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ChatGPT, AI-generated content, and engineering management

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Abstract This study explores the integration of ChatGPT and AI-generated content (AIGC) in engineering management. It assesses the impact of AIGC services on engineering management processes, mapping out the potential development of AIGC in various engineering functions. The study categorizes AIGC services within the domain of engineering management and conceptualizes an AIGC-aided engineering lifecycle. It also identifies key challenges and emerging trends associated with AIGC. The challenges highlighted are ethical considerations, reliability, and robustness in engineering management. The emerging trends are centered on AIGC-aided optimization design, AIGC-aided engineering consulting, and AIGC-aided green engineering initiatives.

Keywords engineering management, AI-generated content (AIGC), ChatGPT, AIGC-aided engineering lifecycle

1 Introduction

With the recent advancement of ChatGPT and AI-generated content (AIGC), companies such as OpenAI, Microsoft, Meta, and Google have significantly increased their investments in the AIGC field. OpenAI's introduction of ChatGPT in November 2022 marked a turning point, leading to rapid developments in AIGC applications (Thorp, 2023). In March 2023, OpenAI unveiled the GPT-4 model, featuring an increased number of parameters, thereby enhancing the reliability of ChatGPT results. Notably, the new ChatGPT based on the GPT-4 model is equipped with image recognition capabilities (van Dis et al., 2023; Baidoo-Anu and Owusu Ansah, 2023).

Additionally, in May 2023, OpenAI introduced web browsing and plug-in functionality to ChatGPT Plus users, resulting in the latest advancements and substantial enhancements in mathematical and scientific computations. By the end of September 2023, ChatGPT had incorporated multimodal functionality, enabling interactions with users through text, visual recognition, auditory understanding, and speech generation, ushering in a new era in AIGC services (Cao et al., 2023). ChatGPT includes several models, including GPT-3.5, GPT-4, DALL-E, and DALL-E3. AIGC represents the capacity of AI systems to generate novel content across various domains, including text, audio, images, video, and 3D, rather than merely executing predetermined tasks or rule-based operations. The application of AIGC in engineering management has attracted increasing attention in recent years.

Given the rapid evolution of technology and the growing complexity of contemporary engineering projects, engineering management, which involves applying management principles to engineering endeavors (Blanchard, 2004; Skibniewski, 2014), has assumed a pivotal role. In this context, recent breakthroughs in AIGC offer transformative possibilities for engineering management. Notably, AIGC engineering management services excel in optimizing resource allocation for engineering projects and enhancing resource utilization.

Moreover, in addition to strategic planning and decision-making, AIGC engineering management services introduce task automation as a valuable asset. This automation alleviates engineers and managers from the burden of routine and repetitive tasks, liberating their time and enabling them to focus on more complex and mission-critical challenges.

Despite the evident potential of applying AIGC to engineering management, a precise understanding of the methodologies and processes employed in this domain remains elusive. This knowledge gap, coupled with the nascent stage of AIGC application in engineering

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management, underscores the necessity for a comprehensive investigation. Hence, the principal aim of this study is to elucidate the potential and forthcoming trends of AIGC in engineering management. To achieve this objective, we will examine the current role and application of AIGC throughout various engineering management life-cycles. Additionally, this research will offer forward-looking insights into the role of AIGC in engineering management by presenting predictions regarding potential future developments. This study endeavors to provide a comprehensive understanding of AIGC, delineating its current landscape, and forecasting forthcoming transformations in engineering management.

2 Overview of AIGC in engineering management

2.1 Development of AIGC with engineering management

With the advancement of technology, AIGC has evolved into a more robust toolkit for engineering management, enhancing its comprehensibility, integration, and utility on a broader scale within the engineering management process. The incorporation of multimodal functionality has enhanced its visual and interactive capabilities, significantly enhancing the applicability of AIGC in engineering tasks related to detection, geolocation, and security interaction.

