

Original Research Article

A preliminary study on the application of artificial intelligence technology in intelligent manufacturing

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Abstract: Nowadays, with the rapid development of science and technology, the integration of artificial intelligence (AI) technology and the manufacturing industry is deepening, and intelligent manufacturing has become an important direction of industrial transformation. Starting from the basic concept of intelligent manufacturing, this paper explores the specific applications of AI in intelligent design, intelligent production, quality inspection, supply chain management, and equipment maintenance, analyzes the advantages brought by these applications, and finally briefly mentions the challenges faced. The aim is to demonstrate the changes AI has brought to the manufacturing industry and inspire thinking on the integration of technology and industry.

Keywords: intelligent decision-making; industrial internet of things; flexible production; fault early warning; manufacturing intellectualization

1. Basic understanding of intelligent manufacturing

Intelligent manufacturing is not simply "replacing humans with machines", but integrating technologies such as AI, the Internet of Things (IoT), and big data into the entire process of the manufacturing industry, enabling the production system to "think and judge" like humans. For example, equipment in factories can automatically adjust parameters, production plans can flexibly change according to orders, and even market trends can be predicted through data analysis—All of which are manifestations of intelligent manufacturing. It is like building an "intelligent network" for traditional factories, integrating originally isolated machines, materials, and personnel into an organic whole, and achieving a leap from "passive execution" to "active optimization".

In traditional manufacturing, workers often repeat labor on assembly lines, and production efficiency is greatly affected by human factors. During a visit to a local auto parts factory last year, veteran workers mentioned that in the past, inspecting part sizes relied entirely on calipers. After a day's work, their eyes would be sore, and errors were inevitable. Now, however, intelligent equipment in the workshop can automatically measure and record data, not only faster but also capable of automatically generating quality reports. This transformation is not just a technological progress but also an innovation in production methods, similar to the leap from handwritten letters to instant messaging, which has completely changed the operation mode of the industry.

2. Specific applications of artificial intelligence in intelligent manufacturing

2.1. Intelligent design: Accelerating the implementation of creativity

When designing a new product, designers often need to repeatedly modify parameters and test performance. For instance, designing a new bicycle frame requires considering both load-bearing strength and weight control. Traditional methods may involve making a dozen samples for repeated tests, taking several months. AI, however, can quickly generate qualified schemes by learning massive historical design cases. By inputting constraint conditions such as material strength, weight, and cost, AI can provide dozens of design schemes within minutes, marking the advantages and disadvantages of each—For example, which is lighter but costly, or which has good load-bearing capacity but is slightly bulky.

This approach not only saves a lot of time but also breaks through the limitations of human thinking. Some automobile companies have tried using AI to design engine components. The algorithm did not follow the conventional symmetrical structure during optimization, and the final scheme was 20% lighter than traditional

designs yet more durable. Engineers later disassembled and analyzed it and found that the algorithm borrowed the mechanical principle of the honeycomb structure—An angle never considered by human designers.

2.2. Intelligent production: Making assembly lines "smarter"

In production workshops, the role of AI is more intuitive. Through sensors installed on equipment, production lines can collect real-time data such as temperature, rotational speed, and energy consumption. AI, acting as a "brain", analyzes these data and adjusts production parameters in a timely manner. For example, in chip manufacturing, if the temperature of a machine suddenly rises by 0.5°C, AI will immediately issue instructions to slow down the machine temporarily and cool it down, avoiding damage to chip circuits caused by temperature fluctuations. This ability to adjust at any time is like installing an "intelligent temperature controller" for the production line, ensuring the stability of the production process.

Intelligent robots are also "spokespersons" of AI. In automobile factories, robots can accurately grasp parts of different models for welding through visual recognition technology, and even automatically adjust the force according to slight differences in parts. As reported in the news last year, the welding robots in a new energy vehicle factory, optimized through AI algorithms, can identify tiny deformations of parts within 0.1 seconds and adjust welding angles, increasing the welding qualification rate from 95% to 99.8%. Data shows that after introducing intelligent robots, the error rate of some production lines has decreased by 90%, while production speed has increased by 30%.

2.3. Quality inspection: Making "defects" visible

Product quality inspection was once one of the most labor-intensive links. Manual inspection is not only slow but also prone to missing subtle defects due to fatigue. For example, scratches on mobile phone screens are only visible under strong light, and workers may easily get distracted after long hours of inspection. AI, through image recognition technology, can analyze hundreds of product images per second and accurately identify millimeter-level scratches, dents, and other issues.

In the electronics industry, components on circuit boards are densely packed, like a "community" of small parts squeezed together, making manual inspection error-prone. After introducing an AI inspection system, a company can inspect 100,000 circuit boards per day with an accuracy rate of 99.98%, 8 times higher than manual inspection efficiency. More importantly, it can record the characteristics of each defect and continuously "learn" how to find problems faster. For example, when encountering misalignment of new-type components, the system will automatically mark and update the inspection model, enabling instant recognition of similar problems next time.

