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Research Article

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Linear two degrees of freedom vehicle model based on Matlab/Simulink simulation

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Abstract Car yawing angular velocity and the center of mass of side-slip angle is to describe the stability of the car, two important indexes based on the linear mathematical model of two degrees of freedom vehicle model set up in Simulink, select daily see ordinary car parameters, for example, car fixed speed input different angle to the front wheel input, car wheel fixed angle input of different initial speed, output side-slip angle of mass center of horizontal pendulum angular velocity and real-time simulation and analysis, it is concluded that the influence of different input on vehicle handling stability

Keywords Linear two degrees of freedom vehicle model, The front wheel angle, Horizontal pendulum angular velocity, Centroid side-slip angle

1. Preface

With the popularity of cars and simulation technology is more and more mature, the simulation software simulation and analysis model of the car, make some of the automobile motion state don't we use physical experiment can obtain more accurate and objective data [1], this paper is based on matlab/simulink to carry on the introduction of study after the basic linear two degrees of freedom vehicle model, a simple simulation analysis.

2. Linear movement differential equation of two degrees of freedom vehicle model

2.1. The toolbar and its menus

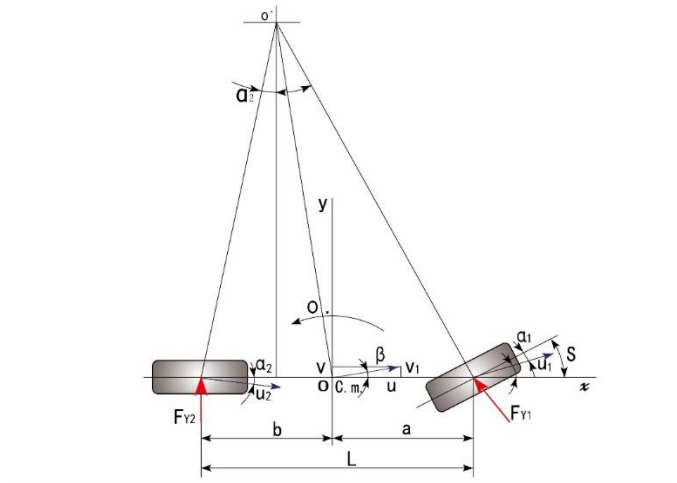

Figure 1:.2 Dof vehicle model

Two degrees of freedom vehicle model of vehicle dynamic system is simplified and assumptions, it basically has the following features: ignore turns into the system, the influence of round corner for the input directly before; Ignore the effect of suspension, body is parallel to the ground surface movement, only around z axis displacement, around the pitching angle of the y axis x of roll angle is zero, the car along the x axis speed u as the same, only the lateral and horizontal pendulum two rounds of two degrees of freedom vehicle model, as shown in [2] [3] Figure 1, the ox with oy as the vehicle coordinate system of the horizontal axis and vertical axis. for the rear wheel cornering force for the front wheel cornering force, for the front wheelside-slip angle, to the rear wheels side-slip angle, as the center of mass side-slip angle, for the front wheel angle.

2.2. List two degrees of freedom vehicle movement differential equation

First use of consolidation in the automotive vehicles coordinate system analysis of the movement:

