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Overall design of a robot based on a PLC operating system

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Abstract: *A series of research problems are targeted at the deployment of control systems for industrial robots, their adaptability in the assembly process, and high-precision motion during operation. The research of this project proposes the design of an intelligent industrial robot. Fully debugged and optimized, this operating system allows precise control of industrial robots, improving overall productivity and resource utilization.*

Keywords: *Industrial robot; Structural design; PLC control system*

1. Introduction

China's industrial robot application from the 1970s to the present, in the continuous development of the same time also faced challenges[1-3].With the technological revolution and the growing field of smart manufacturing, the level of intelligence in China is constantly increasing.On January 19, 2023, the Ministry of Industry and Information Technology released the Implementation Plan for the "Robot +" Application Action, which proposed that the use of manufacturing robots in 2025 doubled its density compared to 2020. The depth and breadth of the application of service robots and special robots in the industry have been significantly improved. The ability of robots to promote the high-quality development of the economy and society has been significantly strengthened[4].As a typical electromechanical integration of digital equipment - industrial robots, it occupies the core position of intelligent manufacturing. It has a high technological added value and a wide range of applications in industry[5].

At present, the application prospects and advantages of robots assembled with intelligent control systems are more obvious than those of traditional assembly robotic arms.Against this background, robots based on PLC operating systems have emerged.PLC is a kind of industrial automation control system, which can realize the control and monitoring of equipment such as conveyor belts and valves in the production process [6].

2. Robot structural design

The whole robot adopts the combination of intelligent dispatching trolley and six degrees of freedom tandem manipulator. The overall structure of the robot adopts solidworks 3D drawing software to design the basic structure of the robot.(shown in Figure 1).

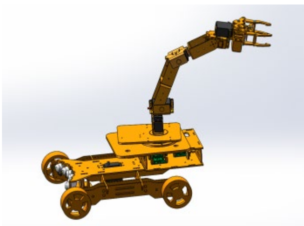

Figure 1: Overall structure of the robot

2.1. Robot arm

This robot arm utilizes a six-degree-of-freedom tandem arm (shown in Fig. 2), a design that gives it a high degree of flexibility and a wide range of applications. It consists of six precision members and

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joints that form a spatial structure capable of flexible movement in three-dimensional space[7]. The movement of each joint is driven by a high-performance motor, which is decelerated by a precise mechanical transmission to ensure smooth and accurate movement. This design enables the robotic arm to easily perform complex three-dimensional surround work to meet a variety of industrial and production needs.

Figure 2: Six-degree-of-freedom tandem robotic arm

The hand claw part adopts a gear and crank rocker structure for transmission (shown in Figure 3), and this design cleverly utilizes the meshing of gears and the linkage mechanism principle of the crank rocker. Through the precise occlusion of the gears, the torque can be effectively transmitted to ensure the stability and strength of the grasping object. Meanwhile, the crank-rocker structure is able to convert the rotary motion into linear motion, enabling the arm's claws to open and close flexibly, thus improving the efficiency and accuracy of the arm's gripping objects.

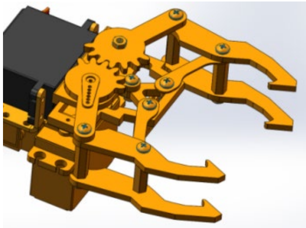

Figure 3: Hand claw

The ball disc design (shown in Figure. 4) is used at the connecting axle table with the carriage, which cleverly utilizes the principle of the ball disc to realize the omni-directional work of the manipulator. The ball disc consists of multiple balls, which can rotate freely on the connecting axle table, thus enabling the manipulator to carry out rotational and translational movements flexibly.

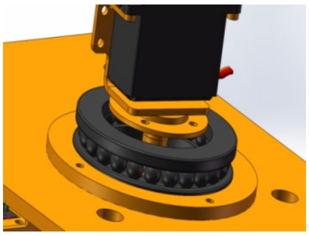

Figure 4: Ball disc design

2.2. Movement control trolley

The trolley is a four-wheel drive, each wheel is equipped with a high-speed rotary motor (shown in Figure 5), and all four motors are controlled by a single motor to ensure the same output; six azimuthal scanners are designed at the rear of the cart (shown in Figure 6) to measure and control the surroundings of the cart in real time.At the same time, the trolley uses a high-precision motion controller LM629 (shown in Figure 7) and VTX adjustable power map transmitter hardware combined with servo control system (shown in Figure 8).The LM629 is responsible for controlling the running status of the motor and can accept the motor motion status parameters fed back from the sensors and transmit the information to the upper computer through the VTX transmitter.

