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Trajectory Tracking Control Method for Flexible Robot of Construction Machinery Based on Computer Vision

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Abstract: For the application of computer vision, this paper proposes a combination of machine language coding method and wavelet neural network positioning method to build a robot intelligent system based on the motion trajectory of the manipulator. The solution can well solve the problems encountered by traditional robots in line tracking control. Research shows that the computer vision theory is used to design a learning toolbox that meets the task requirements and minimizes the time required to complete the task quickly and accurately. The MATLAB software simulation proves that this scheme is feasible. The test results show that the robot needs about 20 seconds in planning the route time, the time to bypass obstacles is within 5 seconds, and the error rate is about 2%.

1. Introduction

As an intelligent mechanical equipment, robot has been developing for a long time, but it is still in the primary stage due to many factors such as late start, immature technology and limited level in the research of industrial robots in China. However, with the emergence and popularization of computer vision and human interactive platform systems and the continuous enrichment and improvement of relevant theoretical achievements [1-2]. More and more important topics with high-precision motion control algorithms and methods developed in the field of computer vision to solve practical problems have become one of the new trends in recent years, among which the most typical is the research on the application of object-oriented programming technology in robots [3-4].

At present, scholars at home and abroad have done a lot of research work on robot bionic motion track tracking methods, and have made certain achievements, multi joint navigation system. Many researchers abroad have proposed a multi degree of freedom dynamic model to describe the

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interaction force and interaction relationship between robot actuators. Practical tests show that this algorithm has good inertial performance, speed stability and other advantages. At the same time, it can also apply visual technology to industrial control to solve nonlinear problems that cannot be solved by traditional methods [5-6]. Many domestic scholars and experts have made some achievements in the research of robot systems, such as the multivariable optimization design of robot vision problems and related algorithms. Some scholars have studied the potential relationship between human perception, visibility, coordination and control in motion by establishing an object-oriented dynamic model. Other scholars use particle swarm optimization to solve the trajectory tracking problem and come up with a solution [7-8]. Some scholars proposed a fuzzy controller based on artificial neural network, which realized the online identification and feedback control of motion state. Therefore, based on computer vision, this paper studies the trajectory tracking control of construction machinery flexible robot.

Aiming at the current situation of robot motion control relying on computer vision, this paper designs a method of trajectory planning and tracking for the system based on machine language controller. The algorithm judges whether flexible rules exist by using the theory of flexible chain lines. The research and simulation of robot 6-DOF trajectory planning problem and multivariable linear fitting experiment are completed by using the sliding window method in MATLAB software, and further optimization will be carried out after the final results are obtained.

2. Research on Trajectory Tracking Control Method for Flexible Robot of Construction Machinery Based on Computer Vision

2.1. Flexible Robot of Construction Machinery

The flexible robot of construction machinery is based on the humanoid motion control mode, and uses computer and sensor technology to analyze, process, simulate and design the data obtained from vision. It can realize the flexible change of space constraints in industrial production. Its basic workflow is as follows. Based on the image acquisition and preprocessing process, the original video sequence is used as the carrier to capture image information. Install a camera on the robot arm and shoot the target motion characteristic parameters, then use the computer to complete the 3D modeling and simulation function, and finally obtain real-time environmental data through the camera for simulation design [9-10]. The flexible robot of construction machinery is a multi-degree of freedom mechanical system, which is mainly composed of drive module, transmission mechanism, controller and sensor. The driving part includes the motor and battery. The driver provides power for the motor and realizes the torque required for its operation. The control module is divided into two sub functional units: position recognition and tracking pattern recognition. The trajectory identification includes the feedback information to the robot after judging the environmental changes to change the speed or direction of the robot when performing tasks, so as to achieve the desired goal. The device is composed of multiple degrees of freedom. Including: mechanical arm, end effector and visual sensor constitute a complete, flexible and movable closed loop system, and visual sensor, servo motor and position control unit constitute the whole machine structure (as shown in Figure 1)

