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REVIEW ARTICLE

RESEARCH AND APPLICATION OF SEMI-ACTIVE SUSPENSION CONTROL AND PERFORMANCE TESTING SYSTEM

Ren Chenglong

School of Automotive and Rail Transit, Nanjing Institute of Technology, China.

*Corresponding Author Email: junsunq56@gmail.com, yuel3348@gmail.com

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ARTICLE DETAILS

ABSTRACT

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Suspension is one of the important components of automobile products, and the smooth operation of the automobiles is closely related to the structure of the suspension. This paper studies the semi-active suspension control and its performance test by firstly introducing the suspension, then analyzing the neural network control basis and designing the single-chip control system, and finally formulating the performance evaluation criteria of suspension to evaluate its function. The performance of the semi-active suspension built on the basis of neural network control theory is better than that of the passive suspension and active suspension, so it can be promoted in the future application.

KEYWORDS

semi-active suspension, control, performance test, application.

1. INTRODUCTION

The unevenness of the road will cause the irregular vibration of the car in its traveling process, which has great side effects for both people and goods on the car. In addition, there is a dynamic load between the wheel and the ground; when it increases to a certain extent, the wheel cannot firmly cling to the ground, impacting its stability. In this context, how to take effective measures to control the vibration of the running vehicle has become one of the focuses of the academic research [1]. The control of the vehicle vibration can be carried out from two aspects: the vehicle and the pavement, which means to improve the pavement and in the meantime to enhance the anti-vibration characteristics of the vehicle. The latter is mainly affected by three factors, namely the tire, suspension and seat, among which the suspension has a key role. In view of this, this paper conducts a research on the application of semi-active suspension control and performance testing system after the introduction of the concept and the classified comparison of automotive suspension, hoping to provide a reference and contribution to the development of automobile manufacturing [2].

2. INTRODUCTION OF SUSPENSION

2.1 The concept of suspension

There is a certain relationship between the frame and the axle of the car, and it is the suspension that plays the role of connection. Therefore, it can be defined as the generic term of all the driving power connecting devices between the frame and the axle. Through the suspension, the driving force can be transmitted to drive the vehicle. Suspension is usually installed between the vehicle body and the tire; if a certain degree of vibration is caused by the uneven pavement, the suspension can play a buffering role to weaken the vibration delivered from the tire to the body [3]. Therefore, the suspension can indeed affect the comfort degree and smoothness of the vehicle to a large extent, the two of which are actually interrelated. Also, it needs to be noticed that vehicle vibration will cause all kinds of noise influencing the passengers, and also damage the parts, leading to hidden worries.

2.2 The role of suspension

The components of suspension can be divided into three kinds: various elastic components including the leaf springs, coil springs and torsion bars; the shock absorber; and the guiding machine. The role of suspension has been briefly described above, and it will be analyzed from three aspects:

Firstly, in the running process of the vehicle, several kinds of forces will be transmitted to the wheels, including the reaction force in the vertical direction, the driving force from the engine, the braking force from the braking system and other vertical or lateral forces. The interaction of these forces and their transmission on the parts of the vehicle may produce other forces, which will eventually be acted on the vehicle, producing vibration of the whole bearing system of the vehicle [4]. The suspension can transfer the forces to the frame, avoiding or reducing impact on the vehicle. The particularly important point is that the suspension can restrain the vertical forces on the wheels, which is very important for the stability of the vehicle.

Secondly, the body and wheels of the car will move relatively to each other or other parts in the running process of the car. Such relative motion is very irregular, and the suspension can lead guide such motion into balance, thus controlling the tendency of side tilt and forward or backward charge, which will make the driver more satisfactory during his operation.

Thirdly, the suspension has certain supporting role for the vehicle. Judging from the three roles of the suspension analyzed above, we need to consider the stiffness and damping of the material when designing the suspension of the vehicle; the former is to facilitate its supporting role, and the latter is to ensure its first two roles. The stiffness and damping of the suspension are also known as the suspension parameters. To decrease the vibration caused by the rough road and the engine, the driving device and the wheels to the vehicle body, the suspension is best to be flexible to be able to play a buffering role [5]. When the tilt and pitch of the car is very

common during its turning, speeding up and braking, the suspension should be designed harder. Therefore, the setting of the suspension parameters is not extreme, but with a balance between the hardness and softness. The contradictions influencing the suspension parameters have been in existence for a long time and will not be eliminated, so what the designers need to do is minimize the contradiction through their mutual restriction to benefit the whole of the car.

2.3 Classification of the suspension

In the development of cars, there are three kinds of suspension with different working principles, which can be classified into three categories: passive suspension, active suspension, and semi-active suspension.