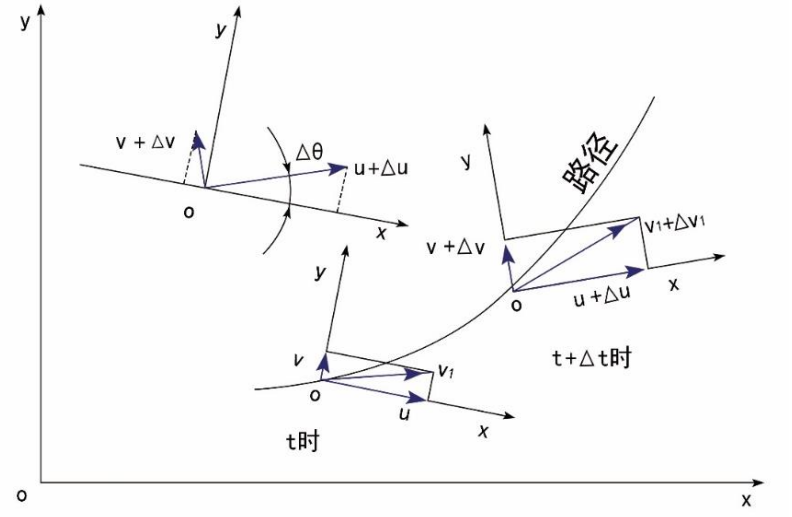

Figure 2: The use of consolidation in the automotive vehicles

The changes of velocity components along the ox axis can be obtained as follows:

$$(u+\Delta u)\cos\Delta\theta - u - (v+\Delta v)\sin\Delta\theta \tag{1}$$

$$= u\cos\Delta\theta + \Delta u\cos\Delta\theta - u - v\sin\Delta\theta - \Delta v\sin\Delta\theta$$

$$\Delta u - v\Delta\theta \tag{2}$$

After finishing to two degrees of freedom vehicle differential equations as follows:

$$(ak_1 - bk_2)\beta + \frac{1}{u}(a^2k_1 + b^2k_2)\omega_r - ak_1\delta = I_Z\dot{\omega}_r \tag{3}$$

$$(k_1 + k_2)\beta + \frac{1}{u}(ak_1 - bk_2)\omega_r - k_1\delta = m(\dot{v} + u\omega_r) \tag{4}$$

I_z is the moment of inertia of the car about the z axis; $\dot{\omega}_r$ is the angular acceleration of the car's yaw. And after deformation are we going to use the output formula is:

$$\left[m(\dot{v} + u\omega_r) + k_1\delta - \frac{1}{u}(ak_1 - bk_2)\right](\frac{1}{k_1 + k_2}) = \beta \tag{5}$$

$$\left[(ak_1 - bk_2)\beta + \frac{1}{u}(a^2k_1 + b^2k_2)\omega_r - ak_1\delta\right](\frac{1}{I_Z}) = \dot{\omega}_r \tag{6}$$

3. Matlab/Simulink simulation analysis

The model is set up

Set up in Simulink model is as follows:

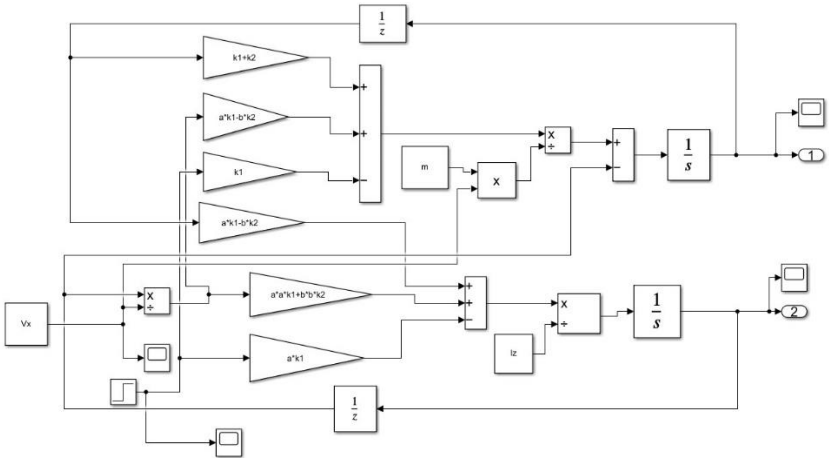

Figure 3: Different angle step input of two degrees of freedom vehicle model of Simulink simulation diagram.

