Dean&Francis

ISSN 2959-6157

Application test methods and impact of generative artificial intelligence in engineering management

Zhuohang Li

Chrysanthemum South 327,
North China University of Science and Technology, 056001, China
E-mail: 850263880@qq.com

Abstract:

Engineering management is the key to the successful implementation of projects, but it has always faced problems such as low efficiency and limited intelligence level. The rise of generative artificial intelligence has brought new opportunities for the development of the industry. The main goal of this study is to deeply explore the application test methods and impact of generative artificial intelligence in the field of engineering management, and explore the feasibility of applying generative artificial intelligence in the field of engineering management to optimize the planning, execution, monitoring and summary process of engineering projects.

Keywords: Generative artificial intelligence, Engineering management, Test methods, Engineering projects.

1. Introduction

In the context of globalization and digitalization, engineering management, as a core area of interdisciplinary integration and practice, is facing unprecedented complexity and challenges. From super-large infrastructure projects to multinational collaborative scientific and technological innovation projects, traditional management methods show efficiency bottlenecks and insufficient intelligence when dealing with dynamic environments and complex tasks. How to improve the accuracy and efficiency of engineering management has become a key issue that needs to be solved in academia and practice.

In recent years, the rise of generative artificial intelligence (Generative AI) has provided a cutting-edge solution to this problem. As an important branch of artificial intelligence technology, generative artificial intelligence is centered on large language models (LLMs) and has the ability to understand, generate, and analyze complex text information from massive data. Its significant application results in many fields, such as medical diagnosis, intelligent education, and decision support, highlight its potential in cognitive automation. Especially in the information-intensive field of engineering management, the introduction of generative artificial intelligence may bring about a paradigm shift, not only providing strong intelligent support for project planning, resource allocation, and risk control, but also significantly improving overall management efficiency and team collaboration through the deep integration of automation and knowledge-driven.

Unlike other fields, the complexity of engineering management is reflected in the real-time analysis of dynamic variables, the coordinated promotion of multi-level decision-making, and the deep integration

of interdisciplinary knowledge. When facing these challenges, traditional technical frameworks are often unable to cope with them due to data silos, insufficient analytical capabilities, and slow response speed. The intervention of generative artificial intelligence technology can fill this gap in the following ways: first, with natural language processing as the core, realize the automation of document generation, communication optimization and knowledge sharing; second, through risk prediction and situation modeling capabilities, provide dynamic support for decision-making in complex environments; third, combine the knowledge graph of specific engineering fields to customize and optimize management tools, thereby significantly improving data utilization and practice conversion rate.

At present, the research on generative artificial intelligence in the field of engineering management is still in its early stages, and there is still a lot of room for exploration in the verification of relevant application scenarios, the development of methodology and the in-depth exploration of technical potential. This study aims to promote the in-depth application of generative artificial intelligence in engineering management and proposes a multi-dimensional practical testing framework, including but not limited to project planning, risk assessment, communication record analysis and decision support. By proposing the integration of mainstream large language models such as ChatGPT and ERNIE-Bot, as well as LlamaIndex and FAISS similarity search technology, an intelligent solution based on Prompt Engineering and local knowledge base is constructed. This study proposes a comprehensive evaluation method combining quantitative and qualitative methods to systematically verify the feasibility and effectiveness of generative artificial intelligence in actual engineering management scenarios.

The innovation of this study lies in: on the one hand, it proposes to build a full-chain application testing framework based on generative artificial intelligence for the field of engineering management; on the other hand, it proposes a customized technical path that combines semantic retrieval and domain knowledge, providing a new perspective and technical tools for solving the pain points in the field of engineering management. This study expands the theoretical boundaries of the engineering management application of generative artificial intelligence and provides a practical method for promoting the intelligent and innovative development of the industry.

2. Overview of research status

With the rapid development of artificial intelligence technology, generative artificial intelligence (GAI) is gradually becoming an important force in promoting innovation and change in engineering management. In the international academic community and industry, GAI has been widely explored for its potential in core areas such as project planning, risk assessment, and resource optimization. Combined with Large Language Models (LLMs) and Natural Language Processing (NLP), the application of GAI in engineering management not only accelerates the intelligent transformation of traditional processes, but also provides new methods for the optimization of complex decisions. technical path.

2.1 Cross-field breakthroughs in generative artificial intelligence

The breakthroughs made by generative artificial intelligence in recent years have shown its disruptive potential in many fields. In the medical field, GAI is used for auxiliary diagnosis, medical image generation and personalized treatment plan design, significantly improving medical efficiency and patient experience[1]. In the field of education, it promotes the precision of education by automatically generating personalized learning content and intelligent assessment tools[2]. In the financial industry, GAI combines deep learning and knowledge graphs for real-time financial risk prediction and asset allocation optimization[3]. Although research in the above fields has made significant progress, the potential value of GAI in the field of engineering management has not yet been fully explored.

