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Cost Forecasting Model of Transmission Project based on PSO-BP Method

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Abstract

In order to solve being sensitive to the initial weights, slow convergence, being easy to fall into local minimum and other problems of the BP neural network, this paper introduces the Particle Swarm Optimization algorithm into the Artificial Neural Network training, and construct a BP neural network model optimized by the particle swarm optimization. This method can speed up the convergence and improve the prediction accuracy. Through the analysis of the main factors on the cost of transmission line project, dig out the path and lead factors, topography and meteorological factors, the tower and the tower base materials and other factors. Use the PSO-BP model for the cost forecasting of transmission line project based on historical project data. The result shows that the method can predict the cost effectively. Compared with the traditional BP neural network, the method can predict with higher accuracy, and can be generalized and applied in cost forecasting of actual projects.

Keywords: *PSO, BP neural network, 110kV transmission line, cost forecasting*

1. Introduction

To meet the social demand for electricity, the power grid around has been constructed much faster.The infrastructure investment of the State Grid Corporation is maintained an annual growth rate of over 10%.A reasonable determinationto the cost of construction projects is importantto improve the returns of the power grid investment. At present, it's mainly through the budget quota shall to estimate accurately the project cost [1], but this method has been increasingly unable to meet the requirements of economic development.In the context of not completely collecting the amount of information, it's hard to predict the project cost quickly and efficiently. Therefore, the introduction of advanced cost forecasting methods and the improvementof cost prediction accuracy have important significance.

Many scholars and experts launched a studyin the field of power engineering cost, but mainly concentrated in factors affecting cost, cost control and management and other aspects, relatively fewer studies on the cost forecasting model. Literature [2] usesthe fuzzy math theory, and estimate the cost of the project to be builtthrough calculatingthe close degree between the completed projects and the projects to be built; literature [3] adopts a linear regression model to predict the cost; literature [4] holds a regression analysis on the key impactive factors on the cost, using multiple linear regression and factor adjustment to establish a comprehensive cost forecasting model for the transmission project; literature [5] uses the GM(1,1) model to establish two principles calculation models, which was used to compilethe estimates of the power engineering projects.In the application of artificial neural network, literature [6] usesthe cost data of historical power engineering projects for ANN training, and adopts the new ANN after training to the cost forecasting of new power projects; literature [7] proposed an approach based on the combining method of gray relational analysis and the neural network; literature [8] proposed a cost forecasting methodbased on BP neural network of the transmission line projects.

However, the BP neural network algorithm exists problems ofbeing sensitive to the initial weights, easy to fall into local minimum and slow convergence [9], so we introduce the PSOalgorithmbased onideas of global stochastic optimization, and adopt the PSO-BP algorithm tothe transmission line cost forecasting.

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2. Analysis of The Influencing Factors of The Transmission Project Cost Based on The Fishbone Diagram

The transmission line project cost is related to many factors [10]. The cost per length is closely related to the voltage levels, terrain, weather, towers, wires, steel, concrete and earthwork, etc. From the perspective of cost forecasting, extractthe main factors affecting the level of its costbased ona new transmission line of certain voltage level the, showed as the Figure 1:

(1) Path and wire factors

The path length directly affects the amount of wire and towers volume, thereby affecting the material acquisition costs and construction costs; the choice of wire model is determined by the transport capacity of the line, and the project costaccounts about 20% of its body cost, indirectlyaffects the infrastructure projectscostsof the tower part [9]. The paper selectsthe single line length, wire volume and wire price as index to reflect the path and wires factors.

