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Application and Study of Expert PID Intelligent Control

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Abstract. Expert system is essentially an intelligent computer program containing reasoning and knowledge, which uses the knowledge and experience of experts in a certain field to solve problems in this field. Expert control combines the concept and principle of expert system with automatic control technology, simulates the intelligence of experts, and realizes the control of the system. In actual production, because of the characteristics of time-varying, non-linear and large lag of single tank level parameters in liquid level system control, a novel expert PID intelligent control is proposed on the basis of traditional PID control in order to achieve the desired level value. According to the simulation results of METLAB, the expert PID intelligent control is superior to the traditional PID control in both dynamic performance index and practical application.

1. Introduction

Intelligent control is a new kind of control with artificial intelligence and information processing system, which studies the law of human-simulated intelligent control activities and information transmission process in control. Intelligent control is based on artificial intelligence, control theory, operations research and other disciplines. It extends the corresponding concepts and principles, including fuzzy control, neural network control, expert control, humanoid control, genetic algorithm and other control technologies. Expert control is one of the main contents of intelligent control technology. Compared with classical control, expert control makes complex systems more flexible, reliable and capable of dealing with uncertain information problems.

Liquid level control system is a common industrial process control system, which has the characteristics of time-varying, lag, coupling and non-linearity. Traditional PID control is difficult to ensure that it can adapt to the parameters of complex systems and cannot achieve the desired results. Aiming at single tank level control system, a novel expert PID intelligent control is proposed, which combines expert control with conventional PID control. The parameters of the PID controller are adjusted by expert control theory. The simulation results show that the expert PID intelligent control can better adapt to the changes of parameters and working conditions of the level control system.

2. Expert Control System

Expert control is a main branch of intelligent control, which belongs to advanced control. Its essence is to design controller by expert experience knowledge, so that the controller imitates expert intelligence. Controllers or systems designed according to the concept and principle of expert control are called expert controllers or expert control systems respectively. Expert system is a complex artificial intelligence system, which utilizes abundant domain knowledge. The essential difference between expert system and computer application program is that the problem solved by expert system has no arithmetic solution and is often based on unknown environment, inaccurate and uncertain information.



The expert system includes five parts: reasoning engine, knowledge base, synthesis database, knowledge acquisition and interpretation interface, as shown in Figure 1.

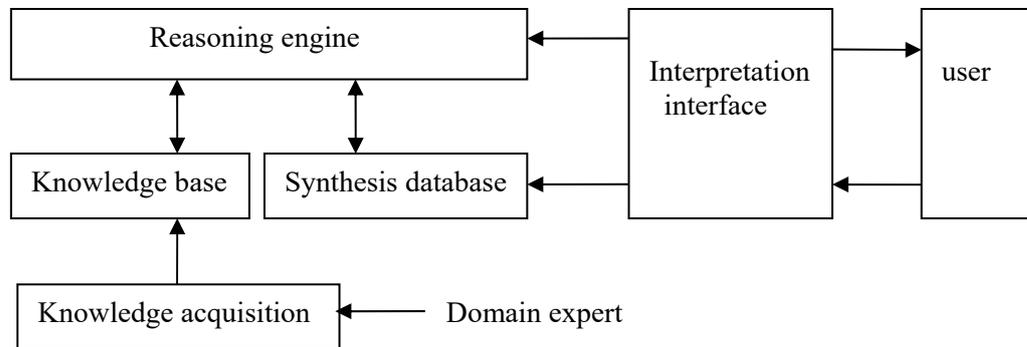


Figure 1. Block diagram of expert system

Expert control system has expert system structure, expert control principle and real-time knowledge information processing function. The blackboard data structure is adopted in the system, which has a large amount of information in the knowledge base, complex content of the inference engine and high requirement for human-machine interface. The simplified form of expert control system is expert controller. In view of the complex process of industrial control, a knowledge base with small amount of information and simple reasoning mechanism is designed according to working conditions, which can save complex man-machine interface. Expert controller is widely used in industrial process control because of its simple structure.

3. Expert PID Intelligent Control

Expert PID control is an advanced control method based on traditional PID control, in which the reasoning ability and practical experience of experts or operators are involved in the process of being controlled. The greatest characteristic of expert PID intelligent control is that expert system realizes PID parameter tuning, and carries out different arithmetic control in different error areas. The response curve of a second-order system is shown in Figure 2. The error e and error rate \dot{e} are divided into four stages in a period.

