

Motion Control of Manipulator Based on Labview

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Abstract

The main study is the use of LabVIEW to achieve the control of the manipulator movement. The robot composes of three parts, the main body, the drive system and the control system. Main body includes the frame and actuator. The driving system comprises a power device, a transmission mechanism and a microcontroller. Control system, which will produce the string command and issue to servo controller through the serial port communication, uses the LabVIEW software development platform. Servo controller can automatically understand a command string, and then control the angle of the steering engine. This design mainly includes the robot hardware design and motion gait design. The six servo pulse width values are stored in the cluster array. By unbundling index data and position interpolation analysis, the mechanical arm movement is stability. The design uses series six degree of freedom robot. Finally, the control effect is verified by sleeve action.

Keywords: manipulator motion control, LabVIEW, Interpolation analysis.

1. Introduction

In 1946, the human made the world's first computer. With the process of science and technology, computers begin to develop towards higher speed and lower price. The mass production of computer built the foundation for robot development. In 1954 the U. S. George Devol proposed the concept of industrial robots. The actuator and servo drives are connected together and program the robot action sequence, so that the robot can act independently without any manual operation [1,2]. The latest generation of robots, also known as intelligent robots, is still in the development stage. It is the integrated use of a variety of sensors, measuring devices, etc. to obtain environmental information, and then use intelligent technology to identify, understand, reasoning and finally make planning decisions [3]. According to the ability of distinguishing its own environment, robot can act autonomously to achieve the intended target [4].

Traditionally, people use text programming languages, such as C. In computer control, C language is the choice of the majority of people. But LabVIEW (NI, USA) offer us a different way of programming, graphical programming language. LabVIEW is a graphical programming language and uses the icon instead of text to program, which has rich signal processing functions and other advantages of programming simply, understanding easily, fine interface [5-7]. NI product development team is working hard to meet the challenge of science and technology, and provides an intuitive, integrated I/O, open, flexible, interactive software environment for the development of autonomous systems. LabVIEW can provide standard software and hardware development platform to help users to design the robot control system. We can achieve rapid integration of any product in the project, which greatly reduces the time and cost of development [8,9].

In this study, the use of LabVIEW is as a control software system development platform. The control system includes PC, control card, servo and intelligent control software. The control card is connected with the PC through the USB. The robot control system sends the stored position information to the micro controller, which can transmit the control signal to the steering gear to realize the steering angle change. The change of position information sequence finally realizes the mechanical arm movement and completes the specified task. The effect of the control system is verified through the experiment of sleeve. This validation uses six degrees of freedom manipulator, but any other using the steering gear as the driving force is applicable. For robotic automation system, the application of LabVIEW is a new chapter in the field of mechanical control [10].

2. Working principle and driving system

2.1. Working principle

The principle of the robot system is showed in Fig. 1.

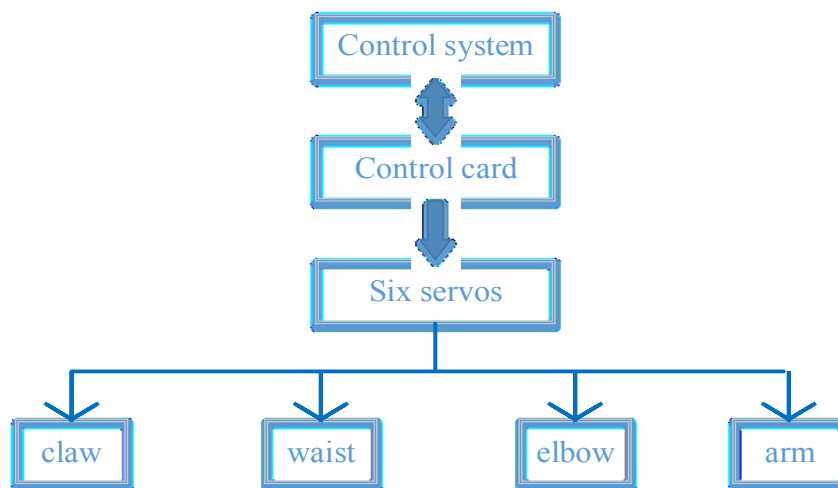


Fig. 1. The principle of the robot system.

