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Research on Engineering Cost Risk Assessment and Control Strategy Based on Artificial Intelligence

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Abstract: *With the rapid development of artificial intelligence technology, its application in the field of engineering cost is also increasingly widespread. This paper first describes the importance of engineering cost risk assessment and control, and analyzes the limitations of traditional engineering cost risk assessment and control methods. Then it introduces the advantages of the application of artificial intelligence technology in engineering cost risk assessment and control, including the improvement of assessment accuracy, enhancement of prediction ability, and improvement of decision-making efficiency. Then the construction of engineering cost risk assessment model based on artificial intelligence is discussed in detail, including data collection and preprocessing, feature selection, model selection and training. At the same time, corresponding engineering cost risk control strategies are proposed, such as risk early warning, dynamic monitoring, optimized decision-making and so on. Finally, the effectiveness of the engineering cost risk assessment and control strategy based on artificial intelligence is verified through actual case study, and the future development trend is outlooked.*

Keywords: *Artificial intelligence; Engineering cost; Risk assessment; Risk control*

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I. INTRODUCITION

Engineering cost refers to all the costs incurred in the construction process of an engineering project, including the various stages of investment decision-making, design, bidding, construction and completion settlement in the early stages of engineering construction. Since the project cost is affected by a variety of factors, such as market price fluctuations, changes in policies and regulations, engineering changes, construction quality, etc., there is a certain degree of risk. Accurately assessing and effectively controlling the risk of project cost is of great significance in ensuring the smooth implementation of the project and improving the investment efficiency.

The traditional engineering cost risk assessment and control method mainly relies on expert experience and statistical analysis, which has the problems of strong subjectivity, low accuracy and low efficiency. And artificial intelligence technology has powerful data analysis and processing capabilities, self-learning capabilities and intelligent decision-making capabilities, which can provide new ideas and methods for engineering cost risk assessment and control.

II. THE IMPORTANCE OF ENGINEERING COST RISK ASSESSMENT AND CONTROL

(i) Safeguarding the smooth implementation of the project

Engineering cost risks, if not assessed and controlled in a timely manner, may lead to shortage of funds, schedule delays, quality problems, etc., in the course of engineering construction, thus affecting the smooth implementation of engineering projects. By assessing and controlling engineering cost risks, potential risk factors can be discovered in advance and corresponding measures can be taken to prevent and resolve them, ensuring that engineering projects are carried out in accordance with the predetermined plans and objectives.

(ii) Improving investment efficiency

Accurately assessing the risk of project cost can provide a scientific basis for investment decision-making and avoid losses caused by blind investment. At the same time, through effective risk control measures, the project cost can be reduced and the investment efficiency can be improved. For example, through reasonable control of engineering changes, optimization of construction programs, etc., it can reduce unnecessary expenses and improve the economic efficiency of engineering projects.

(iii) Enhancing enterprise competitiveness

Under the conditions of market economy, enterprises face fierce competition. Accurately assessing and effectively controlling the risk of project cost can improve the project management level and cost control ability of enterprises and enhance their competitiveness. At the same time, a good risk assessment and control system can also improve the credibility of the enterprise and win more market opportunities for the enterprise.

III. Limitations of traditional engineering cost risk assessment and control methods

(i) Highly subjective

The traditional engineering cost risk assessment mainly relies on the experience of experts, and the assessment results are often influenced by the experts' personal knowledge, experience and subjective judgment, lacking objectivity and accuracy.

(ii) Low accuracy

Traditional risk assessment methods usually use qualitative analysis or simple quantitative analysis methods, making it difficult to accurately quantify the degree of influence of risk factors. At the same time, due to the lack of in-depth mining and analysis of historical data, it is difficult to accurately predict future risk trends.

(iii) Inefficiency

The traditional engineering cost risk assessment and control process is cumbersome and requires a large amount of human, material and time investment. Moreover, due to untimely information transfer and non-transparent decision-making process, it is easy to lead to the lag and failure of risk control measures.

