Research on Intelligent Prediction of Engineering Cost Based on Artificial Intelligence

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Abstract: *However, due to the limited engineering information in the investment stage of the project, the estimation of construction cost generally has the disadvantages of large error and long preparation time. Therefore, how to calculate the cost (or investment) of engineering projects accurately, reasonably and quickly is a matter of great concern to engineering project practitioners and researchers. Through the combination of systematic theoretical analysis and practical work experience, the index system for construction project cost prediction is constructed. The artificial intelligence (AI) theory of neural network (NN) is selected, and the basic principle, network model and prediction method of construction project cost prediction with this method are systematically analyzed. As a theoretical model, a new construction project cost prediction model is constructed. This paper mainly studies the application of AI methods in the field of construction project evaluation. Three kinds of AI evaluation models are established by using particle swarm optimization artificial neural network (ANN) and case-based reasoning to predict the construction project evaluation, and their effectiveness is verified by examples.*

Keywords: *Artificial intelligence; Project cost; Intelligent prediction*

1. Introduction

With the continuous improvement of China's economic level and national comprehensive strength, China is also facing many new situations and new challenges. In the face of these new situations, there have also been some new reform measures, and a large amount of funds have been used for asset investment, especially for infrastructure construction [1]. With the increase of national investment in construction projects, the saving and rational allocation of funds naturally become a very important issue. Only on the basis of improving the existing theories and methods of project cost determination and control, with the help of the latest breakthroughs in theories and methods in other management fields, can we conduct a more in-depth and comprehensive study on the determination and control of project cost [2]. The control of project cost is to strictly calculate, adjust and supervise all costs (controlled system) in the cost formation process (implementation control system) according to the calculated and determined project cost and investment cost, which is the established cost target, to reveal the deviation, correct it in time, and ensure the realization of the cost target. Therefore, the prediction of construction cost is of great significance [3].

The core of the construction industry is construction engineering, so the management of construction engineering has a high practical significance[4]. The current budget management system is mostly in a phased management mode due to the lack of comprehensive management awareness in the whole process [5]. Due to the lack of unified and orderly cost management objectives and communication among the construction, design and construction units, on the one hand, the project supervision can only be confined to the quality and progress management in the construction stage, but cannot be involved in the investment decision analysis; On the other hand, although the design unit can estimate the project budget or even refine it to the budget in the design stage, the lack of control constraints leads to conservative design and high investment [6].

As far as construction engineering is concerned, due to the uniqueness, complexity, diversity, dependence on the construction area and other factors of construction engineering itself, it is impossible to have two completely identical projects, so for construction engineering, it is not possible to completely refer to the established project price [7]. Therefore, architectural design units should pay more attention to the collation and preservation of budget data. However, as there is no effective system for the preservation of budget data, the actual situation of many units is that data are stored unorganized, and there is no unified data warehousing, resulting in many important data resources can

not be used again [8]. These similar projects have different applications according to their characteristics, cost data and depth of project progress. Their common disadvantage is that they fix the most active factors in the competition, which is difficult to adapt to the requirements of the market economy system, ignore the time value of funds, and lack dynamics, resulting in the separation of technology and economy, resulting in the distortion of estimated cost. However, due to the short time limit, the functions of the existing software are still immature, and the manual calculation of the lowest cost price is heavy, complicated and slow. Therefore, simplifying the compilation of the estimated project cost, using advanced means to estimate the project cost and speeding up the compilation of the budget estimate have become the core issues to control the project cost management.

Through the research of this topic, the data of the built projects are used to search for the factors that have a greater impact on the project cost, and the characteristic variables that have a strong correlation with the project cost are selected as the input variables. A mathematical model is established, combined with computer simulation, and then a simple, fast and accurate management system for project cost estimation and control is established.

