Acta Technica *62* No. 2C/2017, 357–364

Construction project cost forecasting method based on artificial neural network model

Fang Cuilan[1,3], Yi Deyong[2]

Abstract. Traditional method of relying on drawings, based on fixed or physical quantity of the project cost forecast method takes a long time, drag the progress of the project. This paper presents a method of building engineering cost forecasting based on artificial neural network model. This paper firstly proves that artificial neural network can be used to forecast the cost of construction project, and then uses RBF neural network to build the construction cost forecasting model, and uses 23 sets of construction engineering data to verify the analysis. The results show that RBF neural network is accurate, fast and feasible for forecasting construction cost, and its prediction error is less than 7 %.

Key words. Construction engineering, cost forecasting, artificial neural network, RBF neural network, engineering characteristics.

1. Introduction

Construction project cost forecast is a basic link in the feasibility study of construction engineering, and it is also a bidding basis of construction project. Its accuracy and fastness directly affect the investment decision and bid competition ability of the project. The traditional cost forecasting method mainly relies on the drawing to calculate the project cost based on the quota or the physical quantity. This method of forecasting takes a long time and is too dependent on the standard specification and does not take good account of the changing mechanism of the market. This can only cause the project cost forecast and the actual project cost error is more and more, and the market gradually derailment. At present, engineers are trying to find a more efficient and accurate prediction method to make up for the shortcomings of traditional methods. Some scholars have proposed fuzzy mathematical probability theory, gray theory and other methods, but because of the lack of

[1]Chongqing Vocational Institute of Engineering, Chongqing, China, 402260
[2]Chongqing Xintong Engineering Cost Consulting Co. Ltd. Chongqing, China, 400020
[3]Corresponding author

cost of the dynamic and marketability, the lack of predictive results of timeliness, not accurate enough. RBF, BP and other artificial neural network method is a new cost forecasting method, which is through the depth of learning to predict training, which can accurately and quickly predict the cost of construction projects.

Many scholars in domestic and abroad have done a lot of research on the prediction of construction cost of artificial neural network. Yang Jiyue constructs the construction project cost forecasting model based on BP neural network, and the accuracy and fastness are better [1]. Niu Dongxiao compares the current methods of using more construction cost forecasting, and proposes a variable structure neural network prediction model, and proves the feasibility of the method from theory and practice [2]. Huang Kunpeng used the value engineering, gray theory and fuzzy mathematics and other methods to control the cost of construction projects were systematically analyzed and compared the advantages and disadvantages of these three methods [3]. Chen Yusu analyzed the basic theory, network model and valuation method of BP neural network method for estimating construction cost [4]. Cao Li established a risk management system based on neural network method, and carried out the detailed design of the system, including the design of knowledge base, main interface and risk comprehensive evaluation [5]. For resolving the limitations of the two methods for gray prediction model and artificial neural network, Chen Congfa introduced the random oscillatory model and the ant colony optimization algorithm The two methods are combined and verified by examples, which provides a good idea for the study of construction cost forecasting method [6]. Osarna Moselhi introduced the application method of neural network method in construction engineering, and provided theoretical support for forecasting the construction cost by using neural network [7]. J. Z. Wu uses the neural network method to simulate the service life of the large-grid structure of the reservoir, which provides a reference for how to select the parameters when the neural network method is used in the building engineering [8]. M. R. Vigder conducted a study on the prediction and control of building costs in the Ottawa area of Ontario, Canada, and compared a variety of forecasting methods [9]. Anonymous introduced a variety of cost forecasting methods and knowledge, providing a more advanced foreign project management and cost forecasting concept [10]. F. C. Chen uses BP neural network to simulate the adaptive self-regulation engineering, and demonstrates the effectiveness of BP neural network in engineering management [11]. Haykin S system introduces the neural network method, and provides theoretical support for the application of neural network method in engineering cost [12].

2. Basic theory of artificial neural network

2.1. Definition of artificial neural network

Artificial neural network first appeared in 1890 William James's "Psychology", the book proposed the famous MP model (McCulloch-Pitts), which created a neural network research precedent. Artificial neural network is similar to human brain or human neural network, with learning, association, self-adaptation, self-organization

and anti-interference ability, it can solve the general information processing methods cannot or difficult to solve the problem, especially some image thinking, reasoning, Summarize, summarize the problem. Artificial neural network to solve the problem fast and accurate, there is a certain degree of fault tolerance, very suitable for the construction cost forecast. Artificial neural network structure model shown in Fig. 1.

