

Application of Sensors in Industrial Robots under the Background of Industry 4.0

Zhenchen Wang

Zhijiang collage of Zhejiang University of technology, Shaoxing 312030, China.

Abstract: Industry 4.0 has high requirements for reducing labor costs and improving efficiency, so the development of industrial robots is the key. And with the wide application of industrial robots in our country and the need to complete complex tasks, higher and higher requirements are put forward for the accuracy of robots. This paper analyzes the principle and application of sensors and the relationship between industrial robots and sensors, studies the role of sensors in industrial robots from the classification of sensors, and finally introduces the application of sensors in industrial robots.

Keywords: Sensor; Industry 4.0; Industrial Robot; Express Sorting; Manipulator

1. Introduction

1.1 Basic concepts of Industry 4.0

Initially, the development concept of Industry 4.0 is the industrial development concept of the new era proposed by the German government. It means that in the context of the technological development of Internet, information and modern social manufacturing, the world manufacturing and industry would enter "the fourth industrial revolution"^[1] Now, Industry 4.0 has basically eliminated the intermediate links between consumers and manufacturers. In addition, due to the high digitization, automation and information, the customization process of the merchandise products has become brief, the production efficiency has been significantly improved, and it helps to reduce the labor cost and production cost of the enterprise, so that the overall production efficiency of the manufacturing industry has been greatly improved.

1.2 Composition of sensor

Based on certain effects or mechanisms in physics, chemistry, and biology, sensors are developed according to certain processes and structures, and the composition details of different sensors are quite different. But in general, the sensor is composed of three parts: sensitive elements, conversion elements, and signal conditioning and conversion circuits ^[2]. Sometimes it is necessary to add auxiliary power supply to provide conversion energy. Sensitive element refers to the part of the sensor that can directly feel or respond to the measurement. Conversion element refers to the part of the sensor that can convert the measurement of feeling or response of the sensitive element into an electrical signal suitable for transmission or measurement.

1.3 Advantages of industrial robots in industry

In 2020, the COVID-19 has had a huge impact on the global economy, but due to Chinese rapid control of the epidemic, the blowouts occurred in many industries in the second half of the year, and the demand for industrial robots has also increased significantly. Industrial robot technology can replace manpower to complete some tasks, such as working in dangerous, harmful, high temperature, low temperature and other harmful environments, avoiding repetitive labor costs.

While improving production efficiency, it can also ensure the quality of products produced by machinery, realizing the automation of mechanical engineering and ensuring productivity [3].

2. Sensors

2.1 Operating principle of sensor

The basic principle of the sensor is to convert a specific measured signal into a certain "usable signal" and output it according to a certain rule through sensitive elements and conversion elements, so as to meet the requirements of transmission, processing, recording, display and control of information. Sensors can sense physical quantities such as force, temperature, light, sound, chemical composition, etc., and can convert them into electrical quantities such as voltage and current according to certain rules, or into the on-off of a circuit. It is generally composed of sensitive elements and conversion elements.

2.2 Scope of application of sensor

Sensors have a wide range of applications in many areas of industry, such as the application of photoelectric sensors in the military industry, and the application of speed sensors in the automotive industry. And sensors play an important role in the composition of robots. In the field of intelligent manufacturing equipment in our country, an industrial system of intelligent manufacturing equipment represented by new sensors, intelligent control systems, industrial robots, and automated complete production lines has been initially formed. [4] The sensor of the robot is different from the general sensor, which requires higher sensing information and intelligent processing, covering the sense of touch, vision, force and distance of the robot.

3. Common Sensors in Industrial Robots

3.1 Vision sensor

Vision sensor. Generally speaking, the sensor is a very special kind of non-contact device, which is mainly used to detect the physical signal of the measured object, and according to the corresponding rules, the signal can be directly transmitted to the electrical signal or other forms required, and then it can be output. The function of this kind of visual sensor is actually similar to that of the human eye. It can distinguish different types of materials, as well as their colors, which guarantees the efficiency and accuracy of the work.

3.2 Color sensor

Color sensor is to detect color by using the sensory characteristics of human eyes towards visible wavelength [5]. Color sensors play an extremely important role in terminal equipment, such as calibration equipment for color monitors, manufacturing of coatings, textiles and cosmetics, and medical applications such as blood diagnosis, urine sample analysis, and dental plastic surgery. The complexity of the color sensor system depends to a large extent on the number of wavelength bands or signal channels used to determine the color. There are many types of such systems, ranging from relatively simple three-channel colorimeters to multi-band spectrometers.

