

Research on Lane Following Control Method of Autonomous Vehicle

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Abstract: Path tracking control is an important part of the key technology of autonomous vehicles. It mainly studies how to control key parameters to make the autonomous vehicles drive along the planned path stably and without deviation. This article introduces some commonly used control methods, and analyzes their research applications in the path tracking of autonomous vehicles. It is pointed out that combining multiple algorithms and improving the integrity of model dynamics constraints will make the path tracking more accurate. the study.

1. Introduction

Autonomous vehicles are a key section of the future smart transport structure. The vehicle system relies on the on-board sensor system to perceive the surrounding environment of the vehicle, and uses the obtained road information, accessory vehicle location information, surrounding obstacle information, red street light and other information as the information source Input, and obtain city road conditions from various maps in real-time through the vehicle network, plan the driving route globally and locally, and control the smart car to reach the predetermined target. Path following control is one of the basic problems in autonomous driving technology, and it is also the basis for chassis execution control. It mainly studies how to reduce the lateral deviation and the planned target path between the actual driving route of the unmanned vehicle and the planned target path, this theory is based on controlling the parameters of the steering system of the autonomous vehicle under the premise of ensuring driving safety and riding comfort. Azimuth deviation. Currently, the main problems and difficulties which has been solved are to further reduce the deviation between the planned path and the actual driving path of the autonomous vehicle: for example, in the controller algorithm, the established car kinematics model needs to be more accurate and complete , In-depth consideration of various dynamic constraints; on the other hand, it is necessary to solve the feedback speed of the tracking control system to meet the requirements of real-time and stability.

2. Intelligent Vehicle Path Tracking Lqr Control Based on Genetic Algorithm Optimization

Optimal control theory has many advantages. It is suitable for complex time-varying systems, can handle multi-objective and multi-constraint situations, and can use computers to quickly calculate. In recent years, nonlinear optimal control has also been widely used in the fields of polyatomic atmospheric reaction dynamics, geological and mineral exploration, and oil and gas development engineering. Modern vehicle R&D design and theoretical research have also applied a lot of optimal control theory methods, such as vehicle active suspension system control, ABS system control and vehicle four-wheel steering control. In the past 30 years, the linear quadratic regulator problem (LQP problem) has attracted more and more attention based on the following reasons: On the one hand, the optimal control of nonlinear problems is difficult to obtain analytical solutions under normal circumstances, and numerical values are used. The method can obtain numerical solutions, but the amount of calculation is large and there are many restrictions. On the contrary, almost all linear optimal control problems (including LQR problems) are relatively easy to obtain analytical solutions and easy to implement technically; on the other hand, , The nonlinear control system under the small signal condition can be linearized, and then the optimal control of the linear problem is applied to obtain the result. Therefore, the LQR problem can replace some

nonlinear problems to obtain an approximate solution to the target.

Wang Wei et al. introduced the theory of vehicle handling inverse dynamics, and considered the degree of freedom of roll when modeling, established a linear three-degree-of-freedom angle input model of the vehicle, combined it with fuzzy control theory, and designed a fuzzy controller. It adopts a control mode of two inputs (deviation signal and deviation change rate) and single output (steering wheel angle). Generally, the roads that are often selected when evaluating vehicle handling and stability are typical roads with double shifting lines and serpentine lines. Therefore, in terms of ideal road input, the above two typical road models are selected for simulation. Aiming at the characteristic that fuzzy logic control cannot be modified after determining the control rules and membership functions, Yang Jun, etc. combined the logic reasoning idea of the fuzzy algorithm with the learning ability of the neural network algorithm, and designed the angular velocity fuzzy neural network controller to control the automatic Drive the vehicle for path following control. The input of the designed fuzzy neural network controller selects two parameters of direction angle error and position error, and uses the learning ability of the network algorithm to adjust the fuzzy parameters and optimize the controller. A.El Hajjaji et al. considered the TS fuzzy model of the car obtained from the nonlinear model, and designed a fuzzy controller based on this model, and then used the Lyapunov method and linear matrix inequality method theory to analyze the proposed vehicle The path tracking control method has been analyzed for stability and verified its effectiveness. The autonomous driving method proposed by Bo Xiang.

