally determined through multiple experiments or empirical formulas. In the construction of BP neural network, in order to find a more reasonable number of hidden layer elements and meet the accuracy requirements, 10, 15, 20 and 25 hidden layers are established respectively in the construction of BP neural network, and they are trained, compared and analyzed. Consider the training error, the number of hidden layer nodes with minimum network error and high prediction accuracy is selected. The network is created in MATLAB by calling the function newff. The network structure model is shown in the figure:

(2) Train the BP network. The standard BP algorithm divides the learning process into two stages: In the forward propagation process, the information of input variables is processed through the input layer through the hidden layer and the actual output value of each unit is calculated; In the process of back propagation, if the output layer fails to get the expected output value, calculate the difference (error) between the actual output and the expected output, and recursively adjust the weight value and threshold value according to this difference layer by layer, so that the error value gradually reduces until the network precision requirements are met. Train by calling the function train.

(3) Using the trained BP network to predict the construction cost. Calling SIM function for cost prediction.

4. Empirical Analysis

The original data of 41 groups of 110kV transmission line projects completed in a certain area of China are taken as samples for analysis. The original data is shown below:
Table 1 Original sample data of transmission line engineering.

| Sample | Total line length (Fold the single), km | Tower material weight, t | Tower cardinality, unit | Amount of wire, t | Wind Speed Path Length in Ice Region, km | Earthwork volume, t | Actual value, Ten thousand yuan |
|--------|----------------------------------------|--------------------------|-------------------------|------------------|----------------------------------------|------------------|---------------------------------|
| 1      | 2.1                                    | 23.12                    | 6                       | 7.02             | 0                                      | 1583.9           | 286.04                          |
| 2      | 1.2                                    | 80.28                    | 4                       | 6.37             | 0                                      | 2146.32           | 372.56                          |
| 3      | 15.3                                   | 189.34                   | 18                      | 22.34            | 0                                      | 2679.85           | 769.38                          |
| ...    | ...                                    | ...                      | ...                     | ...              | ...                                    | ...              | ...                             |
| 36     | 15.63                                  | 298.16                   | 51                      | 37.65            | 0                                      | 6345.91           | 962.03                          |
| 37     | 1.4                                    | 13.56                    | 3                       | 3.51             | 0                                      | 832.95            | 148.02                          |
| 38     | 0.7                                    | 43.14                    | 3                       | 3.51             | 0                                      | 1178.34           | 186.28                          |
| 39     | 28.21                                  | 384.45                   | 46                      | 80.69            | 0                                      | 6279.39           | 876.72                          |
| 40     | 7.76                                   | 157.64                   | 16                      | 19.72            | 0                                      | 2569.99           | 422.62                          |
| 41     | 13.77                                  | 286.07                   | 46                      | 31.61            | 0                                      | 5181.68           | 843                             |

(1) Determine the main influencing factors
The cost level varies with the variation of line length, tower material weight, tower cardinality, amount of wire, wind speed path length in ice region, total earthwork and other factors. The influence factors of line length, tower material weight, tower cardinality, amount of wire, wind speed path length in ice region, sum of earthwork and stonework quantity are expressed by $x_1, x_2, ..., x_6$ respectively.

(2) Constructing BP Neural Network
The BP neural network of the first 36 groups of original engineering sample data in table 1 was simulated and trained by MATLAB, and the neural network model was built.

Several factors, such as line length, tower material weight, tower cardinality, amount of wire, wind speed path length in ice region, sum of earthwork and stonework, are set as input layer nodes, set a hidden layer, with static investment as output layer node.

Construct a neural network cost forecasting model as shown in the figure:

Figure 2. BP neural network diagram of 110kV transmission project

(3) Cost prediction
Five groups of original engineering sample data from table 37-41 in table 1 are taken as reference objects, and the constructed neural network model is used for cost prediction.
Analysis of forecast results

The prediction results are compared with the actual values of 5 groups of reference objects, and the accuracy and reliability of the prediction model are judged according to the errors.

The comparison between predicted results and actual values is shown in the following table:

| Sample | Total line length (Conversion Unit), km | Tower material weight, t | Tower cardinality, unit | Amount of wire, t | Wind Speed Path Length in Ice Region, km | Earthwork volume, t | Actual value, Ten thousand yuan | Predicted value, Ten thousand yuan | Error rate |
|--------|----------------------------------------|--------------------------|-------------------------|------------------|---------------------------------------|-------------------|-------------------------------|-------------------------------|------------|
| 1      | 1.4                                    | 13.56                    | 3                       | 3.51             | 0                                     | 832.95            | 148.02                        | 168.51                        | 13.84%     |
| 2      | 0.7                                    | 43.14                    | 3                       | 3.51             | 0                                     | 1178.34           | 186.28                        | 178.48                        | -4.19%     |
| 3      | 28.21                                  | 384.45                   | 46                      | 80.69            | 0                                     | 6279.39           | 876.72                        | 804.99                        | -8.18%     |
| 4      | 7.76                                   | 157.64                   | 16                      | 19.72            | 0                                     | 2569.99           | 422.62                        | 472.13                        | 11.71%     |
| 5      | 13.77                                  | 286.07                   | 46                      | 31.61            | 0                                     | 5181.68           | 843                           | 865.99                        | 2.73%      |

Comparing and fitting the predicted value with the actual value, the effect is shown in the figure:

As can be seen from table 2, the error rates of the five samples are 13.84%, 4.19%, -8.18%, 11.71% and 2.73% respectively. Among them, the error rates of two samples are relatively high, which are 13.84% and 11.71% respectively. The average error rate of the predicted samples is 8.13%, less than 10%, which proves that this model has good prediction accuracy.

5. Conclusion and prospect

The improvement of the cost control level of transmission line engineering plays an important role for Chinese power grid enterprises to adapt to the power system reform policy and meet the development strategy of lean management. However, due to the large scale of investment, long construction period, multiple control links and influencing factors, transmission line project has increased the difficulty of project cost determination. Combining with the basic principle of BP neural network prediction method, this paper applies fishbone diagram method to analyze and identify the factors affecting the cost of transmission project. The application of the model can provide some reference for scientific analysis of the reasonable level of cost, improvement of investment control ability and investment benefit level.

References

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