For instance, AIGC demonstrates the capability to identify and recognize common elements within the bill of materials for engineering projects, including structures such as buildings and natural features such as parks. Furthermore, it exhibits the competence to identify cities and geographical locations depicted in landscape images.

The integration of AIGC across various facets of engineering functions has the potential to reshape the approaches adopted by engineers and technical professionals. This transformation translates into enhanced efficiency, reduced risks, and a fertile ground for innovation. The prospective development of AIGC within engineering functions includes the following areas.

(1) **Engineering Consulting:** AIGC assumes a pivotal role in engineering consulting, providing consultative support to the engineering industry across diverse domains, including legal, accounting, human resources, marketing, politics, economics, finance, public affairs, and communications expertise.

(2) **Engineering Marketing:** AIGC finds utility in marketing engineering projects, facilitating AIGC-aided sales strategies, AIGC-aided market predictions, AIGC-aided communication for projects, and AIGC-aided post-sales service.

(3) **Engineering Operations:** AIGC is a valuable asset

in engineering operations, offering predictive capabilities to anticipate potential equipment failures or necessary maintenance, enabling intelligent staff scheduling, and enhancing smart production planning.

(4) **Finance and Accounting in Engineering Management:** AIGC contributes to the generation of financial reports and content for audit trails, ensuring that engineering projects adhere to regulatory and compliance standards.

(5) **Engineering Risk Management:** AIGC excels in conducting comprehensive risk assessments for engineering projects. Leveraging historical and real-time data, it forecasts potential risks and generates content outlining preventive measures.

(6) **Engineering Research and Development:** AIGC plays a pivotal role in producing content that assesses the feasibility of engineering designs, identifies potential market opportunities, and addresses technical challenges.

2.2 Classification of AIGC services in engineering management

From a content perspective, the AIGC service comprises five primary classifications: Text, image, audio, video, and 3D, as illustrated in [Fig. 1](#) and [Table 1](#). GAI-Text, GAI-Image, GAI-Audio, GAI-Video, and GAI-3D, as outlined by Epstein et al. (2023) and Jo (2023), represent AI-driven technologies utilized for the creation, administration, and optimization of diverse digital content in the field of engineering management.

GAI-Text involves the implementation of techniques such as content management systems, search engine optimization, and natural language processing. These techniques aim to enhance digital marketing and communication initiatives within the domain of engineering management.

GAI-Image entails the analysis and comprehension of digital images for applications in engineering management. It employs techniques such as object recognition, facial recognition, and text recognition to achieve its objectives.

GAI-Audio employs AI to analyze digital audio files, enabling functions such as speech recognition, music identification, and sentiment analysis. This capability facilitates the assessment of customer sentiment and the enhancement of customer service within the domain of engineering management.

GAI-Video utilizes AI to interpret digital video files, employing techniques such as object recognition, motion detection, and facial recognition. This analysis aids in evaluating the effectiveness of video advertisements and targeting specific demographics.

Last, GAI-3D utilizes advanced computer graphics algorithms to generate, manipulate, and present 3D digital objects and scenes within the context of engineering management applications.

