

# Research on Key Technologies of Artificial Intelligence for Intelligent Manufacturing

-- Case Study Based on Industrial Robots

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**Abstract:** Intelligent manufacturing, as the main form of future manufacturing, is the highland of a new round of competition in the global manufacturing industry, which will fundamentally change the production and manufacturing methods and technological and economic paradigms formed by human beings since the industrial revolution. At present, the intelligent manufacturing industry is still in the early stage of development, which is characterized by three typical characteristics: continuous growth of market size, strong promotion by national governments and diversification of competition subjects. At present, China's manufacturing industry is facing transformation, and the manufacturing industry is bound to need to transform to intelligent manufacturing. Industrial robots are the main content of current intelligent manufacturing, how to fully apply artificial intelligence technology to the manufacturing of industrial robots, so that its manufacturing efficiency, manufacturing accuracy and other product attributes are improved, to maximize its economic benefits, has a particularly important application value. The application of intelligent manufacturing and robots can not only promote the faster development of manufacturing, but also reconstruct new forms of manufacturing. Based on this, the paper first summarizes the application technology of intelligent manufacturing, and then analyzes the key technology of robot application for reference to relevant workers.

**Keywords:** Intelligent manufacturing; artificial intelligence; key technology; industrial robot.

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## 1. Introduction

In recent years, the rapid development of artificial intelligence, cloud computing, Internet of Things and other technologies [1] has promoted major industrial countries to put forward strategic plans for intelligent manufacturing, including Germany's "Industry 4.0", the United States' "Industrial Internet", and China's "Made in China 2025" [2-3], which has boosted the transformation and upgrading of the manufacturing industry from digital manufacturing to intelligent manufacturing. Based on the digital manufacturing system with data and information processing as the core, automation equipment integrates intelligent perception, intelligent planning, intelligent control and other technologies to form an intelligent manufacturing system with knowledge and reasoning as the core [4]. In the specific transformation and upgrading methods, industrial robots, as a kind of automation equipment, through the integration of advanced technologies such as intelligent technology and process digital technology, realize the intelligent application of different job scenarios, job tasks, and job processes, and accelerate the transformation and upgrading process of the manufacturing industry. Therefore, from a single flexible workstation to a large flexible production line, industrial robots have developed into the core and main equipment of intelligent manufacturing systems [5], and are playing an increasingly important role in industrial production and social development.

Science and technology is the driving force of the progress of The Times, with the steady advancement of China's manufacturing power strategy, intelligent manufacturing has

become the clear main direction of "Made in China 2025", and robots are an important content and support for the development of intelligent manufacturing. In the future, intelligent manufacturing and robotics technology will make significant progress, gradually promote the transformation and upgrading of China's manufacturing industry, and continue to move towards the high-end level. Therefore, this paper summarizes and analyzes the key technologies of artificial intelligence application of robots in intelligent manufacturing.

## 2. Overview of Industrial Robots

Industrial robot refers to the robot applied in the production process and environment, which can be divided into multi-joint robot, planar multi-joint robot, parallel robot, rectangular coordinate robot, cylindrical coordinate robot and cooperative robot according to the mechanical structure. At present, most industrial robots are "robotic arms" that require each joint to work together to complete tasks.

Since the early 1960s, human beings created the first industrial robot, the robot has shown its strong vitality, in a short period of more than 50 years, robot technology has been rapid development, in many manufacturing fields, the most widely used field of industrial robots is the automotive and auto parts manufacturing industry, And it's expanding into other areas. In industrial production, welding robots, grinding and polishing robots, welding robots, laser processing robots, spraying robots, handling robots and other industrial robots have been widely used [6]. Figure 1 shows five types of industrial robots.

