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GA BASED PARAMETER OPTIMIZATION OF FUZZY-PID CONTROLLER

Pankaj Kumar Gautam,Madhur Sharma,Ankit kumar
Department of Electrical & Electronics Engg.
Rajshree Institute of Management & Technology, Bareilly.

Abstract— **In this paper optimization is done for various parameters of fuzzified PID Controller and has been compared with conventional PID controller parameters. The genetic algorithm is used to optimize the parameters of fuzzy PID controller over a scaling factor, which is helpful to improve the further performance of steady-state and transient responses. The comparison is done for the simulated fuzzy PID controller over a Genetic algorithm optimized fuzzy PID controller with ITAE which shows the better response compared to all of the above**.

***Index Terms*— fuzzy logic, genetic algorithm, PID controller, scaling factor, optimization.**

1. Introduction

Traditionally, the optimization of PID controller was manually adjusted by the trial-and error approach so that the procedure consumes much time and manpower. The methods of tuning PID parameters have the traditional PID and intelligent PID adjustments. The traditional PID proposed Ziegler and Nichol in 1942 suggests the adjustment formula based on the observation of the sensitivity, amplitude, and natural frequency of systems. However, the tuning algorithm is comparatively complicated and difficult to make the response optimized with the worse vibration and overshoot.

The PID controller with simple structure and stable characteristic has been usually utilized in the industrial circle. The performance of PID controller is related to the setting of parameters, i.e., the proportion (P) plus the integration (I) plus the derivation (D). However, the three parameters are mutual with each other such as the improvement in transient response with the PD controller in some cases yields deterioration in the improvement of the steady-state error with the PI controller, and vice versa. Thus, the over-design of controller system with respect to steady-state errors or transient response will affect more cost or produce other design problems.

fuzzy PID controllers is composed of the conventional PID control system in conjunction with a set of fuzzy rules (knowledge base) and a fuzzy reasoning mechanism[1]. The PID gains are tuned on-line in terms of the knowledge base and fuzzy inference, and then the PID controller generates the control signal. By virtue of the gain scheduling property, this type of fuzzy PID controllers can adapt themselves to varying environments. The main difficulty in using this category of fuzzy PID controllers is that the analysis task is relatively tough, as it is hard to acquire the equivalent nonlinearity of the fuzzy knowledge base. Besides, associating three PID gains adaptively with the system responses requires ad hoc expertise which may not be so straightforward for a user or designer to extract.

Later on, a lot of researches were devoted to the intelligent PID controllers such as the fuzzy algorithm, but the fuzzy rules still need to be optimized. Thus, the biological optimization algorithms such as the evolutionary computing, swarm intelligence, and so on, were introduced to improve the optimization of PID parameters. Regarding to the evolutionary computing, the genetic algorithms (GA) recommended by Lin, Jan and Shieh [2] were implemented to adjust the PID parameters by Oscar Montiel [3]. In addition, the first genetic algorithm (GA) was developed by Holland in 1975. Many studies have extended the application of GA's in searching, optimizing, and machine learning [4].

In this paper, genetic algorithm is used for the searching of optimization of fuzzified PID controller. In addition, the search optimization algorithm is applied to a third order system. According to the experimental results, the genetic algorithm has better efforts to approach the ISE, ITAE, and IAE performance indices. Thus, the GA-FPID algorithm is recommended to implement for parameter optimization.

2. System Modeling and Design

Fuzzified PID controller structure: The block diagram of fuzzy PID controller is shown in Fig.2. Referring to Fig.2, we confine to the following notation, e denotes the error between reference and response (output of the system under control), ΔE is the first-order difference of error signal. Note that the input variables to the fuzzy controller are transformed by the scaling factors whose role is to allow the fuzzy controller to "see" the external world to be controlled [5].

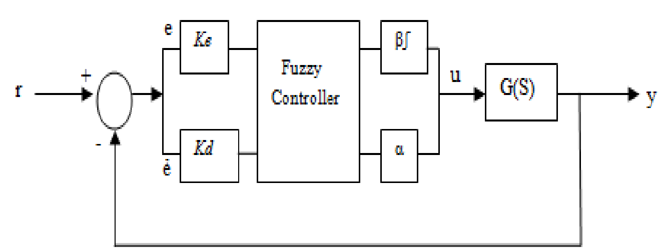

Fig.1. The PID type fuzzy control system

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The above fuzzy PID controller [6] consists of rules of the form: if error is E and change in error *is* ΔE then output gain is ΔU and their membership functions are:

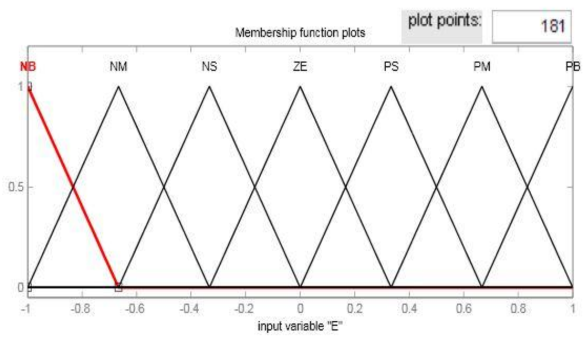

Fig.2: - membership functions

where, NB: negative big, NM: negative medium, NS: negative small, ZO: zero, PS: positive small, PM: positive medium , and, PB: positive big. N: negative, Z: zero, and P: positive. Triangular membership functions are used defined in the input and output spaces. Here these spaces are normalized to the [-1,1] interval as shown in fig.4.

