Research on the Application of Intelligent Robots in Workshop Assembly Production

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Abstract. With the steady development of artificial intelligence technology, the application of robots in workshop production has penetrated into multiple key links. This paper systematically sorts out the application of robots in production scenarios such as handling and assembly, welding and spraying. This paper first introduces the basic technologies of robots in manufacturing, including robotic arms, visual systems, control systems, etc. These technologies lay the foundation for intelligent production. Subsequently, this paper focuses on the analysis of robot perception and control technology, and explores how robots use perception methods such as visual sensors and mechanical sensors to improve job precision, and combine intelligent control systems to achieve efficient production. In addition, this paper also analyzes the technical challenges faced by current robot applications, such as perception accuracy, real-time control, and environmental adaptability, and looks forward to future development trends, including the integration of vision and force feedback technology, intelligent adaptive control and other directions. This paper aims to provide a systematic reference for the in-depth application of robots in industrial production, and to help the development and breakthrough of future intelligent manufacturing technology

Keywords: Perception Technology, Control Technology, Automation, Intelligence, Intelligent Production

1 Introduction

Nowadays, the progress of science and technology, the upgrading of industries and the demand of the market have promoted the development of intelligent robot production. Intelligent robot production has been widely used in multiple fields such as light industry, heavy industry, and high-tech industry. Intelligent robot production has gradually replaced traditional manual production with advantages such as higher efficiency, better product quality and lower production costs. Therefore, in recent years, whether it is the traditional textile industry, the automobile manufacturing industry, or the electronics industry, more and more new robots have replaced a large number of laborers.

In the next few years, robots will continue to play their advantages in the manufacturing industry and provide more convenience for industrial production. In

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particular, perception technology, such as visual sensors, mechanical sensors, etc., and control technology have been constantly innovating recently, and intelligence and automation have been reintegrated. Among them, perception technology represented by visual sensors and mechanical sensors enables robots to perceive the environment more accurately, realize autonomous decision-making and dynamic adjustment; while advanced control technology continues to promote the evolution of robots towards higher intelligence and realize more accurate and efficient automated production. In addition, the integrated application of emerging technologies such as artificial intelligence, big data, 5G communication and cloud computing has further broadened the boundaries of intelligent robot manufacturing, enabling it to adapt to more complex production environments and realize flexible manufacturing [1, 2].

However, although robot intelligent production has shown great potential in industrial manufacturing, it still faces many challenges, such as perception accuracy, real-time control, environmental adaptability, safety and other issues. In addition, how to better combine automation and intelligence to achieve a more efficient and flexible production model is also the core direction of current research. Based on this, this paper aims to conduct an in-depth study of the application of robots in workshop assembly production, and conduct a systematic discussion from multiple aspects such as technical overview, application scenarios, future trends, and challenges, hoping to provide theoretical support and practical reference for the development of intelligent manufacturing.

2 Technical Overview

The basic technologies of workshop robots mainly include robotic arms, visual systems, control systems, etc. People can program the robotic arms to control the movement of joints and their connections at different angles to achieve automated production. The visual system simulates the visual function of the human eye and is used to identify targets and locate. It mainly uses cameras to capture environmental images, and then uses its software algorithms to process images into digital information to achieve recognition functions. The control system mainly uses the signals it receives to operate each part to achieve precise operations.

However, these basic technologies alone are not enough to meet the needs of complex production environments. In order to make robots more autonomous and adaptable, perception technology and control technology are particularly critical. Perception technology enables robots to perceive environmental changes in real time, such as detecting the position of workpieces and identifying obstacles; control technology ensures that robots perform precise operations in complex environments, such as dynamically adjusting the grasping force and optimizing the motion trajectory.

2.1 Perception Technology

Perception technology can be roughly divided into sensor technology, computer vision technology and positioning technology. Perception technology can convert environmental information into digital signals for further operations. In workshop automated production, perception technology is widely used in equipment transportation, quality inspection and other fields to achieve efficient production. This paper focuses on the visual sensor and mechanical sensor in sensor technology.

