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Establishment and Analysis of Dynamic Comfort Model of Driver's Seat

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Abstract

In this paper, the dynamic comfort of the driver's seat is studied by using MATLAB programming simulation to establish the dynamic model movement. The influence of the vibration environment on the driver's comfort experience is mainly considered. On the basis of relevant literature research and dynamic principle, a 6-DOF "driver seat vehicle" dynamic model is established. Newton Euler method is used to construct the differential equations of each part of the whole dynamic system model, and the state matrix equation is established according to the knowledge of control theory. The matlab program based on the established dynamic model is compiled to pave the way for the subsequent simulation. The conclusion of MATLAB simulation shows that: from the time domain diagram, the driver's dynamic comfort feeling is closely related to the road roughness and the speed of the vehicle. As the speed of the car increases or decreases, people feel uncomfortable. Matlab software is used to calculate the root mean square value of the driver in the dynamic model under different levels of road surface and different speed, and compared with ISO263 standard to evaluate the dynamic comfort of the driver's seat.

Keywords

Driver's seat, Dynamic comfort, Evaluating indicator, Dynamic model, Matlab simulation.

1. Introduction

With the steady growth of domestic economy, the continuous development of automobile industry technology and the effective completion of the well-off system in China, automobile has gradually become one of the necessary means of transportation for people. Moreover, in view of the current consumption situation of the automobile market, more and more people have the conditions to own their own cars. When they travel, travel and visit relatives and friends, cars play an important role in these links. At the same time, the comfort of car driving has gradually become the focus of attention of the majority of consumers. On the other hand, with the rapid growth of the domestic automobile industry in the past decade, most of the domestic automobile enterprises, such as JAC, Chery, Geely, BYD etc. have paid more and more attention to the performance of their own cars in all aspects: power performance, energy saving and emission reduction performance, and dynamic comfort of seats. Among them, the dynamic comfort of the driver's seat has become the focus of attention. Therefore, the objective and scientific evaluation method of dynamic comfort of driver's seat has a guiding role and significance for the future research and development of automobile. The research on the dynamic comfort of driver's seat plays an irreplaceable role in evaluating the overall riding comfort of automobile.

2. Establishment of system dynamics model

2.1 Construction of driver seat dynamic model

Usually, affected by the external vibration environment, people will show some of their own biomechanical characteristics in such an environment, which can be called elastic damping

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characteristics in physical sense. Therefore, in the analysis of a series of effects of environmental vibration on human body, human elastic damping characteristics are the key point that can not be ignored. The establishment of human body dynamic model is also the basis of studying such problems. Generally speaking, the parameters of human body dynamic model can be simplified into three main parts: physical equivalent mass, spring and damping parts. The driver's seat is a medium for the body vibration to transmit to the driver's body. In the vibration environment, only the vertical vibration is considered. As a vehicle part with specific damping function, driver's seat can be equivalent to mass, damping spring and damping component in physical level. By simplifying the model of the driver and the driver's seat in the physical sense, only the vertical vibration effect is considered in the whole vibration state, and the "driver-seat" 2-DOF dynamic model is established. The details are shown in Figure 1.

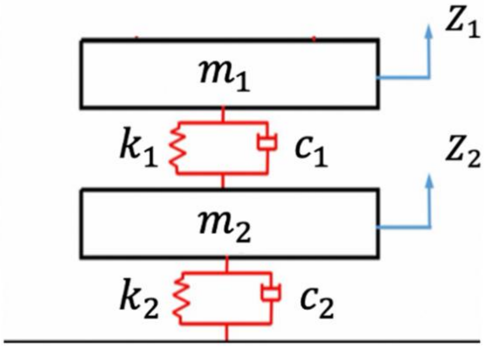

Figure 1. Driver-seat dynamic model

2.2 Establishment of vehicle road physical model

The vehicle itself is a huge and complex dynamic system, so if we want to complete the research and analysis, the dynamic response characteristics in the process of vehicle motion is a very challenging work. Therefore, in the current research, it is necessary to make appropriate physical simplification of the car model to ensure that the whole research results conform to the actual dynamic situation to the greatest extent. Among them, the degree of freedom after simplification is the key of the whole model. Although, generally speaking, the more degrees of freedom, the simulation results of the whole dynamic model will be closer to the actual test results [1-3]. However, too many degrees of freedom will face complicated calculation process, and the more physical parameters are needed in the system, and the acquisition of some physical parameters has certain error estimation, which will lead to the accumulation of errors and the reduction of calculation efficiency.

After considering the above situation in many aspects, in order to ensure that the dynamic model is reasonable and the simulation calculation process is not too complex, the dynamic model as shown in Figure 2 is established.

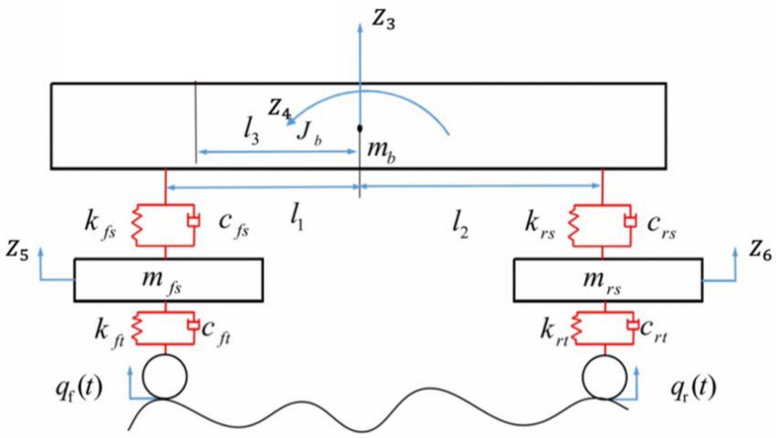

Figure 2. Vehicle-road physical model

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2.3 Establishment of global dynamic model

To sum up, in order to study and analyze the dynamic comfort of the driver-seat, this paper establishes the "driver-seat" 2-DOF vibration model and the "vehicle road" 4-DOF vibration model according to the basic dynamic principle. Finally, a 6-DOF "driver-seat-vehicle" dynamic model is constructed by combining the two models under the condition that the support model is reasonable and the calculation results can accurately reflect the actual dynamic situation. The model is shown in Figure 3.