IV. THE ADVANTAGES OF APPLICATION OF ARTIFICIAL INTELLIGENCE TECHNOLOGY IN ENGINEERING COST RISK

(i) Improved accuracy of assessments

Artificial intelligence technology can build an accurate risk assessment model by learning and analyzing a large amount of historical data. The model can automatically identify and quantify the degree of influence of various risk factors and improve the accuracy and reliability of the assessment results.

(ii) Enhancing forecasting capabilities

Artificial intelligence technology has a strong predictive ability, which can predict the future trend of engineering cost risk changes based on historical data and the current market environment. This helps enterprises to take appropriate risk control measures in advance and reduce risk losses.

(iii) Improved efficiency in decision-making

Artificial intelligence technology can quickly process a large amount of information and provide intelligent decision-making support. Enterprises can make scientific and reasonable decisions in a timely manner based on risk assessment results and forecast information, improving decision-making efficiency and accuracy.

(iv) Realization of dynamic monitoring

Artificial intelligence technology can monitor the changes in engineering cost in real time and discover potential risk factors in a timely manner. At the same time, through the integration with the project management system, the dynamic management and control of engineering cost risks can be realized.

V. CONSTRUCTION OF AN ARTIFICAL INTELLIGENCE-BASED ENGINEERING COST RISK ASSESSMENT MODEL

(i) Data collection and pre-processing

1. Data collection

Collect a variety of data related to project costing, including basic information on engineering and construction projects, bill of quantities, market price information, information on policies and regulations, records of engineering changes, and information on construction progress. Data sources may include internal project management systems of enterprises, industry databases, information released by governmental departments, and so on.

2. Data pre-processing

The collected data are cleaned, organized and converted to remove noisy data and outliers, and the data format is unified to prepare for subsequent data analysis and model construction.

(ii) Feature selection

Select the feature variables related to engineering cost risk from the preprocessed data. The methods of feature selection can include correlation analysis, principal component analysis, random forest and so on. Through feature selection, the data dimensionality can be reduced, and the training efficiency and prediction accuracy of the model can be improved.

(iii) Model selection and training

1. Model selection

According to the characteristics and requirements of engineering cost risk assessment, choose a suitable artificial intelligence model. Commonly used models include neural networks, support vector machines, decision trees, random forests and so on. Different models have different advantages and disadvantages and need to be selected according to the specific situation.

2. Model training

The selected AI model is trained using training data, and the parameters of the model are adjusted so that it can accurately predict engineering cost risks. During the training process, methods such as cross-validation and regularization can be used to prevent overfitting.

(iv) Model evaluation and optimization

3. Model evaluation

The trained model is evaluated using the test data, and the model's performance is evaluated by calculating metrics such as accuracy, recall, and F1 value.

4. Model Optimization

Based on the results of the model evaluation, the model is optimized and improved. The structure and parameters of the model can be adjusted, the amount of data can be increased, and integrated learning can be used to improve the performance of the model.

VI. RISK CONTRAL STRATEGY FOR ENGINEERING COSTS BASED ON ARTIFICIAL INTELLIGENCE

(i) Risk early warning

According to the prediction results of the risk assessment model, set the corresponding risk warning threshold. When the project cost risk exceeds the early warning threshold, an early warning signal is issued in time to remind the enterprise to take corresponding risk control measures.

(ii) Dynamic monitoring

The use of artificial intelligence technology to carry out real-time dynamic monitoring of construction costs, and timely detection of changes in risk factors. Enterprises can adjust the risk control strategy according to the monitoring results to ensure that the project cost is always within the controllable range.

(iii) Optimizing decision-making

Based on risk assessment results and forecast information, it provides intelligent decision-making support for enterprises. For example, it provides scientific and reasonable suggestions in investment decision-making, bidding decision-making, and construction program selection to reduce the risk of project cost.