Visual sensor is an important part of the visual system. It mainly uses the imaging system to simulate the function of the human eye and allow the robot to obtain the environmental picture. It mainly uses the camera to capture the environmental picture (distortion may occur, that is, the actual image and the ideal image are distorted), and uses its own camera algorithm to process the image information to form a picture, which is used to realize recognition and measurement in three-dimensional space.

Force sensor mainly uses the working principle of piezoresistors to control its force and thus control the resistance change, and calculates the force by measuring the change value of the resistance. Some force sensors also use capacitance changes to sense and calculate the change of force.

Perception technology has high requirements for hardware, software, security, etc. Among them, hardware requirements include accuracy, sensitivity and stability, so as to be more reliable. Software requirements include algorithm support, data processing, etc., so as to be more flexible. Security requirements are more important, including data security, network security, platform security, etc., to avoid illegal attacks.

2.2 Control Technology s

Control technology can be divided into force control, motion control, position control and hybrid control. In workshop automation production, it is mainly used in welding, spraying, transportation and other fields.

Position control is to control the trajectory and position of the robot's end effector, focusing on the position of the starting point and the end point. At the same time, some will also require a smooth trajectory and controllable speed to make the accuracy higher and the movement smoother.

Force control is to control the robot's strength during operation so that the robot can sense and adjust its contact force to adapt to different environments and tasks, such as polishing, grinding, assembly, etc.

Robot control technology has high requirements for accuracy, stability, coordination, and safety. It must meet the requirements of precision operations, ensure accurate positions, and maintain stable operation to avoid safety hazards caused by loss of control.

3 Application Scenarios

3.1 Handling and Assembly

Handling tasks are common in the work of modern intelligent robots. Mainly through the use of sensors and visual systems, they can perceive the working environment and determine the shape, size, position, etc. of objects (to help complete the classification of objects). Subsequently, the robot can accurately locate and grab objects according to specific task requirements and transport them to the designated location. During the transportation process, various obstacles must be avoided. For example, the obstacle avoidance function of some robots is to use high-reliability obstacle avoidance sensor elements such as ultrasonic rangefinders and laser rangefinders to achieve the greatest possible avoidance of collisions with obstacles. By combining ultrasound with laser and designing an obstacle avoidance algorithm to complement the advantages of the two, obstacles can be avoided [3]. Ye Danan also found that this also requires the assembly strategy to have a high degree of accuracy and repeatability. In addition, most robots' handling is still limited by time and the number of objects (for example, excessive mass may affect its operating accuracy) [4].

In workshop production, robots can also help humans complete some complex assembly tasks, especially some high-precision assembly tasks. Intelligent robots can identify work and control their robotic arms to operate at high speed based on their visual systems and control systems. Many robotic assembly technologies use advanced visual recognition systems to accurately identify the position and orientation of each part. These robots are equipped with flexible robotic arms that can perform complex tasks such as screwing and plugging in connectors, achieving high-precision operations within a very small error range, thereby ensuring the quality and consistency of product assembly. Throughout the process, the robot can use its control technology (force control, position control, hybrid control) to automatically adjust its force and assembly angle to ensure that all parts are correctly installed. For example, in the production of automobiles, Shaanxi Automobile Group Commercial Vehicle Co., Ltd. integrates advanced automation equipment, robotics technology and information systems to enable assembly lines to achieve fast and accurate production. At the same time, it also significantly improves production efficiency and product quality [5].

3.2 Welding and Spraying

Welding and spraying are also common tasks for intelligent robots in workshop production, mainly used in automobile manufacturing, shipbuilding, aerospace and other production fields.

In the traditional welding process, parameter setting often depends on the experience of the operator, while artificial intelligence can optimize welding parameters through machine learning algorithms. Intelligent robots can analyze a large amount of welding data, learn and predict the best welding parameters, such as current, voltage, welding speed, etc., thereby improving welding quality and efficiency. For example, Ma Hui studied the application of welding robots in metallurgical valve manufacturing, which can obtain welds with high welding stability and good quality [6].