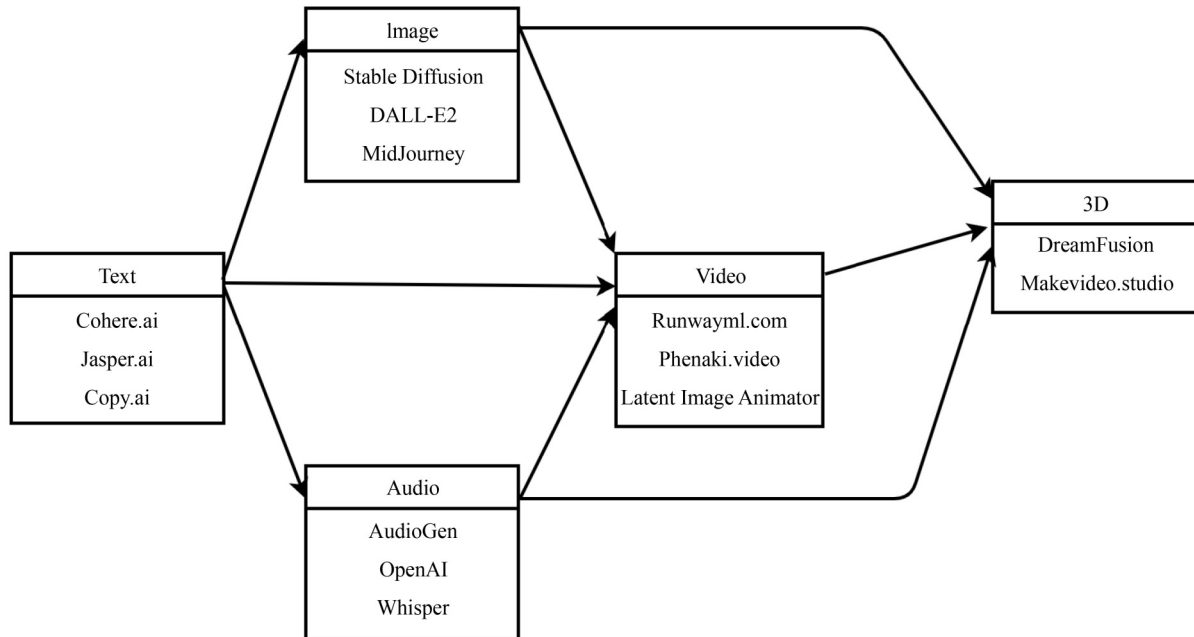


Fig. 1 Types of AIGC.

Table 1 Classification of AIGC

	GAI-Text	GAI-Image	GAI-Audio	GAI-Video	GAI-3D
Techniques	The first successful models were Recurrent Neural Networks (RNNs) and their variant, Long Short-Term Memory (LSTM) networks; Transformers, especially the BERT and GPT architectures, represent some of the latest advancements	Generative Adversarial Networks (GANs) consist of two neural networks (a generator and a discriminator) that produce images; Variations like DCGANs, StyleGANs, and CycleGANs have expanded its capabilities	WaveNet, a deep generative model, represented a breakthrough; Variants and successors have used convolutional networks and transformers	GANs, especially those designed for sequential data, have been used; Video prediction models aim to predict future frames given past frames	Variational Autoencoders (VAEs) and GANs adapted for 3D data, PointNet for point cloud processing
Applications	Chatbots, content generation, automated journalism, language translation, and more	Art creation, image super-resolution, photo-to-photo translation, face generation	Voice assistants, music generation, speech synthesis, sound effects	Video synthesis, deepfakes, video style transfer, video upscaling	3D object generation, scene completion, 3D model repair and enhancement
Examples	OpenAI's GPT-3, Google's BERT	NVIDIA's StyleGAN, DALL-E by OpenAI	Google DeepMind's WaveNet, OpenAI's MuseNet	Deepfake technology, First Order Motion Model for Image Animation	NVIDIA's GANverse3D, PointNet

3 Applications of AIGC in the engineering lifecycle

Nielsen (1992) presents the concept of the engineering lifecycle. The integration of AIGC into this lifecycle offers engineers the opportunity to optimize processes, reduce costs, and elevate product quality and safety. Notably, the advancement of deep learning has catalyzed substantial progress in the field of natural language processing.

The transformer model, introduced by Vaswani et al. (2017) under the auspices of Google, serves as the foundational network architecture for these large-scale models. ChatGPT, a super-large language model introduced by OpenAI in November 2022, operates as a dialog-type

model. It harnesses generative pre-trained transducers (GPTs) to facilitate the processing of sequential data, endowing it with language comprehension and content generation capabilities. Through the integration of DALL-E3 updates, ChatGPT can function as a chatbot, affording engineers the capacity to request additional content for engineering management purposes.