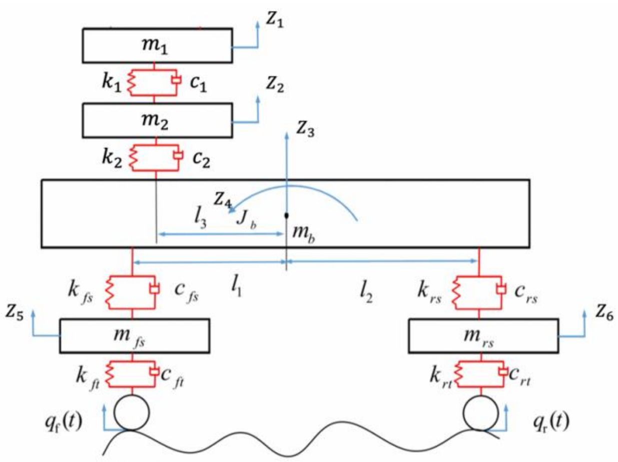

Figure 3. Driver-seat-vehicle dynamic model

Where, Z_1 is the displacement of the driver's center of mass;Z_2 is the vertical displacement of the driver's seat; Z_3 is the vertical displacement of the vehicle's center of gravity; Z_4 is the longitudinal rotation displacement of the vehicle around the center of gravity; Z_5 is the vertical displacement of the center of gravity of the front axle; Z_6 is the vertical displacement of the center of gravity of the rear axle; $q_f(t)$, $q_r(t)$ are the random excitation of the front and rear roads during the driving process. The specific parameters represented by each letter in Figure 3 are shown in Table 1.

Table 1. Parameters of driver-seat-vehicle dynamic model

Parameter	Numerical value	Parameter	Numerical value
m1	75kg	$c1$	2.7KN·s/m
$m2$	105kg	$c2$	660N/m
mb	1700kg	$c$fs	4.7KN·s/m
$m$fs	180kg	$c$ft	0
$m$rs	210kg	$c$rs	1.053KN·s/m
$k1$	700370N/m	$c$rt	0
$k2$	19030N/m	$l1$	1.25m
$k$fs	17000N/m	$l2$	1.51m
$k$ft	571.42KN/m	$l3$	0.40m
$k$rs	22000N/m	Jb	1988kg·m2
$k$rt	571.42KN·s/m		

According to the dynamic model in Figure 3, the dynamic model is composed of three parts: driver, driver's seat and car body. Among them, the driver is physically equivalent to a mass block, and the mass is represented by m_1; the driver's seat is also physically equivalent, and its mass is expressed in m_2; for the vehicle body, this paper selects the 1/2 vehicle system composed of front and rear wheels for equivalence, the body mass is represented by m_b, and the moment of inertia is expressed by J_b. In the whole dynamic model, there are certain vibration relations between the driver and the driver's seat, between the seat and the vehicle body, and between the vehicle body and the road surface,

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which are physically equivalent to springs and dampers. The driver and the seat are connected by spring k_1 and damper c_1; the driver's seat and body are equivalent to spring k_2 and damper c_2. For the specific physical relationship between the vehicle and the road surface, the parameters are expressed as follows: m_{fs} and m_{rs} are equivalent to the non suspended mass on the front and rear wheels of the vehicle; k_{fs} and k_{ft} correspond to the stiffness of the front suspension and front tire; k_{rs} and k_{rt} correspond to the stiffness of the rear suspension and rear tire; c_{fs} and c_{ft} are the damping of the front suspension and front tire; c_{rs} and c_{rt} is the damping of the rear suspension and rear tires; l_1 is the distance from the front axle to the center of gravity of the body; l_2 is the distance from the rear axle to the center of gravity of the body; l_3 is the distance from the driver's seat to the center of gravity of the car.

3. Establishment of mathematical equation of system dynamics

3.1 Hypothetical basis

The whole dynamic model of "driver-seat-vehicle" is constructed in this paper,Based on the above analysis, and considering from the objective and scientific level, the established model needs to meet the actual road driving situation to a certain extent,This paper gives the following basic assumptions for the whole model:

1) The car itself satisfies the physical rigid body in the model and satisfies the central symmetry condition.The driver is vertically above the car In the above model. For the driver, only the vibration displacement in comfortable direction is considered;

2) In the whole simulation system, the car is always in a one-way linear uniform motion and because of the wheelbase difference between the front and rear wheels of a car, the excitation from the road is different;

3) In the process of driving, the tire will not be separated from the road surface, and the inclined motion state in the side direction is not considered;

4) The vibration of the vehicle body in the horizontal direction does not affect the vibration of the whole system;

5) Vibration of driver-seat-vehicle system caused by road unevenness, the stiffness and damping responses of other parts of the response system remain linear correlation.

However, in the real vehicle vibration system, because there are many nonlinear components installed inside the vehicle, the whole vehicle vibration system is actually nonlinear. Therefore, several basic assumptions proposed in this paper will produce error results that are theoretically permissible to a certain extent. According to the assumptions in this paper, the whole dynamic system is regarded as a linear system with constant coefficients. ,According to the basic theory of rigid body dynamics in physics, all differential equations of the whole dynamic system are calculated by Newton Euler method [4].