The robot consists of 3 basic parts: control system, drive system and main body. Among them, the control system uses the LabVIEW program to generate the motion signal, and transmit it to the drive system to realize the mechanism movement of the implementation. Driving system comprises driving devices and a driving control system. Driving devices are steering gear, and driving control system uses 32 channel servo controllers. Mechanical arm body includes the implementation mechanism and a machine base, which is six degrees of freedom.

While the LabVIEW program running, micro controller outputs a PWM signal to realize the control of each actuator component (6 servos). Thus, the robot has a prescribed, sequential, relative motion.

2.2. Main body of manipulator

The robot in this research is a multi-joint general type of six degrees of freedom, which is bionic to arm, as shown in Fig. 2. It is often used in the production of high intensity and relatively monotonous operation like assembly line. Mechanical arm body consists of the executive mechanism and a machine base, while actuator includes the claws, wrist, elbow and arm, and six degrees of freedom. Among them, the wrist and arm are respectively provided with 2 degrees of freedom, as shown in Fig. 2.

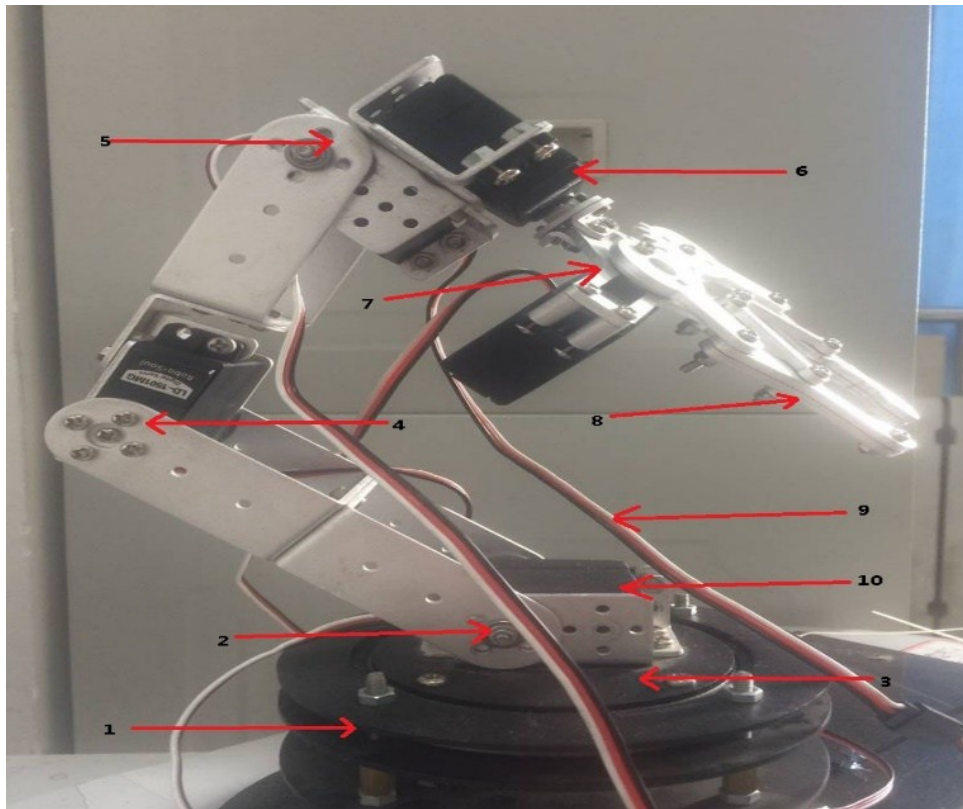


Fig. 2. Robot:1-base;2,3-shoulder;4-elbow;5,6-waist;8-claw;9-servo wire;7,10-digital servo.

The robot arm is directly connected to the base, and the elbow needs to swing and rotate, as shown in Fig. 2. The shoulder and wrist of the bionic arm has two degrees of freedom to increase the movement space. Wrist's freedom guarantees partial flexibility of mechanical arm, while one degree of freedom of hand holding can ensure stability.

