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Research on the Impact of Generative Artificial Intelligence on Electronic Engineering

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Abstract

Generative artificial intelligence (GAI) is a technology that generates text, pictures, sound, video, code and other content based on algorithms and models. GAI cannot be separated from the development and application of deep learning and neural network technology, and GAI has become a transformative force in all walks of our economy, society, industries and our life. This paper systematically studies the profound impact of GAI on Electronic Engineering from many aspects, such as circuit design, electronic programming, electronic testing, electronic management control and electronic engineering measurement, and its industry. Based on the literature, it analyzes how GAI accelerates the innovation of electronic engineering and electronic engineering industry, improves efficiency and promotes interdisciplinary integration. At the same time, the paper also emphasizes that GAI will have an impact on the learning model of electronic engineering. Finally, the paper concludes that the impact of GAI on Electronic Engineering across all sectors and a strong governance framework is needed to ensure its healthy development.

CCS Concepts

• **Applied computing**; • **Enterprise computing**; • **Business process management**; • **Business process management systems**;

Keywords

Generative Artificial Intelligence, Electronic Engineering, Electronic Circuit, Electronic Engineering Industry

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1 Introduction

Generative Artificial Intelligence (GAI) is an important branch of the field of artificial intelligence, which comes into being with the development and application of deep learning and neural networks.

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GAI has developed rapidly since 2023, and its influence has penetrated all areas of our social and living and has produced profound changes and impacts in our world. In the field of electrical engineering and electrical industry, GAI has produced profound changes and impacts too (Janiesch, Zschech&Heinrich, 2021). Through automated data processing and code generation, in the application of new technologies including the Big Data, Internet of Things and 5G communication, with the help of deep learning and neural network technology, GAI is used in the designing, development, testing and application of electronic components, equipment and systems in the electrical engineering and electrical industry. And all aspects of electronic circuit design, communication systems, signal processing, embedded systems, microprocessors and microcontrollers, automatic control, electromagnetic compatibility (EMC), radio frequency and microwave engineering, and optoelectronics, as well as a wide range of fields from the basic theory of electronic engineering to the design of complex systems, GAI has speeded up the design process, improved the efficiency and product quality (Kraus, Feuerriegel&Oztekin, 2020). It provides more advanced technical support and services for the development of electronic engineering. GAI can even revolutionize the processes and methods of electronic circuit design, programming, testing, quality control, and measurement. With the help of GAI, engineers can complete complex tasks more efficiently and intelligently, which is driving the advancement of electrical technology and electronic engineering. For example, GAI can generate circuit designs and schemes through algorithms and models, significantly speeding up the iterative speed of circuit design and improving accuracy and efficiency (Feuerriegel et al., 2024)

In the software field of electronic engineering, GAI directly saves 20 to 45 percent of software costs by reducing initial code, code correction and refactoring, root cause analysis, and rapid completion of new system designs. Deep learning algorithms can mine and analyze the data of electronic engineering to accurately predict equipment failures, enable pre-emptive maintenance, reduce unplanned downtime, and increase productivity. GAI has an important affection in the testing of Electrical Engineering with the automates data annotation and cleansing, improving data processing efficiency and reducing data management costs, which is particularly crucial during the testing phase where large volumes of data must be handled and analyzed (Mitchell and Smith, 2008). GAI also could play an important role in the quality control of electrical engineering with its automatic real-time inspection (Chappell et al., 2014). The trend of using GAI-based reduced order models (ROMs) is expected to be growing. Engineers who utilize these models will improve system performance and reliability in electronic engineering, as well as

the efficiency and effectiveness of system design and simulation. For electronic engineering measurements, this means that GAI can simulate complex phenomena faster, leading to faster iteration and optimization.

