

# A Review on Development and Application of Industrial Robot

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**Abstract:** Stability, efficiency and practicality are important characteristics of industrial robots. This also enables it to well assist human beings in carrying out various complex, tedious and dangerous processes. Nowadays, with the changing international situation, the advanced level of industrial robot technology has increasingly become the standard to distinguish the industrial strength gap between big countries. Therefore, it is necessary to analyze the development and application of industrial robots in detail. This paper first summarizes the development status of industrial robots at home and abroad, and introduces the typical applications of industrial robots in different industries. Finally, it makes a prospect for the development of domestic industrial robots.

**Keywords:** Industrial robot, Development status, Typical applications.

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## 1. Introduction

The origin of the term ‘industrial robot’ can be traced back to 1960, when it was first proposed in the magazine ‘American metal market’. At that time, it was defined as ‘a mechanical component that can be controlled by program, or a special mechanical device controlled by program [1][2]’. This definition has now been widely accepted.

Industrial robots are characterized by stability, efficiency and practicality. A well-designed industrial robot can not only help human beings complete all kinds of complex, boring and dangerous work, but also operate continuously, which greatly improves the production efficiency. Undoubtedly, it will play an irreplaceable role in the transformation and upgrading of China's traditional manufacturing industry.

Since the reform and opening up, under the leadership of the party and the state, industrial robot technology has ushered in its golden period of development. Government support, the influx of workers into big cities and the injection of foreign capital have greatly promoted the development of industrial robots. However, today's global economic model has greatly changed the overall pattern of manufacturing. With the increasing cost of social labor resources, a large number of labor-intensive industries in China are facing the challenges of transformation and upgrading and regional transfer.

The migration of traditional manufacturing industry from developed countries to developing countries seems to be an irresistible trend, which leads to the hollowing out of the economy of large countries with traditional manufacturing industry. Nowadays, the old industrial powers represented by the United States hope to reverse their disadvantageous position in international trade through the return of manufacturing, and industrial robot technology is the key to manufacturing. Google's acquisition of eight robotics companies and its move into logistics and warehousing service robots has attracted widespread attention in the industry [3].

## 2. Industrial Robot

### 2.1. Working Principle of Industrial Robot

Among all industrial robots, manipulator is the most mature and widely used one. The theory of manipulator combines the knowledge of many disciplines, such as machinery, electronics, computer, material chemistry and so on. It can be regarded as a programmable control device, which can simulate human arms to complete tasks such as assembly, welding, painting and so on.

Industrial robot system is a typical closed-loop control system. It gives the reference value through the preset program, uses the sensor to get the feedback value, generates the control signal through the difference between the reference value and the feedback value, generates the control signal through the power amplification circuit, and the control signal acts on the actuator (usually the motor), so as to realize the drive of the robot. High performance general-purpose industrial development robots in factories generally adopt joint type mechanical design structures, and each joint is controlled by an independent drive motor [4][5][6].

A typical manipulator system has many components, they are: manipulator body, computer system and driving device. Technicians can monitor the parameters of the manipulator through the computer system, and can issue instructions in real time to bypass the program and directly control the manipulator. The driving device (usually high-precision motor) is the core of the manipulator system, and it is the power source of the manipulator. By solving forward kinematics, inverse kinematics and dynamics, the control signal of the driver can be obtained, and then the manipulator can be moved to any position in space.

### 2.2. Classification of Industrial Robot

The following is a general classification of industrial robots based on their development history. According to the era of technological innovation, industrial robots can be roughly divided into three generations. [7][8][9][10]

The first to enter the stage of history is the imitation

industrial robot, which is mainly composed of the robot body, motion controller and teaching box. Its typical feature is that the operation is very simple. When the control signal is programmed into the teaching box, the robot will automatically execute the program and make corresponding actions, mainly including linear and circular motion. Due to its simple design and good visibility, analog industrial robots are still widely used in production until now [11][12][13][14].

