

Research on Investment Forecast of Substation Project Based on Neural Network Model

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Abstract. Based on historical datas of substation projects, this report builds an artificial neural network intelligent prediction algorithm by identifying key influence factors. After predicting the cost of 110kV substation projects in a certain province, the results show that the neural network prediction model can quickly predict the construction cost of transmission and transformation projects by inputting key influence factors of the project, and it can achieve the accuracy of project investment in the investment plan filling.

Introduction

From the perspective of the investment analysis carried out by the provincial power grid companies, due to the external environment and design depth of the project construction, the investment surplus rate of some projects is relatively high (the final investment and planned investment have a large deviation), which affects the accuracy reasonableness and actual transfer rate of the company's investment plan, both the formation of the company's effective assets and the approval of transmission-distribution prices will have a certain negative impact.

Through the research of neural network intelligent cost prediction model, supported by the final account data of historical power transmission and transformation projects, the model is trained for reinforcement learning; and by inputting the key influencing factors of substation projects, the reference value of the forecast investment of a single project is output.

Research Status of Neural Network Intelligent Cost Prediction Models for Power Transmission and Transformation Projects

The intelligent cost forecasting model of transmission and transformation projects mainly combines data mining techniques and methods to expand and extend the traditional methods, deepening the depth and breadth of the cost analysis of transmission and transformation projects, and providing accurate supporting evidence on investment planning decision-making for transmission and transformation projects.

Combined with the existing literature on the research of transmission and transformation project cost forecasting methods, it is found that artificial neural networks have been widely used in many research fields with their unique structural connotations and model processing methods [1-5]. This report takes the substation project in the power transmission and transformation project as the research object, and uses artificial neural network technology to build an intelligent prediction model for the cost of the power transmission and transformation project, and conducts a comparative analysis of the prediction results to improve the prediction accuracy and prediction efficiency.

Neural Network Model Theory

Artificial neural network is a mathematical model based on the basic principles of neural networks in biology. After understanding and abstracting the structure of the human brain and the external stimulus response mechanism, it uses the network topology knowledge as a theoretical basis to simulate the processing mechanism of the neural system of the human brain on complex information.

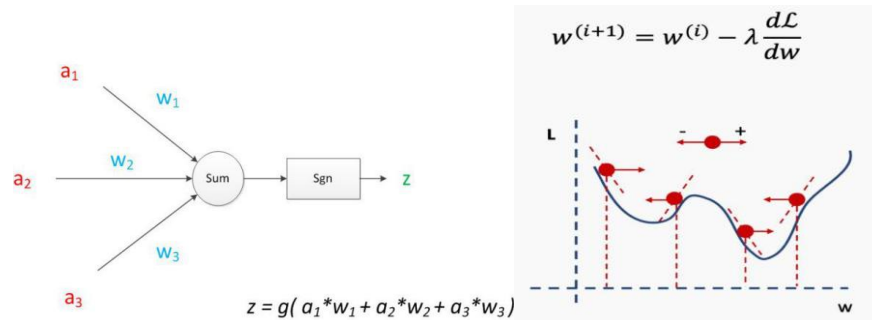


Figure 1. Schematic diagram of neuron symbols.

Figure2. Gradient descent diagram.

z is a linear weighted sum of the input and weight values superimposed by a function g . Generally, g is called an activation function.

The neural network includes an input layer, a hidden layer, and an output layer. A circle in each layer represents a processing neural unit. Several neural processing units form a layer, and several layers form a network, also known as a "neural network".

(1) Forward propagation

Forward propagation is the process of building a complete neural network structure from input to output. The input is the feature value of each sample in the training set, and the output is the predicted value.

(2) Back propagation

Back propagation is the propagation of errors. It is a process of optimizing neural network parameters and improving the accuracy of the model. Before the back-propagation is performed, a loss function is defined to measure the difference, or error, between the predicted value and the true value. The training of the neural network aims to continuously reduce the difference between the predicted value and the real value to update the weight, so that the model can better fit the sample.

(3) Loss function

In the process of iteratively training the model, the idea of gradient descent algorithm is used to update the weight of the network model, so that the loss function continuously approaches the global optimal value, or the minimum value of the loss function. The gradient descent update weight is shown in Figure2:

During the training process, the general trend of the loss function is gradually reduced as the number of iterations increases. When iterating to a certain round, the loss function does not show a downward trend with the increase of the iteration round, indicating that the model parameters have reached the lowest point of the loss function at this time.

