

Research on the Optimization of PID Controller Parameters Based on Teaching and Learning Optimization Algorithm

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Abstract: The parameter adjustment of PID controller is to determine the best value of three parameter spaces, and the control performance of the system is the best. The education and learning optimization algorithm is a new smart optimization algorithm. In order to strengthen the parameter tuning of PID controller and realize the parameter optimization of PID controller, a self-adjusting method of PID controller parameters is proposed. In order to implement the simulation example using MATLAB, particle swarm optimization algorithm and genetic algorithm based PID parameter adjustment method are compared, the method is simple and high accuracy, PID controller parameter self adjustment, can be quickly and effectively realized.

1. Introduction

Due to the simple structure, simple installation, good robustness and high reliability, the pid controller is widely used in process control and motion control. Modern control theory has achieved many successful cases in many control applications[1]. Among them, pid controllers are the most widely used, mature in industrial process control, and still occupy a dominant market position.

PID control performance is directly related to the tuning of the three parameters. The proportional coefficient (P), integration time (I), and differential time (D), that is, K P, K I, D. D. PID parameter tuning is generally divided into a conventional parameter adjustment method and an intelligent parameter adjustment method. The tuning process of the traditional tuning method is cumbersome, it is difficult to achieve optimal tuning of parameters, and it is easy to generate vibration and large upspin [2]. Intelligence parameter adjustment methods such as genetic algorithms (GA) and local loop optimization (PSO) algorithms also have some disadvantages. The former contains many parameters [3], boring encoding and decoding processes, and is computationally expensive [4]. The optimization algorithm for education and learning has several advantages, simple algorithm, easy to understand, strong convergence ability, fast solution speed, high accuracy and so on. In addition, there are better applications for complex optimization problems, such as multi-purpose. Therefore, this paper proposes a pid parameter optimization method based on learning and optimization algorithms.

2. Optimization Algorithm Teaching and Learning Optimization Algorithm

Teaching and learning is a group knowledge optimization algorithm that simulates the teaching process of students and the learning process of students. To improve student achievement. The education and learning optimization algorithm is based on the parent group optimization method to obtain the global optimal solution. The population is students, that is, classes. Algorithm design variables are different learning subjects; student performance is fitness value. Teachers have the highest academic performance, which is the highest fitness value. The specific definition is as follows: $z = \min f(X)$ (May take the maximum value MAX). Search space $S = \{X \mid x_i^L \leq x_i \leq x_i^U, i=1,2,\dots,D\}$, any search point in space $X = (x_1, x_2, \dots, x_D)$ includes the number of dimensions (the number of design variables), x_i^L and x_i^U ($i=1,2,\dots,D$) are the upper and lower limits

of each dimension, and $f(x)$ is the objective function. A class is a collection of all points in the search space. Student is a point in the class, which means $x^j = (x_1^j, x_2^j, \dots, x_D^j)$, $j = 1, 2, \dots, NP$, NP is the number of students, and D is the number of students in the study subject. Teacher X is the best student in the class. The algorithm is divided into two phases. The education stage is to learn from teachers, and the learning stage is to learn from each other.

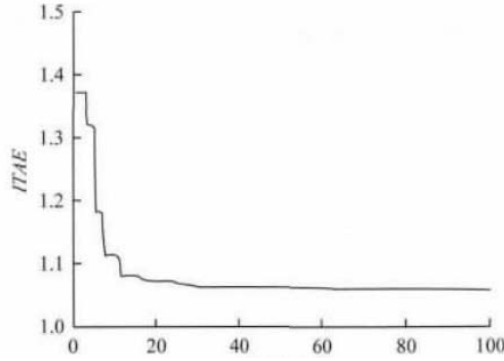


Figure 1 ITAE curve obtained by optimization algorithm

2.1. Teaching Phase

In what kind of learning process, each student learns from the teacher at the teacher stage. The learning method is to find the difference between teacher X teacher and student average. The following formula is used to implement the education process:

$$Difference = r_i \times [X_{teacher} - TF_i \times Mean] \quad (1)$$

$$X_{new}^i = X_{old}^i + Difference \quad (2)$$

X_{old}^i and X_{new}^i new represent the values before and after the i -th student respectively. Using the average = $1/np$ leadership factor $TF_i = round[1 + rand(0,1)]$ and the random coefficient $r_i = rand(0,1)$, the differences in learning effects caused by random factors in the learning process are simulated.

2.2. Learning Stage

There are two ways for students to increase their knowledge. Learn from teachers and communicate with other students (group discussion, classroom communication, etc.). Students can learn from teachers, or from students who do better than him. In the learning stage, for one student x^I , randomly select another student X_j ($j = 1, 2, \dots, NP, i \neq j$) and use the following formula to complete the learning stage according to different students:

$$X_{new}^i = X_{old}^i + r \times (X^I - X^J) \quad (3)$$

$$X_{new}^i = X_{old}^i + r_i \times (X^j - X^J) \quad (4)$$

$$r_i = rand(0,1)$$

3. PID Controller Parameter Optimization Principle

3.1. Parameter Coding

Let the number of students of class P be NP , and the learning object of each student be three control parameters KP, KI, KD of PID controller. This class is represented by a matrix P whose value range is $NP \times DP$ ($NP \times D$) = $11 \times 12 \times 13 \times 21 \times 22 \times 23$. The initial class can be randomly generated within the allowed range.