However, it is of primary importance to place a strong emphasis on ethical considerations and promote transparency when implementing AIGC. This emphasis helps mitigate the risk of inadvertent biases or errors within the engineering process, as depicted in Fig. 2. Furthermore, the provision of adequate training and support is essential to ensure that employees can effectively collaborate with AIGC systems.

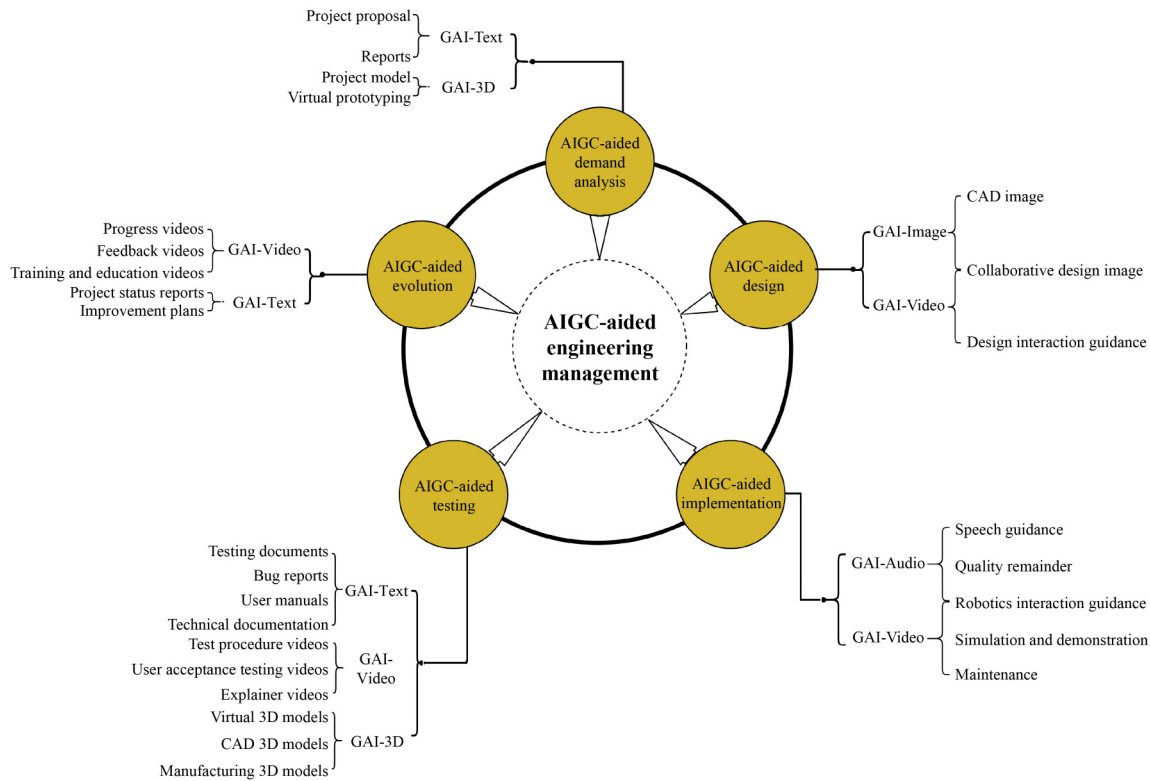


Fig. 2 The lifecycle in engineering.

3.1 AIGC-aided demand analysis

During the requirement analysis phase, engineers can effectively harness a range of AIGC services to streamline and enhance their processes. Specifically, the utilization of AI-based tools can offer significant benefits in technical documentation, virtual prototyping, and demand validation.

In the domain of structured writing, engineers can employ GAI-Text to extract pertinent information from both Professionally Generated Content and User Generated Content, as elucidated by Jin (2023). This entails the extraction of technical specifications and customer feedback, facilitating the identification of prevailing themes and issues.

