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Technology, Application and Development of Industrial Robots

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Abstract: In the context of continuous progress in science and technology and rapid development of industrialization, industrial robot technology, as an efficient, flexible and reliable automation solution, has gradually been widely used in various industries. Industrial robots can not only improve production efficiency and product quality, but also reduce labor costs and labor intensity, creating a greater competitive advantage for enterprises. This paper conducts in-depth research and exploration on the technology, development, application and role of industrial robots, and looks forward to the development trend of industrial robots in the future, and puts forward the development strategy of the industrial robot industry. In order to provide a certain reference value for relevant technical personnel.

Keywords: Robotics, Industry, Intelligent Manufacturing, Technology, Application, Development

1. Introduction

With the rapid development of science and technology, industrial robot technology at home and abroad has been profoundly and comprehensively developed, and has gradually been applied in the industrial field, improving the production efficiency of the factory, ensuring the quality of products, making dangerous work safer, and gradually accepted by the public. With the support of modern science and technology, industrial robots have the advantages of stability, reliability and high precision, which can not only reduce the intensity of manual work and ensure the safety of personnel, but also achieve the fundamental purpose of improving operation efficiency and improving operation quality, and help improve the development level of the manufacturing industry.

At this stage, industrial robots are widely used in handling, palletizing, welding, spraying and other operations. Handling robots are used in the automotive industry, electronics industry, rubber and plastic industry, and metal products industry, mainly for sorting, handling, palletizing and other operations. Therefore, it is necessary to promote the development of various technologies related to robots, and develop in the direction of industrialization.

2. Classification and composition

(1) Classification

Industrial robots are programmable robot systems that can automatically perform various industrial tasks, and can perceive the environment, process information, and perform tasks by carrying various sensors, actuators, and control systems, and realize autonomous operation and production. Industrial robot technology integrates

knowledge and technology from multiple fields such as mechanical engineering, electronics, computer science and artificial intelligence, with a high level of automation and intelligence. Industrial robot technology can be divided into the following five categories according to its structure and function: (i) stationary robots. Stationary robots are robotic systems that are installed in a fixed position and are typically used for repetitive, high-precision operations such as welding, assembly, and packaging on assembly lines. (ii) Mobile robots. Mobile robots have the ability to navigate and move autonomously, and can move freely within the work area, making them suitable for applications that require tasks to be performed in different locations, such as warehouse logistics, mobile assembly, and inspection. (iii) Collaborative robots. Cobots are robotic systems that work with human workers to achieve safety and flexibility, sharing workspaces with humans, and enabling human-robot collaborative production. (iv) SCARA robots. The SCARA robot is a robot with plane motion ability and high precision, which is widely used in the fields of assembly, packaging and precision machining. (5) Delta Robot. Delta Robot is a parallel robotic arm robot with fast movement and high precision, which is suitable for scenarios that require fast processing and high-precision operation, such as rapid packaging and food processing.

(2) Composition

Industrial robots are generally composed of three parts: robot mechanical body, sensing, and control, including five subsystems: mechanical structure, drive, perception, human-computer interaction, and control.

Industrial robot mechanical structure system: The mechanical system usually includes the fuselage, base, arm, wrist, joint and end-of-action effector, each part has multiple degrees of freedom, constituting a multi-degree of freedom mechanical system. Among them, the industrial six-axis joint robot includes the base, the first axis, the second axis, the big arm, the third axis, the small arm, the fifth axis, the sixth axis, the end effector and other main components. Some key basic components play an important role in the performance of the robot, such as the universal and modular component cell, which is very important for the robot.

The robot's drive system: In order for the robot to complete the specified action, it is necessary to install a transmission device at each joint, that is, the robot's drive system. The transmission mode mainly includes hydraulic transmission, pneumatic transmission and electric transmission. The drive system of the whole robot can be obtained by any combination of the above three methods.

Perception system: Industrial robots can transform environmental information into information that robots can analyze and process through perception systems. Sensors are very important in the field of robotics, and position sensors and speed sensors make it possible to perceive variables such as displacement, velocity, acceleration, etc. The operation procedures of industrial robots are mainly perception, judgment and action, and these three motion programs are a cycle of decision-making, and the robot can judge the next action through the perception system.

