ISSN 2683-345X
journal homepage: http://ijiemjournal.uns.ac.rs/

International Journal of Industrial Engineering and Management

Volume 15 / No 2 / June 2024 / 169 - 179

Review article

Generative Artificial Intelligence Technology for Systems Engineering Research: Contribution and Challenges

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ABSTRACT

The advancement of artificial intelligence technology in recent years has had a significant impact on various industries, including the field of systems engineering. Generative Artificial Intelligence (AI), like OpenAI's ChatGPT, is one such tool that has garnered attention. While this technology offers researchers in systems engineering intriguing possibilities, it also introduces certain risks to the traditional research framework. The aim of this paper is to investigate the advantages and drawbacks associated with embracing generative AI. We conducted a comprehensive literature review utilizing resources like Google Scholar, Web of Science, and the Scopus database, along with professional websites and white papers. The analysis highlights the potential benefits of generative AI in systems engineering research, including data processing, analysis, hypothesis formulation, prediction and forecasting, and collaboration enhancement. However, it also underscores various risks, such as potential data bias, the generation of human-like text, potential loss of analytical capabilities, and difficulties in analyzing output from these AI tools. As emphasized in this paper, numerous concerns still need to be addressed regarding the use of generative AI tools due to their relatively new nature and evolving capabilities.

ARTICLE INFO

Article history:
Received December 20, 2023
Revised April 21, 2024
Accepted May 27, 2024
Published online June 05, 2024

Keywords:
Generative Artificial Intelligence;
ChatGPT;
Research;
Systems engineering

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1. Introduction

AI has had a significant impact on all companies, communities, and individuals. As it anticipates in its ecosystems, AI provides systematic capacity for reasoning based on information, and it learns via the many types of anticipated results [1]. When AI first emerged, the emphasis of systems was mostly on unsupervised and supervised learning, where it took cues from biological creatures and physical laws of nature and constructed these laws digitally to address issues requiring large amounts of data [2]. However, structured data was necessary for building models and data processing in classical AI systems. Due to these restrictions, the capacities of these AI algorithms, like decision trees, random forests, and neural networks, were relatively constrained [3].

Many practical applications of natural language processing, including voice and phrase identification, distillation, translators, and textual production, have seen substantial achievements in recent years [4]. However, the established generative AI models, like chatbots, have limits and are unable to deal with natural language messages with highly dependent relation-

Published by the University of Novi Sad, Faculty of Technical Sciences, Novi Sad, Serbia.

http://doi.org/10.24867/IJIEM-2024-2-355

ships. To solve this issue, generative AI models were invented [3]. These models also feature an automatic attention system that assesses the relevance and interrelationship of various input components [5]. As a result, irrespective of a phrase's location within a sentence, these models are extremely resilient in comprehending the link across phrases. A huge language model called the Generative Pretrained Transformer (GPT), which draws on the transformer model, has been very successful in applications requiring natural language processing [6]. The generative AI models have been trained on a large amount of textual information, and they have a high degree of reliability while doing various language-related operations as well as producing text that resembles human speech [7].

Many novel innovations have evolved in recent years, frequently upsetting established norms. People must thus assess and take into account the advantages and risks of such novel technology. Google has been questioned in the past about how this technology would alter how people perceive, consume, and retain information [8]. These issues also apply to generative AI models because they present both enormous potential benefits and risks [9]. The capacity of generative AI models to learn from and modify themselves in response to input is one of their main advantages [10]. This implies that generative AI models have the potential to develop replies and deliver more precise and useful content as more users communicate with them and offer input. The generative AI models, such as ChatGPT, may be tailored to certain industries or jobs, including customer service or technical writing. It's crucial to remember that generative AI models remain AI models with constraints [11]. Much research has been done to investigate how generative AI models will be used in different applications after they are released in 2023. However, generative AI models were only recently introduced with tremendous capabilities and are new research-related innovations [12]. In this work, we examine the possible applications and mitigation measures for generative AI models, with the focus on ChatGPT as the most recognized example, in systems engineering research and provide mitigation measures for possible risks.