2 The History of Generative AI and Its Profound Impact and Value

The origin of artificial intelligence can be traced back to the 1950s. The Dartmouth Conference in 1956 established the disciplinary boundaries of AI, and the Turing test laid the philosophical framework for human-computer interaction. At that time, scientists attempted to program computers to simulate human intelligent behaviors, thus initiating the research journey of artificial intelligence (Bot, 2023). At this stage, artificial intelligence mainly relies on rule engines and expert systems to be realized. By the 1980s, with the rise of machine learning technology, artificial intelligence began to enter a new stage of development. Machine learning enhances the intelligence level of systems by enabling computers to learn patterns from data. Meanwhile, the emergence of technologies such as neural networks and genetic algorithms has also provided more possibilities for the research of artificial intelligence (Parkes and Wellman, 2015). In the 21st century, the rise of deep learning technology marks that artificial intelligence has entered a brand-new era. Deep learning realizes the automatic learning and processing of massive data by simulating the connection mode of human brain neurons. The breakthrough of this technology has enabled artificial intelligence to achieve remarkable results in fields such as image recognition, speech recognition, and natural language processing. Since OpenAI released ChatGPT at the end of 2022, it has marked the entry of GAI into the stage of large-scale commercial application (Zhang and Cheng, 2022).

The empowerment of GAIe has brought brand-new development opportunities to many industries. The impact of GAI on the world is profound and multi-faceted. It not only changes the economic structure but also profoundly influences people's lifestyles, social governance, and cultural fields. GAI is not only an important driving force for economic growth and industrial upgrading but also brings challenges and changes to the job market, social governance and the cultural field (Li, Zhang & Lin, 2021).

3 Applications and Disruptive Impact of Generative AI in Electronic Engineering

3.1 Electronic Engineering

Electronic engineering, a subcategory of electrical engineering, is an engineering discipline oriented towards the electronic field. Electronic engineering is a discipline focusing on the application, control, transmission and information processing of electronic information, which plays a vital role in the development of modern science and technology and society. As an important branch of engineering, it covers everything from basic circuit theory to complex system design, involving the design, development, testing and application of electronic components, devices and systems. The application forms of electronic engineering cover electric equipment as well as various electric switches that employ control technology, measurement technology, adjustment technology, computer

technology, and even information technology (Gruetzemacher et al., 2021).

The origins of electronic engineering can be traced back to the invention of the vacuum tube. Vacuum tubes were used to amplify and convert electrical signals and were a core component of radios, televisions and other early electronic devices. During World War II, with the rapid development of radar technology and computers, electronic engineering began to flourish and gradually became a separate field (Syu et al., 2023). The invention of the transistor at Bell Labs in 1947 marked a major leap forward in electronic engineering. The emergence of integrated circuits (ics) has further promoted the miniaturization and complexity of electronic products and led to the rapid development of computers and consumer electronics. Entering the digital age, breakthroughs in microprocessors and very large-scale integrated circuit (VLSI) technology led to revolutionary products and services such as personal computers, mobile phones, and the Internet. At the same time, advances in communication technologies, such as fiber optic communications, wireless networks, and 5G, have profoundly changed people's lifestyles and social structures. In addition, the rise of sensor technology and the Internet of Things (IoT) has expanded the scope of electronic engineering applications, making significant contributions to areas such as smart homes and smart cities (Ahmed, Jeon & Piccialli, 2022).

Modern electronic engineering is developing towards a highly integrated and intelligent direction. New technologies such as system-on-chip (SoC), multi-core processors, and dedicated accelerators are emerging to improve system performance and efficiency. The application of GAI and machine learning algorithms has given greater autonomy and adaptability to electronic devices, changing the work model and the form of services in various industries, from self-driving cars to smart medical devices (Goel and Joyner, 2017).

3.2 Application and Disruptive Transformation of Generative AI in Circuit Design

The application of GAI in electronic engineering circuit design triggered a profound revolution, by accelerating the design process, improving accuracy and the efficiency with its intelligent means. Electronic circuit design was a highly time-consuming task which was relied on the engineers' experience. Now, this situation is changing because of GAI. By learning from many existing circuit design examples, GAI can automatically create new electronic circuit designs that meet specific functional requirements. GAI also could greatly speed up the processing of electronic circuit design and simulate its innovative solutions that were not previously considered (Lund et al., 2023).

