Analysis of the Application of Collaborative Robots in Automation: Taking Card JAKA Robots as an Example

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Abstract. With the arrival of Industry 4.0 era, traditional manufacturing industry has faced huge challenges. Compared to traditional industrial robots, a new type of industrial robot - collaborative robot - can better promote the development of traditional manufacturing towards automation. Among them, China's JAKA robot, as a typical representative, assists in industrial transformation and upgrading in multiple fields of application. This article provides a comprehensive overview and analysis of the application of collaborative robots in automation. Firstly, the basic principles and characteristics of collaborative robots are introduced. Secondly, taking the JAKA robot as an example, the development and application status of collaborative robots are analyzed and summarized. Finally, the challenges and development trends faced by collaborative robots were analyzed. This article believes that collaborative robots will gradually improve industrial production efficiency, achieve non-separation between humans and machines, and promote the application of industrial robots in a wider range of fields.

Keywords: collaborative robots, automated production, JAKA robots, intelligent manufacturing

1 Introduction

With the progress of the times, information technology is also constantly developing, since the birth and application of the world's first industrial robot in 1961, the world has entered the era of using industrial robots. In 2015, the global industrial robot market sales increased by 15% compared to 2014. Industrial robots will become an extremely important part of industrial automation. For welding, stamping, spraying and other work, automation has gained a certain degree of popularity in these fields due to its dangerous, heavy, and harmful nature to human body and mind. Therefore, industrial robots are gradually entering various industries to replace manpower, but these industrial robots are only suitable for industries that require large-scale production. For some small and medium-sized enterprises that produce in small batches, due to the need for

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updated and iterative product markets and tight manpower, it is necessary to collaborate with others [1-3]. Collaborative robots, as an emerging industry, are more flexible and collaborative than traditional industrial robots. With the emergence of collaborative robots in various fields, industrial robot technology is also becoming increasingly automated and intelligent. Therefore, this article provides a comprehensive overview and analysis of the technological progress and application of collaborative robots in industrial automation.

The overall structure of this article is as follows. In Chapter 2, the basic principles and characteristics of collaborative robots are introduced. Chapter 3 provides an analysis and overview of the development and application status of collaborative robots, taking the JAKA robot as an example. Chapter 4 analyzes the challenges and development trends faced by collaborative robots based on the previous content. Chapter 5 provides a summary of the entire text.

2 Basic Principles and Characteristics of Collaborative Robots

2.1 Basic Principles

Collaborative robots are the product of a new round of transformation in the field of mechanical intelligent manufacturing, which enables people to directly interact with robots within the collaborative area, facilitating complex human-machine interaction operations and breaking the original "fence-like" work. It can carry out production activities without disturbing employees' work, assist them in their work, and maintain synergy at all times. Therefore, this also reflects that the development trend of future intelligent manufacturing is constantly approaching the direction of human-machine collaboration.

2.2 Application Characteristics

Due to the differences in the structural forms of collaborative robots, they can be divided into single arm robots, double arm robots, and composite collaborative robots. The core component of collaborative robots is a multi joint robotic arm, which is composed of flexible joints, hollow torque motors, harmonic reducers, servo drivers, and controllers [4]. Collaborative robots typically have the following characteristics:

(1) Ease of use: it can be easily operated and used by anyone without professional knowledge, reducing training time and labor costs.

(2) Flexibility: the structure of collaborative robots is relatively simple, with relatively few electronic components, making installation and debugging more convenient and not easily limited by workspace, improving the flexibility of the production line.

(3) Safety: the overall design of the collaborative robot is smooth and flat, eliminating sharp corners.

(4) Diversification: with the increasing emphasis on collaborative robots in the entire industry, many enterprises have conducted relevant research and development, and have achieved many research results and products.

(5) Human-computer collaboration: the system and operations built around collaborative robots will simplify them and make them more closely associated with people's perception. In addition, they will be sensitive to changes in the external environment, and when the influencing factors reach the set threshold, they will stop running. The operating system of collaborative robots also undergoes continuous risk assessment internally, so they can work simultaneously with personnel [5].

3 Analysis of the Application Status of JAKA robot

3.1 Development Status

The research on collaborative robots in China started relatively late, but in recent years, with the rapid development of collaborative robots, significant technological breakthroughs have been made, and a number of brands have emerged, such as SIASUN, JAKA, Hans, and so on [6]. Before the First Industrial Revolution, people mainly relied on manual workshop production, with individuals completing products independently and having fewer auxiliary equipment available. Since the outbreak of the first industrial revolution, humanity has entered the era of industrial machines. Workers can complete production by operating machinery. After the Second Industrial Revolution, people entered the era of electricity. Due to the improvement and innovation of technology, the research and application of electrified equipment have improved production efficiency, leading to a shift in people's development towards automation. Today, humanity has officially entered the era of automation, and automation technology has achieved significant development. From Industry 1.0 to Industry 5.0, people's development of the industrial model is no longer constrained by itself, but begins to be people-oriented. In the era of Industry 5.0, human-machine collaboration is the focus of future development, and collaborative robots play an important role in it. The typical feature of collaborative robots is to achieve precise operations through direct operation with operators, which not only reduces the burden, but also can undertake various complex and tedious tasks. The most prominent feature of collaborative robots is the need to collaborate with people, but they can not be limited to working in the same space and can complete tasks through remote collaboration [7].