2.3. The design of driving system

Drive system is the core part of the robot motion, which is usually composed of three parts, which are power, regulation and assistant. This design uses the electric driver that is the most commonly used in industrial robots, which of the main driving mode is general motors, servo motors, stepper motor. The advantage of the electric driver is convenient, vigorous, quick response.

This design uses the steering gear as the driving unit. The steering gear is a position or the angle servo drive, which plays a role of the executive body in the micro electro mechanical system. The simple control method makes it easy to interface with the microcontroller. The steering gear is an automatic control system, which is composed of control circuit, DC motor and reduction gear unit. To the robot control system, steering working condition is an important factor about the robot's motion.

When the steering gear working, the control signal enters the signal modulation chip, and the DC bias voltage which is a benchmark is obtained. The DC bias voltage is compared with internal potentiometer voltage of the steering gear, and the motor drive chip get the voltage difference to determine forward or reverse rotation of steering. When the voltage difference is 0, motor stops rotating. Its working principle is clear, as shown in Fig. 3

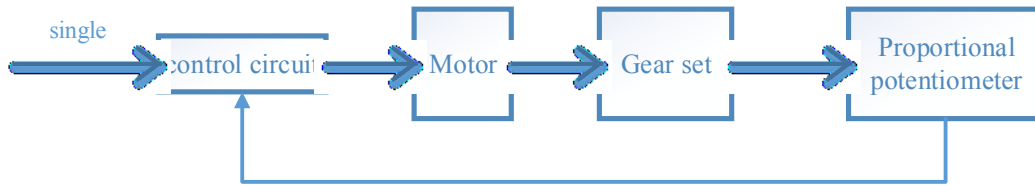


Fig. 3. Principle of servo.

2.4. The design of the 32 channel steering engine controller

Servo controller can be connected with the host computer PC software through the USB line, and get the signal command through the virtual serial port. The controller can generate PWM to control steering gear. The steering engine controller also has the overload protection function and the voltage regulation alarm function.

32 ways servo controller can be connected with the host computer through the USB line, and will generate a serial number, which can be viewed in the computer's device manager. This design generated serial number of COM3, while different PC devices may generate other serial number.

3. Design of the control system

3.1. Introduction to control system

The front panel includes VISA resource name, baud rate, an array of clusters to control manipulator position and six indicators about servo motor position. VISA resource name is VISA configuration serial number. 32 way steering gear controller connects with the host computer through the USB line. To allow them to communicate need to match the serial port. VISA serial port baud rate configuration is default to 9600, but need to input the communication baud rate to 115200 for effective communication.

