The working mechanism of electronic stability control system in automobile driving

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Abstract: In the past few decades, the automobile has made great progress in the improvement of power performance. This momentum is bound to continue into the next century. Another important aspect of the development of automobile technology is the improvement of stability control, which has only been applied to products in recent years. Active steering control adapts to the working state of the wheels in the linear region, and judges the driver's driving intention according to the driving state of the car and the driver's operation. The driver should actively control the steering wheel angle, change the transverse and longitudinal force of the wheel, make the car run according to their requirements, and improve the driving stability of the car. Researchers have developed advanced automotive electronic control systems, such as yaw moment direct control system and anti-lock braking system, in order to better ensure the safety of automobiles. Anti lock braking systems and traction control systems have been used in cars for many years, initially in high-end sedans and later becoming increasingly widespread in general sedans. In order to reduce the incidence of traffic accidents and mitigate the losses caused by traffic accidents, attention should be paid to the application and development of safe driving technology for automobiles.

1. Introduction

Over the past few decades, automobiles have come a long way in improving their dynamics. This momentum is bound to continue into the next century [1]. Another important aspect of the development of automotive technology is the improvement of stability control, which has only been applied to products in recent years [2]. When a vehicle is in extreme longitudinal and lateral conditions, especially when driving at high speeds, sharp turns and low-adhesion roads, it is prone to instability such as sideslip and loss of stability, leading to traffic accidents. Active steering control adapts to the working state of the wheels in the linear area, and determines the driver's driving intention based on the car's driving status and driver's operation [3].The driver should actively control the steering wheel angle, change the transverse and longitudinal force of the wheel, make the car run according to their requirements, and improve the driving stability of the car. Whether the car is accelerating and decelerating in a straight line or turning, it should run smoothly. The most important thing is to make the car not deviate from the driver's ideal driving route, and it should not affect the driver's vision and driving comfort [4]. The investigation found that the main causes of traffic accidents at present are closely related to the driver's cultural quality, road conditions, car conditions, car safety performance and road visibility. Therefore, people, roads, environment and automobile performance are important factors that affect automobile driving safety [5].

In recent years, the active safety performance of automobiles has become the focus of scientific research institutions and major automobile manufacturers [6]. Researchers have developed advanced automotive electronic control systems, such as yaw moment direct control system and anti-lock braking system, in order to better ensure the safety of automobiles [7]. From the working principle of these systems, all of them rely on various parameters that directly reflect the driving state of the car to make corresponding decisions, thus ensuring the safety of the car. It is very important to control the wheel slip and sideslip to maintain the stability of the car [8].Anti-lock braking systems and traction control systems have been used in automobiles for many years. They were first installed on high-end cars, and later became increasingly used on ordinary cars. In the

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context of the establishment of global technical standards for electronic stability systems for passenger cars, it has become a general trend for it to be a standard configuration of vehicles [9]. Therefore, mastering the independent research and development technology of electronic stability control system is a problem that must be solved by my country's automobile industry [10]. In order to reduce the incidence of traffic accidents and reduce the losses caused by traffic accidents, attention should be paid to the application and development of safe driving technology.

2. The role of automotive electronic technology in ensuring safe driving of automobiles

2.1. The role of vehicle stability control

Automotive electronic technology plays a vital role in enhancing the safety and stability of vehicles on the road. Through the integration of advanced sensors, intelligent algorithms, and sophisticated control systems, these technologies enable vehicles to detect potential safety risks in real time, allowing drivers to take appropriate measures to prevent accidents. Central to this system is the control strategy, which serves as the backbone of automotive stability control. The effectiveness of electronic stability programs (ESP) hinges on the precision of these control strategies, ensuring that vehicles respond effectively to dynamic driving conditions. Currently, various control methods are employed within ESP systems, including Proportional-Integral-Derivative (PID) control, logic threshold control, sliding mode control, and optimal control. Each of these methods offers unique advantages in terms of responsiveness and adaptability to changing road conditions. For instance, PID control provides a balanced approach by continuously adjusting the control inputs based on the error between the desired and actual performance. Meanwhile, sliding mode control is particularly effective in systems requiring robustness against external disturbances, such as slippery road surfaces. The steering characteristics of a vehicle can be effectively assessed by measuring the equivalent side slip angle generated by the front and rear axles. Typically, the side slip angle at the rear axle is marginally smaller than that at the front axle. This indicates that the vehicle exhibits desirable understeering characteristics, meaning that a driver must apply a greater steering angle to maintain the intended trajectory. Importantly, while this understeering behavior might initially seem counterintuitive, it falls within the linear zone of steering response, which maintains the vehicle’s controllability.

