

Analysis on the application of artificial intelligence in machinery manufacturing and its automation

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Abstract: With the progress of science and technology, artificial intelligence has achieved significant applications in many fields. This paper aims to explore the application of artificial intelligence in mechanical manufacturing and automation, reveal its advantages, and analyze its specific application in mechanical design, manufacturing, fault diagnosis, information processing, computing and data storage, and autonomous identification system. We find that AI not only helps to improve the efficiency and quality of machinery manufacturing, but also provides broad prospects for the future development of manufacturing.

Keywords: artificial intelligence; mechanical manufacturing; automation; application

1. Introduction

Mechanical manufacturing and its automation are the cornerstone of modern industry. With the intensification of global competition and the rapid change of technology, how to improve production efficiency, ensure product quality and reduce production cost has become an important challenge for the manufacturing industry. In recent years, AI technology has become a key technology to solve these problems due to its powerful data processing, analysis and prediction capabilities.

2. Overview of the AI technologies

2.1 Definition of artificial intelligence

Artificial intelligence (AI), which usually instructs machines to simulate human intelligence. This includes simulating human cognitive functions, such as "learning" and "reasoning". AI is an interdisciplinary technology involving computer science, psychology, neuroscience, neurosciences, cognitive science, linguistics, operational research, economics, biology, cybernetics, statistics, engineering and mathematics.

Artificial intelligence (AI) is a science and engineering discipline that simulates, expands, and enhances human intelligence. The basic idea is to achieve intelligent functions through a computer program or a machine. From the initial symbolic logic reasoning, expert system to the current deep learning, neural network and natural language processing, AI technology has undergone many changes. Deep into the core, AI includes a variety of technologies and algorithms. Machine learning (ML) is the most critical part of this, allowing computers to learn based on data without explicit programming. In recent years, deep learning, a neural network-based machine learning method, has received particular attention, especially in the fields of image recognition, speech processing, and natural language understanding. Moreover, reinforcement learning gives machines the ability to make trial and error in the environment and learn the best strategies, especially for control systems and robotics.

2.2 The correlation between artificial intelligence and mechanical manufacturing and its automation

With the rise of industry 4.0 and intelligent manufacturing, artificial intelligence has gradually become an indispensable part of machinery manufacturing and automation. AI technology can provide a whole process solution from design, manufacturing to maintenance, helping machinery manufacturing to improve efficiency, reduce costs and improve product quality.

In the mechanical design phase, AI can assist engineers in complex simulation and optimization to ensure the reliability and efficiency of product design. In the manufacturing stage, the intelligent

manufacturing system can monitor and adjust the production process in real time to ensure the optimal production efficiency and product quality. At the same time, predictive maintenance and mechanical fault diagnosis are also increasingly dependent on AI technology, aiming to predict and avoid potential failures through real-time data analysis. In addition, with the popularity of automation technology, AI also helps robots and automation equipment work better with humans. Autonomous recognition systems allow robots to work independently in complex environments, while deep learning and computer vision technologies allow robots to identify and process complex tasks.

Artificial intelligence technology has brought revolutionary changes to machinery manufacturing and its automation, and injected new vitality into the traditional manufacturing industry. From design, production to follow-up maintenance services, AI is playing an increasingly important role in pushing the machinery manufacturing industry to a new peak.

3. Specific requirements required to be met by mechanical manufacturing

3.1 Meet the actual needs of mechanical functions

In the field of mechanical manufacturing, whether large production equipment or small precision parts, they need to meet the actual needs of their predetermined functions. Machinery manufacturing provides critical equipment and solutions for a variety of industries that play an indispensable role in daily operations. Therefore, every product manufactured must ensure the highest accuracy, stability, and durability. This means not only that strict quality control needs to be conducted in the design and production stages, but also that every manufacturing process, from the selection of raw materials to the assembly and testing of the final product, must be guaranteed to meet the actual application needs of users. For example, an excavator designed for mining must be able to work long hours in harsh environments without failure; while miniature devices used in the medical industry require extreme precision and reliability because they may be used in critical life support tasks.

3.2 To improve the ability to use cutting-edge technology

With the rapid progress of science and technology, the challenges facing the machinery manufacturing industry are also increasing. The application of cutting-edge technology can not only improve production efficiency, but also bring unprecedented innovation and advantages to mechanical manufacturing. Among them, the introduction of artificial intelligence technology opens up new possibilities for mechanical manufacturing. For example, by leveraging deep learning and neural networks, the machinery can autonomously learn and optimize its operations to make them more adaptable to specific tasks or environments. In addition, big data analytics and cloud computing technology allow machinery manufacturers to monitor the status of their equipment in real time and predict their maintenance needs, thus greatly reducing downtime and maintenance costs. In addition, advanced simulation and simulation technologies can predict the performance of machinery before real production, thus reducing tests and errors and accelerating the speed of product launch. In addition, new materials and manufacturing technologies, such as 3D printing and nanotechnology, bring greater flexibility and customization capabilities to mechanical manufacturing. Overall, the use of cutting-edge technology can not only improve the quality and efficiency of mechanical manufacturing, but also provide users with more personalized and high-performance solutions.

