Vehicle active suspension control strategy research and simulation analysis

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Abstract. Suspension is an important part of the car. Compared with passive suspension and semi-active suspension, active suspension to improve the car's ride comfort and handling stability, etc have shown their superiority. In this paper, two degrees of freedom quarter-vehicle active suspension for the study, primarily for automotive active suspension control strategy and joint ADAMS and MATLAB simulation were studied. The simulation results show that: the fuzzy control used in automotive active suspension control system, improve the car's ride comfort and handling stability and other aspects of better results.

Keywords: Active suspension; Fuzzy control; Simulation.

1. Introduction

Suspension is one of the important part of the car, connecting it with the elastic body and tires, is mainly used to transfer between the body and the tire forces and moments, to ease the vibration due to the body caused by uneven pavement. Currently, most cars are still used in passive suspension technology, although after years of development is relatively mature and perfect, but because of structural constraints, passive suspension has been unable to meet further demands on the vehicle suspension system performance. Therefore, the use of electronic active suspension control technology has been widely attention. Active suspension feedback control based on the actual situation of the road conditions and cars with incentives, so that to achieve the best overall performance of the car. Active suspension vehicle suspension system is the inevitable trend of development.

Currently, the most active suspension research work is based on the mathematical model, and simplified mathematical model of the extent of the findings active suspension has a huge impact. Sometimes, however, difficult to establish a precise mathematical model of a large, but also for the study of active suspension is too complicated. In order to solve the above problems, this paper established a mechanical model of the software ADAMS quarter vehicle active suspension, on the basis of active suspension control strategy for research. To improve the car's ride comfort and handling stability purposes, focused on active suspension adaptability and intelligence to explore the research. Since the cars with the road is complex, thus increasing active suspension adaptability to different road excitation and smart and so have very important implications for improving the car's ride comfort and handling stability.

2. Suspension system architecture

Suspension is a general term for force transmission between connected devices car frame and axle everything. Not only bear in between the wheels and the body of the force, but also can absorb and mitigate vibration and shock when the vehicle is driving on uneven road generated, thereby improving the car's ride comfort, and extend the life of automotive parts . Although modern vehicle suspension structure of a variety of different forms, but generally by the elastic element、damper and guide mechanism composed of three parts, according to the specific form of the structure, including two passive suspension and active suspension

2.1 Passive suspension.

1934, Olley design theory first proposed passive suspension by adjusting the spring stiffness, shock absorber damping coefficient, changing the wheelbase, spring mounting location to improve vehicle ride comfort and handling stability. By passive suspension systems and shock absorbers composed of elastic element, the spring characteristic and damping characteristics is certain, when subjected to external stimulus (such as a certain speed of vehicles passing through uneven pavement), the only "passive" respond, so called passive suspension. Passive suspension without external energy input due to simple structure, low cost, etc. to obtain a wide range of applications. And after decades of development, the people on the research and design of passive suspension has accumulated considerable experience. It is composed of ordinary springs and shock absorbers.

2.2 Active suspension.

Fedrspiel-Labrosse in suspension design first proposed the idea active suspension. Active suspension is the use of active or passive controllable elements form a closed loop or open-loop control system, according to changes in the state of motion of the vehicle system and the external input conditions (road or the driver's steering wheel incentives, etc.) react initiative adjust and produce the desired control, the suspension is always in the best state of vibration. For a variety of different types of controlled suspension system has emerged, according to the extent they are able to improve vehicle performance to classify, from low to high as follows: ride height control suspension, passive adaptive suspension, switchable damped semi-active suspension, adjustable damping semi-active suspension, active suspension and the whole slow active suspension.

3. ADAMS model of active suspension

Application of ADAMS software to build two degree of freedom simulation model of 1/4 vehicle active suspension, as shown in figure 1, and make the following assumptions:

1. All components are assumed to be rigid, deputy within each movement is negligible friction.

2. In order to facilitate the analog input ground excitation, assuming the ground for an entity member tangible to direct contact with the tire, and with reference to the ground by moving the auxiliary connection, do the vertical movement up and down.

