

Model and Motion Planning of Three-Link Mobile Manipulator Based on Programmable Controller

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Abstract: Therefore, most of the researches on kinematics, dynamics and control technology of robots focus on serial manipulator robots. The model of a new type of tandem Chinese massage manipulator is established, and its kinematics and dynamics are analyzed, and its velocity and acceleration are simulated by Adams. In the aspect of path planning, the path planning method of mobile manipulator system is discussed from the perspective of kinematics model, but the dynamic model is not considered, which is not enough for the manipulator system with large weight and inertia. Push operation of humanoid robot with given hand trajectory. The dynamics and control of the two arm space robot grasping system are studied. It uses programmable memory, which stores operation instructions such as logic operation, sequence control, timing, counting and arithmetic operation, and controls various types of machinery or production processes through digital and analog input and output. Robots will be as popular and personalized as today's personal computers. Robotics involves a variety of research and scientific fields, such as biomechanics, touch, neuroscience, virtual simulation, animation, surgery and sensor networks. In this paper, aiming at the problem of the controller design of the three-bar manipulator, the parametric control law of the rotation angle and angular velocity of the connecting rod is proposed, and the motion planning of the three-bar manipulator is carried out based on the programmable controller.

1. Introduction

Programmable controller, an electronic system for digital operation, was first developed by American scientists in the late 1960s for the industrial environment. Therefore, most of the researches on kinematics, dynamics and control technology of robots focus on serial manipulator robots [1]. However, most practical systems are mostly time-varying or highly nonlinear, and the practical research methods are based on the theory of first-order systems, but the stability of closed-loop systems usually cannot provide a complete answer [2]. The model of a new type of tandem Chinese massage manipulator is established, and its kinematics and dynamics are analyzed, and its velocity and acceleration are simulated by Adams. The forward recursion method is used to establish the dynamic model of the mobile manipulator, but a complicated program is needed to solve the driving force problem [3]. In the aspect of path planning, the path planning method of mobile manipulator system is discussed from the perspective of kinematic model, but the dynamic model is not considered, which is not enough for the manipulator system with large weight and inertia [4]. A control strategy based on virtual constraints is proposed for robot trajectory, especially in the design of trajectory tracking controller of three-bar manipulator. Due to the complexity of the model, it is difficult to obtain the feedback gain [5].

Second-order system captures the dynamic behavior of many natural phenomena and has been applied in many fields, such as vibration and structure analysis, aerospace control, elastic structure and robot system. Push operation of humanoid robot with given hand trajectory [6]. The dynamics and control of grasping system of dual-arm space robot are studied. At present, some methods are put forward for the control and planning of mobile manipulator, but the mobile manipulator system needs

to keep the manipulator still during the movement, which reduces the efficiency of the planning of mobile manipulator system [7]. It uses programmable memory, its internal memory to perform logic operations, sequence control, timing, counting and arithmetic operations and other operating instructions, and controls various types of machinery or production processes through digital and analog input and output [8]. Robots will be as popular and personalized as today's personal computers. Robotics involves a variety of research and scientific fields, such as biomechanics, touch, neuroscience, virtual simulation, animation, surgery and sensor networks [9]. At the same time, the intrinsic structure configuration of the closed-loop system is realized, the desired intrinsic structure is obtained, the degree of freedom of the system is provided, and the conditions for improving the performance of the system are provided.

2. The Development Trend of Programmable Controller

2.1 The Development Trend of Traditional Programmable Controller

Modern society requires manufacturers to respond quickly to market demands, and produce products with small batch, multiple varieties, multiple specifications, low cost and high quality. During the simulation, the joint angle is transmitted to the virtual reality scene module of the robot, and the movement process can be displayed visually [10]. The dynamic equation of the three-link manipulator is based on the direct parameterization method, and the control law of the manipulator moving to the vertical equilibrium point is designed by adopting the characteristic structure configuration, so as to realize the stable control of the three-link manipulator [11]. In recent years, with the rapid development of computer technology and the formulation of international standards on programmable controller, an emerging technology that breaks the limitations of traditional programmable controller has developed, which is soft programmable controller technology [12]. But this is completely in line with the motion of the drive. When the drive starts, there will be instability. When the drive is stable, the acceleration will also be stable. When the mobile manipulator system is close to the obstacle, it will be repulsed by the repulsive force field. The closer it is to the obstacle, the greater the repulsive force. When approaching an obstacle, its repulsive force is infinite.