Control system: Compared with robots, control systems are like human brains and are the core part of industrial robot intelligence. The control system can be divided into centralized control system, master-slave control system and decentralized control system according to its control mode.

3. Technological development

(1) Early development

In the 30s of the 20th century, McCano magazine published a robot model that can handle a certain quality of goods, and the main components of the handling robot model are electric motors and mechanical structures, which means that the concept of industrial robots has been proposed. Subsequently, in the 50s of the 20th century, Unimation developed the first industrial robot that can realize digital programming, which can achieve a positioning accuracy of 0.000 254 cm through the use of hydraulic drive, which can not only be used in workpiece handling operations, but also widely used in the production and manufacturing links of Kawasaki Heavy Industries, GKN and other enterprises in Japan.

With the support of scientific and technological means, the use of industrial robots is gradually enriched. For example, in 1969, Japan developed an automatic six-axis articulated robot, which could flexibly adjust the movement path of the robotic arm, known as the "Stanford robotic arm". Taking the IRB6 industrial robot in 1973 as an example, it is the world's first industrial robot equipped with a microprocessor, which can be applied to the direction of the elbow of the grinding and polishing liner, which can not only replace the manual completion of relatively complex operations, but also be used in metallurgy, automobile manufacturing, metal casting and other industries.

In a nutshell, early industrial robots typically employed fixed, single-function robotic arms that were used to perform simple, repetitive tasks. In the 70s of the 20th century, with the rapid development of computer technology, industrial robots were introduced into computer control systems. The use of computers has enabled robots to process more complex tasks and data, improving their accuracy and programmability. During this period, the application scope of industrial robots gradually expanded, and began to set foot in automobile manufacturing, electronic manufacturing and other fields. In the 80s of the 20th century, affected by the development of sensor technology, the perception ability of industrial robots has been greatly improved, and the application of sensors enables robots to perceive and identify the surrounding environment and better adapt to different work scenarios. Since the 90s of the 20th century, the development of industrial robots has entered the stage of intelligence, and the introduction of intelligent control technology has enabled robots to better understand and respond to human instructions, and industrial robots have gradually developed in the direction of human-machine collaboration and flexible production.

(2) Modern development

Traditional industrial robots are usually designed and programmed for specific tasks, while modern industrial robots pay more attention to being able to perform a variety of tasks and adapt to different production needs. With the development of artificial intelligence technology, industrial robots gradually have a higher level of intelligence and autonomous decision-making capabilities, modern industrial robots can obtain information about the surrounding environment through perception technology, make intelligent decisions through learning and reasoning capabilities, and can independently adjust the working mode and path according to needs.

In the modern development process of industrial robot technology, a number of key technology breakthroughs have been made. (i) Machine vision technology. Machine vision technology enables industrial robots to perceive and recognize objects, providing important support for accurate positioning and operation of robots in complex environments. (ii) Collaborative robot technology. Cobots can work directly with humans,

and by introducing sensors and intelligent control algorithms, they can improve production efficiency and human-machine cooperation. (iii) Flexible robotics. Flexible robots have better deformation ability and adaptability, and are able to cope with complex working environments and task requirements, bringing greater flexibility and efficiency to the production process.

4. Applications

(1) Assembly line robots

Assembly line robot refers to a robot system that performs automated assembly tasks on a production assembly line, which is composed of robots, sensors, control systems, etc., and autonomously performs assembly tasks through pre-programming or sensor feedback. Assembly line robots mainly include Cartesian coordinate type, rotary joint type, plane joint type and other types. Taking a motorcycle company as an example, in order to realize the automatic assembly operation of related parts, such as connecting rods, pistons, cylinder blocks, etc., when installing motorcycle engine wiring, it applied an automated wiring robot, and at the same time, combined with the vision system technology, it fundamentally improved the accuracy and accuracy of parts assembly. In addition, when the industrial robot carries out related operations, the vertical multi-joint assembly robot can be divided into six degrees of freedom, which has the advantage of simple operation and can realize the requirements of placing posture at any point in the space. It can also use force control software to replace human haptics, which can ensure the automatic assembly of parts while minimizing the occurrence of workpiece damage. In the automotive manufacturing industry, automated assembly line robots are widely used in body welding, parts assembly, painting and other links, which can accurately carry out welding and assembly operations according to preset programs and sensor feedback to ensure the quality and consistency of products, and can also improve the efficiency and stability of the production line, reducing human error and damage. In summary, assembly robots can complete more complex tasks with assembly requirements, helping to reduce assembly risks.

