Volume 3, No. 6, Nov. 2012 (Special Issue)

ISSN No. 0976-5697

International Journal of Advanced Research in Computer Science

RESEARCH PAPER

Available Online at www.ijarcs.info

Performance Analysis of Optimization Techniques for PID Applications

Richa Sharma*
G.B.T.U, Lucknow, India
S.richa.sharma@gmail.com

Deepak Nagaria
BIET, Jhansi, India
deepaknagaria@gmail.com

Purushottam Sharma
Amity University, Noida, India
puru_mit2002@rediff.com

Abstract– This paper represents the performance analysis of different optimization techniques. A performance index based on integral of absolute error, rise time, controller output and overshoot is given as an objective function of optimization, and genetic algorithm and other optimizations techniques are applied to optimizing parameters of PID controllers.

Keywords: Genetic algorithm; PID controller; performance index; parameter optimization

I. INTRODUCTION

Optimization is the process of making something better. In engineering, optimization algorithms have been extensively developed and well used in all respects for a long time. Optimization consists in trying variations on an initial concept and using the information gained to improve on the idea. The Genetic Algorithm is stochastic search techniques based on the mechanism of natural selection and natural genetics. That is a general one, capable of being applied to an extremely wide range of problems.

Proportional-Integral-Derivative (PID) controllers are widely used in industries for process control applications, due to its remarkable effectiveness, simplicity of implementation and good performance including low percentage overshoot and small settling time for slow industrial processes. However, it is of great importance to choose the method for tuning the parameter of PID controller. Among the existing tuning methods, the Ziegler-Nichols (Z-N) formula [1] may be the most well known technique and works well in a wide range of practical processes. However, in certain cases, it can not provide good tuning and tends to produce surge and big overshoot, particularly for processes with serious non-linearity. To enhance the capabilities of traditional PID parameter tuning techniques, several intelligent approaches have been suggested to improve PID tuning, such as the neural networks [2], the genetic algorithms (GA) [3], the particle swarm optimization (PSO) methods [4]-[6]. As intelligent algorithms, genetic algorithm and particle swarm optimization have great superiority in tuning the parameters of PID controllers.

In this paper, performance of Ziegler-Nichols (Z-N) formula, genetic algorithm , particle swarm optimization (PSO) and particle filter optimization (PFO) for tuning the parameters of PID controller, are compared in order to achieve better performance in dealing with local optima meanwhile reduce the computation complexity of PID parameter tuning process.

II. PID - CONTROLLER

The function of PID controllers is based on three controlling operations; proportional, integral and differential. Proportional actuator multiplies a proportionate gain in error signal and makes the output of this controller. Integral and differential actuators integrate and differentiate on signal error, respectively and make separate for controller. A typical structure of a PID control system is illustrated in Fig. 1. The error signal e(t) is used to generate the proportional, integral, and derivative actions, with the resulting signals weighted and summed to form the control signal u(t) applied to the plant model. A mathematical description of the PID controller is

$$u(t) = K_p \left[e(t) + \frac{1}{K_i} \int_0^t e(t)dt + K_d \frac{de(t)}{dt} \right]$$

Where u(t) is the input signal to the plant model, the error signal e(t) is defined as e(t) = r(t) - y(t), and r(t) is the reference input signal. Kp, Ki, Kd are respectively the proportional, integral, derivative parameters of the PID controllers.

