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Research on the Integration of Artificial Intelligence Technology and Mechatronics Engineering against the Backdrop of Intelligent Manufacturing

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Abstract: *The integration of artificial intelligence (AI) technology and mechatronics engineering is able to promote the level of intelligence, optimize the production process, reduce maintenance costs, improve production efficiency and quality, and enhance the competitiveness of enterprises. It would promote the development in the field of intelligent manufacturing as well as the transformation and upgrading of the manufacturing industry, so as to achieve efficient, intelligent and sustainable production. In this paper, by combining the application of intelligent manufacturing and according to the crucial practical significance of the integration of intelligent manufacturing and mechatronics engineering, we put forward suggestions for the integration of artificial AI technology and mechatronics engineering against the backdrop of intelligent manufacturing, so as to improve the productivity in mechatronics engineering, improve product quality, reduce costs, enhance the management capacity of the supply chain, and to promote the further development in the intelligent manufacturing.*

Keywords: *intelligent manufacturing; artificial intelligence; mechatronics engineering*

1. Introduction

Intelligent manufacturing is a new production pattern based on the in-depth integration of a new generation of information and communication technology and advanced manufacturing technology, which runs through all aspects of manufacturing activities such as design, production, management, service, etc. It has the functions of self-perception, self-learning, self-decision-making, self-execution, self-adaptation and so on. The development of technology has boosted productivity while the pursuit of higher productivity and profitability has promoted continuous changes and reforms in the industry. Currently, developed countries have generally begun to explore Industry 4.0.[1]

Compared with traditional mechanical manufacturing, by introducing AI technology, composite mechatronic engineering and its technology have a greater application prospect, and could adapt to the increasingly complex industrial production and manufacturing needs in today's era of highly developed industrial capabilities. With the help of efficient learning ability and self-improvement ability of AI, the mechatronics engineering technology could continuously improve its own shortcomings in the process of practical application, and continue to improve in the details, so that the overall system gradually presents better stability and adaptability. Mechatronics systems would inevitably involve a certain form of inherent relationships, such as input and output. However, due to the enormous limitations in the conventional description methods, it is quite difficult to describe part of the contents by using conventional methods. By utilizing AI to update and iterate the core concepts of traditional mechanical engineering, we are able to indirectly express the application needs and expected effectiveness of mechatronic engineering in a similar way, and provide more advanced and mature technical support in data mining and automation control.[2]

At present, industry 2.0, and 3.0 technology has been comparatively mature, registering a high level of penetration rate in the global market landing and application. Some countries with mature manufacturing industry capabilities have taken the lead in ushering into the industry 4.0 development stage featuring networking, and intelligence.[3] According to statistics, in 2021, Shenzhen, Jiangsu, Fujian, Shandong, and Beijing encouraged enterprises to carry out standard applications. The number of enterprises in the jurisdiction that have completed the self-diagnosis of intelligent manufacturing capability maturity has significantly increased compared with that in 2020, with a growth rate that ranks high in the country (as shown in Figure 1).

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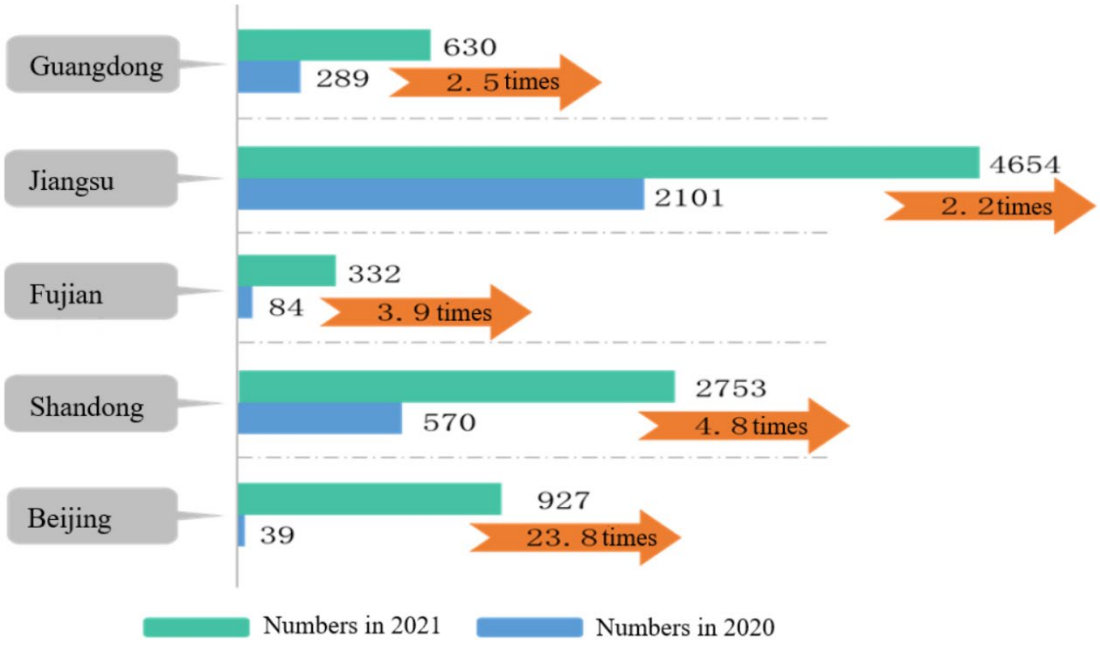