In the context of virtual prototyping, the combined capabilities of GAI-Image and GAI-Text to GAI-3D enable the creation of digital prototypes for products or systems. These prototypes can undergo rigorous testing and refinement prior to physical construction, thereby permitting the early identification of potential issues or design flaws. Consequently, this approach leads to cost savings and a reduction in the time invested in physical testing or deployment efforts.

Last, AIGC proves invaluable in the validation of requirements, automating the process of verifying requirements for completeness, consistency, and traceability throughout the engineering lifecycle. This automated validation enhances efficiency and ensures robust

adherence to requirements.

3.2 AIGC-aided design

Design constitutes a pivotal element within the engineering lifecycle, and the integration of AIGC services offers a potent means to enhance design efficiency. One noteworthy technique is AIGC, which empowers generative design tools to employ algorithms for the generation of multiple design options, adhering to specified parameters and constraints. This approach empowers engineers to explore an expansive array of design alternatives and optimize designs with regard to criteria such as performance or cost, as elucidated by Cheng et al. (2023).

Furthermore, the combined capabilities of GAI-Image and GAI-3D extend to certain facets of computer-aided design. These capabilities include the generation or modification of 3D models and the creation of complex technical drawings, as exemplified in Fig. 3. These enhancements substantially increase accuracy and efficiency within the design process.

Engineers can also collaborate effectively with GAI-Text, GAI-Audio, and GAI-Video in the domain of collaborative design processes. These AIGC systems offer design alternatives or refinements based on input from engineers, thereby further optimizing the design process and yielding superior design results.

Of particular significance is the accumulation of project requirements, standards, and specifications in the domain



Fig. 3 AI-generated engineering building display drawings.

of engineering design, alongside exemplary engineering design cases. This corpus of knowledge can be synthesized into textual materials suitable for GPT-based learning, including domains such as engineering project construction, building materials, and building technology. In this context, AIGC assumes the role of a design and scheme rendering assistant. During the design model generation phase, AIGC articulates building model requirements in natural language and promptly generates Building Information Modeling models amenable to collaborative work by multiple stakeholders. In the design rendering phase, AIGC adjusts design criteria based on parameters and natural language inputs, intelligently generating design-inspired solutions and renderings.

3.3 AIGC-aided implementation

During the implementation phase of the engineering lifecycle, the integration of AIGC services plays a pivotal role in enhancing multiple facets of engineering processes, including robotics interaction, predictive maintenance, and quality control.

Leveraging robotic operational data and data pertaining to human–robot interactions, as elucidated by Gravel and Svihla (2021), AIGC assumes a crucial role in aiding engineers in the design and execution of robotic systems. These systems can operate autonomously or with minimal human intervention, leading to heightened efficiency in task execution.

Moreover, AIGC possesses the capacity to continually monitor the performance of products or systems in real-time. It leverages safety content, engineering project data, and feedback loops to anticipate maintenance requirements, ultimately mitigating downtime and reducing maintenance costs significantly (Yang and Wang, 2020).

In the domain of quality control, AIGC can automate specific aspects of the process by drawing upon internal and external knowledge bases. This includes the detection of defects in products or systems, culminating in superior product quality and a reduction in waste.

3.4 AIGC-aided testing

During testing, the AIGC service plays a significant role in streamlining various aspects, including defect detection (Guo et al., 2023) and performance analysis (Du et al., 2023). With the support of AIGC, engineers can enhance the testing process through tasks such as generating test cases and conducting automated tests. This optimization results in reduced testing duration and costs while simultaneously enhancing the precision and reliability of test outcomes. Moreover, the AIGC service excels in identifying defects within products or systems during testing, harnessing image recognition and other machine learning algorithms. Additionally, it assists engineers in scrutinizing the performance of products or systems during testing by employing machine learning algorithms capable of identifying anomalies and discerning performance patterns.

