Automatic Control of Automobile Engine Based on Neural Network Combined with PID

Wang Lu

School of Mechanical and Electrical Engineering, Liaoning Jianzhu Vocational College, Liaoyang, China

wanglu036@163.com

Keywords: PID; Fuzzy control; Engine; Neural network

Abstract: The automotive engine automatic control system is very complex and has high-order strong non-linear characteristics. The traditional PID controller used in automobile engine, whose parameters are fixed in the whole process of operation, leads to the problem of state change and uncertainty of system parameters in the actual operation process of automobile, and it is difficult to achieve the best control effect. Artificial neural network system is an Abstract and simplified simulation system for the basic characteristics of human brain function. It has the characteristics of flexibility and accuracy, good non-linear processing and fault tolerance, and has been widely used in modern industry. Using neural network to optimize PID control system can effectively solve the uncertain and non-linear problems existing in the operation of traditional automotive engines. Therefore, the automotive engine automatic control system is studied and designed based on the neural network optimization PID control system, and the control ability of the automotive engine automatic control system optimized by the neural network in the running process is verified by simulation experiments. The experimental results show that the system can effectively solve the non-linear problems existing in the traditional engine, and can still guarantee the sTable operation of the vehicle under harsh conditions and failures.

1. Introduction

At present, the automotive engine automatic control system is mostly the traditional fuzzy PID control system. Because the internal parameters of automobiles will change in the operation stage, the non-linearity and time-varying problems of traditional control systems are prominent, which easily lead to great changes in engine controller parameters and deviations in the control process. In addition, when the vehicle runs in bad road conditions, the controller will change dramatically in the process of operation, affecting the control effect. Based on the above problems, this paper studies the existing neural network and combines with the theory of PID fuzzy control, designs an automotive engine automatic control system based on neural network optimization, and applies it to the automotive engine control for simulation experiments. The experimental results show that the system can better adapt to the non-linear problems in the process of automotive operation than the traditional PID controller. In the harsh conditions, the control also receives a more ideal control effect.

2. Neural Network Optimized PID Control System Design

The engine control system of automobile is designed. Firstly, the controlled object is closed-loop controlled by the PID control algorithm, and the control parameters are obtained by the output data of the neural network and tuned online. Using neural network to identify data and acquire information of dynamic control object, the non-linear problem in traditional algorithm is solved, and the dynamic adjustment and optimization of parameters are realized. Figure 1 shows the block diagram of the designed neural network self-tuning controller for system control.

In the neural network system shown above, there are n input points, m hidden points and I output points of the nervous system. WA is the connection weight hidden to the output WB node, Y is the

  DOI: 10.25236/iwmecs.2019.079

input and output weights of hidden layer A and output layer B.

Based on the structure of neural network control, combined with the PID fuzzy control algorithm, the results of the PID algorithm are usually fuzzy estimates, but in the automotive engine control system, precise values are required to ensure the normal operation of the car. Therefore, the obtained fuzzy values are de-fuzzified. According to the different application systems, different methods are used to de-fuzzify the system. The calculation formulas are as follows:

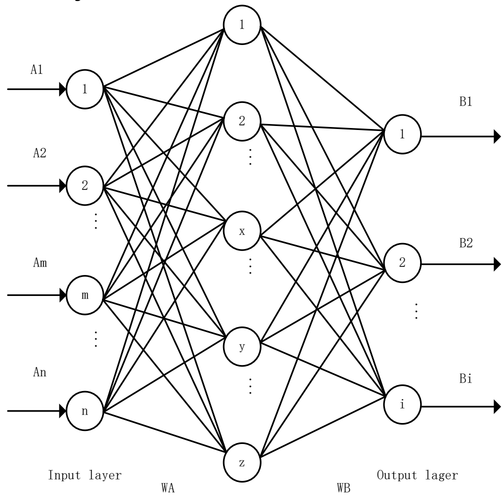

Fig. 1 Neural network control structure

$$S(k)=S(k-1)+\Delta\frac{t}{T}k \qquad (1)$$

Among them, t is the initial time, T is the end time, if a is the original parameter, when the evaluation time is between t I and tn, the algorithm of automobile automatic control system output K is as follows:

$$k=\frac{t_1+\alpha t_i+(1-\alpha)t_{(i-1)}+...+t_n}{0+...+\alpha+...+(\alpha+1)} \qquad (2)$$

