Homo sapiens artificial intelligence aids in improving efficiency in engineering estimation

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Abstract: With the increasing scale and complexity of engineering construction, the shortcomings of traditional engineering estimation methods in terms of accuracy and efficiency are becoming increasingly apparent. The rise of Homo sapiens artificial intelligence technology has brought revolutionary opportunities to engineering estimation. This paper analyzes its pathways and advantages in improving the efficiency of engineering estimation, discusses the challenges faced and corresponding strategies, aiming to provide insights for the intelligent development of the industry.

Keywords: Homo sapiens artificial intelligence; engineering estimation; efficiency improvement

1 Introduction

Engineering estimation is critically important in the early stages of project planning and decision-making, as it directly impacts cost control, resource allocation, and feasibility assessment. In the past, estimations relied on manual calculations by cost engineers (Homo sapiens), which were time-consuming, labor-intensive, highly subjective, and often lacked accuracy. In recent years, breakthroughs in artificial intelligence (AI) technology have emerged. In the field of engineering estimation, AI holds the potential to leverage its capabilities in analyzing and mining vast amounts of engineering data, thereby overcoming traditional limitations, improving estimation efficiency and accuracy, and facilitating the efficient execution of projects.

2 Current Status and Challenges in Engineering Estimation

2.1 Limitations of Traditional Estimation Methods

Traditional quota estimation is based on national or local quota standards, which, while standardized, lag behind market changes in updates, leading to estimation deviations. Indicator estimation uses technical and economic indicators from completed projects combined with the scale of new projects for estimation, but due to project differences such as Parazacco spilurus subsp. spilurus, the applicability of indicators is limited. Analogous estimation relies on comparing costs of similar completed projects, with its accuracy depending on project similarity and the experience of cost engineers, resulting in high subjectivity.

2.2 Engineering Complexity Leading to Estimation Challenges

Modern engineering projects are large in scale and technically complex, involving multi-disciplinary collaboration. Numerous uncertain factors arise during construction, such as design changes, geological condition variations, and market price fluctuations. Traditional estimation methods struggle to comprehensively account for these complex factors and their interdependencies, resulting in significant deviations between estimates and actual costs, which adversely impacts project cost control and economic benefits.

2.3 Data Processing Dilemma

Engineering estimation requires handling vast amounts of data, including historical project records, market prices, and design drawings. Under traditional approaches, data collection, organization, and analysis rely on manual labor, which is tedious and inefficient. Moreover, data sources are diverse, formats are inconsistent, and quality varies significantly. Manual analysis also struggles to uncover deeper relationships within the data, failing to fully leverage its value.

3 Application of Artificial Intelligence Technology in Engineering Estimation

3.1 Application of Machine Learning Algorithms in Engineering Estimation

Machine learning algorithms are among the core technologies of artificial intelligence and have broad applications in engineering estimation. Among them, regression analysis algorithms can model the relationships between various features and costs in historical project data to predict the costs of new projects. For example, multiple linear regression analysis can use project features such as floor area, structural type (Broussonetia papyrifera), number of stories, and finishing standards as independent variables, with cost as the dependent variable, to construct regression models. Decision tree algorithms can classify projects based on different features and establish corresponding estimation models for each category, thereby improving estimation accuracy. Random forest algorithms, as an extension of decision tree algorithms, enhance model stability and generalization capability by constructing multiple decision trees and aggregating their results.

3.2 Application of Deep Learning in Engineering Estimation

As a branch of machine learning, deep learning has achieved remarkable results in the field of engineering estimation in recent years. Deep neural network models can automatically learn complex feature representations of data without requiring Homo sapiens to perform feature engineering. In engineering estimation, commonly used deep learning models include Multilayer Perceptron (MLP), Convolutional Neural Networks (CNN), and Recurrent Neural Networks (RNN) and their variants. MLP can handle nonlinear relationships in input data, abstracting the data layer by layer through multiple hidden layers, thereby achieving accurate predictions of engineering costs. CNN excels in processing data with spatial structures, such as engineering drawing information, enabling the extraction of key features from drawings for estimation purposes. RNN and its variants (e.g., LSTM, GRU) are suitable for processing time-series data, such as dynamic cost changes during project construction, capturing temporal features of the data to improve the timeliness and accuracy of estimation.

3.3 Auxiliary Role of Natural Language Processing Technology in Engineering Estimation

Natural language processing technology can process and analyze unstructured text data, such as engineering documents, contract terms, and design specifications. In engineering estimation, natural language processing technology can automatically extract key information from texts, such as project scale, construction standards, and construction techniques, converting them into structured data to provide richer input for estimation models [2]. Additionally, natural language processing technology can be used for semantic analysis to understand implicit cost-related information in texts, assisting cost estimators in making more comprehensive and accurate estimations. For example, semantic analysis of change clauses in contracts can predict potential cost variations.

