The Design of Control System for Multi Joint Robot based on PC+DSP

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Abstract: A multi joint robot control system was designed based on the universal processor PC+DSP in order to overcome the shortcomings of the control system in terms of flexibility, cost performance, and software transplantation, which use Industrial Personal Computer for the upper monitor and MAC Motion control card for the lower computer. The design of multi joint robot control system is accomplished through hardware circuit design, VC++ programming and so on. Finally, six joint robot platform is used to test the control performance, The results show that the designed control system has the advantages of flexible function, easy expansion and easy porting of software.

Keywords: Multi joint robot; Motion control card; Control system

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1.Introduction

In the current era, many countries have carried out machine substitution work, even raised to the national strategic level.At the same time, a large number of listed companies continued to overweight the robot business, making the robot market unusually hot. By the end of 2016, there were as many as 700~800 domestic Research& Design companies[1-3]. Large amounts of research institutes have also started the joint research and development projects of robots, and achieved a number of landmark results[4]. Such as, industrial 4.0 demonstration production line developed by Shenyang Institute of automation of China Academy of Sciences and Germany SAP company. The robot hand was designed by HIT/DLR joint robot laboratory[5]. Humanoid prosthetic hand developed by Institute of robotics, Shanghai Jiaotong University. Atlas of human brain drawn by Chinese Academy of Sciences automation[6], and so on.

However, the research progress of multi joint robot was slow, especially in the research and development of robot control system. Articulated robot, also called multi joint manipulator, is one of the common industrial robots in industrial field. It is suitable for automatic assembly, spray painting, transportation, welding and so on. For commercial interests, the commercial multi joint robot control system was mostly developed by using application specific IC and special language[7-9]. As a result, the hardware structure of robot control system was heavily dependent on specific environment and specific functions. It was difficult to extend and improve the hardware structure, and the software structure was also bound with a specific processor, so it was hard to transplant between different systems[10-15]. The current industry situation was that the key technology of robots relied heavily on imports, and the cost could not be lowered. The design of robot control system based on general purpose PC and general DSP was discussed in this paper, and the design process would be discussed from two aspects of hardware and software.

2.The Overall Scheme of Robot Control System

The multi axis motion control technology based on universal chip DSP was adopted.The motor of multi joint robot is controlled by software programming, and a general robot control system was constructed.Industrial Personal Computer was used to ensure its stability, openness, modularization and embedding. The MAC motion control card was selected to the motion control part, in order to satisfy the real-time control request, the overall plan is shown in figure 1.

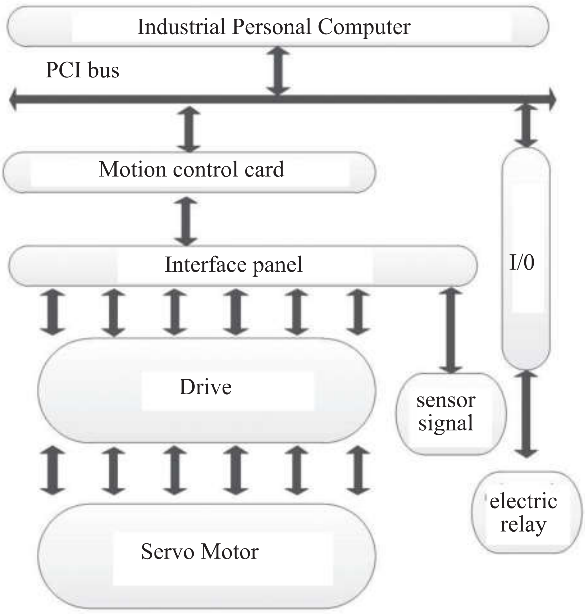

Figure 1. Robot control system

3. Hardware Design and Implementation of Control System

The multi joint robot control system designed in this paper included Industrial Personal Computer, motion control card, I/O module, servo motor, stepper motor, motor drive module and other accessories. The hardware design included the motor control circuit and the general interface circuit.