3. Path Following Fuzzy Control Algorithm Sliding Mode Control

Sliding Mode Control (SMC) is also called variable structure control, which is essentially a special kind of nonlinear control. The so-called nonlinearity is manifested in its discontinuous control system, which is compared with other control methods. The difference is that the structure of the system is relatively unfixed, and it can change purposefully and continuously according to the current state of the system (such as deviations and derivatives, etc.) in the dynamic process, forcing the system to follow a predetermined “sliding mode” state Trajectory movement. The sliding mode control method can be designed and is not related to the target physical parameters and disturbance response, and the response speed of the system is fast, the parameters and disturbances are not sensitive to the influence of the system, the system can be identified offline, and the physical realization is easy to obtain. According to some traditional path tracking control methods, it is difficult to adapt to the complex and changeable driving environment when an accurate mathematical model is required. The author combines the sliding mode control method with the active disturbance rejection control method. Therefore, this path tracking control method is proposed to speed up the rapid response of the system and improve the stability of the entire system. Design non-singular terminal sliding mode and exponential reaching law to design the nonlinear error feedback rate in the active disturbance rejection controller structure to realize the fast and accurate tracking of the yaw angle of the system. Sang Nan et al. designed a vehicle active front-wheel steering control based on the extended state observer (ESO) and non-singular terminal sliding mode (NTSM) based on the two-degree-of-freedom model of the vehicle and used an extended observer to monitor To estimate the real-time state and disturbance of the vehicle, the non-singular terminal sliding mode controller is used to compensate the disturbance in the system and output the control parameters. The lateral stability of the vehicle can be improved after the two are combined. R. Wang et al. studied the path tracking problem of four-wheel steering (4WS) autonomous vehicles (AVs). Based on the dynamic model of the 4WS error, the analysis shows that the four-wheel steering (4WS) autonomous vehicle can eliminate the steady-state error in an ideal state, but the traditional front-wheel steering (FWS) aircraft cannot achieve the elimination of the steady-state error. By introducing the sideslip angle, two sliding mode controllers are used to converge the sideslip bias and heading error to zero, so that the vehicle remains stable under extreme conditions. Aiming at the dynamic characteristics of 4WS vehicles, Qunzhi Zhou et al. proposed a new robust sliding mode controller and applied it to the path tracking problem of 4WS vehicles. Theoretical analysis and simulation results show that this new robust sliding mode controller makes the system

respond to parameter changes and external disturbances, especially changes in the friction between the vehicle and the road, the adhesion conditions, the longitudinal speed of the vehicle and the lateral wind. The same tracking accuracy, stability and robustness. In summary, sliding mode control can cause chattering in the system under certain conditions: but when the model is difficult to establish and the system is susceptible to external disturbances, defects can be better compensated to improve control accuracy and other aspects.

Analysis of emergency obstacle avoidance strategy for autonomous vehicles at high speed

The key technology of autonomous vehicle active obstacle avoidance is to carry out reasonable obstacle avoidance path planning according to the obstacle situation. The high-speed emergency obstacle avoidance system can automatically detect the obstacle in front and comprehensively consider the longitudinal and lateral distance and longitudinal speed to the obstacle in front. And acceleration, automatically plan an obstacle avoidance path, and automatically follow the obstacle avoidance path through the path tracking strategy to complete the obstacle avoidance process, effectively avoiding pedestrians, vehicles or other obstacles in front. Path planning will be affected by both the vehicle's own conditions and obstacle conditions. The planned paths will be different when the considerations and focus are different. The most typical path planning at present is when the vehicle is in an environment with obstacles. Automatically plan a path that can ensure that the vehicle reaches the destination from the starting point safely and accurately, and the lateral stability of the vehicle at high speed needs to be considered.

According to normal driving habits, there are mainly two obstacle avoidance strategies: one is to take braking measures to decelerate and avoid obstacles when there is an obstacle ahead; the other is to steer the vehicle to avoid obstacles by controlling the front wheel angle. Drive on the safe lane. Therefore, when the vehicle detects the presence of an obstacle in front, the vehicle can generally choose the obstacle avoidance strategy of the trailing vehicle, the obstacle avoidance strategy of emergency braking, and the strategy of changing lanes. Three obstacle avoidance strategies were introduced above, each of which has advantages and disadvantages: The trailing vehicle obstacle avoidance strategy is a safe and efficient obstacle avoidance method for dynamic obstacles, but it is greatly affected by the speed of the vehicle in front; emergency braking obstacle avoidance The method is relatively easy to operate, but the driving efficiency is low, and it is easy to cause traffic jams; changing lanes to avoid obstacles can completely get rid of obstacles, and the planning of obstacle avoidance paths is a key factor for the successful implementation of obstacle avoidance strategies. According to different driving conditions with obstacles, this paper designs an obstacle avoidance strategy that can ensure driving efficiency and take into account safety. When the vehicle obstacle avoidance system senses the existence of an obstacle in front, it first determines whether the obstacle is stationary or moving. When the obstacle is stationary, in order to improve the efficiency of passage, the obstacle avoidance system automatically generates the obstacle avoidance path and performs autonomous vehicle path tracking to complete the obstacle avoidance. When the front obstacle is a moving vehicle, first compare the speed of the controlled vehicle with the speed of the vehicle in front. If the speed of the controlled vehicle is lower than the speed of the vehicle in front, there is no risk of collision and the vehicle can continue to move forward at the original speed. If the speed of the controlled vehicle is greater than the speed of the preceding vehicle, the distance between the two vehicles will continue to decrease. When the distance between the two vehicles is greater than the critical safety distance, the trailing vehicle is given priority to avoid obstacles or brake parking. When the trailing vehicle avoids obstacles, the driving distance generated by the controlled vehicle during braking must be less than the critical safety distance of the two vehicles. Suppose the obstacle in front is a low-speed vehicle. When the distance between the two vehicles is less than the critical safety distance, obstacle avoidance and overtaking are required to avoid the vehicle in front.