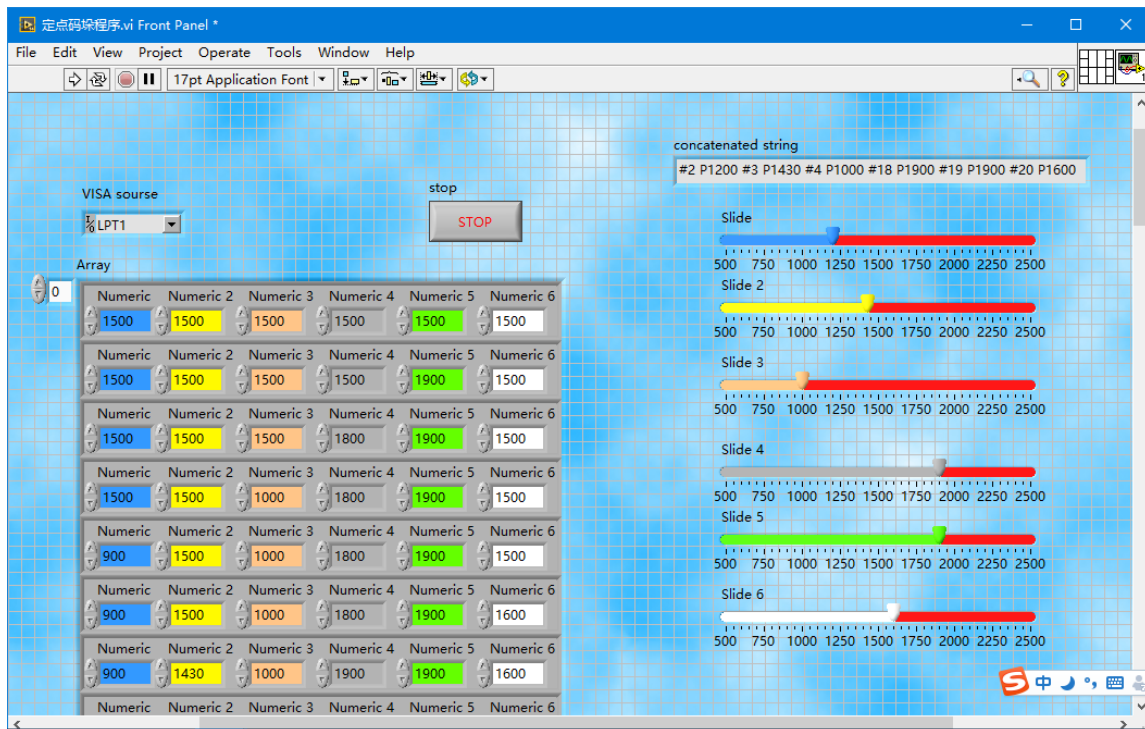


Fig. 4. Front panel of control system.

6 sliding rod are six steering angle indicators, where the operator can observe the robot's claws, wrist, elbow, arm rotation angle and position. When the software is running, the background of LabVIEW program will automatically parse, and combine these data into a command string, through the serial port communication, and transfer to the 32 channel servo controller, thereby control robot's six servos.

3.2. Communication between PC and control board

To Control the serial port, VISA serial port function is used. The function include VISA read, VISA write, VISA close, VISA emptied and VISA serial configuration and etc. This design mainly use VISA serial configuration, VISA write, and VISA close for serial communication, as shown in Fig. 5.

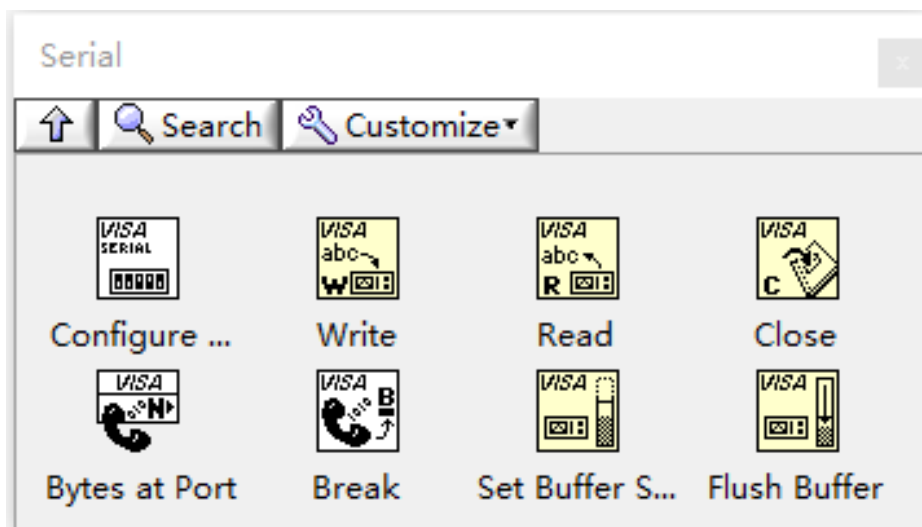


Fig. 5. VISA function.

VISA configuration is mainly used to initialize the data bits, baud rate, serial port resource name, parity and other parameters of serial port.

VISA write has three input ends. The upper input terminal is the serial port resource name of VISA configuration function. The middle one is the written buffer entrance, which the data format supported is a string. The last is an input of the wrong code. If an error occurs, the program produces an error code, with the appearing of error code, the system will interrupt the work.

VISA close, while the program stops, can release the serial port.