(iv) Contract management

In engineering construction projects, the contract is an important basis for restraining the behavior of all parties and clarifying rights and obligations. The use of artificial intelligence technology to manage the contract can automatically identify the risk clauses in the contract and remind enterprises to pay attention to prevention. At the same time, through the monitoring of the implementation of the contract, the risk of breach of contract can be found in a timely manner, and appropriate measures can be taken to solve the problem.

VII. PRATICAL CASE STUDIES

The extension project of a city subway line, with a total length of about 15 kilometers, includes the construction of 10 stations as well as the related track laying, electromechanical equipment installation and other engineering contents. The project involves a variety of complex geological conditions, numerous construction techniques and a large number of materials and equipment procurement, and the project cycle is expected to be 4 years, facing many uncertainties, so it is of great significance to adopt the artificial intelligence-based method for the risk assessment and control of project cost.

(i) Artificial intelligence-based risk assessment process

1. Data collection and organization

Collect data from the archive of similar completed metro projects, including the basic overview of the project (e.g., length of the line, number of stations, proportion of geological types), the composition of the project cost (breakdown of the budget and actual cost of each part of the project), the record of risk events (e.g., number of geologic hazards, number of design changes, fluctuations in the price of materials, and construction safety accidents, etc.), as well as the corresponding risk treatment measures and the final Cost change results. A total of 30 similar metro projects were collected as sample data.

For the specific planning documents, geological exploration reports, preliminary design drawings and other information of the project, relevant characteristic data, such as the geological complexity ratings of different sections, the number of new technologies expected to be used, the expected demand for various types of materials, etc., are extracted and organized into the form of structured data.

2. Artificial intelligence model construction and training

Random forest algorithm was used to construct the risk assessment model. The collected sample data were divided into training set and test set according to the ratio of 70%:30%. The data in the training set are used to train the model, and by constantly adjusting the number of decision trees in the random forest, the depth of the tree and

other parameters, the model is able to learn the intrinsic law between the engineering cost risk and various influencing factors.
Determine the input variables of the model, including the characteristics of project scale (line length, number of stations), geological conditions (percentage of length of soft ground, hardness grade of rock strata), technical complexity (percentage of application of new technology, score of complexity of construction process), market factors (prediction of the range of fluctuation of the price of major materials, supply and demand index of the labor market), and the characteristics of contract terms (flexibility of the change clause, score, payment period). (flexibility of change clause, payment cycle), and so on, totaling 15 variables. The output variable of the model is the construction cost risk index, which takes values between 0 and 1, with 0 indicating extremely low risk and 1 indicating extremely high risk.
Calculation formula for model training evaluation metrics

Accuracy:

$$\mathrm{Accuracy} = \frac{\mathrm{TP}+\mathrm{TN}}{\mathrm{TP}+\mathrm{TN}+\mathrm{FP}+\mathrm{FN}}$$

where TP (True Positive) denotes a true case, i.e., the number of samples that the model predicts to be high risk and are actually high risk; TN (True Negative) denotes a true counterexample, i.e., the number of samples that the model predicts to be low risk and are actually low risk; FP (False Positive) denotes a false positive case, i.e., the number of samples that the model predicts to be high risk but are actually low risk sample size; FN (False Negative) denotes False Counterexample, which is the sample size that the model predicts as low risk but is actually high risk.

Recall:

$$Recall = \frac{TP}{TP+FN}$$

F1 value (F1-Score):

$$F1 = \frac{2 \times Precision \times Recall}{Precision + Recall}$$

Where, $Precision = \frac{TP}{TP+FP}$,After several rounds of training and optimization, the results of the evaluation metrics of the model on the test set are shown in the following table:

Assessment of indicators	numerical value
accuracy	0.82
recall rate	0.8
F1 value	0.81

The results show that the model has good prediction performance and can be used for the project cost risk assessment of this project.

