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Application of BP Neural Network Algorithm in Sustainable Development of Highway Construction Projects

Mingshun Li, Wencui Chen

Department of Project Management
Changsha University of Science & Technology
Changsha China

Abstract

Highway construction project does not exist for its own, but also to meet the needs of the society. Its development strategy should be based on the overall goal of the society, not just for its own. Therefore, the sustainable evaluation of the highway construction should be considered from the two parts of sustainability of social needs and economic development. In this paper, using the BP neural network algorithm, through the analysis of sustainable development of the following four areas in road construction: economics, environmental resources, operations, management systems and policy, the author studies the sustainable development evaluation of highway construction project.

Keywords: BP Neural Network Algorithm, Highway construction projects, Sustainable Development, Evaluation

1. Introductions

From the basic concept of sustainable development, considering the characteristics of highway traffic industry, we can hold that the sustainable development in highway construction is based on the meeting and appropriate advance of the requirements in social economic development, it can not only meet the internal highway traffic and coordinated development of integrated transport system, but also make society, economics, environment and resources to maintain the long-term coordinated development, and ultimately ensure the sustained development of highway transport capacity and sustainable state of development, meet and promote social progress and national economic development. With the social sustained, stable and rapid development, highway construction is at the unprecedented peak. But serious conflicts between the highway construction and the development of national economics still exist. Based on goals of national sustainable development strategy, it is important that how to evaluate sustainable

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development in highway construction project formulate and plan the sustainable development strategy of highway construction in the new era.

Currently, evaluation of highway construction projects have many ways for sustainable development, such as the comprehensive score, expert discussions, cost-benefit analysis, hierarchical analysis, data envelopment analysis, fuzzy clustering, fuzzy evaluation, gray statistics, grey relational analysis, decision-making fuzzy gray matter element and so on. Because the influence factors of road construction project sustainable development are so many and each factor have stochastic that makes a low prediction accuracy of project variation of each factor or the distribution. Relevance of influence factors, subjectivity in the determination of weight, the difficulty of quantitative calculation, evaluation of samples appears noise data and other issues will affect the evaluation method. For artificial neural network has a good fault tolerance and associative memory function、 very strong adaptive self-learning function、 highly nonlinear global role etc, so it can play a good role when using it to solve the above problems. In this paper, BP neural network algorithm based on a comprehensive evaluation method analyzing the sustainable development of highway construction projects. It used a correct analysis and an accurate estimate in overall impact, in order to achieve an effective evaluation and decision-making, and to ensure the smooth realization of the ultimate goal of the project [1].

2. BP neural network model

2.1 BP neural network algorithm principle

Artificial neural network is a new information processing system which basis on a preliminary understanding of human brain structure, activity system. For artificial neural network nonlinear mapping ability and good soft topology, now it is widely used in pattern recognition, data prediction, system identification, image processing, speech understanding, and function fitting, and other fields [2].

Using BP algorithm of multilayer neural network model is called BP neural network. BP artificial neural network is the most widely used neural network, the most studied networks. The basic BP neural network have 3 parts: input layer, middle layer and output layer. The topology shows in Figure 1 [4].

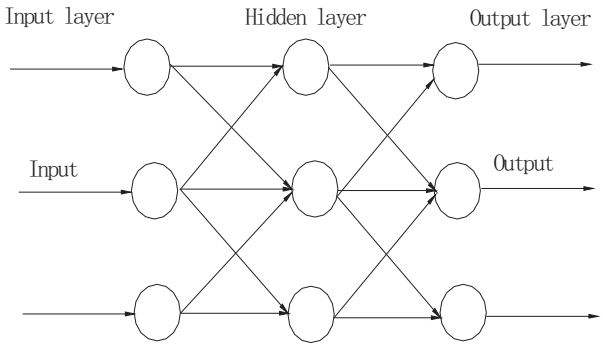

Figure 1 BP neural network topology

2.2 Basic Algorithm

The BP network requires continuous differentiable non-linear excitation function, so usually S-type (Sigmoid) function as the excitation function:

$$\mathbf{f(Net_{kj})} = \frac{\mathbf{1}}{\mathbf{1+e^{-Net_{kj}}}} \tag{1}$$

Equation (1): Net_{kj} state for the Status of network U_j

$$\mathbf{Net_{kj}} = \sum_{\mathbf{i}} \mathbf{w_{ji}\, o_{ki}} + \boldsymbol{\theta}_{\mathbf{j}}$$

Unit output is:

$$\mathbf{o_{kj}} = \frac{\mathbf{1}}{\mathbf{1+exp\,(-\sum_i w_{ji} o_{ki} - \theta_j)}} = \frac{\mathbf{1}}{\mathbf{1+e^{-Net_{kj}}}} \tag{2}$$

Equation (2): θj state for the threshold of unit Uj.