Manipulator has 6 steering gears, which are connected to servo controller 2, 3, 4, 18, 19, 20 channels, respectively. Using the “format into string” function transform the PWM value to string command. The 6 input data of terminal of the function on the left is corresponding to the actual steering pulse width. Format string for communication is #2 P%d #4 P%d #18 P%d #19 P%d #20 P%. The function of %d is to sure a signed integer data behind the letter P, which is the servo PWM value. If all the steering rotation angle is at 90 degrees, the writing command string is #2 P1500 #3 P1500 #4 P1500 #18 P1500 #19 P1500 #20 P1500<cr>.

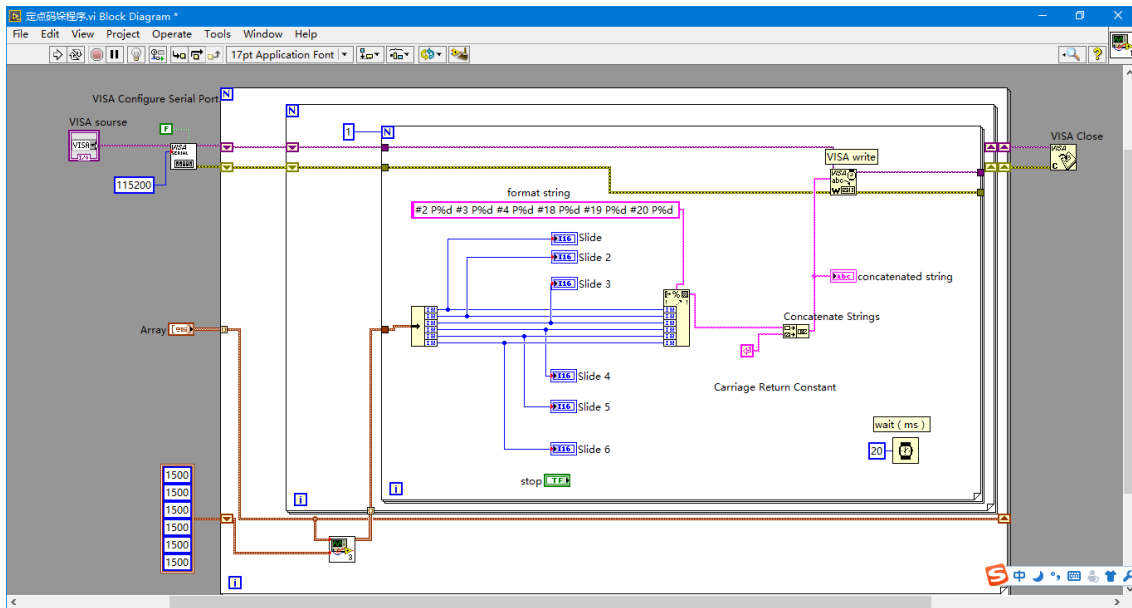


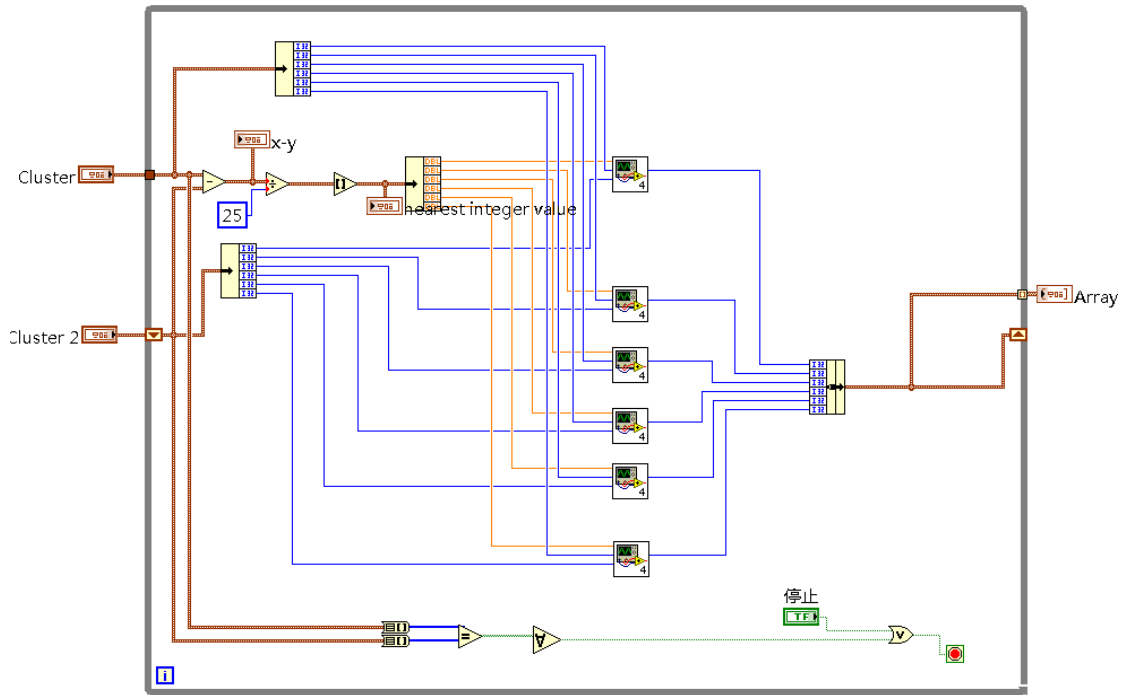
Fig. 7. Block diagram of control system.