(2) Welding robots

Welding robot refers to a robot system that carries out automatic operation in the welding process, which is composed of robots, welding equipment, sensors and control systems, etc., and realizes the autonomous execution of welding tasks through pre-programming or sensor feedback. The welding robot has the characteristics of high speed, high precision and high stability, which can quickly complete the welding task according to the preset program, improve the welding quality and production efficiency, and ensure the consistency of the welding results. In the process of steel structure manufacturing, the robot can carry out the welding of large steel structures, such as bridges, buildings and ships, etc., because the robot has high precision and stability, can quickly complete the welding task, improve the production efficiency and quality of steel structure manufacturing; In the process of electronic manufacturing, the robot can carry out precise welding of small solder joints, improve the manufacturing quality and reliability of electronic products, and can also adapt to the size and complexity of different circuit boards to achieve flexible welding operations. Similar to automotive welding work, the objective requirements of ship welding-related work promote the application of ship welding robots. Due to the relatively large size of the ship, the use of robots for welding construction can effectively improve the efficiency of welding work. In order to achieve the purpose of accurate weld trajectory,

the application of ship welding robot can use system optimization integration technology and control technology to realize offline operation with the cooperation of visual sensors and laser sensors, improve the quality of welding operations, and then better help the robot complete complex component welding. In addition, in order to ensure that the robot completes the relevant welding operations in a closed and narrow space, it is also necessary to use wireless communication technology to improve the efficiency of communication and exchange between the computer and the robot.

(3) Handling robots

Handling robot technology has been relatively widely used in many industries. The handling robot is controlled by multiple sensors and has the function of network interactive control, mainly controlled by the computer to realize the movement and handling of goods. At present, tandem robots can generally be divided into two types: four-axis tandem robots and six-axis tandem robots, both of which are the most frequently used types of handling robots. Among them, the six-axis robot has a low handling speed and is mostly used in the handling of heavy objects, while the four-axis robot has the advantages of fast packaging and fast handling speed, but due to the lack of corresponding axes, the handling of overweight items cannot be realized.

Handling robot is a robot system that can replace manual material handling and transportation, with functions such as autonomous navigation, perceiving the environment, grabbing objects, and transportation, and can realize automated material handling tasks. Handling robots can complete different types of material handling work according to preset paths and tasks, with the advantages of high efficiency, accuracy and safety. The robot can complete the handling task with faster speed and higher accuracy, thereby improving production efficiency, and can accurately perform the handling work according to the preset path and task, reducing the interference of human factors and improving the operation accuracy. Handling robots play an important role in the logistics and warehousing industry, robots can navigate autonomously in the warehouse, carry goods from the shelves to the designated location according to demand, or unload the goods from the transport vehicle to the warehouse, with fast and accurate handling capabilities, which can greatly improve the efficiency of logistics and warehousing and reduce operating costs.

(4) Textile Robots

Textile robot is a robot system that can replace manual textile production tasks, which can perform a series of textile processes such as spinning, weaving, printing and dyeing, finishing, etc., and has functions such as autonomous navigation, perceiving the environment, grasping objects, and processing textile materials. Through a high degree of automation and intelligent technology, automated textile robots improve production efficiency and product quality, and reduce the labor intensity of manual operation.

In the dyeing and finishing process of textile production, the automated textile robot can be applied to the dyeing and finishing process, and the robot can independently add, stir and control the temperature of the dyeing solution according to the preset dyeing scheme to ensure the accuracy and uniformity of dyeing, and can also complete the finishing of the fabric, including folding, stacking and packaging tasks, so as to effectively improve the automation degree and production efficiency of the dyeing and finishing process.