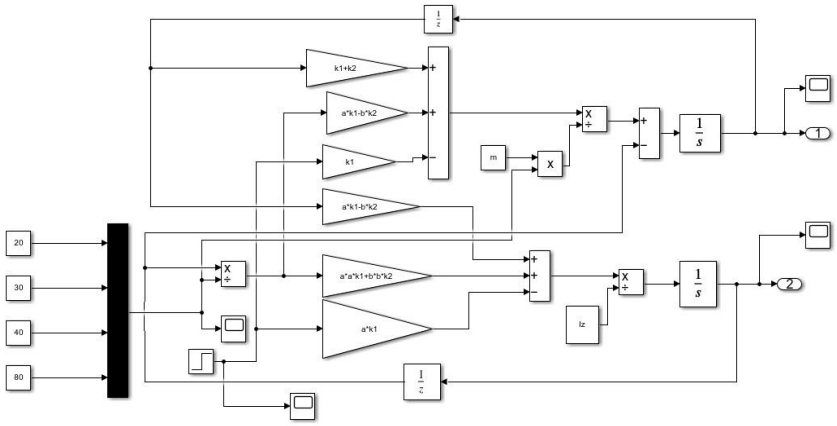

Figure 4: Under the different initial speed of two degrees of freedom vehicle model simulation analysis

4. The simulation and analysis

4.1. The results of simulation analysis of different angle input

Set the initial speed of 30 ㎞/h, to the front wheels respectively when the simulation time for 1 angle step input signal, respectively, make the front wheel angle shifted from 0°to 0.5°, 1.0°, 1.5°, and maintain a constant the angle according to the data in the table again and ready to set the speed, front wheel angle step input, the simulink model in figure 5 in the assignment of the letters should be up and running:

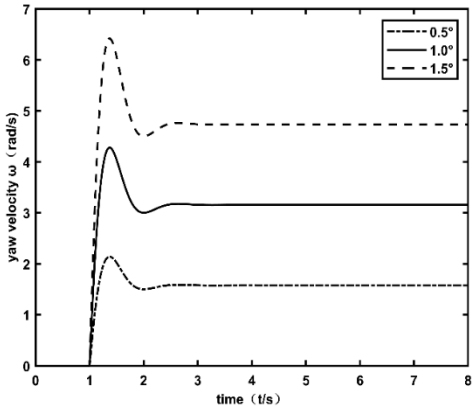

Figure 5: The centroid side-slip angle under different angle input response curve

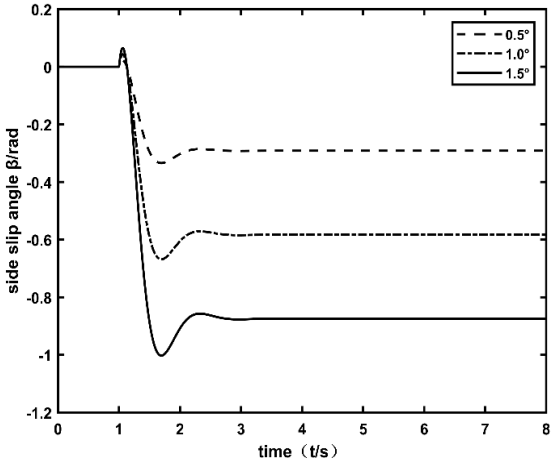

Figure 6: The horizontal pendulum under different angle input angular velocity response curve

and the center of mass of side-slip angle fluctuations is minimized, as the input angle, the greater the time increased, stabilization, the automobile quality, and the heart of side-slip angle fluctuation is increased, the stability of the car fell, consistent conclusions can be combined with the data in table 2.By the figure 6, you can see that the speed of a certain situation, with the increase of the front wheel angle input, auto yawing angular velocity overshoot amount increase gradually, into the steady time experienced by increased slightly, which you can see by the picture, the front wheel angle of 0.5 yawing angular velocity of the first to reach the stable value and increase the time the shortest, and with the increase of angle, yawing angular velocity to achieve stability in the time required to more and more long, and stable value rise time is getting longer and longer, the data in table 3 can be consistent conclusions. Figure in conclusion, we combined with the test data and results can be concluded that in the process of practical manipulation of the car, should be avoided in high speed turn the steering wheel to produce larger angle, otherwise easy to cause unstable body [4].

