Dynamic prediction model of bridge project life cycle cost investment based on decision tree algorithm

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Abstract. In order to further improve the dynamic prediction effect of bridge engineering life cycle cost, a life cycle cost prediction model of bridge engineering is established by using decision tree algorithm, and the influence coefficient of bridge engineering characteristics on cost is analyzed by data acquisition method. After analysis, the project characteristics which have great influence on the cost of bridge engineering are determined. The decision tree algorithm is used to establish the dynamic prediction model of bridge engineering life cycle cost; through MATLAB software, a good bridge cost prediction model is gradually established, and the model is trained, modified and verified according to the actual engineering data. The dynamic prediction model of life cycle cost investment of bridge engineering is established by using decision tree algorithm, which effectively improves the prediction accuracy and has strong practicability.

1. Introduction
Dynamic prediction of life cycle cost of bridge engineering project is an important part of investment decision. In order to evaluate the project cost reasonably and effectively, we must make investment plan, apply for loan, raise funds and control the cost. The existing engineering cost estimation methods mainly include quota method, analogy method, regression analysis method and artificial intelligence method, each of which has its own advantages and disadvantages[1]. For example, the preparation time of quota method budget document is long, the process is complex, but the result is accurate. The analogy method is simple, but the estimation accuracy is low. As a cost estimation method to establish regression model, regression analysis method has many factors, especially uncertainty factors, and it is difficult to quantify[2]. The larger error of project cost will not only lead to the error of investment decision, but also affect the quality of the project. Serious will lead to work stoppage and rework, to the construction unit caused huge economic losses. Then, the decision tree algorithm is used to establish the dynamic prediction model of bridge engineering life cycle investment[3]. The experimental results show that the dynamic prediction model of life cycle cost of bridge engineering based on decision tree algorithm can flexibly and dynamically solve the problem of cost prediction in actual operation, which is more scientific, convenient and reliable than the traditional prediction methods, and fully meets the needs of research.
2. Dynamic prediction model of life cycle cost investment of Bridge Engineering

2.1. Life cycle cost evaluation of Bridge Engineering

The whole life cycle cost investment of bridge engineering is based on the cost data of the bridge over the years. Through scientific calculation, combined with the subjective experience and judgment of the forecaster, the future cost trend of the bridge is speculated. The choice of model directly affects the accuracy of cost forecast\cite{4,5}. Taking the cost index as the eigenvalue of the bridge cost volatility, the volatility is calculated and the risk degree is quantitatively evaluated. Therefore, the reasonable project cost index forecast is the premise and foundation to grasp the project cost risk\cite{5,6}. As a result of the establishment of a 5-level information decision tree model for bridges, the cost estimation model of complex bridge engineering is improved from level 1 to level 5. The name of evaluation level of each layer is shown in figure 1.

![Cost evaluation grade of Bridge Engineering](image)

In the cycle cost structure of bridge engineering in figure 1, the first level, that is, the initial level, the whole bridge engineering enterprise has realized the importance of cost estimation, and began to master the basic knowledge of cost estimation\cite{7}. The second level is the evaluation process and standard. Bridge enterprises pay attention to the accumulation of experience in the cost estimation process, and then recognize and apply it. The third level is the organization standard and institutionalization process of cost management\cite{8}. Bridge construction enterprises have established a standardized organization system. The fourth level is the process of transforming quantitative utility. Then, using different bridge engineering organization system, according to the actual bridge environment and market economy conditions, determine the cost of complex bridge\cite{9}. The fifth level, that is, the optimal level, is the comprehensive optimization model of various factors inside and outside the evaluation system, which can evaluate the cost of the target bridge.

2.2. Prediction algorithm of life cycle cost investment cost of Bridge Engineering

The time series composed of cost indexes in each stage of the whole life cycle cost investment of bridge engineering can better reflect the change and development trend of project cost, and objectively reflect the price change level and supply-demand relationship of bridge market\cite{10}. The life cycle cost investment price index of bridge engineering is an important index to reflect the price trend of bridge market, which has a good reference value for bridge market participants, construction project investment decision-making and government macro-control. Furthermore, the structure of life cycle cost investment of bridge engineering is studied and optimized. The details are shown in Figure 2.
Bridge life cycle investment prediction index is an important part of risk management. The basic process of life cycle cost investment of bridge project includes four stages: decision-making, preparation, construction and sales. This paper puts forward the project cost risk in the decision-making stage and preparation stage of the cost investment project of bridge engineering, namely the internal risk index, and the project cost risk index in the construction and sales stages; the cost risk weight in the decision-making stage of bridge engineering is expressed as the cost risk weight, and the cost risk weight in the early stage is expressed as the guarantee of bridge construction. The cost risk index of normal operation:

\[ W_2 = f \sqrt{\prod_{e=1}^{N} a \sum_{k=1}^{d} d + Ni} \]  

(1)

In formula (1), \( N \) is the external risk index of bridge engineering cost, \( f \) is the external risk evaluation coefficient, \( g \) is the upper bound of the external risk evaluation coefficient, and \( k \) is the lower bound of the external risk evaluation coefficient of bridge engineering cost. The simultaneous formula of cost risk index of bridge deck engineering is as formula (2).

\[ W = (W_2 - W_1) + \frac{(r + d)}{4M + N} \]  

(2)

Based on the cost risk index of bridge engineering, the method of setting difference degree is used to analyze the original calibration results, and the results of different management performance are obtained, and compared with the theoretical value, the management performance analysis based on cost risk index is completed. The calculation factor of the risk index of bridge engineering cost is the initial calibration score, and the expression is shown as formula (3),

\[ A = \frac{4W + MN}{4s \cdot \delta} \]  

(3)