(5) Palletizing robot

Due to the complex product structure and long production cycle, each product needs to be strictly packaged and protected. The traditional manual operation method is not only inefficient, labor-intensive, and high-safety risk, but also has a large risk of cross-contamination. Therefore, the use of industrial mobile robots to replace manual work in the production process has become one of the important ways for enterprises to reduce production costs and improve production efficiency. The basic task of the industrial mobile robot in the palletizing area is that after the staff completes the code disc operation, the industrial mobile robot will first extract the whole pallet at the interface point, and then complete the overall transportation according to the transportation path designed by the system, and pick up the goods at the designated receiving point of the conveying and sorting code inventory point, and then run it to the warehouse door set by the system to carry out the overall transportation operation of the whole pallet. Due to the multiple interfaces and the whole pallet outlet, the AGV trolley will take out the goods from the specified interface according to the system instructions, and then automatically transfer them to the warehouse interface originally set by the system to complete the entire pallet sorting and transportation process.

(6) Warehouse robots

As a key equipment for modern logistics transportation and flexible production, warehouse robots can play an important role in the storage area, and their operation efficiency directly affects the overall efficiency of logistics. The warehouse robot mainly moves the goods to the specified area and then records the goods. In order to complete the unmanned warehouse operation of the whole process and realize the equipment management of the whole process, it is necessary to integrate various automation equipment, such as transmission lines, palletizers, etc., which perform their own duties, and then use software to realize interconnection and interaction. Inside the warehouse, the unmanned operation of the warehouse robot is mainly when the car is directly transported to the warehouse through vehicle transportation, the car docks its own tail to the unloading position of the warehouse, and then matches the current driving path of the warehouse robot. At this time, the control center can issue a task to dispatch the warehouse robot closest to the goods to arrive at the unloading point, and then the robot can directly move the counted goods to the inbound conveyor line according to the pre-set driving route. If the number of warehouse robots is limited and the number of goods in storage is large, the warehouse robots will complete the work task of one pick and one place repeatedly, and then, the warehouse robot will transport the piles of empty pallets to the split blocks of the empty pallets for on-site splitting, so as to ensure that the supporting supply of goods and pallets can follow up the handling of goods at the same time.

(7) Sorting robots

In the assembly line, due to the characteristics of the assembly line, it is usually necessary to find the shortest route for logistics. The intelligent sorting operation system of the sorting robot mainly realizes the "goods-to-person" sorting operation. This sorting mode adopts advanced hardware and software technology, and only needs to set up different picking strategies to maximize warehousing efficiency for the operation scenarios of on-site equipment collaboration. The picker only needs to follow the instructions on the screen and the RFID tag on the loading wall, and then pick out the corresponding goods at the designated location and then put them

in the order information box, breaking the traditional "human delivery" model, and compared with the traditional automatic sorting technology, the risk is less and more flexible. According to the division of the warehouse, the business process of the sorting area can be mainly divided into order commodity sorting and parcel sorting. The sorting robot can continuously carry out a large number of sorting, compared with the cross-type sorter, the special wheel frame of the sorting robot adopts a load-bearing rotating structure, which has a longer lasting and stronger movement capacity than the general light wheel frame, which meets the high-speed operation of the special wheel frame of the sorting robot, and can realize the 24-hour uninterrupted equipment operation, and the product is designed to occupy a small area, have high sorting efficiency, save labor, reduce operating costs, and completely solve the problem of inefficiency in logistics.

5. Future development trends

With the development of various emerging technologies, such as 5G technology, cloud computing technology, 3D printing technology, digital twin technology, big data technology, AI technology, etc., these technologies will be integrated with robotics technology and applied to the intelligent manufacturing process. At present, it can be combined with industrial robots through Internet technology, so that the intelligent operation of industrial robots can be effectively realized. The application of industrial robot technology in the medical and food processing industries is also deepening, and at present, biomimetics is the main development direction of industrial robot technology. With the development of intelligent technology, self-learning will be the mainstream mode of the main development of industrial robots in the future. The application effect of industrial robots can only be guaranteed after they have the ability to learn independently, and they can respond to emergencies quickly and accurately. The application of industrial robots needs to be supported by corresponding safeguard measures, first of all, to enhance the attention of industrial robots in the application of intelligent manufacturing, but also to train technical teams and technicians to play the role of industrial robots in the field of intelligent manufacturing.

