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Research of Vehicle Stability Control System Based on the Implementation of Global Positioning System

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ABSTRACT

The research expounds the appearance of global positioning system (GPS) test theory. The double antenna combined with global positioning system (GPS) receiver device to measure the lateral angle of automobile body. At the same time we can access to other parts of state data. And then, this study combined with kalman filter equipment combining inertial navigation system and global positioning system (GPS) to measure the car related data. Based on the theory of synovial control system to construct a system of car stability with Matlab and simulink. Simulation of car in the driveway, and the specific control effectiveness of the controller of car in a variety of different conditions. This study aims to take synovial control theory as the core, research in the automobile body ideal horizontal swing angular velocity and lateral Angle of motor vehicles and the corresponding actual car body lateral swing Angle and the difference between the lateral Angle of car body. And see it as import auto control system of the different control variables, conpile the joint synovial controller.

KEYWORDS

Global positioning system (GPS); Lateral angle; Stability; Control systems.

INTRODUCTION

In recent years, vehicle purchases surge, the corresponding car production is also growing. But the current lack of something which is used to measure the automobile body design of car lateral Angle of the sensor. And now mainly using the method of model estimation method or the integral gain side-slip Angle value. The disadvantage of model estimation is the parameters which of the transformation is very sensitive. Once the parameters change, acquired values will change, and integral method requires the cumulative data, so often prone to error. This research with the aid of global positioning system (GPS) uses double antenna pose measurement system for measuring automobile body side-slip Angle. At the same time, using the kalman filter to realize the global positioning system (GPS) to achieve efficiency and stability of measurement data and inertial navigation system is the combination of the relevant data. This study aims to clarify the global positioning system application in the vehicle control system. the realization of the stability of the car, the stability of the global positioning system (GPS) design in automotive body lateral horizontal pendulum Angle and vehicle velocity of horizontal pendulum torque based on the sliding mode controller.

CAR DYNAMIC MODEL

The vehicle model is shown in Figure 1 of automobile vehicle model used for this research[1].

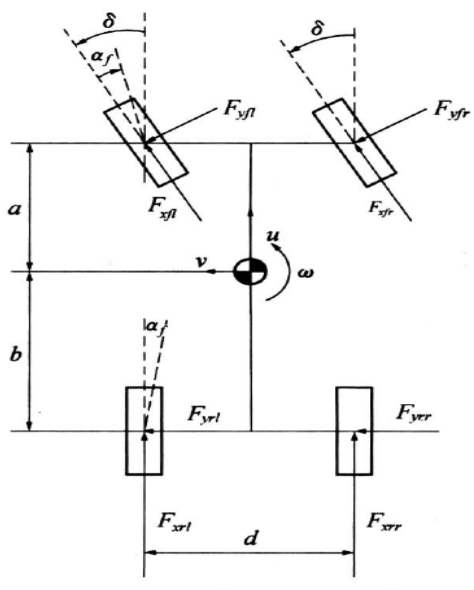

Figure 1: The model of the vehicle

The formulas from the model of the vehicle are shown as:

$$mu = F_{xr} + F_{xf}\cos\delta - F_{yf}\sin\delta + mwv \quad \textbf{(1)}$$

$$mv = F_{yr} + F_{xf}\cos\delta + F_{yf}\sin\delta + mwu \quad \textbf{(2)}$$

$$I_z w = \alpha F_{xf}\sin\delta + \alpha F_{yf}\cos\delta - bF_{yr} + \frac{d}{2}(F_{xfr} - F_{xfl})\cos\delta + \frac{d}{2}(F_{xrr} - F_{xrl}) \quad \textbf{(3)}$$

In these formulas, *m* is the total weight, F_{xfl}, F_{xfr}, F_{xrl}, F_{xrr}, F_{yfr}, F_{yfl}, F_{yrl}, F_{yrr} are respectively along the x axis and y axis of the front and back, left, right tire force component. a and b, respectively, said the vehicle front axle to distance to center of mass of the car. d is the car distance between left and right wheels (Premise is the wheel spacing of vehicles before and after the wheel is the same). I_z is motor vehicle turning around the Z axis transverse oscillation of moment of inertia. U is the speed of the vehicle longitudinal. v is for car lateral velocity. X for motor vehicle lateral swing angular velocity; D is the rotation of the wheel for the car before. C_f, C_r for car front and rear tire lateral partial degrees[2].