3. Risk assessment results and analysis

Characteristic data of the project was inputted into the trained AI model, and a project cost risk index of 0.65 was obtained, indicating that the project was at a moderately high risk level. Further analysis of the model outputs ranked the importance of each variable in the following table:

variable name	importance score
Characterization of geological conditions	0.28
Forecast of the range of material price fluctuations	0.22
Forecast of the number of design changes	0.18

Construction Process Complexity Score	0.15
Other factors (residual variables combined)	0.17

From the results, it can be seen that geological conditions and material price fluctuations are the main factors affecting the risk of the project cost. Complex geological conditions may lead to increased construction difficulty and frequent changes in the project, which in turn affect the cost; large fluctuations in material prices will make it difficult to control the project cost.

(ii) Risk control strategy development and implementation

1. Risk control of geological conditions

(1) Deepening geological exploration:

Increase the density of exploration points in key construction areas to obtain more accurate geological data. The additional exploration cost is about 500,000 RMB, but it is expected to reduce the proportion of risk of engineering changes due to unknown geology as calculated below:

Let the original probability of risk of engineering change due to unknown geology be P1, and the probability of risk after taking measures be P2, then the proportion of risk reduction $R_1 = \frac{P_1 - P_2}{P_1} \times 100\%$, is expected to be R1 = 30%.

(2) Optimize the construction program:

Based on detailed geological data, a team of experts will be organized to formulate targeted construction plans and adopt advanced tunnel boring technology and support measures. It is expected to increase the cost of construction technology R&D and equipment procurement by 2 million yuan, but can reduce the proportion of delay and cost overrun risk caused by geological problems Calculation:

Let the risk probability triggered by the original geological problem be P3, the risk probability after taking measures be P4, and the proportion of risk reduction $R_2 = \frac{P_3 - P_4}{P_4} \times 100\%$, it is expected that R2 = 40%.

2. Material price fluctuation risk control

(1) Establishment of a price warning mechanism:

In cooperation with professional market data organizations, we monitor the prices of major materials such as steel and cement in real time. When the price fluctuation exceeds a set threshold (e.g. 10%), the procurement plan will be adjusted in a timely manner or a hedging strategy will be adopted. Through this mechanism, it is expected that the impact of material price fluctuation risk on the construction cost can be reduced by a percentage calculation:

Let the proportion of the impact of raw material price fluctuations on the construction cost be I1, and the proportion of the impact after taking measures be I2, reducing the proportion $R_3 = \frac{I_1 - I_2}{I_1} \times 100\%$, it is expected that R3 = 25% .

(2) Strategic partnerships:

Entered into long-term strategic cooperation agreements with some major material suppliers, agreeing to stabilize supply within a certain price range and giving certain purchase volume commitments. It is expected to lock in some of the material costs and reduce the price fluctuation risk ratio calculation:

Let the original price fluctuation risk ratio be I3, and the risk ratio after taking measures be I4, reducing the ratio $R_4 = \frac{I_3 - I_4}{I_3} \times 100\%$, it is expected that R(4)=15% .

3. Design change risk control

(1) Enhanced design review:

Introducing a multi-disciplinary collaborative review mechanism at the design stage, using BIM technology for collision detection and simulation analysis, and discovering design defects in advance. The proportion of the number of design changes expected to be reduced is calculated:

Let the original number of design changes be N1, and the number of design changes after taking measures be N2, and the reduction ratio $R_5 = \frac{N_1 - N2}{N_1} \times 100\%$ is expected to R(5)=20% , which reduces the corresponding cost risk.

(2) Strict change management process:
Establishing a design change approval system, clarifying the necessity and reasonableness review criteria for changes, and controlling the scope and cost of changes. It is stipulated that only changes approved by the owner, design unit, construction unit and other parties can be implemented, which is expected to reduce the calculation of the proportion of cost risk caused by arbitrary changes:
Set the original arbitrary changes caused by the proportion of cost risk for C 1, take measures to reduce the proportion of risk for C 2, reduce the proportion of $R_6 = \frac{C_1 - C2}{C_1} \times 100\%$, it is expected that R 6 = 30%.