3.5 AIGC-aided evolution

Evolution represents the final phase of the engineering lifecycle, and during this stage, the integration of AIGC can significantly enhance project assessment and contribute to the advancement of project management science, as highlighted by Lv (2023).

Users, design firms, and project implementers all have the opportunity to incorporate pertinent data into a shared database. For instance, engineering design companies can contribute essential data related to completed projects, including design schemes, architectural results, and usage feedback. This input serves as a valuable resource for AIGC, facilitating engineering implementers in the evaluation process.

Furthermore, the AIGC service proves instrumental in assisting engineers with various aspects during this phase, including product improvement, decision support, and real-time performance monitoring. In the domain of product enhancement, engineers can leverage the AIGC service to scrutinize data from products or systems, thereby identifying areas for improvement. Machine learning algorithms adept at detecting usage patterns or

analyzing user feedback play a pivotal role in this context.

In the domain of decision support, the AIGC service functions as an invaluable asset, offering assistance in decision-making throughout the evolution phase. Last, engineers benefit from real-time performance monitoring through AIGC, with machine learning algorithms capable of detecting anomalies and identifying performance trends. This multifaceted approach enhances the effectiveness of engineering processes during the evolution phase.

4 Challenges and trends of AIGC in engineering management

4.1 Challenges of AIGC in engineering management

4.1.1 Ethical issues

The incorporation of AIGC services within the domain of engineering management offers significant advantages but concurrently introduces ethical complexities that warrant careful consideration.

First and foremost, the utilization of AIGC may inadvertently perpetuate biases present in the training data, potentially resulting in unfair or prejudiced results in engineering management decisions. For instance, AIGC designs may exhibit a bias toward specific materials, suppliers, or contractors based on historical data, potentially sidelining other viable alternatives. Addressing this ethical concern is of utmost importance.

Second, AIGC services must take into account the environmental and societal repercussions of engineering management decisions, including factors such as resource consumption, waste generation, and community involvement. Ethical considerations necessitate that AIGC promotes sustainable and socially responsible practices within the engineering management domain.

Last, the deployment of AIGC services raises questions surrounding intellectual property ownership, including designs, plans, and reports. The formulation of explicit guidelines regarding intellectual property rights and ownership is pivotal to mitigating potential disputes and safeguarding the interests of all stakeholders.

Potential solutions to these ethical challenges include the establishment of an industry-recognized database and the implementation of transparent algorithms. In the context of engineering management, where standards such as engineering safety and construction standards remain consistent despite project variations, the creation of an integrated database specifically tailored to engineering management can prove beneficial. Regular audits and reviews of the datasets used to train AIGC models should be conducted to ensure impartiality and representativeness of the data.

Furthermore, the deployment of transparent and interpretable AIGC models enable users to comprehend the rationale behind the AI's conclusions, rendering its recommendations and actions more trustworthy. This transparency fosters accountability and enhances the ethical integrity of AIGC services in engineering management.

4.1.2 Reliability

Reliability stands as a primary consideration when integrating AIGC services into engineering management. Ensuring the quality and dependability of AIGC is of utmost importance, given that inaccuracies or errors have the potential to result in project delays, cost overruns, or safety hazards.

To establish and maintain reliability, the implementation of rigorous validation and verification procedures is crucial. These procedures serve to mitigate potential risks and determine that AIGC aligns with the requisite standards. In essence, assuring the dependability of AIGC services necessitates the execution of rigorous validation and verification processes. These processes serve the purpose of evaluating the AIGC model's performance, identifying potential issues, and confirming its suitability for the intended application.

The reliability of AIGC services hinges on their seamless integration with existing engineering management systems and processes. Ensuring compatibility and interoperability between AIGC services and other tools is critical for upholding reliability and facilitating a cohesive workflow. To further enhance the reliability of AIGC, the industry can adopt a proactive approach by continuously monitoring and periodically auditing outputs. This practice ensures that AIGC outputs remain within expected parameters, effectively detecting anomalies and upholding the consistent performance of AI systems.

