Research Status and Tendency of Intelligent Industrial Robot

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Abstract. In order to adapt to the overall industrial upgrading of the global manufacturing industry, adding the artificial intelligence technology to the field of industrial robots has a very realistic and far-reaching significance. This paper will analyse the research status of intelligent industrial robots at home and abroad. Then we will focus on the introduction of industrial robots based on deep learning and machine vision. According to the present situation of industrial robot industry at home and abroad, we will put forward the development tendency of intelligent industrial robot in the future.

1. Introduction

With the arrival of the era of artificial intelligence. Big data technology becomes the core, and the rise of mobile edge computing technology provides more advanced technical support for the improvement of industrial robot performance. In the development process of industrial robots, their operations tend to be simpler and more accurate. This change can be widely used in many fields, and the input cost shows a tendency of constant decrease. In the industrial field, intelligent robots are applied in product testing, assembling, welding, packaging and logistics handling and other key links [1].

The application of artificial intelligence in industrial production is increasingly regarded as the current industrial revolution in nowadays society. As a cutting-edge technology, artificial intelligence could bring disruptive changes to all industries, and it could promote the development of all industries, and overcome many weaknesses in the industry. The application of artificial intelligence technology can improve the manufacturing efficiency of products and shorten the design and production cycle of products. Industrial robots can effectively liberate people's labor force so as to deal with China's labor contraction and rising costs. The products produced by industrial robots could also have great competitiveness in the market. It could better achieve economic benefits and promote the development of the real economy. Therefore, the application of artificial intelligence technology in industrial production and the research of industrial robots based on artificial intelligence have a very realistic and far-reaching significance [2].

Deep learning is a new field of AI, which was proposed by Professor Hinton who is an AI expert at the university of Toronto in 2006. He proposed a fast algorithm for training deep neural network, which started a boom in the research of deep learning in the field of artificial intelligence [3]. The learning process is similar to the process of human understanding of information. Through the continuous abstraction of images and other data, the attributes or features are found. In recent years, with the development of deep learning technology, many breakthroughs have been made in object recognition, detection, tracking and other fields. The accuracy has been greatly improved. In addition, the performance of GPU and other hardware facilities has been improved. So that the processing speed of deep learning related technologies is getting faster and faster. Many deep learning models have reached the real-time processing speed [4]. Intelligent industrial robots must have strong self-learning
ability to achieve flexible manufacturing, so it is a hot issue to apply the method of deep learning to the research of industrial robots.

2. Research and Development Status of Industrial Robots with Artificial Intelligence at Home and Abroad

Industrial robot is the product of the combination of computer, cybernetics, mechanism science, information, sensing technology, artificial intelligence, bionics, and other multi-disciplinary advanced technologies. As a key component of advanced manufacturing technology and high-end equipment, it will play an increasingly important role in future production and social development. Industrial robots have become an important symbol to measure a country's manufacturing level and scientific and technological level [5].

2.1. Research and Development Status of Intelligent Industrial Robots in Foreign Countries

In particular, the United States, Germany, Japan and other industrial powers have made remarkable achievements in industrial robotics research areas. At present, the industrial robot industry in developed countries represented by Japan, the United States, Germany and South Korea is becoming increasingly mature and perfect. The industrial robot produced by them has become a standard widely used in the world. Japan, which was known as the "robot kingdom". The amount of industrial robots in Japan ranks first in the field of production, use and export in the world. Its industrial robot equipment accounts for about 60% of the world's industrial robot equipment. The United States is the birthplace of robotics [6]. The world's first industrial robot was developed in 1962 in America. The total number of industrial robots in Germany occupies the third place in the world, only next to Japan and the United States. South Korea is a rising star of industrial robots. It began to develop industrial robot technology in the late 1980s.

In 2011, Japanese FANUC company took the lead to launch the robot simulating the body factory, which reflects the application of flexible manufacturing technology of modern robot system in the whole vehicle industry. The company has launched FANUC r-2000iB handling robot, FANUC r-1000iA/100F spot welding robot, FANUC m-20iA arc welding robot and FANUC P250 spraying robot and other 7 industrial robots. In the field of food and medicine factory automation, the robot

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system of "vacuum bagged medicine in a whole line" has been launched. The robot can realize the processes of quick picking, visual positioning, accurate grasping and then assembly in a whole line. It shows the application tendency of flexibility, high speed and intelligence in modern factory production such as packaging, assembly, handling and picking. In addition, the FANUC-LiA small robot can realize chocolate bean picking, high-speed handling steel balls, gasket insertion, and labeling and other operations.

