

Intelligent Driving Based on PID Control

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Abstract. With the development of artificial intelligence, intelligent driving may become the most common mode of transportation on the road in the future. Among them, the lateral and longitudinal controls are particularly crucial, respectively controlling the steering and speed. PID control can effectively implement control algorithms in both horizontal and vertical directions. This paper studies the algorithm optimization resulting from the combination of different algorithms and the PID algorithm based on PID control, including but not limited to MPC, LQR, neural networks, etc. Some have even developed original algorithms that combine multiple algorithms. Different control systems distinct from PID control were obtained in the results. The advantages and disadvantages of different algorithms were analyzed, and the optimization of the original algorithm in different directions all achieved good results. Based on this research, the understanding of PID control and different algorithms can be deepened.

Keywords: PID control, Intelligent Driving, AGV, LQR, MPC

1. Introduction

PID control has been widely applied in most fields since its research. Nowadays, with the increasing demand for environmental protection, electric vehicles have been elevated to a very high position and enjoy an unparalleled status. The development of artificial intelligence has brought the possibility of driverless electric vehicles. PID control plays a very important role in it, including longitudinal control and lateral control. Among them, the longitudinal control aims to ensure the distance between the front and the back, calculate the gap between the front and the back, and thereby maintain the distance between the front and the back. Lateral control ensures that the vehicle does not shift to either side during driving. At present, the PID algorithm alone is far from sufficient to achieve intelligent driving. Therefore, various algorithms and those combined with PID have been developed, such as MPC and LQR proposed by Jia Zhilong and Huo Tingting [1]; The sliding mode control, predictive control, fuzzy control, neural network [2] and other algorithms proposed by Wang Xikui, Huang Keyong and Li Yanan were combined with PID; Wang Hong, Zha Yunfei, Deng Jianxian, et al., jointly applied LQR and double preview PID mechanisms to transverse and longitudinal control [3]; K. Nazir, Y.-W. Kim and Y.-C. Byun [4] combined PID control with a hybrid framework of advanced machine learning to optimize AGV performance, etc. At present, few people have summarized the

numerous algorithms required for intelligent driving. This article aims to elaborate on these several methods, taking them as research targets, and summarize the advantages and disadvantages of several improvements and combinations of PID. Finally, gain a deeper understanding of PID control to clearly understand the predicaments faced by intelligent driving and its future prospects. For instants, horizontal and vertical control and battery thermal management. Understanding that PID can really control and manage the aspects of automatic vehicle.

2. The advantages and disadvantages of LQR, MPC, and PID control

LQR, MPC, and PID are respectively linear secondary regulator, Model predictive control, and proportional-integral-derivative control. Among them, PI control is easy to implement and thus becomes the simplest speed regulation method for DC motors. To further enhance motor performance, LQP has become a better choice [4]. S. Roy, A. Basak, A. Majumder and S. Chowdhuri[5] used the in the Simulink environment of MATLAB to design a trajectory tracking experiment, concluding the date from the diverse methods and proved that its performance was significantly higher than that of the DC motor under the PI controller. PID, LQR, and MPC each have their own application scenarios for vehicle routing. PID can be used for low-speed driving, LQR is suitable for medium and high-speed scenarios, and MPC has the best lateral control but a relatively high computational complexity [3] (table 1). It can be seen that PID control is a basic control system that is easy to implement, but it has its limitations in both motor aspects and vehicle road simulation. Therefore, choosing different control methods to better achieve the control required in engineering, such as combining PID and MPC, or combining PID and LQR, such as PID-MPC and PID-LQR, which can optimize and improve performance, has become a better choice at present.

Table 1. comparing

Algorithm	Performance in simulation	Suitable scenarios
MPC	The lateral error control is optimal	Suitable for various scenarios
LQR	suboptimum	Suitable for medium and high-speed scenarios
PID	bigger error	Suitable for low-speed scenarios

3. Intelligent control of high-speed trains

Not only do family cars need intelligent control, but high-speed trains also require such efficient and useful control systems. Senior engineers Wang Xikui, Huang Keyong, Li Yanan [6] and others designed a train autonomous driving controller to ensure precise control of train operation.

It adopts a method that combines PID control with other algorithms, such as sliding mode control, predictive control, fuzzy control, neural networks, etc. Zhang Zichi has conducted significant research in neural network control [3]. He pointed out that neural network algorithms play a crucial role in handling complex roads and uncertain factors. Train driving is a continuous and complex process. In the ATO system designed by Wang Xikui, Huang Keyong and Li Yanan, the neural network algorithm is relatively important [2]. The ATO system is a new type of train control system based on PID. It plays a prominent role in the intelligent control of trains. The simulation results show that its algorithm has higher tracking accuracy [2]. After the number of iterations increases, the error can be reduced and the trajectory can approach the target rules, thereby proving that this is an efficient and superior algorithm.