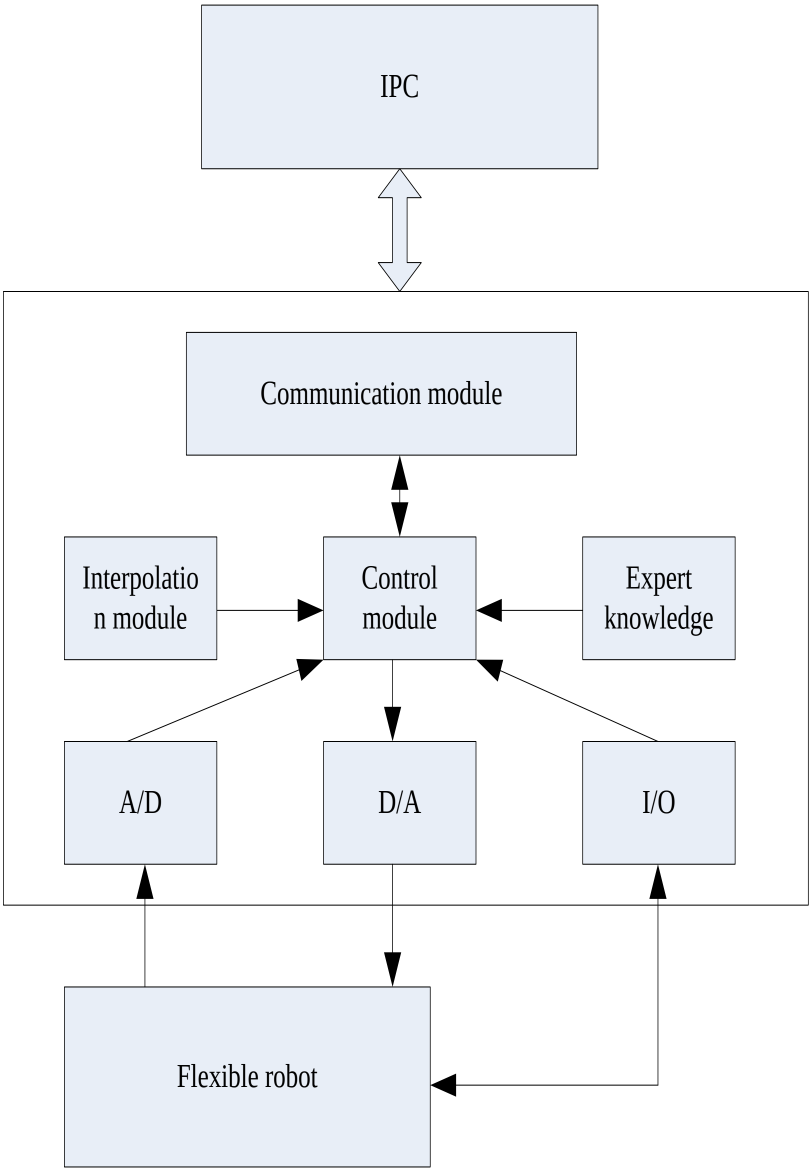

Figure 1. Flexible robot framework diagram

At present, most robots use the artificial sensing method to realize their movement. Although this method has many shortcomings, such as low efficiency and poor reliability, and because of the poor working environment. The research of flexible robot in construction machinery is to solve the problems of traditional vision methods and make it suitable for working objects with different functions, dimensions and spatial positions (or specific environments). At present, 3D Cartesian coordinate system has been used abroad for trajectory planning. Because X-ray scanning technology, geometric constraint control theory based on kinematic equations and two-dimensional point tracking algorithm can achieve high tracking accuracy of industrial robots and can track objects of arbitrary shape in the straight circumferential direction [11-12].