2. Basic Theory and Principle of Artificial Intelligence Technology on Intelligent Prediction

2.1. Research and Application Fields of Artificial Intelligence

For decades, people have always regarded computers as machines that can only calculate numbers very quickly, skillfully and accurately. However, in today's world, the problems to be solved are not all numerical calculations, such as language understanding and translation, graphics and sound recognition, decision management, etc., which requires that computers can be expanded from "data processing" to "knowledge processing" [9]. The transformation of computer capability category is an important factor leading to the rapid development of "AI". That is to say, AI is the basic theory, method and technology of how to apply computer hardware and software to simulate some intelligent behaviors of human beings by studying the laws of human intelligence activities, constructing artificial systems with certain intelligence, and studying how to make computers complete the tasks that used to require human intelligence. Artificial NN is inspired by studying the mystery of human brain, trying to imitate the engineering structure and working mechanism of human brain nervous system with a large number of processing units [10].

In terms of research methods, synthesis rather than decomposition is emphasized, because decomposition has been basically completed, that is, the NN can be decomposed into very simple neurons and the interconnection between neurons. As a research field of AI, machine learning mainly studies how to make computers have the learning ability similar to human beings, so that computers can automatically acquire knowledge and skills through learning, and achieve self-improvement. In order to achieve this goal, he will carry out three aspects of research, namely, the study of human learning mechanism, the study of learning methods and the establishment of a task oriented learning system.

2.2. Prediction and analysis of construction cost

The construction cost refers to the construction price of the construction project. Generally, there are two definitions of construction cost. Definition 1: Construction project cost refers to the total cost for building a project, which is defined from the perspective of the construction unit. From the investment estimation in the early stage of the project to the final maintenance management, etc., all belong to the scope of construction project cost; Definition: Construction project cost is the total price of construction projects, which refers to the total transaction price formed in the market transaction activities in order to complete a certain project. The construction project cost here mainly refers to the total cost of construction and installation projects of construction projects. Among them, the investment in the design stage, the decision-making stage and the construction stage of the project can be controlled to determine the reasonable cost, so that the project cost can be controlled within the allowable range, the manpower, material resources and financial resources can be saved to the greatest extent, and the investment and social benefits of enterprises can be improved. Government departments are not responsible for organizing the formulation of project estimates, budgetary estimates, labor, materials and machinery consumption quotas, etc., which are formulated by several regional guilds according to the accumulated data of various construction enterprises and the actual situation of the region. According to the engineering structure, material types, decoration methods, etc., they set the

consumption and base price of the building area as the basis of the engineering cost, and then input the data into the computer to market. Although these data were not formulated by government departments, they were generally recognized by the society because of their scientificity, accuracy and fairness, and were successfully implemented. Most of the established projects lack the scientific and reasonable feasibility study in the early stage, which leads to blind investment, false estimation and false budget estimate of the construction unit, which brings great obstacles to the follow-up management.

Project cost estimation is a work with strong policy, knowledge and professionalism. It is not difficult to know how hard and meticulous it is. The most difficult and meticulous work is the calculation of quantities. The accuracy of the quantities is related to the quality of the estimation. Sometimes the quantities are calculated incorrectly, sometimes it is deliberately increased artificially, which is caused by the subjective reasons of the cost engineer. Therefore, the reference of the ANN is of great significance to the research and application of imitating the cost engineer's brain thinking mode in the actual project. The most important thing for the prediction of project cost is to maintain the accuracy and speed of the prediction. The rapid and accurate realization of the construction project cost prediction can provide investors with good decision support; It will increase valuable bidding thinking time for Party B, especially the general construction contractor. Of course, the accuracy of construction project cost prediction will also directly affect the cost, progress and quality control of later project construction. It can be seen that it is of great significance to accurately and quickly realize the construction cost prediction.