Figure 1: Number of enterprises that have completed the self-diagnosis of intelligent manufacturing capability maturity[4]

2. Characteristics of Mechatronics Engineering

Mechatronics engineering is a cross-discipline that integrates the knowledge of mechanical engineering and electronic engineering, which combines mechanical design, manufacturing and electronic technology. It is applied to various industrial fields, such as manufacturing, automotive engineering, aerospace and aviation. Its characteristics are five folded.

First, it is comprehensive. Mechatronics engineering integrates the knowledge in both mechanical and electronic fields and involves the knowledge of multiple disciplines, thus requiring the comprehensive use of knowledge from various fields to solve problems.[5] Second, it features automation. Mechatronics engineering is often combined with automation technology to realize the design and development of automated control systems. By utilizing sensors, actuators, control algorithms, etc., the automated operation and intelligent control of mechanical systems could be achieved. Third, it features precision. The systems in mechatronic engineering often require design and manufacturing with high precision to meet the requirements of high precision, high speed and high stability. Therefore, the requirements for design and manufacturing processes are high. Fourth, it features innovation. Mechatronics engineering is a field full of constant innovation. With the development of science and technology and the demands in applications, it is necessary to constantly develop new technologies and solutions to deal with complex engineering problems. Fifth, it features multidisciplinary cooperation. Mechatronics engineering often needs to cooperate with other disciplines, such as computer science, materials science and so on. Interdisciplinary cooperation could provide more integrated and effective solutions.[6]

3. Current Development Situation of AI Technology against the Backdrop of Intelligent Manufacturing

3.1 Data-driven Decision-making

AI technology could realize data-driven intelligent decision-making by analyzing and processing a large amount of data in real time. The analyzed data could come from sensors, equipment, and process parameters on the production line. Through machine learning, deep learning and other technologies, the production process could be monitored and predicted in real time while quality control and optimization of production efficiency could be achieved. In the development of data-driven intelligent manufacturing, the maturity level of intelligent manufacturing capabilities in the industries of computer electronic devices, automobiles, electrical appliances, food, pharmaceuticals, special equipment manufacturing,

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chemical raw materials and products, and non-ferrous metal smelting ranks in the forefront of the country.[7]

3.2 Computer Vision and Image Processing

Computer vision technology combined with AI technology could realize industrial quality inspection, product tracking and other functions. By using image processing and pattern recognition algorithms, products during the production process could be automatically detected and classified to improve product quality and productivity. In addition, the application of AI technology in the field of robotics enables robots to operate more complex tasks and collaborate with humans. By utilizing technologies such as visual perception, autonomous obstacle avoidance, machine learning, robots could automatically assemble, package, handle on the production line, improving productivity and production security.[8]

3.3 Intelligent Fault Diagnosis and Management

With the help of AI technology, supply chain management could achieve more intelligent scheduling and coordination. By analyzing and optimizing the real-time data of the supply chain, it could achieve the goals of timely supply, inventory reduction, optimization of logistics, etc., so as to improve the efficiency and response capability of the supply chain. At the same time, the application of AI technology could provide intelligent fault diagnosis and predictive maintenance for equipment and production lines. According to the real-time analysis of equipment sensor data, the occurrence of equipment failure could be predicted and the optimization of maintenance plans could be carried out, so as to improve the reliability of production equipment and the stability of production lines.

4. Significance of Integration of AI Technology and Mechatronics Engineering

4.1 Enhancing Level of Intelligence

AI technology could make the equipment and systems in mechatronics engineering intelligent. By introducing machine learning, deep learning and other technologies, the equipment and systems could learn and adapt to different working conditions and tasks, and carry out intelligent operations and controls, which could improve the automation and intelligence level of the equipment and systems, and enhance the productivity and production quality. The statistical data show that the maturity level of intelligent manufacturing capacity in China's manufacturing industry in 2021 has been improved compared to 2020. The proportion of low maturity enterprises under Level 1 has decreased by 6 percentage points, and the number of high-maturity enterprises above Level 3 increased by 5 percentage points (Figure 2).