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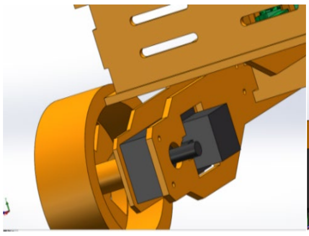

Figure 5: Motor

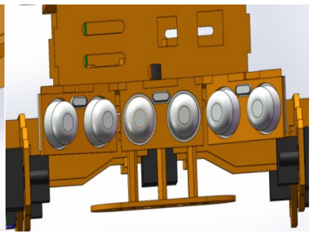

Figure 6: Scanner

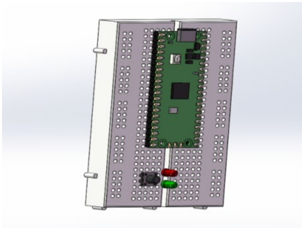

Figure 7: Motion Controller LM629

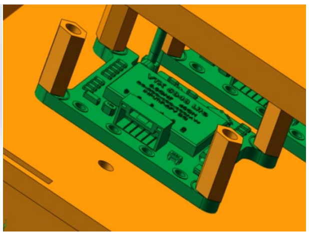

Figure 8: VTX transmitter

3. Robot control system design

PLC has better data analysis and logic judgment function than industrial robots, which can improve the intelligence level of industrial robots[8-10]. The first step is to build an exhaustive mathematical model of the robot and continuously monitor the real-time position and attitude of the robot as shown in Figure 9.This can provide the basis for subsequent motion planning and control. Mathematical modeling allows accurate prediction of the robot's kinematic characteristics during task execution. A total of key parameters such as joint angles and end-effector positions are set.

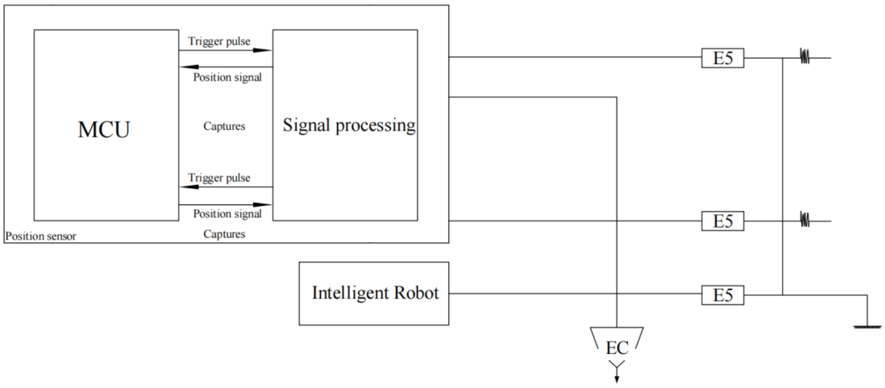

Figure 9: Sensor Structure Design

The next fine plan the master-slave coordinated motion trajectory of the robot and set the corresponding motion constraints.The design of the master-slave coordinated motion system takes into account the synergy between the multiple actuators of the robot. This ensures that they can move together in an optimal way when accomplishing tasks.

In order to accurately determine the position and attitude of an intelligent robot and provide accurate feedback data to the control system. A variety of sensors need to be installed at the robot's joints and actuation positions.These include position sensors (VL53L0CXV0DH/1), speed sensors (74402-05B), and rotary arc sensors (AHG17C5M).The position sensor measures the robot joint position in real time, the velocity sensor monitors changes in motion speed, and the rotational arc sensor accurately records the angle of joint rotation.

4. Conclusion

This paper discusses the key role and development trend of industrial robots in intelligent manufacturing. It describes the global and Chinese policy background and strategic approach in the

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field of intelligent manufacturing. Industrial robots are emphasized as a key technology to promote high-quality economic and social development. Structural design, this paper describes in detail the design of using intelligent dispatching trolley combined with six degrees of freedom tandem manipulator. However, further breakthroughs and optimizations are still needed in practical applications to cope with complex production demands and improve operational efficiency.

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