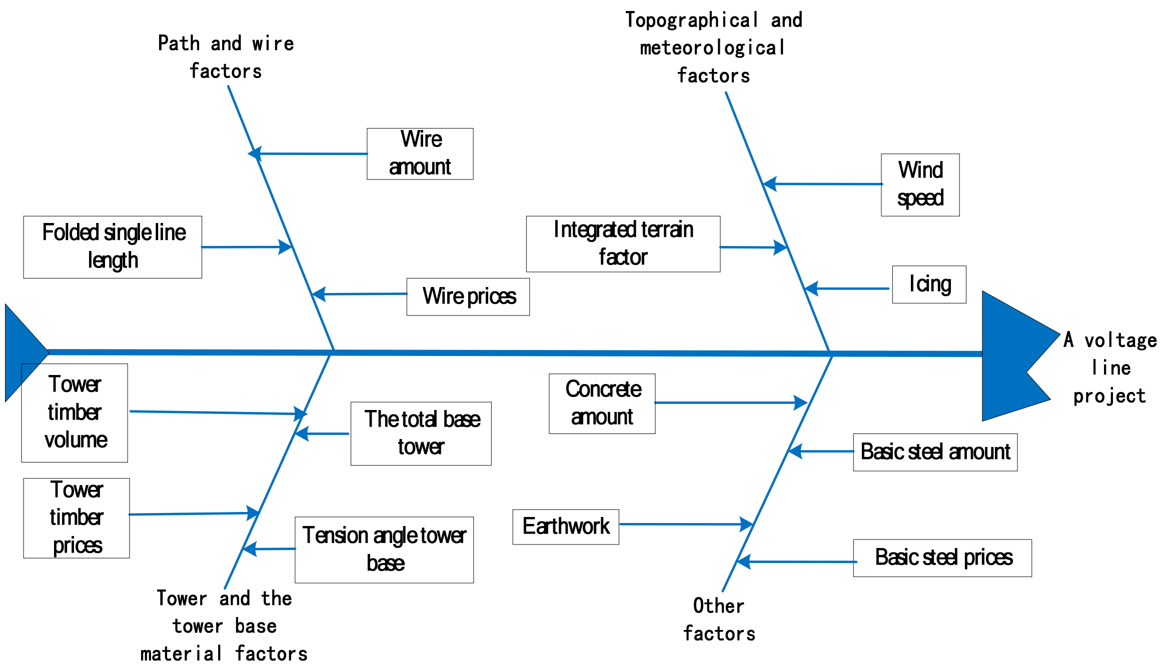

Figure 1. Analysis of the influencing factors of the transmission project of certain voltage level based on the fishbone diagram

(2) Topographical and meteorological factors

Different terrain directly affects the ease of transmission line engineering construction, tower-based form and human transport distance.The terrain is divided into hills, mountainous, mountains, majestic mountains and slough.This paper combines the increased costs coefficient of various types of terrain and terrain accounted given in the quota to calculatea comprehensive value, and uses the integrated terrain coefficient to show the effect of topography on cost. In addition, meteorological factor is also one of the important factors affecting the cost of power transmission lines, wind and icing have special requirements to the selection of wires and towers.

(3) Tower and tower base material factors

The determination of tower selection, tower and other materials should consider the path of the line, voltage levels, the number of loops, terrain, weather and other factors, and these account for a large proportion of the cost of the line engineering body. If the selection of transmission line corridor becomes more difficult and the tortuous path coefficient increases, it will cause increases of strain, corner towers and material consumptions, as a result, the body investmentincreases, and therefore, the number of strain and corner tower is one of the important factors affecting cost.

(4) Other factors

Earthwork and concrete amount influence on the construction costs of transmission lines a lot. Other materials used in power transmission lines, such as the steel consumption and price alsoaffect great on its cost and are the critical sectionof construction work costs.

3. The Cost Forecasting Model of Transmission Project Based on The PSO-BP Method

3.1 The Basic Models

(1) BP neural network

BP neural network is a multilayer feed-forward network trained by error back-propagation algorithm.It's widely used and has a strong generalization ability and fault tolerance. BP neural network can learn and store input - output relationship mapping.It's learningrule is the steepest descent method, and through the back-propagation, constantly adjusting the weights and thresholds of the network, so that the squared error reaches the minimum [11]-[12].

(2) Particle swarm optimization algorithm

The PSO first is to generate a feasible solution, and then the objective function determine a fitness value [13].Each particle will move in the solution space, and speed will determine its direction and distance [14]. Typically, the particles will follow the current optimal particle, and through searching each generation to find the optimal solution. In each generation, the particles will track its optimal solution found so far and the two extremes of the optimal solution found so far [15].

3.2 The PSO-BP Hybrid Algorithm and Its Implementation

From a point of mathematical view, the BP algorithm naturetakes the error sum of squares as the objective function, and finds the minimum with the gradient method.Therefore, the squared error function is positively definite, otherwise there must exist a local minimum points; the PSO algorithm essentially belongs to a random optimization process, and there is no local convergence problems.The field where the PSO is most widely used is optimization [16]. Therefore, combinethe PSO and BP neural network,and the stepsof this algorithm (PSO-BP) is shown in Figure 2.