The control performance of the PID controller is better than that of other types of controllers, and the performance is ideal. Therefore, combined with the above calculation method, the traditional PID automobile engine control system is designed. The PID fuzzy control algorithm is mainly divided into two parts: the forward data acquisition and transmission and the reverse error output transmission. In the forward acquisition and propagation stage, the input layer of the neural network is transmitted to the output layer through the hidden layer, and the output signal is finally generated. In the reverse propagation stage, the error signal starts to propagate forward from the output end layer by layer, and dynamically adjusts the connection weight of each unit layer according to the error signal. Finally, the error signal is continuously corrected by forward propagation and reverse adjustment. Its specific operation process is as follows:

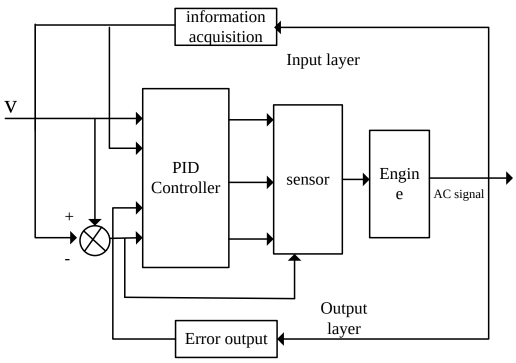

Fig. 2 Theory of PID control system

Combining the above-mentioned PID fuzzy control algorithm and neural network structure, the automotive engine controller is designed. The structure of the neural network system is output to the PID control system, so as to analyze the change of parameters in the control process timely and accurately. At the same time, the flexibility of the neural network system is used to set up the execution module so as to make the control effect more precise. The concrete results are shown in the figure.

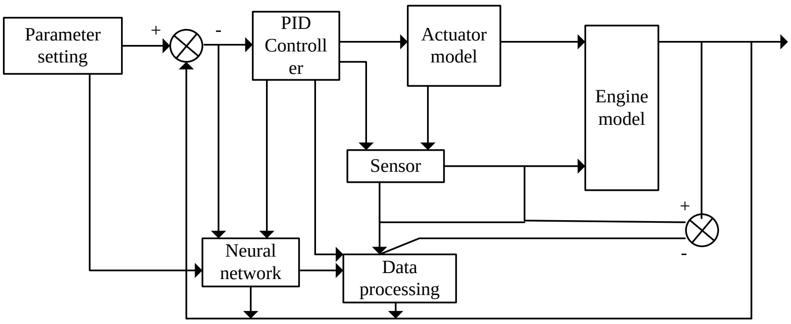

Fig. 3 Neural network optimized PID marine engine automatic control system

The system shown in Figure 3 combines the PID fuzzy algorithm with the neural network. In complex situations, the system can control the vehicle more stably and flexibly, which is helpful to solve the non-linear problems existing in the traditional control system.

3. Experimental simulation results

In order to verify the stability and flexibility of the system's automatic control performance, simulation experiments were carried out. At the beginning of the experiment, the operation of automotive engine is tested, and the error values of the traditional automotive engine automatic control system and the optimized PID automotive engine automatic control system proposed in this paper are tested under the same internal and external factors. The simulation process is as follows:

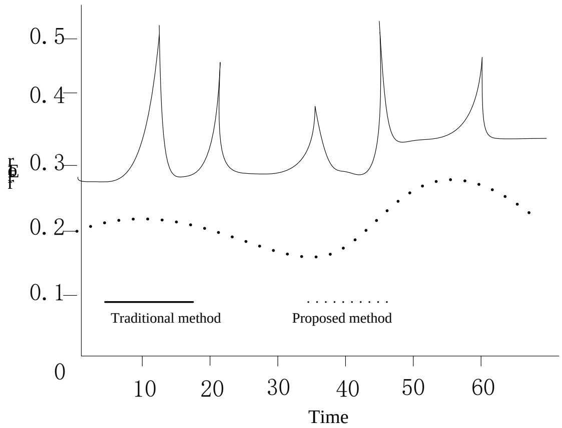

Fig. 4 Comparison of self-control of engine

Through the above simulation results, it can be seen that the automotive engine automatic control system optimized by neural network PID can achieve sTable and effective control in the automotive operation. Compared with the traditional control accuracy curve of automobile engine, the error accuracy of the two control systems under the same conditions is 0.08, which proves that the experimental method has higher control accuracy and smaller error than the traditional method. Compared with the traditional control system, the automatic control system proposed in this paper tends to be more sTable. The experimental curve of the traditional method fluctuates greatly under the relatively bad external conditions, while the curve obtained by the experimental method tends to be gentle. It proves that the neural network optimization PID automobile engine automatic control system proposed in this paper has higher stability and can effectively protect the high-precision output of the control system data. .

On the basis of the above simulation, the stability and accuracy of the engine automatic control system are further verified. After the engine output is sTable, the system control of the two engines in the same abrupt and harsh environment is tested. The following results are obtained:

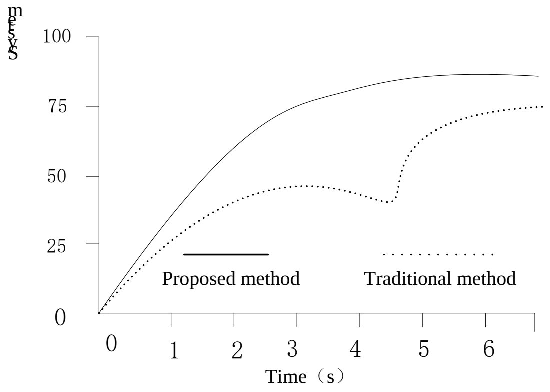

Fig. 5 abrupt control of engine control system

Through the above simulation results, it can be seen that the traditional engine automatic control effect is relatively poor, and the system control curve fluctuates greatly in sudden adverse circumstances, which proves that its ability is relatively poor and its stability is low. The neural network optimization PID automotive engine automatic control system designed in this paper can maintain sTable operation even when the parameters change suddenly and the environment is bad. The experimental results show that the system has a good ability to suppress and deal with the external environment disturbance and parameter mutation. This is because the neural network tuning PID control system will adjust real-time and accurately with the change of parameters, and its adaptability to non-linearity is much better than that of traditional methods. The experiment proves that the neural network optimization PID automotive engine automatic control system has high stability, simple operation, short time-consuming, and the control effect is obviously better than the traditional method.

4. Conclusion

In the actual operation process of the vehicle, the parameters of the control system will be changed directly when the running time and external environment of the vehicle change greatly. The traditional propagating engine control can only adjust the PID parameters frequently, and the result is ambiguous, so the precise control instructions can not be obtained to meet the actual needs. Therefore, for the controlled object with non-linear and time-varying characteristics, the control system is not effective and can not achieve the desired control effect. Therefore, the dissemination engine automatic control system based on neural optimization PID is proposed. The simulation results show that the system has better stability and flexibility, which can effectively solve the non-linear problems and ensure the precise operation of the vehicle.

References

[1] DANG Xia. Temperature control for injection molding machine based on adaptive neural network PID[J] China Synthetic Resin and Plastics, 2018, 35(6):83-86.

[2] Jauregui C, Duarte-Mermoud M A, Orstica R, et al. Conical tank level control using fractional order PID controllers: a simulated and experimental study [J]. Control Theory & Technology, 2016, 14 (4): 369-384.

[3] YU Zhimin. Water Level Control Optimization and Simulation of Automobile Boiler Based On Fuzzy Neural Network [J]. Electronics World, 2017, 24:495-496

[4] ZHANG Yan,WANG Yong-rong. Automatic control of marine engine based on neural network optimization PID [J]. Ship Science and Technology.2018, 40(6):49-51.