An Improved PID Control Algorithm for Smart Car

Sheng Pu
School of Transportation, Huanggang Normal University, Hubei Huanggang, China
Email: 18623582@qq.com

Adong Yu
School of Electronic & Information, Huanggang Normal University, Hubei Huanggang, China

Hongbo Liu
Xinyang Vocational&Technical College, Henan Xinyang, China

***Abstract*—In the smart car, the speed and direction of control is the core of the entire smart car system control. Due to the limitations of the system hardware, there is a certain delay on the control of speed and direction of smart car, which has adverse effects on the control of smart car. In this paper, The speed and turning control algorithm was the PID algorithm, and the feed-forward and feedback control methods are applied to the control of the smart car, and the interference caused by the deviation will process in advance. In order to improve the dynamic performance of the system, the digital PID algorithm is improved and the incomplete differential algorithm is introduced into the PID algorithm. With this new algorithm, the dynamic performance of the smart car system has been greatly improved.**

***Index Terms*—PID, Feed forward, Fuzzification, smart car**

I. INTRODUCTION

Smart car system is a time-varying and non-linear system. The single feedback control of the traditional PID algorithm can cause the system will exist in varying degrees of overshoot and oscillation phenomenon, and can not get the ideal control effect. In this paper, the feed forward control is introduced into the control of the intelligent vehicle system, which improves the real-time performance and the reaction speed of the system[1]. According to the characteristics of the smart car system, improved the digital PID algorithm, and introduced the first differential and incomplete differential, and the dynamic characteristics of the system are improved. At the same time, the fuzzy control has the characteristics of insensitive and robustness to the parameter variation [2]. In this paper, the fuzzy algorithm and the PID algorithm are combined to effectively improve the adaptability and robustness of the smart car, and a better control performance of the system.

II. IMPROVED PID ALGORITHM

The control of the smart car is completed by Free scale Carle's K60 chip, so we use computer control methods for the control of smart car. Aiming at the specificity of smart car control, this paper makes some improvements to the traditional digital PID algorithm, so that can better meet the needs of smart car control.

A. Incomplete differential PID

The differential part is introduced into the direction and speed control of smart car, which can improve the dynamic performance of the system obviously, but it is also sensitive to the sudden change of the error disturbance, and has some adverse effect on the stability of the system. In order to overcome the above shortcomings, this paper adds a first-order inertia part to the PID algorithm [3], the structure of the incomplete differential PID algorithm is shown in Figure 1.

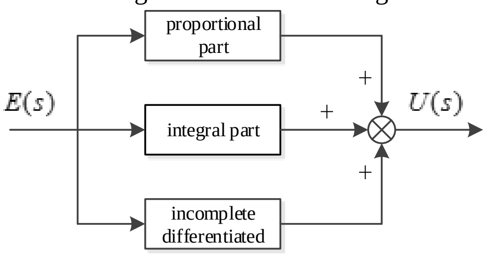

Figure 1. the structure of the incomplete differential PID algorithm

The first-order inertia part directly to the differential part, the system can be obtained transfer function:

$$U(s)=(K_p+\frac{K_i}{s}+\frac{K_d\cdot s}{1+T_f\cdot s})=U_p(s)+U_i(s)+U_d(s) \quad (1)$$

The derivative terms of (1) are derived and collated to get the following equation:

$$u_d(k)=K_d(1-\alpha)[e(k)-e(k-1)]+\alpha\cdot u_d(k-1) \quad (2)$$

For programming convenience, the formula (2) can be written as follows:

$$\begin{aligned}u_d(k)&=K_d(1-\alpha)e(k)+\alpha u_d(k-1)-K_d(1-\alpha)e(k-1)\\&=K_d(1-\alpha)e(k)+H(k-1)\end{aligned} \quad (3)$$

In the formula $H(k-1)=\alpha u_d(k-1)-K_d(1-\alpha)e(k-1)$

Analysis (3) shows that after the introduction of incomplete differentiation, the differential output in the first sampling cycle is reduced, and then decays in a certain proportion[3][4]. The experimental results show that the incomplete differential effectively overcomes the adverse effects of the disturbance of the intelligent vehicle to the speed control, and has better control effect. Figure 2 for the incomplete differential PID algorithm program flow figure.

