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Study on an improved algorithm for optimization of PID parameters

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ABSTRACT

The improved ant colony algorithm is the hybrid algorithm consisting of the genetic algorithm and ant colony algorithm convergence. Through the introduction of the gauss mutation, we achieve the goal of improving ant colony algorithm. Using coal-fired power plant unit as main steam temperature controlled object, we design the PID controller based on improved ant colony algorithm. And setting of PID parameters by Z - N method has carried on the comparative analysis of the main steam temperature control system. Simulation results show that PID optimization based on improved ant colony algorithm can greatly improve the dynamic performance of the control system. So we verify the sophistication and effectiveness of the algorithm.

KEYWORDS

Improved ant colony algorithm; Genetic algorithm; Gauss mutation; PID; Optimization.



THE INTRODUCTION

Ant colony algorithm^[1] is a kind of hot bionic algorithm after new bionic algorithms such as the simulated annealing method, genetic algorithm, tabu search algorithm and artificial neural network. Genetic algorithm^[2] is a kind of search algorithm based on space, through the selection, heredity and mutation operation, and Darwin's theory of survival of the fittest, simulating the natural evolution to find for solution of the problem. Genetic algorithm and ant colony algorithm are both very good artificial intelligence algorithms, including good abilities of global optimization. However, a lot of research results show that the single use of genetic algorithm or ant colony algorithm to solve a variety of optimization problems, makes it impossible to get a satisfied solution^[3].

Based on this, we put forward a kind of improved ant colony algorithm combined with a new ant colony algorithm and genetic algorithm.

THE TEMPERATURE CONTROL SYSTEM

For main steam temperature of 300MW power plant^[4] of the object, in a cascade control system, object properties as shown in Figure 1.

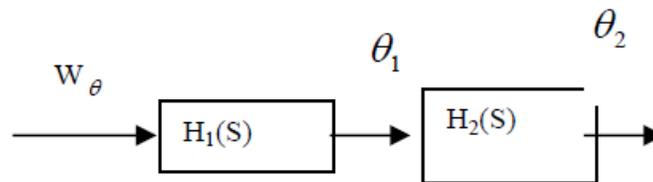


Figure 1 : Object properties

Controlled object is the big inertia, big lag since the scale of the object. In the control system, object model is:

$$H_1(S) = \frac{-1.20}{1 + 33S} e^{-6s} \tag{1}$$

$$H_2(S) = \frac{8}{1 + 90S} e^{-53s} \tag{2}$$

By the main steam temperature control system design principle^[5], the principle diagram of the control system is shown in Figure 2.

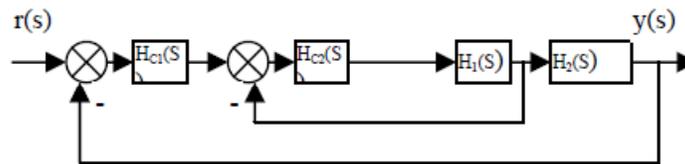


Figure 2 : The main steam temperature control system controlled by cascade

PID SETTING BASED ON IMPROVED ANT COLONY ALGORITHM

The basic principles of improved ant colony algorithm

Ant colony optimization (ACO) algorithm^[1] is a population based on heuristic bionic evolutionary algorithm, this algorithm adopts a distributed parallel computing, positive feedback mechanism, easy to combine with other methods, having stronger robustness, especially suitable for the solution of the combinatorial optimization problem (COP). Joining the gauss mutation operation is to make use of the Gaussian distribution which has better local search ability of ant algorithm to solve the lack of local optimization ability weak. Using the decision variable to be set in the upper and lower bounds of the variance and mean, results in a meet the conditions of Gaussian distribution. Through the operation of the gauss mutation variance attenuation with increasing of the number of iterations, we can shrink it to the size of the global search. In a word, because the basic ant colony algorithm is easy to fall into local optimum, and through the gauss mutation operation can be very good to overcome this shortcoming, we can find the global optimal point of high efficiency and high precision.

PID setting steps based on the improved algorithm

Optimization of PID parameters is a continuous domain the function optimization problems in applications of ant colony algorithm. Based on improved ant colony algorithm of nonlinear continuous function optimization problem of the specific steps are as follows:

- 1) Make the constraint function into the objective function and determine all the decision variables;
- 2) Estimate the scope of each decision variable;
- 3) Ants position initialization, pheromone initialization, set up each subspace of the decision variables, within the scope of the decision variables as the random determine each ant in the various decision variable initial subspace;
- 4) The number of iterations $nc=nc + 1$;
- 5) Ant $j=j+1$;
- 6) The decision variables $i=i+1$;
- 7) In the case of decision variables I , choose subinterval of j , and randomly select candidate values within the subinterval, through gauss mutation to generate new candidate values;
- 8) i is greater than the number of decision variables, or turn 6);
- 9) j is greater than the number of ants, or turn 5);
- 10) Make all the decision variables of subspace of pheromone updated, new candidate generates by comparing the objective function value and the old candidate values, fitness good new candidate values to replace old candidate values;
- 11) Optimize requirements, or turn to 4);
- 12) Output the result.