Moreover, contemporary vehicle stability control systems utilize various sensors to measure the vehicle's rotation around its vertical axis. This data enables the rapid and accurate determination of whether the vehicle is experiencing understeer or oversteer, thus allowing for timely corrections to maintain stability. Many of these sensors and control technologies have been adapted from the aviation industry, reflecting their robustness and reliability. The compact and durable nature of automotive sensors ensures they can withstand the challenging conditions of vehicle environments, including vibrations, temperature fluctuations, and moisture. In conclusion, the implementation of electronic technology in vehicle stability control significantly enhances the safety performance of automobiles. By minimizing the likelihood of accidents through real-time monitoring and intervention, these systems are crucial in promoting safer driving experiences. As automotive technology continues to evolve, the integration of advanced stability control systems will likely play an increasingly important role in reducing traffic accidents and improving overall road safety.

2.2. Its role in collision early warning and blind area monitoring

The collision warning and blind spot monitoring system is an advanced vehicle safety assistance technology that integrates radar and camera systems to enhance driver awareness of potential hazards. This system is designed to detect and alert drivers to imminent collision risks and monitor areas that are not visible in traditional mirrors, significantly reducing the likelihood of accidents. By providing real-time information about nearby vehicles and obstacles, it empowers drivers to make informed decisions and take timely actions. At the core of this system lies a variable structure control strategy, particularly the sliding mode variable structure control, which distinguishes itself from conventional control methods through its inherent control discontinuity. This feature is essential in managing the anti-lock braking system (ABS), particularly in scenarios where the vehicle is on the brink of losing stability. A crucial aspect of maintaining vehicle stability involves suppressing the side slip angle of the vehicle's center of mass, especially when navigating challenging road conditions. To achieve this, a joint controller that employs a nonlinear change of weight coefficient is designed to dynamically adjust control inputs based on real-time conditions.

When the lateral force on the front axle reaches saturation, the risk of slipping increases, causing the vehicle to stray from the intended path. Similarly, excessive lateral force on the rear axle can lead to dangerous situations like oversteering. To counteract these risks, the system can modulate the throttle and transmission shift to reduce torque, functioning as an invisible hand guiding the vehicle back onto its correct trajectory. Sliding mode motion encompasses two phases: approaching motion and sliding mode motion. The former refers to the system's journey from any initial state towards the switching surface, while the latter involves the maintenance of the vehicle's desired state once it has reached this surface. The application of this technology significantly enhances driving safety and comfort, allowing drivers to navigate with increased confidence and responsiveness, ultimately contributing to a reduction in collision incidents on the road.

3. Development Trends of Automotive Electronic Technology

3.1. From passive safety to active safety

Market research shows that the future automotive safety system tends to be "intelligent", and major semiconductor companies and vehicle companies are studying the application of cutting-edge electronic technology in the field of automotive safety. The calculation accuracy of the automotive electronic stability program simulation system depends on the selection of the vehicle model, reference model, and control method, as well as the accuracy of the vehicle parameters, programming, and numerical solving algorithms during simulation. The car makes a step left turn at a certain initial speed. As shown in Figures 1, 2, and 3.