The following are the study's major contributions. The study first examines the advantages of adopting generative AI models in research contexts. Above all, generative AI offers unique qualities, including availability, customization, conversation style, and affordability, and may be employed in research in a variety of ways. Second, the article offers threat-reduction tactics in the context of generative AI models. Despite its best efforts to deliver precise and useful content, it occasionally makes mistakes or delivers material that is incorrect or lacking. Furthermore, generative AI has limitations when it comes to comprehending non-verbal signals, sensations, and context, which might affect its capacity to correctly decipher and reply to specific kinds of requests. In general, generative AI models are effective tools that can help with a diversity of language-based activities. Third, in light of such a ground-breaking generative AI model, the study explores future research prospects. The remainder of the article is structured as follows: Section 2 introduces the research background; Section 3 investigates the advantages of generative AI in systems engineering research. Section 4 discusses generative AI's possible challenges in systems engineering research; Section 5 discusses the research implications; and finally, Section 6 concludes this paper.

2. Generative AI Technology Background

In general, the term "generative AI" refers to a class of AI models and approaches that are intended to create new text, pictures, or audio materials based on current data patterns and instances [13]. These models learn to comprehend and imitate the fundamental structure and properties of the data by training on sizable datasets. Through this method, generative AI models may produce fresh and accurate outputs that closely mirror the input information and are frequently indistinguishable from material that was developed by humans [14]. In this section, we summarize the most known generative AI models before focusing on ChatGPT as the most researched model.

2.1. Generative Artificial Intelligence Models

Several well-known generative AI models have made significant advances and received great acclaim in the field. Some of the more notable ones, in addition to ChatGPT, are the following:

(1) Generative adversarial networks (GANs): The most widely used generative AI method currently is GANs. Two sets of neural networks are used by a GAN [15]. One, referred to as the generator, creates the content (such as a picture of a person's face). The second, often referred to as the discriminator, assesses the veracity of the content generated by the generator (i.e., if the face is real or not). Once the generator creates material

that the discriminator is unable to distinguish between actual and synthetic, the networks resume this generate/discriminate cycle [6].

(2) GPT: GPT models can generate text in a variety of languages and produce words, phrases, and paragraphs that have a human-like tenor on nearly any subject and in any writing style [16]. These have evolved over numerous generations, with each generation having a larger parameter set trained on a larger online text corpus than the prior.

(3) Generative Diffusion Model (GDM): A set of training data distributions is used as the basis for the GDM's content synthesis, and noise is gradually added before the GDM learns how to reverse the noise addition process and retrieve the training data distribution [17]. In doing so, the learned denoising process produces data from randomly sampled noise.

(4) Geometric DL (GDL): The GDL makes an effort to comprehend, analyze, and explain AI models using geometrical concepts [17]. These ideas have already been thoroughly investigated in a variety of contexts, including grids, graphs, homogeneous spatial modifications, and vector bundles.

(5) Vector Quantized Variational Autoencoder (VQ-VAE): For the synthesis of images and videos, the VQ-VAE model is employed [6]. To provide rich and varied visual material, it combines the quantization of vectors with variational autoencoder design.

(6) DALL-E: A generative model created by OpenAI called DALL-E is intended exclusively for producing visuals from textual descriptions [16]. It can produce original and imaginative visuals from verbal cues, demonstrating the promise of generative AI in the visual realm.

(7) Style-based Generative Adversarial Network (StyleGAN): A generative model called StyleGAN is renowned for producing photos with excellent resolution and eye-catching design [15]. It gives users control over a variety of photo-creation factors, such as stance, style, and other elements.

(8) CycleGAN: It is a model that concentrates on translating images into other images [15]. Without paired training data, it may learn to map pictures from one field to another, facilitating the translation of pictures from one style to another.

