Study of simulating human intelligent control

Jing ZHAO
Northwestern Polytechnical University Ming De College. Xi’an, China
351057219@qq.com

Abstract. Because the temperature control system of glass furnace has the characteristics of non-linear, time-varying, large amount of interference, large lag and so on, the traditional PID control is difficult to ensure the temperature control accuracy and can not achieve the expected effect, the artificial intelligent control is proposed for the temperature control system of glass furnace. Humanoid intelligent control is to make the controller imitate the control behavior of human. It uses control theory and computer technology to act on the actual control system. Through the analysis of the simulation curve of the artificial intelligent control of glass furnace temperature, the superiority of the artificial intelligent control is verified.

1. Introduction
Glass furnace is the most important thermal process equipment in glass factory. It is also a complex control object with large lag, nonlinear, time-varying characteristics, intense disturbance and large amplitude. Its structure and control technology will affect the quality of products and production costs. The traditional PID control is generally used in the temperature control system of glass furnace. The advantage of this control method is that it can achieve good control effect in a small range near the working point, but its disadvantages are also obvious, because the furnace is affected by many disturbance factors in the operation process, and it is difficult to control the system stably and timely when the operation conditions fluctuate greatly, which has great limitations. Therefore, the temperature control system of glass furnace is controlled by the method of artificial intelligent control.

Humanoid intelligent control[1] is to make the controller imitate human control behavior, apply the results of control theory and computer technology, adopt the method of hierarchical intelligent control, directly identify, summarize and summarize human control experience, skills and various intuitions and reasoning logic, and make it into various simple, practical and real-time control algorithms, which can be directly applied to actual control system.

2. PID Control
The conventional PID control algorithm[2] includes proportional, integral and differential control functions, which have different characteristics. In the proportional function, once the deviation is generated, the controller immediately has a control function, which makes the controlled variable change in the direction of deviation reduction, so that the controlled variable tends to be stable, but the proportional control will make the controlled variable have residual error, increasing the amplification factor $K_p$ can reduce the residual error, but the excessive amplification factor $K_p$ will lead to the deterioration of the system dynamic performance, resulting in system instability; integration The action can memorize the deviation and eliminate the residual difference, but the integral action has the lag characteristic, and it is easy to cause the integral saturation and even the system instability; the differential action can differentiate the deviation to get its change trend, increasing the differential
control action can accelerate the system response, reduce the overshoot and increase the system stability, but the differential action is also sensitive to the interference to reduce the interference suppression ability of the system.

The PID control parameters can be adjusted properly according to different controlled objects, which can achieve satisfactory control effect, but this control effect is difficult to solve the contradiction between the stability and accuracy of the system. Increasing the control function can reduce the system deviation, improve the accuracy, but reduce the system stability; similarly, in order to ensure the system stability and limit the control function, the system accuracy will be reduced. [3] Therefore, when the traditional PID algorithm is applied to the temperature control system of glass furnace, the accuracy of temperature control is difficult to be guaranteed.

3. Human simulated intelligent controller

The basic algorithm of humanoid intelligent control is based on the observation, decision-making and other governance behaviors of skilled operators. The control strategy is determined according to the deviation and change trend of controlled variables, so it is close to the way of human thinking. When the deviation of the controlled variable increases, the control effect of the controller increases and the deviation is restrained; when the deviation tends to return to zero (start to decline), the control effect of the controller decreases, waiting for and observing the change of the controlled variable; at the same time, the controller keeps recording the extreme value of the deviation, and corrects the control point of the controller to meet the change requirements. [4]

\[
  u = \begin{cases} 
    K_P e + k K_P \sum_{i=1}^{n-1} e_{m,i} & e \cdot \dot{e} > 0 \cup e = 0 \cap \dot{e} \neq 0 \\
    k K_P \sum_{i=1}^{n-1} e_{m,i} & e \cdot \dot{e} < 0 \cup \dot{e} = 0 
  \end{cases}
\]

Where \( u \) is the controller output; \( K_P \) is the proportional coefficient; \( k \) is the suppression coefficient; \( e \) is the deviation, \( \dot{e} \) is the variation rate of deviation; \( e_{m,i} \) is the ith peak of deviation.

The step response curve, deviation curve of the controlled variable and characteristic curve of human simulated intelligent controller are shown in Figure 1. (0.a) segment deviation meets the condition \( e \cdot \dot{e} < 0 \cup \dot{e} = 0 \), the output \( u = k K_P e_{m,1} \), the system is in the holding control stage (controller output is independent of deviation, which is the open-loop control stage); (a,b) segment deviation meets \( e \cdot \dot{e} > 0 \cup e = 0 \cap \dot{e} \neq 0 \), controller output \( u = K_P e + k K_P e_{m,1} \), the system is in the proportional control stage (closed-loop control stage), the controller output changes proportionally with deviation; (b,c) segment deviation meets the condition \( e \cdot \dot{e} < 0 \cup \dot{e} = 0 \), controller output \( u = k K_P (e_{m,1} + e_{m,2}) \), system the system is in the holding control stage (open-loop control stage), which is smaller than the last holding value; (c,d) segment deviation meets condition \( e \cdot \dot{e} > 0 \cup e = 0 \cap \dot{e} \neq 0 \), the controller outputs \( u = K_P e + k K_P (e_{m,1} + e_{m,2}) \), and the system is in the proportional control stage (closed-loop control stage); if the control is carried out in this way, the final deviation \( e \) converges to 0, and the controller output \( u \) converges to the constant value.
Figure 1. The step response curve $y$, deviation curve $e$ of the controlled variable and characteristic curve $u$ of human simulated intelligent controller

4. Conclusion
The humanoid intelligent control is applied to the temperature control system of glass furnace. According to the simulation curve of human simulated intelligent temperature control in Figure 2, it can be shown that the system has the advantages of short adjustment time, small overshoot, avoiding vibration, keeping the temperature at the given value, good dynamic performance and good control effect.

Figure 2. Human simulated intelligent temperature control curve

References
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