3.2 Application Status

3.2.1 Introduction of JAKA Robot. JAKA robots currently play an important role in the collaborative robotics industry in China. By adding collaborative robots to workshop production processes with lower initial automation levels, local automation is achieved and production efficiency is improved. The JAKA adopts the "3S" product design principles, namely Smart, Simple, and Small. This type of robot achieves a high degree of automation through six independent components, which not only ensures stable operation but also provides convenience for operation. Compared with traditional industrial robots, this type of robot has obvious technological advantages, such as flexibility, simplicity, safety, and intelligence [8].

3.2.2 Application of JAKA Robot. With the advancement of technology, teaching aids have become the best choice for teaching programming. Compared to other similar teaching aids, the JAKA robot utilizes its advanced APP technology to not only overcome the shortcomings of traditional teaching aids, but also overcome the limitations of space and distance. A smartphone and tablet can easily manipulate hundreds of JAKA collaborative robots, greatly improving the flexibility and efficiency of teaching. By using advanced technology, our JAKA robot can be remotely manipulated and coordinated, and its reliability is guaranteed through independent safety verification. This has greatly changed the communication mode between humans and machines. In the event of changes in product models on the same production line, the JAKA collaborative machine has a high degree of customization and configurability, which can be flexibly adjusted and optimized according to different process requirements and production line layout. Through the application of PAD or APP, the production line can be adjusted to the optimal equipment in a few minutes, greatly reducing the cost of secondary installation, thereby greatly improving the operational efficiency of the factory and enhancing the market share of the enterprise.

On the robot operating system, the JAKA robot adopts an interactive method of graphical programming and drag-and-drop teaching, allowing employees to quickly get started without having to master basic theoretical knowledge. One of the unique advantages of the JAKA Mobile Terminal APP is that it adopts a graphical approach for editing, so that whether it is variables, operators, mathematical principles, conditional analysis, loops, higher-order operations, or motion control, they are no longer subject to any restrictions, and there is no need to learn any complex programming knowledge. With just the drag of the mouse, various operations can be easily completed. Using the APP can easily accomplish robot tasks, whether in path planning or transportation methods. Firstly, you can drag and drop instructions from templates such as "joint motion", "linear motion", "target point position", "rotational speed", and "acceleration rate" on the programming control page of the APP to "start". Then, based on the information in these templates, the robot can gradually achieve path planning and finally achieve the expected task.

The JAKA robot has developed a monitoring system called "JAKA Visual Protection System" using technologies such as monitoring cameras and intelligent image processing outside the robot's body. The JAKA visual protection system uses an industrial wide angle camera as the visual data input terminal. When foreign objects (people or equipment) enter the monitoring area, the system processes real-time monitoring images to identify their safety, and quickly sends instructions to the robot to take corresponding measures to ensure the safety of people and machines [9, 10]. The first is a programmable security control system. When robots and employees work together in a work environment, their walking distance can be precisely controlled through programming to avoid duplication between the optimal route planned by robots and human activities. Secondly, there is mandatory control - the robot implements emergency braking through hardware devices, such as emergency stop buttons. The last line of defense is the robot's autonomous environmental perception ability. In order to balance safety and efficiency at the same time, collaborative robots are usually equipped with sensors to obtain sharp environmental perception ability, achieve

automatic obstacle avoidance, collision stop, and other effects. For example, visual sensors capture images through cameras, process the images through algorithms, and combine them with the visual system to perceive the surrounding environment and people; The force sensor is equipped with a torque sensing module, which senses the force and torque exerted by the robot on the object, and then sends a signal to the robot's control system. When a collision exceeds the set torque limit, the robot immediately stops moving.

Compared to robots with fixed workstations, "AGV+Collaborative Robots" (also known as "Composite Robots") can be suitable for more complex working environments. Collaborative robots can be seen everywhere in high temperature, high cleanliness, or other noisy and dusty environments such as LED chip pallets workshops. The robotic arm is the "hand", the AGV is the "leg", machine vision is the "eye", and the decision-making system is the "brain", working together to adapt to complex environments and make the most reasonable adjustments and decisions. For example, in early 2022, JAKA Robot, in collaboration with Shanghai Hongtan Biotechnology Co., Ltd., launched the first medical testing composite robot to relieve pressure on the hospital's nucleic acid testing work. This composite robot helps medical staff complete the transfer of samples and reagents in the complex environment of the epidemic, ensuring no pollution and error during this process, and effectively isolating medical staff from contact with potential positive samples.