2.2. ChatGPT Model

OpenAI, a pioneer in AI research, has developed several revolutionary models, including GPT-2, GPT-3, and finally ChatGPT. Continuing its efforts to develop and research after the achievement of GPT-3, OpenAI produced ChatGPT, which is founded on the GPT-4 framework [16]. ChatGPT delivers enhancements in contextual comprehension, answer creation, and overall cohesion and is created for use in conversation-based activities [16]. The goal of GPT models is to produce natural language writing that is cohesive with human speech, including phrases, segments, and full papers. The primary strength of GPT is its capacity for pre-training massive volumes of textual data and then fine-tuning certain subsequent duties, including text categorization or question response [16]. The preparation of data included websites, blogs, publishers' databases, and so on, in an unsupervised manner. The model learns to detect and extend linguistic patterns, including semantics, vocabulary, and interpretation [16]. The primary characteristics of ChatGPT make it appropriate for a variety of applications and domains, such as relational knowledge, duties versatility, multiple language abilities, flexibility, research, and workload adaptation, among other applications [6].

3. Generative Artificial Intelligence in Systems Engineering Research

Due to its emphasis on the conceptualization, design, implementation, operation, sustainment, and retirement of technologically enabled systems, systems engineering research stands apart from other study disciplines. It includes a comprehensive strategy that takes into account a system's complete lifespan while meeting stakeholders' needs and demands at every turn. The development and optimization of complex systems stresses the integration of many disciplines, approaches, and technologies in systems engineering research [18]. Researchers in systems engineering frequently collaborate with a variety of stakeholders, such as users, designers, engineers, and policymakers, to handle complicated problems and produce desired results [19]. Additionally, to study, create, and optimize systems, systems engineering research employs strict procedures, modern tools, and modeling and simulation approaches.

Generative AI tools may have the potential to provide advantageous benefits to systems engineering research, which may aid in data analysis, insight gen-

eration, decision assistance, collaboration, and improvement of the entire research process. As generative AI has developed beyond its early forerunners to its present stage, it has become an indispensable instrument for improving scientific research, with effects seen in many applications. We may anticipate further advancements and discoveries as AI technology develops, which will impact scientific research in the future [20]. The invention of generative AI has received tremendous support recently from the scholarly sector [6].

Figure 1 provides an overview of the challenges and benefits associated with the utilization of generative AI in systems engineering research, which we identified in this paper. Subsequent sections explore various avenues through which generative AI can propel research forward. Table 1 presents a summary of these advantages and how they can enhance research in general, with a particular focus on systems engineering research.

3.1. Data Processing and Analysis

In the field of systems engineering, the ability to process and evaluate vast amounts of data holds immense significance for research endeavors. The advent of generative AI has significantly transformed how scholars engage with and comprehend data in this domain [19]. In the context of systems engineering, generative AI serves as a valuable tool for knowledge retrieval from scientific articles [13]. Leveraging sophisticated natural language processing algorithms, generative AI can swiftly recognize and extract crucial data, including scores, results, and implications, from research papers [4, 24]. This capability enables systems engineers to efficiently obtain and integrate data from various sources, minimizing the time spent on traditional literature reviews and enhancing the overall effectiveness of the research process [9]. By leveraging generative AI technologies, systems engineers can streamline the retrieval and consolidation of data,

Figure 1. Generative AI in systems engineering research

Table 1. Advantages of utilizing generative AI in systems engineering research

Advantage	Study	Support
Data analysis	[1, 9, 19, 21, 22]	• Capacity to prepare, process, and analyze large volumes of data • A valuable tool for retrieving knowledge from scientific articles • Integrate data from multiple sources
Hypothesis generation	[6, 22]	• Capability of identifying connections, anomalies, and relevant associations in the data • Promoting the development of new theories and fostering creativity in research endeavors • Providing recommendations for suitable ideas, procedures, data interpretation, and alternative interpretations or forecasting
Prediction & forecasting	[6, 21]	• Generating forecasts for future events and trends
Research directions	[2, 9, 23]	• Identifying gaps in current knowledge by comparing and analyzing results from different studies • Uncovering gaps in the current knowledge
Researchers' collaboration	[1, 9, 21]	• Exchanging concepts, information, and perspectives • Connecting academics with expertise, specialists, business partners, and resources • Perform real-time translation

allowing them to dedicate more time to analysis and generating valuable insights from the amassed information. The integration of generative AI in systems engineering research has the potential to revolutionize data-driven approaches, enabling more efficient and impactful investigations in the field [1].