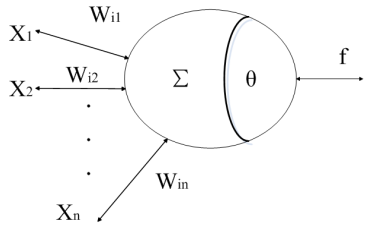

Fig. 1. Artificial neural network structure model

Neural network learning process is also known as training, refers to the environment through the neural network to stimulate the adjustment of the free parameters of the neural network, making the neural network in a new way to make a certain response to the external environment of the process. Neural network learning is divided into two kinds: there are teacher learning (learning with a teacher) and no teacher learning (Learning without a teacher). There is a mentor to learn that there is a mentor in the training process. Although the neural network is unknown to the external environment, the tutor has an understanding of the external environment. The tutor can be represented by a set of samples consisting of input and output. The supervisor signal or the desired response represents the optimal result of the implementation of the neural network, that is, the neural network input is used to adjust the neural network parameters so that the neural network output is as close as possible to the pilot signal or desired response. No tutor to learn without a tutor signal, but through continuous use with the external environment to minimize the performance of the scalar index and completed, the training process did not evaluate the entire training process, but to provide a neural network learning on the quality of the method Measure the scale by which the free parameters of the network are optimized.

Artificial neural network is an advanced means of bionic computing, which has three distinct characteristics:

Nonlinearity. Artificial neurons can be linear or non-linear. If the artificial neural network is made of non-linear artificial neurons, the artificial neural network is nonlinear and can be used to simulate many complex nonlinear problems.

Input-output mapping (Input-Output Mapping), artificial neural network has the ability to learn, one can get through the training input to the mapping between the output method. We can input a lot of training samples, the sample has an input signal and output signal, artificial neural network through this group of training samples to sum up the input to the output of the mapping, or can become a functional relationship, and after several trainings gradually reduce the error until the satisfaction so far, so that the input from the input to the mapping. This method

is used to carry out the basis of construction cost forecast.

Adaptability (Adaptivity). Artificial neural networks can adjust the connection weights to accommodate changes in the initial environment. Artificial neural networks can be easily trained to adapt to changes in the initial environment if they encounter minor changes in the initial environment after training in a particular environment. Said it has a certain degree of self-adaptability.

2.2. Feasibility of artificial neural network used in predicting construction cost

The cost of construction works has a direct relationship with the characteristic factors of construction engineering. This relationship is obviously a non-linear relationship, and its relationship with the most important features of construction is very close, or the weight Larger. Because of this non-linear, complex, multi-input problem, the cost forecast of construction is often not easy to predict accurately. The most prominent feature of artificial neural networks is the ability to solve nonlinear problems and complex problems, such as modeling, time series analysis, pattern recognition and signal processing and control, and so have excellent performance. We can take the characteristic factors of the construction engineering as the input of the artificial neural network, take the cost of the construction project as the output of the neural network, and make the multi-group construction project which has been completed, the clear characteristic factor and the final real cost as the training sample, The Mapping Relationship between Characteristic Factors and Construction Cost. Artificial neural network since the date of birth, many scholars at home and abroad has been in its in-depth research and application, the current application of artificial neural network has been very wide. With the artificial neural network algorithm matures, based on artificial neural network construction cost forecast is completely feasible.

2.3. Two commonly used artificial neural network methods

There are two main methods of artificial neural network: BP (Back Propagation) algorithm and RBF (Radial-Basis Function) algorithm, namely multi-layer sensor network method and multi-variable interpolation radial basis function method.

BP algorithm has the ability of non-linear approximation of two-level perceptron, which makes the network connection more connected, which makes the BP algorithm have extremely powerful computing ability. It is a kind of artificial neural network algorithm which is more popular and widely used.

The RBF algorithm uses the radial basis function as the "base" of the hidden unit to form the hidden layer space. The hidden layer transforms the input vector, transforms the low-dimensional input data into the high-dimensional space, so that the linear indivisibility problem in low-dimensional space can achieve linear separability in high-dimensional space.

There are two main differences between the two methods:

The number of parameters is different. BP algorithm requires global approximation of the nonlinear mapping relation of the samples, while the nonlinear function

of the local exponential decay used by the RBF algorithm is local approximation to the mapping of the nonlinear input and output. If the same precision is achieved, the RBF algorithm needs of the parameters than the BP algorithm much less.

The calculation accuracy is different. RBF network model to predict the results of the project cost is relatively stable, the basic accuracy can be controlled within $\pm 10\,\%$, while the BP network model of the accuracy of the forecast is easy to large ups and downs.

The calculation speed is different. RBF algorithm because there is only one layer of hidden layer, the calculation speed is relatively fast, easy convergence. The BP algorithm often has a slow convergence rate, easy to fall into the local minimum point of the problem.