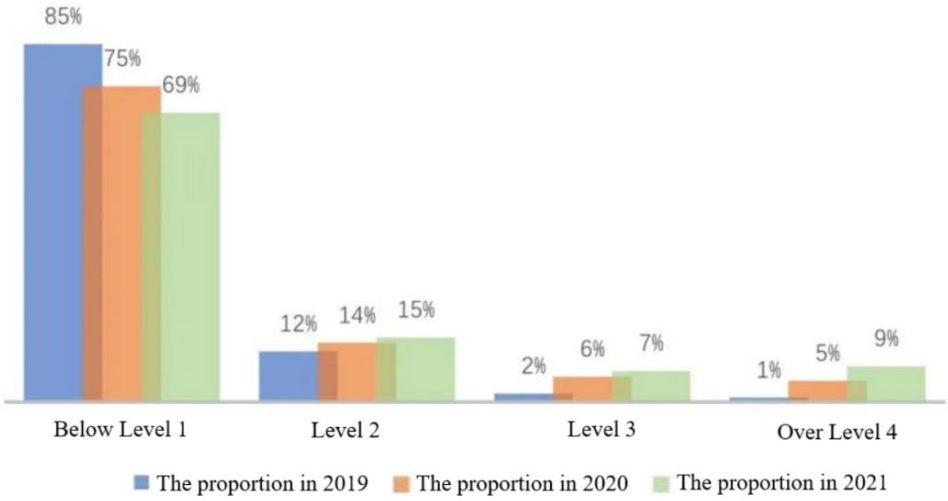

Figure 2: Improvement in the maturity of the intelligent manufacturing industry[9]

In addition, the integration of mechatronic engineering and AI technology would promote the process of industrial intelligent development. Through the application of technologies such as automation, intelligent control and data analysis, a more efficient and intelligent production pattern could be realized to improve the efficiency and quality of industrial production. This is of great significance for promoting

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industrial transformation and upgrading and enhancing the competitiveness of the national manufacturing industry.

4.2 Real-time Monitoring and Predictive Maintenance

The equipment and systems in mechatronics engineering could realize real-time monitoring and predictive maintenance through AI technology. With the help of sensors and data collection technologies, data such as equipment operating states and process parameters can be collected in real time. Moreover, by using machine learning and data analysis algorithms, fault prediction and optimization of maintenance plans could be realized. Besides, potential problems can be found and solved in a timely manner so as to enhance the reliability of equipment and the stability of the production line. The integration of AI technology and mechatronics engineering could also improve the safety of the production process and the reliability of equipment. Equipment failures and potential dangers could be found in advance through AI based fault prediction, optimization, and maintenance, so as to reduce the risk of accidents. At the same time, the intelligent and automated control of mechatronics equipment could reduce the direct contact and operation of personnel and improve safety.[10]

4.3 Optimizing Production Process and Enhancing Productivity

The integration of AI technology and mechatronics engineering could optimize the production process. Through the analysis of big data and the realization of automatic optimization control algorithms, it could also improve production efficiency, save the use of resources, and reduce energy consumption. Additionally, AI technology could also realize the dynamic adjustment of the production plan, the agile production method, so as to further improve productivity and response capability. At the same time, AI technology could enable mechatronic equipment and systems with the ability of self-learning and adaptiveness. Through the application of machine learning algorithms and real-time monitoring of sensor data, the equipment could continuously learn and improve its operating strategy to achieve autonomous adaptation and optimization. In this way, we could improve the stability and performance of equipment, reduce manual intervention and adjustment, and lower operating costs.

4.4 Realizing Intelligent Manufacturing Environment

The integration of AI technology and mechatronics engineering could realize an intelligent manufacturing environment. By applying technologies such as computer vision, autonomous collaborative robots, and intelligent supply chain management, automation, intelligence, and a high degree of collaboration could be achieved in the production process. This could improve the flexibility, response ability, and quality control of the production line to adapt to changes in demand and rapid market competition. After the construction of the intelligent manufacturing environment is completed, the integration of AI technology and mechatronics engineering could also realize personalized production and satisfy customized demand. Through data analysis, intelligent optimization algorithms and other technologies, personalized customization of the product design and manufacturing process could be accomplished. Therefore, the requirements of the market for diversified products and personalized demand could be met while customer satisfaction and market competitiveness could be enhanced.

