The Motion Trajectory Optimal Control of Robot Based on Small PLC

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Abstract: in the process of studying robot motion trajectory optimal control method, when using the current algorithm to process optimal control for robot motion trajectory, there are problems of a large amount of calculation and complex control process. For this purpose, a robot motion trajectory optimal control method based on small PLC algorithm is proposed. The ruled surface generation principle is fused to describe position and posture of robot end effector, ruled surface area and its change rate formed by the motion trajectory of equivalent angular displacement vectors are acted as functional extremum, Lyapunov function is introduced into PLC instruction system on the basis, and the robot feedback tracking control law is designed to establish robot nonlinear kinematic model based on Small PLC control, and then effectively complete robot motion trajectory optimal control. The experimental simulation shows that the motion trajectory optimal control method based on the small PLC algorithm has the high accuracy, and the adaptability is high.

1 Introduction

In China, with the continuous improvement of the level of science and technology, robot motion trajectory control technology has a very important position in the robot design and planning [1.2.3]. But current robot trajectory optimal control research mostly limits to the motion trajectory control method based on parallel control robots, this method is easy to produce singular point in control paths, which leads to optimal trajectory control algorithm cannot be used in the practical application problems [4.5.6]. The optimal control method of robot motion trajectory is an effective way to solve this problem, which has caused many experts and scholars' attention. Due to the robot motion trajectory optimal control method is of far-reaching development significance, so it has become the focus of expert to study, and has received extensive attention, at the same time, there are a lot of good methods [10].

2 robot motion trajectory control principle

In the control process of the robot motion trajectory, the main goal of the robot motion trajectory control is to control the center of mass of the robot, including make the center of mass trajectory of the robot change in accordance with the requirements, namely the so-called robot trajectory control problem, according to the motion of the centroid, according to a certain trajectory to control. And robot trajectory generation is generally given several points on the expected track, through the inverse kinematics model to calculate joint control angle reversely, by the controller of the robot to control joint angle motion to implement drive control of robot. The concrete steps is as follows:

In the process of controlling the trajectory of robot motion, there are $f(x)\in C[a,b]$, $p(x)\in H_n$, if there is $x=x_0$:

$$f(x_0)-p(x_0)\big|=\left\|f(x)-p(x)\right\|_\infty=\max_{a\le x\le b}\left|f(x)-p(x)\right|=\mu \quad (1)$$

In the formula mentioned above, x_0 is the deviation point of $p(x)$, and $\mu\ge 0$ is called the deviation mode of $p(x)$ for $f(x)$. $n=20$, $x_0=0$, $\Delta x=-40$, the centroid coordinates x_i of the robot are calculated by using the following formula:

$$x_i=x_0+(\Delta x/2)\left[1-\cos(i\cdot\theta-\theta/2)\right] \quad (2)$$

In the control of the motion trajectory of robot, the corresponding y_i is calculated by $y_i = f\left(x_i\right) = x_i^2 / 20$.

3 principles of robot motion trajectory control optimal method

3.1 robot optimal trajectory planning

Assuming the position of the robot is described with the position of robot end effector reference point p in Cartesian coordinate. Posture of the robot is described with Φ, Φ is equivalent vector of angular displacement of the robot and $\Phi = \varphi s$, s is equivalent rotation shaft, φ is equivalent angular displacement, posture vector Φ overlaps with line S and through point P. So the robot's position equation can be described as:

$$X = \left[P, \Phi\right]^T \quad (3)$$

In the process of robot motion trajectory optimal control, based on the above content, it can be explained that, in the ruled surface, the two ends of the posture vector Φ described with P and Q on line S, accordingly, motion start and end points of robot end effector reference points represented by P_S, P_e and Q_S, Q_e. In the robot pose ruled surface, two lines represents robot posture trajectories, $P_S P_e$ and $Q_s Q_e$ can be expressed as the following equation:

$$\begin{cases} p\left(t\right) = r_1\left(t\right) \\ Q\left(t\right) = r_2\left(t\right) \\ \Phi\left(t\right) = r2\left(t\right) - r1\left(t\right) \end{cases} \quad (4)$$

In the formula, $t \in \left[t_1, t_2\right]$, t_1 and t_2 are the starting time and the end time of the motion respectively. In the process of robot motion trajectory optimal control, the upper organized as follow

$$r\left(t, \lambda\right) = r_1\left(t\right) + \lambda\left[r^2\left(t\right) - r^1\left(t\right)\right] \quad (5)$$

In the process of robot motion trajectory optimal control, the area of the robot pose surface can be calculated by the following formula:

$$A = \int_{ps}^{Pe} \int_{QS}^{Qe} da \quad (6)$$

In the process of robot motion trajectory optimal control, the area of the robot's lined surface and its one, two order change rate are $r^1\left(t\right)$, $r^2\left(t\right)$ and $r_1\left(t\right), r_2\left(t\right)$ function. The size of the area of the ruled surface can reflect the size of the robot's movement speed and the length of the path, the change rate of time can reflect the size of the acceleration. Since the dynamics performance of the robot is directly related to the velocity and acceleration, if minimal ruled surface area and rate changes of time are obtained, the robot position trajectory with minimal movement speed or the shortest path, minimum acceleration or optimum dynamics performance is obtained,.

Considering the robot's dexterity, the area of the lined surface and its rate of variation, planning objective function can be expressed as:

$$F = \int_0^1 d\lambda \int_{t1} \frac{1}{\xi} \varphi\left(t\right) \left| p\left(t\right) + \lambda \Phi\left(t\right) \right| dt \quad (7)$$

3.2 the realization of the optimization method for trajectory control of robot motion

In robot motion trajectory optimal control, Lyapunov function is introduced into PLC instruction system on the basis, and the robot feedback tracking control law is designed to establish robot nonlinear kinematic model based on Small PLC control, and then effectively complete robot motion trajectory optimal control.