2.2. Robot Track Tracking

The trajectory tracking of robot is to observe the mechanical system in real time, and calculate the corresponding path in the computer according to the detected position and attitude. This algorithm needs enough sensor feedback signals to determine the motion state [13-14]. Therefore, in general, the angle between the input point and the output point is the angular velocity vector value of the robot end track, which is manually written in a two-dimensional rectangular coordinate system or three-dimensional spatial coordinates (such as lines, arcs, etc.). For different tracking systems, the detected position and attitude will also change accordingly. Trajectory tracking is to observe the motion of the robot, according to the actual control requirements, without affecting the real-time performance and system stability. Establish the corresponding relationship between the terminal operator and the computer. In order to ensure that the machine can accurately complete the task and reach the required point of arrival or leave the ground at a certain angle, so as to ensure that the whole trajectory is always stable and traceable. The information obtained from the sensor is used as a decision support robot to accurately control the surrounding environment, so as to determine the coordinate value and expected motion attitude of the final manipulator in space. The trajectory of a robot refers to the figure needed by the robot to walk and perform tasks in space. Because of some limitations of human beings, these data cannot be accurately described by mathematical knowledge. Therefore, in order to make better and more effective use of ground information, researchers can control the position of machine tools. The purpose of robot trajectory tracking is to minimize the uncertainty in the motion process, so as to ensure the overall performance of the system [15-16].

2.3. Computer Vision Technology

Computer vision uses image processing technology to recognize human eyes, and realizes information transmission between machine and brain through digital signals, so as to achieve intelligent purposes. The application of computer vision system in robot field can effectively improve the working efficiency of robot. At the same time, it has strong robustness. At present, a new type of artificial intelligence algorithm based on neural network, fuzzy set theory, support vector machine and other artificial intelligence algorithms is widely used [17-18]. Computer vision refers to the use of digital image processing technology and parallel storage to complete the real-time detection of robot trajectory. This method can obtain the robot position information accurately and quickly. Computer vision technology is a multi-source parallel system, which can be a complete, open and inclusive system. It is widely used in industrial production. This method is mainly composed of three steps. The image acquisition, preprocessing, decision-making process and final output result constitute the whole closed-loop control system. The most important two links are feature extraction and selection. The latter is to classify and identify the input signals and give corresponding rules. Computer vision has a wide range of applications in the field of robots, and is the most active, potential and promising research and development. It can obtain the target motion state information through the image acquisition system. The technology can quickly identify and locate objects in complex environments, and automatically adjust tracking algorithms and path planning parameters according to real-time conditions. The sensor feedback data can also be directly stored in the network database. In addition, computer vision has made quite good achievements in the field of robots, and its powerful functions make it highly adaptable and robust. Robust path searching strategy is adopted in the robot motion track tracking to ensure that the machine can find the optimal route as quickly as human beings. At the same time, appropriate iteration times can be selected according to different task requirements, so as to better use computer vision technology to process and classify complex data. The framework flow chart is shown in Figure 2:

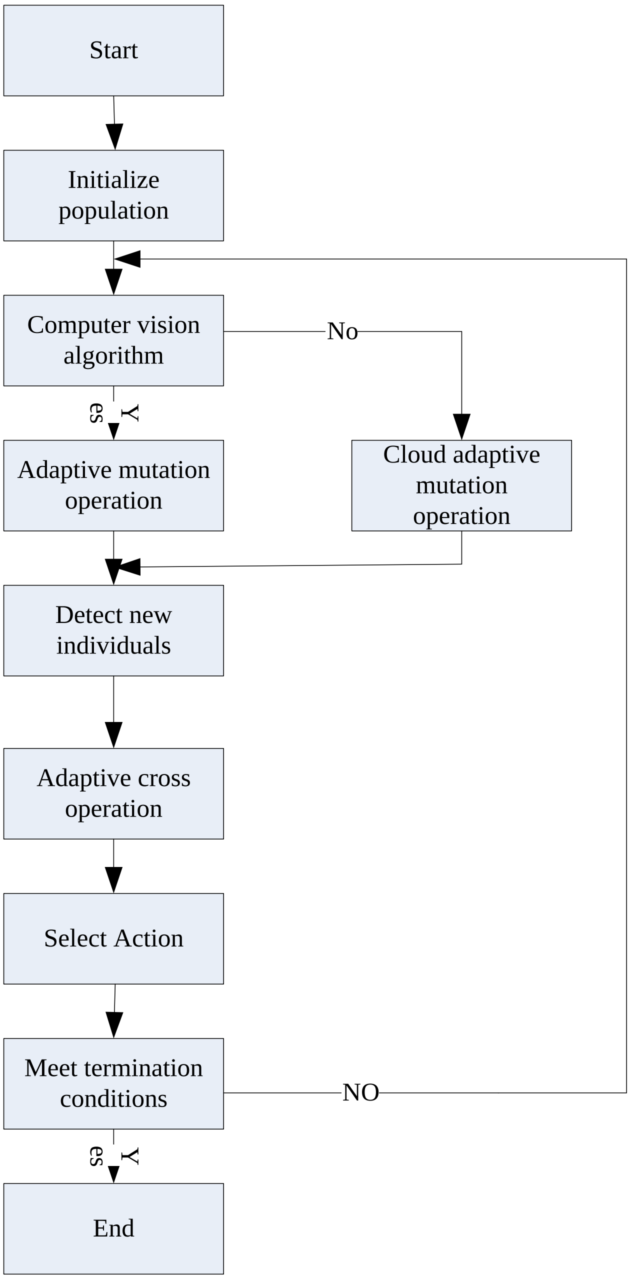

Figure 2. Flow chart of the computer vision algorithm

In computer vision technology, the gray level transformation of an image is the same as that of each pixel in the image, which makes the gray level value of the image pixel more smooth. The target area of a gray image is compressed between certain gray values without strong gray transformation. The linear image grayscale transformation function f (x) is a one-dimensional function, as shown in Formula 1:

$$f(x) = fA * x + fB \tag{1}$$

The grayscale transformation equation of the image can be obtained from the transformation function, as shown in Equation 2:

$$DB = f(D4) = fA * DB + fB \tag{2}$$

If the exposure is excessive or insufficient, the light and shade distribution of the image will not be scattered, so the overall gray level of the image will be scattered into a small area, the displayed image will become blurred, and the gray level of the image will become worse.

3. Experiment Process of Trajectory Tracking Control Method for Flexible Robot of Construction Machinery Based on Computer Vision