4. Case Study

4.1 Parameters Setting

In order to verify the validity of PSO-BP algorithm used in cost forecasting of the power transmission line projects, the paper selects 43 sets of data of 110kV long line (> 1km)projects in Zhejiang province.We select 34 sets of data as the training samples, and the rest of the 10 sets as test samples, and use the BP algorithm and the PSO-BP algorithm topredict, and carries on the contrast analysis.

In this paper, a BP neural network with 3 layers is used: the number of neuronsin input layer is set to 14, and they arethe14 factorsscreened in thesecond section; the hidden layer is determined by trial and error method, and eventually identified 29 neurons; the number of output layer is 1, and it's the cost per length of each project .The transfer function used in the hidden layer is logsig, and the purelin in the output layer. The training function is traingdm, the training times of network is 10000, and the error of training goals is 1e-5. The number of particles is 20, the evolution times is 20, the maximum allowable number of iterations is 20, the acceleration constants c1 is 2.8 and c2 is 1.3, and the maximum speed limit of Vmax is1.

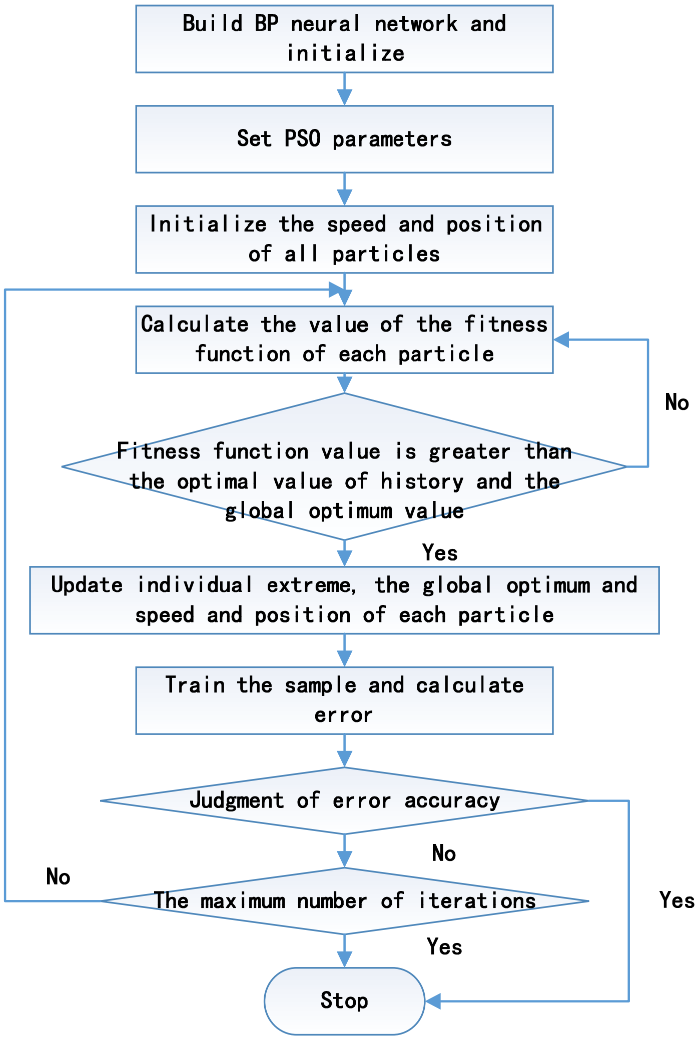

Figure 2.Steps of the PSO-BPalgorithm

4.2 Results

Before the sample data is input to the neural network, normalize the data according to the formula (1).