Most user programs of PLC can be simulated and debugged in laboratory. After debugging, PLC control system can be installed in production site for on-line adjustment. In terms of maintenance, the failure rate of PLC is very low, and it has perfect diagnosis and implementation functions. Once the input devices and actuators outside the PLC fail, the reasons can be quickly found out according to the information provided by the LED on the PLC or the programmer [13]. When the mobile manipulator system works in an unknown environment, the obstacle avoidance must rely on the vision sensor of the mobile manipulator system, but the complete reconstruction of the obstacle surface must be detected from multiple angles of the obstacle [14]. According to the structure of traditional programmable controller, soft programmable controller system is composed of development system and operation system. It can also be divided into editing environment and running environment. If the company's factory master data acquisition and analysis system and view aster color image system are equipped on the console, it is very convenient to manage and control the whole factory [15].

2.2 Soft Programmable Controller Technology

In the late 1990s, people gradually realized that traditional programmable controllers have some shortcomings: it is difficult to build an open hardware architecture because the products among the manufacturers of traditional programmable controllers are incompatible with each other and lack clear and consistent standards. Generally, the input and output circuits of the programmable controller use photoelectric couplers to transmit signals, so that there is no circuit connection between the external circuit and the CPU, which effectively inhibits the influence of external interference sources on the programmable controller, and at the same time, prevents external high voltage from entering the CPU module. These tasks require the arm to be light weight and high stiffness. The double arm is made of aluminium square tube, which meets the requirements of light weight and high stiffness,

facilitates the operation of the arm and provides a basis for the selection of drive motor. The goal of planning is viewed as a gravitational field, so that a mobile manipulator moving in the working environment can effectively bypass obstacles and reach the planned target location under the combined action of attraction and repulsion.

At present, personal computer is mainly used as programmer, operation station or man/machine interface terminal of programmable controller, and its development is to make programmable controller have the function of computer. In the aspect of man-machine interface, more intuitive CRT, such as real information, is adopted, which completely replaces the original instrument panel, making the programming and operation of users more convenient and flexible. On the one hand, I/O modules of programmable controllers develop intelligent I/O modules with microprocessors, on the other hand, they also pay attention to increasing the number of I/O points to meet the needs of increasing the control range and using A/D, D/A communication and other special function modules in the system. According to the designer of the format, it was designed to provide a specification for describing robots as generically as possible. Adopt a variety of relevant international industrial standards and a series of de facto standards; All of them use software to realize the function of traditional programmable controller, which is the high-tech soft programmable controller technology appearing in the world.

3. Kinematic Analysis

3.1 End Pose

The analysis of manipulator end position is to determine the relationship between the spatial position of manipulator end-effector and the spatial position between links, which is the basis of manipulator spatial position analysis. Figure 1 shows the 3D modeling of mechanical arm.