3.1. Trajectory Tracking Control Method for Flexible Robot of Construction Machinery Based on Computer Vision

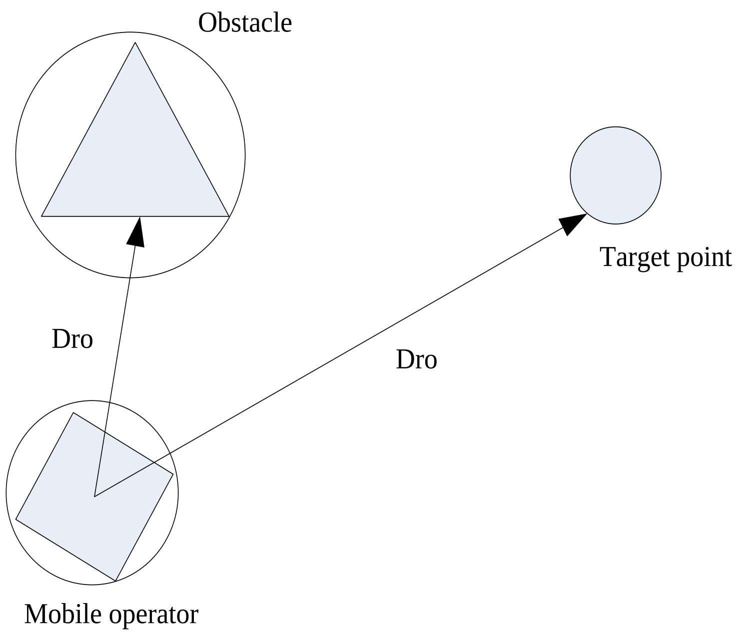

Figure 3. Robot movement trajectory

The robot system (as shown in Figure 3) is composed of an actuator, motion control and trajectory tracking. The motion control system includes servo motor drive, position detection and path planning. In the whole closed loop, a stepping motor is used as the driver to drive the mechanical arm to perform corresponding actions. When the robot hand completes the specified task, the PLC will judge its travel speed and direction and feed it back to the CPU to realize the command output device. The target position within the current space range of the robot is called the idle place or fixed point. At this time, the computer system controls the robot claw to move to the specified position according to the command. The robot system is composed of two drivers, four joints and six sensors, one of which is the control end, and the other is the trajectory movement. After a lot of experiments, it is found that the robot adopts the parallel mechanical vision method to realize the real-time feedback of object position information (such as images). In order to improve the research level of flexibility, flexibility, adaptability and robustness. Two different size and attitude sensors, angle measurement module and visual filtering algorithm are used in the robot system. The trajectory tracking control of robot is a complex and huge system, which involves many disciplines, such as computer vision, electrical machinery and machine learning. For researchers in different fields, they have different views on robot models. This paper mainly uses MATLAB programming software to carry out dynamic simulation to realize trajectory optimization design, and analyzes and compares the simulation results to verify the practicability and accuracy of this method and give corresponding suggestions, and at the same time, it provides some reference and direction of thinking for the following chapters. The trajectory tracking control model of the robot is based on the feedback information of sensors and actuators in the control system, combined with the trajectory deviation value calculated by the controller to carry out target location, path planning and global optimal route optimization.

3.2. Performance Test of Trajectory Tracking Control Method for Flexible Robot of Construction Machinery Based on Computer Vision

In this system, a robot hand based on computer vision is used to control the robot's path. First, obtain the objects and tools in front through the camera module. Then use the camera to capture the image and transmit the data to the server, and generate the corresponding command in the processing background to return to the controller for the next frame cycle motion trajectory analysis and feedback adjustment. Finally, WIFI is used to realize the environmental information and real-time path tracking function as well as the final route selection and task operation for hand posture sensors, accelerometers and other devices, and to detect the path of the robot. In the process of motion, if two objects are found to have an included angle greater than 90 degrees or an angle less than 45 degrees, an alarm will be given. If there is an angle between the two targets, the system will enter the task execution state. When these problems are solved, the system will start the next step of work and run to the ultimate goal of stopping the robot, and feedback the entire designed position to the computer for processing and adjustment.

4. Experimental Analysis of Trajectory Tracking Control Method for Flexible Robot of Construction Machinery Based on Computer Vision

4.1. Performance Test and Analysis of Trajectory Tracking Control Method for Flexible Robot of Construction Machinery Based on Computer Vision

Table 1 shows the performance test data of the trajectory tracking control model of the flexible robot of construction machinery.

Table 1. Track tracking control model performance test

Test times	Robot trajectory error rate(%)	Robot route planning time(s)	The robot bypassed the obstacle time(s)
1	2	25	3
2	3	21	2
3	2	24	4
4	1	23	3
5	2	21	4

