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Research on Lateral Path Tracking Control of Driverless Vehicle

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Abstract: The unmanned vehicle system has nonlinear, time-varying characteristics and uncertainties. The traditional single control algorithm can not effectively coordinate the autonomous steering control system and can not meet the control requirements under different working conditions. The path tracking control is the core technology of the driverless vehicle, which makes the driverless vehicle travel along the target trajectory through the lateral and longitudinal control of the vehicle. First of all, the research on the joint simulation platform of driverless vehicles under different working conditions is carried out from the aspects of accuracy, real-time, stability and ease of realization of the lateral motion of driverless vehicles; Then, a suitable joint simulation platform for driverless vehicle is built; Finally, the joint simulation platform is used to study the path tracking control of driverless vehicles in order to comprehensively investigate the effect of path tracking control. The results show that the path tracking control system improves the reliable control performance under a wide range of driving conditions.

Keywords: Driverless cars, Lateral control, Path tracking.

1. Introduction

The number of cars has increased year by year, leading to traffic accidents, traffic congestion, environmental pollution and other problems [1] [2]. In addition, the state of the driver determines the driving state of the vehicle. The mature driverless system is more reliable than the uneven driver technology [3] [4]. Path tracking control is also one of the key technologies of driverless vehicles. Its performance directly affects the tracking effect of driverless vehicles on the planned path. Due to the strong coupling, nonlinear, time-varying and other dynamic characteristics of the vehicle itself, and the changeable driving conditions, it is still a great challenge to make the driverless vehicle have better tracking control performance. The traditional single control algorithm can not effectively coordinate the control requirements of the autonomous steering control system under different working conditions, and some key technologies need to be explored and studied [5] [6] [7].

2. Analysis of Current Situation of Driverless Vehicle Lateral Path

The progress and technical points of attention of each institution are different in the current situation of horizontal path research. The basic driverless technical route is similar, mainly including four aspects of capabilities: perception, planning, processing and execution. In autonomous vehicle, multi-sensor fusion, various electrical equipment and actuators form a neural network of autonomous driving technology, which processes the environment sensed by sensors, converts it into execution commands, and realizes unmanned driving. Figure 1 shows the installation positions of various visual sensors on the A8. In addition to automobile enterprises, some Internet enterprises have also made in-depth layout of driverless technology, such as Google in foreign countries and Baidu in China.

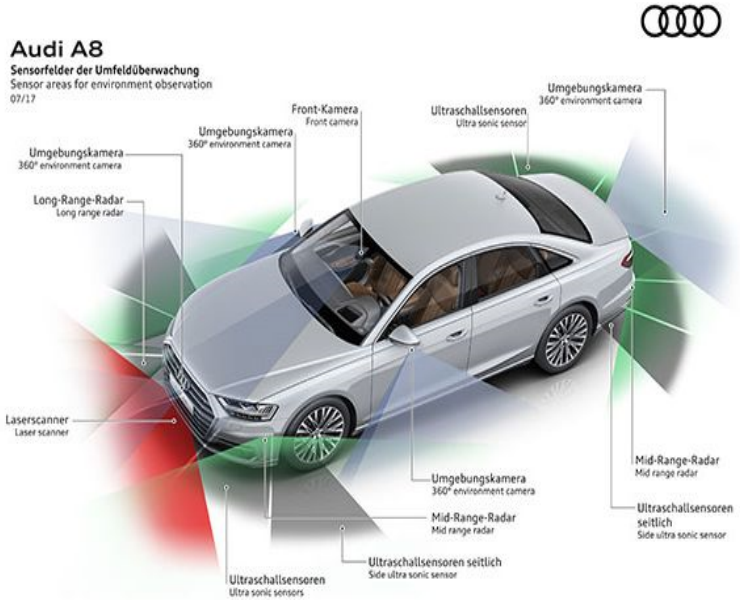

Figure 1. Position of Audi A8 sensor

From the aspects of the accuracy, real-time, stability and ease of realization of the lateral motion of driverless vehicles, the research on the joint simulation platform of driverless vehicles under different working conditions is carried out, and a suitable joint simulation platform of driverless vehicles is built. On this basis, the path tracking control of driverless vehicles is studied by using the joint simulation platform to comprehensively investigate the effect of path tracking control. Through this research, students will be driven to participate in the lateral path tracking control of driverless vehicles, and the level of talent training will be improved; Focusing on the research of intelligent control engineering technology of electric vehicles, we will accelerate the research and application of electric vehicles and intelligent vehicles.