4. The application advantages of artificial intelligence in mechanical manufacturing and its automation

4.1 Improve the safety management ability

Safety is always the primary consideration in mechanical manufacturing and its automation. Traditional security management often relies on manual monitoring and manual inspection, and this method has certain limitations, such as the blind area of monitoring, human negligence and so on. Artificial intelligence technology, especially the combination of computer vision and sensor technology, can monitor various activities on the production line in real time and comprehensively. For example, with cameras and deep learning algorithms, the system can identify possible security risks in real time, such as abnormal behavior, devices that do not operate as required, and immediately issue a warning or automatic shutdown.^[1] In addition, predictive maintenance technology can predict and detect potential

faults of the equipment in advance, to avoid safety accidents caused by equipment failure. This active and intelligent safety management method greatly improves the safety of mechanical manufacturing.

4.2 Accelerate the product production speed

In the highly competitive market environment, the production speed is often directly related to the competitiveness of enterprises. AI provides a variety of solutions in this regard. First, through intelligent production planning and scheduling, the system can automatically optimize the production process, reducing waste and downtime. For example, when an equipment fails, the system can automatically adjust the production plan, transfer tasks to other equipment, and ensure that the production is not interrupted. Secondly, the adaptive control technology can adjust the production parameters in real time to ensure that the production process is always in the best state. For example, when the nature of the raw material changes, the system can automatically adjust the processing parameters to ensure the stable quality of the product. In addition, through autonomous learning and model optimization, the system can continuously improve its production efficiency, gradually reaching or exceeding the level of manual operation.

4.3 Improve the maintenance effect

In the field of machinery manufacturing and its automation, the maintenance and overhaul of equipment is the key to ensure the continuous and stable operation of production. Traditional maintenance methods are often based on fixed time intervals or on taking actions after problems occur, which may lead to excessive maintenance or neglect of potential problems. Artificial intelligence technology, especially data analytics and machine learning, has shown strong potential in this area.

First, AI systems can achieve predictive maintenance through continuous data acquisition and analysis. This means that the system is able to identify signs of impending failure or performance degradation of the device and then act before the problem occurs. This approach can not only prevent sudden downtime, but also save on unnecessary maintenance costs. Secondly, artificial intelligence technology can improve the accuracy of maintenance. With advanced image recognition and pattern matching techniques, AI systems can identify tiny cracks, wear, or other problems that may be overlooked. At the same time, the system can also use historical data and machine learning models to automatically determine the best maintenance method and timing to ensure that the device operates in the best condition. Finally, AI can also help to improve the efficiency of the maintenance teams. For example, through virtual reality and augmented reality, maintenance engineers can get real-time, all the device-related information, including the history of the device, the current status, and recommended maintenance measures, which can help them quickly and accurately locate problems and take action.

5. The specific application of artificial intelligence technology in mechanical design, manufacturing and automation

5.1 Application of artificial intelligence technology in mechanical design

Mechanical design is a complex and high-precision field. Artificial intelligence has revolutionized the field. First of all, artificial intelligence technology can help engineers through parametric design and optimization algorithm faster and more effective preliminary design sketches. These algorithms can generate all kinds of feasible design schemes automatically according to designer's constraint conditions and design goals, thus greatly improving the design efficiency. In addition, through deep learning and image recognition technology, mechanical design software can recognize the designer's hand-drawn sketch, fast conversion to digital model, simplifying the process from sketch to design model. Artificial intelligence can also predict and automatically fix common design errors, such as size mismatches or poor material choices, as shown in figure 1. ^[2]Using machine learning and historical data, AI can help engineers select materials and optimize structures to ensure that designs not only meet functional requirements, but also have good economic and life-cycle performance.



Figure 1: Intelligent manipulator adjusts the material dimensions

5.2 Application of artificial intelligence technology in mechanical manufacturing

In the process of mechanical manufacturing, artificial intelligence has become the key technology to improve production efficiency and quality. First of all, in the production line automation and intelligence, artificial intelligence can achieve accurate production scheduling and resource optimization. Through the real-time analysis of production data, we can predict production line bottlenecks and faults, real-time adjustment of production plan, to ensure the efficient and stable operation of production, as shown in Figure 2. ^[3]In addition, artificial intelligence technology also plays an important role in quality control. The system uses image recognition and sensor data to monitor every link in the production process in real time, find and repair the deviation and unqualified products in time, and ensure the stability of product quality. The application of robot technology in mechanical manufacturing is more and more extensive. Using artificial intelligence, manufacturing robots can perform more complex tasks, such as delicate assembly and welding operations, to free up human resources for higher-value work.