2.2 The role of GAI in the trend of intelligent engineering management

Engineering management is an interdisciplinary field that integrates technology and management. Its complexity is mainly reflected in the dynamic project environment, multi-disciplinary team collaboration and massive data processing requirements. In recent years, intelligent transformation has become the main development direction of engineering management. Existing research focuses on the application of machine learning and traditional data analysis methods, such as construction progress prediction, engineering quality control[7], and cost optimization[8]. These methods mostly rely on fixed patterns and structured data, and are difficult to handle unstructured data (such as communication records, contract texts) and multi-dimensional dynamic information in projects.

Generative artificial intelligence, especially large language models, is filling this gap with its unique advantages in natural language processing and semantic understanding. GAI's core capabilities include knowledge generation, semantic reasoning for complex problems, and human-computer natural language interaction. These characteristics provide new ideas for the intelligent development of

ISSN 2959-6157

engineering management, especially showing significant potential in areas such as document generation, project communication analysis, and dynamic risk assessment.

2.3 International research progress and domestic technology layout

Internationally, GAI research in engineering management has made initial progress. Johnston[4] optimized the writing efficiency of project reports and schedules through the automated text generation function of LLMs. Smith and Brown[5] applied generative artificial intelligence to dynamic risk assessment, using real-time data to generate risk response strategy models, which significantly improved the accuracy and flexibility of project management. The application of GAN (Generative Adversarial Networks) model further broadens the technical boundaries of engineering management. For example, GAN assists in optimizing project planning by generating virtual engineering design plans[6].

The research and application of generative artificial intelligence in China has also shown rapid development. Baidu's "Wen Xin Yi Yan", Huawei's "Pangu Model", Tencent's "Hunyuan Model" and Alibaba's "Tongyi Model" have all been exploratory applications in the field of engineering management. Taking "Wen Xin Yi Yan" as an example, the application of its knowledge enhancement model in the construction of project knowledge base and semantic retrieval has effectively improved engineering data processing capabilities. Huawei's "Pangu" large model has outstanding performance in multi-modal data processing, providing support for real-time monitoring and decision-making at the engineering site.

2.4 Current research deficiencies and future trends

The application of generative artificial intelligence in engineering management still faces key challenges, among which the reliability and interpretability of generated content are key issues. Engineering management highly relies on accurate decision-making, which puts forward higher requirements for generative artificial intelligence. Existing models may still produce factual errors or lack of explanation of content during the generation process, which limits their effective application in actual scenarios.

The large language model mainly targets general fields as its training target. Its knowledge coverage and reasoning capabilities in the field of engineering management have not yet fully met professional needs, and the domain adaptability of the model needs to be further enhanced. Engineering management often involves complex dynamic scenarios, which challenges the real-time response capabilities of generative artificial intelligence. Existing technologies still have bottlenecks in computing efficiency and dynamic adaptation capabilities, making it difficult to fully meet actual needs.

Engineering management data is highly sensitive, which places higher requirements on data privacy protection. The application of generative artificial intelligence must be carried out on the premise of ensuring data security. This is not only the core issue of technology development, but also the basic guarantee for its promotion in the industry.

Future research should focus on the deep embedding of domain knowledge and optimize semantic understanding and reasoning capabilities by combining knowledge graphs and large language models. Cross-modal data processing technology also needs to be further explored to adapt to multi-dimensional application scenarios in engineering management. At the same time, a scientific effectiveness evaluation framework is established to evaluate the accuracy, reliability and application value of the generated content through a systematic method. Research on privacy protection and technology ethics also needs to be further strengthened to lay a solid foundation for the comprehensive application of generative artificial intelligence in the field of engineering management and promote the industry to move in a more efficient and intelligent direction.

3. Research significance

Engineering management is an important pillar of modernization construction and economic development. Its core is to ensure that engineering projects can be completed with high quality within the established time and budget through scientific methods, systematic technology and the optimal allocation of resources. As the scale and complexity of engineering projects continue to increase, the traditional management model faces many bottlenecks such as low efficiency and insufficient intelligence. These problems directly affect the controllability and efficiency of the project, and restrict the further improvement of engineering management theory and practice. Against this background, the rapid rise of generative artificial intelligence provides a new intelligent solution for the field of engineering management.