3.2 Differential equations of motion

According to the kinetic model in Figure 1 and the parameter data in table 1, six differential equations of dynamics are derived by using the physical theorem[5].The details are as follows:

The differential equation of driver motion is as follows:

$$\mathrm{m_1\ddot{z}_1 = c_1\dot{z}_2 - c_1\dot{z}_1 + k_1z_2 - k_1z_1} \tag{1}$$

The motion differential equation of the driver's seat is as follows:

$$\begin{aligned}\mathrm{m_2\ddot{z}_2} &= \mathrm{c_1\dot{z}_1 - (c_1 + c_2)\dot{z}_2 + c_2\dot{z}_3 - l_3c_2\dot{z}_4 + k_1z_1 - (k_1 + k_2)z_2} \\ &\quad \mathrm{+ k_2z_3 - l_3k_2z_4}\end{aligned} \tag{2}$$

The vertical motion differential equation of automobile body is as follows:

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$$\begin{aligned} m_b\ddot{z}_3 = {} & c_2\dot{z}_2 - (c_{fs} + c_{rs} + c_2)\dot{z}_3 + (l_1c_{fs} - l_2c_{rs} + l_3c_2)\dot{z}_4 + c_{fs}\dot{z}_5 \\ & + c_{rs}\dot{z}_6 + k_2\dot{z}_2 + k_2z_2 - (k_{fs} + k_{rs} + k_2)z_3 \\ & + (l_1k_{fs} - l_2k_{rs} + l_3k_2)z_4 + k_{fs}z_5 + k_{rs}z_6 \end{aligned} \tag{3}$$

The differential equation of vehicle body pitching motion is as follows:

$$\begin{aligned} J_b\ddot{z}_4 = {} & -l_3c_2\dot{z}_2 - (-l_1c_{fs} + l_2c_{rs} - l_3c_2)\dot{z}_3 \\ & - \left({l_1}^2c_{fs} + {l_2}^2c_{rs} + {l_3}^2c_2\right)\dot{z}_4 - l_1c_{fs}\dot{z}_5 + l_2c_{rs}\dot{z}_6 \\ & - l_3k_2z_2 + (l_1k_{fs} - l_2k_{rs} + l_3k_2)z_3 \\ & - \left({l_1}^2k_{fs} + {l_2}^2k_{rs} + {l_3}^2k_2\right)z_4 - l_1k_{fs}z_5 + l_2k_{rs}z_6 \end{aligned} \tag{4}$$

The vertical motion differential equation of the front road is as follows:

$$\begin{aligned} m_{fs}\ddot{z}_5 = {} & c_{fs}\dot{z}_3 - l_1c_{fs}\dot{z}_4 - (c_{ft} + c_{fs})\dot{z}_5 + c_{ft}\dot{q}_f(t) + k_{fs}z_3 - l_1k_{fs}z_4 \\ & - (k_{ft} + k_{fs})z_5 + k_{ft}q_f(t) \end{aligned} \tag{5}$$

The vertical differential equation of automobile rear wheel is as follows:

$$\begin{aligned} m_{rs}\ddot{z}_6 = {} & c_{rs}\dot{z}_3 + l_2c_{rs}\dot{z}_4 - (c_{rt} + c_{rs})\dot{z}_6 + c_{rt}\dot{q}_r(t) + k_{fs}z_3 + k_{rs}z_4 \\ & - (k_{rt} + k_{rs})z_6 + k_{rt}q_r(t) \end{aligned} \tag{6}$$

The above dynamic differential equations are written in matrix form:

$$M\ddot{Z} + C\dot{Z} + KZ = BQ \tag{7}$$

Where, M--mass matrix; C--damping matrix; K--stiffness matrix; B--coefficient matrix; Q--excitation matrix; $\{Z\}$, $\{\dot{Z}\}$, $\{\ddot{Z}\}$ correspond to the displacement, velocity and acceleration matrix of each mass after physical equivalence of the dynamic model.

Therefore, the matrix of the model is as follows:

The mass matrix of each part of the model is as follows:

$$[M] = \mathrm{diag}[m_1 \quad m_2 \quad m_b \quad J_b \quad m_{fs} \quad m_{rs}]$$

Damping matrix in the model:

$$[C] = \begin{bmatrix} c_1 & -c_1 & 0 & 0 & 0 & 0 \\ -c_1 & c_1 + c_2 & -c_2 & l_3c_2 & 0 & 0 \\ 0 & -c_2 & c_{fs} + c_{rs} + c_2 & -l_1c_{fs} + l_2c_{rs} - l_3c_2 & -c_{fs} & -c_{rs} \\ 0 & l_3c_2 & -l_1c_{fs} + l_2c_{rs} - l_3c_2 & {l_1}^2k_{fs} + {l_2}^2k_{rs} + {l_3}^2k_2 & l_1c_{fs} & -l_2c_{rs} \\ 0 & 0 & -c_{fs} & l_1c_{fs} & c_{ft} + c_{fs} & 0 \\ 0 & 0 & -c_{rs} & -l_2c_{rs} & 0 & c_{rt} + c_{rs} \end{bmatrix}$$

Stiffness matrix of each part of the model:

$$[K] = \begin{bmatrix} k_1 & -k_1 & 0 & 0 & 0 & 0 \\ -k_1 & k_1 + k_2 & -k_2 & l_3k_2 & 0 & 0 \\ 0 & -k_2 & k_{fs} + k_{rs} + k_2 & -l_1k_{fs} + l_2k_{rs} - l_3k_2 & -k_{fs} & -k_{rs} \\ 0 & l_3k_2 & -l_1k_{fs} + l_2k_{rs} - l_3k_2 & {l_1}^2k_{fs} + {l_2}^2k_{rs} + {l_3}^2k_2 & l_1k_{fs} & -l_2k_{rs} \\ 0 & 0 & -k_{fs} & l_1k_{fs} & k_{ft} + k_{fs} & 0 \\ 0 & 0 & -k_{fs} & l_2k_{rs} & 0 & k_{rt} + k_{rs} \end{bmatrix}$$

Coefficient matrix:

$$[B] = \begin{bmatrix} 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \\ c_{ft} & 0 & k_{ft} & 0 \\ 0 & c_{rt} & 0 & k_{rt} \end{bmatrix}$$