2.4. Supply chain management: Improving logistics efficiency

A product goes through multiple supply chain links from raw materials to finished products, like a relay race across multiple cities. AI can predict the demand for raw materials and transportation time by analyzing data such as market demand, weather, and traffic. For example, a home appliance company used AI to predict a surge in air conditioner sales in summer and allocated core components such as compressors from different suppliers one month in advance. This not only avoided stockouts during the peak season but also prevented inventory backlogs—Something almost impossible in the past when relying solely on experience.

In the logistics link, AI can also optimize transportation routes. In the past, drivers might choose routes based on experience, but AI comprehensively considers factors such as real-time traffic conditions, fuel prices, and even weather forecasts to provide the most economical solution. After a logistics company tried this, transportation costs decreased by 15% and delivery time was shortened by 20%. For example, in the transportation of home appliances from Guangzhou to Beijing, the system avoids rainstorm-affected sections and chooses to travel on highways at night, saving tolls and preventing goods from getting wet.

2.5. Equipment maintenance: Reducing machine "downtime"

If a machine in a factory breaks down suddenly, the entire production line may stop, causing huge losses. Data shows that the shutdown of a large injection molding machine for one day may cost an enterprise more than 100,000 yuan. By analyzing machine operation data, AI can predict faults like a "doctor". For example, in a steel mill, AI predicted that the bearings of a rolling mill might wear out 3 days in advance by analyzing changes

in its vibration frequency. The enterprise took the opportunity to replace the parts during non-production hours, avoiding shutdown losses.

This "predictive maintenance" method is more efficient than traditional regular maintenance. The traditional approach is like regular physical examinations, conducting full checks regardless of whether there are problems, which wastes money and may interfere with normal operations. AI, however, can accurately judge the "health status" of machines, like installing a "health bracelet" for them, only reminding maintenance when needed. After a auto parts factory introduced this technology, equipment failure downtime decreased by 40%, and maintenance costs were reduced by 25%.

3. Advantages of artificial intelligence for intelligent manufacturing

The most intuitive advantage is improved efficiency. Whether in design, production, or inspection, AI can complete tasks at a speed far exceeding that of humans, enabling enterprises to respond to market demands more quickly. For example, a new product that used to take half a year from design to mass production can now be launched in three months with the help of AI. This is particularly important in the fiercely competitive consumer electronics industry—Whoever launches a new mobile phone first can seize more market share.

Cost reduction is also significant. Reducing manual operations means lower labor costs. After a electronics factory introduced an AI inspection system, the number of quality inspectors decreased from 20 to 3, saving more than 80,000 yuan in monthly wages. Accurate quality inspection and equipment maintenance also reduce waste and shutdown losses. Surveys show that manufacturing enterprises applying AI have reduced average production costs by 10%-20%.

More importantly, AI makes manufacturing more flexible. Small-batch, personalized orders used to be a headache for traditional factories. For example, custom-made sports shoes required separate adjustments to the production line in the past, resulting in high costs. AI, however, can quickly adjust production plans to achieve "multi-variety, small-batch" production. For example, a clothing company can now use AI to adjust cutting schemes based on customers' height and body shape data, achieving "one version per person" custom production while ensuring efficiency—Something only high-end custom brands could do a few years ago.

4. Challenges in the application of artificial intelligence

Data is the "food" of AI, but data in factories is often messy. Different devices have different data formats, like dialects from different regions that are hard to understand. Some data also contains errors, such as abnormal values caused by poor sensor contact, which affects AI judgment. For example, the sensors in a factory occasionally transmitted incorrect temperature data, leading AI to mistakenly judge equipment failures and causing frequent production line shutdowns. Later, engineers spent three months cleaning the data before the system returned to normal.

Technology costs are another issue. Installing sensors and purchasing intelligent systems require significant investment. A basic AI production management system may cost hundreds of thousands of yuan, which some small and medium-sized enterprises may find difficult to afford. Moreover, operating these intelligent systems requires professional knowledge, such as learning data analysis and adjusting system settings. Currently, there is a shortage of talents who understand both manufacturing and AI. At a technology lecture last year, an entrepreneur said that their factory bought advanced AI equipment but could not find operators, so they had to ask the manufacturer to send personnel for maintenance, which increased costs instead.

5. Conclusion

Artificial intelligence is bringing unprecedented changes to intelligent manufacturing. From design to production, from inspection to logistics, it acts as an invisible thread connecting all links of the manufacturing industry, making production more efficient, accurate, and flexible. Although it currently faces challenges such as data, costs, and talents, these problems will eventually be solved with continuous technological progress—Just like when computers first appeared, they were once difficult to popularize due to high prices and complex operations, but now they have been integrated into all walks of life.

Watching the intelligent robots operating efficiently in factories and listening to engineers discuss AI-optimized production schemes, I deeply feel the power of technology. Perhaps in the near future, every product around us, from mobile phones and bicycles to clothes and home appliances, will incorporate the "wisdom" of AI. The transformation of the manufacturing industry will also make our lives more convenient and better—For example, we can buy better-fitting clothes, use more durable products, and enjoy faster services. All of this makes me full of expectations for the integration of technology and industry.

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