Data cleansing, representation, and analysis are just a few of the activities that generative AI may help with, in addition to giving researchers access to a lot of data [9]. Researchers may use this to their advantage to find emerging trends and insights in their research findings and to provide ideas that might inspire additional studies [21]. Generative AI can innovatively solve issues beyond just examining already-published material, producing original thoughts and notions that can result in revolutionary theories. Generative AI can suggest creative answers to challenging scientific issues by utilizing its deep understanding basis and pattern detection capabilities. This encourages research scholars to think creatively and question accepted wisdom [22].

3.2. Hypothesis Generation

Generative AI is capable of recognizing associations, abnormalities, and other relevant links in the data by utilizing its predictive skills, providing scholars with useful insights that might not be instantly apparent via traditional analysis. Automatic recognition of patterns can assist scholars in finding novel relationships, developing new theories, and fostering creativity in research [6]. By doing so, scholars can create hypotheses that may be verified through more testing and develop new research concerns. The formulation and evaluation of hypotheses is one of the key components of scientific research. Generative AI can help with this endeavor by recommending suitable study ideas and procedures, finding potential causes of confusion and bias that might affect the outcomes of experiments, using analytical methods and statistical analyses for data interpretation, and coming up with other interpretations or forecasts that can be compared to the initial hunch [22].

3.3. Prediction and Forecasting

Forecasting and prediction are two other uses of generative AI in research in systems engineering. Generative AI models may produce forecasts for upcoming occurrences and trends by examining previous data and recognizing deeper patterns [6]. This prediction skill may be helpful in a variety of fields, such as epidemiological, atmospheric, and financial studies, where precise forecasting can guide decisions based on evidence and aid in the creation of effective solutions and strategies [21].

3.4. Future Directions Suggestion

Generative AI can offer prospective research areas for scientists and engineers to investigate by revealing concealed relationships and generating novel

perspectives that could otherwise be ignored by scanning through enormous quantities of scientific literature [2]. Generative AI may discover gaps in existing knowledge by contrasting and analyzing the results of various studies, in addition to recommending new study ideas [9]. Generative AI can bring up areas of confusion or gaps and direct researchers to issues that require more exploration, advancing scientific understanding [23].

3.5. Improving Collaboration among Researchers

Collaboration and efficient communication are critical to the achievement of scientific undertakings [9]. A useful tool for fostering research and interaction is generative AI. It acts as a forum for peers to exchange concepts, information, and perspectives. Scholars can work together and exchange knowledge with global peers more readily because of the generative AI tool's capacity to execute instantaneous translation, which decreases language barriers [1]. Generative AI can be an essential tool for encouraging cooperation and accelerating advancement in a variety of sectors since it may link academics with comparable interests and areas of expertise [21]. Additionally, it supports the development of grant submissions, research publications, and presentations for conferences by connecting researchers with essential specialists and resources [9]. The disparity in communication between academics and everyone else, alongside legislators, business partners, and other stakeholders, can be filled in by generative AI's capacity to deconstruct complex scientific ideas and produce clear clarifications [1].

4. ChatGPT Technology Limitations in Research

Generative AI can be used in both good and bad ways. It is useful to be aware that generative AI models, such as ChatGPT, may not always be precise or provide all the pertinent information users want. Even though generative AI has been demonstrated to be a helpful instrument for furthering research, it is important to acknowledge and address the difficulties and issues related to its use. This section looks into these concerns and considers generative AI potential in the field of research. Table 2 summarizes these challenges.

