Explore the Advantages of Current Applications of Industrial Robots

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Abstract. The global manufacturing industry is undergoing a profound change brought about by robotics technology. Robots are widely used, improving production efficiency and product quality, and gradually replacing manual operations. This paper aims to deeply analyze the application advantages, current challenges and future development of industrial robots. Studies have shown that the high precision, high efficiency and high safety of industrial robots make them increasingly important in industries such as automobile manufacturing, electronic processing, and food processing. They can complete high-precision tasks that most workers cannot complete, and have strong adjustment capabilities. In addition, industrial robots have important applications in welding, assembly, handling and testing. Although China has advantages in the application of industrial robots, there is still a big gap with developed countries. This study aims to illustrate the importance of industrial robots in modern manufacturing and their future development, provide reference and reference for the future development of China's robotics industry, and promote the transformation, upgrading and high-quality development of China's manufacturing industry.

Keywords: Industry, robots, application scenarios, challenges, development trends.

1. Introduction

With the advent of the "Industry 4.0" era, the global manufacturing industry is undergoing unprecedented changes. In this change, robotics technology, as the core driving force of automated production lines, has gradually replaced workers who rely on preset programs to work autonomously with its unique advantages. As the core equipment of modern intelligent manufacturing, industrial robots have not only changed the production model of traditional manufacturing but also greatly improved production efficiency and product quality [1, 2].

After the breakthrough of industrial robots in the mid-20th century, they have gradually become important equipment in modern manufacturing after decades of development. Especially in industries such as automobile manufacturing, electronic processing, and food processing, industrial robots have become an indispensable part of the production line with their high precision, high efficiency, and high safety. They can complete high-precision tasks that most workers cannot complete, with small repeatability errors, strong adjustment capabilities, and the ability to quickly adapt to different production tasks [3, 4].

In China, as the government attaches great importance to and strongly supports the artificial intelligence industry, the intelligent robot industry has also begun to develop rapidly. Data shows that since 2010, the annual installation volume of industrial robots has exceeded 10,000 units, and in 2017 and thereafter, the annual installation volume has reached 150,000 units [5]. After 2008, the number of domestic patent applications has achieved rapid growth. In 2011, China surpassed the United States to become the country with the largest number of patent applications [5]. These achievements not only reflect China's strength in the field of intelligent manufacturing but also provide strong support for the transformation and upgrading of China's manufacturing industry.

However, although industrial robots have shown many advantages in applications, their development still faces many challenges. For example, there is a significant gap with developed countries in core technologies and key components, insufficient high-end supply capabilities, and a shortage of professional talents. These problems not only restrict the further development of the

industrial robot industry but also have an impact on the technological upgrading and transformation of downstream industries.

Therefore, this article will conduct an in-depth analysis of industrial robots from the aspects of their definition, development history, application scenarios, and advantages, and discuss the challenges they face and future trends. The aim is to provide references and insights for the future development of China's robotics industry.

2. Definition of industrial robot

Industrial robots can be divided into automobile manufacturing, electronic processing, food processing and other robots according to different application scenarios. In the current manufacturing production line, the trend of industrial robot front-end application is that according to the mechanical structure and working movement form, robots can be divided into rectangular coordinate type, cylindrical coordinate type, spherical coordinate type, joint type and other types [6, 7]. Industrial robots can complete workpiece tasks that mold workers cannot complete, and the repeatability of workpieces is small. They have strong adjustment capabilities, that is, they can quickly adjust parameters and configurations to adapt to new production needs and have the ability to quickly adapt to different production tasks. They can perform multiple tasks at the same time.

Degrees of freedom refer to the number of variables that describe a physical state and independently affect the results of the physical state in physics. In mechanical engineering, degrees of freedom are used to describe the ability of a mechanical system to move independently under constraints. The higher the degrees of freedom, the more flexible the machine is and the more complex the operations it can perform.

Some advanced robots currently used in production have more than 7 degrees of freedom. In addition to mechanical structure and hardware support, industrial robots must also be matched with corresponding software control programs. The preset programs and instructions are equivalent to the human brain. The operation of the robot relies on the control instructions to implement the established operations through the coordination of the driver and the execution structure [7].

3. The development history of industrial robots

Industrial robots are not new, and their development history can be traced back to the middle of the 20th century. Since American George C. Devol created the world's first programmable robot in 1954, robotics technology has made continuous breakthroughs and has been gradually applied to various fields [1]. Initial development from 1958 to 1970. From 1970 to 1984, industrial robots already had perception and adaptive capabilities. From 1985 to the present, intelligent robots have multiple sensors, collect and integrate information, make intelligent decisions, and can adapt to a variety of environments [1].