Optimization of the PID controller model

The improved ant colony algorithm and PID combination, can optimize the three parameters of PID controller online K_p , T_i , T_d . The PID control system based on improved ant colony algorithm structure, as shown in Figure 2

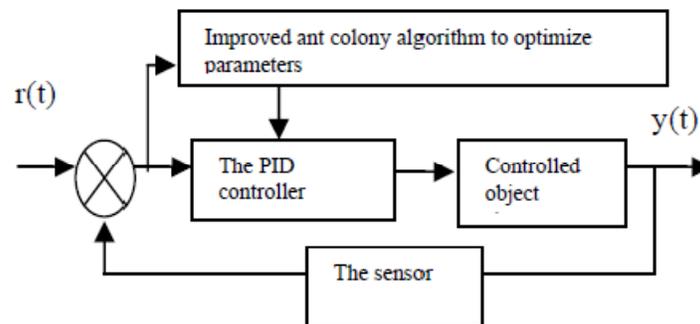


Figure 3 : The principle diagram of the control program of improved ant colony algorithm

The choice of optimal performance index

Based on integral square error (ISE) performance index^[2], namely:

$$ISE = \int_0^{\infty} e^2(t) dt \quad (3)$$

THE SIMULATION TEST STUDY

The simulation parameters

By using Z - N setting of PID parameter control method, to calculate the parameters of the PID regulator $K_p = 0.4508$, $T_i = 170.0$, $T_d = 20.0$.

Improved ant colony algorithm parameter Settings

Ant colony algorithm of variable initializations are: the number of iterations $k = 20$. The number of ant colony of ants $N = 100$; Pheromone volatilization coefficients $\rho = 0.8$; Information enhancement coefficient $Q = 1$; The ants crawling speed is 0.4; Set the upper and lower bounds of the three control parameters as:

$K_p \in (0.2, 10)$, $T_i \in [0.002, 0.008]$; $T_d \in [17, 21]$, $\alpha = 1$, $\beta = 1.5$; After running the program in matlab 7.0 get setting of control parameters based on improved ant colony algorithm is as follows: $K_p = 0.2147$, $T_i = 0.0022$, $T_d = 19.8433$

The results of simulation and analysis

By using Z - N setting system response curve as shown in Figure 4: the Z - N method of setting PID parameters, adjust the time $t_s = 78$ s, overshoot $\sigma_p = 21\%$. With the improved genetic algorithm setting the step response curve is shown in Figure 5: adjust the time = 55 s, overshoot $\sigma_p = 0\%$.

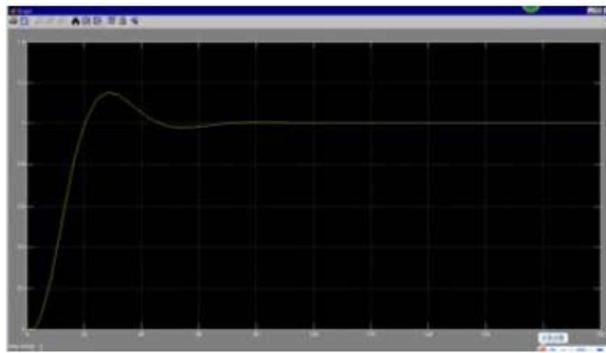


Figure 4 : Z -N setting system response curve

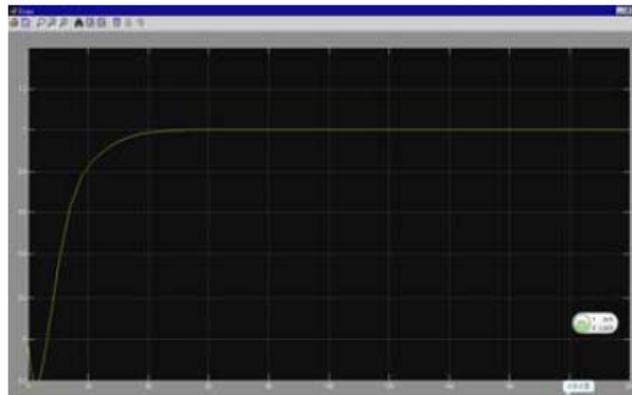


Figure 5 : PID control system response curve based on optimizing of improved ant colony algorithm

Improved ant colony algorithm for PID parameters optimization performance index, and with Z - N setting method of comparison of the results are shown in TABLE 1.

TABLE 1 : PID parameters settings between Z -N optimal and VACA contrast

Algorithm	K_p	T_i	T_d	t_s	σ_p %
Z-N	0.4508	170.0	20.0	78s	21%
VACA	0.2147	0.0022	19.8433	55s	0%

CONCLUSION

Combining ant colony algorithm and genetic algorithm, using a new method of improved ant colony algorithm, in coal-fired power plant unit for main steam temperature controlled object, we design the PID controller based on improved ant colony algorithm. And setting of PID parameters by Z - N method has carried on the comparative analysis of the main steam temperature control system. Simulation results show that: the Z - N method of setting the main regulator control system to adjust time, overshoot amount is larger, and based on improved ant colony algorithm to optimize the control system has good dynamic performance..

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