- Fake content: To address the deep fake content issue, ongoing research efforts are necessary to develop techniques that can effectively identify and mitigate the text that contains subtle forgeries. Furthermore, it is crucial to tackle the issue of bias in training data [25]. If the model was trained on a dataset that contains biases, there is a risk that it may generate language that perpetuates stereotypes related to gender or other sensitive attributes [26]. Taking proactive measures to mitigate bias during the training process is vital to ensuring fair and unbiased outputs from generative AI models. More diversified datasets for training and assessment criteria that take into consideration a variety of languages and cultures must be developed in order to tackle these biases [6]. On the other hand, the extensive quantity of data obtainable through the Internet, which covers both positive and negative elements, was used to train generative AI models, which might lead to the spread of errors [27]. This emphasizes the need to keep an eye on and confirm the data utilized in developing generative AI models as well as the results they generate. The spread of false information is another serious generative AI flaw [26]. These models may deliver erroneous replies if they are given incorrect or deceptive data during training. This may result in serious repercussions, particularly in situations where the knowledge supplied by generative AI models is relied upon, including when making decisions or disseminating information [27].
- Regulations and laws: The ignorance of local regulations and laws is another problem. Because generative AI models work on a worldwide basis, their solutions might not be compliant with national legal requirements [27]. This may lead to the spread of material that is illegal or improper from a cultural standpoint [12]. In circumstances like this, the legal structure frequently falls short of offering organizational blueprints and operational patterns [28]. Changes of this nature may also generate a scenario lacking in standards and frameworks for acceptable structures and methods, as well as confusion and ambiguity [12].
- Contextual knowledge: Generative AI models generate responses by leveraging statistical patterns observed in the input data. However, these models may not always take into account the broader context of a specific research problem or topic [12]. It might also lack the intuition or common sense that humans possess [25]. Despite having access to vast amounts of

Table 2. Disadvantages of utilizing generative AI in systems engineering research

Disadvantage	Study	Concerns	Recommendations
Fake content	[25-27]	· Bias in choosing data for training · Low quality of training data	· Developing effective techniques to detect and mitigate subtle text forgeries · Tackling the issue of bias in training data · Monitoring and verifying the data used in the development of generative AI models
Regulations & laws	[12, 27, 28]	· Ignorance of local regulations and laws · Illegal material spread	· Developing standards and frameworks for acceptable models · Addressing the dissemination of illegal material
Context knowledge	[6, 11, 25]	· Fail to consider the wider context of a specific research issue · Lack the human-like intuition or common sense	· Improving and refining AI models by incorporating realistic and practical scenarios
Low quality information	[26, 28, 29]	· Low-quality and incorrect replies	· Providing continuous tracking, training, and improvement are necessary · Clarifying the accountability for the choices and behavior of the generative AI models
Complexity	[6, 14, 30]	· Generative models pose challenges in terms of comprehension and analysis	· Enhancing the explainability of generative AI models
Security & privacy	[19, 31]	· Extensive access to generative AI models for user data Adversarial attacks	· Establishing policies and regulations
Malicious uses	[3, 21, 32]	· Dispersion false information	· Implementing monitoring techniques
Ethical considerations	[6, 19, 21]	· Authorship, patents, and intellectual property	· Developing protection techniques for intellectual property · Strengthening the research community committed to ethical AI usage

data, there may be certain fields of study where generative AI models lack the requisite experience or understanding to provide accurate or comprehensive insights [11]. Moreover, these models might struggle to produce truly original or unique thoughts, as their responses are based on patterns and information they have been trained on [12].

- Low-quality information: Low-quality or incorrect replies could be generated by generative AI models [25]. Continuous tracking, training, and improvement are necessary to guarantee that generative AI models continually produce high-quality content [29]. It is crucial to establish who is accountable for these models' choices and behavior [28]. This relates to issues such as who is responsible for the data used to train these models, who is accountable for the results generated, and who is responsible for any negative repercussions of using generative AI models [26].
- Complexity: Generative AI models are complicated, which makes them challenging to understand and analyze [6]. Due to this, it could be difficult to understand how the model makes decisions and spot any potential biases or inaccuracies [14]. Building confidence and enabling users to make more knowledgeable judgments based on the created material may be achieved by making generative AI models' explanation ability better, how they make choices more visible, and revealing knowledge about their internal operations [30].
- Security and privacy concerns: Generative AI models raise several privacy and security issues and concerns [6]. The existence of privacy and data protection concerns arises due to the extensive access of generative AI models to user data, which may require training on sensitive content for accurate responses [19]. To ensure the responsible utilization and safeguarding of user data, it is essential to establish policies and regulations. As the use of generative AI for analyzing and interpreting data grows, apprehensions regarding data security and privacy also increase [25]. Therefore, prioritizing the security of sensitive data and the ethical use of data is crucial [33]. Moreover, these models