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The model comes from the external excitation matrix:

$$[Q] = [\dot{q}_f(t) \quad \dot{q}_r(t) \quad q_f(t) \quad q_r(t)]^T$$

The displacement matrix of each part of the model is as follows:

$$Z = [z_1 \quad z_2 \quad z_3 \quad z_4 \quad z_5 \quad z_6]^T$$

The velocity matrix of each part of the model is as follows:

$$\dot{Z} = [\dot{z}_1 \quad \dot{z}_2 \quad \dot{z}_3 \quad \dot{z}_4 \quad \dot{z}_5 \quad \dot{z}_6]^T$$

The acceleration matrix of each part of the model is as follows:

$$\ddot{Z} = [\ddot{z}_1 \quad \ddot{z}_2 \quad \ddot{z}_3 \quad \ddot{z}_4 \quad \ddot{z}_5 \quad \ddot{z}_6]^T$$

4. Random road model of vehicle driving

4.1 Unevenness function of road surface

In fact, if the vehicle is driving in a straight line with uniform speed, the vibration excitation source is mainly generated by uneven road. Among them, the uneven road surface is also one of the main reasons for physiological and psychological discomfort during driving. Among them, the road unevenness curve is shown in Figure 4. The height of the pavement relative to the reference plane is q, and the change $q(I)$ of the length I along the road trend is called the pavement unevenness function [6].

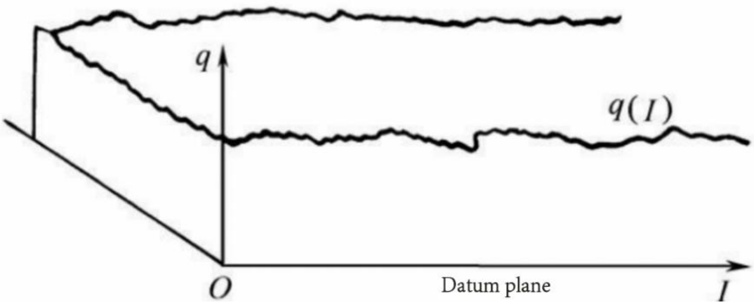

Figure 4. Road unevenness curve

4.2 Principle of power spectrum

Generally speaking, the power spectrum of different road surfaces can be used to represent the input characteristics of random excitation of road surface unevenness, which is of great significance to the study of dynamic comfort of driving seat. The dynamic characteristics of the driver, the driver's seat and all parts of the car can be obtained by using the random vibration theory when the random excitation signal of the road unevenness and the characteristics of the whole vehicle are known. By comparing the vibration characteristic results with the existing standardized vibration comfort data, the dynamic comfort of the driver's seat can be evaluated to a certain extent, and suggestions for improving the dynamic comfort of the driver's seat can be put forward, and the design of the driver's seat can be guided.

According to the national standard GB/t7031-2005 [7], the power function is used as the fitting expression of pavement power spectral density:

$$G_q(n) = G_q(n_0)\left(\frac{n}{n_0}\right)^{-\omega} \tag{8}$$

In the above formula, n-spatial frequency(m^{-1}); n_0-spatial reference frequency(m^{-1}); Gq(n0)-pavement coefficient(m^3); ω-fitting power spectral density index.

Speed power spectrum formula:

$$G_{\dot{q}}(n) = (2\pi n)^2 G_q(n) \tag{9}$$

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Acceleration power spectrum formula:

$$G_{\ddot{q}}(n) = (2\pi n)^4 G_q(n) \tag{10}$$

If $\omega = 2$, the combination (1-9) and formula (1-10) can be obtained:

$$G_{\dot{q}}(n) = (2\pi n_0)^2 G_q(n_0) \tag{11}$$

$$G_{\ddot{q}}(n) = (2\pi n_0)^4 G_q(n_0) \tag{12}$$

By observing the above formula, it can be seen that in the whole frequency range, the side value of road speed power spectral density is a constant, that is, the value of "white noise" is only related to the unevenness coefficient $G_q(n)$, which can be used to calculate the power spectrum of vibration response conveniently.

4.3 Stochastic pavement time domain model

For the established dynamic model system, the random excitation of the front wheel of a car from the road surface can be expressed by the first-order filtered white noise in time domain, the mathematical formula is as follows:

$$\dot{q}_f(t) + \alpha v q_f(t) = \omega(t) \tag{13}$$

Where, α is a constant(m^{-1}), v is speed(m/s), $\omega(t)$ is white noise signal,$N = 2\alpha v p^2$ is strength, the specific parameters are shown in table 2.

Table 2. Pavement spatial frequency parameters and p values

Pavement grade	$\alpha/(m^{-1})$	$p/(m)$
A	0.1320	0.0015
B	0.1303	0.0032
C	0.1200	0.0060
D	0.1007	0.0115
E	0.09	0.022

The relationship between the front and rear wheels in frequency domain is as follows:

$$\frac{Q_r(s)}{Q_f(s)} \approx \frac{2-\Delta_s}{2+\Delta_s}(\Delta = l/v) \tag{14}$$

Where,Laplace transformation of $Q_r(s)$,$Q_f(s)$ as $q_r(t)$,$q_f(t)$; s is the operator of Laplace transform; Δ is the time delay of the rear wheels; l is the distance between the front and rear wheels.

Combined formula (1-11) and formula (1-12) have:

$$\dot{q}_r(t) = -\frac{2}{\Delta} q_r(t) + \left(\frac{2}{\Delta} + \alpha v\right) q_f(t) - \omega(t) \tag{15}$$

Where $q_r(t)$ and $q_f(t)$ represent the random excitation of the front and rear wheels respectively.

5. Establishment of pavement model by Simulink

5.1 Introduction of MATLAB / Simulink software

Matlab is a software for mathematical calculation developed by MathWorks company of America. After years of development and continuous optimization, it has been widely used in big data processing, machine deep learning, computer vision recognition, wavelet analysis, artificial intelligence algorithm and control engineering. Automobile design itself is a complex dynamic engineering, which is the combination of mechanical parts and motor control. The traditional research and development method has been unable to complete the whole design task process, and the birth of MATLAB software has solved this problem. Using MATLAB software programming can accurately

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complete the simulation of the whole dynamic system of the automobile and improve the work efficiency.