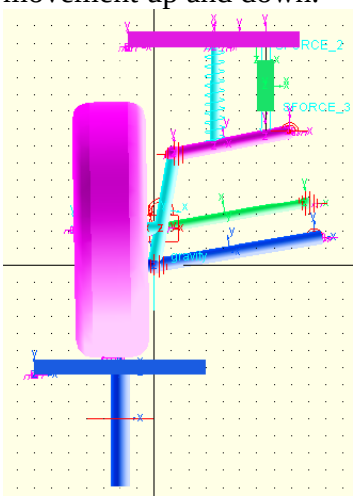

Fig. 1 ADAMS model of active suspension

4. Control Strategy

Active suspension control system is the core component of the suspension system, excellent control algorithm or not directly affect the suspension performance is good or bad. Vehicle suspension is a very complex, multi-variable, time-varying, nonlinear systems. Although it can be established through a variety of simplified mathematical model, but not accurate. The traditional PID control method is based on a mathematical model must be determined on the, this is bound to have a great situation with the actual error. The fuzzy controller does not need to have a precise mathematical

model as a basis, you can also design a more excellent controller. Therefore, in recent years the fuzzy controller to be more widely used in the automotive sector. Fuzzy controller is the core part of fuzzy control system, fuzzy control rule is based on fuzzy control rules describe the condition language, so fuzzy controller is also known as fuzzy language controller. Fuzzy controller based on the exact amount of the conversion to the fuzzy input information, in accordance with the language control rules for fuzzy reasoning, given the fuzzy output decision, which was converted to the exact amount of feedback to the controlled object. This paper uses a two-dimensional fuzzy controller, vehicle active suspension fuzzy control system block diagram shown in Figure 2.

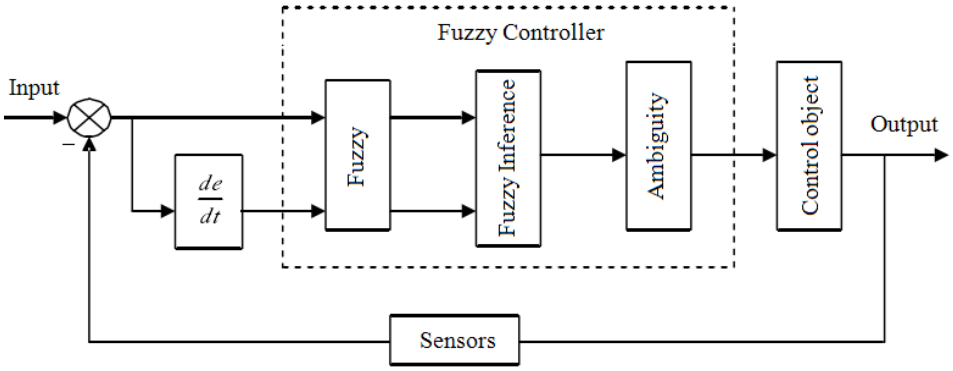

Fig. 2 Structure of the fuzzy controller

This document defines the error E, error change EC and output U of domain are: E, EC, U = {- 3, -2, -1,0,1,2,3}. The exact amount of fuzzy variables after blurring is divided into seven fuzzy subsets, namely:{NB (negative big), NM (negative medium), NS (negative small), Z0 (zero), PS (positive small), PM (positive medium), PB (positive big)}

After the input and output variables of fuzzy sets and domain are identified, you must determine the membership functions of the fuzzy variables, namely fuzzy variable. Determine the fuzzy subset division usually fuzzy membership functions similar variables, have certain subjectivity, are usually determined empirically or statistical methods. Membership function of fuzzy variables is to assign a number between 0 and 1 to each fuzzy subset. Fuzzy membership function can be expressed in the form of its function table can also be used in the form of a graphical representation of the curve. In the fuzzy control, the membership function of the fuzzy variable distribution, commonly used to describe the normal form, in order to facilitate the calculation and analysis, generally choose a similar triangular distribution with a normal distribution, and the triangular distribution and other more complex membership functions derived smaller difference between the control results. Figure 3 shows the fuzzy variables E, EC, U of membership function.

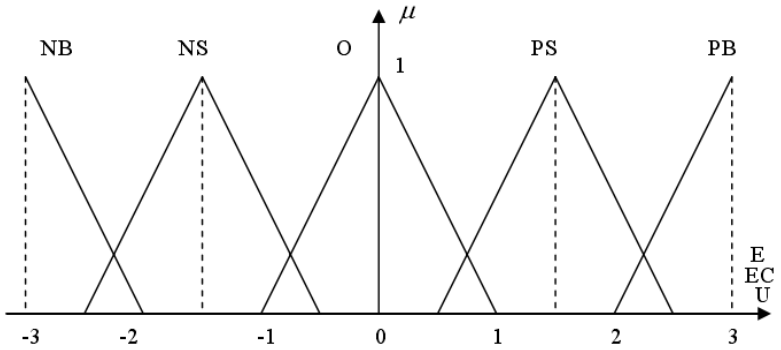

Fig. 3 Membership function of E, EC, U

5. Simulation analysis

In recent years, with the rapid development of automobile industry, the joint simulation technology in the field of auto control system of research and development has been widely used, and obtained ideal results. This chapter is mainly aimed at 2 dof 1/4 vehicle active suspension and passive suspension system, application of ADAMS and MATLAB joint simulation software, and the

