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DESIGN CONTROLLER FOR ROBOT JOINTS OF 5 DEGREES

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ABSTRACT

In the joint control system, the control quantity is the position of the robot joint: the rotation angle for the joint; Direct displacement for translational joints. The controller is designed to ensure the position of the joint always sticking to the position, ie the deflection of the position of convergence to zero with the smallest time. The position of the joint is calculated from the position of the robot hand position in the work space through reverse bias calculation. The advantage of the control method in the joint space is that the controller acts directly on the drive system of the joint. However, this control system is difficult to ensure the accuracy of the position of the hand when there are mechanical errors or lack of information on the position relationship between the robot and the object.

Key word:
robot joint, 5 degrees, joint control system, rotation angle, Direct displacement for translational joints.

INTRODUCTION

CONTROL SYSTEM CONFIGURATION A SUBSECTION SAMPLE

The function of the motion control system is to ensure that the robotic hand moves in a pre-set trajectory in the work environment. Robot movements are made by robot-assisted drive systems. On this basis, there are two types of motion control systems: the control system in the joint space and the control system in the work space.
The Lagrange Equation of the 5 DOF robot is a second order nonlinear differential equation, which controls the input of the force acting on each joint of the robot as unknown (assuming that the robotic actuator is considered to be the source force and momentum). The problem is how to control the force on each joint to achieve the desired position. There are many techniques and control methods, the simplest one to consider here is independent coupling. Each robot arm joint is referred to as a one-to-one system.
Synthesized motor control loop
The rotational speed control system for DC motors has a number of rotary gradients with a rotary speed regulator in the outer ring and a regulator in the inner loop. The adjusting circuit has the effect of rolling torque (due to flux constant, torque depends only).
In [1,2,3,4] we have built the Lagrange Equation of the 5 DOF robot and design controller for robot joints of 5 degrees
The actuator model has three control loops (current, speed, position) as shown in Fig. 1.

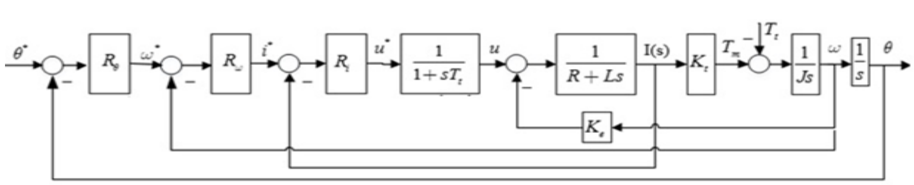

Fig. 1. Controlled-system diagram

Adjust the armature current for the design of the current regulator, we use the transfer function of the armature circuit and ignore the induced electromotive force. The flowchart is structured as shown in Fig. 2.

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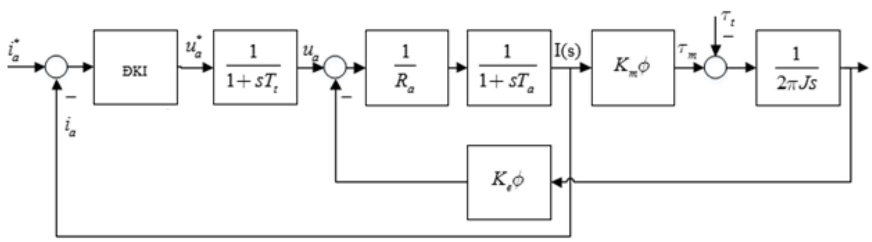

Fig. 2. DC motor current adjustment circuit

Appropriate control rectifier is proportional to the inverse of the inertia of the armature circuit

$$G_I(s)=\frac{i_a(s)}{u_a^*(s)}=\frac{1}{1+sT_t}\frac{1}{R_a}\frac{1}{1+sT_a} \tag{1}$$

The time constant of the armature circuit and the amplitude we know

$$T_1=T_a=\frac{L_a}{R_a};\qquad K=\frac{1}{R_a} \tag{2}$$

Adjustment of the selected line is the PI step, designed according to the optimal module we have

$$T_{RI}=T_1=T_a;\qquad K_{RI}=\frac{T_1}{2T_tK}=\frac{R_aT_a}{2T_t} \tag{3}$$

From this we obtain the transfer function of the PI line regulator as follows

$$G_{RI}=\frac{u_a^*(s)}{i_a^*(s)-i_a(s)}=K_{RI}\left(1+\frac{1}{sT_{RI}}\right)=\frac{L_a}{2T_t}\left(1+\frac{1}{sT_a}\right) \tag{4}$$