GLOBAL POSITIONING SYSTEM (GPS) TO MEASURE BODY SIDE-SLIP ANGLE

Measuring principle

Global positioning system (GPS) with all-weather, continuous and real-time positioning the function of the car, it can accurately obtain car speed signal, measure the attitude of cars. In addition to the use of global positioning system, but also based on the theory of phase interference theory guidance. Antenna layout technology as the core technology. In simple terms, the attitude of the global positioning system (GPS) to measure is installed on the vehicle to accept global positioning system (GPS) signal of the antenna with the aid of global positioning system (GPS) to determine the vehicle's specific posture. Based on global positioning system (GPS) signal of the antenna connection number to determine the baseline, general connection two antenna line as baseline. Once you determine the direction of the baseline, the direction of the baseline is referred to as the baseline vector. As shown in Figure 2, the vehicle body vertical direction antenna equipment by 1 and 2, formed the baseline vector b1, 2. Combined with the baseline vector can judge the attitude Angle of car body, one is the heading Angle, the other is pitching Angle. For the side Angle of the vehicle body, it associated with the global positioning system (GPS) signal receiving antenna 3. And three antenna with longitudinal vertical, so form the baseline vector b1,3[3].

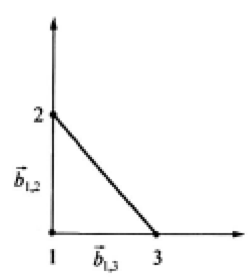

Figure 2 : The receiver antenna layout

Baseline vector coordinates, first of all, by the WGS - 84 coordinate system to local coordinate system, then switch to car body coordinate system, car body heading Angle, pitching Angle and roll Angle can be obtained as follows:

$$\Psi = -\arctan(\frac{Y_{1,2}}{X_{1,2}}) \quad \textbf{(4)}$$

$$\theta = \arctan(\frac{Z_{1,2}}{\sqrt{(X_{1,2})^2 + (Y_{1,2})^2}}) \quad \textbf{(5)}$$

$$Y = -\arctan((X_{1,3}\sin\Psi\sin\theta - Y_{1,3}\cos\Psi\sin\theta + Z_{1,3}\cos\theta)/(X_{1,3}\cos\Psi + Y_{1,3}\sin\Psi)) \quad \textbf{(6)}$$

$:(X_{1,3}, Y_{1,3}, Z_{1,3})$ is the baseline vector $b_{1,2}$ component coordinates in local horizontal coordinates. $(X_{1,3}, Y_{1,3}, Z_{1,3})$ at a local level in the coordinate system to baseline vector $b_{1,3}$ component coordinates.

As shown in Figure 3, Vehicle mass center heading Angle between the direction Angle F W and speed difference is known as the vehicle side Angle B, speed direction Angle F can be acquired through the global positioning system (GPS). V refers to the speed of the vehicle, X refers to the speed of the vehicle lateral swing Angle, x0, y0 for car body coordinate system[4]

$$\beta = \zeta - \Psi \quad \textbf{(7)}$$

This study measure lateral Angle of car body and other car B state parameter basis on Vector Crescent[5].

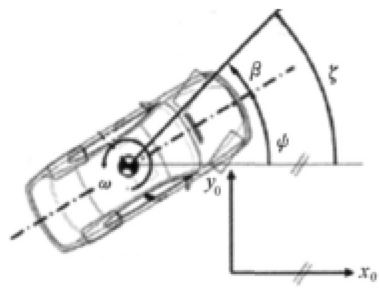

Figure 3 : Body side-slip angle diagram

GPS and INS

The stability of the system have direct relationship with the acceleration and angular velocity of the vehicle, INS (inertial navigation system) can get the car's acceleration and angular velocity. To obtain data on lateral swing angular velocity of integral can be horizontal pendulum Angle and heading Angle, speed is obtained by car acceleration signal points which can measure the body lateral swing Angle and the Angle between the speed, the lateral Angle of the vehicle. But the disadvantages of this measure is prone to drift phenomenon, this is because the integral tend to cause the error.

The combination of GPS and INS using the update rate to maximum extent, promote the signal. This can greatly increase and expand the global positioning system (GPS) signal receiving and avoid bad signal caused by the global positioning system failure. It is able to carry out a series of static deviation of compensation and estimation at the same time, thus reduce the specific requirements of INS level accuracy. This study combined with double linear positioning model, implement measure combined with INS. Kalman filter based on kinematics model can be built. Implementation of vehicle lateral swing Angle variable information such as estimate.