simulation results were analyzed. Firstly established in the ADAMS/View software two degree of freedom mechanical model of a quarter car suspension system, and then establish the communication connection between ADAMS and MATLAB, the last under the environment of MATLAB/Simulink to establish control algorithm, a simulation model of the combination of the two software simulation. Joint application of simulation technology, makes the mechanical design and electric control most of the organic union, the simulation results more accurate response the real situation.

Using Gauss white noise as the road input during the process of simulation, the waveform is shown in figure 4.

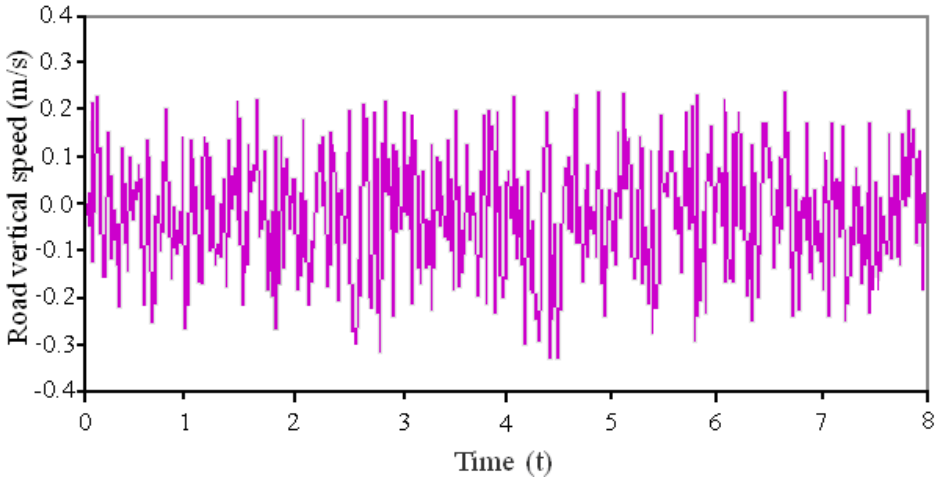

Fig. 4 Road input

The fuzzy control is applied to the vehicle control system to stroke the body vertical acceleration and suspension for the study, and the active suspension and passive suspension comparing simulation results shown in Figure 5-8.