In this excitation function, there are:

$$\mathbf{f'_j(Net_{kj})} = \frac{\partial \mathbf{o_{ki}}}{\partial \mathbf{Net_{kj}}} = \mathbf{o_{kj}(1 - o_{kj})} \tag{3}$$

Therefore, the output layer unit:

$$\boldsymbol{\delta}_{\mathbf{kj}} = (\mathbf{t_{kj}} - \mathbf{o_{kj}}) \cdot \mathbf{o_{kj}(1 - o_{kj})}$$

For hidden layer units:

$$\boldsymbol{\delta}_{\mathbf{kj}} = \mathbf{o_{kj}(1 - o_{kj})} \sum_{\mathbf{m}} \boldsymbol{\delta}_{\mathbf{km}}\, \mathbf{w_{uj}}$$

Weight adjustment is:

$$\Delta \mathbf{w_{ji}(t+1)} = \boldsymbol{\eta} \boldsymbol{\delta}_{\mathbf{kj}} \mathbf{o_{ki}}$$

In the actual learning process, learning rate η is a great impact on the learning process η is the step of gradient search. The larger the η is, the more the dramatic changes in weight. Practice, we usually take a η value which as large as possible under a premise that it's not create oscillations. In order to make learning fast enough and not easy to produce oscillations, we often combined with a "key state of affairs" in the δ rule, namely:

$$\Delta \mathbf{w_{ji}(t+1)} = \boldsymbol{\eta} \boldsymbol{\delta}_{\mathbf{kj}} \mathbf{o_{ki}} + \mathbf{a} \Delta \mathbf{w_{ji}(t)} \tag{4}$$

Equation (4): a is a constant, which determines the past weight changes to the weight impact at present [3].

3. The neural network model of Evaluation of Sustainable Development of Highway Construction Project

3.1 Establishment of evaluation index system

Establish Highway Construction Project evaluation index system of sustainable development is a necessary means that put sustainable development of highway construction projects from qualitative analysis phase to quantitative analysis phase change. In order to assess sustainable development of highway construction projects under a scientific and comprehensive manner, with the awareness, research status, the existing research results of sustainable development of highway construction projects and obtain expert advice, propose highway construction project evaluation index system of sustainable development shown in Table 1. Highway construction project evaluation index system of sustainable development has three layers, that are the total evaluation index (comprehensive index), an evaluation index (classification and evaluation index), and two evaluation indices (single evaluation index). Specifically, Highway Construction Project evaluation index system of sustainable development composite four major categories of indicators, 18 individual indicators.

Table 1 Sustainable development of road construction project evaluation index system

Target A	Classified Index B	Single evaluation index C
The sustainable development effect evaluation of Road Construction project	Evaluation of socio-economic sustainable development X1	Degree of social development indicators X_{11}
		Index of economic development level X_{12}
		Promote political stability index X_{13}
		Improve the quality of the road sector level evaluationX_{14}
	Evaluation of sustainable development of environmental resources X2	Evaluation of pollution controlX_{21}
		Utilization and protection of natural resources indexX_{22}
		Evaluation of the impact of ecological balanceX_{23}
		Environmental Management EvaluationX_{24}
	Construction project operation evaluation of sustainable developmentX3	The main highway engineering and traffic safety evaluationX_{31}
		Communication Systems Engineering EvaluationX_{32}
		Monitoring system evaluationX_{33}
		Evaluation index system engineering feesX_{34}
		Evaluation of other engineering systems X_{35}
		Service area and conservation engineering systems evaluation X_{36}
		Highway transportation level of coordination with other modes of transport indexX_{37}
	Sustainable development management system and policy evaluation X4	"Software" Management and Policy EvaluationX_{41}
		"Hardware" Management and Policy EvaluationX_{42}
		Construction Cost and Financial Management IndexX_{43}

3.2 Evaluation model

Sustainable development of highway construction projects neural network structure identified as (n, m, 1) (Figure 1) number of input nodes corresponding to the number of Sub-element layer's factors; Evaluation value corresponding to the output layer nodes; Hidden layer is 1, the number of hidden nodes is m. According to the number of training samples to determine an appropriate number of hidden nodes u. Empirical formula commonly used are:

$$\mathbf{u = \sqrt{n + m} + a(1 \le a \le 10)} \tag{5}$$

$$\mathbf{u = \log_2 m} \tag{6}$$

$$\mathbf{u = (2m + 1)} \tag{7}$$

This initial value of hidden nodes U used:

$$\mathbf{u = \max\left(\sqrt{n + m}\right) + a, \log_2 m, 2m + 1} \tag{8}$$

Where, m is the number of nodes of input layer, n nodes for the output layer.