3. Research on Lateral Path Tracking Control

Intelligent vehicles are the synthesis of various cutting-edge technologies, including multi-sensor fusion, information transmission, wire control and artificial intelligence. Intelligent vehicle technology can make judgments according to the obtained traffic environment information, and control the lower control objects through various control algorithms in the upper layer, that is, to complete horizontal and vertical control of vehicles. Intelligent vehicles will reduce traffic congestion, reduce the incidence of traffic accidents, improve energy efficiency, improve driving safety and comfort, and free people from the monotonous and boring work of drivers to engage in more meaningful work. The continuous improvement of intelligent vehicle technology will eventually serve mankind in the form of driverless vehicles. The driverless vehicle is mainly composed of five modules: environment perception, positioning and navigation, path planning, central processing unit, motion control and auxiliary driving. The detailed composition and relationship of each module are shown in Fig. 2.

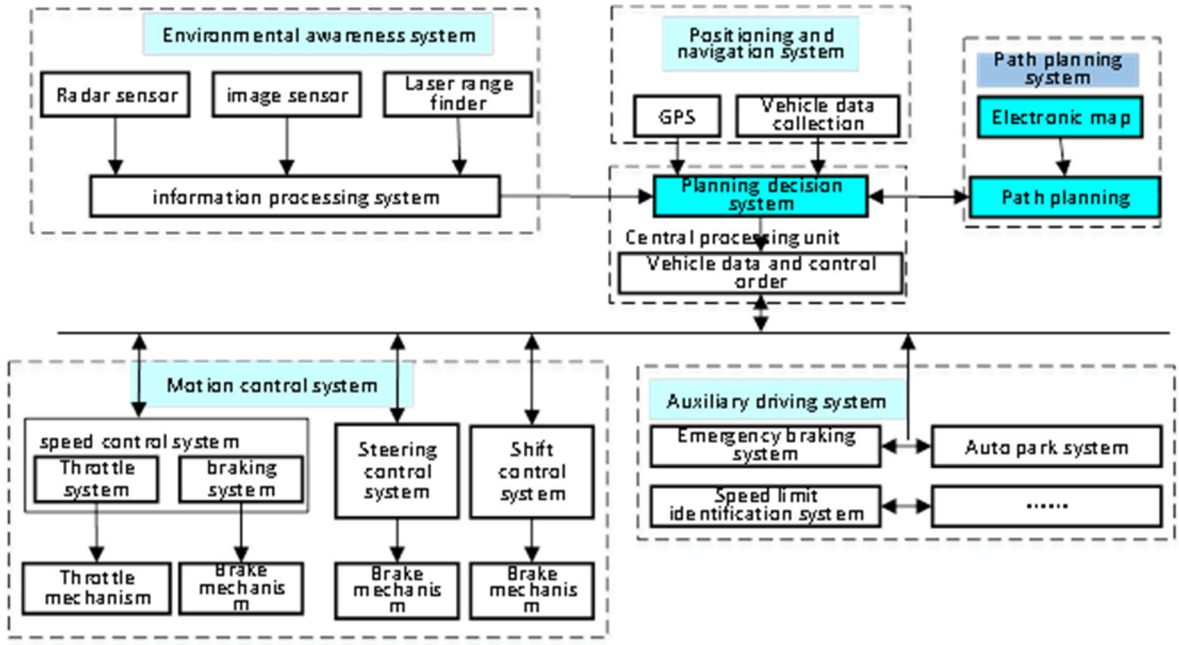

Figure 2. Five modules of driverless vehicle

Path tracking control is one of the key technologies of driverless vehicle, and its performance directly affects the tracking effect of driverless vehicle on the planned path. Due to the strong coupling, nonlinear, time-varying and other dynamic characteristics of the vehicle itself, as well as the variable driving conditions, the tracking control algorithm based on preview theory is used to track and predict the path, further improving the accuracy.

3.1. Tracking control algorithm based on preview theory

The tracking control algorithm based on the preview theory is mainly designed on the basis of the optimal preview control theory proposed by academician Guo Kong-hui and others. Its basic principle is to set one or more preview points at a certain distance in front of the vehicle, then obtain the position and attitude deviation information at the preview points, and then control the vehicle according to these information and the real-time motion state of the vehicle, so as to track the desired path.

At first, model predictive control was mainly used in the field of industrial control, also known as rolling time-domain optimal control. In essence, this control algorithm is a solution method based on objective function optimization. The algorithm can be divided into three steps: model-based state prediction, constrained optimization in finite time domain, and feedback correction. The path tracking control algorithm based on the model predictive control theory has the advantage of dealing with multiple model constraints. There are many constraint problems such as dynamics and kinematics in the driving process of driverless vehicles. Model predictive control provides an ideal method to solve these constraint problems. At the same time, it can effectively reduce the influence of time-varying, uncertain and external environmental interference factors on the control effect of driverless vehicles, But it also has the disadvantages of slow solution speed and high model accuracy.