From the above three reasons, we can see that the performance of RBF network is better than BP network as a whole, so this paper uses RBF neural network to forecast the construction cost.

3. RBF neural networks

3.1. RBF network structure

From the structure point of view, RBF network is a three-tier forward network, the first layer for the input layer, which is composed of signal source nodes. The second layer is the implicit layer (RBF algorithm has only one layer of hidden layer), the number of hidden units is determined by the problem of the fixed, hidden unit of the transformation function is a center of the radial symmetry and attenuation Non - negative nonlinear function. The third layer is the output layer, it responds to the input layer, the structure shown in Fig. 2.

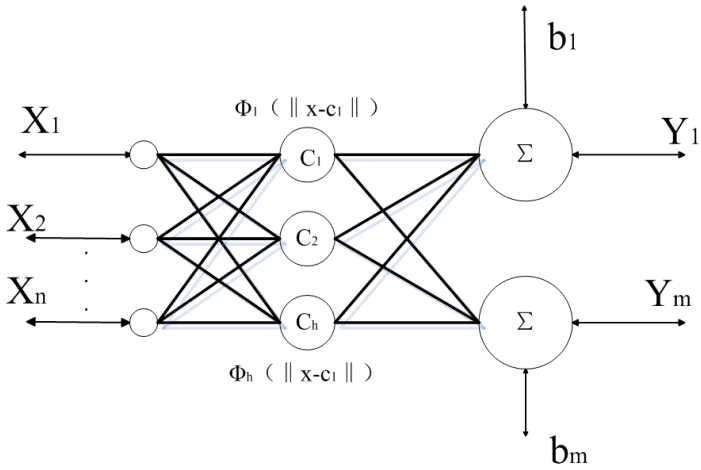

Fig. 2. RBF network structure diagram

3.2. RBF algorithm flow

The algorithm for determining RBF is actually a process of determining the number of hidden nodes in the RBF network, the data center of the radial basis function, and the output weights. After these parameters are determined, the hidden layer to the output layer is a multiple linear system of equations, and then learn the weight can be used to solve the least squares method. Commonly used algorithms include clustering method, gradient training method, orthogonal least squares learning algorithm and so on.

The most classic RBF network algorithm is based on the K-means clustering algorithm RBF network, the method is proposed by Moody and Darken. The main idea is to use the method without instructor to study the clustering analysis to determine the number of hidden nodes in the RBF network, and then find out the distance of the data center to determine the expansion constant of the activation function in the hidden layer, Finally, you can use the least squares method to directly find the weight, that is shown in Fig. 2.

4. Verification analysis of construction cost based on RBF neural network

In this paper, we use MATLAB to write the algorithm program, mainly using the software toolbox radbas (radial basis transfer function) and newrb (radial basis network function), based on the minimum gradient method to prepare the algorithm to simulate the simulation training program.

In this paper, a total of 23 sets of construction project cost examples were collected to verify the algorithmic program. For the selection of engineering features, this paper chooses the eight engineering features which are most influential to project cost, namely, foundation type, main structure type, wall type, layer number, layer height, single floor building area, inner and outer wall practice and door and window type , The above eight engineering features as RBF network training sample values for input to the single cost, the amount of concrete, the amount of steel used in these three factors as the output of the sample. After training, the error map and the forecast result output table are shown in Fig. 3 and Table 1, respectively.

In the training, the error err_goal is set to 0.01, the width of the hidden layer Gaussian function is set to 0.5, the maximum number of iterations is 100, As can be seen from Fig. 3, only after 13 iterations after less than 0.01, the error convergence rate is relatively fast.

In the training, because the data is not a lot, only 23 groups, and RBF network structure is relatively simple, so only after 13 iterations to achieve the expected range of error, and the actual cost and forecast cost error is small, in addition to individual data, The error is less than 7 %, all data are less than 10 %. Due to the limited space, this paper only lists the results of samples 5 and 15, the prediction results are shown in Table 1.