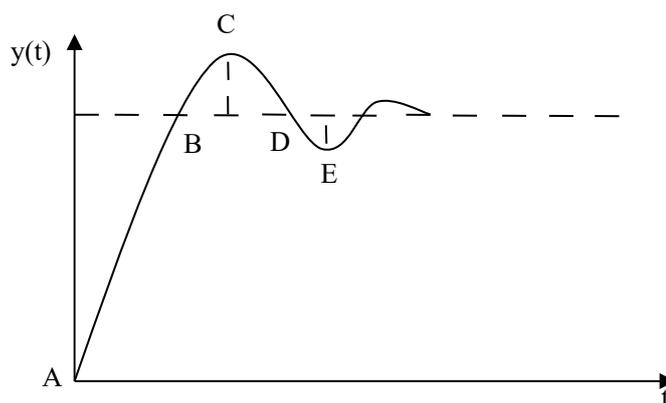


Figure 2. Step response curve of second-order system

At AB stage, $e > 0$, $\dot{e} < 0$, the system error decreases slowly. The overshoot is reduced and the response speed of the system is faster. The proportional gain decreases gradually from larger to smaller, and the differential gain increases accordingly.

At BC stage, $e < 0$, $\dot{e} < 0$, the system error increases accordingly. The overshoot is further reduced and the reverse control effect is increased. The proportional gain and differential gain are gradually increased, and the integral effect is strengthened.

At CD stage, $e < 0$, $\dot{e} > 0$, the system error decreases gradually. In order to make the system error tend to zero, we should introduce appropriate differential and integral effects.

At DE stage, $e > 0$, $\dot{e} > 0$, the system error increases. In order to make the system error quickly and steadily zero, we should increase the integral effect and introduce appropriate differential action.

The essence of expert PID intelligent control is to intelligently tune the PID parameters of four stages with the constraints of error and error rate, so as to improve the dynamic performance and steady-state accuracy of the control system.

4. System Simulation

In order to meet the production requirements of complex working conditions, we propose a novel expert PID intelligent control on the basis of traditional PID control. The liquid level control system of single tank in actual industrial production process is taken as the research object, and the liquid level transfer function is established by mechanism method. The traditional PID control and expert PID intelligent control are adopted respectively for the liquid level control system of single tank. Expert PID intelligent control is based on expert experience rule and error zoning control algorithm. The simulation curves of expert PID intelligent control and traditional PID control are shown in Figure 3 and Figure 4 respectively.

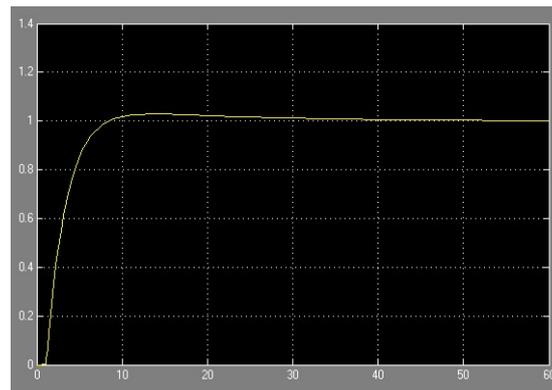


Figure 3. Expert PID Intelligent Control Simulation Curve

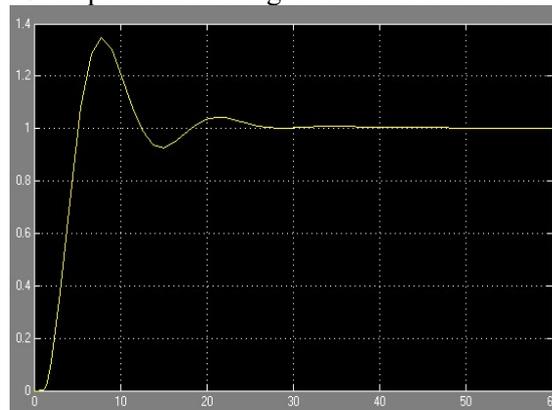


Figure 4. Simulation curve of traditional PID control

According to the simulation curve of expert PID intelligent control in Figure 3 and the simulation curve of traditional PID control in Figure 4, it can be seen that the overshoot of expert PID intelligent control in Figure 3 is very small and the transition time is fast. The response curve is smooth and steady-state error tends to zero .

5. Conclusion

Generally speaking, expert PID intelligent control and traditional PID control are effective in liquid level control system, but expert PID intelligent control system is better than traditional PID control. Expert PID intelligent control is a partition control algorithm based on expert rules to control the system, and expert rules make the system control more detailed, thus achieving a better control effect.

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