3.1 Design of Motor Control Circuit

The motor system consisted of servo motor and stepping motor. The control principle of the stepping motor was shown in Figure 2. The motion control card sent the pulse signal CP, the level signal DIR and the enable signal EN to the drive, and controlled the speed and the direction of the stepping motor. The control principle of servo motor was shown in Figure 3. The motion control card transmitted the pulse signal PUL, the directional signal SIGN and the servo ON signal to the driver, and controlled the rotation, the direction and the servo state of the servo motor. When the motor driver failed, the alarm signal "ALM" is "ON" state. After the control card received this signal, the pulse and the motor stopped immediately. At the same time, the output code number A, B and Z were sent to the servo driver, and then sent to the motion control card after the frequency division, which was used to feedback the actual position of the servo motor, and finally to achieve closed-loop control.

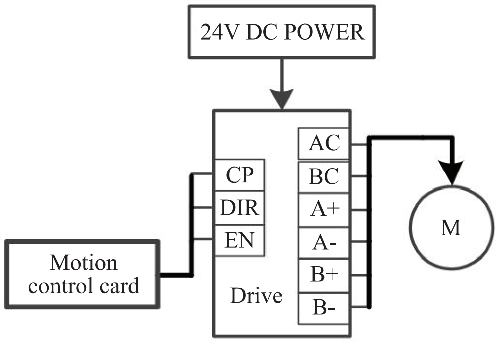

Figure 2. Stepper motor control system structure

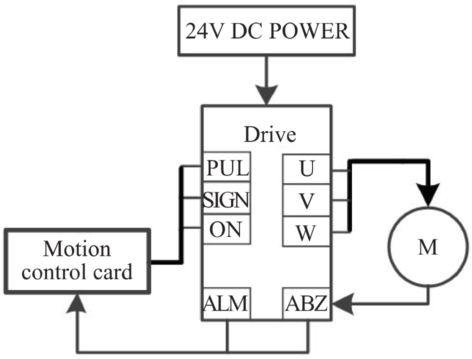

Figure 3. Servo motor control system structure

3.2 Signal Interface Circuit Design

16 - way input and 16 - way output signal were adopted in this paper. The load current of the output port was not more than 200mA, as shown in figure 4.When the output logic level of the control card was "1", the output load circuit was conducted. The pulse and direction signal circuit was shown in Figure 5.In differential mode, each signal was divided into a pair of mutually exclusive signals, such as OUT+ and OUT-.The use of difference method could effectively reduce the interference in the transmission process.In the open collector mode, the OUT- and DIR- served as the output of the pulse and directional signals, and the current flowing through the OUT- and DIR- terminals was no more than 20mA and was supplied by the +5V power supply.

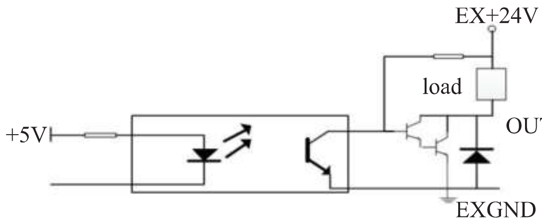

Figure 4. Schematic diagram of universal digital output circuit

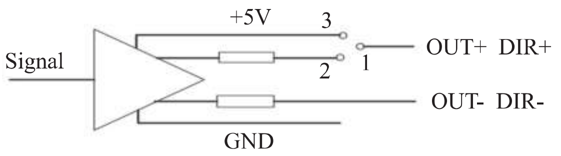

Figure 5. schematic of Pulse and directional signal output

3.3 Hardware Line Connection

The hardware connection of robot included the connection between Industrial Personal Computer and MAC motion control card and the connection between motion control card and driver. IPC and motion control card was connected by PCI bus, motion control card and motor drive connected by two adapter plate, each adapter plate had signal output port signals of the motor were receiving the corresponding port. Figure 6 was hardware electrical wiring diagram, DRV1 was stepping motor drive signal interface circuit, DRV2 was servo motor drive signal interface circuit, CN1 was connector, XT1 was adapter board, KM1 was relay interface circuit. The multi-pin interface with the motion control card was set up on the adapter board to send the control signal and receive the encoder signal, so that the motion control card and the adapter board were connected by the cable. The power supply terminal for the 5V, 12V, and 24V was provided on the adapter board to provide a control power for the motion control card and the driver.