By the gyroscope measured lateral swing angular velocity can be written as:

$$\omega_{INS} = \Psi + \omega_0 + \omega_1 \quad \textbf{(8)}$$

In this formula, ω_{INS} is nertial navigation sensor measured horizontal pendulum angular velocity, Ψ is heading angle, ω_0 is transverse angular velocity deviation, ω_1 is noise.

Measured by double antenna GPS receiver yawing Angle can be written as :

$$\Psi_{gps} = \Psi + v_1 \quad \textbf{(9)}$$

In this formula : Ψ_{gps} is the global positioning system (GPS) receiver measured yawing Angle (course Angle). Kalman filter state equation:

$$x = \begin{bmatrix} \Psi \\ \omega_0 \end{bmatrix} = \begin{bmatrix} 0 & -1 \\ 0 & 0 \end{bmatrix} \begin{bmatrix} \Psi \\ \omega_0 \end{bmatrix} + \begin{bmatrix} 1 \\ 0 \end{bmatrix} \omega_{INS} + \begin{bmatrix} \omega_1 \\ 0 \end{bmatrix} \quad \textbf{(10)}$$

The measurement equation is:

$$y = \begin{bmatrix} 0 & 0 \end{bmatrix} \begin{bmatrix} \Psi \\ \omega_0 \end{bmatrix} + \begin{bmatrix} v1 \\ 0 \end{bmatrix} \quad \textbf{(11)}$$

When Global positioning system (GPS) to measure something, the observation is matrix C [0, 1]. When the system can not work, the observation was matrix C [0, 0]. Figure 4 for the steering wheel step to input by the global positioning system (GPS) combined with INS vehicle lateral Angle and combined with the degree of freedom model of vehicles. Compared with calculating the lateral Angle of the ideal, the standard deviation is less than 0.2[6].

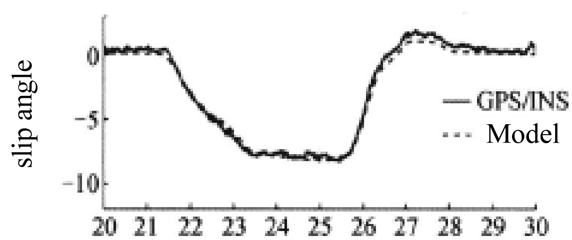

Figure 4 : The GPS/INS integrated measuring body side-slip angle of comparison

THE DESIGN OF THE MOTOR CONTROLLER

This research use lateral swing torque control mode to improve car safety, reliability and stability of the control system. Transverse oscillating torque control system set's intention is the lateral Angle of automobile body and the horizontal swing angular velocity tracking vehicles expected lateral Angle and lateral swing angular velocity. In an emergency situation, car body control system of transverse oscillation stability performance through the implementation of steering, braking or traction differential control import produce certain correction of the horizontal pendulum power help drivers to achieve the stability of the vehicle. Combined with the linear two degrees of freedom vehicle model,we can obtain ideal situations car lateral Angle of horizontal swing Angle in Bd and ideal speed Xd, namely the ideal body side-slip Angle.

$$\beta_f = \frac{\left[\dfrac{2C_f(2a^2C_f + 2b^2C_r)}{(2aC_f - 2bC_r + mu^2)} - 2aC_f \right]}{\left[\dfrac{(2C_r + 2C_f)(2a^2C_f + 2b^2C_r)}{(2aC_f - 2bC_r + mu^2)} + (2bC_r - 2aC_f) \right]} \delta \quad \textbf{(12)}$$

The ideal horizontal pendulum Angle is shown as:

$$\omega f = \min\left\{\left|\frac{v}{(a+b)\bullet(1+\frac{u^2}{v^2_{ab}})}\delta\right|,\left|\frac{\mu\bullet g}{u}\right|\bullet \mathrm{sgn}(\delta)\right\} \quad (13)$$

Ideal yawing Angle of sliding mode control with scientific theory as the core of control system, in order to nonlinear control system for the implementation of strategy , to control the system deviates from the synovial membrane surface to adjust the structure of the controller. The control system run according to the movement rule of advance, this is a kind of efficient synovial level control system. This paper choose the actual lateral swing angular velocity X and car lateral Angle B and expect horizontal pendulum eastern angular velocity Xd and auto tracking error between lateral Angle of Bd as car controller control target. Creating synovial controller, as far as possible to promote the actual lateral swing angular velocity and the vehicle lateral Angle difference within a certain range expectations as shown in Figure 5[7].