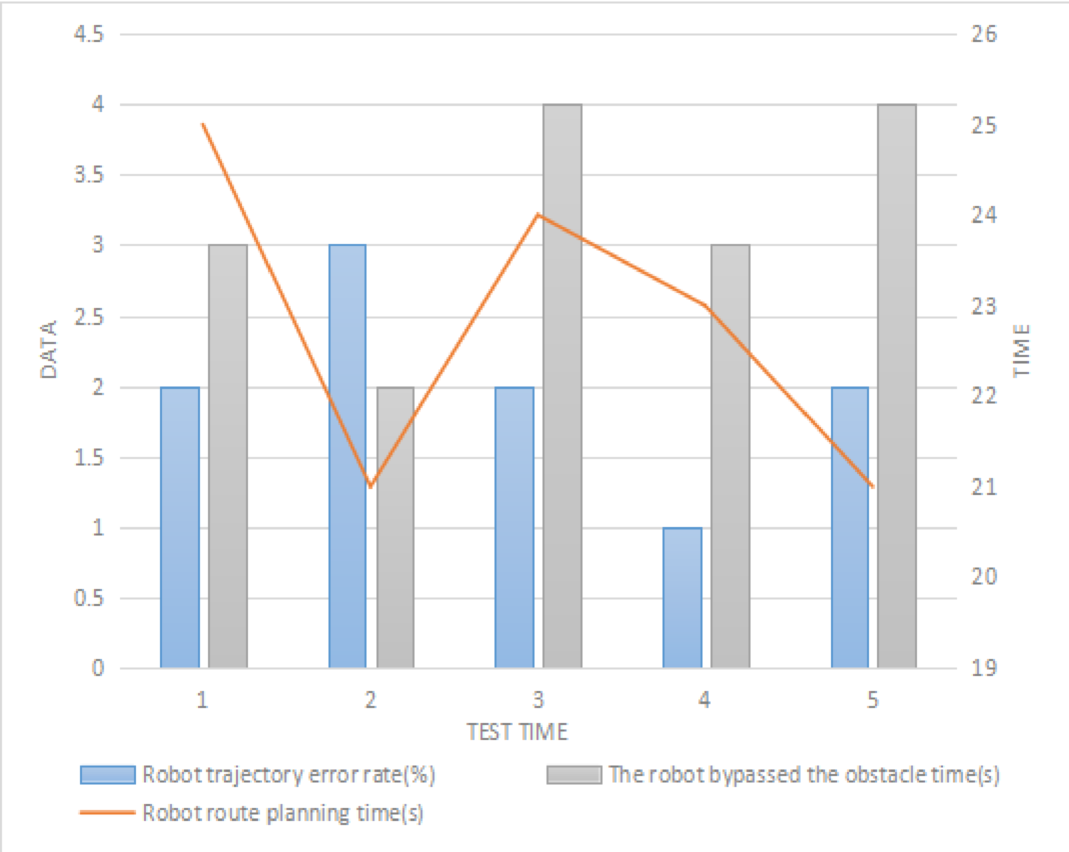

Figure 4. Performance testing

Path planning and trajectory optimization are carried out for the robot. After the robot's route is completed, the network card is used to record and analyze its walking speed, and then MATLAB programming is used to calculate the required direction, steps and time of movement. Then, by comparing the data results obtained under different algorithms, determine whether the algorithm can achieve the desired results. Finally, the sliding window method is used to judge whether the optimal scheme is not ideal or fine tune the trajectory before continuing to move forward until the goal is finally achieved. It can be seen from Figure 4 that the robot needs about 20 seconds in planning route time, the time to bypass obstacles is within 5 seconds, and the error rate is about 2%.

5. Conclusion

In the field of industrial robots, due to the low quality of the image obtained by the visual sensor, it has the characteristics of large inertia ratio and high complexity. Based on a robot system with flexible computer as the core and geometric structure, this paper studies the Glex programming trajectory planning method, which uses bionic design to realize machine dependent intelligent control technology; After the algorithm is simulated and verified, a platform that can track the motion state of industrial robots in real time is built by using Matlab development environment, and is displayed in MATLAB software with model language.

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Data Availability

Data sharing is not applicable to this article as no new data were created or analysed in this study.

Conflict of Interest

The author states that this article has no conflict of interest.

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