With the development of computer technology, off-line programming robot has come into people's sight. The biggest feature of off-line programming robot is that it can verify the reliability of the technical scheme in advance through simulation technology. In the simulation environment, technicians can establish a complete robot model, and analyze and verify the reliability and practicability of the model through the powerful computing power of the computer, which greatly improves the efficiency of development [15][16]. Today, ROS (robot operation system) system has become the world's recognized largest robot development platform, which is free to all robot developers around the world.

In recent years, with the rise of artificial intelligence technology, intelligent robots have gradually become a research hotspot. It not only has the advantages of the first and second generation robots, but also has the ability of environmental perception and intelligent decision-making. Intelligent robot has a strong ability to adapt to the environment. It can work independently in the unknown environment without relying on human intervention. The core to realize this function is the sensors carried by the robot, such as visual odometer, laser sensor, monocular camera, etc. When working, the sensor can directly or indirectly capture external information, which will generate control signals after processing, and flexibly control the robot to work according to the changes of the external environment [17][18][19]. This kind of robot is widely used in arc welding and handling work. At present, China's intelligent robot technology is still relatively backward, and can only be applied in some basic fields, such as assembly, welding, painting, etc.

### 2.3. Robot Operating System

The so-called robot operating system usually refers to ROS (robot operating system). ROS originated from a scientific research project of Stanford University in 2007. Then, the technology company willow garage took over ROS in 2008 and launched version 1.0 of ROS in 2010. The launch of version 1.0 marks that the development of ROS has entered a new stage. The classic turtle routines inspired countless robot developers and have been used until now. In 2013, OFRs took over ROS. Under the management of OFRs, ROS developed rapidly, and the version iterated rapidly at the speed of two years. At the same time, with the unremitting efforts of developers who are keen on robots all over the world, the functions of ROS have been continuously improved. Up to now, ROS has become the most widely used robot development platform in the world.

At present, ROS system still relies on a subsystem of Linux system and cannot run independently. Although it also has a version suitable for window, the overall completion degree is still low. However, Microsoft has made it clear that it will spare no effort to develop ROS on the window platform; Semiconductor company ST company also joined the ranks of developers and proposed to develop ROS system suitable for the whole series of St microcontrollers. It is believed that

in the near future, ROS will become the most powerful tool in the hands of robot developers to realize their ideal of powering the world's robots.

## 3. Development Status of Industrial Robot

### 3.1. Development Status of Industrial Robot in China

The development of industrial robots in China is in an unprecedented golden period. On the one hand, the party and the state strongly support the transformation of traditional manufacturing and the development of high-end manufacturing, and have given many policy support. On the other hand, the development focus of manufacturing industry has changed from 'speed' to 'quality'. China's manufacturing industry has abandoned the rugged development model of seeking rapid development at the expense of destroying the environment, and is gradually undergoing a complete transformation. Following the development strategy that green water and green mountains are golden mountains and silver mountains, the manufacturing industry pays more attention to environmental protection while developing steadily.

At the same time, in the era of artificial intelligence sweeping the world, the development of industrial robots in China is increasingly combined with artificial intelligence technology. The combination of artificial intelligence technology such as pattern recognition, machine vision, machine learning and industrial robot technology has become a research hotspot of domestic scholars. The combination of artificial intelligence algorithm and manipulator trajectory planning and Slam (simultaneously localization and mapping) technology are the perfect combination of artificial intelligence technology and robot theory.

On the whole, China has basically mastered many important technologies in the design, manufacturing, application and research of industrial robots [23][24]. Many domestic enterprises have fully mastered the key technology of producing manipulator, that is, the hardware design technology and software programming technology of manipulator. Relevant theoretical research has also made some progress. The key technologies of arc welding, spot welding, large robot automatic production line and external equipment development and preparation have reached or approached the international advanced level. China's industrial robot technology is developing at an unimaginable speed.