Simulink is one of the important toolkits contained in MARLAB software, which provides users with a huge virtual computing environment [8]. The use of Simulink toolkit contains each module can be directly used, as long as the modules are effectively connected. After the module of the system is established, the simulation can be carried out and the expected results can be obtained. This paper uses Simulink to model and simulate the road surface of the dynamic model.

5.2 Road Simulink module creation

According to formula (13) and (15), the random excitation module of road unevenness is established by using Simulink. The details are shown in Figure 5.

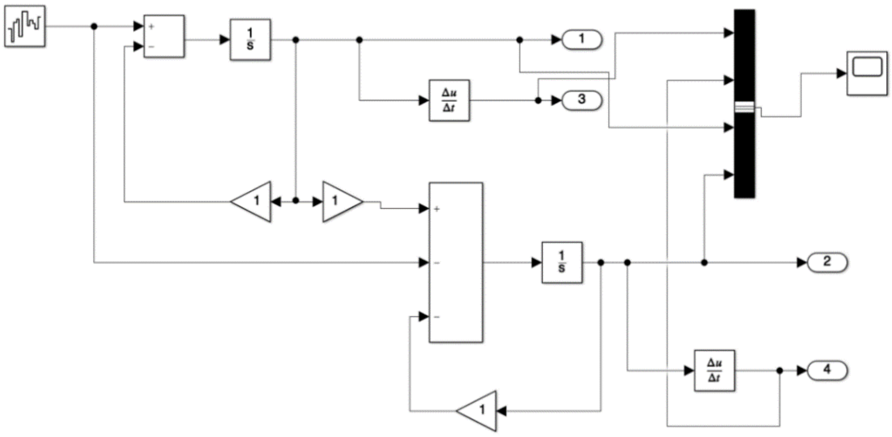

Figure 5. Simulink model for random excitation of road unevenness

5.3 Simulation of common pavement models

According to the actual situation of domestic highway pavement [9], grade B and grade C pavement are the most common. Among them, grade B pavement is usually asphalt road, and grade C pavement is usually gravel road. Therefore, this paper takes B and C grade pavement as the research carrier. When the speed of the vehicle is 50km/h, the time-domain simulation curves of the front and rear wheels of B and C random roads are shown in Figure 6 and Figure 7.

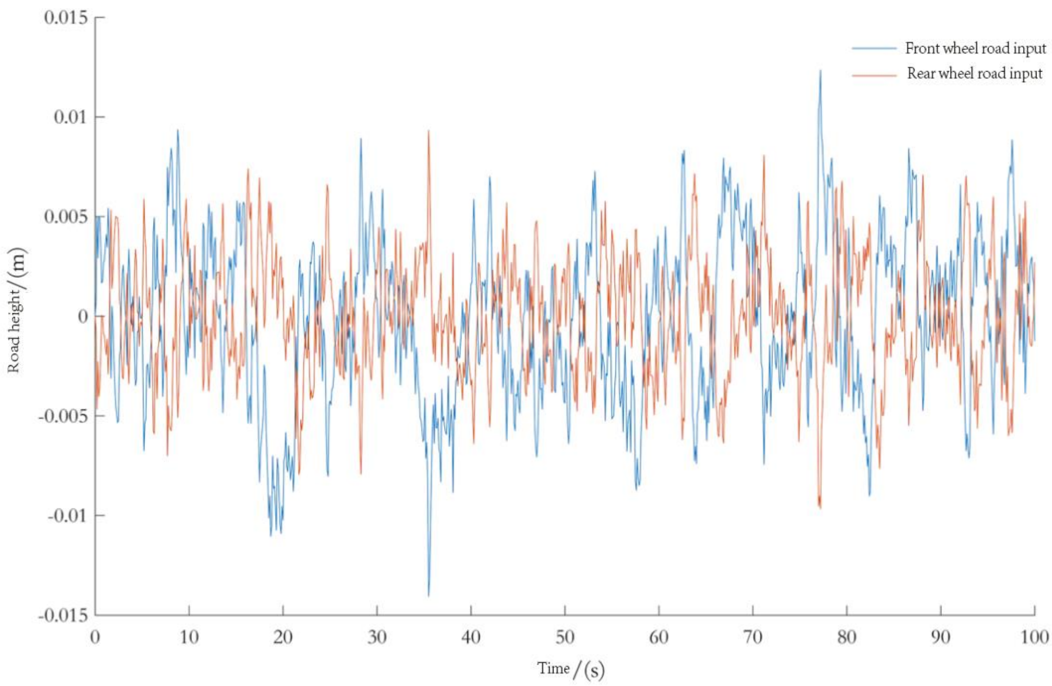

Figure 6. Time domain diagram of random excitation of class B pavement

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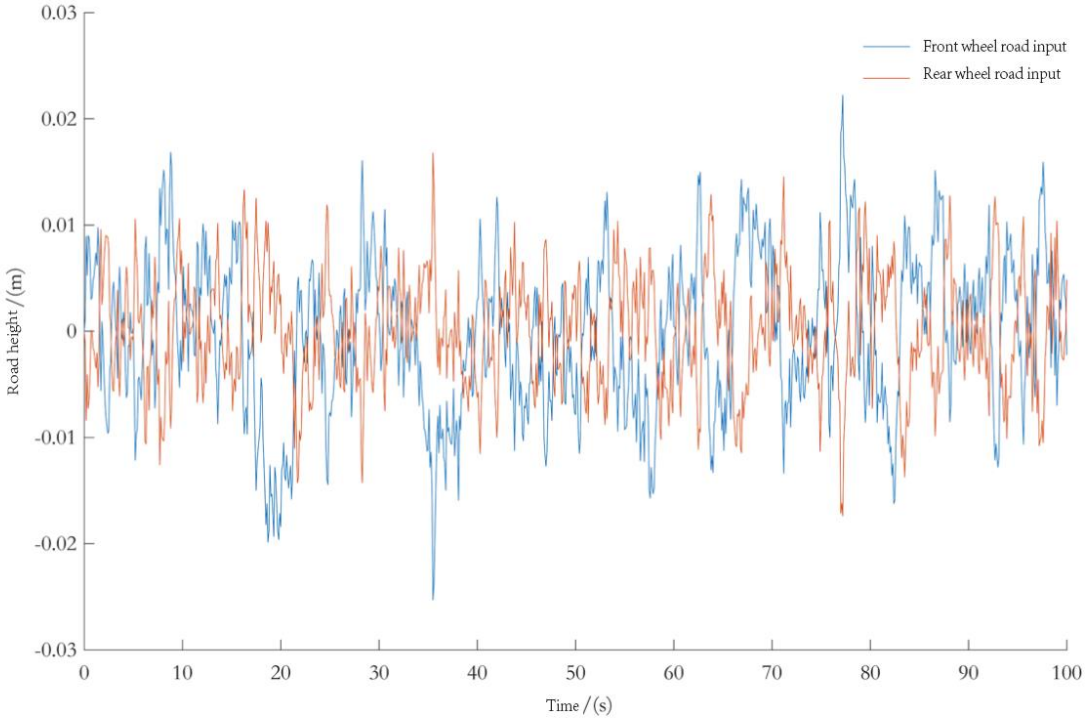