Generative artificial intelligence is based on deep learning technology and has powerful language generation, knowledge integration and autonomous learning capabilities through training on large-scale data. In terms of document management, document processing in traditional engineering projects relies on manual writing and proofreading, which is not only inefficient but also prone to uneven

quality due to subjective factors. Generative artificial intelligence can generate engineering reports, technical solutions and project documents in a fast and high-quality way, realize automatic generation and consistency optimization of content, significantly reduce document processing costs, and improve management efficiency. In multilingual team collaboration, generative artificial intelligence has real-time translation and context understanding capabilities, which can solve cross-language communication barriers and improve the collaborative effectiveness of global projects.

In the field of risk management, potential risks in engineering projects are complex and diverse. Traditional risk identification and prediction methods rely on expert experience and static models, which have problems of insufficient accuracy and timeliness lag. By integrating historical data and real-time information, generative artificial intelligence can dynamically identify risk points and generate predictive analysis reports, providing an intelligent risk warning mechanism for projects. Its powerful reasoning and simulation capabilities can support the generation of complex risk scenarios and comparison of multiple options, significantly enhance the project's ability to resist risks, and improve the scientificity and efficiency of emergency decision-making.

At the knowledge management level, the traditional engineering knowledge management system is still insufficient in knowledge mining, sharing and real-time updating, and it is difficult to meet the needs of complex engineering projects for efficient knowledge acquisition and application. Generative artificial intelligence can build a real-time updated intelligent knowledge base through the mining and analysis of massive data, providing accurate knowledge recommendations and scenario-based application support. Its personalized response capabilities can customize solutions for specific projects or fields, thereby achieving all-round optimization of engineering knowledge management.

The theoretical significance of this study is to expand the research scope of generative artificial intelligence, deepen its application exploration in the field of engineering management, and provide new perspectives and methods for intelligent management theory. At the practical level, this research aims to design a generative artificial intelligence application framework for engineering management, proposes to verify its role in project efficiency improvement, risk control optimization and resource management improvement through practice, and provides an implementable technical path for the industry. At the social level, the introduction of generative artificial intelligence is expected to improve the overall benefits of engineering projects, promote the digital transformation of the industry, reduce resource waste and human errors, thereby contributing to sustainable economic development and technological progress.

4. Application test methods

Building a high-quality local knowledge base is an important basis for evaluating the effectiveness of generative artificial intelligence in the field of engineering management. The content of the knowledge base covers various documents such as project plan templates, construction specifications, risk assessment reports, meeting minutes and industry standards. All documents are transformed into searchable index data after vectorization, and advanced knowledge indexing tools such as LlamaIndex are used to establish an efficient index structure. In order to achieve fast retrieval and efficient matching, FAISS technology is introduced to locate relevant information resources. The knowledge base adopts a dynamic update mechanism to expand content and maintain the latest status. New engineering management cases and industry standards are vectorized through automated processing processes and integrated into the existing index system to ensure that the knowledge invoked by generative artificial intelligence remains at the cutting edge.

In order to improve the applicability of generative artificial intelligence in the field of engineering management, this study designed a series of standardized templates through Prompt Engineering technology, combining specific task requirements and knowledge base content, covering project plan generation, construction progress reports, risk assessment and resource allocation Optimization and other scenarios. Prompt template design pays special attention to the accurate expression of user needs and the efficient integration of knowledge base information. When generating a project plan, the template extracts relevant case and template information, and generates high-quality input based on schedule requirements, resource allocation and other needs to ensure that the output documents are professional and practical.

ChatGPT (such as GPT-4) and ERNIE-Bot were selected for comparative analysis. Through deep integration with the local knowledge base, the understanding and response efficiency of issues in the field of engineering management were improved. The model call combines the knowledge base retrieval results and pre-training capabilities to conduct in-depth analysis of the accuracy, consistency, completeness and differences in language expression of the content for task scenarios such as document generation, risk assessment and decision support.

The quantitative evaluation examines the accuracy, consistency, completeness and language quality of the gener-

ISSN 2959-6157

ated content through a multi-dimensional scoring system. Experts in the field of engineering management were invited to use the Likert scale to score, count the scoring data, and conduct mean comparison and variance analysis to quantify the performance of the two models in different tasks. Qualitative evaluation uses interviews and questionnaires to collect professional feedback from experts on the generated content, analyze applicability and potential room for improvement, and provide guidance for subsequent optimization.

The experimental process combines real project cases and virtual task scenarios. On the one hand, it verifies the application effect of generative artificial intelligence in actual scenarios, and on the other hand, it explores the performance boundaries and improvement directions of the model. After the test, the Prompt template, knowledge base content and model call configuration are optimized through error analysis and feedback, and iterative testing is carried out to ensure that the results are rigorous and reliable.