The initial cost risk index of bridge engineering is \( \delta \), the standard value of performance is \( s \), the performance management coefficient is \( m \), and the number of performance nodes is \( M \). Based on the cost risk index of bridge engineering, management performance can be expressed by the following formula:
In formula (4), $A$ represents the management performance based on the risk index of bridge engineering cost, $c$ is the initial performance parameter, $z$ is the performance analysis coefficient, $H$ is the comprehensive performance variable, $b$ is the lower limit of management performance, and $v$ is the upper limit of performance. Based on the cost management of each element, this paper introduces the life cycle theory, and constructs a new dynamic cost management model by standardizing constraints and determining accounting elements. Following the concept of life cycle, the arithmetic of cost management risk index list of bridge construction project can be defined as $\tau$, the quantity operation can be defined as $\xi$, utilize $\tau$, $\xi$ cost of the whole life cycle bridge project can be represented is shown as formula (5).

$$
\xi = \begin{cases} 
\psi A \cdot \sqrt[j]{\tau^2}, & \psi \leq 0.81 \\
\frac{\psi}{\tau^2 (\xi + m)^n}, & \psi > 0.81 
\end{cases}
$$

In formula (5), $\xi$ is the specification condition of life cycle cost constraint, $j$ is a small amount of cycle cost constraint, $\rho$ is a fixed cycle cost constraint, $\tau$ is a small amount of pending engineering cost variables, $\xi$ is a large number of cycle cost constraints, $\psi$ is a linear cost constraint, $m$ is a variable of engineering cost to be processed.

2.3. Realization of life cycle cost investment prediction of Bridge Engineering

Based on the life cycle cost requirements of bridge engineering, the cost index of construction project can be divided into the cost index of bridge installation project, the cost index of equipment and appliance project and other project cost index. Among these indexes, the cost index of bridge installation engineering includes the following comprehensive indexes: labor cost index, material cost index, construction machinery shift cost index and other direct and indirect cost indexes. Based on this, further research on the structure of bridge engineering cost index is carried out. The composition of bridge engineering cost index is shown in figure 3.

![Fig. 3 Composition of bridge engineering cost index](image)

According to the real number and forecast value of historical data, the exponential addition method is used to predict. The essence of the prediction method is to develop the moving average addition method. The exponential smoothing method is a typical prediction method in time series prediction. It considers that the importance of near and far data shows a nonlinear decreasing trend, that is, the influence value of far and near data is large, and the weight is small. According to the historical statistical data, following the principle of "valuing the near and neglecting the far", the exponential smoothing average prediction method is adopted to modify the prediction model and obtain the time-
varying parameter values. Therefore, it is necessary to further study the exponential smoothing technology. When \( \alpha = 0.1,0.2,0.5,0.8 \), the SSE is the smallest when \( \alpha = 0.1 \). Analysis of double error standard deviation:

\[
\sigma_1 = 23.48, \sigma_2 = 58.15, \sigma = 81.63
\]

(6)

The relative weight of index is determined by the intuitionistic decision tree weighting method, and the influence coefficient \( H(\lambda, I) \) of the engineering eigenvalue \( I \) is calculated by the formula, then the investment parameter algorithm of the bridge project life cycle cost is shown as formula (7).

\[
H(\lambda, I) = \left[ \omega_1^{(i)}, \omega_2^{(i)}, \ldots, \omega_n^{(i)} \right]
\]

(7)

The engineering characteristics of value range coefficient \( H(\lambda, I) \geq 0.5 \). Furthermore, according to the properties of the model parameters, the model can be divided into centralized and distributed. In order to improve the project management, improve the project management level and effectively control the cost, it is necessary to improve the system and process. Through the audit, various defects in the system can also be compensated to prevent various illegal operations. In order to accurately control the project progress, effectively implement the project plan, and make a work completed within the specified time, it must be completed within the specified time. The project acceptance shall be carried out throughout the whole process of bidding, design and construction. All rules and regulations shall be strictly implemented to ensure the quality of the project and effectively reduce and control the cost of the whole project.

3. Analysis of experimental results

In order to verify the feasibility of the dynamic prediction model of bridge engineering cost investment based on decision tree algorithm, the following comparative test methods are used to study the model. In the experiment, there are two windows 10 operating systems, the central computer memory is 128 GB, in which the computer with the new dynamic management model is an experimental group, and the control group is another experimental group. The accuracy of risk factor assessment of bridge engineering cost and the change of comprehensive management level during the test period of experimental group and control group method are recorded. The specific experimental price results are shown in figure 4.

![Fig. 4 Comparison Chart of risk factor assessment accuracy](image)

The results show that, with the extension of test time, the accuracy of risk factor assessment of bridge engineering cost increases with the increase of test times. When the number of tests is 40 ~ 50, the accuracy of evaluation is higher than the upper limit of 71.25%; when the number of tests is 40 ~ 50, the accuracy of evaluation is higher than 82.09%; when the number of tests is 40 ~ 50, the accuracy of evaluation is lower than the number of tests. This proves that the dynamic prediction
model of bridge project life cycle cost investment proposed in this paper can better realize the management of project cost and avoid the loss of engineering cost and materials in the practical application process.

4. Conclusion
In this paper, the direct decision tree analysis method is used to quantitatively analyze the engineering characteristics of bridge engineering. Considering the complexity of engineering characteristics and the decision tree of discrimination, the influence coefficient of each engineering characteristic is determined. The selected engineering features are input into the decision tree for extraction and mining, and the nonlinear relationship between complex engineering features and engineering cost is obtained. The example shows that the prediction accuracy of the model meets the requirements, and it can effectively screen the engineering features. And the decision tree has a strong adaptive learning ability, which can adapt to the dynamic changes of project cost.

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