Figure 7. Time domain diagram of random excitation of class C pavement

It can be seen from the above two figures that the time domain simulation of different levels of road surface will be different under the same driving speed. Compared with the two figures, the maximum height of Road C is higher than that of Road B, which is in line with the actual road situation.

6. Time domain analysis of driver acceleration response

By combining matlab program and road Simulink module, the driver-seat-vehicle dynamic model established in this paper is simulated, and the driver's acceleration response curve graphs in 50km/h, 70km/h and 90km/h models on B road are obtained. The details are shown in Figure 8, Figure 9 and Figure 10.

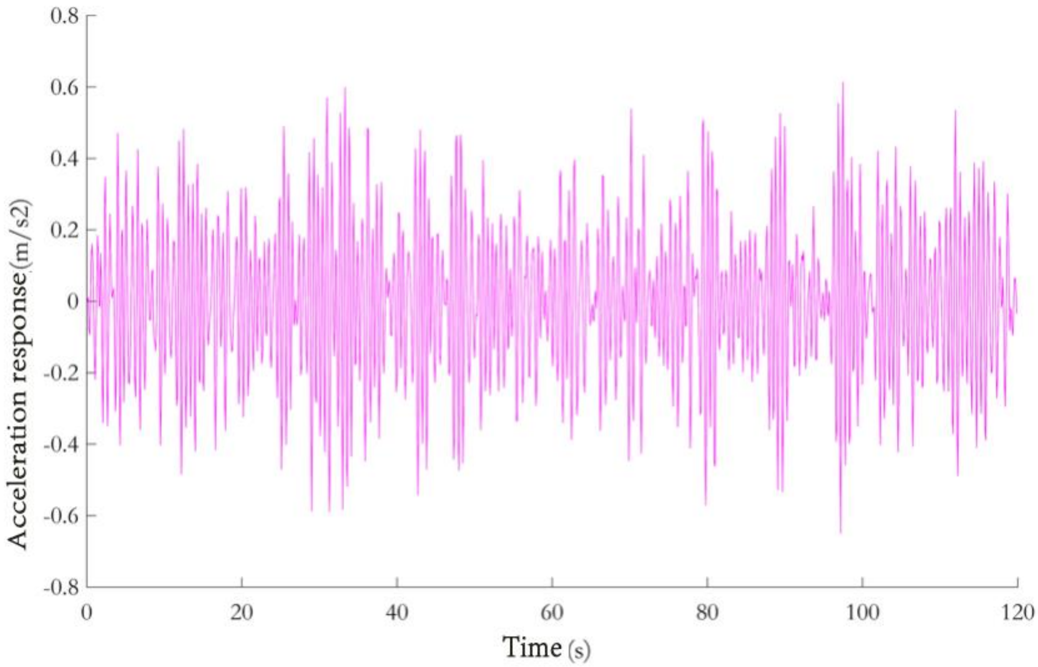

Figure 8. Response of driver's body acceleration at 50km/h (B)

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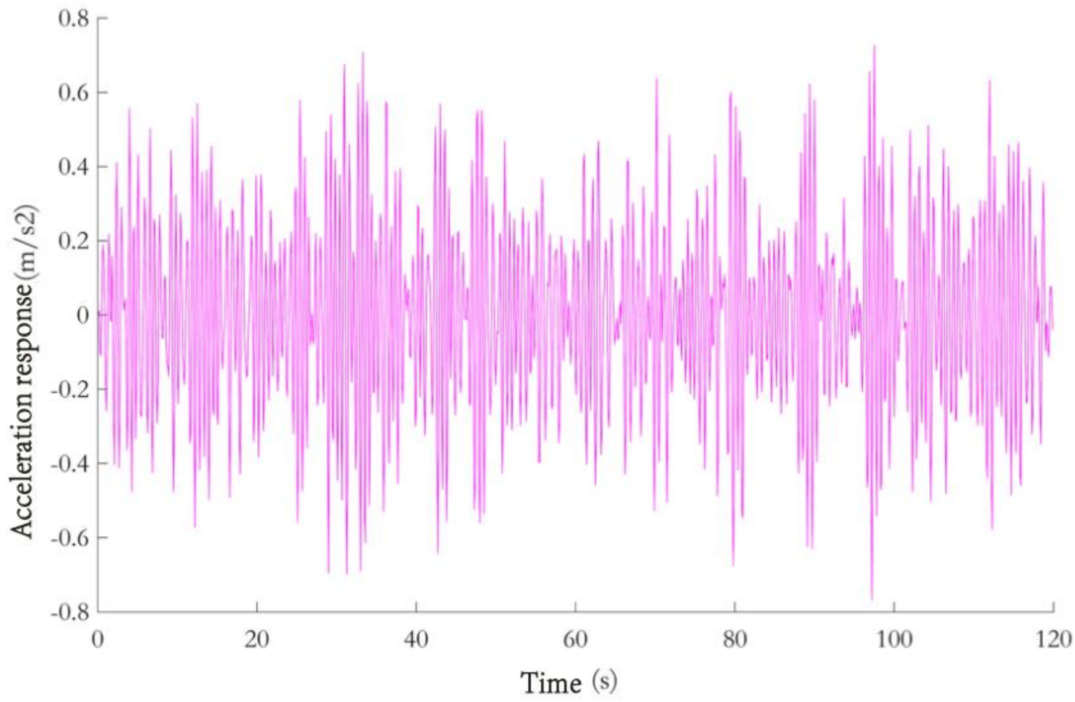

