ATTITUDE CONTROL OF TWO WHEELED SELF-BALANCING VEHICLE

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Abstract:-

This paper mainly introduces the STM32 as the development platform of the two wheeled balancing car, and successfully developed a car model. Firstly, the paper studies the overall design scheme and the basic working principle of the car system. Secondly, the control flow of the software system of the two wheeled balancing car is deeply studied, and the double closed loop control of DC motor speed position is adopted to realize the normal operation of the car. Then, in the process of debugging, the three parameters of the virtual decomposition of the car system (the vertical ring, the speed loop, the steering ring) were tested respectively. In the end, the prototype of the two wheeled balancing car is debugged, and the running test is carried out for the obstacle free and the obstacles. The experimental results show that the two wheeled balancing car can be operated stably, and can realize the basic function.

Keywords:- *Two wheeled self- balancing car; STM32 MCU; balance control; PID control*

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INTRODUCTION

Two wheeled balancing car is the practical application of mobile robot in real life. The research of mobile robot involves the fields of computer technology, software technology, microelectronics technology, and related disciplines such as automatic control theory, modern control theory, C language, circuit and so on. Because it involves a wide range of research is difficult, but the technical content is high, the demand for talent, so it can be said that the development of robots can represent a country's overall national strength. The effect of noise interference, engineering, communications, aerospace, industrial automation and other fields with a wide range of applications. Two wheeled balancing car is also a kind of wheeled mobile robot, which can adjust the acceleration of the motor according to the tilting angle of the car body so as to ensure the balance of the car. The model of two wheeled vehicle is derived from the inverted pendulum, which has the characteristics of uncertainty, nonlinearity and strong coupling. Therefore, the two wheeled self-balancing car for the inspection of various control algorithms are of great significance.

In the automobile and other motor vehicles prevailing in the moment, the motor industry has brought serious environmental pollution, traffic problems and energy issues. Compared with the traditional wheeled robot, the two wheeled balancing car has the advantages of in situ steering, no brake, small power, etc., and can be operated in some complex paths, and can be used in special occasions such as narrow space, etc.. Research on control algorithm of rotation angle sensor, most researchers mainly based on the selection of the sensor, obtained the stationary data more accurate, but much depends on the mobile robot during acceleration, dynamic instability, controllable small angle problem. The key point is that the two wheeled self-balancing robot controls the attitude control, and the attitude control is the core of the control algorithm. Colman filter as the best prediction method, this method has the effect of suppressing the noise interference, engineering, in communications, aerospace, industrial automation and other fields with a wide range of applications.

1 Basic principle of two wheeled self-balancing car
1.1 balance method

In order to make an accurate and quantitative analysis and design of a controller and improve the ability of the controller to control the system. For the two balanced car system, because the system is complicated, unstable, nonlinear, time-varying, will produce servo, tracking, robustness and other issues, the force analysis of the mathematical model is more important. The closer to the actual situation, the more accurate the system model is, the better the control effect is.

Two wheeled self-balancing car system is mainly composed of three parts: wheel, motor and car body. Because the motor is fixed on the vehicle body, the motor and the vehicle body can be regarded as a whole, which is collectively called a vehicle body. The mechanical model of the two wheeled balance car and the single inverted pendulum is different, in which the single inverted pendulum is balanced by the external force, and the balance of the vehicle system is to rely on their own motor torque output to achieve system balance. The wheel is driven by a motor and can output torque, which is an active mechanism. In order to realize the self-balance of the car, it is necessary to control the motor in a timely manner to correct the output torque to maintain the balance of the car.

Obviously, in the absence of any control measures under the conditions, the car suddenly opened in the vertical, will fall. If you want to keep the car upright posture, you must have a good control of the car's center of gravity, so that the car balance.

1 static: the car center of gravity falls on the left and right wheels and the ground contact point of the connection center position, the car to keep balance. At this point, the wheels do not need to do any action to achieve the balance requirements.

2 forward: the body center of gravity, then the body will lean forward until the car fell to the ground, to keep the car balance, must control the wheel forward, the support and the body again moved forward to coincide, to keep balance.

3 After dipping: the body center of gravity, then the body will gradually tilted backwards until the car fell to the ground, and forward the same. It is necessary to control the wheel backwards, so that the support point back to the body and then re coincide in order to maintain balance.

As shown in the figure, to ensure that the car's stability, we must first know what the car tilt direction and angle, then as a basis to adjust the direction of motor and speed, specific value according to the tilt angle and the car.
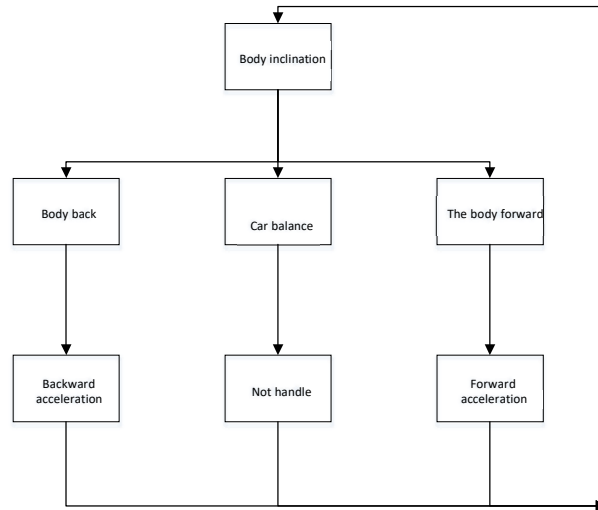
Figure 1 Block Diagram 1.2 Calman filter design

Calman filter is an efficient recursive autoregressive filter, which can estimate the state of a dynamic system by using system noise and observation noise. The operation of the Calman filter includes two stages of prediction and update. In the prediction stage, the last two balanced filter according to the attitude of the robot, estimate the present moment angle; in the update stage, filter using the latest observations measured MPU6050 optimization of sensor module in the forecast stage data, to obtain more accurate estimates.