### 3.2. Development Status of Industrial Robot in Other Countries

After World War II, with the beginning of the cold war, the US Soviet hegemony undoubtedly accelerated the development of industrial robots. Military, aerospace and nuclear technology all rely on more precise parts, which puts forward higher requirements for the performance of industrial robots. In this context, foreign industrial robot technology has achieved unprecedented development.

Nowadays, in the developed industrialized countries led by the European Union and the United States, automatic assembly lines and their supporting industrial robots have become the measurement of the degree of factory evolution, and high-precision industrial robots have also become the focus of academic research. All kinds of industrial machines

are widely used in chemical industry, materials, automobiles, electrical appliances, video, steel, logistics and other fields. Today's industry can't live without robots. [20].

Globally, Western European countries and East Asian countries (especially Japan) have the strongest grasp of industrial robot technology. Industrial robot companies from the above countries, including FANUC, Yaskawa (Yaskawa) in Japan and KUKA in Germany, account for 60% to 80% of the global share of industrial robots [21]. The United States is good at special robot technology, and its robots used in service, aerospace and military fields account for 60% of the global share [22]. China is the largest market for industrial robots, with an annual growth rate of 25% to 30%. In recent years, driven by policies and the international situation, domestic industrial robots have developed rapidly, and there is a great trend to replace foreign industrial robots.

## 4. Typical Applications of Industrial Robot

### 4.1. BIW Welding Robot

The production of BIW requires large-scale and fast-paced welding on 55 ~ 75 stations, with up to 4000 ~ 5000 welding points [25]. BIW Welding production line is the place to complete the welding of body in white. It contains dozens of robots. They work together to complete the highly complex welding work, with a high degree of automation. The car bodies of brands such as BMW and Ford are welded completely by BIW Welding production line. In addition, Italian Comau company is in a leading position in the production line of mixed assembly of multiple vehicle models. The main welding line assembly platform developed can produce more than 4 different vehicle models at the same time [26].

### 4.2. Robot Automatic Assembly Line

According to the motion characteristics of manipulator joints, assembly industrial robots can be roughly divided into three categories: rotating assembly robots, stretching assembly robots and combined assembly robots. Most of them have 6 degrees of freedom, and the end of the arm can reach any position in space driven by the driver. Aircraft joint assembly robot is a typical combined assembly robot, which is light, fast and reliable, and is frequently used in production lines [27]. Nowadays, the traditional manipulator technology has been very mature, and the research focus of manipulator has gradually shifted to multi arm cooperative work, space manipulator and rotor flying manipulator. In addition, the combination of manipulator technology and artificial intelligence technology is also a research hotspot at home and abroad.

### 4.3. Handling Robot

In order to improve production efficiency and automation, enterprises often need to adopt more efficient and flexible ways to transport materials than conveyor belts, and handling robots came into being. Handling robots can usually be divided into four axis robots and six axis robots. The former is generally used to transport heavy objects; The six axis handling robot is small, flexible and fast, which is suitable for occasions with high real-time performance and light load, and is widely used in logistics occasions. In addition, combined with the double action platform structure, the handling robot can complete operations with high precision in three-

dimensional space, and can effectively improve the efficiency of sorting, picking up, packing and assembly operations.

## 5. Conclusion

Nowadays, the development of China's manufacturing industry shows the development trend of automation, intelligence, greening, networking and informatization. In recent years, the competition in domestic and foreign markets has become increasingly fierce, the labor cost has increased year by year, and users' requirements for product personalization have become higher and higher. At the same time, the problem of population aging has gradually become prominent. Under many challenges, China's manufacturing industry needs to seize the time to upgrade technology and equipment and enhance its core competitiveness. Therefore, as the core technology of manufacturing development, industrial robot technology has a huge development space.

In the next few years, intelligent chemical plants will grow rapidly and spread all over the world, and the supporting intelligent industrial robots will also usher in the golden age of development. The development of industrial robots will strongly support the upgrading of manufacturing.

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