Pieter Abbeel, a professor of the department of electrical engineering and computer science at UC Berkeley. He has focused on bringing artificial intelligence to industrial production in recent years. He also stresses the synergy of human and machine. There are three main types of learning in machine learning. They are supervised learning, unsupervised learning and reinforcement learning. Supervised learning is pattern recognition, and artificial intelligence actually has no real goal. For example, if a machine is given a sentence of English, the sentence will be converted into Chinese. Unsupervised learning, where you feed the system images, not labels, and the machine starts with a lot of images to understand what the world looks like, and then by building that understanding, it can learn other things faster in the future. Reinforcement learning, when given a goal in a system, the goal is to force the machine to perform at a higher level. For example, let the machine win a game of chess, let the car to achieve automatic driving. After researchers taught neural networks how to recognize objects from millions of three-dimensional models and images, a robot could manipulate objects it had never encountered before [7].

2.2. Research and Development Status of Intelligent Industrial Robots in China
With the transformation and upgrading of China's manufacturing industry, industrial robots will be more widely used. Since 2013, the sales volume of industrial robots in China has been increasing, and the domestic industrial robots have also developed rapidly. The sales volume growth rate of industrial robots exceeds some foreign brands. In 2016, China's industrial robot sales grew by 31% year-on-year. It is far higher than the world average growth rate of 14%. In recent years, the sales volume of domestic industrial robot manufacturing enterprises has increased rapidly. Some enterprises have continuously improved the product quality and adjusted the product structure according to the users’ demand.

2.2.1. Main domestic intelligent industrial robot products. As the largest robot industrialization company in China, Shenyang Sinsun is committed to the manufacturing of digital high-end equipment. Their business scope is particularly wide, covering industrial robots, cleaning robots, mobile robots,

![Figure 3. Sinsun's visual double-arm cooperative robot](image1)

![Figure 4. Intelligent mechanical arm series of GSK](image2)

service robots, special robots and medical robots. With a market value of nearly 35 billion yuan, the company has become the largest enterprise in Shenyang. It is also one of the most complete robot product categories in the world and a leading enterprise in the domestic robot industry. In the field of industrial robots. The first dual-arm cooperative robot with flexible multi-joint and movable binocular vision system independently was developed by Sinsun. The robot is featured by high flexibility, safety, autonomous obstacle avoidance and rapid configuration.
GSK was founded in Guangzhou in 1991. Relying on more than 20 years of industrial control technology research, the company has made some intelligent industrial robots with full intellectual property rights. It also includes the robot controller, servo motor, servo drive, reducer and other key functional parts. At present, the series of industrial robot products include six series of functions. They are handling, welding, stacking, polishing, spraying and parallel operation. There are more than 20 product models in this company, including horizontal, parallel and series four-joint and six-joint robots, and the load level can reach up to 300kg.

2.2.2. Domestic intelligent industrial robots are facing challenges. It can be seen that the development of China's industrial robot industry is still facing many challenges. First, domestic industrial robots need to actively promote the industrialization process. The upstream core parts industry is seriously lacking. The domestic core technology is missing. As a result, the complete industrial chain cannot be formed. Reducer, servo motor, controller, system integration and other core hardware and software are controlled by foreign enterprises [8].

Second, the integration of artificial intelligence and industrial robots is still in its infancy. On the one hand, China's industrialization process has been basically achieved, but automation, informatization, intelligence and other aspects have not been fully achieved. The industrial basic capacity needs to be improved. Some of the core parts of the robot are still controlled by others, and the industrial robots' production are only at the middle and low end. On the other hand, the tendency of intelligent industry development is increasingly obvious. The key technologies such as artificial intelligence is in urgent need of breakthrough. Most of artificial intelligence algorithm for industrial robots still needs further development and exploration [9].

3. Research on Industrial Robots Based on Deep Learning and Machine Vision

With the rise of neural networks, the application of machine vision and deep learning to industrial robots has emerged. Deep learning is a hot research topic in scientific research and industrial production. Companies, universities and research institutions are investing heavily. The latest advances in this field have had considerable results, even exceeding human capabilities in some areas [10].