are susceptible to adversarial assaults, in which unscrupulous users purposefully supply inputs to the model in order to cause undesirable or damaging outcomes [31].

- Malicious use: The potential malicious uses of generative AI models, such as the dispersion of false information, producing bogus news, and satirizing individuals, raise significant concerns [32]. To ensure the proper and ethical use of these models, it is crucial to address these issues effectively [3]. Implementing measures like content shifting, user authentication, and monitoring can help lower the possibility of unsafe use [21].
- Ethical concerns: As generative AI models can assist in generating research concepts, theories, and written content, issues surrounding authorship attribution, patents, and intellectual property rights become apparent [19]. The protection of related intellectual property and the identification of the entities that should receive protection, as well as the extent of that protection, are important considerations as well [6]. Moreover, strengthening the scientific community and developers dedicated to the ethical use of AI is of utmost importance in preventing abuse. It is essential to avoid researchers becoming overly reliant on powerful generative AI tools like ChatGPT since they might impede their ability to think critically, analyze in a comprehensive way, and solve problems independently [21].

5. Discussion and Future Research Directions

The benefits outlined in this paper stem from conceptual analysis and a literature review rather than empirical data. Empirical evidence supporting these findings, especially in the realm of systems engineering research, is notably lacking. While few empirical studies specifically address systems engineering, most existing research on generative AI focuses on adoption factors using established models like the Technology Acceptance Model (TAM) and the Unified Theory of Acceptance and Use of Technology (UTAUT) [34]. We refer to some of these studies to complement our discussion. For example, Gupta et al. [18] empirically validated a model for generative AI adoption, finding factors like social influence, technology familiarity, and system quality to impact adoption perceptions among entrepreneurs. Sallam et al. [23] emphasized the importance of considering risk perceptions and attitudes toward technology, in integrating ChatGPT into healthcare education. Similarly, Duong et al. [35] identified effort expectancy and knowledge sharing as key drivers of ChatGPT adoption among higher education students. Lai et al. [36] highlighted intrinsic motivation as a significant predictor of ChatGPT acceptance for active learning, with perceived usefulness playing a crucial role. Soni [37] surveyed professionals in digital marketing roles, revealing drivers like efficiency and scalability but also barriers such as complexity and creativity limitations. Finally, Cardon et al. [12] found that ChatGPT is increasingly used for professional purposes, particularly among executives and managers, with organizational policies supporting comfort, trust, and efficiency in its usage. The lack of empirical evidence, both in systems engineering and other disciplines, emphasizes the necessity for further empirical research on generative AI across various domains.

Indeed, generative AI models have been utilized for both positive and negative purposes, as previously mentioned. Responsible utilization of these models is essential due to their unique capabilities that can be either misused or abused [13]. Therefore, the aforementioned constraints and concerns must be carefully considered to maximize the benefits of generative AI models. It is significant to acknowledge that there are instances where finding logical responses with generative AI models can be challenging. To fully harness the potential of this groundbreaking invention, researchers need to be mindful of generative AI models' limitations [22].

The ongoing ethical debate surrounding generative AI models primarily revolves around the anticipated effects of their applications. Within research circles, for systems engineering, for instance, the discussion on plagiarism and the integrity of researchers' work has experienced a significant shift due to generative AI models [26]. The problem has transformed from researchers manipulating the systems by "buying" their papers to a situation where they input their research data into generative AI models, make slight adjustments to the generated output, and present it as their own research [21]. Reactions to this range from pure dismay to proposals for the development of systems that can assess submissions to determine the involvement of generative AI. While attempts have been made in this direction, such as Turnitin, the current methods are still based on probability and have limitations that prevent them from being entirely foolproof.