Robot welding can also achieve real-time monitoring and quality control. By integrating a visual recognition system, artificial intelligence can detect defects in the welding process in real time, such as weld discontinuity, pores, cracks, etc. Once a problem is found, the system can automatically adjust the welding parameters or notify the operator to intervene, thereby reducing the scrap rate and improving product quality.

Robot spraying has more advantages than other spraying equipment, with higher spraying quality and faster spraying efficiency. For example, in automobile production, Wang Liang and others from China First Automobile Group Corporation pointed out that with the development of the automobile industry and the improvement of people's living standards, people pay more and more attention to the aesthetics of vehicle appearance. In order to improve the aesthetics and practicality of automobiles, it is necessary to innovate automobile painting processes [7]. This also reflects the important position of spraying robots in promoting contemporary industrial production. Spraying robots are mainly composed of robot bodies, computers and corresponding control systems. Some advanced spray painting robots have flexible wrists that can bend in all directions and rotate. Their movements are similar to those of human wrists, and they can easily reach into the interior of the workpiece through a smaller hole to spray its inner surface.

Compared with ordinary manual spraying, spraying robots have higher spraying quality. Spraying robots can spray accurately along the trajectory without deviation and perfectly control the start of the spray gun to ensure the specified spraying thickness and minimize the deviation.

4 Technology Hotspots and Future Trends

4.1 Vision and Force Feedback Technology

In vision feedback technology, the camera converts the light signal passing through the lens into an electrical signal, and feeds back the acquired information to the control system to implement the operation. This technology can detect targets and track them, or measure distances and perform three-dimensional reconstruction. The implementation of this technology focuses on image acquisition and preprocessing.

First, there are certain requirements for the selection of camera lenses. Generally, the larger the aperture, the brighter the image will be. The camera sensor usually uses CCD or CMOS sensors. CCD performs better in image quality, while CMOS has low power consumption. At the same time, it is also necessary to be equipped with a high-performance processor to handle complex image processing and analysis tasks. Dedicated hardware such as GPU or DPS is required to accelerate image processing algorithms and realize real-time computing.

In force feedback technology, sensors and control systems are usually used to enable it to be accurately sensed and precisely controlled. This involves sensor detection, data transmission, etc. The robot is equipped with sensors to detect information such as position, force, torque, etc. in the environment, and transmit the data to the control system. In addition, the research results of Jia Yanhui et al. show that the use of remote operation guidance technology can further improve the completion speed and quality of robot assembly tasks [8].

4.2 Future Trends

In the wave of automated production, intelligent robots will continue to innovate and develop in the future, driving the transformation and upgrading of industrial production. Nowadays, intelligent robots can recognize, grasp and place objects by equipping them with high-precision sensing devices and advanced visual systems, realizing automated assembly processes. For example, industrial robot assembly workstations can also add MES systems to further achieve precise control of the production process and track and correct production data in real time, saving labor costs and better meeting the needs of enterprises for upgrading traditional production models [9].

In the future, robots may develop more intelligent and flexible technologies, allowing robots to be applied in a wider range of fields. Overall, robots will play a more important role in the manufacturing industry, promoting the digital transformation and high-quality development of the manufacturing industry. Conclusion Robots have been widely used in the manufacturing industry, helping enterprises improve production efficiency and reduce costs, but there are also some challenges. In the future, the development prospects of robots are promising, and the continuous innovation of technology will enable robots to play a greater role in more fields.

5 Challenges

At present, the development of intelligent robots still faces a series of challenges, such as immature technology and operational and privacy security issues. For example, the research and development and manufacturing of high-precision sensors still require a lot of investment. In addition, some technical difficulties cannot be ignored. Although artificial intelligence technology has made great progress, its application in smart factories still faces some technical difficulties. For example, in the experiment of visual recognition technology by Lu Linyan et al., the progress of camera model training will change with the environment, and the recognition accuracy will decrease. However, the robustness of recognition can be improved through filtering [10].