In the field of traditional vision, target detection is a very popular research direction. Target identification and positioning is an important part of industrial production. Many manufacturing industries need to test, identify and classify products. Especially for the enterprises with large production scale, multiple production types and diverse production environments. The degree of automation and intelligence level of the workshop directly determines the benefits of industrial production [4]. The integration of machine vision and deep learning technology into industrial robots can make industrial robots have strong recognition ability and self-learning ability.

A home-service robot, named EL.E, has been developed at Georgia Institute of Technology in US. The main function of EL.E robot is to help people grasp objects, such as cups and other small objects. The robot is equipped with binocular stereo vision sensor for machine vision acquisition. This service robot mainly uses the assistance of the laser command stick to capture the target task, uses the binocular camera to collect the image and segment the object in the image, and then calculates the 3D coordinates of the object’s center of mass and captures the object.

Researchers in the UC Berkeley, have applied techniques such as machine vision and reinforcement learning to the PR2(Willow Garage Personal Robot 2), which could watch a scene and then perform some specific actions. Experiments show that the neural network learning process of mobile has done a good job, so that the robot has a certain degree of learning ability. By learning for many times, the robot can complete some tasks such as placing clothes hangers, twisting bottle caps and classifying objects of different shapes without pre-programming. The robot has acquired certain artificial intelligence.

China's intelligent industrial robot started late, artificial intelligence research is also weaker than the countries who has world's advanced level. In the field of intelligent industrial robots, Chinese universities, research institutes and enterprises have also carried out a series of research work. Especially in recent years, with the rise of machine vision technology and artificial intelligence.
universities in China have carried out a lot of research in the field of industrial robots based on deep learning and machine vision.

Harbin Institute of Technology has realized the navigation of autonomous soccer robot with heterogeneous binocular vision system. Cameras that installed in different positions are used to monitor the scene in different directions at the same time. In addition, a binocular coordinated navigation model and a behavior-based target realization strategy are proposed, which can significantly improve the measurement accuracy and processing speed. The robot can simultaneously capture multiple effective targets and integrate the target data to improve the measurement accuracy.

The intelligent robot research laboratory of Shandong university studied the grab of the robot arm. The grab target was QR coded, and the object recognition was converted into QR coded recognition, which reduced the difficulty of target recognition and it easy to realize the goal of recognition and grab.

Aiming at the problem of crop target recognition, Zhang Tie-Zhong from Agricultural University of China proposed a vision system image segmentation algorithm based on color space reference table. It is suitable for fruit picking robot. The wheeled mobile home service robot developed by Shanghai University can realize the function of object recognition, navigation and other functions through the analysis of scene information with a multi-camera.

4. The Development Tendency of Industrial Robots Based on Artificial Intelligence
The arrival of the era of artificial intelligence is unstoppable, especially the robot will get a wider range of promotion and application. The outstanding advantages of industrial robots are high precision, high work efficiency, and the ability to withstand greater work intensity. Those could further promote the development of industry [11]. Based on this background, intelligent industrial robots will further develop in the following aspects: 1) The development of industrial robots is more systematic, with enhanced overall performance and wider application range. 2) Based on the needs of industrial development, it shows more biological and biomimetic characteristics and strengthens in the improvement of production efficiency in adverse working environment. For example, ant-colony robot and swarm robot. 3) Based on the constantly upgraded and updated computer information technology and the popularization of artificial intelligence technology, the industrial robot control system is more perfect. The realization of unification and standardization is accelerated. 4) The technology of integrated sensor fusion configuration is becoming increasingly mature and perfect, it will realize the multi-functional bionics of human thinking and nerves.

5. Conclusion
Industrial robot is the product of the integration and development of multiple disciplines, which is of great significance to the development of industry and manufacturing industry. It could even promote the progress of human industrial civilization. Therefore, based on the information age and supported by artificial intelligence technology, it is necessary to accurately grasp the development tendency of industrial robots. We should define the technical characteristics, so as to reduce the manufacturing cost of industrial robots and gradually enhance their performance. At the same time, attention should be paid to the research and application of machine vision and deep learning in the field of industrial robots. The continuous upgrading and transformation of control system functions should be strengthened. We should accelerate the development of multi-sensor fusion configuration technology. And we must greatly improve the intelligent level of industrial robots. The robots must have the ability of self-learning, so as to reduce the cost of manual training and promote the standardization and unification of the whole industry. Finally, we should expand the application field of industrial robots, so as to better play the value of industrial robots in the era of artificial intelligence.

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