3.2. Main research contents of lateral path tracking control

(1) Research on typical working conditions of lateral motion control of driverless vehicle

According to the actual driving environment of the vehicle, combined with the requirements of different working conditions on the vehicle speed and path, a typical lateral motion control working condition is formed. The typical driving path of driverless vehicle under different driving conditions is studied.

(2) Research on road model and vehicle dynamics model of typical driving conditions

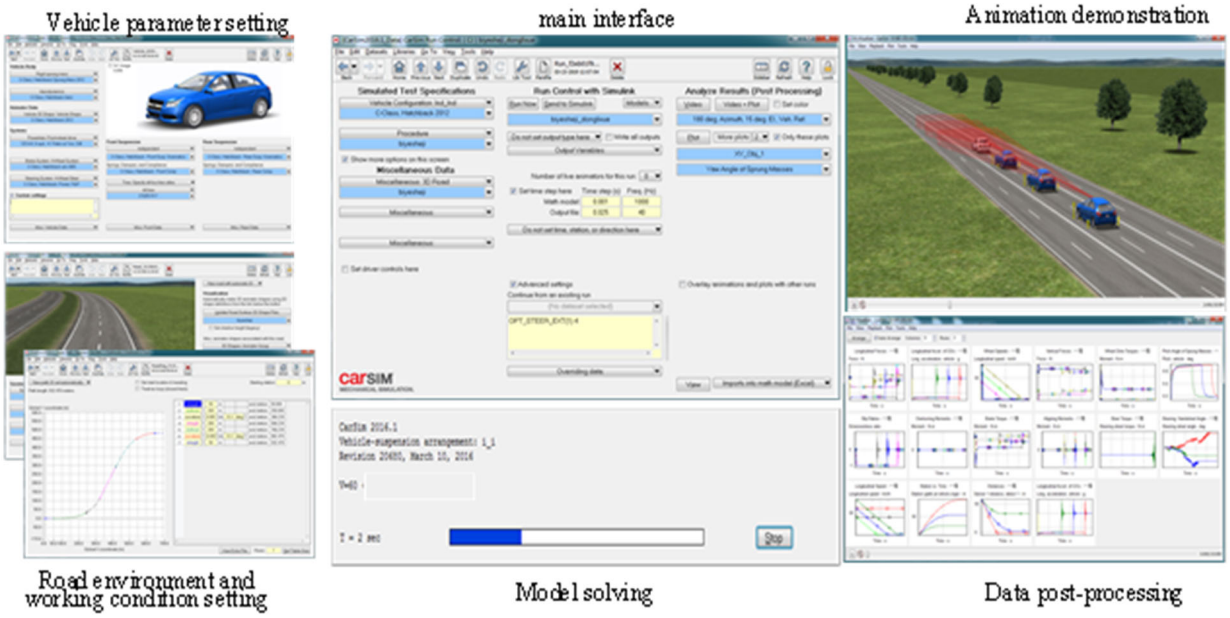

Figure 3. Function and interface diagram of CarSim

Study the key technologies of road model and vehicle dynamics model based on parametric modeling. Based on a parametric modeling software, typical parametric modeling software is shown in Figure 4. All road models and vehicle dynamics models required for lateral motion control are established to realize the visualization of road information of driverless vehicles. The subsystems and setting interfaces included in the vehicle dynamics model are shown in Fig. 4.