4. Construction process complexity risk control
(1) Training of construction personnel:
Specialized training courses and on-site practical exercises will be conducted for complex construction processes to improve the skill level of construction personnel. The training cost is estimated to be 800,000 yuan, which can improve the construction efficiency and reduce the calculation of the proportion of cost increase risk due to improper operation of the process:
Set the probability of cost increase risk due to improper operation of the original process as P5, the probability of risk after taking measures as P6, and the proportion of risk reduction $R_7 = \frac{P_5 - P_6}{P_5} \times 100\%$, is expected to R(7) = 20%.

(2) Technical advisory services:
Engage industry experts as technical consultants to provide technical guidance and solutions at key construction nodes. The cost of the consultant is about 1.5 million RMB, which can effectively deal with the construction process difficulties and reduce the risk ratio calculation:
Let the probability of risk due to the original construction process difficulties be P7, the probability of risk after taking measures be P8, and the proportion of risk reduction $R_7 = \frac{P_7 - P_8}{P_7} \times 100\%$, which is expected to be R8 = 30%.
(iii) Assessment of the effectiveness of risk controls
One year after the implementation of the above risk control strategy, the project was risk assessed again. Inputting the updated project data (including the actual situation after the implementation of the control strategy) into the model, the new project cost risk index is 0.48, which is significantly lower than the initial 0.65, indicating that the risk control strategy has achieved a better effect, effectively reduced the project cost risk, and safeguarded the smooth advancement of the project and the achievement of the cost control target.
It can be seen through this case that the project cost risk assessment based on artificial intelligence can accurately identify the key risk factors, based on which the risk control strategy is formulated with strong pertinence and effectiveness, which provides a scientific and reliable method and practical experience for the cost management of large-scale infrastructure projects.

VIII. CONCLUSIONS AND OUTLOOK

(i) Conclusion
This paper draws the following conclusions by studying the risk assessment and control strategy of engineering cost based on artificial intelligence:
1. Engineering cost risk assessment and control is of great significance in ensuring the smooth implementation of engineering projects and improving investment efficiency.
2. The traditional engineering cost risk assessment and control methods have the problems of high subjectivity, low accuracy and low efficiency.
3. Artificial intelligence technology in engineering cost risk assessment and control has the advantages of improving assessment accuracy, enhancing prediction ability, improving decision-making efficiency, and realizing dynamic monitoring.
4.The construction of engineering cost risk assessment model based on artificial intelligence includes data collection and preprocessing, feature selection, model selection and training, model evaluation and optimization.
5. The risk control strategy of engineering cost based on artificial intelligence includes risk early warning, dynamic monitoring, optimization decision-making, contract management and so on.
6. the effectiveness of the engineering cost risk assessment and control strategy based on artificial intelligence is verified through actual case studies.

(ii) Outlook

With the continuous development and application of artificial intelligence technology, the future engineering cost risk assessment and control based on artificial intelligence will show the following development trends:

1. Multi-source data fusion

Fusion of various data of engineering and construction projects, including structured data, unstructured data, real-time data, etc., to improve the accuracy and comprehensiveness of risk assessment.

2. Application of deep learning techniques

Deep learning technology has powerful feature extraction and pattern recognition capabilities, which can further improve the accuracy and prediction ability of engineering cost risk assessment.

3. Development of intelligent decision support systems

Build a more intelligent decision support system to provide enterprises with more comprehensive, accurate and timely decision-making information, and improve the efficiency and accuracy of corporate decision-making.

4. Deep integration with project management systems

Deeply integrate engineering cost risk assessment and control with project management system to realize the whole process and all-round management of engineering projects and improve the level and efficiency of project management.

In conclusion, artificial intelligence technology provides new ideas and methods for engineering cost risk assessment and control, and has a broad application prospect. In the future, with the continuous development and improvement of technology, engineering cost risk assessment and control based on artificial intelligence will play a more important role in the construction of engineering projects.

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