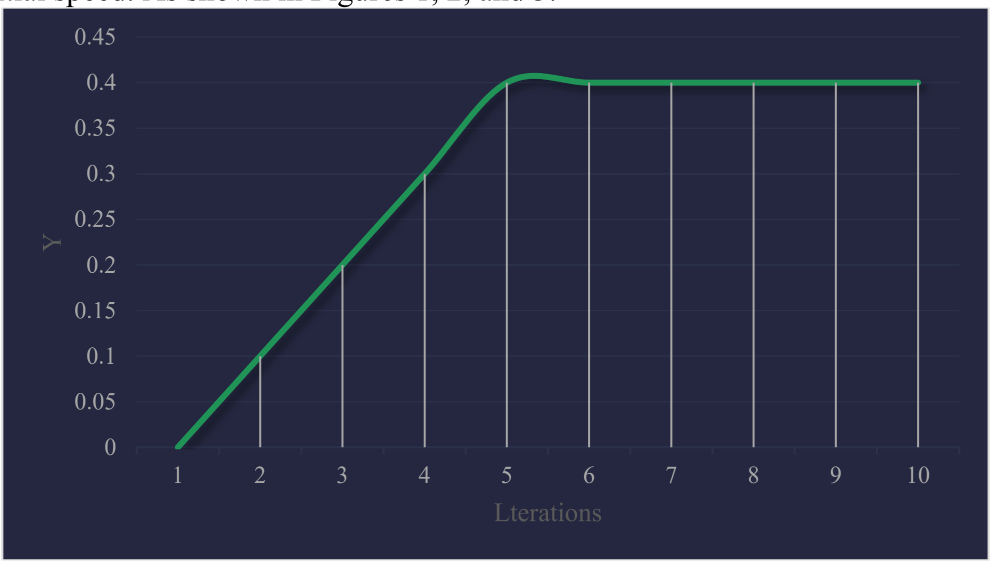

Figure 1 Ideal model yaw angular velocity calculation result curve

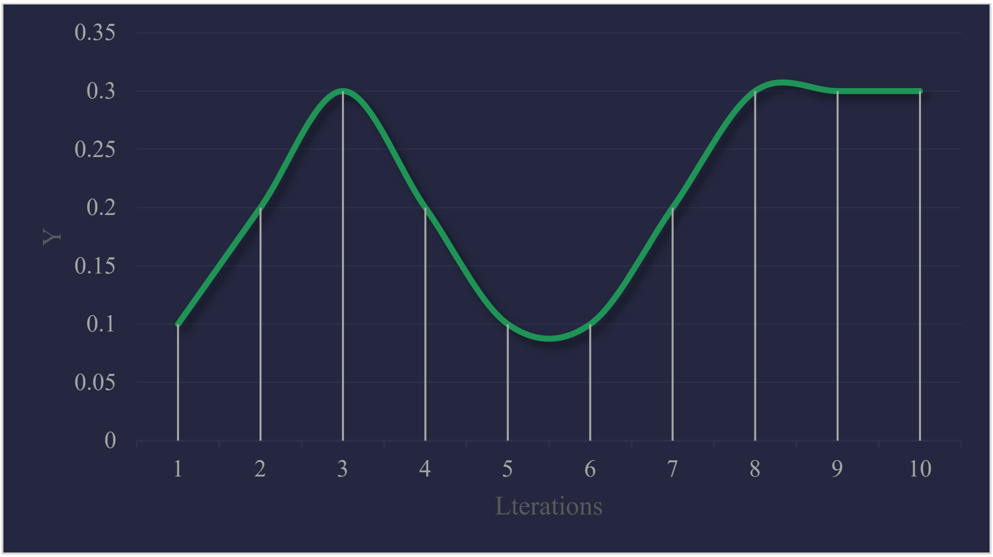

Figure 2 Simplified model yaw angular velocity calculation result curve

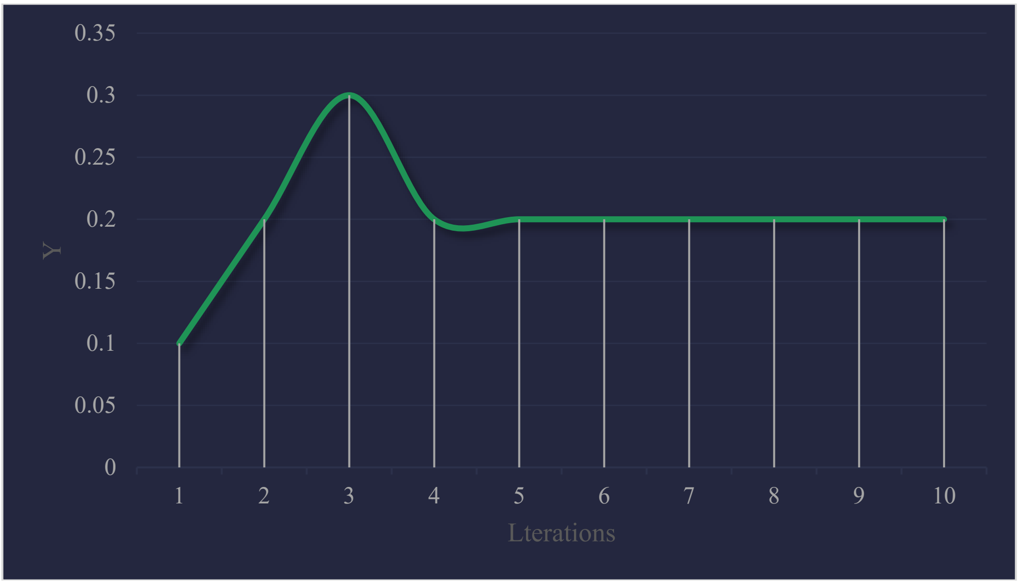

Figure 3 Calculation result curve of yaw angular velocity under the action of ESP

In most cases, the driver generally adjusts the car linearly through the steering wheel when driving the car, and this linear adjustment is mainly based on the perception of the yaw rate, yaw angle and lateral acceleration of the car. When driving in a certain circle test slip field and tortuous test track, the car is much more stable when the system works than when it doesn't, and it is easier to recover if it deviates. However, due to the complex driving conditions of the vehicle, when the vehicle system state simultaneously meets the requirements of active yaw moment control and anti lock braking control, it is easy to cause confusion in the vehicle control objectives. This not only affects the control quality of the chassis electronic control system, but may also lead to danger and even loss of control of the vehicle. If there is fatigue driving, the system will use sound warning or tighten the seat belt to remind the driver to stop and rest in time to avoid traffic accidents.

3.2. Developing towards intelligence

Driven by both technological advancements and user demands, significant progress has been made in the intelligentization of automotive safety systems and in car entertainment information systems. Select to read data, a database record number selection dialog box will pop up, enter the record number, click the OK button, and the specific car parameters corresponding to the number will pop up, realizing the function of reading data from the database. And this nonlinearity is unfamiliar to ordinary drivers, so they cannot take correct actions. Therefore, traffic accidents are prone to occur in this situation. This algorithm determines the appropriate vehicle response in a certain situation. Sensors monitor the speed, steering angle, lateral acceleration, throttle position, and brake pressure of each wheel. Although it is not possible to completely replace actual vehicle testing. However, the characteristics of high