Figure 2: Intelligent manipulator is in the process of production scheduling

5.3 Application of artificial intelligence technology in mechanical fault diagnosis

Mechanical fault diagnosis is the key link to ensure the normal operation of the factory and the production line. Traditional fault diagnosis methods often rely on experienced engineers, but it is time-consuming and may not be accurate. With the development of artificial intelligence technology, the mechanical fault diagnosis has been greatly improved.

By exploiting large amounts of mechanical operation data collected by the sensors, machine learning models can be trained to identify early signs and patterns of failure. ^[4]This method can not only monitor the device status in real time, but also predict future failures to achieve preventive maintenance. For example, by analyzing vibration, temperature and sound data, AI systems can detect damage to bearings,

gears and motors in advance, so as to conduct timely repairs and avoid production downtime. At the same time, deep learning techniques, especially convolutional neural networks (CNN), have been used to process complex sensor data, such as images and sound waveforms, for more accurate fault detection.

5.4 Application of artificial intelligence technology in information processing

In the manufacturing industry, information processing is the core link, and the type and quantity of data involved are growing rapidly. Artificial intelligence technology plays a vital role here, ensuring that information is processed and utilized quickly and accurately.

Natural language processing (NLP) technology can be used to parse and understand documents, manuals, and maintenance records in factories to automatically extract key information, such as equipment parameters, maintenance history, and failure patterns. This information can be used to build knowledge graphs to help engineers find solutions to problems more quickly. Secondly, in the supply chain and logistics management, AI can achieve more efficient resource scheduling and optimization by analyzing a large number of orders, inventory and transportation data. For example, by forecasting future order demand, manufacturers can plan production ahead of time, thereby reducing inventory costs and improving production efficiency. In addition, AI can help factories achieve more efficient energy management. Through real-time monitoring and analysis of the energy consumption data of the production line, the AI system can automatically adjust the working mode of the equipment to ensure the optimal use of energy, thus reducing the production cost.

5.5 Application of artificial intelligence technology in computing and data storage

In the digital age, data is the new oil. With the increasing number of data in the manufacturing industry, how to effectively store, calculate and utilize these data has become a big challenge. Artificial intelligence technology offers unprecedented possibilities in this regard.

Traditional data processing and storage methods may encounter bottlenecks when processing large amounts of real-time data. Artificial intelligence, especially edge computing, allows data to be processed quickly where it is generated, greatly reducing the need for data transmission and central processing. This means that for a factory, the sensors on its production line can analyze data in real time, sending only important information or conclusions to a central server, greatly improving efficiency. Moreover, deep learning models require substantial computational resources, especially during the training phase. Model training can be greatly accelerated by using hardware accelerators specifically designed for AI, such as GPU and TPU. This also supports real-time decision-making in the manufacturing industries.

In terms of data storage, AI can help optimize storage solutions through intelligent analysis to determine which data is necessary and which can be compressed or deleted. This not only saves on storage costs, but also ensures data availability and integrity.

5.6 The application of artificial intelligence technology in the autonomous identification system

Autonomous recognition systems, such as image recognition, speech recognition and biometric recognition, have become key technologies in the modern manufacturing industry. AI plays a central role in these systems, making them more precise and practical.

On the manufacturing line, image recognition technology can be used to automatically detect product quality.^[5] For example, with a trained deep learning model, the camera can identify minor flaws or inconsistencies on the product, thus ensuring that each product meets a predetermined quality standard. Voice recognition technology provides operators with a way to interact with a machine without using their hands. This is particularly useful in certain settings that require continuous hand manipulation. Workers can control the machine with voice commands, or get real-time feedback about the state of the machine. Biometric recognition,^[6] such as fingerprint and facial recognition, provides a highly secure and personalized access control approach for manufacturing. This not only ensures the security of the equipment and data, but also provides a customized work environment and settings for each worker.

6. Conclusion

The application of artificial intelligence in machinery manufacturing and its automation reveals for us the infinite possibilities of the coordinated development between technology and industrial production.

By studying in-depth applications of AI in various aspects, we can not only better understand its impact on current manufacturing, but also foresee its potential impact on future manufacturing. With the further development of technology, we expect that AI will bring more innovations and breakthroughs to machinery manufacturing and its automation, and push the manufacturing industry to a new peak.

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