# 5 Types of Industrial Robots

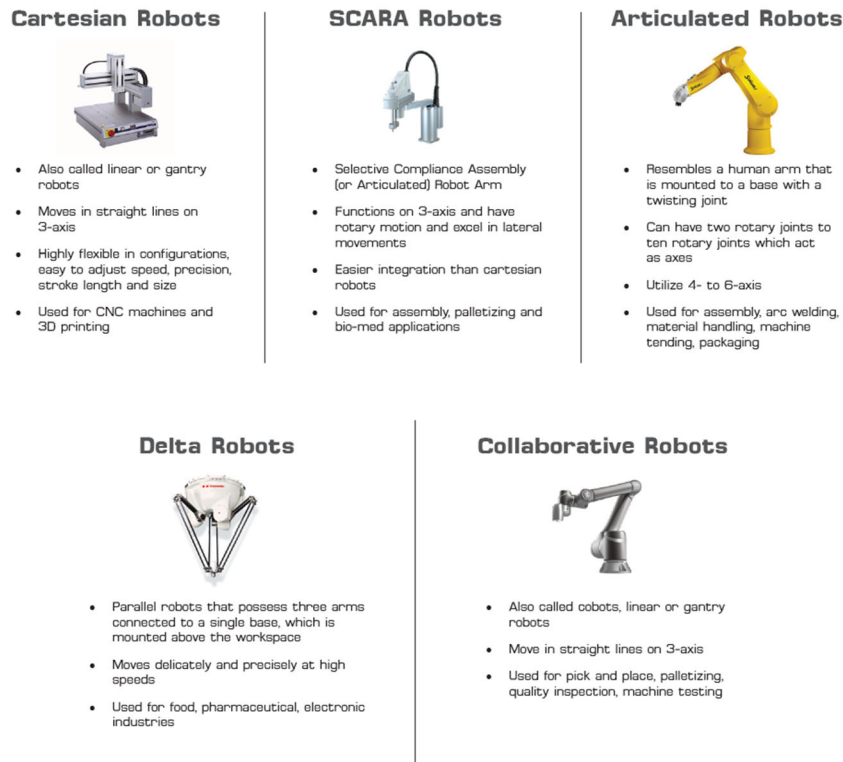


Figure 1. Five types of industrial robots

## 3. Key Technologies of Industrial Robots

### 3.1. Basic system structure of robot

The industrial robot consists of 3 parts and 6 subsystems. 3

Most of them are mechanical parts, sensing parts and control parts. The six sub-systems can be divided into mechanical structure system, drive system, sensing system, robot environment interaction system, human-computer interaction system and control system.[7]

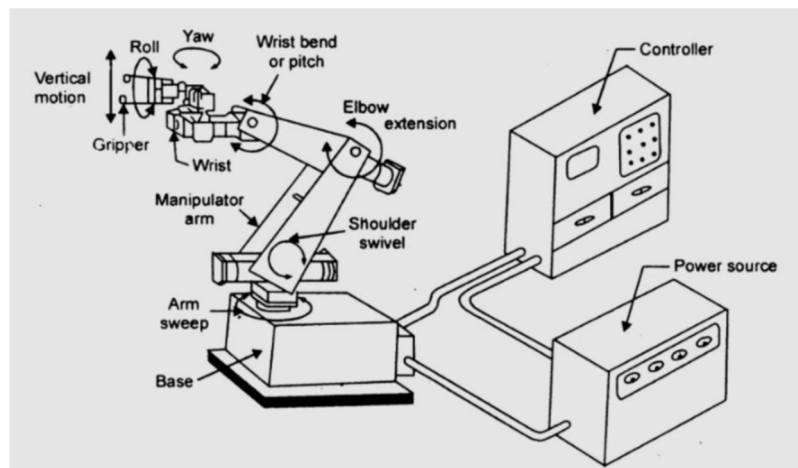


Figure 2. Basic system structure of robot

### 3.2. Robot drive system

The drive system of industrial robots is divided into three categories according to the power source: hydraulic, pneumatic and electric. According to the need, these three basic types can also be combined into a compound drive system. Hydraulic technology is a relatively mature technology, it has the characteristics of large power, force to inertia ratio, fast response, easy to achieve direct drive and so on. Pneumatic drive has the advantages of fast speed, simple

system structure, convenient maintenance and low price. Pneumatic suction cup and pneumatic robot claw motor drive is a mainstream drive mode of modern industrial robots, divided into four categories of motors: DC servo motor, AC servo motor, stepper motor and linear motor.

### 3.3. Robot perception system

Robot perception system converts various internal state information and environmental information of robots from signals to data and information that can be understood and

applied by robots themselves or between robots. In addition to the need to perceive mechanical quantities related to their own working state, such as displacement, speed, acceleration, force and moment, visual perception technology is an important aspect of industrial robot perception.

### 3.4. Key basic components of the robot

The robot has four components, the body cost accounts for 22%, the servo system accounts for 24%, the reducer accounts for 36%, and the controller accounts for 12%.[8] The key basic components of robots are the components that constitute the robot drive system, control system and human-computer interaction system, play a key role in the performance of robots, and have universality and modularity. The key basic

parts of the robot are mainly divided into the following three parts: high-precision robot reducer, high-performance AC/DC servo motor and drive, high-performance robot controller, etc.