The absence of formal ethical principles and institutions surrounding generative AI can create an environment that fosters exploitation and abuse [6]. Without well-established official structures in place, perpetrators may face less likelihood of punishment, and there may be limited effective means to hold cheating or plagiarizing individuals accountable legally [26]. To address this concern, publishers and academic institutions have started to establish guidelines outlining expectations for researchers and users when utilizing generative AI [23]. These guidelines aim to provide clarity and set standards for responsible and ethical usage of the technology. By promoting awareness and establishing guidelines, it becomes easier to hold individuals accountable for their actions while using generative AI models.

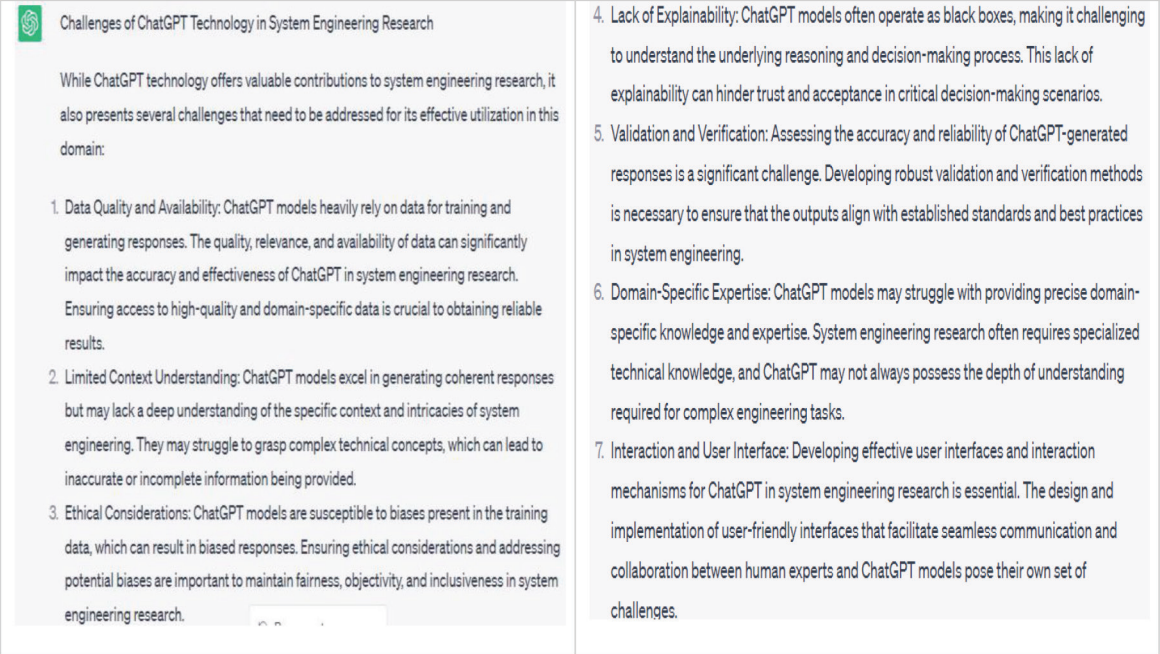
The absence of established regulatory systems highlights the urgency of creating a code of conduct for the researchers' community that provides comprehensive instructions for the appropriate use of generative AI in academic publications [12, 38]. Such a code of conduct would serve as a guiding framework to ensure the responsible and ethical usage of generative AI within academic circles [39]. Moreover, it is indeed essential for diverse authorities to collaborate to establish more widely recognized regulations. By fostering international cooperation, it becomes possible to address the global impact of generative AI and develop harmonized regulations that promote ethical practices across borders.

