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Research on Palletizing Robot System of Multi - axis Synchronous Control Technology

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Abstract: Due to the increasing demand for personalized objects, the palletizing packaging of personalized objects has attracted people ' s attention. To improve the efficiency of the palletizing system, a palletizing robot based on multi-axis synchronous control technology is proposed in this paper. The robot takes SIMATIC S7 - 1200 PLC as the control core, uses the master command synchronization method to achieve multi-axis synchronization control, and realizes human-computer interaction through PROFINET communication with the touch screen. The multi-sensor is connected with the input and output modules of the PLC, and the review of the grasping object is realized. After the robot is put into use, the flexibility of the palletizing system is improved, the multi-axis synchronous control technology is improved, and the palletizing efficiency of personalized objects is greatly increased.

Keywords: Robot; multi-axis synchronous control; master synchronous; PLC.

1. Introduction

With the increase of people's demand for substance and culture, people's demand for personalized objects is also gradually increasing, so the sales of personalized objects are expanding. As the only way in the production and sales process, handing and palletizing have also ushered in unprecedented challenges. As an important support device for the process, the palletizing robot determines the efficiency of the process. Therefore, a large number of researchers have done a lot of research on the palletizing robot. For example, Hu Min has greatly improved the intelligence of the palletizing robot by combining the machine vision system and the automatic palletizing algorithm into the palletizing system. However, the end effector of the palletizing system is a rigid suction cup, which can only grab at most 2 objects at a time; Yang Shu-yuan established a theoretical model of the electrical system design of the palletizing robot by using the PID control principle combined with the structural characteristics and motion interpolation functions of each articulated arm, which greatly improved the stacking accuracy and the obstacle avoidance success rate of each articulated arm.

In this paper, by using a PLC controller as the control core of the palletizing robot system, a set of multi-axis palletizing robot control systems using multi-axis synchronous control technology is designed.

2. Palletizing System

2.1 Structure of The Palletizing System

The palletizing system is mainly composed of a belt, manipulator, manipulator end actuator, touch screen, double-speed chain, etc. Its structure is shown in Figure 1. The belt is powered by a servo motor, and the start and stop of the motor are controlled by a servo drive. A pair of length measuring sensors, 5 pairs of in-position sensors, and blocking bars are installed on the belt, and their function is to judge the size of the object and its in-position condition. The model used is EPSON LS20-B804S, LS20-B is a high-performance robot that continues at high speed and is cost-effective, high capacity is achieved by increasing the allowable U-axis moment to $1.00 kg \cdot m^2$. Secondly, the clock time is improved by high-speed movement, and the time by swinging the arm is shortened. The manipulator end actuator is composed of 5 sets of suction cups, each set of suction

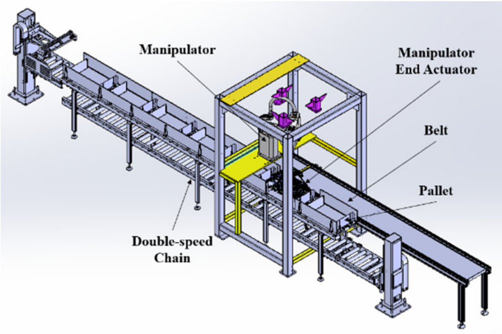

Fig.1 System of palletizing

cups has an independent groove sensor and height measuring sensor, which are used for the detection of the origin and the review of the height of the object. The height measured sensor also has the function of object drop protection. As the benchmark of the manipulator end actuator, the third group can only move in the Z-axis direction, and its fourth group can also move in the X-axis direction. Each set of suction cups consists of 1 suction cupboard and 8 suction cups, each suction cupboard is connected with a solenoid valve to control the suction and blowing of the suction cups. As a human-computer interaction interface, the touch screen can realize the parameter setting of the system, the manual control of the end actuator, and the signal display of each electrical control link. The double-speed chain is used for pallet switching, which can move the palletized pallet to the next station, move the empty pallet to the palletizing position, and send a allow palletizing signal at the same time.