Figure 9. Response of driver's body acceleration at 70km/h (B)

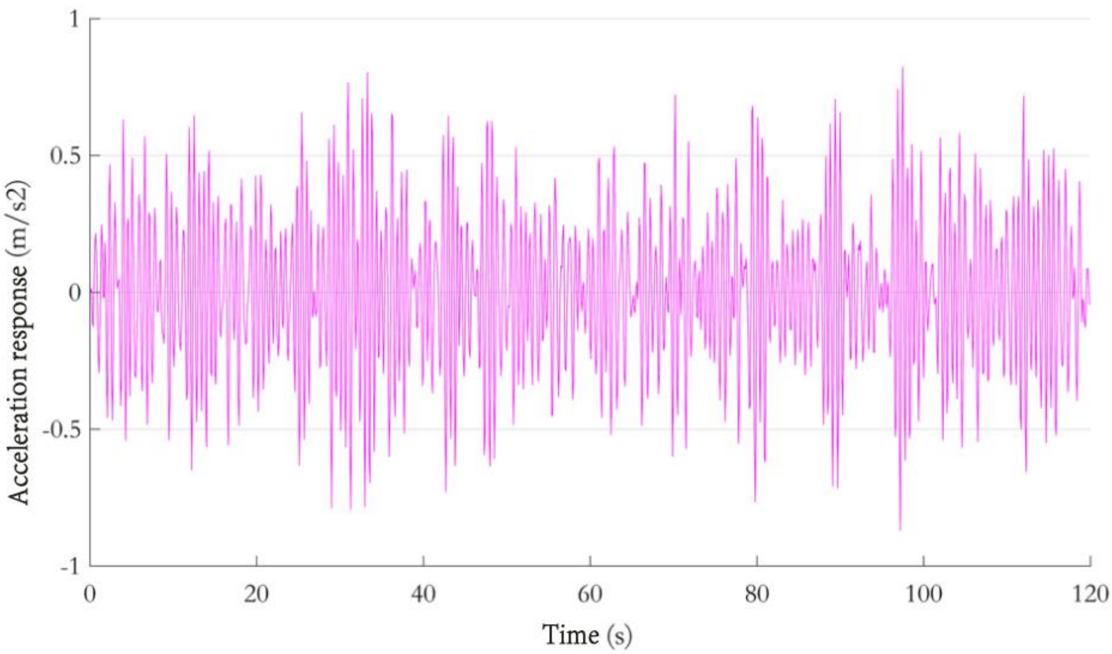

Figure 10. Response of driver's body acceleration at 90km/h (B)

It can be seen from the above figure that under the same road conditions, when the vehicle speed is 50km/h, the maximum response of the driver's body acceleration is not more than $0.6\mathrm{m/s^2}$; when the speed increases to 70 km/h, the maximum response value is close to $0.8\mathrm{m/s^2}$; when the speed reaches 90 km/h, the response value of the driver's body acceleration is close to $1\mathrm{m/s^2}$. It can be seen that the acceleration response value of human body increases with the increase of speed under Road B, which indicates that the driver is more and more sensitive to the external environment.

At the same three speeds of C road, the response curve of driver's body acceleration is obtained. The details are shown in Figure 11, Figure 12 and Figure 13.

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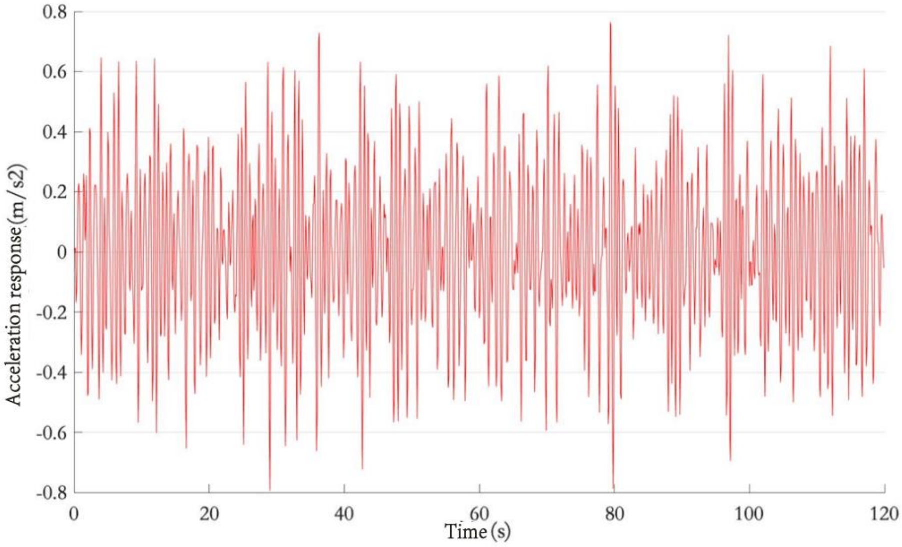

Figure 11. Response of driver's body acceleration at 50km/h (C)