4. Dual preview PID compensation for the control of the longitudinal and transverse directions

The above description describes the application scenarios of LQR control and PID control. This mechanism improves the tracking accuracy of vehicles under high-speed and complex working conditions by optimizing the LQR algorithm and combining it with PID control [6]. Wang Hong, Zha Yunfei, Deng Jianxian, et al. constructed a framework for bidirectional previewing in both horizontal and vertical directions through PID control. Subsequently, they completed the entire program setup by applying a series of formula derivations, data analyses, and introducing variables [6]. The program was simulated multiple times on simulink/carsim to achieve the expected goal. Finally, the program achieved the goal of optimizing lateral deviation, heading deviation and precisely controlling vehicle speed. It has been verified that it demonstrates excellent robustness and adaptability under high-speed and large curvature conditions, and can effectively cope with complex road curvature changes and external disturbances [6]. This experiment makes full use of PID and, on this basis, combines the LQR algorithm to ultimately propose a new method for trajectory tracking in intelligent driving at high speed and large curvature [6]. It has a good effect on the optimization of horizontal and vertical control and provides a good inspiration for subsequent schemes.

5. Performance optimization of tractors

In specific examples of intelligent driving, automated guided vehicles (AGVs) cannot be ignored. They play a role in various fields, such as transportation, assisting the elderly in traveling, and storing books [7]. The efficacy of AGVs has been optimized to varying degrees through different means. K. Nazir, Y.-W. Kim, and Y.-C Byun et al. optimized the performance of AGVs by combining genetic algorithms with machine learning and PID algorithms [4]. And Moshayedi Ata Jahanji, Li Jinsong, Sina, Nimma, Chen X, Liao, Liefu, Gheisari, Mehdi, Xie, Xiaoyun proposed four methods, namely: Ziegler-Nichols method, empirical method, Particle Swarm Optimization (PSO) algorithm and Beetle Antenna Search (BAS) algorithm (optimizer) [7]. The former prioritizes the synergy between traditional optimization techniques and modern machine learning models, aiming to facilitate the adjustment of AGV performance through combined methods and thereby optimize the system. The latter highlights four methods and proposes specific and effective solutions to select the optimal solution based on PID control. The last two methods were simulated differently on different platforms. Both of these methods

are significant contributions to AGVs and are helpful for improving their performance. Enable the efficiency in different fields to be correspondingly enhanced.

6. Challenge

At present, the development of PID control has nearly reached its end. This method is not suitable for future applications and may even hinder research. For instance, the traditional PID control has a relatively large error in heading deviation, which seriously affects the further advancement of intelligent driving. It is not merely the problem caused by large errors. The control of the motor for energy utilization [8] and the thermal management of the battery [9] are also important issues among them. Therefore, how to solve these problems on the existing algorithms is the issue that needs to be considered now. At present, there are proposals to solve these problems by combining methods or emphasizing the use of better algorithms to replace the PID algorithm. This has led to an unclear future for PID, and it is unknown whether there will be another development of PID. These are all the problems we are facing at this stage.

7. Expectation

There are already many new algorithms that have been developed by combining algorithms with PID. These new algorithms have been optimized in different aspects to reduce errors and improve performance. In the future, better PID-based algorithms will be applied to intelligent driving, ultimately improving intelligent driving. Realize cars without drivers and without danger. It is believed here that PID control will have an outstanding performance and broader application in the future intelligent driving, such as being combined with various efficient algorithms like neural networks, LQR, and MPC. And different materials can be combined with PID. For instance, a thermal management system that uses PCM material and fuzzy PID control can optimize the battery thermal management of intelligent driving [9]. The key lies in the fact that the termination of simulation experiments can better study and design intelligent control [10].

8. Conclusion

Through a review of PID control applied in different fields and under different control conditions, such as describing the advantages and disadvantages of LQR, MPC, PID, ATO control of intelligent trains, horizontal and vertical control of intelligent vehicles by PID, and the combination of PID algorithms with other algorithms to optimize the performance of AGVs. I have gained a deeper understanding of the basic principles of PID control and the loopholes within it. This article, based on various studies, demonstrates the shortcomings of PID control, but the reference of other different algorithms can reduce the original error to a very low level. Even a new type of algorithm has been designed and applied to various fields, not just intelligent driving. Make high-speed trains also achieve intelligent driving, making them safer and more reliable. The PID is used for dual sight to achieve control in both the horizontal and vertical directions. Optimize the guiding vehicle to various degrees to achieve more efficient working efficiency in different fields. Then, the areas where PID needs to be changed at the current stage

are proposed, such as large errors in many aspects. Finally, there is a high degree of affirmation and belief in the future of PID. It is believed that the PID control system will continue to play a key role in the subsequent systems.

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