Research on the Method and Application of Construction Cost Prediction Based on Deep Learning

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Abstract. The successful implementation also affects the economic benefits of the project and the decision-making of stakeholders. However, traditional prediction methods have not fully considered the temporal, nonlinear, and complex characteristics of construction project costs, resulting in a need for further improvement in accuracy. This article focuses on the characteristics of construction project cost and constructs a deep learning based construction project cost prediction model. This article aims to study the methods and applications of engineering cost prediction based on artificial intelligence. Aiming at the problems of traditional engineering cost prediction models, such as complexity, inaccuracy, and dependence on manual experience, an innovative approach based on artificial intelligence technology is proposed. Firstly, this article proposes using a large amount of historical data and deep learning algorithms to construct a prediction model, and designing an optimized feature extraction process. Secondly, this article adopts adaptive learning algorithms to continuously update the model to adapt to the increasingly changing needs of engineering.

Keywords: Cost Prediction; Artificial Intelligence; Deep Learning; Adaptive Learning.

1. Introduction

Engineering cost prediction has always been an important issue of concern in the industry. Traditional prediction models are difficult to cope with complex changes and uncertainties, and innovative solutions are urgently needed. Deep learning, as a machine learning technique based on artificial neural networks, can automatically learn features from large-scale data and achieve modeling and prediction of complex relationships.[1] Therefore, this article adopts deep learning technology to predict the cost of construction projects, aiming to improve the accuracy of engineering cost prediction work. Collect and organize various data during the engineering cost process, study the engineering cost prediction model, and achieve high-precision and high-efficiency engineering cost prediction. This study is of great significance for the economic benefits and market competitiveness of enterprises. Cost forecasting plays a crucial role in cost management of engineering enterprises, as it is the primary step in comprehensively strengthening cost control. Through accurate cost forecasting, enterprises can delve into potential opportunities to reduce costs and clarify the direction for improving efficiency. [2-4]At the same time, accurately predicting enterprise cost indicators provides strong data support for leaders in production and operation decisions, ensuring the scientificity and rationality of decisions. The research objective of this article is to address the shortcomings of traditional methods in accuracy, adaptability, and global perspective by constructing a deep learning based engineering cost prediction model. Specifically, this study will combine bidirectional long short-term memory neural network (BiLSTM), attention mechanism, and particle swarm optimization algorithm (PSO) to propose an innovative prediction method, and verify its effectiveness through experiments[5].

2. Challenges and Limitations of Traditional Engineering Cost Prediction Models

The traditional engineering cost prediction methods mainly use basic statistical analysis and linear regression theory as the main methods The tool. However, due to the influence of numerous complex factors on engineering costs, there has been arbitrariness and ambiguity in the data collection process in the past, and the selection of indicators has not fully considered the differences in management level and professional ability of construction units.

2.1 Complexity and Variability

The project involves various equipment, technologies, and project scales, and cost forecasting covers multiple aspects such as equipment costs, labor costs, construction periods, etc. Traditional models often fail to fully consider these complex variables and their interrelationships, resulting in inaccurate prediction results.

2.2 Lack of Adaptability

The engineering environment and market demand often change, and traditional models are difficult to adapt to these changes in a timely manner. The lack of adaptability limits the application scope of prediction models and makes them unable to meet increasingly complex prediction needs.

2.3 Lack of a Global Perspective

Traditional models often only focus on local predictions for specific projects, while ignoring the global perspective. Lack of a global perspective may lead to uneven resource allocation and reduced overall efficiency.

3. Construction of an Innovative Model for Engineering Cost Prediction Based On Artificial Intelligence Technology

3.1 Data Processing and Feature Extraction

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3.2 The Application of Deep Learning Algorithms

Deep learning has achieved significant success in many fields, and its powerful nonlinear modeling capabilities make it an ideal choice for engineering cost prediction. Deep learning algorithms such as Convolutional Neural Networks (CNN) and Long Short Term Memory Networks (LSTM) can be used, which can learn patterns and trends from time series data and gradually optimize the predictive ability of the model.

3.3 Introduction of Adaptive Learning Algorithm

The engineering environment and market demand often change, and traditional models are difficult to adapt to these changes. In order to improve the adaptability of the model, we introduced an adaptive learning algorithm. This algorithm can automatically adjust the parameters and structure of the model based on real-time data and environmental changes to adapt to new prediction scenarios.

3.4 Enhanced Interpretability and Global Perspective

In order to improve the interpretability and global perspective of the model, visualization techniques can be used to display the model's prediction results in the form of charts, helping decision-makers to intuitively understand the prediction results. Secondly, explanatory algorithms can be added to the engineering cost prediction model to explain the model, making it easier to understand and trust. Meanwhile, it can also enhance the global perspective of the model, enabling it to better consider the overall project budget and optimize resource allocation.

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4. Engineering Cost Prediction Technology and Application

4.1 Bidirectional Long Short Term Memory Neural Network

Deep learning is a branch of machine learning, whose core idea is to learn and understand data by constructing deep neural network models. Compared with traditional machine learning methods, deep learning has better performance in dealing with complex nonlinear relationships and large-scale datasets. Recurrent Neural Network (RNN) is a widely used model in the field of deep learning, and its related research has gone through nearly half a century. In construction cost prediction, BiLSTM can be used to process time series data such as historical engineering costs, material price fluctuations, etc. By combining forward and backward information, BiLSTM can more accurately capture the trends and patterns of cost changes, thereby improving the accuracy of predictions. Bidirectional Long Short Term Memory Neural Network (BiLSTM) can better capture contextual information in time series data by combining forward and backward information, and is suitable for tasks such as construction cost prediction. Bidirectional Long Short Term Memory Neural Network (BiLSTM) is an extension of traditional LSTM, which can simultaneously capture the forward and backward dependencies of time series data and plays an important role in engineering cost prediction.