### 3.5. Robot operating system

The Universal Robot Operating System (ROS) is a standardized construction platform for robots that enables every robot designer to use the same operating system for robot software development. ROS will push the robotics industry towards hardware and software independence. ROS provides standard operating system services, including hardware abstraction, underlying device control, implementation of common functions, interprocess messaging, and packet management.

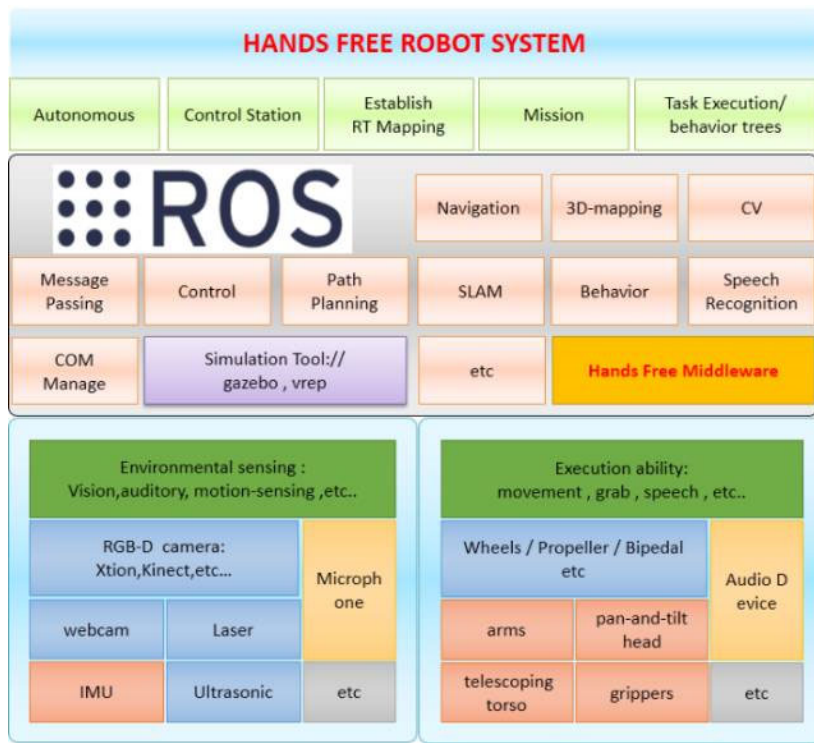


Figure 3. The Universal Robot Operating System (ROS)

### 3.6. Robot motion planning

Off-line motion planning can be divided into path planning and trajectory planning. The goal of path planning is to make the distance between the path and the obstacle as far as possible and the length of the path as short as possible. The purpose of trajectory planning is to make the running time of the robot as short as possible or the energy as small as possible during the movement of the robot joint space[9].

## 4. Analysis of Application Status of Artificial Intelligence Technology in Industrial Robots

One of the purposes of upgrading the manufacturing industry is to liberate productivity and improve product quality and production efficiency. In the real industrial field, industrial robots and their supporting equipment are gradually replacing workers and traditional automation equipment, and in the digital world, robotics and artificial intelligence, big data, cloud computing and industrial Internet technology integration, to give the traditional control strategy intelligent attributes. Through the collaboration of the "cloud-side-end" system, the integration of the real scene and the digital world is realized. Therefore, the core of intelligent application of industrial robots is the integration of hardware intelligence and software intelligence. The realization of hardware intelligence is to add multi-modal information sensing hardware equipment to the robot body by changing the shape of the industrial robot body or integrating intelligent sensors such as vision and force perception in the robot system. The realization of software intelligence is to integrate the

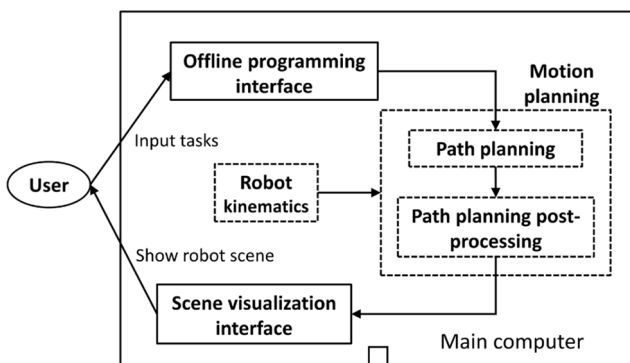


Figure 4. Robot motion planning

empirical product processing technology with robots, artificial intelligence, big data and other technologies into a digital process that can drive the robot hardware to perform job tasks.