Fig. 8 (a) and (b) are two sub VI block diagrams. In the sub VI3, the end position value of the action and the start make a difference to determine the direction of movement. And then difference is divided by 25, which is the interpolation interval, and takes a nearest integer to get the number of the interpolation points. The corresponding action position of each interpolation point is calculated in the sub VI4, and outputted the combined array. The points is typed to the motor controller through the VISA write function and transferred to action position, so the manipulator complete a set of actions.

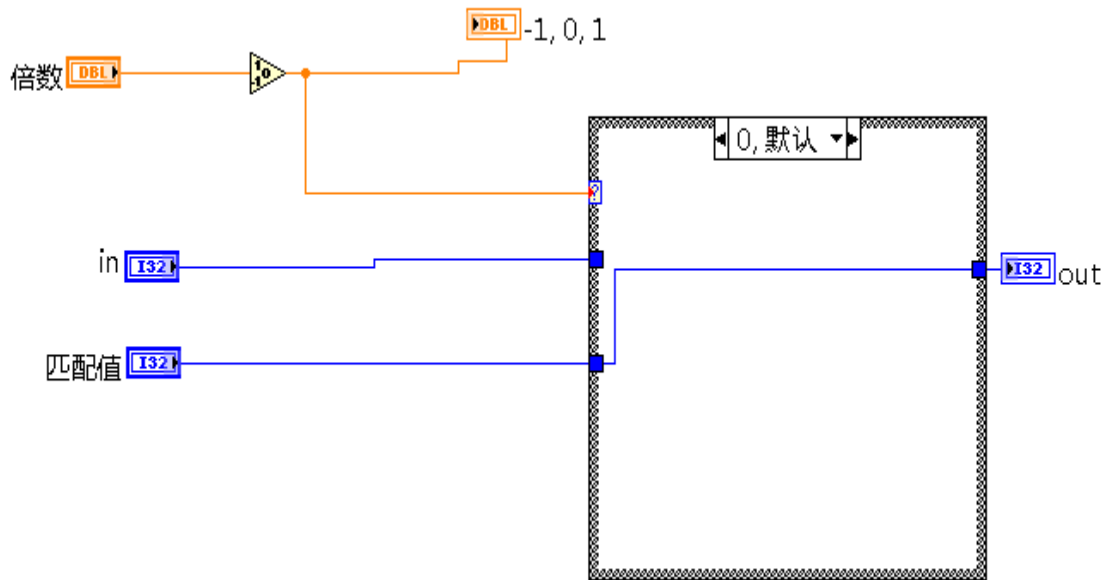
4. Examples of mechanical arm movement

4.1. Sleeve action design

This design is the imitation of a "Tower of Hanoi" game to study rigid motion of robot and take the joint robot with six degrees of freedom as the research object. Place a working platform on a certain distance from the base shaft and two artifacts on the platform. One is a cylindrical workpiece, and the other is a workpiece with a hole in the middle. The former is named as the workpiece 1, another is named as the sleeve. There is a certain distance between the two workpiece. Now, the manipulator needs to take the workpiece 1 to the top of the sleeve, and put it into the hole of the sleeve by vertical drop. In order to increase the design difficulty, the aperture of the sleeve is set as large as the cylinder diameter at the bottom of the workpiece 1. If there is some deviation between the workpiece and sleeve aperture, the workpiece will not be able to successfully enter the sleeve.