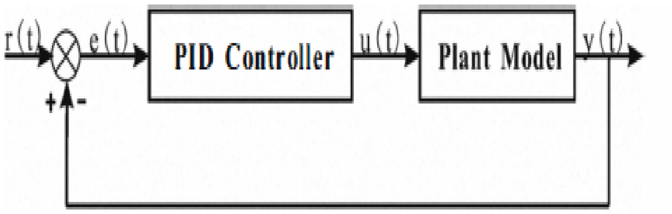

Figure 1 PID control system

Generally, a "performance index" is defined as a quantitative measure of the system performance. For a PID control system, four performance indices are widely used to depict the system performance. The PID controller is used to minimize the error signals, or we can define more rigorously, in the term of error criteria: to minimize the value of performance indices mentioned above. For the stochastic optimization algorithm, the smaller value of "performance index" indicates better fitness of a point x

© 2010, IJARCS All Rights Reserved

CONFERENCE PAPER
II International Conference on Issues & Challenges in Networking, Intelligence & Computing Technologies
Organized by Krishna Institute of Engineering and Technology (KIET) Ghaziabad, India

= { Kp, Ki, Kd} in the parameter space, and vice versa. Thus, we define the fitness function as:

$$f(x) = \frac{1}{\text{performance index}}$$

III. OPTIMIZATION TECHNIQUES

A. Genetic Algorithm (GA):

The GA, differing from conventional search techniques, start with an initial set of random solutions called population. Each individual in the population is called a chromosome, representing a solution to problem at hand. The chromosomes evolve through successive iterations, called generations. During each generation, the chromosomes are evaluated, using some measures of fitness. To create the next generation, new chromosomes, called offspring, are form by either merging two chromosomes form current generation using a crossover operator or modifying a chromosome using a mutation operator. A new generation is form by selecting, according to the fitness values, some of the parents and offspring; and rejecting others so as to keep the population size constant. Fitter chromosomes have higher probabilities of being selected .After several generations, the algorithms converge to the best chromosome, which hopefully represents the optimum or suboptimal solution to the problem.

B. The Particle Swarm Optimization (PSO):

Particle swarm optimization is similar to a genetic algorithm [7] in that the system is initialized with a population of random solutions. It is unlike a genetic algorithm, however, in that each potential solution is also assigned a randomized velocity, and the potential solutions, called particles, are then “flown” through hyperspace. Each particle keeps track of its coordinates in hyperspace which are associated with the best solution (fitness) it has achieved so far. (The value of that fitness is also stored.) This value is called *pbest*. Another “best” value is also tracked. The “global” version of the particle swarm optimizer keeps track of the overall best value, and its location, obtained thus far by any particle in the population; this is called *gbest*.

The particle swarm optimization [9] concept consists of, at each time step, changing the velocity (accelerating) each particle toward its *pbest* and *gbest* (global version).Acceleration is weighted by a random term, with separate random numbers being generated for acceleration toward *pbest* and *gbest*.

C. Particle Filter Optimization (PFO):

The PFO method is first presented in [8], as a generalized tool for optimization problems. The process of PFO can be described as an integration between the swarm move strategy and particle filter algorithm. Therefore, to understand PFO clearly, two methods have to be first introduced, namely particle swarm optimization (PSO) and particle filter methods. The basic idea of PFO is that the swarm move strategy is incorporated into a particle filter optimization algorithm. Specifically, in a generalized PFO [10] method, the update equation of particle swarm move in PSO algorithm is treated as the system dynamic of a state space model, while the objective function in optimization problem is designed as the observation model to motivate the swarm moving toward the optimal position.

IV. PERFORMANCE ANALYSIS

Here, we provide the complexity results in terms of the total number of functional calculations, for PFO, GA and PSO. The complexity comparison is described as follows:

a. Genetic Algorithm (GA) Number of particles is 100. Number of iterations is 500. Therefore, the total number of functional calculations is 100 x 500 = 50, 000.
b. Particle Swarm Optimization (PSO) Number of particles is 100. Number of iterations is 200. Therefore, the total number of functional calculations is 100 x 200 = 20, 000.
c. Particle Filter Optimization (PFO) Number of particles is 50. Number of iterations is 100. Therefore, the total number of functional calculations is 50 x 100 = 5, 000.
d. From above complexity comparison, we can observe that

PFO require significantly lower computation complexity than that for GA and PSO, meanwhile achieve better performance.