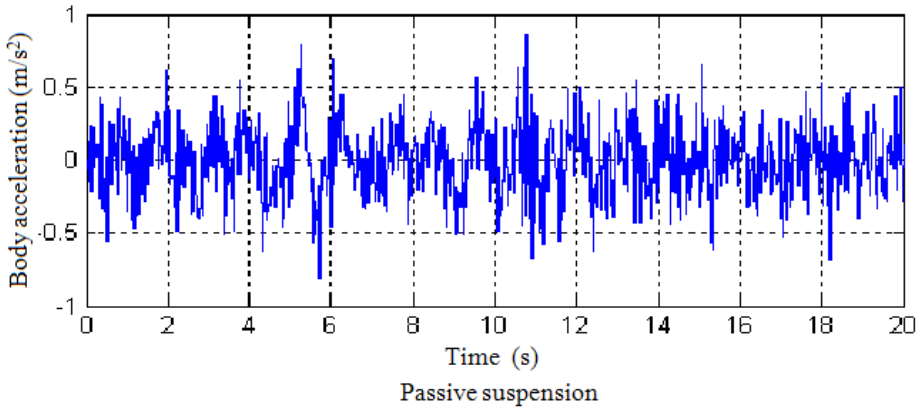

Fig. 5 Body acceleration of passive suspension

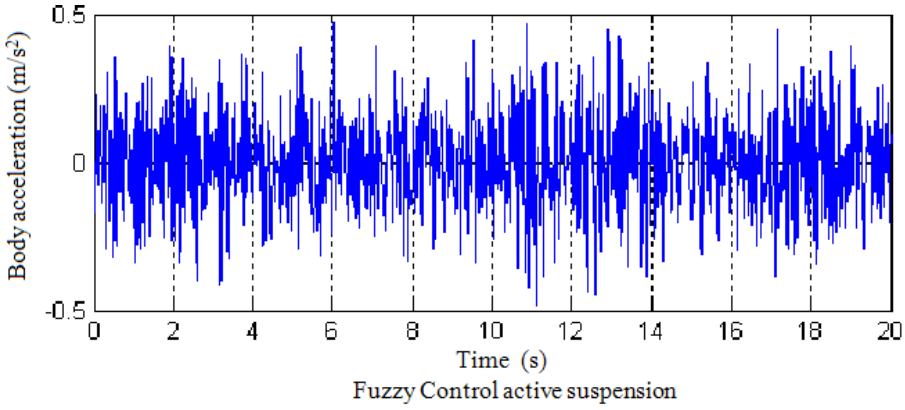

Fig. 6 Body acceleration active suspension

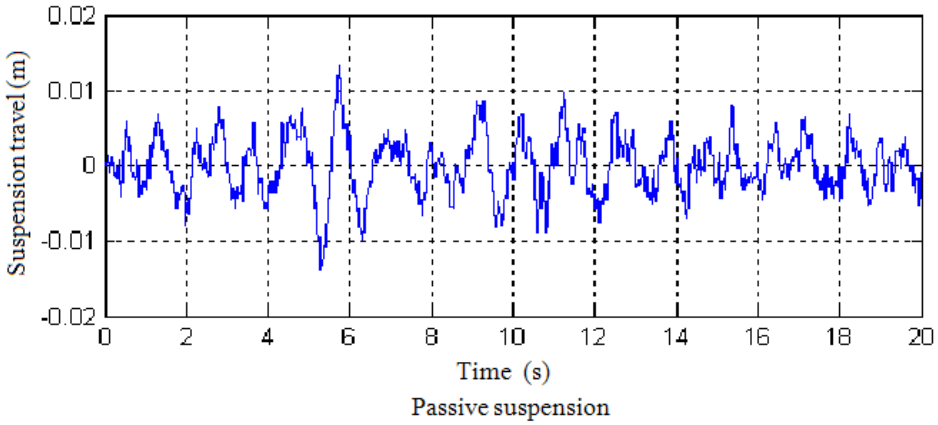

Fig. 7 Travel of passive suspension

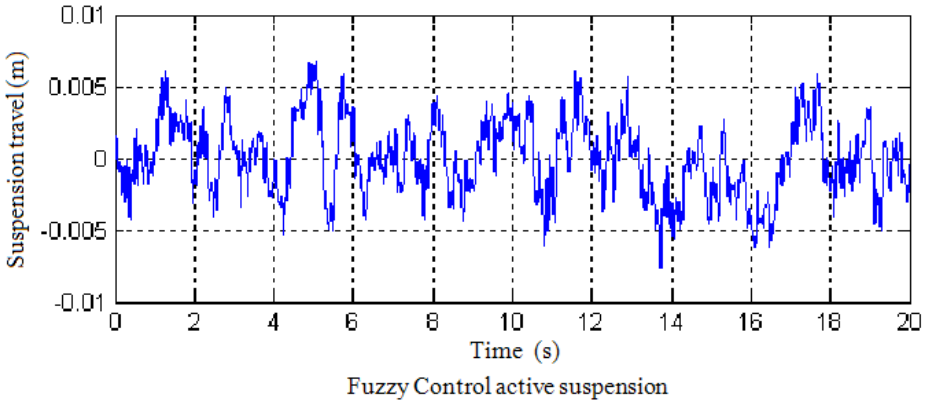

Fig. 8 Travel of active suspension

Can be observed from the figure, compared with passive suspension, active suspension system of fuzzy control car body vertical acceleration of the moving average value and suspension travel the decrease of the average value is obvious, and the change trend more smoothly, mutation phenomenon than the passive suspension has a better improvement, therefore, vehicle riding comfort and handling stability improved better.

6. Conclusion

In order to overcome the disadvantage of passive suspension can't real-time online setting, were studied in this paper, the active suspension system, the fuzzy control strategy is put forward, through the simulation analysis concluded that the fuzzy control strategy can effectively eliminate the incentive from the pavement, reduce automobile vibration amplitude, make cars in the process of driving always maintain good ride comfort and handling stability and ride comfort.

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