2.2 Rigid palletizing system

The rigid palletizing system has high requirements for objects, and all objects must be highly consistent. In the face of the rapid development of personalized object sales, the system can only be seized by multiple times and with fewer bars. Although it has been further improved compared with manual stacking, it is far from enough to face the current market diversification. As shown in Fig. 2, the three-dimensional figure is a rigid palletizing system with four grips, which can simultaneously adsorb four objects of the same height. In this system, it can grasp multiple objects, but the orders of diversification cannot be coped with. To achieve the orders of diversification, the volume of the manipulator end actuator needs to be reduced, and the number of grasping objects at the same time also decreases. The flexible palletizing system can not only deal with the problem of orders of diversification, but also realize the simultaneous capture of multiple objects, which meets the current market demand.

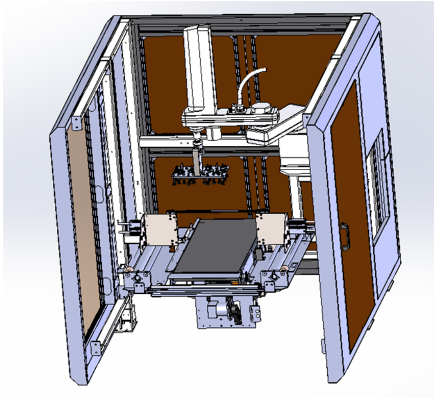

Fig.2 Rigid palletizing system

3. Multi-axis Synchronization Control Technology

Based on the control mode, multi-axis synchronization control can be divided into mechanical synchronization and electronic control synchronization. Mechanical synchronization is composed of a multi-axis and gear system, relying on the mechanical structure to achieve synchronization, this synchronization control mechanism is complex, high machining accuracy requirements, so it has been eliminated. Electronic control synchronization methods mainly include master-slave, cross-coupling, master synchronous, and virtual axis synchronization.[6]-[8].

Master-slave synchronization takes the actual output of the motor as the given parameter of the slave motor to realize the synchronization from the motor to the main motor. The synchronization performance of the control method is difficult to do well, mainly because the given signal is transmitted from the main motor to the slave motor, which makes the synchronization control command of the slave motor lag.

Master synchronization is similar to master-slave synchronization, which is driven by a separate motor for each axis. Each motor driver is controlled by the same command signal source, and then the controller assigns the signal source and sends the allocated signal to the motor drive to complete the whole synchronization control.

Virtual axis synchronization is the combination of master synchronization and cross-coupling synchronization. The control command is filtered by the virtual main motor as the given value of each actual motor. However, this synchronization method needs to complete the calculation of the virtual motor, and there is a problem that the calculated amount of parameter dependence is not small[9].

Based on the above several synchronization methods, because there is no coupling between the motors in the master synchronization method, any motor axis disturbed by the external load will not affect the normal operation of other shafts. Therefore, this paper selects the master synchronization method to control the motion of the end actuator. The system structure diagram is shown in Figure. 3.

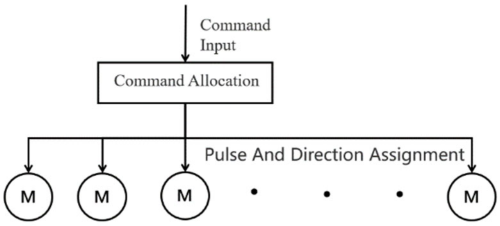

Fig.3 Schematic diagram of master control

4. Hardware Design

The control system is mainly composed of PLC (master and slave), stepper motor, driver, touch screen, and groove sensor. The system includes four X-axis origin sensors and five Z-axis origin sensors, which are used to detect the positions of the X-axis and Z-axis of the sucker. The separate drive of nine motors ensures that the motors do not interfere with each other, and can also visually display the fault information of each motor. The hardware structure is shown in Fig. 4.

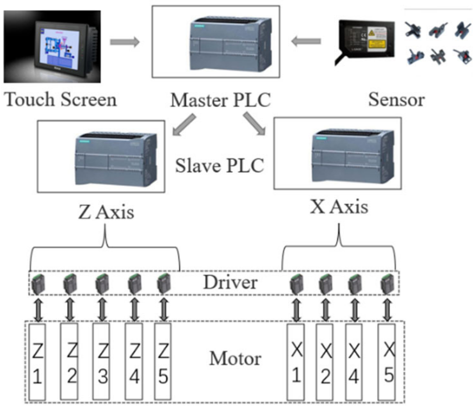

Fig.4 Hardware structure of control system

PLC is called Programmable Logic Controller, it has complex logic algorithm control ability, but also has the function of timing and counting. The system uses Siemens S7-1200 PLC and S7-1200 PLC as a compact controller that does not limit its function. The controller is mainly for simple and high-precision automation tasks, and it also has high flexibility, which can largely meet the various needs of customers. It realizes the communication with HMI and PLC through the integrated PROFINET interface and can be programmed through this interface. It can also support communication with third-party devices through the open Ethernet protocol.The addresses of the motor output signal and the origin photoelectric input signal of the multi-axis synchronization control system in the PLC controller are shown in Table 1.