If intelligent robots want to be more widely used in industrial production, they must have higher perception and autonomous decision-making capabilities to cope with complex and changing production environments. However, the application of artificial intelligence technology is highly dependent on data support, and these data are often scattered in different systems and databases, and in different formats. How to efficiently collect, integrate and use data is a problem that needs to be solved urgently.

In addition, the operation of smart factories also faces the management challenge of human-machine collaboration, that is, how to achieve efficient collaboration between artificial intelligence technology and human workers. This not only involves technical training and job transformation of workers, but also requires corresponding adjustments to the factory operation model to ensure the rational allocation of intelligence and human resources.

Overall, although intelligent robots have shown great potential in the field of industrial manufacturing, they still need to further break through core technology bottlenecks, optimize data management and security mechanisms, and improve human-machine collaboration models to promote their wider application in smart factories.

6 Conclusions

With the continuous development of intelligent manufacturing technology, intelligent robots have become an indispensable and important part of modern industrial production. In workshop assembly production, robots gradually replace traditional manual operations with their highly automated and intelligent characteristics, improve production efficiency, reduce production costs, and improve product quality. Intelligent robots not only reduce the labor intensity of workers, but also optimize the production process, making the manufacturing industry develop in a more refined and efficient direction.

This paper mainly studies the application of intelligent robots in workshop assembly production, and conducts research from multiple application angles such as handling, welding, spraying, and assembly. It is found that the efficient operation of intelligent robots is inseparable from the support of perception technology and control technology. These technologies are mainly reflected in obstacle avoidance, detection, grasping, installation, etc. Compared with traditional manual production, they have greatly improved production efficiency and eliminated many limitations of human factors.

In the future, more innovations should be made in precision and algorithms to reduce manufacturing costs and continue to improve production efficiency. I believe that intelligent robots will be able to play a greater role in the manufacturing field in the future.

Authors Contribution

All the authors contributed equally and their names were listed in alphabetical order.

References

1. Lee, J., Lapira, E., Bagheri, B., et al.: 'Recent advances and trends in predictive manufacturing systems in big data environment', Manuf. Lett., 2013, 1, (1), pp. 38–41
2. Lee, J., Davari, H., Singh, J., et al.: 'Industrial artificial intelligence for industry 4.0-based manufacturing systems', Manuf. Lett., 2018, 18, pp. 20–23
3. Huang, J., Qi, D., Sun, Q., et al.: 'Design of a submerged agricultural warehouse handling robot', Digit. Agric. Intell. Agric. Mach., 2024, (9), pp. 119–123
4. Ye, D.: 'Research on precision assembly technology of industrial robots based on machine vision', China High-Tech Sci. Technol., 2024, (18), pp. 47–49, DOI: 10.13535/j.cnki.10-1507/n.2024.18.13
5. Zheng, L., Zhao, Q., Li, H., et al.: 'Application of intelligent manufacturing technology in automobile assembly lines', Auto Test Rep., 2024, (15), pp. 23–25
6. Chen, H.: 'Application of copper-steel composite strip in deep drawing field', Nonferrous Met. Process., 2014, 43, (6), pp. 9–13
7. Wang, L., Gui, H., Mi, C., et al.: 'Application of robot spraying technology in automobile painting', Auto Test Rep., 2024, (10), pp. 8–10
8. Jia, Y., Chen, C.: 'Experimental study on teleoperation assembly system of industrial robots based on force feedback devices', Electromech. Eng., 2025, 42, (1), pp. 137–145

9. Zhao, W., Li, L.: 'Design of an industrial robot assembly workstation architecture based on machine vision', Autom. Technol. Appl., 2025, pp. 1–5 [Online], [Accessed: 09 Feb. 2025]
10. Lu, L., Huang, W., Zhang, Z.: 'Research on visual recognition and adaptive handling robot technology in complex industrial environments', Mech. Manage. Dev., 2024, 39, (12), pp. 279–281