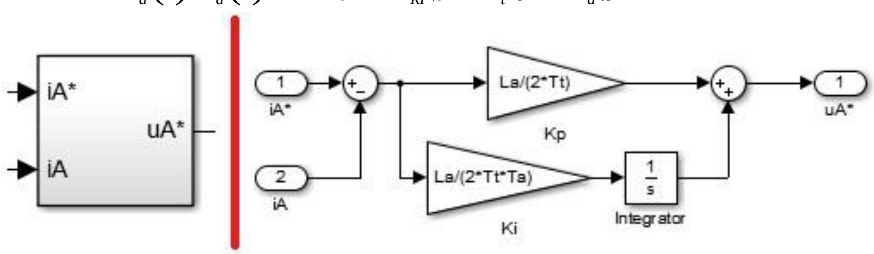

Fig. 3. Patching armature adjustment line

Adjust the speed of rotation

For the rotary speed control loop, the design loop is designed as a sub-loop, which can be grouped into a part of the control object with the transfer function as follows:

$$G_{Nt}(s)=\frac{i_a(s)}{i_a^*(s)}=\frac{1}{1+2T_ts+2T_t^2s^2}\approx\frac{1}{1+2T_ts} \tag{5}$$

In addition to the mechanical transmission function, the general control object will now have the function model as follows:

$$G_N(s)=\frac{n(s)}{i_a^*(s)}=\frac{K_mf}{2pJs}\frac{1}{1+2T_ts}=\frac{1}{T_Ms}\frac{1}{1+T_ss} \tag{6}$$

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With two parameters of the object is the mechanical time constants and the time constant of the inner circle we apply the design method of the standard symmetric optimization and obtain the parameters of the adjustment phase.

$$T_{RN} = 4T_s = 8T_t; \qquad K_{RN} = \frac{T_M}{2T_s} = \frac{1}{4T_t}\frac{2pJ}{K_m f} \tag{7}$$

With the above parameters we obtain the generalized transfer function of the rotary speed control loop according to the symmetrical optimization standard

$$G_{NI}(s) = \frac{n(s)}{n^*(s)} = \frac{1+8T_t s}{1+8T_t s+16T_t^2 s^2+16T_t^3 s^3} \tag{8}$$

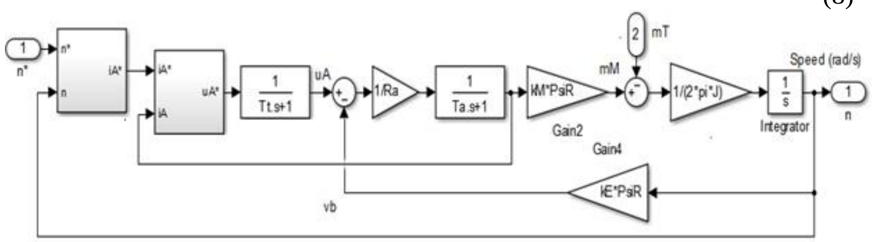

Fig. 4. System structure of rotary speed control of DC motor

The Lagrange Equation of the 5 DOF robot is a second order nonlinear differential equation, which controls the input of the force acting on each joint of the robot as unknown (assuming that the robotic actuator is considered to be the source active momentum). The problem is how to control the force on each joint to achieve the desired position. There are many techniques and control methods, the simplest one to consider here is the independent coupling control. Each robot joint is considered one-to-one, and the joints between the joints are considered interference components.

The PID tester demonstrates the following:

$$F = K_p e + K_i \int_0^t e(\tau)d\tau + K_d \dot{e} \tag{9}$$

The position of the joint is calculated from the position of the robot in the working space (S) through the reverse bias calculation; e is the error between the set value and the output value; K_p, K_i, K_d is the ratio of the integral, the differential of the PID controller.

The transfer function of the PID controller is written as:

$$G_{PID}(s) = K_p + \frac{K_I}{s} + K_D s = K_p\left(1+\frac{1}{T_I s}+T_D s\right) \tag{10}$$

Table 1: Parameters and values of DC motors selected for simulation

Parameters	Value
Armature resistance	$R_a = 250\ mW$
Inductive armature	$L_a = 4\ mH$
Inertia	$J = 0{,}012\ kgm^2$
Definition term	$f = 0{,}04\ Vs$
Engine constant	$K_e = 236{,}8$ $K_m = 38{,}2$

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Table 2: DH parameters of the 5 DOF robot selected for simulation

Band	Joint	θ_i	α_i	d_i	a_i
1	0-1	θ_1	90^0	1	0
2	1-2	θ_2	0	0	1
3	2-3	θ_3	0	0	1
4	3-4	θ_4	90^0	0	1
5	4-5	θ_5	0	1	0

The time constant of the rectifier stage $T_t = 100\,ms$. Matlab's optimization software determines the optimum parameters of the controller. Classic PID controller: $K_P = 545; T_I = 59530; T_D = 0.1$