All in all, the future of industrial robots will pay more attention to the improvement of perception and cognitive capabilities, through more advanced sensor technology and machine vision systems, can more accurately perceive and understand the environment, adapt to complex work scenarios, will have more powerful learning and decision-making capabilities, through machine learning and deep learning algorithms, can learn from a large amount of data and make intelligent decisions, improve work efficiency and quality; the future of industrial robots will be more autonomous and adaptive, able to adjust and optimize work strategies according to task requirements and environmental changes, to achieve automated and intelligent production。 At the same time, in the future, industrial robots will have higher programmability and flexibility, and can quickly adjust and adapt to the needs of different tasks to achieve diversified and personalized production; will tend to multi-functional and modular design, through replaceable and combined modules, adapt to different work needs, realize the switching and expansion of multiple functions; pay more attention to collaboration and shared workspace with human staff, achieve closer human-machine cooperation, and improve production efficiency and work safety.

6. Role

With the evolution of the new round of industrial revolution and scientific and technological revolution, the continuous integration of scientific and technological achievements represented by artificial intelligence such as industrial robots and traditional manufacturing industry has significantly promoted the transformation of manufacturing quality, efficiency and power. (i) The application of industrial robots can optimize the allocation of resources in the manufacturing industry. The application of industrial robots accelerates the processing and integration of information in the manufacturing sub-industry system, reduces the misallocation of resources, avoids the waste of resources to a certain extent, improves the overall utilization efficiency of resources, and realizes the optimal allocation of resources; (ii) Industrial robots promote the improvement of the overall production efficiency of the manufacturing industry. Industrial robots can not only assist human work, but also replace human labor to perform complex tasks, and more and more labor is being replaced by robots. The factors of production have changed from labor to capital and technology, and the manufacturing industry has realized intelligent production, management and operation, fundamentally improving productivity and improving production efficiency; (iii) The application of industrial robots has promoted the innovation ability of the manufacturing industry. The application of industrial robot technology can transform the traditional manufacturing industry, promote the manufacturing industry to shift to R&D, design and other value chains, and promote the transformation of the manufacturing industry to a technology-intensive direction, so as to achieve intelligent manufacturing and promote high-efficiency and high-quality production in the manufacturing industry.

7. Recommendations

(1) Improve the industrial robot industry policy

In the world, industrial robots have become the hot spot, focus and strategic commanding heights of high-tech competition, and have become an industrial technology that needs to be prioritized. As early as 2011, in order to cooperate with the development strategy of industrialized countries and the return of the manufacturing industry, the United States invested 2.8 billion US dollars to implement the "Advanced Manufacturing Partnership Program", and based on mobile Internet technology, to accelerate the scale of robot research and development; in 2012, South Korea in order to accelerate the expansion of the scale of the Korean robot industry, to promote robot enterprises to enter the overseas market, released the "Robot Future Strategic Outlook 2022"; Germany based on robot technology, to build an intelligent manufacturing system, in 2013 to fully implement " In 2014, Japan listed the robot industry as a major support industry and released a "new economic growth strategy". By increasing the support of the industrial machinery industry and improving the industrial development policy, the quality of industrial robot technology application can be improved within the specified period in the future. It is necessary to introduce relevant policies to support the industrial robot industry, and continuously strengthen the support of the industrial robot industry, so as to expand the wide use of industrial robots; In addition, it is necessary to give full play to the market advantages of artificial intelligence, reduce the cost of using industrial robots as much as possible, and let more manufacturing industries choose to apply industrial robots for production. In this way, the automation of manufacturing production can be improved, the production cost of the manufacturing industry chain can be reduced, and the high-quality development of the manufacturing industry can be finally realized.

