

Design of advanced control experimental platform for main steam pressure based on Matlab

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Abstract. In the field of process control, MATLAB is used for system simulation because of its powerful data processing functions. The subject of this thesis is to optimize PID parameters based on various optimization algorithms. The purpose of cascade PID controller is to control the main steam pressure, simulate the control system by MATLAB and connect Simulink with GUI interface. The parameters are set in the interface, and all the parameters are input and displayed in the GUI interface, which makes the user clear and convenient to optimize the operation interface and get the optimal value. The result of Simulink simulation was optimized and modified to achieve a complete control platform.

1. Introduction

The main steam pressure of the power plant boiler refers to the saturated steam coming out of the steam drum after being heat-exchanged with the high-temperature flue gas through various forms of superheated steam provided in the boiler flue and finally obtained at the outlet of the super heater steam pressure. Temperature is a necessary indicator to measure the quality of steam and is a very important monitoring and control parameter in the process of power plant production. High temperature or low temperature will affect the safety and economy of the unit. With the cascade control loop PID controller and the two main administrators of the main steam temperature, plus interference suppression, the secondary circuit to control sub-loop vice inertia, thereby increasing the system response speed. Therefore, the Cascade PID control for the main steam temperature regulation make the system put into operation. It makes the unit tuning, debugging intuitive, convenient and good controlling. Literature [6] adopted fuzzy PID control strategy to control the main steam pressure of the boiler, and better control effects can be obtained by optimizing the quantization and scaling factors by the particle swarm optimization. Literature [7] using neural network to control neural PID control scheme is a good solution to the main steam temperature control inaccuracy. Literature [8], [9] combined with predictive control and genetic algorithm, predictive control to overcome the time-varying delay, so that it is integrated into genetic algorithm parameters optimization, a genetic algorithm based predictive self-tuning PID control algorithm. However, the rule base of fuzzy neural network control is very large, and the designer lacks systematicness, the structure is generally more complicated.

The Matlab GUI is an extensible experimental platform that is easy to use, easy to use and versatile. The principle of the GUI interface design is to use the different controls provided by MATLAB GUI to design the interface platform. Callback function designing principle is based on the interface designing requirements to achieve the function of the interface callback function programming to achieve the desired effect of the design [3]. GUI interface not only supports WINDOWS basic controls,



but also has a good time-driven mechanism, which also provides the MATLAB mathematical library interface, so choosing GUI interface designing to control the simulation platform is very reasonable.

This paper design the main steam pressure advanced control experimental platform based on the MATLAB , the platform uses MATALB graphical user interface (GUI) designing tools for conventional algorithms, fuzzy algorithms, genetic algorithms to GUI interface design, simulation results added to GUI interface, expressed in the GUI interface for input parameters, thereby changing the optimization curve.

2. Algorithm Introduction

2.1. The Cascade PID control algorithm

Cascade Control System (Cascade Control System) is a complex Control System with wide applicability.

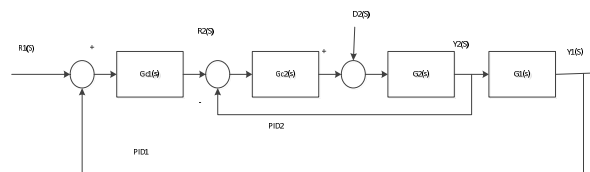


Figure 1. Cascade control system diagram

As shown in Fig. 1, the block diagram of cascade PID control system has two PID controllers in the control system. $G_{c1}(s)$ is called the transfer function of the adjuster, and the inner ring that surrounds $G_{c2}(s)$ is called the secondary loop. $G_{c1}(s)$ is called the main regulator transfer function, surrounded by a c outer ring called the main loop. The main controller of the output control u_1 as the secondary circuit of a given amount $R_2(s)$. The transfer function of the closed loop of the secondary loop can be obtained from the upper block diagram as follows:

$$\varphi_2(z) = \frac{Y_2(z)}{U_1(z)} = \frac{G_{c2}(z)G_2(z)}{1 + G_{c2}(z)G_2(z)} \quad (1)$$