4 Challenges and Development Trends

4.1 Existing Challenges

From the technological perspective, the development history of collaborative robots is not long, and the technical threshold for developing collaborative robots is high, so the current technology of collaborative robots is not mature enough. For example, due to the fear of harming humans who work together, the movements of collaborative robots are intentionally designed to be slower at this stage. Therefore, it is not as efficient as traditional industrial robots in terms of production efficiency. In addition, due to the lightweight and mobile nature of collaborative robots, their repeated positioning accuracy is one order of magnitude inferior to traditional industrial robots. Therefore, for production tasks with particularly high precision requirements, collaborative robots are currently unable to meet the requirements. Further technological upgrades are needed to coordinate various parts to achieve higher accuracy requirements.

From the market perspective, due to its short development time, collaborative robots are rapidly growing from a lower base. The scale of the collaborative robot market has not yet exceeded $1 billion and is still an edge subcategory of industrial automation. To make potential customers aware of the value of collaborative robots, the industry needs to spend a lot of time and effort on popularizing them. And then, there is a phenomenon of homogenization and monopoly in the current collaborative robot industry internationally. To avoid internal competition competing in the market, research should be conducted in more directions.

4.2 Development Trends

In the future, collaborative robots will incorporate more technological applications for optimization. Not only can collaborative robots make intelligent changes in autonomous decision-making by monitoring their own environment, but they can also enable collaborative robots working in different areas to interact with each other and complete tasks together.

While ensuring the handling performance of the robot, the human-machine interaction performance can be further enhanced. By modeling communication networks, not only can networked robots be constrained, but also the control accuracy of robots can be improved. At the same time, by overcoming the adverse effects on robot control performance under various conditions, the robot can achieve the goal of wireless interconnection and remote cooperation.

Collaborative robots are an emerging industry with high technological barriers. But it will develop towards cultivating professional talents and increasing the proportion of design and research personnel, thereby promoting industrial development.

5 Conclusion

This article focuses on the technological progress and application analysis of collaborative robots in industrial automation. Firstly, the application background and significance of collaborative robots in industrial automation are analyzed. Secondly, the basic principles and application characteristics of collaborative robots are introduced separately. Then, taking the JAKA robot as an example, the current application status of collaborative robots was analyzed. Subsequently, the limitations of existing technologies and future development trends were discussed. Authors believe that collaborative robots will not erode the market for traditional industrial robots, as both are competitive but also irreplaceable. Moreover, as an emerging field, collaborative robots have not yet formed a certain scale of application in many manufacturing enterprises. The emergence of collaborative robots has become the central axis of full automation and manual operation, achieving non-separation between humans and machines, promoting the application of industrial robots in a wider range of fields, and providing better development prospects for industrial robots.

Authors contribution

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

References

1. Kragic, D., Gustafson, J., Karaoguz, H., Jensfelt, P., and Krug, R.: Interactive, Collaborative Robots: Challenges and Opportunities. In Proceedings of the Twenty-Seventh International Joint Conference on Artificial Intelligence, pp. 18-25. (2018).

2. Sherwani, F., Asad, M. M., Ibrahim, B. S. K. K.: Collaborative robots and industrial revolution 4.0 (ir 4.0). In 2020 International Conference on Emerging Trends in Smart Technologies (ICETST), pp. 1-5. IEEE, 2020.
3. Yongan L.: Collaborative technology and the development of industrial robots. Equipment Manufacturing Technology, 2, 143-5 (2019).
4. Knudsen, M., Kaivo-Oja, J.: Collaborative robots: Frontiers of current literature. Journal of Intelligent Systems: Theory and Applications, 3(2), 13-20 (2020).
5. Hadidi, R., Cao, J., Woodward, M., Ryoo, M. S., Kim, H.: Distributed perception by collaborative robots. IEEE Robotics and Automation Letters, 3(4), 3709-3716 (2018).
6. Huaqiu L., Huang L., Yiwei C.: Research on the Development Status and Technology of Collaborative Robots at Home and Abroad. Modern Manufacturing Technology and Equipment, 59(3), 93-6 (2023).
7. Nanfeng M., Xifan Y., Feixiang C.: Humanistic Intelligent Manufacturing for Industry 5.0. Journal of Mechanical Engineering, 58(18), 88-102 (2022).
8. Wang L.: JAKA Robot: Leading a New Direction in the Development of Collaborative Robotics. Shanghai Information Technology 11, 18-20 (2020).
9. Dingding L., Xiumin S., Sanpeng D.: Summary of Technology and Development Trends in the Collaborative Robot Industry. Equipment Manufacturing Technology, 8, 73-6 (2021).
10. Hentout, A., Aouache, M., Maoudj, A., Akli, I.: Human–robot interaction in industrial collaborative robotics: a literature review of the decade 2008–2017. Advanced Robotics, 33(15-16), 764-799 (2019).