Tab.1 I/O allocation

Input Signal		Output Signal	
Address	Function	Address	Function
ZKPLC I0.0-3	X1, X2, X4, X5 Groove Sensor	PLCX Q0.0, Q0.2, Q0.4, Q0.6	X1, X2, X4, X5 Pulse
ZKPLC I0.4-8	Z1, Z2, Z3, Z4, Z5 Groove Sensor	PLCX Q0.1, Q0.3, Q0.5, Q0.7	X1, X2, X4, X5 Direction
		PLCZ Q0.0, Q0.2, Q0.4, Q0.6, Q0.8	Z1, Z2, Z3, Z4, Z5 Pulse
		PLCZ Q0.1, Q0.3, Q0.5, Q0.7, Q0.9	Z1, Z2, Z3, Z4, Z5 Direction

5. Software Design

The Hardware system is the carrier of the control system, and the software system is the key to measuring the stability and reliability of the whole system. By setting the PLC program and the human-machine interface, the multi-axis synchronous control is realized, and the motion control of the human-machine interface on a single axis is realized so that the manipulator end actuator of the palletizing system can achieve synchronous operation and independent control.

5.1 PLC Program Setting

This process is based on the master synchronization mode. The system is connected in series with the enable, reset, human-machine interface reset, X-axis pitch, Z-axis pitch, X-axis, and Z-axis speed, grasping and placing coils, and controlled by a contact point to realize the multi-motor control of a signal source. The X-axis variable distance and Z-axis variable distance are distributed through the object's data sent by the host computer, and then uniformly called to enable each axis to achieve synchronous variable distance. The poor position of the sucker will appear in the process of synchronizing the varying distance of the sucker, resulting in a large load on the sucker, so the synchronization of the system is destroyed. The corresponding alarm program is designed in the system. By comparing the target position and the return target position, the unreturned target position coil is triggered to achieve the alarm effect. The alarm can be removed by reset and man-machine interface reset, which greatly reduces the time of manual troubleshooting.

5.2 Man-machine Interface

The man-machine interface of the palletizing system mainly includes the main interface of palletizing, sensor parameter interface, data interface, palletizing data interface, sucker motor interface, and manipulator interface. The sucker motor interface is the main interface of the control robot, as shown in Fig. 5. The bit state switch in the interface is directly connected to the relevant contacts in the electrical control program through the connection port Net. The corresponding address type is selected and then the corresponding contact address is input for communication, to realize the motion control of the X and Z axes. When the sucker arrives at the slot sensor, the electric opportunity automatically stops. This method is to obtain the signal of the suspension shaft by connecting a zero-point switch in series with a constant contact point of a positive and negative point of touch.

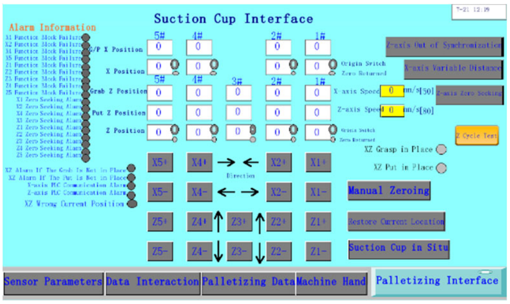

Fig.5 Human-computer interface

6. Conclusion

To improve the palletizing efficiency of personalized objects, this paper designs a palletizing system based on multi-axis synchronous control technology, which breaks the limitations of the original rigid palletizing system and realizes the simultaneous grasping of multiple objects. The system takes Siemens S7 - 1200 PLC as the control core and speeds up the operation process of the system by setting the master-slave PLC. The master-slave synchronous mode is used to control the movement of each motor, and the synchronization of each sucker is realized. Then, the human-computer interaction interface based on the touch screen is designed to control the drive of a single motor. Through field tests, the stacking efficiency of the system is far greater than that of the rigid sucker, which improves the stacking efficiency of personalized objects and has good stability.

Acknowledgments

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