After the circuit completed, a lengthy physical prototyping and testing process was required to ensure the expected performance as the prototype verification and testing of electronic engineering design. GAI could build a high-fidelity virtual model that enables engineers to quickly test and validate circuit designs in a software environment, dramatically reducing the concept-to-product cycle. In addition, by learning from large amounts of historical data, GAI could predict the potential problem areas and provide pre-emptive recommendations which could reduce the failure rates in real-world testing. This ability for virtual simulation and rapid iteration greatly

of GAI improves the success and efficiency of electronic engineering designs, enabling new products to get to market faster (Mao et al., 2019).

3.3 Disruptive Change of GAI in Program Design of Electronic Engineering

GAI has completely changed the traditional programming of electronic engineering and improved the development efficiency and code quality with its intelligent methods. Writing programs to control and manage complex electronic systems traditionally requires engineers with deep domain knowledge and extensive programming experience (Waqas et al., 2022). With the emergence of GAI, this has become more automated, efficient, and capable of generating creative and optimized solutions.

By learning from a wide range of existing code libraries and programming patterns, GAI can automatically write programs that meet specific functional requirements. For example, in embedded systems, GAI can automatically generate initialization code and device drivers based on hardware configuration, greatly reducing the workload of manual coding. In addition, GAI can dynamically adjust algorithm parameters based on real-time data streams to ensure optimal system performance under the different operating conditions. This intelligent optimization feature allows the developers to focus on higher-level design decisions while delegating tedious details to GAI.

3.4 Application and Disruptive Change of GAI in Testing of Electronic Engineering

GAI can quickly generate various testing scenarios, including edge and abnormal situations, to cover potential issues more comprehensively. GAI can automatically generate initialization code and device drivers based on hardware configuration and simulate different operating environments to verify software functionality and stability. This ability enables developers to conduct thorough testing and debugging in virtual environments, identifying and fixing errors earlier in the development cycle, greatly reducing the time from development to deployment (DeCost et al., 2020).

GAI has also made new progress in defect prediction and intelligent monitoring. By analyzing a large amount of historical defect data, GAI can predict the types and quantities of defects that may appear in the new versions and help the engineers solve problems in the early stages. It is easy to achieve intelligent monitoring and early warning, timely detection and resolution of potential problems, to ensure stable application operation with the application of GAI.

3.5 Application and Disruptive Change of GAI in Management and Control of Electronic Engineering

The application of GAI in management and control of electronic engineering has achieved a comprehensive upgrade of traditional models through intelligent resource allocation, efficient project management, precise quality control, and flexible customized services. It not only improves work efficiency and reduces human errors but also provides the company with a stronger competitive

advantage with the technological advancement of GAI and leads the field of electronic engineering towards higher levels of automation and intelligence era of management and control (Pattayam, 2021).

GAI optimizes resource allocation and improves production efficiency. In the electronic manufacturing process, GAI can analyze real-time data from production lines, automatically adjust equipment parameters and production processes to adapt to different product requirements and working conditions. For example, in the semiconductor manufacturing industry, GAI can schedule production and optimize process paths intelligently based on the current order conditions and inventory levels and ensure each step runs effectively.

3.6 Application and Disruptive Change of GAI in Measurement of Electronic Engineering

The application of GAI in measurement of electronic engineering has comprehensively upgraded traditional measurement methods with its automated measurement optimization, non-contact measurement and remote monitoring, data analysis and prediction, and personalized customized measurement plans. It improves the measurement efficiency and accuracy, provides stronger competitive advantages and lowers the errors. GAI has shown great value in non-contact measurement and remote monitoring. In some electronic application scenarios, such as electronic devices in difficult to access or hazardous environments, or high-voltage power systems or devices in nuclear radiation zones, GAI can combine image recognition, laser scanning, and other sensing technologies to perform accurate non-contact measurements. This not only improves safety but also broadens the scope of measurement applications. With the application of IoT technology and cloud platforms, GAI can achieve remote monitoring and management of electronic devices distributed globally. Engineers can monitor device status in real-time through the cloud, receive real-time alerts, and perform remote fault diagnosis and maintenance, greatly improving work efficiency and business response speed with GAI (Mao et al., 2019).

