

# Design of Industry Manipulator Based on the Motion Controller

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**Abstract:** At the present stage, industrial manipulator uses hydraulic or pneumatic drive as control mode, but these two kinds of mode exist problems, they are difficult to achieve good automation of material transport, this paper proposed a design of industrial manipulator using electric driving control, used the motion controller as the core, stepper motor as executive element. The design of hardware and software was finished. It can realize the control of the manipulator, ensure the flexibility and accuracy. And it has a certain reference significance to the development of manipulator.

**Keywords** Industry manipulator; motion controller; stepper motor

## INTRODUCTION

The manipulator for industrial use in China at the present stage is always driven by hydraulic or air pressure, these approaches have the advantages of a simple structure and easy to control. But at the same time, hydraulic or pneumatic pressure need to configure the source to work properly, it has poor flexibility and reliability, and it is not conducive to realize the automation of production process[1-4]. The electric control can overcome the above shortcomings of hydraulic or air pressure. The electric control uses stepper motor as the main power to drive the manipulator arm and torso movements. It has high flexibility and good reliability, and it can satisfy the requirements of industrial use [5-7].

In recent years, the motion controller due to its good reliability and high universality has been widely used [8-10]. In this paper, designed the manipulator based on the motion controller as control core.

## THE WORKING PRINCIPLE AND STRUCTURE DESIGN

### Materials

#### *The working principle*

First of all, do the operation that the manipulator comes to the initial position, after the manipulator back to the starting position, start to control the chassis rotation, then the chassis rotate to the corresponding position for pickup; Column drops after reach the designated position, then the arm moves forward. Stop and grab the goods after moved to the specified location, when it finished, column rises, at the same time, the arm moves backward (See Fig.1).

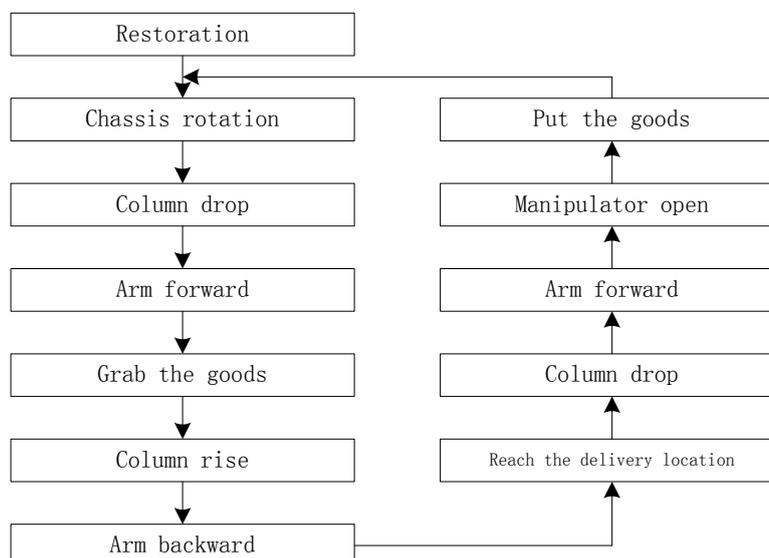


Fig. 1 Workflow

After coming to the delivery location, the column drop, then the arm moves forward. The hand opens, and puts the cargo on the specified location. After the completion of the restoration of the manipulator, go to the next operation of workflow. Workflow is shown in figure 1. In the practical work, which requires manipulator can reach any point of the space, so as to meet the demand of catching the goods.

**Interpolation function**

In order to make the manipulator can come to the specified location to catch the goods. In this article, adopted the method of cylindrical coordinates in the space for the manipulator displacement[11-12]. In order to achieve the specified function, manipulator consists of chassis, columns, arm and hand, it is shown in figure 2. Among them, 1 is for the stepper motor, 2 is for telescopic stepper motor, 3 is for the vertical axis, 4 is for chassis rotating motor, 5 is for chassis, 6 is for hand, 7 is for hand control motor, 8 is for the horizontal axis. The three degrees of freedom manipulator under cylindrical coordinate system can reach any location. The horizontal axis and vertical axis and chassis are equipped with limit switches, in each setting location also has a photoelectric switch (See Fig.2).

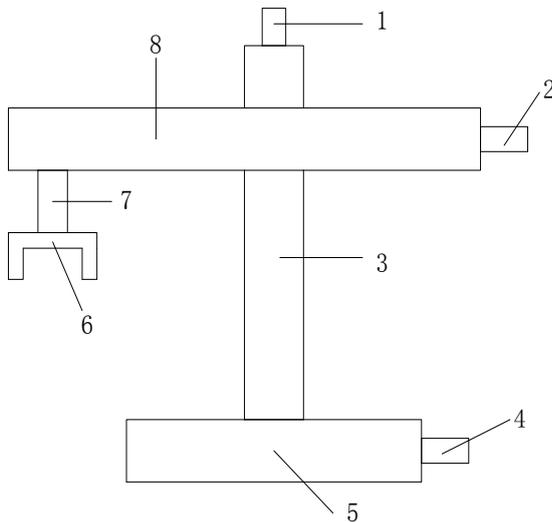


Fig. 2 The overall structure of manipulator

**CONTROL SYSTEM AND HARDWARE DESIGN**

**Control system**

According to the technological requirements of the manipulator, the design of control system is shown in figure 3. Control system used motion controller as the core, through the way that the PC as upper computer

and motion controller as lower computer to construct the control system, motion controller through three different modules to realize the corresponding function, I/O module is used to feedback the photoelectric switch and the limit switch signal, then control the position of the manipulator; Motion module uses the information feedback of I/O module to control the stepping motor, and make the stepper motor to perform the corresponding action; Interaction module can be used to monitor the real-time variables of state, and also can carry on the simple settings of the system. Motion controller program can be written through PC, and then transmit to the motion controller.