3.3 Photoelectric sensor

Photoelectric sensors work based on the photoelectric effect, which refers to the phenomenon of electrons released by materials such as metals or semiconductors under light. It can be divided into the outer photoelectric effect and the inner photoelectric effect. [6] The photoelectric sensor is composed of three parts: transmitter, receiver and detection circuit. The transmitter emits the beam at the target, or changes the pulse width. In the front of the receiver, there are optical elements such as lens and aperture, and behind it is the detection circuit, which can filter out the effective signal and apply the signal.

4. Introduction to reality application

4.1 Express sorting

4.1.1 Development needs

In the sorting process, the mechanical arm has become an indispensable part. The earliest mechanical arm used operating tools and equipment installed on the arm to replace humans to do some heavy handling tasks. Due to its high speed, large carrying capacity, and high precision, it played a great role in improving production efficiency. And now the development of Industry 4.0 has high requirements for reducing manpower and improving efficiency. Therefore, express sorting needs to be intelligence. Among them, automatic detection and mechanization are particularly important, that is, the application of detection devices such as robots and sensors. Related detection devices include photoelectric sensors, ultrasonic range finders and gravity sensors, and the sorting port is judged by checking the monitoring information and the database information model.^[7]

4.1.2 Introduction to some functions of the sensor

The express sorting system is mainly composed of a cross-belt structure, and the cross-belt sorter includes the package feeding device, package feeding table, host, outlet and mechanical arm. The package feeding device is the telescopic belt conveyor, which unloads the goods through the telescopic loading machine, delivers the goods to the feeding port, and then the goods quickly pass through the conveyor belt. If the photoelectric sensor detects that there is a large package during the passage, it would feed back to main controller. The main controller instructs the mechanical arm to grab the goods to the conveyor belt, and then the goods are transported to the corresponding outlet by the conveyor belt. The color sensor mainly realizes the acquisition of RGB data for the items of the assembly line, accurately obtains the color value, and provides data support for the later data processing ^[8] A photoelectric sensor and a mechanical arm are installed near the outlet. After the photoelectric sensor receives the signal from the main controller, it will feed the information back to the main controller when the package reaches the corresponding position, then the main controller instructs the robotic arm at the outlet to grab the corresponding package and send it into the outlet to complete the parcel unpacking. The small package enters the corresponding conveyor belt through the conveyor belt and is sent to the packing station.

4.2 Manipulator for garbage sorting

4.2.1 Future prospects

At present, the demographic dividend of our country is gradually weakening, and the application of robots to various fields instead of manual operation can reduce production costs, improve work efficiency, and improve the market competitiveness of enterprises ^[9] The garbage sorting robot is a machine that replaces manual garbage sorting. This robot combines virtual prototype technology, machine vision technology, intelligent control technology, and vision and sorting. Through these technologies, objects on the workbench can be accurately identified and sorted. This work studies the intelligent mobile garbage sorting robot based on visual recognition technology, which can plan the path to traverse the cleaning area, scan and identify the garbage and grab the garbage. The work is suitable for cleaning garbage including beer bottles, paper, cardboard, cans, plastics, etc. in living rooms, home gardens, parks and other places. It has the characteristics of high automation, low cost, and high efficiency, which can greatly save the manual cleaning of garbage, and has a good prospect of popularization and application.^[9]

4.2.2 Use of sensor

The main principle of the garbage sorting manipulator is to put the garbage sorting robot in the environment to be cleaned, to make a preliminary comparison and classification of the color sensor and the information in the database, and then to be navigated around the garbage according to the instructions of the navigation unit. At the same time, adjusting the relative position of the garbage sorting robot according to the position of the garbage. In the process of navigation, the visual sensor is used to obtain more accurate information than the color sensor, and then it is compared with the characteristic parameters of the garbage stored in the selected system library after preliminary classification. If the similarity of the characteristic parameters exceeds 90%, the system will judge it as garbage that can be identified in the learning library, and then the control unit will control the manipulator to grab it.

5. Conclusion

With the development and progress of Chinese economy and science and technology, Chinese industrial robot technology has made a great improvement, and it has been more and more applied in various fields, becoming an important part of Chinese manufacturing industry. However, as a latecomer to Industry 4.0, China is far behind developed countries such as Germany and the United States in terms of maturity and systemization. To improve industrial robot technology, sensor technology is a very important part. In the future, we must vigorously cultivate innovative talents with all-round and strong comprehensive capabilities to contribute to the construction of mechanical engineering in our country.

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