4 Impact of GAI on the Electronics Industry

4.1 Impact of GAI on the Electronics Industry

GAI is changing and driving the innovation and development of electronics industry. It is redefining the design of electronic products, shifting from relying on engineers' experience and expertise to automated systems that can learn from large datasets of existing design and programming patterns, autonomously generate new circuit designs and code to meet specific functional requirements. This transformation not only accelerates the design process but also creates the innovative solution that the designers may not have considered before (Pattayam S P., 2021).

In the electronics manufacturing industry, GAI could analyze real-time data from production lines, optimize resource allocation, and improve production efficiency. It can automatically adjust equipment parameters and production processes to adapt to different product requirements and working conditions. For example, in the semiconductor manufacturing industry, GAI can schedule production based on current order conditions and inventory levels, optimize process paths, and ensure efficient operation at each stage intelligently and more easily (Zhang & Lu, 2021).

It is very significant change in the testing and quality control of electronics industry by GAI. GAI can quickly generate the different testing scenarios, including edge cases and exceptions, and provide the more comprehensive coverage of potential issues. With image recognition technology and sensors, GAI can monitor the product quality in real-time and detect defects such as welding defects or component installation errors on circuit boards. Once the problem is identified, GAI will trigger an alarm and immediately provide its corrective measures to ensure its quality. The predictive maintenance function of electronics manufacturing systems, which is supported by data-driven of GAI could insight the problems before they occur and reduce the maintenance costs.

GAI has also had a great potential impact in supply chain management and its quality control in the electronics industry. By analyzing many historical transaction records and market trends, GAI can predict fluctuations in raw material prices and the risk of supply shortages and get a better procurement strategy. And more, GAI can also remotely monitor and manage electronic devices distributed worldwide. Engineers can monitor device status in real-time through the cloud, receive real-time alerts, perform remote fault diagnosis and maintenance, significantly improving work efficiency with GAI too (Zhang & Zhang, 2025).

4.2 The Impact of GAI on the Supply Chain of the Electronic Industry

The impact of GAI on the supply chain of the electronic industry is profound and multidimensional, which has reshaped the operational models and promoted the innovative development of the Supply Chain of the Electronic Industry.

Upstream: Accelerating its innovation and improving its efficiency

At the upstream level, GAI accelerates innovation and improves efficiency. By learning from large datasets of existing design and programming patterns, GAI can generate new circuit designs and the code autonomously which will meet the specific functional requirements. GAI not only accelerates the design process but also proposes innovative solutions. And more, GAI helps optimize material selection by recommending the most suitable materials and technologies based on cost-benefit analysis to reduce production costs. With a deeper understanding of material properties, GAI can select environmentally friendly and economical alternatives without the compromising performance and promote the green manufacturing practices.

Midstream: Improving its production efficiency and quality control

At the midstream level, GAI could optimize the resource allocation and improve production efficiency. By analyzing real-time data from the production line, GAI can adjust equipment parameters and production processes to adapt to different product requirements and working conditions automatically. In addition, GAI can predict the equipment's failures and allow for proactive maintenance plans. By utilizing the image recognition technology and the sensor, GAI can monitor the product quality in real-time and detect the issues such as welding defects or component installation errors on circuit boards.

Downstream: Strengthen its market sales and services

At the downstream level, GAI could predict consumer behavior and technology trends by analyzing the extensive market data and developing effective marketing strategies and the new product development plans. GAI could learn from the historical sales data, discover the hidden patterns and trends, accurate the demand forecasts, optimize the inventory management and the supply chain configuration. In addition, GAI can enhance customer service, improve customer satisfaction and improve loyalty through its personalized recommendations provided by intelligent chatbots and virtual assistants.