	ΔE							
E		NB	NM	NS	ZE	PS	PM	PB
	NB	NB	NB	NB	NB	NM	NS	ZE
	NM	NB	NB	NB	NM	NS	ZE	PS
	NS	NB	NB	NM	NS	ZE	PS	PM
	ZE	NB	NM	NS	ZE	PS	PM	PB
	PS	NM	NS	ZE	PS	PM	PB	PB
	PM	NS	ZE	PS	PM	PB	PB	PB
	PB	ZE	PS	PM	PB	PB	PB	PB

Table1:- Rule Base for the controller

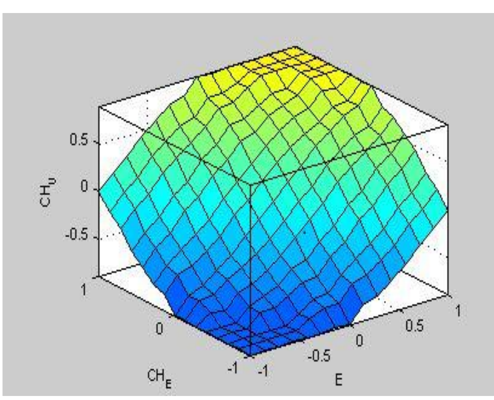

Fig.3: - Surface of FPID controller

3. Genetic Algorithm

GA's are search algorithms modeled after the mechanics of natural genetics. They are useful approaches to problems requiring effective and efficient searching, and their use is widespread in applications to business, scientific, and engineering fields. In an optimally designed application, GA's can be used to obtain an approximate solution for single variable or multivariable optimal problems. Before a GA is applied, the optimization problem should be converted to a suitably described function. The corresponding function is called "fitness function." It represents a performance of the problem. The higher the fitness value, the better the system's performance. The objective of a GA is to imitate the genetic operation process, e.g., reproduction, crossover, or mutation, to obtain a solution corresponding to the fitness value. Recently, many GA's have been presented. The basic construction of a GA can be simply described as follows.

a) *Define the String of a Chromosome:* The string of searching parameters for the optimization problem should be defined first. These parameters are genes in a chromosome, which can be binary coded or real coded and termed "chromosome." Different chromosomes represent different possible solutions.

b) *Define the Fitness Function:* The fitness function is the performance index of a GA to resolve the viability of each chromosome. The design of the fitness function is according to the performance requirements of the problem, e.g., convergence value, error, rise time, etc.

c) *Generate an Initial Population:* sets of chromosomes should be randomly generated before using a GA operation. These chromosomes are called the initial population. The size of the population, is chosen according to the sophistication of the optimization problem. Generally speaking, the larger values of require fewer generations to come to a convergent solution. However, the total computation effect depends on times the generation numbers.

d) *Generate the Next Generation or Stop:* GA's use the operations of reproduction, crossover, and mutation to generate the next generation. From generation to generation, the maximum value of the fitness value is achieved for each generation.

a) *Reproduction:* Reproduction is the operator carrying old strings through into a new population, depending on the fitness value. Strings with high fitness values obtain a larger number of copies in the next generation.

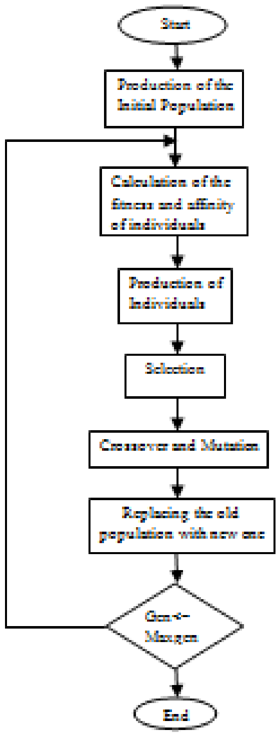

Fig.4:- Flowchart of GA.