3.3 Application of neural network model

Model of the application process is that make the factors which affect the evaluation projects numerical and input the trained network model, and then can get the best highway construction project value of comprehensive evaluation of sustainable development.

Next, basis the evaluation value's class intervals do analysis and decision-making. At the same time, make recommendations. Supposing the sustainable development of highway construction project evaluation class space as D, in our paper we share 5 class, that D = {big, bigger, general, small, smaller}. Sustainable development of the comprehensive evaluation value based interval [0, 0.2] express small, so on (0.2, 0.4] express smaller, (0.4, 0.6] for the general; (0.6, 0.8] for big, (0.8, 1] for bigger. Based on the above neural network model obtained intervals of comprehensive assessment of the value, determine the level of evaluation. If the level of comprehensive evaluation under the smaller level, forecast the rating scale of sustainable development to the investors and policymakers and give them some suggests.

4. Applications

In this paper, we use Chang'an highway comprehensive evaluation of sustainable development as the example to analysis. Chang'an highway (Two Guang highway of Changde to Anhua section) begins Changde, Dingcheng district Shimen bridge, connects the propose Quchang highway and Chang'an highway which already been built, ends Anhua Meicheng. The total length is 95 km. It has started in November 2008, and plans to open for the traffic in 2012.In that time, it will make Changsha,Changde,Yueyang，Yiyang etc cities achieve "high speed" butt and promote "the economic circle around Dongting Lake" regional economic development. At the same time it can meet the needs of Dongting Lake's flood disaster.

Combining the specific circumstances of the project, through expert Consultation questionnaire survey and based on fuzzy comprehensive evaluation method, getting the project index value of each factor shows in Table 2. Meanwhile, collecting 15 highway projects relevant data, selecting some experts, based on fuzzy comprehensive evaluation method, gets these highway construction projects of social impact assessment of sustainable development index value and the value of comprehensive evaluation. Choosing 12 items' data do the training samples, the other three items' data as test samples.

Table 2 Chang'an highway factors of sustainable development appraisal value (input value)

Factors	X11	X12	X13	X14	X21	X22	X23	X24	X31
Input	0.7432	0.7429	0.7514	0.8421	0.7960	0.8043	0.8099	0.8027	0.7275
Factors	X32	X33	X34	X35	X36	X37	X41	X42	X43
Input	0.7422	0.7377	0.8849	0.8245	0.8241	0.8335	0.8473	0.8861	0.8891

According to the previous design of BP neural network model, selected 18 social impact assessment values as input, one of the output layer node as comprehensive evaluation value. The initial value of the hidden layer nodes taken 37 by 2M +1. Sustainable development of the highway project the initial BP model structure identified as (18, 37, 1). In this paper, the training function algorithm is function trainbpx method which in Matlab neural network toolbox and uses the momentum method and adaptive learning rate strategy. In the sample model training process constantly adjust in order to determine the number of hidden nodes. Network results and the operating parameters shows in Table 3 the largest Network training times is 1500 and the get actual error is 0.01362. The whole process achieves on the Matlab6.5.

Table 3 BP neural network parameters

Type	Parameters	BP neural network
Network structure	The total number of layers	3
	Hidden layers	1
	Input layer nodes	1
	Hidden nodes	13
	Output layer nodes	1
	The number of training samples	12
	Test samples	3
Training parameters	The number of iterations	1500
	Error	0.01362

In this paper, using the trained BP neural network, distinguish 18 factors of fuzzy evaluation value as input and get the comprehensive evaluation of the sustainable development of road value. The integrated value of the BP neural network output as 0.71912.It's in the interval (0.6, 0.8], Comprehensive Evaluation of the value of rating is larger. That shows that the road can be better achieved its social objectives.

5. Conclusions

Statistical analysis methods and practical results have all showed that based on BP neural network model to highway construction project on assessment of sustainable development is feasibility and applicability. Using the model that based on BP neural network model to highway construction project on assessment of sustainable development is meaningful and this method provides a more reliable reference and evaluation methods for highway construction projects for the sustainable development strategy.

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