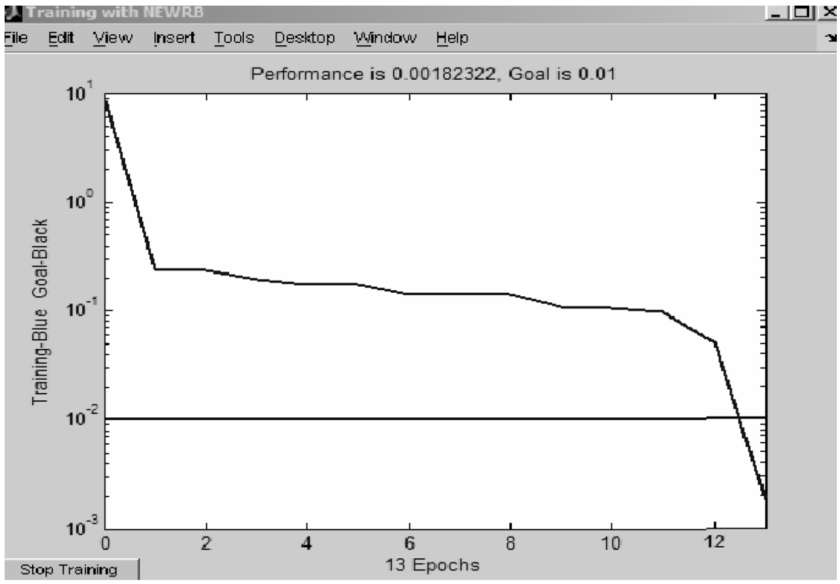

Fig. 3. Error training chart

Table 1. The distribution of the dynamic comfort

Sample No.	No.5			No.15		
Input item	Each cubic cost	Concrete	Steel bars	Each cubic cost	Concrete	Steel bars
Actual value	954.6	1992	588	712.8	1752	1207
Predictive value	977.8	2103	561	676.2	1667	1285
Tolerance	2.43 %	5.54 %	-4.59 %	-5.13 %	-4.82 %	6.46 %

5. Conclusion

In this paper, the construction cost is forecast by using RBF neural network, and the results of 23 sets of construction engineering are verified, and get the following conclusions Artificial neural network model to predict the cost of construction projects is accurate, fast and feasible.

RBF neural network is simple in structure, fast convergence, less required parameters, and less prediction error, and can be applied to construction cost forecast.

Based on the engineering cost forecast of eight engineering features of the 23 sample sizes mentioned in this paper, although the error is less than 10 %, but most still more than 5 %, it is still necessary to further increase the number of samples and refine the engineering characteristics to improve predictive accuracy.

References

[1] J. W. Zhang, D. L. Ye, G. C. Ye, J. Z. Zhou: *Engineering project risk evaluation system construction and research based on BP model.* Applied Mechanics and Materials *367–370* (2013), 2050–2053.

[2] G. H. Kim, J. E. Yoon, S. H. An, H. H. Cho, K. I. Kang: *Neural network model incorporating a genetic algorithm in estimating construction costs.* Building and Environment *39* (2004), No. 11, 1333–1340.

[3] W. Li, S. C. Li, D. Wang: *Risk evaluation of the wind power project investment based on BP neural network.* Advanced Materials Research *108–111* (2010), 256–261.

[4] G. Zhang, B. E. Patuwo, M. Y. Hu: *Forecasting with artificial neural networks: The state of the art.* International Journal of Forecasting *14* (1998), No. 1, 35–62.

[5] H. Adeli: *Neural networks in civil engineering: 1989–2000.* Computer-Aided Civil and Infrastructure Engineering *16* (2001), No. 2, 126–142.

[6] J. S. Shane, K. R. Molenaar, S. Anderson, C. Schexnayder: *Construction project cost escalation factors.* Journal of Management in Engineering *25* (2009), No. 4, 221–229.

[7] H. Golizadeh, A. N. Sadeghifam, H. Aadal, M. Z. A. Majid: *Automated tool for predicting duration of construction activities in tropical countries.* KSCE Journal of Civil Engineering *20* (2016), No. 1, 12–22.

[8] C. M. Wen, S. L. Hung, C. S. Huang, J. C. Jan: *Unsupervised fuzzy neural networks for damage detection of structures.* Structural Control and Health Monitoring *14* (2007), No. 1, 144–161.

[9] A. L. Yver, L. M. Bonnaillie, W. Yee, A. McAloon, P. M. Tomasula: *Fractionation of whey protein isolate with supercritical carbon dioxide-process modeling and cost estimation.* International Journal of Molecular Sciences *13* (2012), No. 1, 240–259.

[10] Y. Xu, F. Elgh, J. A. Erkoyuncu, O. Bankole, Y. Goh, W. M. Cheung: *Cost engineering for manufacturing: Current and future research.* International Journal of Computer Integrated Manufacturing *25*, (2012), Nos. 4–5, 300–314.

[11] S. G. Tzafestas, G. G. Rigatos: *Neural and neurofuzzy FELA adaptive robot control using feedforward and counterpropagation networks.* Journal of Intelligent and Robotic Systems *23* (1998), Nos. 2–4, 291–330.

[12] G. H. Kim, S. H. An, K. I. Kang: *Comparison of construction cost estimating models based on regression analysis, neural networks, and case-based reasoning.* Building and Environment *39* (2004), No. 10, 1235–1242.

Received July 12, 2017