The major events in the early development of robotics technology include: the installation of the first Unumate robot for die casting in 1961; the invention of Shakey, a free computer-controlled walking robot with vision, at the Stanford Research Institute in 1968; the invention of the adaptive robot with vision by ETL in 1970; the invention of the coordinated control method of computers by D.E. Whiney in 1972; and the completion of programmed assembly with robots at the Stanford Research Institute in 1976, marking an important advancement of robotics technology in the fields of automation and intelligent manufacturing.

Compared with developed countries, my country's intelligent robot industry started later, but after entering the 21st century, the Chinese government attached great importance to the development of the artificial intelligence industry and listed it as a strategic emerging industry. Driven by policy support, technological innovation, market demand and other factors, the domestic intelligent robot industry is showing a rapid development trend [2].

4. Current status of robot development in China

Since the concept of Industry 4.0 was proposed, governments have increased related investment and technological research, applied modern information technology to all aspects of production, and changed the entire industrial production mode. In this wave of global technological revolution, China's intelligent development trend is particularly prominent, especially in the large-scale application and technological research and development of industrial robots. According to data from the International Federation of Robotics (IFR), China's total installed robot volume reached 1.191 million units from 2011 to 2021, ranking first in the world. According to CNKI patent data, the number of domestic robot patent technology applications reached 377,000 in the same period, nearly 6.5 times that of 2000-2010. At the end of 2021, the Ministry of Industry and Information Technology and other departments emphasized that by 2035. China's industrial enterprises above a certain scale will fully popularize digital technology and become a global highland for robot technology innovation and application [8, 9].

China's robotics industry is standing at a new historical development opportunity period. With the increasing maturity of large-scale robotics technology and the diversification of market demand, Chinese robots not only play a core role in the manufacturing industry but also in the logistics industry and service industry [5].

In the context of "Industry 4.0" and smart factories, collaborative robots are increasingly being used in the manufacturing industry. Human-machine collaborative technology will become an important development direction, and collaborative robots will become an indispensable part of efficient production and life [5].

5. The role of industrial robots

5.1. Key technologies

Welding, assembly, handling and inspection robots are particularly important in automated production such as automobile manufacturing. Welding robots use laser or argon arc welding technology to reduce labor costs and improve welding quality [6,10]. Welding robots use advanced laser welding technology, which increases welding speed by 30% and welding quality consistency to 99% compared to traditional manual welding. They are widely used in the automobile manufacturing industry (such as Ford).

Assembly robots can complete component assembly with high precision, and combined with microelectronics and communication technology, improve system integration [6]. In the production of electronic products, assembly robots have achieved micron-level precision assembly, and combined with communication technology, they have significantly shortened the production cycle.

The handling robot responds to instructions and efficiently performs handling tasks. It is widely used in logistics, construction and other fields [6]. At JD Logistics' warehouse center, the handling robot can handle 10,000 pieces per day, which is three times that of manual labor.

Inspection robots work stably, comprehensively evaluate product performance and quality, and improve work efficiency. They are widely used in the fields of pharmaceutical and food testing [6]. Inspection robots use high-precision sensors to achieve comprehensive quality assessment of food and medicine, improving inspection efficiency while ensuring safety.

5.2. Application

The installation position and work content of the robot in the automated production line can be flexibly adjusted according to the specific needs of the production line and the type of robot [7].

(1) Processing. Perform various processing such as grinding, cutting, and milling to achieve high-precision and high-repeatability high-efficiency production [7].

(2) Production assembly. Replace manual assembly and assembly of parts and components to improve assembly efficiency and consistency [7].

(3) Quality inspection. Use sensors and visual systems to inspect and control products, monitor and inspect products in the production line in real-time, and automatically sort out defective products.

(4) Handling and packaging. Accurately grasp and place items in the production line, automatically process packaging boxes, take photos, scan and identify on the conveyor belt, and automatically stack.

(5) Human-machine collaboration. In some necessary situations, intelligent robots can collaborate safely with workers, provide operational assistance, and complete tasks together.

Robot technology can independently complete various complex production tasks under a pre-programmed intelligent control system. In most cases, it can replace traditional manual operations, thus effectively improving the automation level of the production line. Robot technology has also played a great role in improving the flexibility of the production line. It can quickly adjust the working mode and production process of the production line according to production needs, thereby achieving the purpose of rapid conversion [10]. In addition, robot technology has also played a great role in product quality control. During the production process, it can monitor and detect the quality status of the product in real-time, and promptly discover and correct defects and problems in production, thereby ensuring the stability and reliability of product quality and improving the competitiveness of the product [11, 12].