4 System Software Design and Programming

In this paper, the system software included motion control program, human-computer interaction program and so on.

4.1 Motion Control Program Design

The realization of motion control function based on PCI bus and high The motor driver drives the motor according to the instruction signal. Multi axis motion control card MAC.We use Visual C++ to write interfaces and call the motion function. The motion function then sent the control command to the control card through the motion control card driver, and then the motion control card sent out the corresponding instruction signal according to the control instruction to the motor driver.The motor driver drove the motor according to the instruction signal.MAC motion control card contains multiple function libraries, function names and functions are as follows:

Function name	Function description
ssp2_initial	Software initialization
ssp2_enum_cards	Enumeration of MAC cards in the system
ssp2_close	Software shutdown
ssp2_set_out_mode	Set pulse output mode
ssp2_start_pt_move	The starting velocity curve is trapezoidal
ssp2_get_position	Read back counter

The flow chart of the motion control program was shown in figure 7.

4.2 Human-computer Interaction Interface Design

As the background management of the whole system, the application software of the upper computer completed the task with weak real time. The interpolation calculation, position calculation, servo loop update and so on, which required a strong real-time task was completed by the motion control card. Using the MFC class library in VC++6.0 to develop the application program which suits his own requirements, and completed the design of human-computer interaction interface. The CMainDlg class was the main frame class of the application program. It constructed the main frame of the whole application, the initialization of the error system and the selection of the motion control card, as well as the corresponding motion function processing. The CDialog class was a view class created by the application automatically, which was responsible for drawing the human-computer interaction interface graph. After the design of MFC interactive interface, the motion control function could be added to each Button, and the

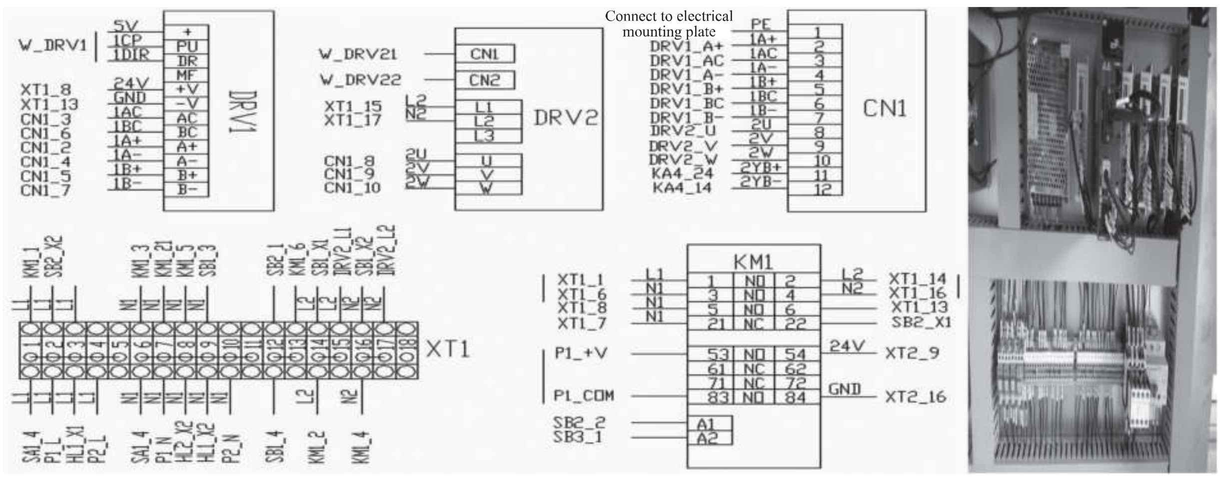

Figure 6. Electrical connection diagram

Figure 7. Motion control flow chart

DLL function could be called. Through this module, users could realize multi axis linkage, straight line interpolation, arc interpolation and other operations for multi joint robot. The main control interface of this paper was shown in Figure 8.