3.2. Selection of Fitness Function

In order to evaluate personal value and solutions, the algorithm in this paper uses fitness as the basis of future teachers' generation and learning, and the initial solution gradually develops into the optimal solution[5]. The matching functions commonly used in PID parameter optimization include integral square error, integral absolute value error, integral time multiplied by absolute value error,

integral time multiplied by square error, etc. In this article, the minimum objective function is used as the performance index of IEAE. That is $F = \int_0^\infty t |e(t)| dt$.

3.3. Algorithm Flow

The algorithm flow is as follows: the initial stage of class application[6]: determine the optimization problem, the initial stage of optimization application, that is, the number of students in class (NP) determines, and then, repeat (g), the number of design variables (d), the upper and lower limit of each variable (U max) application, as well as the decision of fitness function $f(x)$.

(2) initialization class matrix: class matrix P is randomly generated according to the number of students, the number of design variables and the upper and lower limits of each variable.

teaching stage: calculate the scores of each student and select the best teacher. That is, $X_{teacher} = X_{f(X)} = \min$; calculate the average value of each column of the class matrix. That is, the average value M_1, M_2, M_D ; calculate the difference and x I new of the difference according to formula and formula[7]. If x I new has better fitness value, please accept it, otherwise please reject it.

learning stage: randomly select students X and me $X^j = (x_1^j, x_2^j, \dots, x_D^j)$, $j = 1, 2, \dots, NP$, NP, and and complete the students, learn from each other, and get a new X. End condition: end when the end condition is established, otherwise repeat step[8]. The specific algorithm implementation process is shown in. It allows teaching optimization algorithms to learn.

Table 1 Performance comparison of PID parameter optimization method in second order system

Algorithm	K_p	K_I	K_D	ITAE	Iteration times
PSO	33.6917	0.1662	38.8852	1.0581	94
GA	33.7908	0.1665	38.5647	1.0584	77
Algorithm in this paper	33.0957	0.1662	38.2064	1.0580	64

4. Simulation Example

In order to verify the design method of this paper, a simulation example of PID control parameter setting of unstable control object is given. In the experiment, there were 100 middle school students and 100 repetitions. Set the range of three parameters to be optimized, K_p, K_I, K_D to $[0, 50], [0, 1], [0, 50]$. After optimization, the optimal control parameters and performance indexes of the controller are as follows $K_I = 0.1662$, $K_D = 38.5689$. the time weighted absolute error integral (itee) curve of the performance index obtained by the PID controller parameter optimization method based on the teaching and learning optimization algorithm[9]. Based on the particle controller algorithm and genetic algorithm PID controller parameter adjustment method to optimize the controlled object. The results are shown in Table 1.

5. Concluding

In industrial control, PID controller is the most widely used and mature control method. In this paper, learning parameter optimization algorithm is used to search the whole parameter in parallel. The simulation results of parameter optimization show that the algorithm is simple, the installation is simple, the parameters are small, the calculation is small, and the optimization efficiency is high, so it can be optimized. It can not only improve the performance of the control system, but also greatly reduce the design difficulty of the control system. The algorithm has been widely used and developed since the beginning, but it is the first time to apply the parameter self-tuning to PID controller. PID controller parameter optimization method based on education and learning optimization algorithm has a good application prospect and research value in the field of control engineering.

At present, there are many documents about PID controller, and the design combining intelligent

control and intelligent algorithm is very popular. In this study, in order to optimize the control parameters, fuzzy control and antenna algorithm are selected, and simulation experiments are carried out on FPGA.

When installing the fuzzy control PID, in order to construct each module, we use the graphic method to simulate each module individually and confirm the realization of each module. The graphic method, which is used to compare the fuzzy theoretical model with the program description, is simple to use, and each module seems to be helpful to understand the whole process of fuzzy control. When this design method is fuzzy, I am proficient in various steps and details of graphic design of qualities simulation software.

In order to combine the language and the graphic method to build the mathematical model, the choice is made in this design. In order to realize the conversion from integer to floating point, the floating point macro module is called to build various function graphs. Finally, the language state machine is used to perform the operation of each module.

The optimization of PID parameters, for a variety of algorithms and PID controller combination of donkey strike system, can improve through simulation, huge, and algorithm computing time and memory occupy a large amount. This is actually a hardware implementation problem. In the future research, 'PID control', which can simplify the recoding and quantization of membership required by designers, can not be obtained directly. The previous model of ant colony algorithm is based on the improvement of ant colony TSP problem. Sometimes, more parameters need to be optimized to increase the calculation of data. For future research, we can pay attention to the method of simultaneous search of multiple elements. The above operations can be performed by bit operations according to the design requirements. As a result, data processing is very demanding. The method of directly responding to PID parameters without additional processing is also the research direction.

It can be seen from table 1 that the parameters of PID controller are optimized in this paper, and the result is basically the same as that of particle swarm optimization algorithm, and the result is better than that of genetic algorithm. In the same number of repetitions, this paper can quickly find the best value and control the object. In this paper, this algorithm is better than PID parameter optimization algorithm based on particle swarm optimization and genetic algorithm.

Compared with GA algorithm, there is no need for parameter coding, decoding, selection, crossover and mutation. There are only two steps in education and learning. In addition, PSO algorithm indicates local convergence when inertia weight ω and constraint coefficient κ are small. In the upper and lower limits of students and variables, the problem of high-dimensional reuse peak optimization is easy to fall into local optimization. Global optimization of PID controller parameters and other problems. The algorithm is more simple, practical and easy to use because of its less parameters, less computation and fast convergence. This paper presents a new simple, practical and efficient parameter optimization method, which is used to adjust the parameters of PID controller in industrial control.

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