Available sub-regulation control law:

$$G_{c2}(z) = \frac{\varphi_2(z)}{G_2(z)(1 - \varphi_2(z))} \quad (2)$$

General choice:

$$\varphi_2(z) = z^{-n} \quad (3)$$

2.2. Introduction to Genetic Algorithm

Genetic algorithm (GA) is a search algorithm of "generate and test" iterative process. Genetic operations mainly include three operations: selection, crossover and mutation. Genetic algorithm (GA) is usually used for convergence criteria: the rule of the largest evolutionary algebra; the best personal fitness value has not changed or changed a few times and so on. Genetic algorithms are used to design control parameters: number of iterations, population size, length of population individuals, binary, decimal selection, crossover probability and mutation probability. Enter the variable num/den. Optimal optimization shows that P, I, D optimal choice: PI, PD and PID. The length of the encoded string depends on the accuracy of the desired optimization solution.

The basic steps of genetic algorithm are as follows: 1. In a certain coding mode, a population is randomly generated; 2. According to the size of individual fitness value, some individuals with larger fitness value are selected from the population to form a mating pool. 3. The crossover operator and mutation operator of the mating pool of individuals in the genetic operation, and the formation of a new generation of populations; 4. Steps 2 and 3 are repeated until the convergence criteria are satisfied.

2.3. Fuzzy PID control principle

Fuzzy controller is a controller of expert knowledge composed of fuzzification the fuzzy rules are

used to express the control experience and form the rule base, the stored knowledge in the rule base is invoked by fuzzy reasoning, and the output is defuzzified to achieve the control purpose. K_p is the proportional coefficient, K_i is the integral coefficient, K_d is the differential coefficient, Set K_p , K_i , K_d generation setting to K_p' , K_i' , K_d' . Using fuzzy rules for fuzzy inference. We getting K_p , K_i , K_d as Δk_p , Δk_i , Δk_d . Use PID parameter tuning formula to get the parameters of PID controller.

PID parameters K_p , K_i , K_d are calculated as follows:

$$k_p = k'_p + \Delta k_p \quad (4)$$

$$k_i = k'_i + \Delta k_i \quad (5)$$

$$k_d = k'_d + \Delta k_d \quad (6)$$

Then (4) (5) (6) calculated into (7), calculated

$$u(t) = k_p e(t) + k_i \int_0^t e(t) dt + k_d \frac{de(t)}{dt} \quad (7)$$

In the fuzzy PID control process, the computer system completes the tuning of the PID parameters by processing the results of fuzzy logic rules, looking up tables and computing. The workflow shown in Fig. 2, where $e(k)$ that error, $y(k)$ that the output, r said given value.

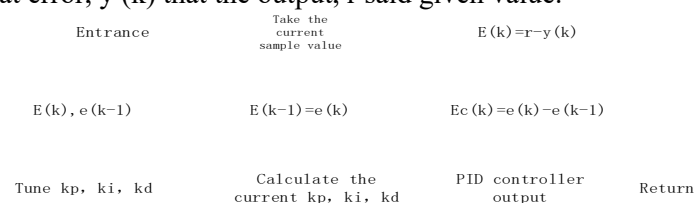


Figure 2. Fuzzy PID control flow

2.4. Neural Networks

BP (Back Propagation) neural network is the most in-depth and widely used model in artificial neural network at present, and its structure is shown in Fig.3. In the figure, x and y are input and output vectors of the network. Each neuron is represented by a node. The network consists of input layer, hidden layer and output layer node. The hidden layer can be one layer or multiple layers. (The figure is a single hidden layer), the front layer to the rear layer nodes are connected by a weight coefficient. The former layer and the posterior layer are connected by weight coefficient. When the learning of BP neural network, the input signal from the input layer through the hidden layer to output layer (toward), if the output layer to get the desired output, the end of the learning algorithm, otherwise, turn to the back propagation.