Definition of sliding mode control of switching function is:

$$s = \omega - \omega_d + \xi(\beta - \beta_d) \quad (14)$$

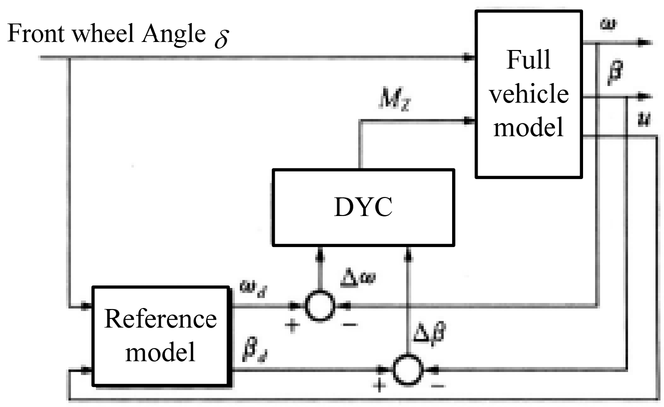

Figure 5: The stability of control system design

Due to the front and back brake torque distribution ratio is fixed, so the set yawing moment is:

$$Mz = \frac{a}{k+\cos\delta}F_{yf}\cos\delta + \frac{b}{k+\cos\delta}F_{yr} + \frac{I_z}{k+\cos\delta}(\omega_d - \xi(\beta-\beta_d) - \eta_\delta) \quad (15)$$

THE ANALYSIS OF SIMULATION RESULTS

This study is based on the software of Matlab/Simulink was carried out by a set of simulation research, designed to test and improve vehicle stability and effectiveness of the controller. This study analysis the with and without controller control vehicle responsiveness of the vehicle. In Figure 6 ~ 8 tire-road friction coefficient of 0.7, at a speed of 25 m/s transformation when the car lane conditions of the simulation results. Figure 6 is the vehicle front wheel Angle D import curve, Figure 7 is the vehicle of sliding mode controller to the transverse swing moment MZ, Figure 8 is the ideal vehicle lateral swing angular velocity, Figure 9 is the response of the automobile body side Angle curve. From these Figures we can see that,when controller use it's stability, a car to the appropriate track vehicles ideal horizontal swing angular velocity. And to the lateral Angle of the car control within a certain range, so the driver can control the vehicle front wheel rotation direction.

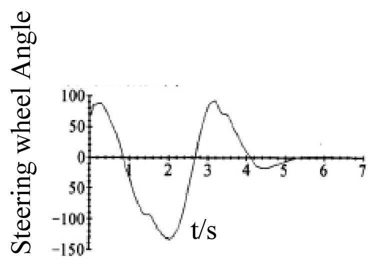

Figure 6 : The front wheel angle δ

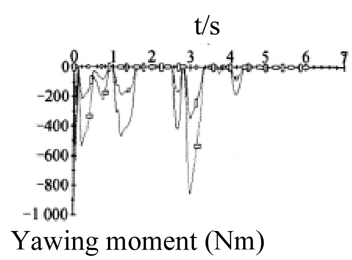

Figure 7 : The controller output of brake torque

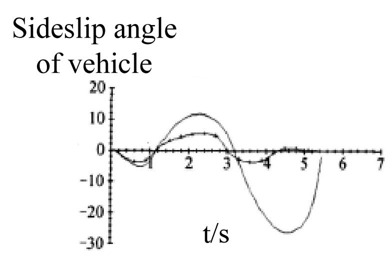

Figure 8 : Yaw velocity time response curve

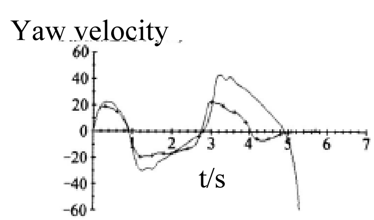

Figure 9 : Body side-slip angle time response curve

CONCLUSION

Combined with global positioning system (GPS) pose measurement system for automobile body lateral Angle measuring system， at the same time, kalman filter as a device for the combination of global positioning system and inertial navigation system， with the help of the data related to the actual measurement to the vehicle. Analyzing the stability, execution and credibility of this measurement method. Test results show that, compare with the installation of auto control system of the car and the car is not installed control copper, generally speaking, the vehicle with the control system can have the best response. At the same time, the horizontal swing angular velocity and lateral Angle of motor vehicles can be more smoothly expectations, and motor vehicle lateral oscillation has strong stability.

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