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Comparison of Speed Control of DC Motor Using Fuzzy-PID and PSO-PID Technique

Akansha Kaushal[1], Nirbhay Thakur[2] and Deepak Nagaria[3]

M.Tech, Electrical Engineering, N.I.T.M College. Gwalior (M.P), INDIA.
M.Tech, Electrical Engineering, N.I.T.M College. Gwalior (M.P), INDIA.
Reader and Head Electrical Engineering B.I.E.T Jhansi (U.P).

ABSTRACT

This paper shows the comparison of fuzzy logic controller and particle swarm optimization technique in controlling the speed of DC motor. The application of particle swarm optimization for adjusting the gains of proportional-integral-derivative (PID) controller parameters of a DC motor is presented and Fuzzy logic controllers are the successful applications of fuzzy set theory, its major features are the use of linguistic variables, defined as variable whose values are sentences in natural language may be represented by fuzzy sets. This paper demonstrated in detail how to employ the PSO and fuzzy method to search efficiently the optimal PID controller parameters of DC motor. The proposed approach had superior features, including easy implementation and good computational efficiency. Fast tuning of optimum PID controller parameters yields high-quality solution

INDEX TERMS - DC Motor, PID Controller, Particle Swarm Optimization, Fuzzy Logic Controller.

INTRODUCTION

DC motors have long been the primary means of electrical traction. Direct current (DC) motors have been widely used in many industrial applications such as electric vehicles, electric cranes and steel rolling mills due to precise, wide, simple and continuous control characteristics. The development of high performance motor drives is very important in industrial as well as in other application [1]. The advantage of using controller is its simplicity to implement. It is not easy to find another controller with such a simple structure to be comparable in performance. A very important step in the use of controllers is the controller parameters and tuning process [2].

Fuzzy rule-based models are easy to comprehend because it uses linguistic terms and the structure of if-then rules [3].

In this paper, an optimal PID controller solution is defined for DC motor drive systems using Particle Swarm Optimization Technique (PSO) and by Fuzzy PID technique. There is no constraint in the searching space of the optimal PID parameters. The PID tuning algorithm is applied to the speed control of DC motors [2].

FUZZY LOGIC CONTROLLER

Fuzzy logic controllers have the following advantages over the conventional controllers that they are cheaper to develop, they cover a wide range of operating conditions, and they are more readily customizable in natural language terms.

In Mamdani type FIS the crisp result is obtained by defuzzification, in the Mamdani FIS can be used for both multiple input and single output and multiple inputs multiple outputs system [6].

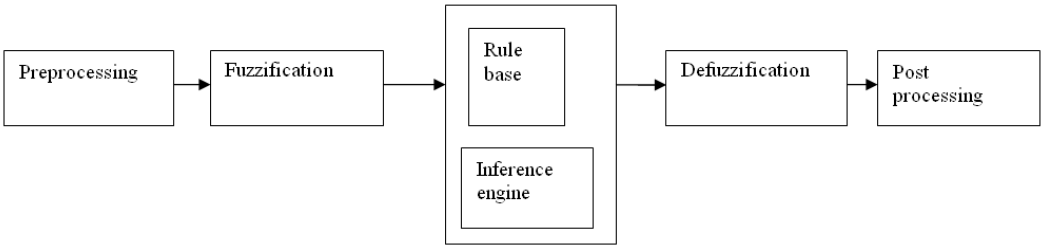


Figure1: Arrangement of fuzzy logic controller [1]

PID CONTROLLER

PID controllers are composed of three basic control modes i.e proportional mode integral mode and derivative mode. They are simple to implement and provide good performance. A PID controller does not "know" the correct output to bring the system to the set point. It moves the output in the direction which should move the process toward the set point and needs to have feedback to perform [2].

The PID controller has the following form in the time domain:

$$u(t) = k_p e(t) + k_i \int_0^t e(t)\,dt + k_d \frac{de(t)}{dt} \quad (1)$$

Table1: Basic Control Actions [2]

Proportional control	$u(t) = k_p$e(t)
Integral control	$u(t) = k_i \int_0^t e(t)dt$
Derivative control	$u(t) = k_d \frac{de(t)}{dt}$

PARTICLE SWARM OPTIMIZATION

Particle Swarm Optimization is a technique used to explore the search space of a given problem to find the settings or parameters required to optimize a particular objective [4]. PSO has two main concepts: the first is through the observation of human decision making, it was proposed that humans use both their own best experience and others' best experience to form a basis of making a decision, to develop the concepts of individual learning and cultural transmission. The second is to propose a simple theory to explain group behavior in nature, and to modularize the theory to create systems to simulate things. The biggest characteristic of PSO is in its simple structure, fast convergence, and its ability to prevent falling into a local optimum solution. At the same time, PSO is a random algorithm with a parallel structure. Firstly, a uniform distribution is used to randomly create a particle swarm. Each particle represents a feasible solution to the problem, the particle swarm refers to the individual's best experience, and the group's best experience, and logically chooses the method it will move itself. After continuous iterations, the particle swarm will gravitate towards the optimum solution [5].

The 4 parts of PSO are shown below:

$v_i^{k+1} = wv_i^k + c_1$* Rand()*$(Pbest_k^i - s_i^k) + c_2$*
Rand()*$(Gbest^k - s_i^k)$ (2)

Where

c_1 = learning factor of PSO

c_2 = learning factor of PSO

Rand = Random number between 0 and 1.