The concrete steps is as follows:

In the process of robot motion trajectory optimal control, the mobile robot is regarded as a four wheeled car of two wheel drive. Its kinematic model is taken as:

$$[\dot{x},\dot{y},\theta]=[v,\omega]\begin{bmatrix}\cos\theta & \sin\theta & 0\\ 0 & 0 & 1\end{bmatrix} \quad (8)$$

In the formula, $[\dot{x},\dot{y},\theta]$ is the derivation of current position of the robot in Cartesian coordinates, v,ω respectively for translational and rotational speed. Due to the local effect of trajectory tracking is difficult to meet the mobile robot work requirements , thus, directly consider to introduce Lyapunov functions into the PLC instruction system, and design the robot feedback tracking control law, and establish nonlinear kinematics model of robot:

The Lyapunov function is introduced into the PLC instruction system, and the feedback tracking control law of robot is designed:

$$U_O=[v_0 \quad \omega_0]=\left[v_r\cos\tilde{\theta}+K_X X,\omega_r+v_r\left(K_Y y+k_\theta\sin\theta\right)\right] \quad (9)$$

In the process of robot motion trajectory optimal control, the Lyapunov function of the control law is obtained according to the formula.:

$$V_0=\frac{1}{2}\left(x^2+y^2\right)+\frac{1-COS\vartheta}{K_Y} \quad (10)$$

In the process of robot motion trajectory optimal control, "back" to the whole system, design control law is:

$$U=[u_1,u_2]=[\dot{v},\dot{\omega}]=-kz+U_0-\left[\frac{\partial v_o}{\partial p}\right]^T\left[g(p)\right]^T \quad (11)$$

The above equation can explain, v,ω are velocity state variables of dynamics model, V is Lyapunov function of dynamics model, control law U can make $V\le 0$. Under the function of control law, state variables of the PLC instruction system is changed from $[X,Y,\theta]$ in kinematics model to five dimension state variable $[X,Y,\theta,v,\omega]$ of dynamical model, namely PLC instruction system control variables "back" in kinematic model is PLC instruction system state variables of dynamics model.

4 experiments and simulation results

In order to prove the effectiveness of the robot motion trajectory optimal control method based on the small PLC algorithm, an experiment is needed.

The robot tracking line trajectory is: $y_r-x_r=0$, $\omega_1=0$, $v_r=1m/S$, when the initial state variable are $[0 \quad 0 \quad 2 \quad 1]$, $[0 \quad 0 \quad 2 \quad -1]$, the improved algorithm and the traditional algorithm are adopted for control experiment of linear motion trajectory of robot, the control experimental results of two algorithms are compared to measure the control effectiveness of the different algorithms.

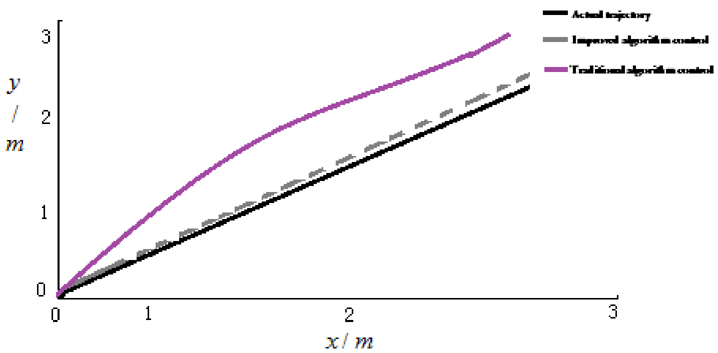

Fig. 1 the control results of different algorithms at $\omega=-1rad/s$

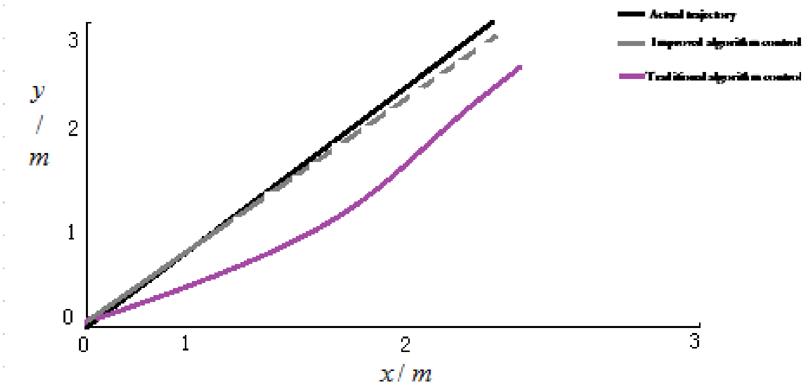

Fig. 2 the control results of different algorithms at $\omega = 1rad / s$

From Figure 1 and Figure 2 can be seen, the control effect of the improved algorithm is in agreement with the actual robot motion trajectory, which proves that trajectory optimization control method based on small PLC algorithm of high control accuracy, and strong adaptability.

5 Conclusions

The current algorithm for robot motion trajectory optimal control, has problems of a large amount of calculation and complex control process. For this purpose, a robot motion trajectory optimal control method based on small PLC algorithm is proposed. The ruled surface generation principle is fused to describe position and posture of robot end effector, ruled surface area and its change rate formed by the motion trajectory of equivalent angular displacement vectors are acted as functional extremum, the Lyapunov function is introduced into PLC instruction system on the basis, and the robot feedback tracking control law is designed to establish robot nonlinear kinematic model based on Small PLC control, and then effectively complete robot motion trajectory optimal control. The experimental simulation shows that the motion trajectory optimal control method based on the small PLC algorithm has the high accuracy, and the adaptability is high.

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