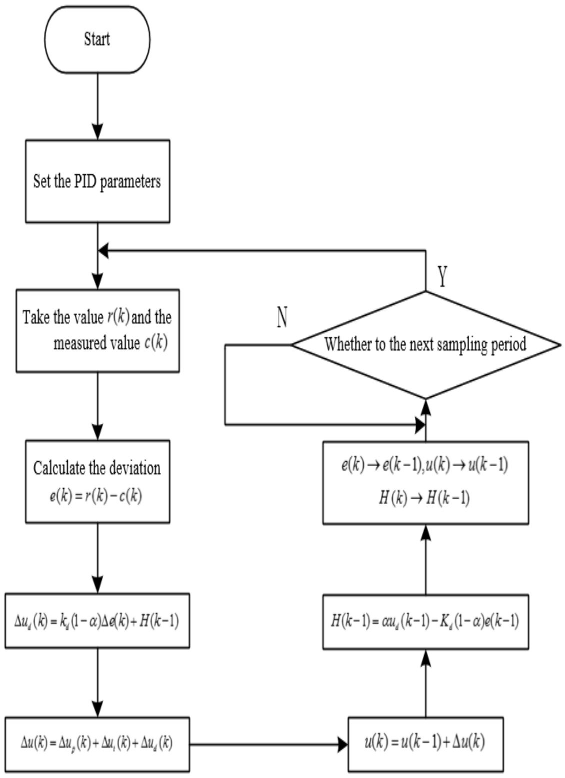

Figure 2. The incomplete differential PID algorithm program flow chart

B. Differential prior PID

As the smart car driving on the runway, often encounter the situation that need to turn, so the speed setting value and direction setting value of the smart car will change frequently, which will cause oscillation of the system. In order to solve the bad influence of the frequent change of the set value on the system, this paper introduces the differential PID algorithm in the speed and direction control of the smart car, which is characterized by only the differential output, that is, only the speed measurement and The deflector deflection is differentiated, and the set point of velocity and direction is not differentiated. In this way, when the set value changes, the output does not change, while the control amount of change is relatively moderate, which can avoid the frequent changes in the set value to oscillation that the system caused by, and it obviously improve the dynamic performance of the system.
Figure 3 is the differential prior PID control structure, differential prior incremental control formula is as follows.

$$\Delta u(k) = K_p[e(k) - e(k-1)] + K \cdot e(k) - K_d[c(k) - 2c(k-1) + c(k-2)]$$
$$-K_d[c(k) - c(k-1)] \qquad (4)$$

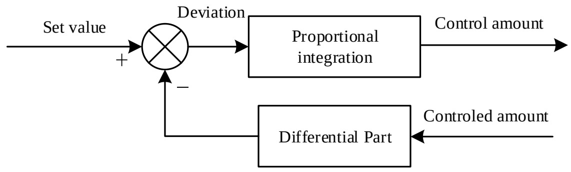

Figure 3. The differential prior PID control structure,Application of feed forward control

III. STRUCTURE OF SMART CAR CONTROL SYSTEM

Smart car control is mainly reflected in two aspects: one is the direction of control, that is, the control of the steering gear; the other is the speed of control, that is, the control of the servo motor. The mathematical model of the steering gear is relatively simple, with good linear characteristics, only the feed forward control; smart car speed control is relatively complex, the speed model can not be accurately established, using feed forward - improved PID algorithm for control. smart car control system structure shown in Figure 4.

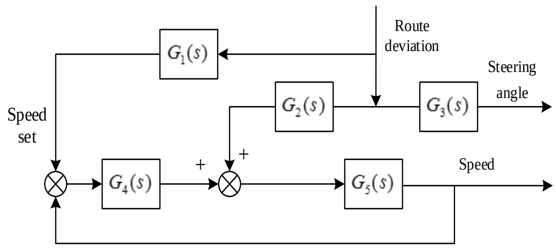

Figure 4. smart car control system structure

In Figure 4, $G_3(s)$ and $G_5(s)$ and B are the mathematical models of the steering gear and servo motor respectively. As you can see from the figure, the direction control and speed control of the smart car are independent of each other, and they are determined by the route deviation. The correspondence between the steering angle and the deviation of the steering gear is based on the mathematical model of the steering gear. In the speed control loop, both the feedback loop and the feed forward are included. The control amount of the servo motor is based on the feed forward compensation, and then calculated by the incremental PID algorithm.

A. Application in direction control

There are two requirements for the direction control of a smart car: the direction is stable on the straight path; the direction at the turn needs to change accurately and quickly. Only in this way the smart car can be kept in high speed and stable running on the runway. In order to improve the robustness of the directional control, this paper also deals with the blurring of route deviations. Figure 5 is the structure of the directional fuzzy feed forward control of the smart car. The $G_Z(s)$ and

$G_W(s)$ in the figure are the feed forward control functions in the two cases of straight path and curve respectively.