To test the capabilities of generative AI using ChatGPT as a tested model, the researchers inquired about the potential contributions and challenges of utilizing ChatGPT in systems engineering research. The response from ChatGPT, as depicted in Figure 2 and Figure 3, included several interesting answers. For contributions, ChatGPT reported that it can help in designing and modeling, decision support, risk assessment, and monitoring and maintenance. Although this paper addressed many other contributions of generative AI models for systems engineering research, the contributions generated by ChatGPT are valuable to be incorporated into the aforementioned discussion. When it was asked about the challenges of using ChatGPT in systems engineering research, it provided the majority of the issues that were discussed in this paper.

6. Conclusions

In the field of systems engineering research, generative AI models, such as ChatGPT, have the ability to supplement human intellect and research processes. Generative AI may free up researchers' attention so they can concentrate on higher-level tasks that call for emotional intelligence, creativity, and critical thinking by making use of its skills to help activities like data analysis, literature reviews, and hypothesis formulation. Generative AI models can also be prac-

Figure 2. Potential contributions for ChatGPT in systems engineering research (Source: Authors conversation with ChatGPT)



Challenges of ChatGPT Technology in System Engineering Research

While ChatGPT technology offers valuable contributions to system engineering research, it also presents several challenges that need to be addressed for its effective utilization in this domain:

1. Data Quality and Availability: ChatGPT models heavily rely on data for training and generating responses. The quality, relevance, and availability of data can significantly impact the accuracy and effectiveness of ChatGPT in system engineering research. Ensuring access to high-quality and domain-specific data is crucial to obtaining reliable results.
2. Limited Context Understanding: ChatGPT models excel in generating coherent responses but may lack a deep understanding of the specific context and intricacies of system engineering. They may struggle to grasp complex technical concepts, which can lead to inaccurate or incomplete information being provided.
3. Ethical Considerations: ChatGPT models are susceptible to biases present in the training data, which can result in biased responses. Ensuring ethical considerations and addressing potential biases are important to maintain fairness, objectivity, and inclusiveness in system engineering research.
4. Lack of Explainability: ChatGPT models often operate as black boxes, making it challenging to understand the underlying reasoning and decision-making process. This lack of explainability can hinder trust and acceptance in critical decision-making scenarios.
5. Validation and Verification: Assessing the accuracy and reliability of ChatGPT-generated responses is a significant challenge. Developing robust validation and verification methods is necessary to ensure that the outputs align with established standards and best practices in system engineering.
6. Domain-Specific Expertise: ChatGPT models may struggle with providing precise domain-specific knowledge and expertise. System engineering research often requires specialized technical knowledge, and ChatGPT may not always possess the depth of understanding required for complex engineering tasks.
7. Interaction and User Interface: Developing effective user interfaces and interaction mechanisms for ChatGPT in system engineering research is essential. The design and implementation of user-friendly interfaces that facilitate seamless communication and collaboration between human experts and ChatGPT models pose their own set of challenges.

Figure 3. Potential challenges of ChatGPT in systems engineering research (Source: Authors conversation with ChatGPT)

tical tools for fostering communication and cooperation in the research domain because of their capacity to interpret natural language and provide replies in a conversational fashion. They can also speed up analysis and produce better results because of their ability to swiftly develop insights from massive datasets.

This paper introduces a novel exploration into the benefits of incorporating generative AI models in research within the field of systems engineering, marking one of the initial endeavors in this domain. Despite the unique attributes of generative AI tools, such as availability, customization, conversational style, and affordability, they may occasionally produce errors or incomplete content. The study is constrained by the limited number of papers included in the review, given the scarcity of publications in this area, and lacks empirical evidence to support its findings. Nevertheless, it serves as a valuable resource for guiding systems engineering research endeavors.

It's crucial to remember that a generative AI model cannot take on the role of human intellect. As a new technology, generative AI has several difficulties regarding rules and standards, bias issues, the quantity of fictitious or inaccurate data used to train the model, ethical concerns, and security and privacy concerns. Overall, generative AI and human intelligence can improve the research process by collaborating. However, it is crucial to recognize that this is a developing field of study and that there are prospects for more investigation to support these claims with empirical evidence.

Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

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