Figure 8. Control interface

4.3 Interpolation Motion Debugging

The interpolation motion of the robot was implemented by the hardware on the control card, and the upper computer sets the interpolation speed, acceleration, terminal position and other data.The linear interpolation and circular interpolation were tested below. The motion parameters of the test were read through the MAC-3003SSI2 servo motor motion control card debugging window. In the linear interpolation motion, the acceleration was trapezoidal, and the position was relative,

the target position X axis was 20000 pulses, the target position Y axis was 20000 pulses, the initial speed was 100 pulses/sec, the running speed was 3000 pulses/sec, the acceleration time was 2 seconds. The test results were shown in Figure 9.In the arc interpolation, circular interpolation direction was clockwise, position direction of relative position, acceleration was trapezoidal, starting speed of 100 pulses per second, running speed of 1000 pulses per second, transmission time 1, X axis center position of the 3000 pulse, 7000 pulse position X axis, Y axis center position of the 4000 pulse Y axis position, 7000 pulse, the test results are shown in figure 10.Through the window, it could be seen that the robot can complete the interpolation motion of the straight line and the arc line according to the setting parameter.

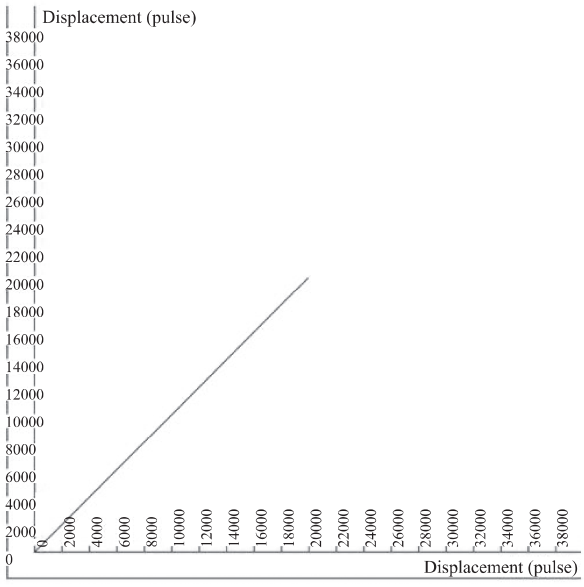

Figure 9. Linear interpolation motion

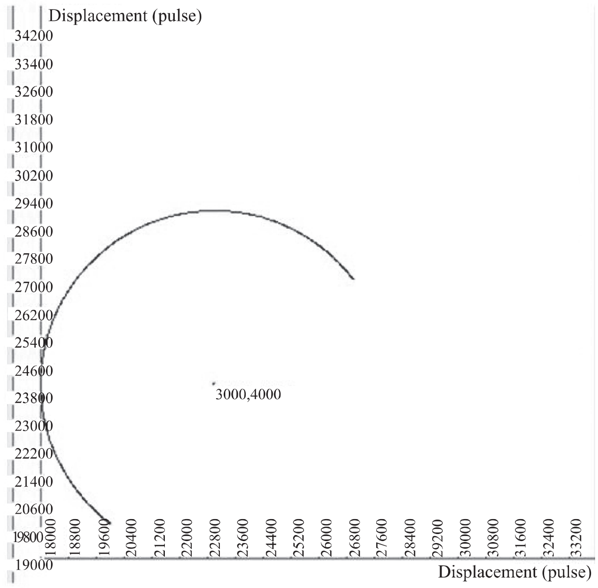

Figure 10. Circular interpolation motion

5. Conclusion

The robot control system based on PC+DSP was presented in this paper, the corresponding hardware circuit design and software were completed, and finally system performance was tested using six joint robot. Tests showed that the robot can control the joint motion and interpolation motion of the robot at the designed human-computer interaction interface, so the robot programming can completed the assigned task.Due to the adoption of the PC+DSP architecture, the system became more flexible, could be customized according to the specific requirements of production control system, robot control system reduced the difficulty of development, increased the scalability and portability of the system development.

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