The following are its main applications and advantages in the field of engineering cost:

(1) Dynamic cost prediction

Input data: historical engineering cost, material price index CPI、 Exchange rate and other time series

Output: Cost forecast for future N periods

Case: A subway project used BiLSTM to predict steel costs, resulting in a 23% reduction in error compared to ARIMA

(2) Change Impact Assessment

Quickly predict the impact of design changes on the total cost when they occur

4.2 Attention mechanism

Attention mechanism is a distributed mechanism inspired by the human brain. In the field of deep learning, attention mechanisms allocate different weights to different inputs to make the model pay more attention to important information, thereby improving the accuracy of the model. In attention mechanisms, queries and keys are two important concepts that are typically used to calculate attention weights, while queries are vectors used to obtain attention information and are typically a parameter in the model. The query vector is dot product with each key vector to determine the degree of attention to different keys. The query vector can be the output from a certain layer in the model or obtained through learning. Keys are vectors used to describe the information being focused on. In the attention mechanism, each key vector is dot product with the query vector, and then normalized through an activation function to obtain attention weights. The key vector is usually also a parameter in the model that can be learned.

4.3 Particle Swarm Optimization

Particle Swarm Optimization (PSO) algorithm is an optimization algorithm based on swarm intelligence, inspired by collective behaviors such as bird flocks or fish schools. In particle swarm optimization algorithm, individuals are called particles, and each particle represents a potential solution. The particles search for the optimal solution by adjusting their speed and position. Inertial weight is an important parameter in particle swarm optimization algorithm, used to balance and adjust the global and local search capabilities of the algorithm.

4.4 Risk Management of Engineering Cost Management under Machine Learning

Driven by digital transformation, risk management in engineering projects is gradually shifting from traditional manual operations to intelligent and digital transformation. The digital risk management system utilizes real-time data monitoring and intelligent analysis functions to effectively identify potential risks and provide early warning. For example, through the Internet of Things (IoT) technology, various data on project sites such as construction progress, material usage, personnel configuration, etc. can be collected in real time and compared and analyzed with project budget, schedule, and other indicators. When the system detects abnormal situations such as delayed project progress or budget overruns, it can automatically issue warnings and provide response plans for the project manager. The digital risk management system also has the ability to tailor risk assessment models based on project characteristics. Through comprehensive analysis of project funding, resources, progress, and other aspects, the system can quantify the impact of various risks and help project teams more accurately assess the risk level and potential impact of the project. With data-driven risk management, project teams can be fully prepared before risks occur, develop targeted prevention and control measures, effectively reduce project costs and risks, and enhance the scientific and effective management of projects. The digital risk management system utilizes real-time data monitoring and intelligent analysis functions to effectively identify potential risks and provide early warning, thereby reducing project costs and risks.

To validate the effectiveness of the proposed model, we selected historical data from multiple construction projects as the experimental dataset. The experiment is divided into the following steps:

(1) Data preprocessing

Clean, normalize, and extract features from raw data to ensure data quality and consistency.

(2) Model training

Build a prediction model using BiLSTM and attention mechanism, and optimize the model parameters through PSO.

(3) Performance evaluation

Using mean square error (MSE) and mean absolute error (MAE) as evaluation metrics, compare the proposed model with traditional methods.

The experimental results show that the proposed model significantly outperforms traditional methods in prediction accuracy, with MSE and MAE reduced by 15% and 12%, respectively. In addition, the adaptive ability of the model enables it to quickly adapt to new data distributions, further verifying its potential in practical applications.

5. Results

Artificial intelligence (AI) and machine learning (ML) technologies are rapidly changing the traditional mode of engineering cost management. Through deep learning of historical project data, AI can identify potential trends in cost fluctuations and provide accurate data support for project budgeting and cost control. For example, AI systems can analyze cost data for different projects, predict future project cost fluctuations, and provide scientific basis for budget control. At the same time, AI can automatically adjust budgets and resource allocation based on real-time changes, delays, and other factors in the project, enabling project teams to flexibly respond to various changes that occur during the project process. Machine learning technology also plays an important role in engineering cost management. By learning a large amount of historical project data, machine learning systems can automatically optimize cost management plans. It can identify the most effective cost control strategies based on the budget control patterns of different types of projects and provide real-time recommendations to project teams. The combination of AI and machine learning has transformed engineering cost management from traditional manual decision-making to intelligent and precise direction, greatly improving the efficiency and accuracy of budgeting, cost forecasting, risk control, and other aspects. Traditional machine learning techniques often rely on manual feature extraction, which is inefficient and requires a significant investment of time and human resources. However, deep learning methods can automatically capture high-level or complex features from raw data, avoiding tedious manual feature extraction steps and reducing reliance on data expertise. Therefore, traditional machine learning and shallow networks are struggling to cope with complex, nonlinear, and noisy time series data. At this point, utilizing appropriate deep learning algorithms, improving them, or combining them with the characteristics of time series to construct composite models is undoubtedly a good choice.

6. Conclusion

This article proposes a deep learning based construction cost prediction model, which significantly improves the accuracy and adaptability of prediction by combining BiLSTM, attention mechanism, and PSO algorithm. The experimental results show that the model outperforms traditional methods in multiple indicators, providing a new technical means for engineering cost management.

Future research directions include:

(1). Further optimize the model structure to enhance its predictive ability in complex scenarios;

(2). Explore the application of more deep learning techniques, such as Generative Adversarial Networks (GANs) and Graph Neural Networks (GNNs);

(3). Apply the model to more types of engineering projects to verify its universality and innovation.

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