4.1.3 Robustness

Robustness assumes a pivotal role when employing AIGC services in the domain of engineering management. The challenges associated with robustness include several key considerations.

A robust AIGC service should possess the capacity to extrapolate its knowledge obtained from training data to navigate novel and unforeseen scenarios within the domain of engineering management. The development of AI models capable of adapting to diverse project contexts, requirements, and constraints while consistently maintaining performance stands as a critical requirement for robustness.

Furthermore, the robustness of AIGC services hinges on their seamless integration with established engineering

management systems and processes. Ensuring compatibility and interoperability between AIGC services and other tools is of primary importance for system-wide robustness.

Potential solutions to bolster robustness involve the design of systems that can revert to safe default actions or prompt human intervention in instances of uncertain predictions. This approach effectively mitigates the risk of implementing potentially hazardous automated actions based on unreliable outputs, safeguarding the integrity of engineering management processes.

4.2 Trends of AIGC in engineering management

The integration of AIGC within the engineering management industry paves the way for numerous research avenues to explore. As the industry continues to evolve, several research topics are poised to receive increased attention, including AIGC-aided optimization design, AIGC-aided engineering consulting, and AIGC-aided green engineering.

First, the convergence of AIGC and optimization in engineering management design offers the promise of expeditious, highly efficient, and often innovative services. AIGC can present a multitude of optimized design variations, taking into account factors such as material efficiency, structural integrity, and aesthetics, while aligning with the design objectives and constraints of consumers, architects, and engineers. Moreover, AIGC can facilitate the creation of safe and efficient designs by conducting testing and simulations to assess structural load distribution.

Second, engineering consulting plays a pivotal role in assessing a project's financial sustainability and profitability. Traditionally reliant on human expertise, engineering consulting firms can leverage AIGC to analyze historical interactions, payment behaviors, and project results to profile clients. This data-driven approach aids contractors in making informed decisions regarding project bids. Engineers can further harness AIGC to construct models that predict results based on specific variables, expanding the engineering consulting experience database. For instance, AIGC can generate optimal bidding strategies by analyzing historical bid data, market trends, and competitor bidding behaviors. Additionally, it can automatically identify scenarios where claims may arise and assist in quantifying the claim amount.

Last, the integration of AIGC into green engineering amplifies its potential effect, facilitating the development of more efficient and environmentally friendly solutions. The AIGC's predictive capabilities enable the anticipation of energy consumption patterns, contributing to the construction of energy-efficient buildings and structures. This alignment with green engineering principles is poised to revolutionize sustainable practices within the industry.

5 Concluding remarks

AIGC possesses substantial potential to revolutionize the field of engineering management, as demonstrated by its far-reaching effect on engineering practices spanning various lifecycles. These lifecycles include demand analysis, design, implementation, testing, and evaluation. The strategic application of AIGC within these phases holds the potential to elevate decision-making processes, optimize resource allocation, and streamline project workflows.

AIGC's capacity to handle vast datasets, extract valuable insights, anticipate emerging trends, and automate repetitive tasks greatly contributes to its transformative potential. The integration of AIGC into engineering management practices empowers organizations to achieve heightened efficiency, foster innovation, and secure a competitive advantage within the industry.

To further enhance the efficacy of AIGC within engineering management, stakeholders can collaborate in establishing industry-recognized databases. These databases serve as a valuable source of data for AIGC, presenting an opportunity to address critical challenges such as reliability, ethical considerations, and robustness. Additionally, research endeavors focusing on AIGC-aided optimization design, AIGC-aided engineering consulting, and AIGC-aided green engineering can play a pivotal role in advancing the application of AIGC within the domain of engineering management.

Competing Interests The authors declare that they have no competing interests.

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