Research on Manipulator Stability Control

Donghai Chen¹,a*, Quan Tian³ and Dongxu Bai³,b

1 Changjiang institute of survey, planning, design and research, Wuhan, Hubei 430081, China.
2 Zhixing college of Hubei University, Wuhan, Hubei 430081, China
3 Key Laboratory of Metallurgical Equipment and Control Technology of Ministry of Education, Wuhan University of Science and Technology, Wuhan, Hubei 430081, China
a) chendonghai@cjwsjy.com.cn, b) 1002022585@qq.com

Abstract. In order to have good accuracy, robustness and stability, it is necessary to control the manipulator accurately. But at present, for the precise control of manipulator, for the control mode and control system of manipulator, the research is not in-depth and perfect. This paper mainly summarizes the manipulator control system and control mode, and analyzes and summarizes the dynamics modeling, control accuracy, PLC control of the manipulator. At the same time, the control direction of the manipulator is prospected, such as cluster control, planning coordination control, autonomous motion control, etc.

1. Introduction

In 1962, the United States produced the first manipulator. Since then, the research on the application of manipulator has become more and more in-depth and extensive, which plays an important role in promoting social development.

In industry, manipulator is often responsible for heavy, dangerous and repetitive work. In the application of related interactive environment, manipulator often needs to have: security, friendliness, accuracy, flexibility and so on. At the same time, manipulator will also develop towards high positioning accuracy, high flexibility and high speed in the future [1].

Manipulator control system needs to have the following functions: operability, perceptual ability, a certain degree of intelligence, data processing and so on. At the same time, the control of the rigid dexterous hand with multiple degrees of freedom also needs to be able to carry out precise force position control.

At present, most of the technologies related to manipulator manufacturing are monopolized by foreign enterprises [2]. The related theoretical research and application research in China is not in-depth and perfect.

Therefore, it is imminent to improve the intelligence and industrialization of the manipulator, improve the research and development level, and improve the output and quality. The research on manipulator, especially the control of manipulator, is also imminent.

2. Control Modeling

The manipulator is used in all aspects of life, realizing the mechanization and automation of industrial production, and providing a lot of help for human beings. Manipulator often has a certain degree of freedom, such as 14 degrees of freedom, 16 degrees of freedom and so on. When the manipulator grabs the object, the hand will be restricted to some extent, and the degree of freedom of the hand will be reduced. Such as dexterous hand grasping, hand operation and so on, all need the manipulator to
have the very high stability, the accurate and so on control request. As shown in the figure below.

Huang Zhen [3] has made a lot of analysis by using the theory of helix. Because it is more convenient to use the theory of helix for some analysis of spatial structure, and it can also use the theory of anti helix to analyze the kinematic properties of multi degree of freedom series robots.

Manipulator control needs precise control, especially in the industrial field.

To construct the control system of manipulator, it is necessary to establish a dynamic model of manipulator. Zhang Ji [4] used Lagrangian dynamic equation to get the corresponding model. Chang Zongyu and Chen bingcong [5] use exponential product formula and Kane equation to model underwater manipulator system.

In dynamic modeling, motion analysis, inertial force and generalized inertial force, generalized active force and other active forces should also be considered.

Different methods and equations can be used to model the dynamics of manipulator control system. This has expanded the research direction for our manipulator control.

3. Stability Control
Both industrial manipulator and service manipulator need high control precision. At the same time, it needs more precise control. And the manipulator should have a proper force control object, which cannot be large or small, which requires precise control and stable control. Next, we will focus on the application of manipulator in control mode and PLC control.

3.1. Control Mode
Industrial robots can be divided into two different control methods according to the control method [6], namely: point control and continuous trajectory control.

The control system of manipulator is mostly based on PLC (Programmable Logic Controller), and the application of PLC in manipulator control system is more and more extensive [7].

At present, there are many problems in manipulator, such as low control accuracy and complex control scheme. Yi Jingshu [8] designed a closed-loop structure control system based on Arduino. The system can reduce the control cost and realize the control of motor torque by motor feedback current.

Wan min and An lingzhi [9] designed a variable universe fuzzy controller with precise mathematical model. Compared with the traditional PID control, the controller has the advantages of high precision, small error, good robustness, good stability and fast response speed.

At the same time, the manipulator should ensure its stability and safety when grasping objects. The manipulator control system designed by Li haihiao et al. [10] takes ARM9 microprocessor as the control core and combines the control of grating, sensor, etc. to realize the precise control of the manipulator's movement track and grasping action.

The use of improved control system, improved controller or combined control can make the manipulator control system achieve the expected advantages. This provides us with a wide range of references for the design of manipulator in the future.

3.2. PLC Control
Using PLC to control the manipulator can effectively reduce the failure rate of the control system, and make the manipulator run stably and reliably [11].

At present, there are many problems in picking manipulator, such as low efficiency, slow response speed, low control accuracy, etc. Shao Changyou et al. [12] aimed at this problem, let the manipulator integrate PLC pneumatic control system and MCGS industrial control configuration software.

Nowadays, a large number of goods are piled up in many industrial automation production lines, and some production lines cannot use computers to control the coordination of multiple manipulators. Lu Qun et al [13] designed a control system of multi manipulator for this problem. The system adopts OLE for process control technology, namely OPC technology to solve the problem of data exchange between the control system and its data source. In order to realize the control of computer to multi manipulator. At the same time, the system can also realize the communication control between PLC and motor driver.

In the industrial manipulator, there are many special fields, which are widely used in assembly,
welding, spraying, casting, etc. [14]. Li Shengduo et al [15] designed a set of PLC control system of configuration simulation for the special casting manipulator. By using the shift register, the configuration software monitoring system and the embedded MCGS hardware platform, the casting manipulator is well controlled.

The results show that the control accuracy of the manipulator controlled by PLC or combined with PLC is obviously improved.

4. Future Direction
At present, the control of manipulator is mostly single control, few cluster, a large number of control. However, in industrial production, there should be certain information sharing and transmission functions between multiple manipulators, and the controllers of different manipulators should be independent of each other. Therefore, it is more and more urgent to carry out collaborative control, cluster control, planning and coordination control for manipulator [16].

In the cluster control, the manipulator needs a certain degree of autonomy to avoid danger by emergency braking. If we can't plan and coordinate the control, the manipulator will have cross collision and other accidents.

Autonomous control is also the future research direction. V. A. Kartashev, V. V. safronov [17] improved the automatic safety motion control system for the robot's autonomous control.

At present, there is a long way to go for the research of manipulator control. How to improve the stability, robustness and accuracy of the manipulator, how to better let the manipulator in the medical, military and other special fields, these are the problems that scholars need to think about, and also one of the future research directions. All of these provide new thinking and research direction for our future robot control.

5. Conclusions
With the development of manipulator control theory, manipulator has been applied in many fields. Both industrial manipulator and service manipulator need precise and stable control. This requires the manipulator to have good robustness, stability and accuracy.

Through a lot of research and practice, it is shown that different dynamic modeling methods, different structure combined control and software combined control can make the manipulator have good control accuracy. I believe that through unremitting efforts, the algorithm optimization and control optimization level of manipulator operation control system will continue to improve.

In this paper, the control of manipulator is summarized, focusing on the theoretical research and Application Research of some manipulator control system and control mode, for the reference of relevant personnel.

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