3. Project Evaluation Model Based on PSO Optimizing BP Neural Network Parameters

3.1. Artificial Neural Network Algorithm Model

Many factors affect the cost estimation of construction projects, and the work is extremely complicated. However, an experienced project cost engineer can quickly and roughly estimate the required cost by using NN according to a certain project type and characteristics, referring to past experience and built project data, without mechanical quota application and numerous tedious calculations from beginning to end. The more experienced, the more comprehensive the data and information, the more accurate the estimated cost will be. The structure of BP NN is a kind of NN with three or more layers. The neurons in the upper and lower layers are all connected, and the network learns according to the way teachers learn. When a pair of learning patterns are input into the network, the neurons are activated, and the activation values of neurons propagate from the input layer to the output layer through the intermediate layers. Then, by reducing the error between the expected output and the actual output, the connection weights are corrected from the output layer through the intermediate layers layer by layer, so it is called "error back propagation" as the name implies. In essence, it is an intelligent science that imitates the structure and function of human nerve center. This new science in recent years can provide some functions similar to those of human brain. The core idea is that it can adapt to complex actual environment and predict the future under specific circumstances through its self-organization, self-learning ability and high fault tolerance. We know that although a single neuron has a simple structure and clear functions, there are hundreds of millions of neurons in the human brain. Therefore, we can see the complexity of the mathematical model of NN. For ANN, its basic processing unit is artificial neuron, and the earliest one defined as artificial neuron model is model. Its general model is shown in Figure 1.
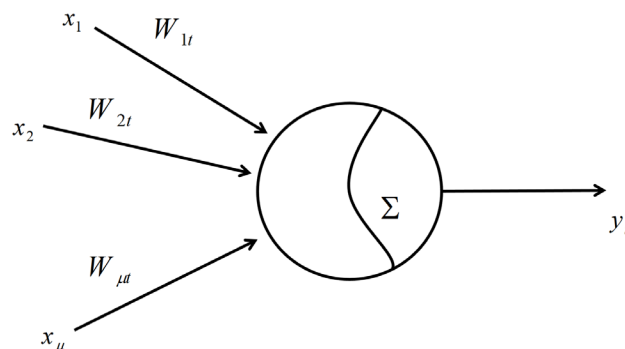

Figure 1: Artificial Neural Network

Artificial neuron is also called processing unit, node or short-term memory because it is a processing node in ANN. The output of other neurons or external environment constitutes the input vector $(x_1, x_2, x_n)^T$, where x_i is the output or excitation level of other neurons or external environment.

When the actual output value of the network is not equal to the expected output value, there is an output error of E, and the definition formula of the error is (1):

$$E = \frac{1}{2}(D-O)^2 = \frac{1}{2}\sum_{k=1}^{m}(d_k - o_k)^2 \tag{1}$$

When the error signal propagates backward from the output to the next level, the adjustment of network weight is completed by error feedback. By constantly adjusting the weight value, the actual output of the network is closer to the expected output. If S excitation function is adopted, the correction formula for connection weight is:

$$w_{jk}(t+1) = w_{jk}(t) + \eta \delta_k o_j \tag{2}$$

The above two processes alternate repeatedly until they converge. Because errors are transmitted back layer by layer to correct the weights and thresholds between layers, this algorithm is called error back propagation. This error back propagation can be extended to multilayer networks with several intermediate layers, which are often called BP networks. The weights of the standard BP algorithm are revised in the opposite direction of the gradient of the error performance function.