5. Suggestions for Integration of AI Technology and Mechatronics Engineering Against the Backdrop of Intelligent Manufacturing

5.1 Promoting Interdisciplinary Cooperation

AI technology and mechatronics engineering are both interdisciplinary involving multiple subject areas. Promoting close cooperation and communications among researchers, engineers and technicians in related fields could accelerate the process of integration and application. We need to establish interdisciplinary research teams and cooperation mechanisms to solve problems together and share resources and experience.

5.2 Integration of Data Resources

The application of intelligent manufacturing technology is based on the integration of data resources. Effective data integration could achieve rapid product design, shorten the R&D cycle, reduce R&D costs,

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and improve the efficiency and quality of R&D. The results of data analysis show that digital R&D tools have been widely applied in enterprises currently with a proportion of 89%, increasing from 73% in 2020. 30% of enterprises have applied digital design modeling simulation technology while 55% of enterprises have realized design based on 3D models. Moreover, 32% of enterprises have established a typical component and design knowledge base and applied it effectively (e.g., Figure 3). Data support for intelligent manufacturing includes various sensor data, equipment state data, product quality data in the production process. As for the integration of AI technology and mechatronics engineering, an important step is to integrate and manage these data resources. We should establish a platform to collect, store, and deal with data to achieve real-time and reliable circulation of data, thus providing a sufficient data basis for the training and optimization of AI algorithms.

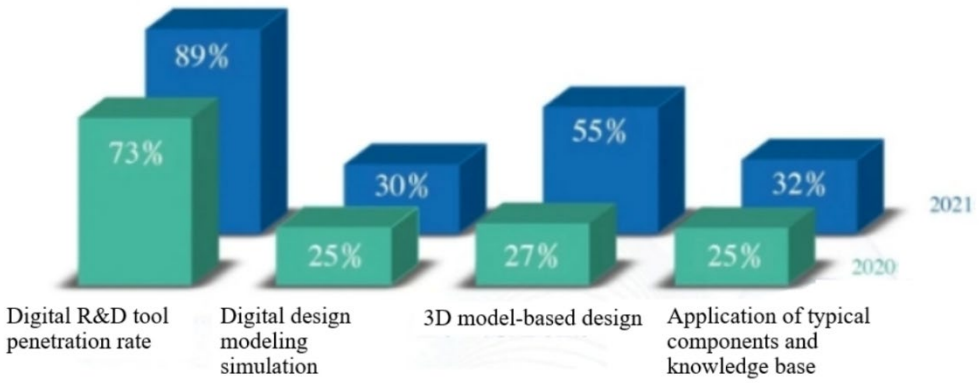

Figure 3: Application of intelligent manufacturing technology[11]

5.3 Developing Intelligent Algorithms and Models

The application of AI technology in intelligent manufacturing is closely related to intelligent algorithms and models. As for the integration, it is necessary to develop and apply intelligent algorithms and models related to mechatronics engineering, such as machine learning, deep learning, optimization algorithms, so as to solve the problems of equipment control, production scheduling, quality optimization and so on. At the same time, we should optimize the design and application of algorithms and models by combining the characteristics and needs of the field of mechatronics.

5.4 Practical Verification and Continuous Improvement

In the integration of AI technology and mechatronics engineering, it is necessary to conduct practical verification and continuous improvement. We should evaluate the effect and results of the integration through practical application cases and experimental validation. According to the feedback results, we should continuously improve and optimize the methods and techniques of integration so as to promote the innovation and development of technology.

5.5 Strengthening Talents Cultivation

Against the backdrop of intelligent manufacturing, we need more professionals with knowledge of AI technology and mechatronics engineering. We should also strengthen the training of talents in related fields, and cultivate engineers and researchers with strong comprehensive abilities and rich interdisciplinary backgrounds. Meanwhile, it is essential to promote cross-education and research on AI and Mechatronics Engineering, and cultivate talents with innovative ability and teamwork spirit.[12]

6. Conclusion

The integration of AI technology and mechatronics engineering is of great significance in intelligent manufacturing, which could achieve intelligent, personalized and effective production and promote the innovation and development of manufacturing. It would provide more competitive advantages for enterprises and promote further development of applications and research in the field of intelligent manufacturing. Such integration could be promoted through suggestions such as interdisciplinary cooperation, integrating data resources, developing intelligent algorithms, practical validation and continuous improvement, and enhancing talent cultivation, thus facilitating the development of

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innovation and progress in intelligent manufacturing.

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