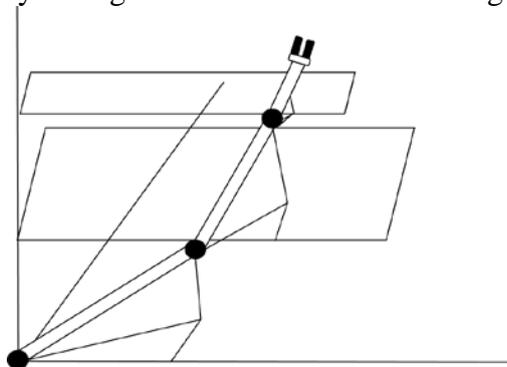


Fig.1 Three-Dimensional Modeling of the Robotic Arm

Improve and develop the man-machine dialogue technology composed of new programming language, high-performance external equipment and graphic monitoring technology. Besides ladder diagram, flow chart and special language instruction, the programming function and fault-tolerant function of BASIC language are also added. During this period, the programmable controller developed from a hard-wired sequence controller with contacts to a contactless programmable logic controller for minicomputers. Compared with previous relay control systems, the reliability was greatly improved and the flexibility was enhanced. The fixed-base three-link manipulator system with in-plane motion is taken as the research object, and the influence of gravity is not considered here. Taking a three-link manipulator moving from an initial position to an upright balance point as an example, the mechanical parameters of the three-link manipulator are validated by numerical guidelines to verify the effectiveness of the algorithm. In order to reduce the instability of the end-effector during the motion of the manipulator, simultaneous driving of each joint should be considered. This reduces the sudden acceleration caused by the sequential driving of the joints, but also improves the overall operating speed of the manipulator.

Considering a certain mobile robot, the two rear wheels of the mobile robot platform are driven by independent motors, and a 3-link mechanical arm is assembled at the centroid position of the mobile robot platform, and its hinge point position is driven by a motor. Figure 2 shows the mobile robot arm and its working environment.

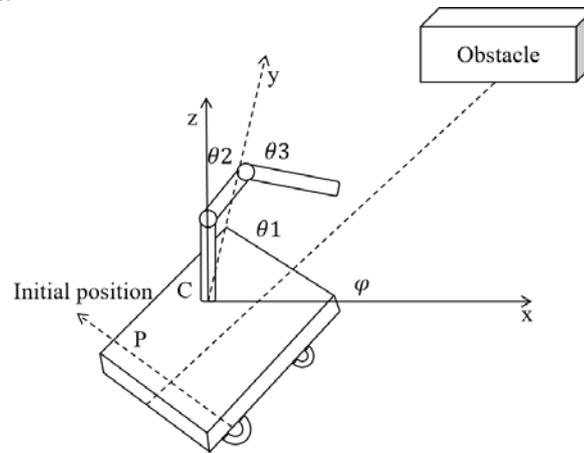


Fig.2 Mobile Robotic Arm and Its Working Environment

Programmable controllers and computers have interfaces, which are connected into a network by twisted-pair cables, coaxial cables or optical cables to realize the exchange of information, and can form a distributed control system with centralized management and decentralized control. The functions of PLC have added floating-point operation, square, trigonometric function, correlation number, look-up table, list, pulse width modulation transformation, etc., and initially formed the network system of distributed PLC, which has communication function and remote processing ability, and the programming language is more standardized and standardized. The end motion of a fixed base three-link manipulator system achieves the desired circular trajectory. The circular trajectory is highly consistent with the simulation results of the simulation system implemented by the self-compiled function, which demonstrates the computational reliability of the simulation model built on the toolbox of the robot system. The relationship between the speed in the basic coordinate system of the robot and the speed of each joint as well as the contact force between the hand and the outside world and the corresponding joint can be established by using the Jacobian matrix.

3.2 Kinematic Analysis

Kinematics analysis of robot arm is the basis of studying the motion of robot arm, and it is also the basis of studying the control of robot arm. Kinematics analysis of robot can make the control determine the position quickly, and it can be completed in as short a time as possible to achieve the goal of fast and accurate. In fact, it is very difficult to do this in the planning process. Here, the sensor is used to reconstruct only the scanned part, so that the reconstructed function is only a part of the obstacle function. The programming methods of products from different manufacturers are very different, and the technical exclusivity is strong. Workers must go through a long period of professional training before they can master the programming methods of a certain product. The production of traditional programmable controllers is monopolized by several manufacturers, which causes the performance-price ratio of programmable controllers to increase slowly. Modern programmable controller not only has functions such as logical operation, timing, counting, sequence control, but also has functions such as A/D and D/A conversion, numerical operation, data processing and so on. In this way, if the preheating operation is independent, the whole product production only needs six operations. The control task of this system is to control the automatic completion of these six processes. Figures 3 and 4 are shown.