V. CONCLUSION

In this paper, we have given an idea of different optimization techniques which are used for tuning PID controller parameters. From the comparison study with Z-N, GA, PSO, we can also conclude that the PFO method can make the convergence speed for PID parameters optimization problems faster with good global searching ability.

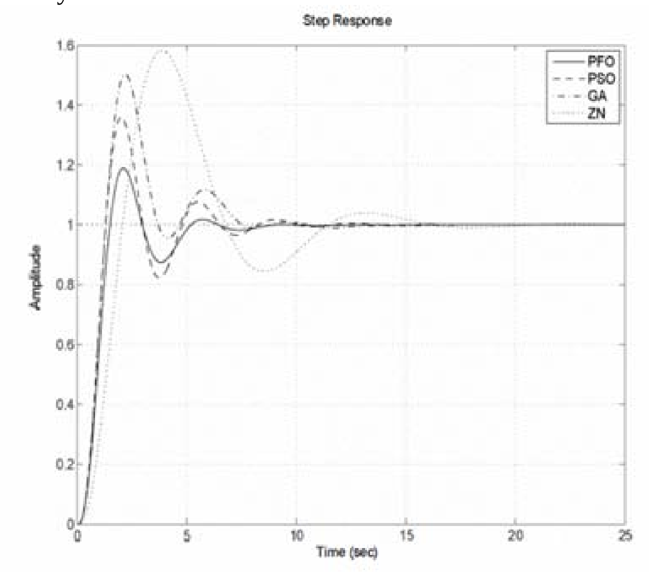

Figure. 1. Step response for different optimization techniques

VI. REFERENCES

[1] G. Ziegler and N. B. Nichols, "Optimum setting for automatic controllers," Trans. ASME 64, pp. 759-768, 1942.

[2] Ching-Hung Lee, Yi-Hsiung Lee and Ching-Cheng Teng, "A novel robust PID controllers design by fuzzy neural network," American Control Conference, pp. 1561-1566, 2002.

[3] Yunan Hu and Bin Qu, "Application of Iterative Learning Genetic Algorithms for PID Parameters Auto-Optimization

© 2010, IJARCS All Rights Reserved

CONFERENCE PAPER
II International Conference on Issues & Challenges in Networking, Intelligence & Computing Technologies
Organized by Krishna Institute of Engineering and Technology (KIET) Ghaziabad, India

of Missile controller", Intelligent Control and Automation, WCICA, pp. 3435-3439, 2006.

[4] P. B. de Moura Oliveira, 1. Boaventura Cunha, and 1. Paulo Coelho, "Design of PID Controllers using the Particle Swarm Algorithm," The lASTED Conference on Modelling, Identification, and Control , pp. 350-359, 2002.

[5] Yijian Liu, Jianming Zhang, Shuqing Wang, "Optimisation design based on PSO algorithm for PID controller," Intelligent Control and Automation, WCICA. pp. 2419-2422, 2004.

[6] Maolong Xi, Jun Sun and Wenbo Xu, "Parameter Optimization of PID Controller Based on Quantum-behaved Particle Swarm Optimization Algorithm," Complex System and Applications-Modelling, Control and SImulations, DCDIS Series B, Vol. 14, pp. 603-607, 2007.

[7] L. Davis, Ed., Handbook of Genetic Algorithms. Van Nostrand Reinhold, New York, NY, 1991.

[8] C. Ji, Y. Zhang, M. Tong, and S. Yang, "Particle filter with swarm move for optimization," Proceedings of the 10th International Conferenceon Parallel Problem Solving from Nature, LNCS 5199, pp. 909-918, 2008

[9] Russell Eberhart, James Kennedy, “A new optimizer using particle swarm theory”, Sixth International Symposium on micro Machine and Human Science, 1995.

[10] Jie Li, Tianyou Chai, Lisheng Fan, Li Pan , Jingkuan Gong, “PID controller tuning using particle filtering optimization”, IEEE 2010.

© 2010, IJARCS All Rights Reserved