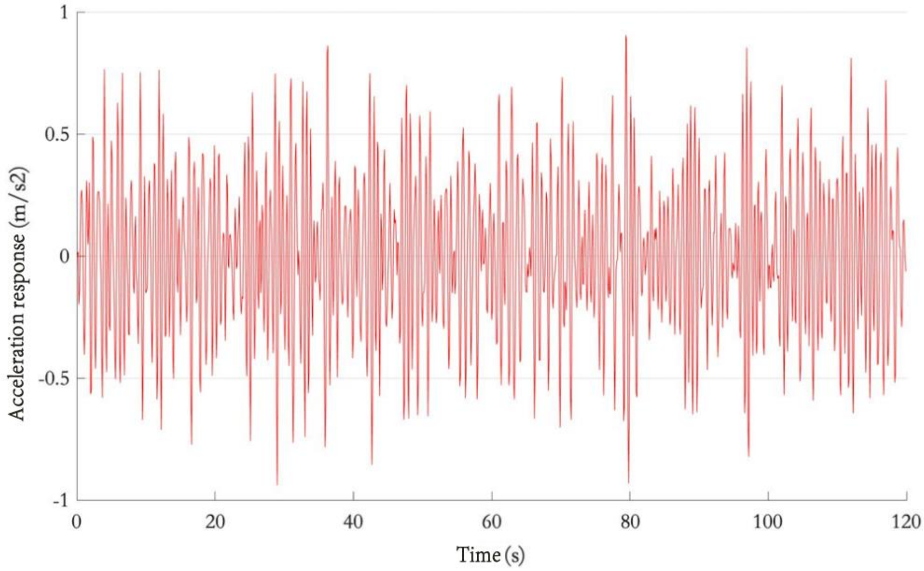

Figure 12. Response of driver's body acceleration at 70km/h (C)

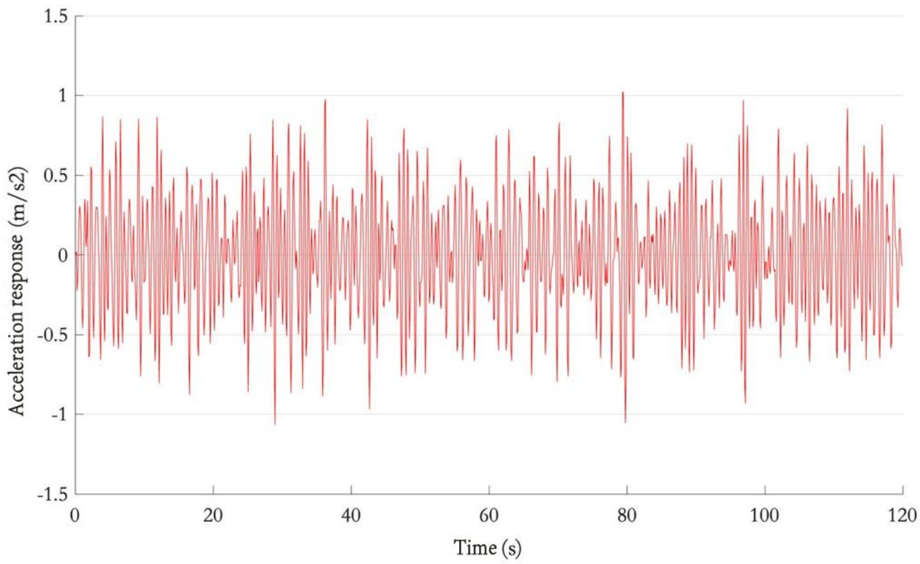

Figure 13. Response of driver's body acceleration at 90km/h (C)

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For Road C, the acceleration response curve of the driver's body under three speeds shows that the acceleration response value of the driver's body increases gradually with the increase of vehicle speed on the same road. However, for the same speed, different road driver's body acceleration response analysis shows that the response value of driver's body acceleration on Road C is obviously larger than that on road B. At the speed of 90km/h, the maximum response value of Road C is 1.5 times of that of Road B at the same speed.

To sum up, the impact of external vibration on drivers of the same grade is more and more significant with the increase of speed; at the same speed, the lower the road level is, the more the impact of external vibration on drivers is. This result is in line with the actual driving situation.

7. Weighted root mean square value of acceleration response of each part of dynamic model

Matlab programming is used to solve the weighted root mean square value of the driver's vertical acceleration on common B and C roads [10-14]. See table 3 and table 4 for details. And table 5 is the standard dynamic comfort evaluation index.

Table 3. Root mean square value of road B acceleration

Speed(Km/h)	50	70	90	110
$a(m \cdot s^{-2})$	0.2147	0.2540	0.2880	0.3184
Dynamic comfort evaluation	No discomfort	No discomfort	No discomfort	Slightly uncomfortable

Table 4. Root mean square value of road C acceleration

Speed(Km/h)	50	70	90	110
$a(m \cdot s^{-2})$	0.2911	0.3444	0.3905	0.4317
Dynamic comfort evaluation	No discomfort	Slightly uncomfortable	Slightly uncomfortable	Slightly uncomfortable

Table 5. Standard dynamic comfort evaluation index[15]

Root mean square value of weighted acceleration/$(m \cdot s^{-2})$	Subjective feelings	Comfort
<0.315	No discomfort	1.0
0.315~0.63	Slightly uncomfortable	0.8
0.5~1.0	A little uncomfortable	0.6
0.8~1.6	Discomfort	0.4
1.25~2.5	Great discomfort	0.2
>2.0	Extremely uncomfortable	0

The results show that the influence of driving seat comfort is different with the road surface and speed. The more uneven the road surface, the faster the speed of the car, the greater the acceleration response value of the driver's body, and the root mean square value obtained gradually increases. The dynamic comfort of the driver's seat is worse, which is consistent with common sense. It can be seen that the simulation conclusion is reasonable.

8. Conclusion

This paper is mainly about the dynamic system of human, seat and automobile in vibration environment. Firstly, the "driver-seat" model and the "car road" model are created. After analysis, the six degree of freedom dynamic model of "driver-seat-vehicle" is established. Then, Newton Euler method is used to solve the differential equation of the whole dynamic model. Then, according to the power spectrum theory, the time domain model of road random excitation is generated, and the Simulink model of road unevenness random excitation is established and simulated.

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