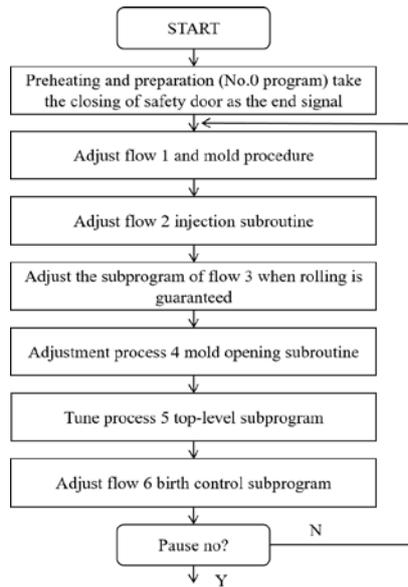


Fig.3 Sequence Control Block Diagram of Injection Molding Machine

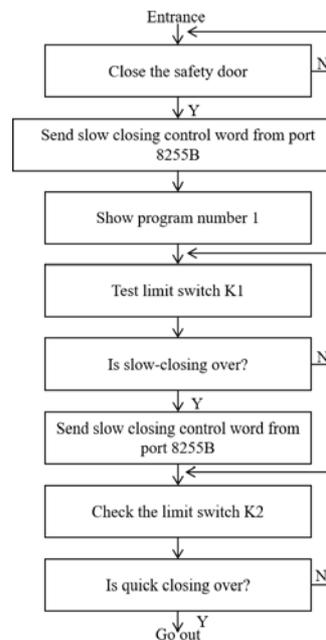


Fig.4 Clamping Subroutine

The state feedback gain of the time-varying system is also time-varying, that is, the state feedback gain varies with the rotation angle and angular velocity of the connecting rod. When the eigenvalue is given, the designed time-varying controller transforms the three-link manipulator system into a linear steady closed-loop system. When running to the third cycle, the gentle part becomes less obvious, which indicates that there is a certain vibration due to the driving and starting of the motor in the first period of time, which also conforms to the law of motion. The dynamic model of the manipulator system is established, and the Lagrange dynamic equation, which is the energy balance equation, is used to analyze the motion of multiple links under mutual constraints. Referring to the model, the dynamic model of the mobile arm system can be obtained:

$$M(q)\ddot{q} + V(q, \dot{q}) + G(q) = B(q)\tau - A(q)^T \lambda. \quad (1)$$

Substituting into equation (1) and eliminating λ gives:

$$M(q)\dot{q} + V(q, \dot{q}) + G(q) = B(q)\tau. \quad (2)$$

Among

$$M(q) = S^T MS, V(q) = S^T (V + MSv), G(q) = S^T G, B(q) = S^T B.$$

Equation (2) can be transformed into a stream:

$$\bar{M}(q) = \ddot{X} + \bar{V}(q, X) + \bar{G} = \bar{B}(q)\tau. \quad (3)$$

Among:

$$\bar{M} = MJ^{-1}, \bar{V} = V - MJ^{-1}J, \bar{G} = \bar{G}, \bar{B} = B.$$

According to the simulation results, we can see that the feedback gain designed by the direct parameterization method can make the time response of the time-varying system in practical application converge to zero quickly, that is, the system response quickly reaches a stable state. With the continuous upgrade of hardware and programming tools, programmable controller manufacturers are moving closer to manufacturing automation protocols, standardizing and standardizing the technology of basic parts of programmable controller, making different products compatible and easy to networking, so as to truly facilitate users and realize automation of factory production.

4. Conclusions

Programmable controller control technology will become one of the main means of industrial automation in the future. Compared with solving the characteristic structure of a closed-loop system through right coprime decomposition and singular value decomposition, the proposed direct parameterization method is particularly simple, and the desired system dynamic characteristics can also be obtained. The simulation process has good universality, and it is also applicable to most other elastically deformed objects, only by modifying the three-dimensional model of elastically deformed objects. And control the time of its display and disappearance according to the specific situation, then the program can be used for simulation. Firstly, the kinematics and dynamics models of the mobile manipulator system are established by using Lagrange dynamics method and Rhodes equation of nonholonomic dynamics. In the future industrial production, programmable controller technology, robot technology and CAD/CAM technology will become the three pillars of industrial production automation. At the same time, the parametric expression of the feedback gain also contains the degrees of freedom in the system, which can be used to improve or improve other aspects of the system performance.

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