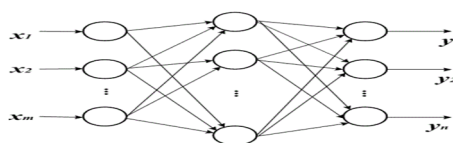


Figure3. BP neural network structure

3. Introduction to GUI experiment platform

Matlab GUI is an easy way to operate simply. A wide range of functions can be extended into experimental platform. The most basic way to create GUI interface is to use M file, Matlab graphical user interface development environment (referred to as GUIDE), GUIDE is a user interface design tool set. The user can also save the created GUI interface as a FIG resource file, and the FIG file will automatically generate the M file corresponding to the interface. This file contains the GUI code, the

interface layout control and interface object initialization code.

In the main steam pressure experimental platform design, each interface design includes GUI interface design and callback function design two steps. GUI main interface shown in Fig. 4.

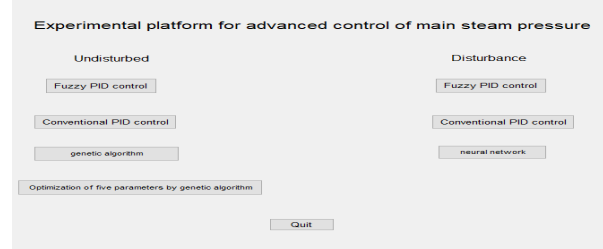


Figure4. GUI main interface

4. The example analysis

The first task of the Main steam pressure control system is to maintain the pressure constant of the Main steam pipe or to fluctuate within the allowed range. The steam pressure is an important index to measure the steam consumption of the boiler and the steam consumption of the load equipment, which is an important technological parameter of the boiler.

The second task of Boiler main steam pressure control system is to improve the thermal efficiency of boiler, to maintain the boiler combustion efficiency, it needs a boiler air output and fuel quantity proportion coordination, which maintain a reasonable coal than the wind. Keep air volume and fuel quantity, in the right proportion, keep the excess air coefficient of furnace flue gas outlet is the best value, make the boiler thermal efficiency is highest, reduce the pollution to the environment, to achieve the purpose of saving energy and reducing consumption.

4.1. Cascade PID algorithm and GUI interface design

Simulink is used for simulation. The PID control method is adopted to design the controller, the initial value of the error is realized by the clock function, and the integral and differential of the error are realized in the M function to control the main program, as shown in fig. 5.

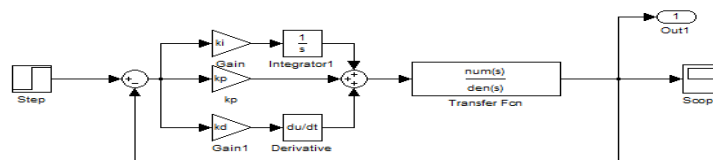


Figure5. Cascade PID control Simulink simulation

The GUI interface of conventional PID (undisturbed) is shown in fig. 6. The conventional PID (disturbance) GUI interface is shown in fig. 7

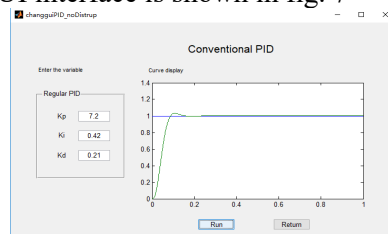


Figure 6. conventional PID (undisturbed)

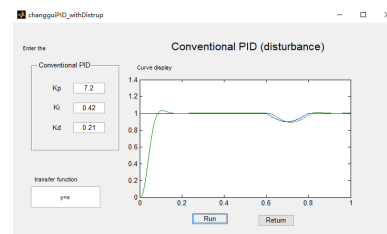


Figure 7. conventional PID (disturbance)

4.2. GUI interface design of Genetic Algorithm

According to the basic process based on the genetic algorithm and its operation operator compiled into the corresponding M function file, get the genetic algorithm optimization toolbox. The GUI interface design shown in Fig.8. You can enter the specific parameters in the interface, click run genetic algorithm is applied to optimize the GUI interface design of five parameters of cascade PID control system as shown in fig. 9.