Passive suspension is the form adopted by many cars at present, the stiffness and damping of which are fixed. It is designed with the optimized suspension parameter as the target, its dynamic deflection as the constraint conditions, the smooth index of the acceleration in the vertical vibration of the car and the security index of the relative dynamic load of the tire as the comprehensive requirements of the entire issue to finally get the optimal results of the suspension parameters. The design and manufacturing technology of passive suspension has been quite mature with simple structure and high reliability [6]. However, once the parameters of passive suspension are determined, they cannot be changed, because it is essentially a fixed device incapable of responding to unexpected situations. Therefore, the passive suspension is no longer that popular when the driving environment and the people have higher requirements for its stability.

The active suspension is relative to the passive suspension, which is based on the development of electronic control technology and servo hydraulic technology. Contrary to the passive suspension, active suspension needs external energy to maintain its control. The hydraulic cylinder of the active suspension as the source of the active force has replaced the role of the spring and shock absorber of the passive suspension [7]. The high-pressure liquid outside the suspension is the energy source of the active suspension. The system is equipped with sensors, so the state data will be delivered to the electronic control unit; and after the analysis, judgment and order of the unit, the hydraulic cylinder will produce active force. The whole operation process is a closed loop line. The active suspension has good adaptability, but with complex structure and high cost of design and production, which make it unable to be widely used.

Semi-active suspension also has its own electronic control system with similar structure to other control systems. The semi-active suspension system is installed sensors, which will collect the information about the speed and acceleration of the running car. The microprocessor at the superior level of the sensor will analyze the information collected by the sensors and make judgments to give an order, thus the whole control process begins. Semi-active suspension system has multiple sensors, located in different parts of the vehicle with different tasks [8]. For example, there are two sensors on the body: one is for acquisition of the acceleration, and the other is for acquisition of displacement. In addition, there are also sensors responsible for collecting information about the speed, steering wheel angle as well as acceleration pedal.

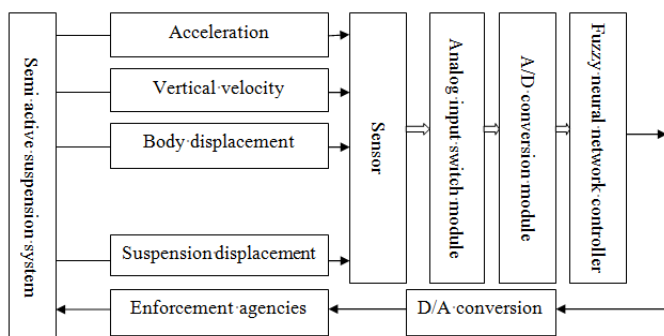


Figure 1: Components of semi active suspension system

3. NEURAL NETWORK CONTROL AND ITS CONTROLLER

The appropriate control method and controller should be selected in order to control the object effectively. The vehicle suspension system, a control object in this paper, has many special properties related to the control. The first is the uncertainty of suspension model due to the many parameters in determining the suspension model. According to relevant information, the current parameters for suspension model have reached 83 even though not all variables have been taken into account. The excessive parameters may lead to the gap between the suspension model and the practicality. The second is that many parameters determining the suspension model are nonlinear, such as the springs, tires and damping. These parameters are usually assumed to be linear in theoretical analysis for convenience. The third is that the suspension parameters are not static; after put into practice, its parameters will change along with time. Although these parameters are assumed to be invariant theoretically, these long-time accumulated changes in the actual situations may lead to the imbalance of the system.

3.1 The basis of neural network control

3.1.1 The forms of neural network

The mystery of how human intelligence is achieved and why other animals are not equipped with artificial intelligence has been attracting countless scientists to work hard on it. Eventually, biologists and neuroscientists jointly established the neural network theory and the theory of nervous system structure, believing that the complex structure of the brain is the foundation for the orderly development of human intelligent activities.

To understand the characteristics of the neural network, we must know its topology and learning methods, which are the main decisive factors. From this point of view, the neural network has the following four forms. The first one is forward network, where the neurons are listed in a hierarchy with the neurons of two adjacent layers interrelated instead of all the neurons. This form has been applied in artificial neural network including sensors and linear network. The second is feedback network, where each neuron node will accept externally input information and the feedback information from other nodes. The classical model used by this feedback network is Hopfield network. The third is combined network where each neuron, being equal with others, is connected to the neurons forward and backward. Each neuron is not only the receptor of the signal output of other neurons, but also the subject to output signals to other neurons. The fourth is mixed network. If the forward network is regarded as a layered structure, the combined network is a net structure, and the mixed network is a network form between the two.

3.1.2 Application of neural network

Neural network theory has been applied to many fields of real life since its establishment. One is the field of automatic control. The neural network is very complex with each part closely related, and such a huge system is achieved by careful control system. Therefore, the optimal design, optimal control and learning control of the control system are based on the neural network. Another is the application in dealing with combinatorial optimization problems, among which the most admirable example is the solution to problems of traveling salesman. And also, the neural network is applied in pattern recognition, image processing, sensor signal processing, artificial intelligence robot control and many other aspects including health care, economy, chemical industry and geography.