3.2. Model demonstration and analysis

In the ANN, feedforward NN is the most common network structure in the whole NN system, including perceptron NN, linear NN, BP network and radial basis function network (RBF). At present, most of the NN models use BP network or its variation form, and it has become the core part of the feedforward NN. The construction project cost prediction model built in this study is simulated and analyzed on the platform. It is developed based on matrix operation. Its instruction expression is similar to engineering mathematics language, which can greatly reduce the tedious problems of programming based on language and other languages, greatly reduce programming statements, and improve the operation efficiency. It can be said to be a powerful mathematical software, which is very suitable for mathematical modeling and processing very complex mathematical operations. We will separate the selected sample projects, select the first project as the training set and input it into the NN prediction model for training to build a NN based construction cost prediction model. In order to better study the absolute error and relative error between the predicted value and the actual value of the test sample, the function fitting graph of the predicted value and the actual value is redrawn in this study, as shown in Figure 2.
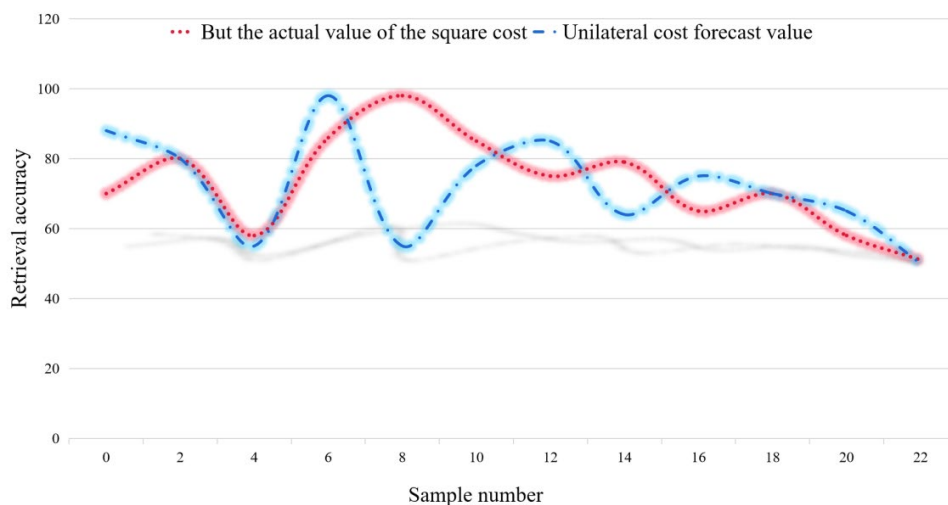

Figure 2: Prediction Results of Test Samples

It can be seen from the above figure that the new model performs well in controlling the relative error and has strong stability, and the simulation analysis well verifies the prediction effect of the new model. In addition, the establishment of the whole model and the realization of the construction project cost prediction are all on the platform, which can be realized by programming. Compared with the traditional methods of estimating the construction project cost such as budget software, the prediction speed of the construction project cost prediction model constructed in this study is faster. Among the characteristic variables, structure type, labor productivity, standard floor height have strong correlation with project cost, while the correlation between foundation engineering, equipment engineering, building height and project cost is relatively weak. Secondly, there are no missing variables that have great influence on the cost in the selected characteristic variables, and the dynamic index of the cost in this model-labor productivity is reflected; In addition, because the quantity and quality of the test samples affect the learning efficiency and learning speed of the model, some data in the test results are biased; In addition, some indicators that have a weak impact on the cost are ignored, which makes the sensitivity performance of some indicators inaccurate.

4. Conclusions

At present, simplifying the compilation of estimated project cost, using advanced means to estimate project cost and speeding up the compilation of budget estimate have become one of the main problems in controlling project cost management. Based on this purpose, the research work of this paper was started. Then, by studying the basic principles of NN, fuzzy system and genetic algorithm, consulting a large number of literatures and making detailed analysis and research on the existing commonly used building engineering cost estimation models, it is found that in order to further improve the accuracy of the calculation results of the models, only by combining NN, fuzzy system and genetic algorithm, while giving full play to the advantages of NN and fuzzy system, making full use of the global search of genetic algorithm and reducing the influence of subjective factors on the results, an estimation model based on genetic fuzzy NN is finally put forward. Finally, this paper takes the construction project cost estimation as the research object, establishes the building evaluation model based on AI, and applies the two intelligent methods of ANN and case reasoning to the construction project evaluation model. The first part uses particle swarm optimization algorithm to optimize the NN parameters to improve the network performance, and then establishes the building engineering evaluation model based on the ANN parameters.

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