4. Simulation Results:-

The proposed control scheme can be applied to a variety of control problems. In this section, we test the effectiveness of the fuzzy PID controller [7] by applying it to the system given by:

$$G(s) = \frac{1}{s^3+3s^2+3s+1}$$

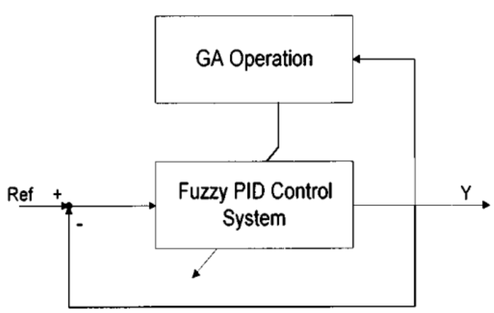

Fig.5: - GA operation on FPID controller

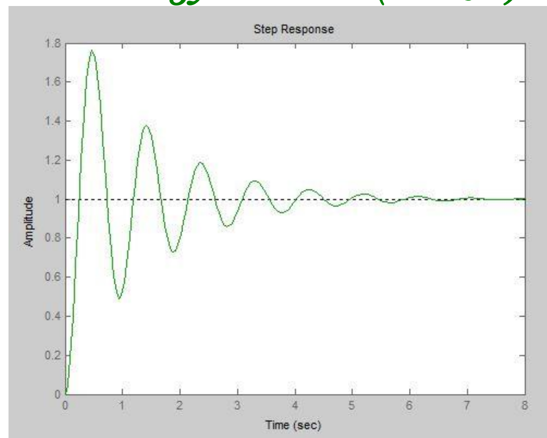

Fig.6:- Response of the system without GA

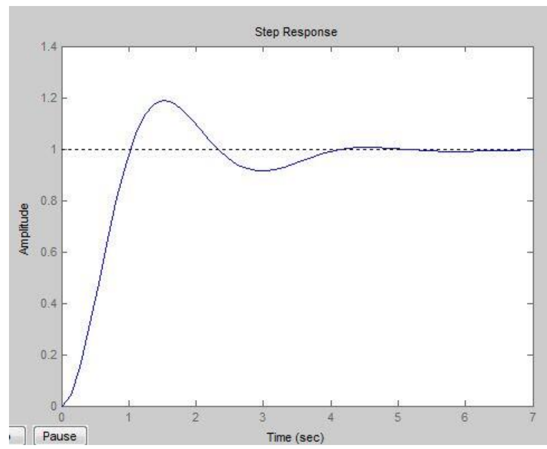

Fig.7:- Response of the system with GA

Experimental Results

The best optimum values of parameters are:

response & PID values	ITAE
fitness function	1.323
sttling time (sec)	4.4
rising time (sec)	0.33
% overshoot	1.21
kp	72.6873
ki	98.8572
kd	46.3014

5. Conclusion

In this paper we have applied genetic algorithm for optimization process of fuzzy PID controller to get best optimum results. GA has been used for developing an optimal Fuzzy controller. The simulation result shows that the proposed method is effective and efficient. This technique can save time when compared to a conventional trial-and-error design procedure. The optimal fuzzy controller through a systematic search requires only a few fuzzy variables. It does not require extra professional expertise or mathematical analysis for the plant's model.

References:-

[1] W. Gharieb", Member IEEE , G. Nagib, "Fuzzy Intervention in PID Controller Design", ISIE 2001, Pusan, Korea.

[2] C.-L. Lin, H.-Y. Jan, and N.-C. Shieh, "GA-Based Multiobjective PID Control for a Linear Brushless DC Motor", *IEEUASME Trans. Mechatronics*, vol. 8, No. 1, pp. 56-65,2003,

[3] Oscar Montiel , Roberto Sepulveda , Patricia Melin , Oscar Castillo ,Miguel Angel Porta, Iliana Marlen Meza, "Performance of a Simple Tuned Fuzzy Controller and a PID Controller on a DC Motor" *Proceedings of the 2007 IEEE Symposium on Foundations of Computational Intelligence* (FOCI 2007), pp531-537.

[4] J. Zhong, X. Hu, M.Gu and J. Zhang, "Comparison of performance between different selection strategies on simple genetic algorithms", *International Conference on Computational Intelligence for Modelling, Control and Automation, and International Conference on Intelligent Agents, Web Technologies and Inetrnet Commerce, Vienna*, pp.1115-1121, 2005.

[5] Yi-Sheng Zhou and Lin-Ying Lai, "optimal design for fuzzy controllers", IEEE Transactions on industry applications,
Vol. 36, No. 1, 2000.

[6] Shih-Feng Chen, "Partical swarm optimization for PID controllers with robust testing", *Proceedings of the Sixth International Conference on Machine Learning and Cybernetics, Hong Kong*, 19-22 August 2007.

[7] Gwo-Ruey Yu and Rey-Chue Hwang "Optimal PID Speed Control of Brushless DC Motors using LQR Approach" 2004 *IEEE International Conference on Systems, Man and Cybernetics*, pp 473-478.