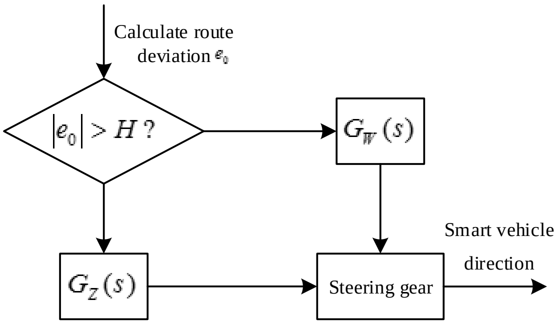

Figure 5. The structure of the directional control system of the smart car

B. Application in speed control

In turning, to prevent the smart car from running out of the runway, the speed of the smart car must be reduced, which requires that the speed control system of the smart car has good acceleration and deceleration performance. When the smart car passes the continuous turning runway, the frequent change in route deviation will cause the frequent change of the speed setting, which will lead to the oscillation of the speed control system and cause the instability of the system. In order to solve the above problems, this paper improved the digital PID algorithm, and introduced the incomplete differential and differential prior into the PID algorithm, which greatly improves the dynamic performance of the speed control system.

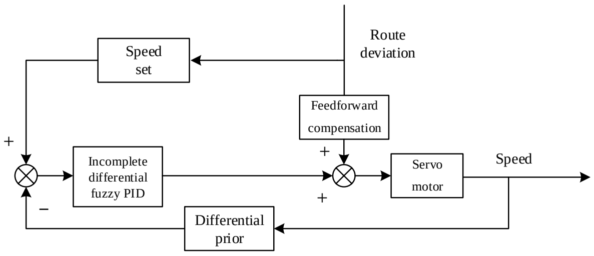

Figure 6. Structure of speed control system for intelligent vehicle

Figure 6 is the smart car speed control system structure. In order to improve the adaptability of the system, the fuzzy PID algorithm is adopted in the speed control system. The speed setting and the actual speed are fuzzy sub-file, and the relative optimal PID parameters are obtained by debugging, which ensures that the speed control system has better control effect under different conditions.

IV. CONCLUSION

The improved PID algorithm proposed in this paper is an effective method for smart car control. The algorithm makes the smart car system not only have good dynamic performance and reaction speed, but also improves the adaptability and robustness of the system, so that the smart car can be in different run on the runway at a faster speed. The experimental results show that the control algorithm this paper proposed improves the performance of the smart car, and the smart car with the new PID algorithm is faster than the smart car with the traditional PID algorithm when smart car is running on the 60-meter race runway, the average time of running a circle is reduced by 6.5 seconds, and the algorithm proposed in this paper also improves the stability of the intelligent vehicle operation and improves the adaptability of the intelligent vehicle to the runway.

REFERENCES

[1] MILLER R M, SHAH S L, WOOD R K, etal. “Forecast and PID control technology” [J]. ISA Transactions, 2008,38(1):11-23.

[2] B Remenant. “Sequencing of K60, type strain of the major plant pathogen Ralstonia solanacearum” [J]. Journal of Bacteriology, 2012, 194(10):2742-3.

[3] L.N.Zhao, K.Zhao, L.Li, X.J.Zhao, Y.Li.“Research on Special Path Recognition and Control Algorithm Based on K60 for Intelligent vehicle” [J]. Electronic Technology(Chinese), 2016, 53 (3), 20-23

[4] S.D.YU, D.P.HUANG, J.P.TIAN, Y.HU. “Control System Design of Intelligent vehicle Based on Kinetis K60” [J]. Journal of Si chuan University of Science ＆ Engineering(Natural Science Edition,Chinese), 2014, 27(5), 37-42

[5] Z.Z.GAO, L.N.ZHAO, S.J.LI, X.Z.BAI, S.S.SONG. “Design of Intelligent Vehicle Control System Based on Camera” [J]. Automation ＆ Instrumentation(Chinese), 2015, 32(6), 1-5

[6] Z.C.Yang, K.Lü, L.Zhu. “Design of Upright－moving Intelligent vehicle Based on 32－bit Kinetis－K60 Micro controller of Free scale” [J]. Journal of Hu bei University of Automotive Technology(Chinese), 2014, 28(2), 46-51

[7] W.XU, W.M.CHEN. “Design of a Predictive Adjustable Two Wheel Upright Intelligent Car” [J]. Industrial control computer(Chinese), 2016, 29(8), 45-49

[8] G.QIN, C.DU, D.Y.WU. “Simulation and Analysis on Intelligent Car Turning Control Algorithm” [J]. Techniques of Automation & Applications(Chinese), 2012, 31(12), 49-64