(2) Promote the deep integration of industrial robots and manufacturing

The deep integration of industrial robot technology and all aspects of manufacturing production and operation can improve production efficiency, optimize operation mode, and rationalize the allocation of resource elements, so as to achieve high-quality development of the manufacturing industry. It is necessary to continuously strengthen the integration between the innovation chain, the industrial chain and the talent chain, and promote the wide application of industrial robots in the manufacturing industry. All industries should continue to improve the infrastructure of industrial robots, expand the application scope of industrial robot technology, develop high-end industrial robot technology, and improve the intelligent management system. In this way, we can fundamentally improve the production, operation and management capabilities and efficiency of industrial robots, continuously enhance the breadth and depth of the integration of industrial robot applications and manufacturing, and significantly promote the quality, efficiency and power transformation of the manufacturing industry.

(3) Adopt differentiated industrial robot application strategies

Different industries should implement a differentiated "industrial robot + manufacturing" development model. At different technical levels, high-tech industries should attach importance to the cultivation of high-tech personnel and accelerate scientific and technological progress, and medium-tech industries should continue to actively promote the application of new technologies in manufacturing production. Low-tech industries should reasonably increase the application of industrial robots, promote the continuous and deep integration of industrial robots and the manufacturing industry, and provide new momentum for the manufacturing industry to turn to high-quality development. At the level of industrial robot application rate. For the field of industrial robot application with a high degree of application, increase the amount of investment in robots, improve the ability of technological innovation, and give full play to the advantages of other manufacturing branches and automobile manufacturing. In industries with a low penetration rate of industrial robots, such as food and beverage processing and manufacturing and other industries, it is necessary to reasonably grasp the application of industrial robot technology in production, and can solve the problems of low efficiency and unreasonable application of industrial robots by optimizing the industry operation mode, management mode and technical level;

(4) Give full play to the positive role of production efficiency.

Improving production efficiency is the core driving force for the high-quality development of the manufacturing industry. (1) It is necessary to attach importance to the leading role of innovation and vigorously promote technological innovation. Under the new round of scientific and technological revolution, only by attaching great importance to the improvement of independent innovation capabilities in various industries in the manufacturing industry, gradually improving the industry technological innovation system, and increasing investment in industrial robot research, can intelligent manufacturing and efficient manufacturing be realized. Support all industries in the manufacturing industry to establish a technological innovation mechanism for the integration of production, education and research, encourage the industry to build an efficient and shared robot technology research and development platform, continuously improve the technical level of industrial robots,

promote the technological progress of various industries in the manufacturing industry, and realize the transformation from a manufacturing country to a manufacturing power. Encourage cooperation between scientific research institutions, universities and the industrial robot industry. Promote the close integration of industrial robot application and manufacturing development, and accelerate the high integration of industrial robot technology and manufacturing industry. It is necessary to improve the training system of technical personnel and improve the mechanism for introducing personnel from overseas. Pay attention to cultivating high-end talents in the field of industrial robots. Optimize the curriculum system of universities and research institutes, promote the interdisciplinary development of characteristic disciplines, exercise students' innovative thinking and ability, and accelerate the cultivation of compound professionals who not only understand the operation of industrial robots, but also master the development of the manufacturing industry. In addition, we will make reasonable use of the talent introduction plan to attract overseas technical talents through salary packages and good working atmosphere.

(5) Aiming at the advanced layout of future application fields

Industrial robots are widely used in the field of automobile manufacturing at this stage, and in developed countries, more than 53% of the total number of robots is automotive industrial robots. In the international market, the professional technology of industrial robots in the automotive field is relatively strong. In contrast, the application of industrial robots in many fields such as the plastics industry, the pharmaceutical industry, the electronics industry and the food industry has grown relatively fast. In this case, to promote the development and construction of industrial robot enterprises, we should focus on the field of industrial robots with rapid market growth, and strive to develop dislocation competition by building a huge industrial scale, accelerating patent layout and robot research and development.

8. Summary

To sum up, industrial robot technology, as an important tool and means of modern manufacturing, plays an important role in improving production efficiency, product quality and safety of the working environment. With the continuous progress and innovation of science and technology, industrial robot technology will be applied in more fields to create a better life for human beings.

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