efficiency and low cost play a very important role in the development and development of automobile-related functions. Yaw angular velocity is one of the key parameters of vehicle driving. The smoothness of the response is an important parameter for predicting dangerous situations such as vehicle sideslip or tail drift. Therefore, it is effective to compare the simulation results of yaw angular velocity with the experimental data. In order to realize the intelligence of cars, we need to re-understand car usage scenarios, analyze user needs, integrate cutting-edge technologies, and put people first, so that intelligent products can better serve consumers.

4. Conclusions

The function and application of contemporary automotive electronic technology in safe driving of automobiles are described in detail, and the application of automotive active anti-collision control system, rear-end collision control system and millimeter-wave radar based on information fusion is explained in depth, and the development trend of automotive electronic technology is predicted. According to the need of control system, the state estimation of vehicle and road surface and the algorithm of vehicle running state are studied, and a joint estimation algorithm of road adhesion coefficient based on vehicle model and dynamics principle is proposed. The established vehicle dynamics model and electronic stability program control strategy are programmed and realized. The system includes database, test selection, data calculation output and other modules. The electronic stability system represents the most advanced automotive safety technology in the world today. However, due to technological reasons, Chinese domestic enterprises have not yet developed the ability to produce automotive electronic stability systems. The suppliers of automotive electronic stability systems for complete vehicles can only be foreign or joint ventures. On the basis of vehicle dynamics analysis, a vehicle handling dynamics model was established, which can effectively simulate the driving state of the vehicle. In the future, automotive electronic technology will transition from passive safety to active safety, and develop towards intelligence and safety and environmental protection.

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