5 Impact of GAI on the Education of Electronic Engineering

5.1 Changes in Teaching Methods for Electronic Engineering Educators

GAI is changing the teaching methods of electronic engineering educators. With automatically generating high-quality educational materials such as lecture notes, lab manuals, and exercises based on the course outlines and the student progress, GAI could reduce the preparation burden on teachers and ensure that the teaching materials are kept up to date with the latest technology and research achievements. Recognizing that every student has unique learning abilities and interests, GAI can customize the personalized learning paths or solutions. GAI evaluates the students' comprehension abilities continuously, recommends the resources and activities that are the most suitable for their current level, and it would promote effective knowledge acquisition.

The implementation of an intelligent tutoring system driven by GAI could provide uninterrupted support, whether it is answering questions or providing one-on-one guidance. With the natural language processing (NLP) technology, these systems facilitate the dialogue interaction, encourage the students to ask questions and interact with virtual assistants, which develop critical thinking skills. In addition, GAI could help the educators collect and analyze the large amounts of learning data, including attendance, participation, and exam scores. Through in-depth analysis of these data, the teachers can identify the students' common difficulties and weaknesses and adjust his teaching strategies accordingly. In addition, GAI can monitor the students' learning progress, detect the potential problems early, and take proactive measures to ensure that all students keep up with the course schedule automatically.

5.2 Transformation of Learning Modes for Electronic Engineering

The application of GAI is profoundly changing the way of Learning Modes for the students of Electronic Engineering, providing more personalized, interactive, and efficient educational resources. The traditional laboratory equipment of Electronic Engineering is expensive, and its space is limited, while the combination of GAI with Virtual Reality (VR) and Augmented Reality (AR) can create the laboratory environments of Electronic Engineering. GAI provides real-time feedback on experimental results to help students correct errors and improve experimental design. In addition, by assigning tasks, tracking progress, and evaluating contributions, GAI could improve teamwork skills and serve as a virtual advisor,

providing technical guidance and resource links to help students overcome their challenges. GAI encourages exploratory learning by proposing open research topics and projects, inspiring students to explore unknown areas and propose new solutions and thereby promoting the students' innovative thinking.

5.3 The role of GAI in the innovative national

GAI plays an indispensable role in promoting innovation in national on the electronic engineering industry. It not only drives technological progress, but also fundamentally changes education models, research methods, and industry collaborations. GAI analyzes a wide range of academic literature and technical reports to provide researchers with the latest findings and trends, helping them quickly identify the key issues and propose innovative solutions to accelerate the research. GAI brings the interdisciplinary integration, bridges the disciplinary gap, promotes the deep integration of computer science with other fields such as biology, medicine, and art, and generates many novel research directions and technological solutions. The application of GAI in supply chain management and quality control has improved the synergy of the entire electronic engineering industry chain. GAI promotes the Green manufacturing with optimizing circuit design, reducing energy consumption, and lowering the carbon footprint of products. By gaining a deep understanding of material properties, GAI can select the more economical and environmentally friendly alternatives without affecting performance, to promote green manufacturing (Zhang, & Lu, 2021).

6 Conclusion

The development and application of GAI not only represent a significant leap forward in the field of electronic engineering technology but also brings unprecedented changes to electronic engineering industry. Tracing its historical development, GAI has evolved from an early concept to a widely applied technology, demonstrating unique advantages and potential in various fields including the learning model of electronic engineering. GAI, with its ability to learn and generate data, has achieved innovative applications in dimensions such as images, text, and audio, not only improving efficiency and accuracy, but also redefining industry operating models to a certain extent on electronic engineering.

GAI optimizes the process of circuit design and programming, profoundly changing aspects such as testing, management, and measurement. GAI makes the changes to the methods of upstream R&D design, midstream manufacturing and the market sales and service models of downstream which make the whole supply chain more tightly connected, responsive, and providing enterprises with stronger competitive advantages.

In the foreseeable future, GAI will continue to have a profound impact on the innovation of electronic engineering. Meanwhile, we need to establish a governance mechanism for GAI to ensure that human civilization and the development of GAI could be in harmony and coordination.

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