3.1.3 Characteristics of artificial neural network

Artificial neural network has many obvious characteristics and evident advantages compared with computers. The first point is parallelism; the artificial neural network is connected with a large number of neurons, so the calculation and storage of the traditional calculation methods can be combined to greatly accelerate the computation speed. The second is the characteristics of self learning. Different from computers, the artificial neural network can form some understanding of the objective world in the working process, which can be continuously improved and optimized with the deepening of understanding. The third is the ability of imagination and memory. The fourth is the robustness and fault tolerance, which means

that the entire network structure will still run normally with its performance reduced a little even if a few neurons have been damaged. The fifth is that the neural network is very similar to a nonlinear relationship, which is the relationship between most things in the world in the strict sense.

3.2 The design of neural network controller

The control system of suspension structure is expected to have the following functions: the single-chip control system receives the operation state signals of the vehicle, which are not from the multi-way switch but collected by multi-sensors; the function of the magnified circuit and filter circuit in the control system is to process the signals input into the system; the signals input into the system, presented in the form of data, will be converted by the control system, and the binary number will be converted to three byte floating point. To show the function and the execution flow of the controller clearly, the main program of the neural network controller is given in the following figure.

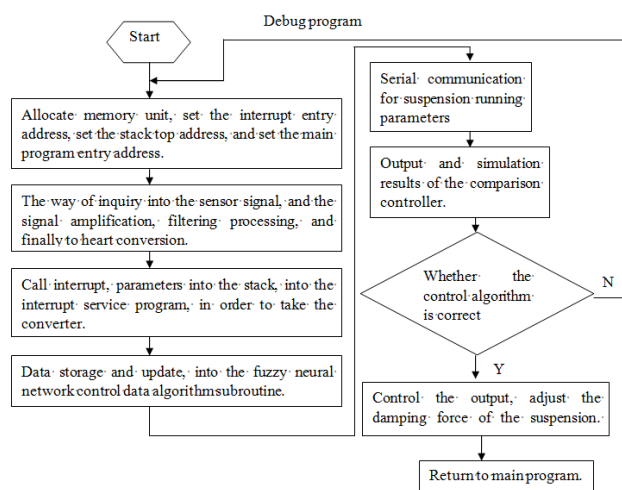


Figure 2: Flow chart of the main program

4. PERFORMANCE EVALUATION STANDARDS AND TESTING PROCEDURES OF THE SUSPENSION

4.1 Performance evaluation criteria of suspension

If the elastic components or shock absorber on the suspension device is damaged in the using process, the angular stiffness will decrease, and the vibration displacement of high-frequency non-suspended quality will also be greatly increased, which will eventually lead to bad contact between the tire of the vehicle and the ground; if the vibration in vertical direction is too large, the tire may lose contact with the ground. In view of this, almost all of the suspension detection devices are based on force exerted by the vehicle tire on the ground. The load the tire bears in the steady state is static contact force, and that borne by the tire with external influence is dynamic loads. Its evaluation index is the absorption rate, which refers to the ratio of the minimum dynamic vertical load with the static vertical load of the wheel in the resonance of the tires, expressed with percentages. If the index value is between 80% and 100%, it is excellent; between 60% and 79%, good; between 40% and 59%, deficient; between 0% and 39%, weak.

4.2 The detection process of suspension

To present the flow of the suspension test system more clearly, the test

flow chart of the suspension is given below. All the steps are closely related to form an orderly process.

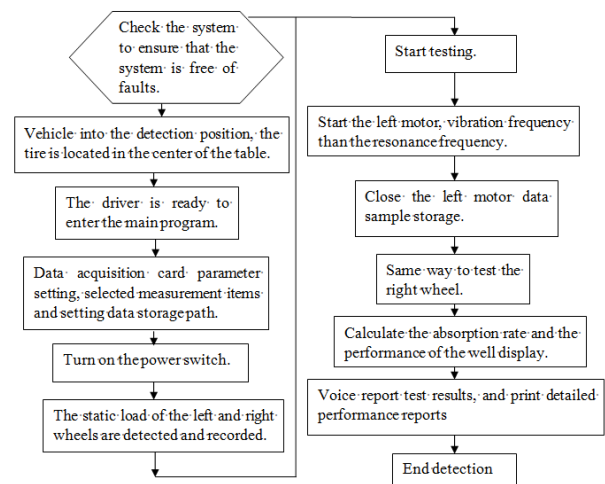


Figure 3: Schematic diagram of detection process

5. CONCLUSIONS

This paper mainly conducts a research on the application of semi-active suspension control and performance testing system. After the introduction of the concept, classification, application and characteristics of suspension, the neural network control theory and the controller based on this theory are studied, and the suspension performance detection system is also analyzed. Suspension is very important for cars; only the standardization of its control system and the strict and effective performance test before use can enhance the reliability and safety, thus reducing accidents and increasing comforts.

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