**Hardware design**

i) Motion controller. motion controller is commonly based on digital signal processing (DSP),it has advantages of fast response, high precision and good extensibility. And it is the core of the control hardware. The multi-axis motion controller used in the manipulator control system requires to do the real-time communication with PC, fast send signals to the stepper motor, at the same time, accurately process the feedback information, through the cooperation between upper and lower computer to realize accurate control of the manipulator. In this manipulator system, the multi-axis motion controller selected Trio MC405 multi-axis motion controller, the controller control five step motor shafts. At the same time, the controller also has Ethernet interface, USB and RS232/485 standard interfaces, it is equipped with I/O modules, and the quantity of I/O interfaces can expand, the I/O interfaces can be up to 256. The controller programming is convenient, programming software is provided by the Trio-"Motion Perfect V3", the programming language is Trio Basic, the language is similar to Basic, it is easy to get started.

ii) Stepper motor. Stepper motor is an important executive device, it can realize accurate control, the stepper motor in this manipulator is eight clap for two phase hybrid stepper motor, drive circuit adopts the model of SH – 2H090M (H), the driver is mainly composed of the power input module, signal input module and output module (A + and A - and B + and B -) and so on, it is shown in figure 4. There are three main input for the driver, they are: CP is used to input the stepper pulse signal to control the step motor speed and position; DIR is used to input the level of the input signal to control the stepper motor rotation direction; FREE is used to input offline level input signal.

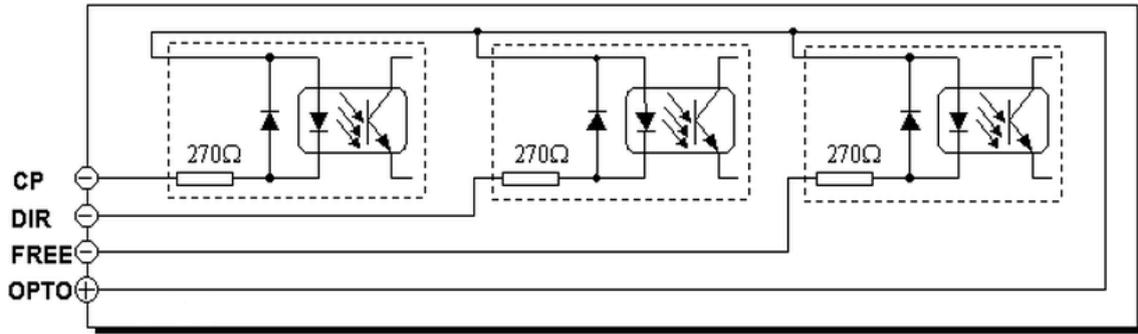


Fig. 3 Driver signal input

**SOFTWARE DESIGN**

*I/O module*

Signal input and output of the manipulator is realized by I/O module, the input and output of the control

system of manipulator distribution table is shown in table 1 and table 2 respectively. The input is used to determine the position of the manipulator and the motion state, and the output is used to control the motor movement, in order to achieve the corresponding control.

Table 1 Input allocation table

Input	IN (0)	IN (1)	IN (2)	IN (3)	IN (4)	IN (5)	IN (6)	IN (7)	IN (8)
	Photoelectric Switch 1	Photoelectric Switch 2	Photoelectric Switch 3	Travel switch 1	Travel switch 2	Travel switch 3	Travel switch 4	Travel switch 5	Travel switch 6

Table 2 Output allocation table

Output	OUT (1)	OUT (2)	OUT (3)	OUT (4)	OUT (5)	OUT (6)	OUT (7)	OUT (8)
	Horizontal axis motor forward	Horizontal axis motor reverse	Vertical axis motor forward	Vertical axis motor reverse	Chassis axis motor forward	Chassis axis motor reverse	Hand axis motor forward	Hand axis motor reverse

*Motion module*

Motion module is for motor control, motion control uses both automatic and manual work mode.

When choosing the way of manual work, first choose the operation shaft to separate control every movement. When pressing the "down" button, the selected shaft will come down; When pressing the "rising" button, the selected shaft will rise up. You can manually make the position of the manipulator return to the origin.

**INTERACTION MODULE**

Interaction module is shown in figure 6, including state selection, parameter setting and parameter display, state selection is mainly used for selecting manual mode or automatic mode when choosing a working state, the parameter setting is mainly used for setting up related parameters, the parameter display is mainly used for real-time display of the various parameters in the process of mechanical work.

**CONCLUSIONS**

This article in view of the present existing problems in industrial manipulator and the characteristics of the manipulator, designed a kind of industrial manipulator based on the motion controller. This manipulator can achieve fast and accurate control, realize the automation of the material transfer. At the same time, the way that using motion controller as the core to build system for industrial manipulator provides a new way for industrial manipulator design, it has a positive significance.

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