4.2. The simulation of different initial speed input

Different initial speed input in the simulation time for 1 s to the front wheels when an angle step input, the front wheel angle is 0.5 and remains the same, the quality, and the heart side-slip angle curve as shown in figure 7.

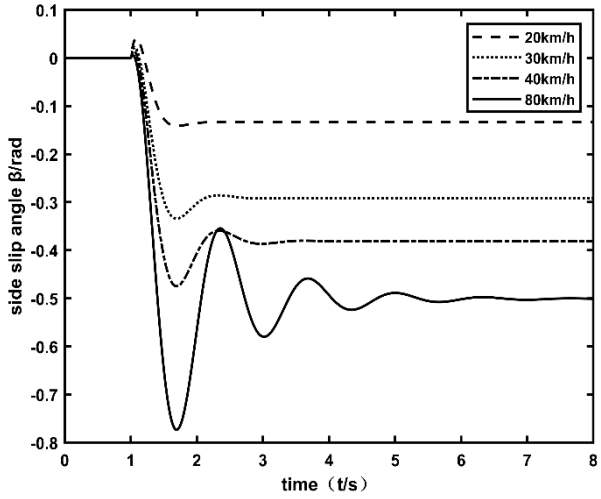

Figure 7: The car under different initial speed input centroid side-slip angle response curve

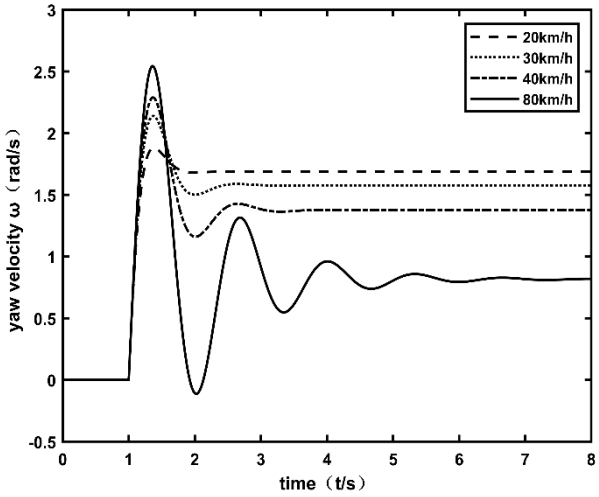

Figure 8: The car under different initial speed input yawing angular velocity response curve

Under the specific angle input, the vehicle speed on the characteristics of the speed, with the increase of the speed car's center of mass of side-slip angle and yawing angular velocity changes will gradually increase, and the time required to achieve stable growth. When the input speed than characteristic velocity, the car's center of mass side-slip angle and yawing angular velocity changes sharply, acute manipulation stability of the vehicle Play down, very likely turn side even occur.

5. Conclusion

Content of this paper is through the study of simulation courses this semester have a preliminary knowledge of matlab software in the mid-term assignment based on combining the derived differential equation of two degrees of freedom vehicle model in simulink module of matlab software simulation model. By car of two degrees of freedom differential equations can be seen that the yawing, lateral movement and the front and rear wheels cornering stiffness, longitudinal velocity and mass center position, angle, the quality of the vehicle. Among them, vertical speed, front wheel corner is the driver control, the so-called slow down when turning is to prevent due to lateral acceleration through large lateral spreads, or rollover [5]. The mass, centroid position, cornering stiffness front and rear wheels is the intrinsic characteristics of the vehicle; So according to the daily situations, people use it by changing the driver can control the front wheel angle, longitudinal speed (that is, when the longitudinal speed is fixed, different front wheel corners are entered respectively, and when the front wheel corners are fixed, different initial speeds are entered respectively) model for the simulation analysis, respectively, through the analysis of each curve, obtained in the speed of a certain characteristic speed (do not exceed characteristic speed) the stability of the front wheel steering angle is smaller vehicles is better; The greater the speed of the vehicle when the front wheel Angle is fixed, the better the stability of the vehicle. When the speed exceeds the characteristic speed, the handling stability of the vehicle will decline sharply.

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