$Pbest_i^k$ = individual best optima for particle i after k iterations

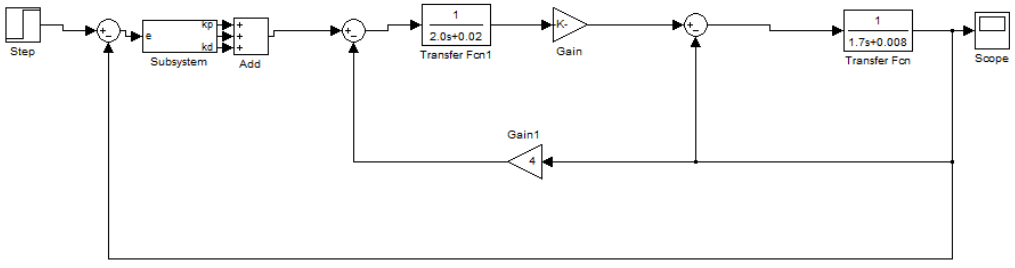
$Gbest^k$ = group optima after k iterations.

W = weighting.

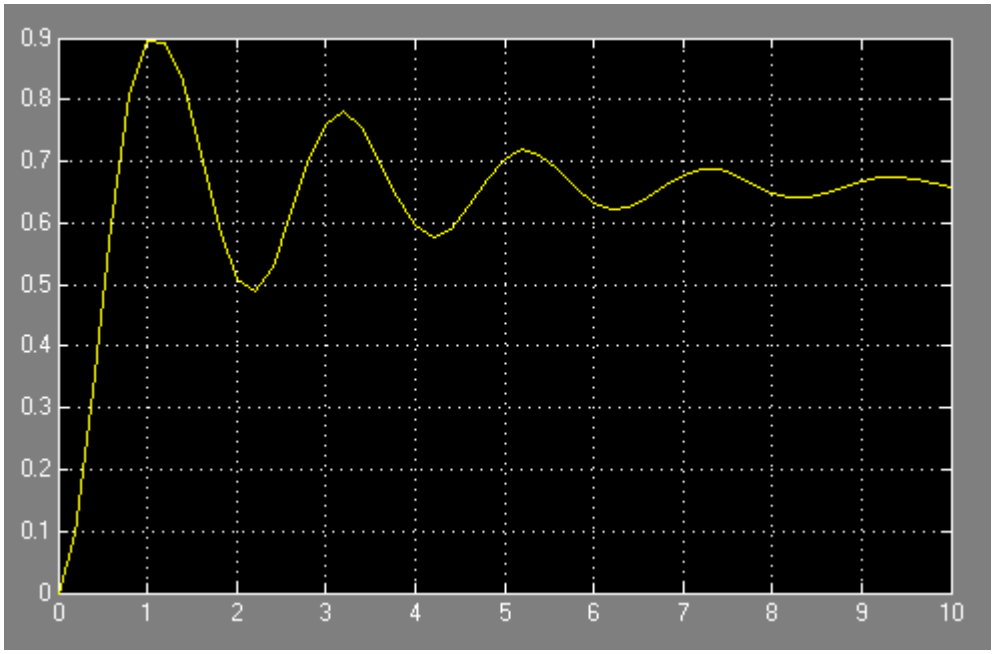
v_i^{k+1} = velocity of particle i in iterative k+1

s_i^k = position of particle i in iterative k.

4.1 *Implementation of Fuzzy-PID and PSO-PID Controller*



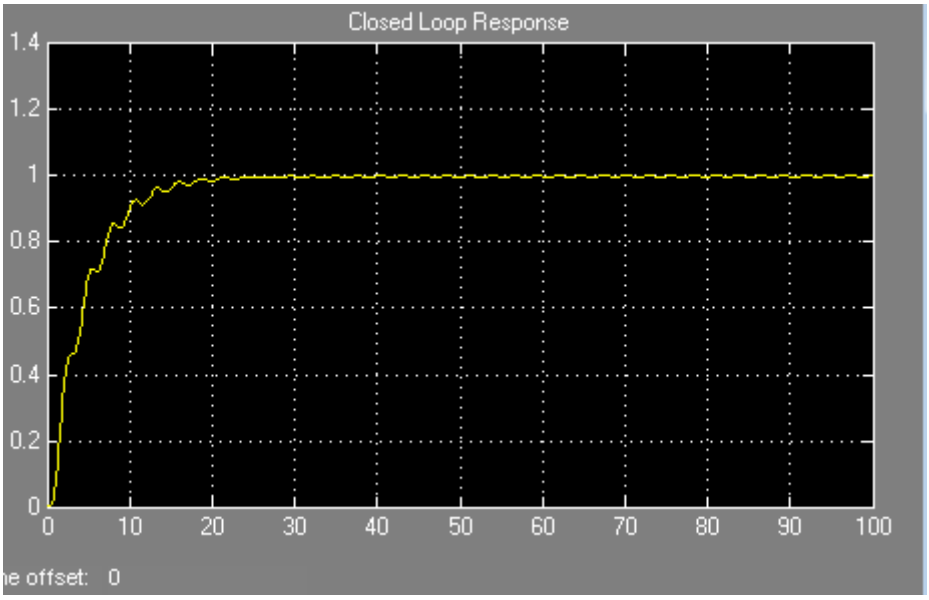
4.1.1 Result of Fuzzy- PID Controller.



4.2 Implementation of PSO-PID Controller

In this paper, a PID controller using the PSO algorithm is developed to improve the results of speed control of DC motor. The PSO algorithm is mainly utilized to determine three optimal controller parameters *kp*, *ki*, and *kd*, such that the controlled system could obtain a desired step response output [4].

4.2.1 Result of PSO-PID Controller



5.CONCLUSION

This paper shows two different methods of determining the PID controller parameters using PSO algorithm and Fuzzy Controller. While comparing with both the results the PSO-PID shows better output as compared to Fuzzy-PID.

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