Model Construction

Data Samples

The typical project selected for the modeling training sample is the final settlement data of 110kV real transmission and transformation projects in a province from 2016 to 2018. There are a total of 54 samples of 110kV substation data. According to the analysis of the main influencing factors of

the substation project, nearly 40 initial basic indicators that have a large impact on the cost level were sorted out for the new / expansion substation project.

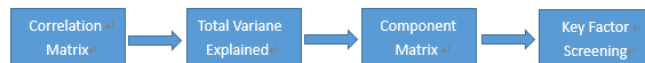
Data Preprocessing

In the process of statistically sorting the historical cost data of power transmission and transformation projects, it was found that not all cost data were directly imported and calculable. Most of the data had problems for the next stage of data analysis and data mining such as unevenness, unclear concept levels, and different orders of magnitude. Therefore, it is particularly important to carry out data preprocessing. Four methods, such as data cleaning, integration, transformation, and protocol, are required to perform data preprocessing to ensure the authenticity and accuracy of the training sample data of the input model.

Identification of Key Influencing Factors

Not all factors selected after data preprocessing have significant effects on the cost results, and changes in some factors within a certain range will not have a large impact on the overall cost level. Therefore, the key factors can be selected from the original factor database for further analysis by principal component analysis.

Screening steps:



By comparing the correlation coefficients of the variables in each of the main components, the main variables with larger correlation coefficients are selected, and all key factors are finally screened. The key factor screening results are shown in the following table:

Table 1. Key factors of substation project.

X1	X2	X3	X4	X5	X6
Construction nature	Total capacity	High voltage side outlets	Medium voltage side outlets	Low voltage side outlets	Low voltage capacitors
X7	X8	X9	X10	X11	X12
Land acquisition area	Area of main control building	Construction site requisition and cleaning fees	Main transformer price	High voltage side power distribution unit type	High voltage side circuit breakers unit price
X13	X14	X15	X16	X17	X18
Medium voltage side circuit breakers unit price	Cost of inbound road	Foundation treatment cost	Field leveling cost	Retaining wall and slope protection	Power cable

Model Training and Verification

There are a total of 54 substation 110kV data samples, 10 randomly selected as the verification sample set, and the remaining 44 as the training sample set. The model builds a neural network with three hidden layers, and the number of neurons in each layer is 32, 64 and 32 respectively. The number of training rounds is 10,000, and the learning rate is 0.01.

Table 2. Substation project sample data.

Project Number	X1	X2	X3	X4	X5	X6	X7	.....	X18
Project1	1	40	0	0	6	6.00	0	.....	600
Project2	1	50	0	0	6	8.00	0	.....	2264
Project3	2	50	2	4	9	8.00	10.12	.....	3570
Project4	1	50	0	0	3	8.00	0	.....	1202
Project5	1	50	0	5	4	8.00	0	.....	1270
.....
Project44	2	50	2	4	8	8.40	6.67	.....	3460

The 10 pieces of data are verified, and the verification result table is as follows:

Table 3. Substation neural network model verification results.

Project Number	Construction Nature	Substation Capacity (MVA)	Actual Static Investment (10k Yuan)	Forecast Static Investment (10k Yuan)	Deviation Rate (%)
1	New main transformer	50	2774.58	2796.22	-0.78
2	New main transformer	50	2533.58	2713.35	-7.10
3	Main transformer expansion	50	775.47	584.86	24.58
4	New main transformer	50	2613.55	2550.96	2.39
5	Main transformer expansion	50	936.53	894.93	4.44
6	New main transformer	50	2821.10	2797.27	0.84
7	New main transformer	50	2730.78	2736.11	-0.20
8	Main transformer expansion	50	827.83	1054.43	-21.49
9	Main transformer expansion	50	876.43	915.41	-4.45
10	New main transformer	100	3759.05	2687.62	28.50

According to the above table, 7 of the predicted static investment and real static investment have deviations within 10%, and there are 3 above 10%. The average deviation rate is 2.67%, and the model performs well on the entire sample of the validation set data.

The accuracy of the neural network prediction is acceptable, but there are some samples with large deviations. This occurs because the sample capacity is too small. For example, the values of many indicators in the samples of some extended substations are 0, which is special and causes large prediction errors. If a large and abundant reliable sample is used for training and prediction, a better fit is expected.

Conclusions and Prospects

Based on historical transmission and transformation engineering data, this report through the identification of key influencing factors, construct an artificial neural network intelligent prediction algorithm. Using this model to predict the cost of transmission and transformation projects above 110kV in a province, the results show that the neural network prediction model can quickly predict the project cost of transmission and transformation projects by inputting key influencing factors of the project, and it can achieve the accuracy of project investment in the investment plan filling.

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