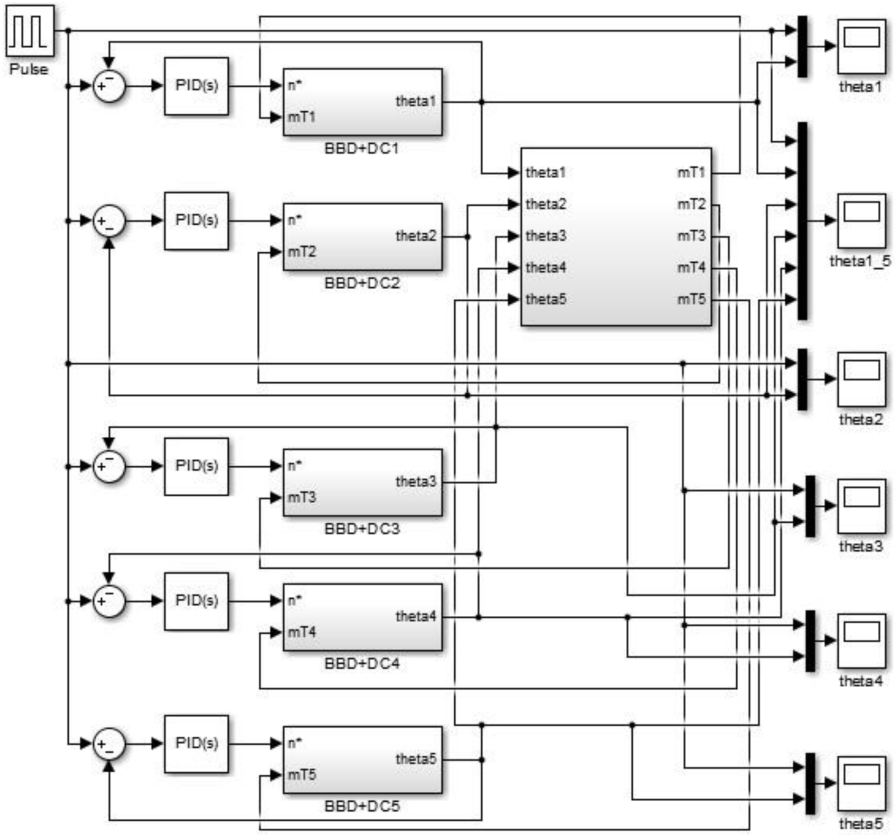

Fig. 5. Diagram of robot control system 5 DOF by PID

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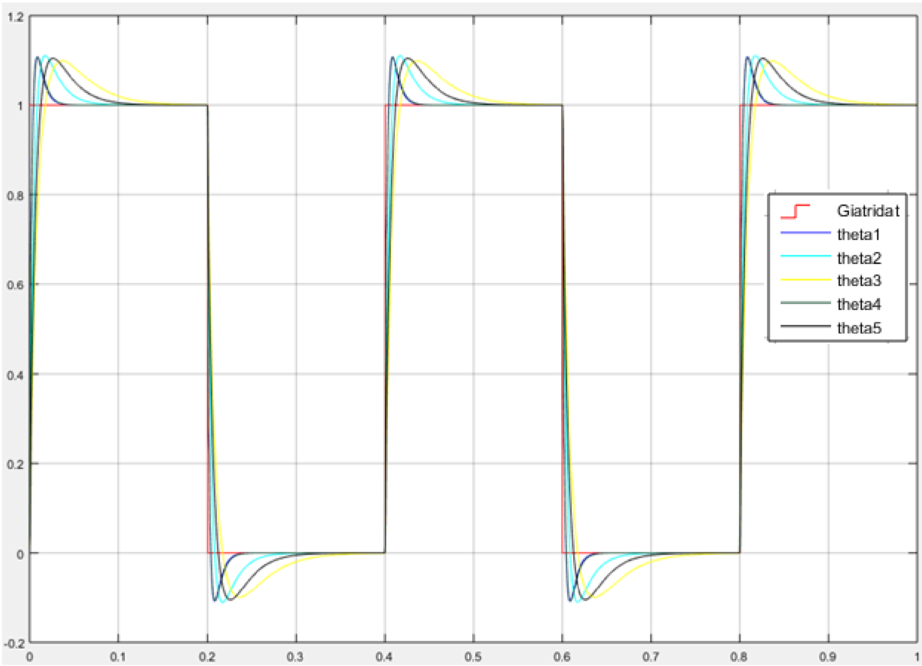

Fig. 6. Characteristics of joints when controlled by PID

The simulation results show that the output response is based on the set value. However, the result was limited in quality, namely over-adjustment (less than 10%). To overcome this we use nonlinear adaptive controllers built on the basis of modern control theory.

CONCLUSION

This research has designed the controller for robot joints of 5 degrees. Attaching motors to the robot, we can construct a diagram simulating the mechanical hand's joint position control system using classic PID. The actuator transfer function includes line adjustment, rotation speed adjustment. Simulating 5 degrees of freedom robot, actuator on Matlab; Build a robot motion control system using classic control rules.

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