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Research on Simple Inverted Pendulum

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Abstract. Inverted pendulum is a typical automatic control device. It not only establishes its dynamic model, but also constructs its transfer function, and studies its poles and stability conditions. PID is used to control its movement, through a lot of experiments, the corresponding data sent to the host computer, and the data were analyzed to determine the parameters, P, I, D, to achieve automatic upside down in the range of angles within a small, and can realize the circular motion. The inverted pendulum has the characteristics of strong anti-interference and quick response.

Introduction

Inverted pendulum is a typical automatic control device, whose working principle is similar to that of a simple pendulum, so it is necessary to study its dynamic model for analysis. Can be regarded as an inverted pendulum, rotating around a fixed axis, similar to the rotation of a rigid body. Careful analysis of the force, the corresponding dynamic model can be established, on the basis of the conversion to the transfer function of automatic control, in the complex domain to its research, establish the final transfer function is available, the PID control algorithm.

Theoretical Analysis

The inverted pendulum model is shown in figure 1. The equations of motion of the model are derived. First, the force of the car model is analyzed, as shown in equation (1):

$$F = mg\sin[\theta(t)] - ma(t)\cos[\theta(t)] + mLx(t) \quad (1)$$

For further derivation, the following differential equations can be obtained:

$$L\frac{d^2\theta(t)}{dt^2} = 3g\theta(t) + 3Lx(t) \quad (2)$$

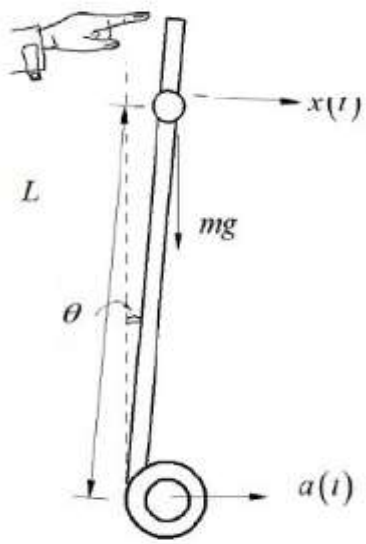

Figure. 1 inverted pendulum model

Software program

In this design, under KEIL 5, programming with C language. PID control of inverted pendulum. Some code is given below:

```
int Position(int Encoder)
{
Static float Position_PWM,Last_Position,Position_Bias,Position_Differential;
static float Position_Least;
Position_Least =Encoder-Position_Zero;
Position_Bias *=0.8;
Position_Bias += Position_Least*0.2;
Position_Differential=Position_Bias-Last_Position;
Last_Position=Position_Bias;
Position_PWM=Position_Bias*Position_KP+Position_Differential*Position_KD;
return Position_PWM;
}

int TIM1_UP_IRQHandler(void)
{
if(TIM1->SR&0X0001)
{
TIM1->SR&=~(1<<0);
if(delay_flag==1)
{
if(++delay_50==10)
delay_50=0,delay_flag=0;
}
Encoder=Read_Encoder(2);
Angle_Balance=Get_Adc_Average(7,15);
Balance_Pwm =balance(Angle_Balance);
    Position_Pwm=Position(Encoder),Position_Target=0;
Moto=Balance_Pwm-Position_Pwm;
Xianfu_Pwm();  if(Turn_Off(Voltage)==0)
Set_Pwm(Moto);
Led_Flash(100);  Voltage=Get_battery_volt();
Key();
}
return 0;
}

int balance(float Angle)
{
float Bias;
static float Last_Bias,D_Bias;
int balance;
Bias=Angle-ZHONGZHI;
D_Bias=Bias-Last_Bias;
balance=-Balance_KP*Bias-D_Bias*Balance_KD;
Last_Bias=Bias;
return balance;
}

void Key(void)
```

```
{
    int Position=2080;
    static int tmp,flag,count;
    tmp=click_N_Double(100);

    if(tmp==1)flag=1;
  if(tmp==2)flag=2;

    if(flag==1)
    {
        Position_Zero++;
        count++;
        if(count==Position)   flag=0,count=0;
    }
        if(flag==2)
    {
        Position_Zero--;
        count++;
        if(count==Position)   flag=0,count=0;
    }
}
```

Summary

In this paper, the working principle and control method of inverted pendulum are studied. It is equivalent to an inverted pendulum, and its dynamic model is studied. Differential equations are established. The differential equation is transformed into transfer function, and it is controlled by PID. The parameters of P, I and D are determined by experiment, and the control of inverted pendulum in a small range is realized. It has certain practical value.

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