(a)



(b)

Fig. 8. Block diagram of sub VI 3 and 4.

The cylinder and hollow cylinder is placed in platform and robot placed in the distance of 128mm with platform. The platform length is 300mm, width is 100mm, and height is 100mm. The cylinder that diameter of 20mm at the bottom and height of 80mm and quality of 300g will be putted into the sleeve of

aperture of 21mm and height of 45mm, the center distance of the two parts is approximately 130mm. The robot load is 300g. In the process of lifting and putting down the cylinder, the swing of the arm is more than 52 degrees. In order to keep the cylinder level movement, the elbow is about 23 degrees in the process of moving. In the whole stroke of the robot, the robot is required to move smoothly at angular speed of $w=5$ degrees / second and without acceleration. The position of the workpiece on the platform is clear, as shown in Fig. 9.

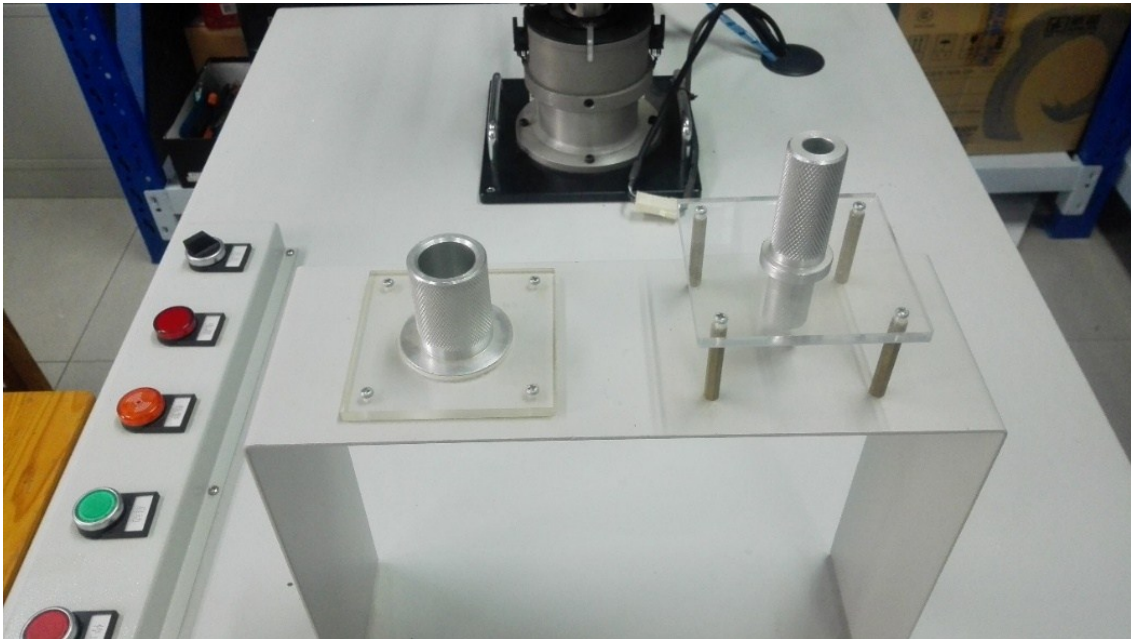


Fig. 9. Workpiece and sleeve.

4.2. Actual operation of the sleeve action

In the installation of the robot hardware, using the 32 channel servo controller transferred six steering angle to 90 degrees, and the corresponding pulse width is 1500us. In order to reduce the load of each actuator, the robot initial state and final state are vertical upward.

The total length of robot is 460mm, among it arm length is 105mm, elbow length is 100mm and claw length is 150mm. In the design of the path according to robot size, the steering gear on base is set as O point, upper arm OA, lower arm AB and claw BC. OE length is 246mm, which is the distance from the center of the base to the workpiece. The cylinder position is set to G point and sleeve is set to H point.