1.3 Filter prototype

The Calman filtering algorithm consists of two equations for the measurement and estimation of the two processes and the time update and the measurement update. Calman filter prediction - correction flow chart. The time updating equation can also be regarded as the prediction equation, and the equation can be considered as the correction equation. Calman filter iterative process is as follows:

（1）prior state estimation

$$\hat{x}_{k|k-1} = A\hat{x}_{k-1} + Bu_{k-1} \qquad (1)$$

(2)a priori estimation error covariance

$$P_{k|k-1} = A_K P_{K-1} A^T + Q \qquad (2)$$

(3)Calman gain

$$K_k = P_{k|k-1} H^T (H P_{k|k-1} H^T + R) \qquad (3)$$

(4) Posterior state estimation

$$\hat{x}_k = \hat{x}_{k|k-1} + K_k (z_k - H\hat{x}_{k|k-1}) \qquad (4)$$

(5) a posteriori error covariance

$$P_k = (I - K_k H) P_{k|k-1} \qquad (5)$$

$K_K : n \times m$ matrix， Calman gain.

1.4 experimental data analysis

The STM32 MPU6050 module and IIC communication module, with a good IIC program is available, so we only need to know three axis accelerometer and gyroscope three axis data register read address can be read data, and then through the conversion can be obtained to filter data.

In the laboratory environment, the three groups of sensors installed in the vehicle platform, different installation position but at the same level, and ensure three sensors x, y, Z axis in the direction of the level of two wheeled vehicle. The data collected from each group of sensors and the fusion data were analyzed.
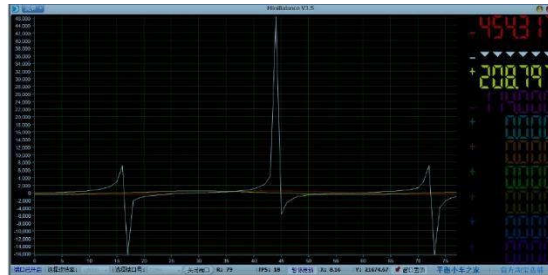

Figure 2 MPU6050 block attitude information collection

2   PID analysis

The PID controller is very important in the field of automatic control. PID controller is to input the proportion of deviation (proportion), integral (integral), differential (differential) linear operation, and then the results of the input to the control mechanism for automatic control. In daily life everywhere can see the figure of PID controller.

3   speed position double closed loop
3.1 speed closed loop control

We usually use the incremental PI control in the speed closed-loop control system. In our microprocessor, because the controller is implemented by software and other control algorithms, it is necessary to simulate regulator is discretized, it only need to compute the value of sampling time deviation control. So we need to use the discrete difference equation to replace the continuous differential equation.

If the sampling time is very short, the code is 10ms, do the following: First order differential; Replace integral.

Based on the incremental discretization PID formula:

Pwm+=Kp*[e(k)-e(k-1)]+ki*e(k)+

Kd*[e(k)-2*e(k-1)+e(k-2)] (6) e(k): This deviation(k-1): Previous deviation； e(k-2): Last deviation;

Pwm represents incremental output. is not high, so we only use the P control. In fact, the steering information can be PI control is used in our speed obtained by encoder and gyroscope, so control system, so the PID controller can the steering ring has a variety of control be reduced to the following formula:
Methods, summarized as follows: Pwm+=Kp[e(k)-e(k-1)]+ki*e(k)]   (7)   1 using the integral value of the

3.2 position closed loop control

According to the position discrete   wheel encoders as the deviation, the Z PID formula: axis gyroscope is used as the input of the

Pwm=Kp*e(k)+Ki*∑e(k)+Kd*

differential control to control the PD.

Only PI control is used in the axis gyroscope to get the steering angle closed-loop control system of our as the deviation, the Z axis gyroscope is position, so the PID controller can be used as the input of the differential reduced to the following formula: control to control the PD. The utility

3.3 double closed loop control

The differential control can increase the proportional control coefficient to the speed position double loop improve the response of **schematic** the system. The control is nested by the above two disadvantage is that the long-time controllers.

4 steering control

increase of system error. The balance of the car steering ring 3 the difference between the data of using P (proportional) controller or P the left and right wheel encoders is used (proportional) D (differential) controller, as the steering speed deviation for P as we have said, the general control control. Advantage is simple, system with P control or PI control can The disadvantage is that the be, is the "general steering ring control encoder cannot detect the wheel sliding, system", in response to the requirements and has high requirements on the

encoder accuracy. 4 using the data of the Z axis gyroscope as the steering speed deviation for P control, the goal is to keep the steering speed set value. The utility model has the advantages of simple algorithm, avoiding the phenomenon that the encoder cannot detect the sliding of the wheel and the drift of the gyroscope, etc..

5   Summary and expectations

With the rapid development of science and technology in China, people pay more and more attention to the problems of environment and energy. The two wheeled balancing car has the characteristics of energy saving, no pollution and so on. The purpose of this paper is to research and design a two wheel balance car with vertical, adjustable speed, steering and remote control. After thorough investigation and careful consideration, the whole two wheeled balancing car is designed and assembled in detail with the rapid development of science and technology in China, people pay more and more attention to the problems of environment and energy. The two wheeled balancing car has the characteristics of energy saving, no pollution and so on. The purpose of this paper is to research and design a two wheel balance car with vertical, adjustable speed, steering and remote control. After thorough investigation and careful consideration, the whole two wheeled balancing car is designed and assembled in detail

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