4. Proportional-Integral-Derivative Control

PID algorithm and its derivative algorithms have been widely used in industrial engineering. PID control technology is based on the precise mathematical model (transfer function and state equation)

of the controlled object. Its core idea is to control the controlled object by adjusting three key control parameters (KP, KI and KD). The required adjustment result. The function of the proportional parameter KP is to make the input and output of the controller proportional to reduce the deviation. The integral parameter KI is mainly used to eliminate the difference between the output value and the set value after the system is stabilized, that is, the static difference. Differential parameter KD reflects the variation law or trend of deviation signal. According to the nonlinear characteristics of path tracking, taking the accuracy as the control target, Li Linchen et al. proposed a path tracking algorithm for mobile robot based on genetic algorithm optimization and PID control adaptive ability to improve the path tracking accuracy of mobile robot. The parameters of PID controller are adjusted by genetic algorithm, which improves the steady-state and dynamic adaptability of the system. Yang Zhao mainly studies the path tracking control of unmanned surface aircraft, mainly using PID control method, using course deviation angle and distance error, and combining fuzzy inference rules to dynamically adjust PID parameters, so as to realize the movement attitude adjustment of unmanned surface aircraft, thus realizing autonomous tracking of the end of this road. Pouria Sarhadi et al. proposed a model with anti-saturation compensator in view of the uncertainty of the model when designing the saturation of the controller and actuator. The adaptive function can reduce the influence of saturation and make the control signal smoother. Riccardo Marino et al. designed a nested PID steering control system for self-driving vehicle based on visual navigation, which took the steering wheel angle of the vehicle as input and tracked the path with uncertain curvature. The double integral PID control based on lateral offset was adopted to suppress the disturbance of curvature increasing linearly with time, and an external control loop was designed to calculate yaw rate. The essence of PID control method is a control strategy independent of mathematical model. The error between the actual behavior of the controlled object and the controlled object can be used to generate a control strategy to eliminate this error. However, the traditional PID algorithm has some shortcomings such as too simple signal processing.

5. Conclusion

The main problems caused by automobiles are automobile safety and traffic congestion. In response to these problems, countries and many scientific research institutions around the world are studying key strategies to solve the above problems. And this is not only a social issue that researchers are concerned about, but the general public is also concerned about this issue. This is a problem that arises with the development of science and technology but needs to be solved urgently. Intelligent transportation systems can effectively solve the more difficult traffic problems that exist today. Autonomous vehicles are an important part of the intelligent transportation system. The main purpose of its research is to reduce the incidence of traffic accidents, solve the problem of road congestion, improve the efficiency of existing road traffic operations and passing efficiency, and alleviate non-renewable energy such as petroleum and renewable energy Problems such as energy consumption and environmental pollution emissions can also be solved. The key core part of the intelligent transportation system is the ground autonomous vehicle. The ground autonomous vehicle is a high-tech carrier with highly integrated environment perception, decision planning and autonomous control functions, which can carry out and realize autonomous driving according to different road conditions and environments, such as: Carry out accurate path tracking along the planned path and ensure the stability and handling stability of the autonomous vehicle. It has a good lane keeping function while driving. The detection and recognition system actively recognizes obstacles in front and Realize active obstacle avoidance function to ensure the safety of vehicle driving. In addition, lane departure warning and automatic correction system, adaptive cruise system, lane changing and overtaking, and automatic car following technologies all belong to the category of intelligent driving, which are all conducive to the realization of intelligent vehicles.

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