Robot clamps workpiece 1 at G-spot, and lifts it with the arm and elbow, keeps the workpiece perpendicular to the ground and rotate. Finally, the workpiece is putted into the hollow cylinder as shown in Fig. 10.

In the design, the quality of the workpiece is in the load range that mechanical arm can bear. Robot six servo motor is connected in series, therefore, to make the robot follow along a given trajectory. Each steering angle must cooperate with each other to arrive at a predetermined point.

5. Conclusion

This paper mainly studies the design of robot based on the LabVIEW including the hardware and software of control system.

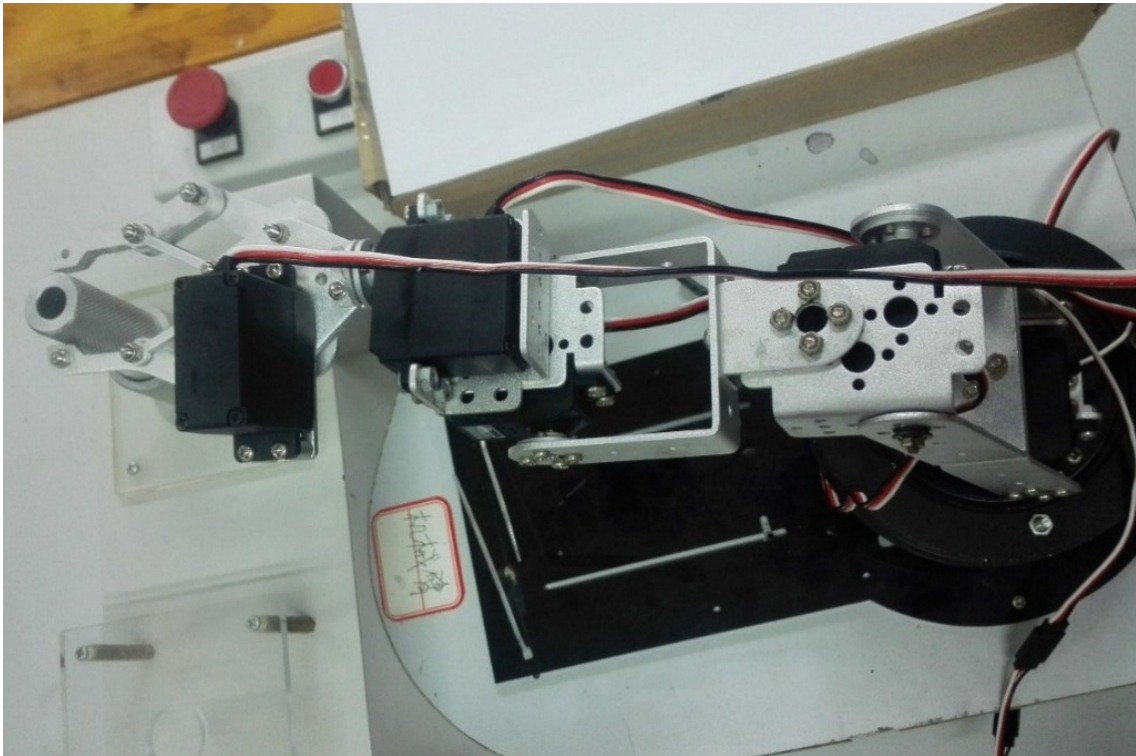


Fig. 10. Experimental result.

The overall design of robot hardware system includes the main body and the drive system. Body comprises a frame and actuator, which is six degrees of freedom bionic robot. The driving system consists of drivers 32 channels steering gear controller. Research on control system software development platform of robot uses LabVIEW. LabVIEW is a graphical programming language. In this design using VISA function issues the string command to the client through the serial port communication. Lower computer automatically understands the command string and controls the angle of the steering engine, so that manipulator realizes the desired action.

The control engineering analyses slow and steady movement of robot only, but there's no research on the optimal route and the best interpolation point, which is the deficiency of this work and will be the next research direction.

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