$$X' = \frac{X - X_{min}}{X_{max} - X_{min}} \quad (1)$$

Figure 3 and Figure 4 are the the test sample fitting maps for transmission line engineering with BP algorithm and PSO-BP algorithm. Figure 5 is the comparison chart of the predicted value and the actual value of transmission line based on BP algorithm and PSO-BP algorithm. This paper selects the mean absolute percentage error (MAPE)to judge the forecasting effects, and the formula is:

$$MAPE = \frac{1}{N}\sum_{n=1}^{n}\left|\frac{O_i - D_i}{D_i}\right| \quad (2)$$

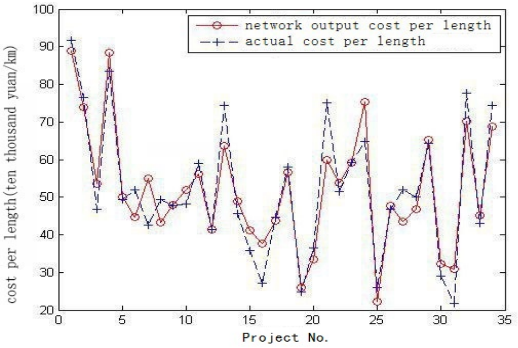

Figure. 3 The test sample fitting map based on BP algorithm

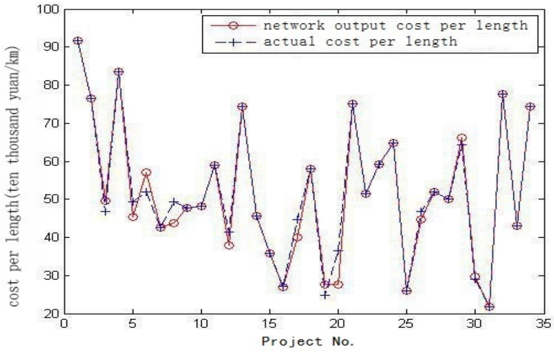

Figure. 4 The test sample map based on PSO-BP algorithm

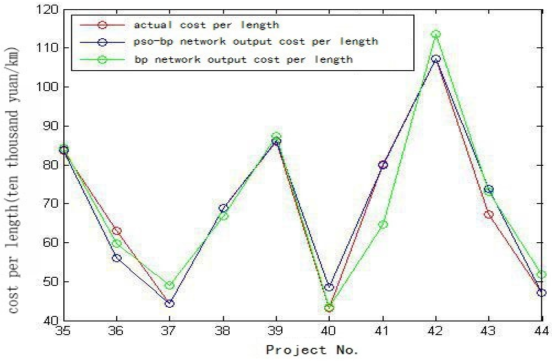

Figure. 5 The comparison map of the forecasting and actual value based on BP and PSO-BP algorithm

The detailed results are shown in the Table 1:

Table.1 The forecasting and actual value based on BP and PSO-BP algorithm

Project No.	Actual Value	Forecasting Value (BP)	Forecasting Value (PSO-BP)	Relative Error (BP)	Relative Error (PSO-BP)
35	83.69	84.44	83.79	0.90%	0.12%
36	63.13	59.80	56.00	5.27%	11.29%
37	44.37	48.91	44.32	10.25%	0.10%
38	68.90	66.84	68.92	2.99%	0.03%
39	86.06	87.26	86.13	1.39%	0.08%
40	43.11	43.39	48.60	0.65%	12.74%
41	80.01	64.74	79.99	19.08%	0.02%
42	107.19	113.52	107.15	5.91%	0.03%
43	67.31	73.19	73.86	8.74%	9.74%
44	47.11	51.81	47.10	9.98%	0.02%

Using the equation (2) we can obtain thatthe MAPE of the BP algorithm is 6.52%, and 3.42%based on PSO-BP algorithm.This indicates that the PSO-BP model has obvious advantages on improvingthe forecasting accuracy.

5. Conclusion

(1) This paper digs and analyses the main factorsaffecting the cost of the transmission line projectbased on the fishbone diagram from four aspects of the path and lead, topography

and meteorological factors, the tower and tower base materials and other factors.

(2) This paper combines the particle swarm optimization algorithm and BP neural network, proposing the PSO-BPforecasting model.Through the actual measurement of the power transmission line projects in Zhejiang Province, we get the cost of the actual engineering.The predicted results show that, the application of PSO-BP model in transmission line cost forecastinghas good application effects of fast convergence speed and highprediction accuracy.

(3) The prediction model PSO-BP can use the global search ability to optimize the initial weights value, so that can solve the problems of sensitive to the initial state, easy to fall into local optimal value and slow convergence rate of BP neural network. The algorithm has some advantages, and can be widely used in transmission line project cost forecasting.

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