6. Challenges and future trends of industrial robot applications

Although my country has achieved certain research results in the field of intelligent robots, compared with developed countries, there is still a significant gap in core technologies and key components. Due to the lack of core competitiveness, the competitiveness of domestic intelligent robot products in the international and domestic markets is relatively limited. In addition, over-reliance on core components and insufficient innovation capabilities makes intelligent robots unsustainable. Many core technologies are still in the imitation stage and cannot achieve a qualitative leap [3].

China's supply capacity in the field of high-end industrial robots is still insufficient, which restricts the overall development of the industry and also affects the technological upgrading and transformation of downstream industries [5].

The rapid development of China's robotics industry has brought about a huge demand for professional talent (Fig.1). At the same time, it involves multiple disciplines and requires a high comprehensive strength of talents. They must have both innovative capabilities and good interdisciplinary collaboration capabilities [5].

"Intelligence" and "humanization" will become the future development direction of the robot industry. Intelligent robots have the ability to perceive and think. Intelligent robots can obtain, process and identify a variety of information and autonomously complete more complex operation tasks. Compared with general industrial robots, intelligent robots have greater flexibility, mobility and a wider range of applications [1].

Foxconn has been gradually replacing workers with robots since 2010. By 2016, the number of workers had been reduced by 100,000. Gree Air Conditioner now uses fully automatic assembly lines, which basically do not require manual labor, and only require skilled workers to coordinate with robots. Researchers at Oxford University conducted a study on 702 occupations and found that in the next 20 years, 47% of jobs are likely to be replaced by artificial intelligence or robots [4].

"High speed, high precision, heavy load, lightweight, and intelligent" are the main development trends of industrial robots [8]. With their precise positioning and navigation capabilities, efficient working capabilities, ability to adapt to harsh environments, and powerful data processing and analysis functions, industrial robots are gradually replacing manual labor to complete various tasks. For example, chemical plants, loading plants, and noise pollution plants are inseparable from the help of industrial robots due to their special characteristics. Other types of processing plants, such as food processing plants, are also gradually transforming into intelligent automated factory operations.

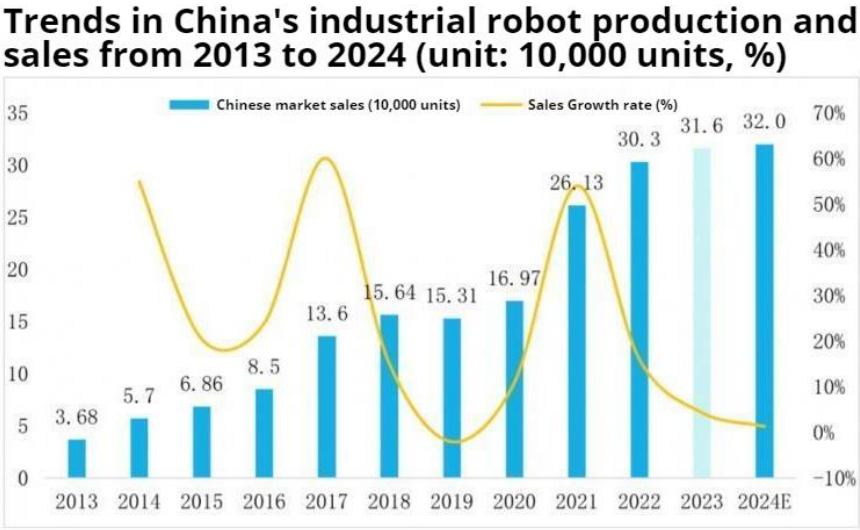

Figure 1. Trends in China's industrial robot production and sales from 2013 to 2024 [5]

7. Conclusion

This article mainly analyzes the definition, development status, application scenarios, etc. of industrial robots, and explores current challenges and future development trends, in order to study the advantages, importance and future development of industrial robots in modern manufacturing.

As can be seen from the above, industrial robots have important applications in welding, assembly, handling and testing, and have many advantages over manual operations. It is an inevitable trend for industrial robots to replace manual labor. Although my country started late and lacks core technology, high-end industries and talents, it is precisely because of this that China has given strong support in terms of policy, economy and industrial scale. China's industrial robots are in a stage of rapid development, with the integration of robots and large-scale model technology, a new era of human-machine collaboration and the continuous expansion of application scenarios. What we need to do is to break through core technologies, continuously cultivate and introduce more interdisciplinary talents, and seize the opportunities of "Industry 4.0" to occupy a place in the field of robots.

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