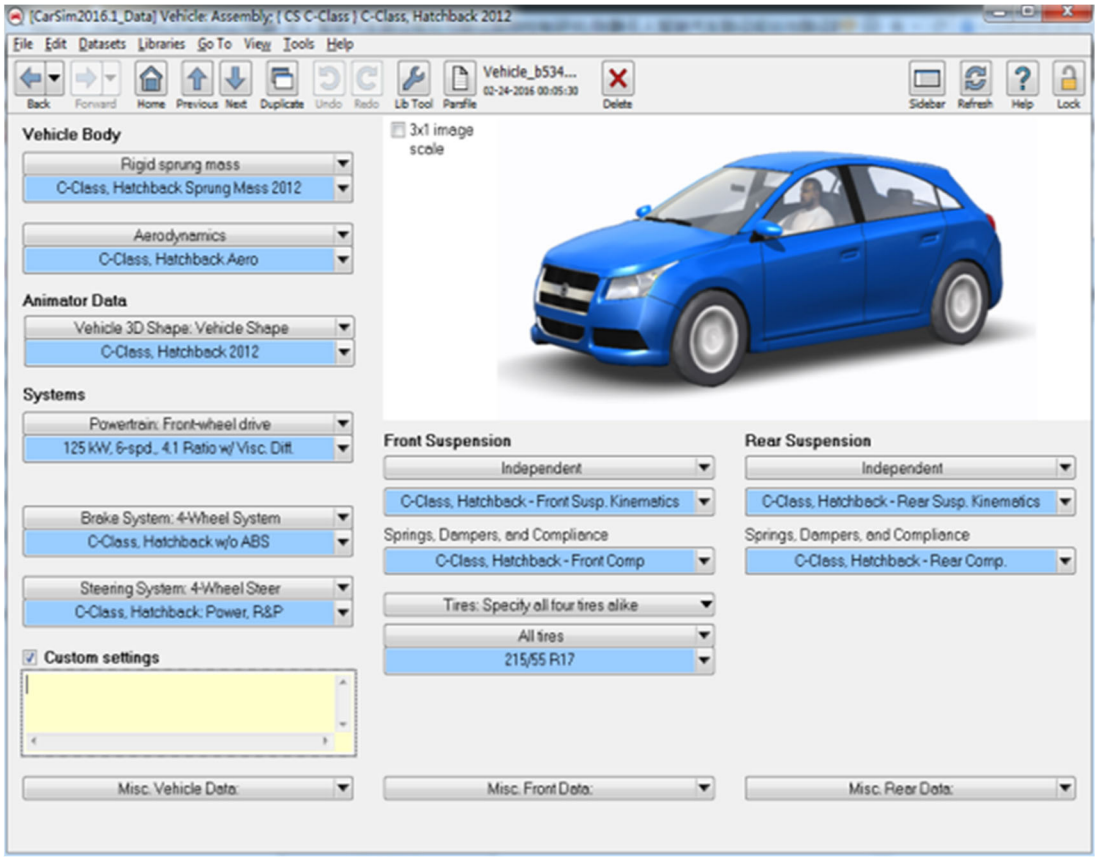

Figure 4. Vehicle subsystem and CarSim vehicle model setting interface

(3) Research on lateral path tracking control based on path tracking control algorithm

The path tracker is designed through the path tracking control algorithm, and the influence of the design parameters on the path tracking controller is studied. The model predictive control parameters suitable for the project are obtained, so that the path tracking controller can take into account the calculation speed and control accuracy.

(4) Research on joint simulation platform based on typical road conditions and path tracking control algorithm

Research on the joint simulation platform for driverless vehicles under different working conditions, and build a suitable joint simulation platform for driverless vehicles. On this basis, the path tracking control of driverless vehicles is studied by using the joint simulation platform to comprehensively investigate the effect of path tracking control.

4. Key Technologies

(1) Research on typical working conditions of lateral motion control of driverless vehicle and establishment of corresponding road model

It is proposed to build a typical road model for lateral motion control based on a parametric modeling software. It is necessary to output the road information of the road model in real time, and complete the establishment of the reference trajectory under this road model. It is one of the technical keys of the project to output the reference trajectory and road information to the path tracking controller.

(2) Research on path tracking controller based on path tracking control algorithm

Firstly, the traditional single lateral path control algorithm is studied to find out its advantages and disadvantages. Combined with the multi condition road model, the lateral path control algorithm is improved, and on this basis, the path tracking controller is established to achieve more accurate lateral tracking control of driverless vehicles.

(3) Realization of a joint simulation platform for driverless vehicle lateral path tracking control

Using the road model, the vehicle dynamics model and the path tracking controller, the driverless vehicle joint simulation platform is built to complete the tracking control of the given path through the simulation platform, and verify the effectiveness, accuracy and real-time of the path tracking control algorithm. Research on the lateral path tracking control of driverless vehicles parametric modeling software realizes the visualization of road, vehicle dynamics and typical working conditions. It overcomes the shortcomings of traditional path tracking control, which only tracks the desired path, and can output real-time operation information of vehicles; It can not only better reflect the running behavior of the vehicle, but also provide a basis for the establishment of the path tracking controller. Combined with the joint simulation technology of the joint simulation platform of typical road conditions and path tracking controllers, the path tracking and road conditions form a closed-loop control, which can better verify the tracking ability of the vehicle model to the desired path, and output the vehicle state in real time to judge the effectiveness of path tracking. The verification of the effectiveness and accuracy of the driverless vehicle path tracking control, the simulation and verification of the built joint simulation platform, and the technical specifications based on the path tracking control will be more perfect, which provides the possibility for the follow-up in-depth research.

5. Summary

Through the design of the path tracking controller of the driverless vehicle, the research on the lateral path tracking control of the driverless vehicle can be used in the auxiliary steering of the vehicle to a certain extent, which can improve the safety of the vehicle. The joint simulation technology of the joint simulation platform based on the typical road conditions and the path tracking controller can study the effectiveness of the driverless vehicle on the desired path tracking in real time, and has more practical significance. The combination of driverless systems and the completion of certain promotion and application will have great social and economic value.

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