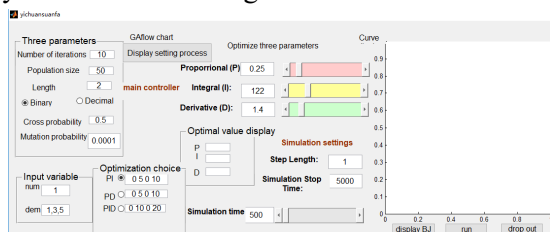


Figure 8. Genetic Algorithm Optimization GUI interface(Three-Parameter)

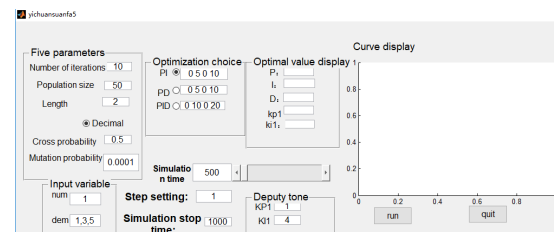


Figure 9. Genetic Algorithm Optimization GUI interface(five-Parameter)

4.3. GUI interface design of Fuzzy algorithm

To compare the control performance of PID control and fuzzy PID controller, Simulink and Fuzzy Toolbox in MATLAB are used to simulate the control object. Set the control object:

$$G_1(s) = \frac{\text{num}(s)}{\text{den}(s)} = \frac{20000}{(s+1/6)(s+20)(s+100)} \quad (8)$$

$$G_2(s) = \frac{\text{num}(s)}{\text{den}(s)} = \frac{20000}{(s+1/6)(s+20)(s+100)} \quad (9)$$

Fuzzy PID (undisturbed) GUI interface design shown in Fig. 10. Fuzzy PID (disturbance) GUI interface design as shown in Fig. 11.

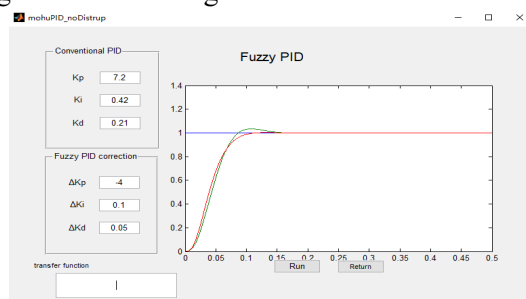


Figure 10. Fuzzy PID (undisturbed)

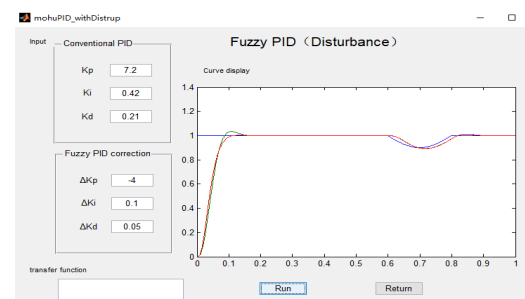


Figure 11. Fuzzy PID (disturbance)

4.4. GUI interface design of Neural Network PID Control

Neural Network PID control undisturbed GUI interface as shown in Fig. 12. Neural Network Control PID with Disturbance The GUI interface is shown in Fig. 13.

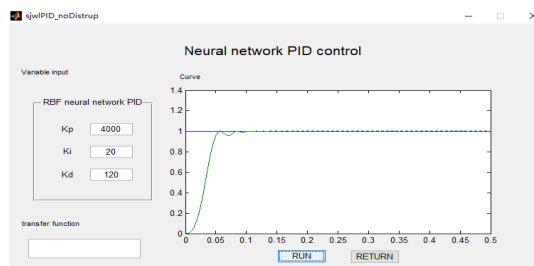


Figure 12. Neural Network PID (undisturbed)

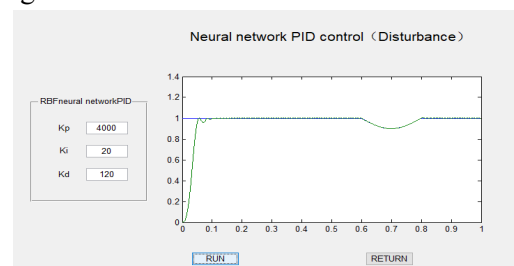


Figure 13. Neural Network PID (disturbance)

Acknowledgments

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