#### 4.1. Application of industrial robot vision

Machine vision, the use of binocular cameras or monocular cameras and other equipment, the camera is responsible for collecting pictures, and then analyze these pictures, and then the analysis results are fed back to the control system, so as to accurately control the object grab or abnormal recognition functions, compared with artificial machinery, machine vision accuracy is high, and the speed is fast and the cost is low. As far as robot perception is concerned, robot vision is an extremely important part. Robot vision can greatly improve the ability of robots and help robots perfectly complete tasks such as grasping and recognition. Actively integrating artificial intelligence technology into the vision system of industrial robots can help robots better plan visual paths and control high-speed motion. In industrial production, logistics sorting and other industries, artificial intelligence positioning, image recognition, high-precision detection, item grasping and other technologies have been widely used. With the help of its visual function, the robot can accurately grasp objects. With the help of deep learning algorithms, and then combined with 3D cameras, very accurate images and in-depth information can be obtained, and the robot can accurately position and grasp the objects. With the help of machine vision, the quality inspection work based on the image can be well completed and the quality inspection work can be accurately judged whether a certain product is defective or defective. After the camera obtains the product photo information, it uploads it to the cloud, and can complete the product quality inspection with the help of deep learning model. The extensive application of the Internet of Things technology and 5G technology has made the technology of machine vision to detect items widely used.

#### 4.2. Predictive maintenance on a data-driven basis

Predictive maintenance refers to the real-time data obtained based on the analysis of sensors (such as temperature and humidity, vibration frequency, etc.), and then combined with the historical digital model to predict whether the current operating status of the equipment is safe, whether there are possible faults, etc., combined with monitoring data, to predict the location and practice of possible failures of the equipment, so as to prevent major accidents well. It can also effectively extend the use time of the equipment, minimize the cost of equipment maintenance, gradually realize the intelligent and personalized equipment diagnosis and maintenance, and gradually change from the previous passive maintenance to the current preventive maintenance. The use of preventive maintenance methods can also reduce the loss of downtime to the minimum.

#### 4.3. Security Applications

Industrial robots are commonly used in the manufacture and maintenance of large machinery and high-precision equipment, so professional staff must pay continuous attention to them. The use of artificial intelligence technology can effectively relieve the pressure of staff, and can greatly avoid human errors in daily work. At the same time, it can also assist the staff to remotely control and detect the data of

the robot, so that problems can be found and solved in time.

#### 4.4. Human-machine collaboration based on reinforcement learning

Human intelligence level is very high, learning ability is very strong, at the same time, human also has a very rich work experience, so human can better adapt to a variety of ever-changing working environment, power, speed, high precision is the advantage of industrial robots, artificial intelligence based industrial robots, can effectively improve work performance. How to combine the robot's precision, speed, strength and people's work experience, flexible use of ability, accurate judgment, give full play to the advantages of both, with the flexible manufacturing to better meet personalized customer needs, and strive to achieve differentiated, small batch production is still a very challenging topic. When interacting with the surrounding environment, the thought agent based on reinforcement learning will receive corresponding rewards based on the feedback of the environment, and then continuously adjust and optimize its strategy to achieve the best decision, which is better suited to the decision optimization problems that cannot provide a large amount of data. In other words, the robot can receive positive or negative rewards from the surrounding environment, and then use this data to determine whether the task it performs has achieved the desired effect. By reasonably switching the level of cooperation, the robot gradually develops from full self-manipulation (that is, according to the learning function, it decides which behavior to adopt) to semi-autonomous decision-making (that is, the robot performs certain actions according to the guidance of the operator), and the robot will add these new knowledge to its learning function. Then adjust its program to the latest state, so that when the robot encounters a similar task next time, it only needs to use the work experience this time, after the execution of many man-machine collaboration, the robot itself can build an efficient man-machine collaboration system, and it can better complete the man-machine collaboration task.

### 5. Conclusion and Prospect

In summary, in the future development of the industrial process, we must attach great importance to artificial intelligence technology, because it plays a very important role in promoting the development of industrial robots, and only by attaching great importance to it can we grasp the general direction of the development of industrial robots more accurately. In the work practice, but also actively use bionics technology in the field of industrial robots, with the form of system function optimization, and strive to improve the intelligence level of industrial robots, so that the intelligence level of the industry has been improved, give full play to the advantages of industrial robots, and improve the development quality of the industrial industry.

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