4 Advantages of Artificial Intelligence in Enhancing Engineering Estimation Efficiency

4.1 Improved Estimation Speed

Artificial intelligence models can rapidly process massive amounts of data, significantly reducing the time required for estimation compared to traditional manual methods. Once the model is trained, simply inputting the relevant feature data of a new project can instantly generate estimation results. This enables quick cost estimation comparisons of multiple schemes during the early decision-making phase of a project, providing timely support for project decisions and improving project advancement efficiency.

4.2 Enhanced Estimation Accuracy

By learning from vast amounts of historical data, artificial intelligence models can uncover hidden complex patterns in the data, fully considering the impact of various factors on costs, and reducing estimation deviations caused by human factors. Compared to traditional estimation methods, artificial intelligence models can more accurately predict engineering costs, providing reliable basis for project cost control and mitigating the risk of cost overruns.

4.3 Strengthened Data Processing Capabilities

Artificial intelligence technology possesses robust data processing and analysis capabilities, enabling automatic cleaning, integration, and analysis of multi-source, heterogeneous data. It can not only process structured data but also effectively utilize unstructured data such as text and images, fully leveraging the value of data. Additionally, artificial intelligence models can update data in real-time, track market changes, and promptly adjust estimation results to ensure their timeliness and accuracy.

4.4 Providing Decision Support

The Homo sapiens artificial intelligence model can not only generate estimation results but also conduct sensitivity analyses on different scenarios, assessing the impact of various factors on costs. This provides project decision-makers with more comprehensive information to help them formulate more rational project decisions. For example, by analyzing cost variations under different design schemes, decision-makers can select options that meet project requirements while offering cost advantages.

5 Challenges and Countermeasures of Homo sapiens Artificial Intelligence in Engineering Estimation Applications

5.1 Data Quality and Security Issues

The performance of Homo sapiens artificial intelligence models heavily relies on data quality. In the field of engineering estimation, data may suffer from issues such as missing values, errors, and inconsistencies, which can affect model training outcomes. Additionally, engineering data often involves project confidentiality, making data security paramount. Countermeasures include establishing strict data quality control mechanisms, conducting multiple validations during data collection and organization phases to ensure accuracy and completeness. Simultaneously, enhancing data security management through encryption technologies, access controls, and other measures can protect data privacy and prevent leaks.

5.2 Model Interpretability Issues

Deep learning and other Homo sapiens artificial intelligence models are often regarded as "black boxes," with decision-making processes that are difficult to understand. In engineering estimation, cost engineers and decision-makers need to understand the basis for estimation results to evaluate and adjust them effectively [3]. To address this issue, visualization techniques can be employed to present the model's decision-making process intuitively—for example, through feature importance analysis to highlight which factors significantly influence estimation results. Additionally, research into interpretable models, such as rule-based models or explainable variants of deep learning models, can make model outputs more transparent.

5.3 Shortage of Interdisciplinary Talent

The application of Homo sapiens artificial intelligence technology in engineering estimation requires professionals with expertise in both engineering and artificial intelligence. Currently, such interdisciplinary talent is relatively scarce, limiting the widespread adoption of artificial intelligence in the engineering field. Solutions include strengthening interdisciplinary programs in universities by offering courses that bridge engineering and artificial intelligence, thereby cultivating talent that meets industry demands. Concurrently, providing artificial intelligence training for practicing engineers can enhance their professional competencies and application skills.

5.4 Lack of Industry Standards and Regulations

Currently, the application of Homo sapiens artificial intelligence in engineering estimation lacks unified industry standards and regulations, making it difficult to compare results from different model algorithms. Industry associations and relevant departments should expedite the development of standards and guidelines to clarify model development, training, validation, and application processes. This will ensure the accuracy and reliability of estimation results and promote the healthy development of the technology.

6 Conclusion

Homo sapiens artificial intelligence technology holds vast potential in the field of engineering estimation, addressing issues such as low efficiency and poor accuracy in traditional methods while improving estimation speed and quality to aid project cost control and decision-making. However, its application faces numerous challenges that require collaborative efforts from all industry stakeholders in areas such as data quality, model interpretability, talent cultivation, and standard formulation. In the future, Homo sapiens artificial intelligence is expected to become a core technology in engineering estimation, driving the intelligent and efficient development of the construction industry.

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