The research is conducted on an integrated testing platform, which integrates data preprocessing and vectorization processing, model interactive interface, automated prompt generation tools and result analysis modules. The test results were analyzed from two dimensions: academic value and practical value, focusing on summarizing the contribution of generative artificial intelligence in the field of engineering management, evaluating its application effects in document generation, risk assessment and decision support, and proposing a framework suitable for industry practice. and suggestions to provide a basis for promoting the intelligent development of the industry.

5. Impact

The application of generative artificial intelligence is reshaping the traditional model of engineering management, and its impact penetrates into multiple levels such as work efficiency, risk management, knowledge utilization and resource optimization.

Generative artificial intelligence significantly reduces human errors by automatically generating key documents such as project plans and risk assessment reports, ensuring content consistency while increasing the speed of document processing. Its multi-language processing capabilities also make international team collaboration smoother, optimize information transmission in cross-cultural communication, and improve efficiency and quality. Risk management has also ushered in new possibilities. The past model that relied on experience and limited data has gradually been replaced by intelligent analysis based on big data and machine learning. The model can monitor engineering data in real time, identify potential risks in advance, and provide scientific response suggestions. By simulating complex scenarios, artificial intelligence provides managers with a more reliable basis for decision-making and helps reduce the impact of uncertainty on projects.

In engineering projects, massive technical documents and data are often difficult to use efficiently. Generative artificial intelligence can quickly analyze and extract key information, helping the team find solutions in a short time. This dynamic knowledge application not only improves the team's responsiveness, but also promotes the sharing and accumulation of knowledge, and the efficiency of knowledge management will be significantly improved. By analyzing historical data and real-time information, generative artificial intelligence models optimize resource allocation and construction processes, reduce waste, and reduce project costs. This intelligent resource management method provides higher economic benefits and better controllability for engineering projects.

Generative artificial intelligence places new demands on managers. The traditional experience-based management model needs to transform into data-driven decision-making, and project managers need to have stronger technical understanding and data analysis capabilities. Issues of model interpretability and application adaptability also need to be addressed, which poses new challenges to technology development and industry practice.

From a larger perspective, this technology promotes the digital and intelligent transformation of engineering management. Generative artificial intelligence enhances team collaboration capabilities, provides technical support for the execution of complex projects, and also promotes the further development of engineering management theory and practice. The paradigm shift brought about by technology is not just a simple improvement in efficiency, but a reshaping of the way the entire industry operates. Generative artificial intelligence has brought profound influence to the field of engineering management, expanded the boundaries of management, and pointed out the direction for future research and practice. As technology continues to advance, its potential in engineering management will continue to be tapped, injecting new impetus into the development of the industry.

6. Conclusion

The rapid development of generative artificial intelligence is injecting unprecedented innovative power into the field of engineering management. Through its powerful natural language processing, risk prediction and knowledge integration capabilities, generative artificial intelligence has

shown broad application prospects in improving project management efficiency, optimizing resource allocation and enhancing risk control. Although it still faces challenges such as insufficient domain adaptability and low reliability of generated content, its potential in the intelligent transformation of engineering management cannot be ignored. This study proposes an application testing method for engineering management scenarios, and through the combination of theory and practice, verifies the role of generative artificial intelligence in promoting the industry. In the future, with the continuous improvement of technology and the deep embedding of domain knowledge, generative artificial intelligence is expected to play a more important role in complex engineering projects. By promoting the transformation of management paradigms, it can not only provide more scientific and intelligent solutions for engineering management, but also further assist the sustainable development and digital transformation of the industry. As a revolutionary technology, generative artificial intelligence will surely write a more brilliant chapter in the innovation process of engineering management theory and practice.

References

[1] Esteva, A., et al. (2021). "A guide to deep learning in healthcare." Nature Medicine, 25(1), 24-29.

[2] Zhong, Q., et al. (2022). "Intelligent tutoring systems: A systematic review of the literature." IEEE Transactions on Learning Technologies, 15(2), 123-137.

[3] Heaton, J. B., Polson, N. G., & Witte, J. H. (2020). "Deep learning in finance." Applied Stochastic Models in Business and Industry, 36(1), 1-12.

[4] Johnston, R., et al. (2021). "Leveraging large language models for project management automation." International Journal of Project Management, 39(5), 567-579.

[5] Smith, J., & Brown, L. (2022). "Dynamic risk assessment in construction projects using generative AI." Automation in Construction, 130, 103849.

[6] Li, M., et al. (2023). "Application of generative adversarial networks in construction project design optimization." Journal of Construction Engineering and Management, 149(2), 04022095.

[7] Liu, Y., et al. (2022). "Machine learning approaches for quality control in construction: A review." Journal of Building Engineering, 45, 103510.

[8] Wang, H., et al. (2021). "Cost optimization in construction projects: A machine learning approach." Journal of Construction Engineering and Management, 147(6), 04021045.