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Improve performance of fast steady state response for DC servo motor by fuzzy logic implementation

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Abstract:- The DC Servo Motors has top position in various servomechanisms. It is important to study DC Servo motor along with its position control study. Generally transient responses of DC Servo Motor are improved by using PID controller. Currently, to provide workable initial value most tuning methods have been designed. The workable initial value further manually corrected for special requirement. The work presents fast tuning and flexible method which is based on Fuzzy logic. The GA (genetic algorithm) is used to determine some optimal parameter of PID controller. In this paper simulation results shows Fuzzy logic satisfied with wide range of requirement with compared to the tuning method. Fuzzy logic gives the actual response with respect to required response .

General Terms
Fuzzy logic, Genetic algorithm

Keyword
Dc Servo Motor, Fuzzy Logic, Genetic Algorithm.

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1. INTRODUCTION

Servomotors are kind of rotary actuators that can have a precise control of velocity, acceleration and angular position. It comprises of a suitable motor and a sensor who both coupled to sense the position feedback. In most of the cases sophisticated controller is also used which is a dedicated module specifically designed for servo motors. Servomotors term is mostly used for a motor dedicated for usage in closed loop system as they don't fall in specific class of motors [1]. Servomotors applications include process/industrial control, robots, CNC etc.

Servomotors are a close loop servomechanism which utilizes position feedback to control the motion and final position. It has an input of analogue or a digital signal according to which the commanding output is given to motor shaft.

Stepper continuously consumes power to reach the commanded position and then to hold that position. Whereas, a servomotor consumes power for reaching the commanded position but after it they rests.

Servomotors are regarded as high performance substitute of stepper motor. The stepper motor has built-in output steps, which makes it intrinsic ability to control position. Therefore, they are often used as an open-loop control without having a feedback encoder, because the drive signals given to it defines the number of steps for movement to rotate, but this requires the stepper motor on power up to make the controller 'know' the position. Hence, the stepper motor will be activated by the controller, on first power up, the end limit switch is activated. When the inkjet printer is switch on, it can be observed that the controller will move ink jet carrier to extreme left and right for establishing the end positions. Now in case of servomotor, it will immediately turn to the angle instructed by the controller, irrespective of the initial position at power up.

Encoders were made along with the first servomotors. During World War II, intensive work was done on these systems in development of anti-aircraft artillery and radar.

In servomotor any type of motor may be used. Permanent magnet DC motors with brushes are the simplest to be used as they are simple and cheap. Servomotors used in small industry are typically electronically commutated motors without brushes [1]. AC induction motors are used in large industrial servomotors, often allowing control of their speed with the help of variable frequency drives. Brushless AC motors having permanent magnetic field are used as a compact package for ultimate performance and large versions having DC motors.

Motor is a device which converts electrical energy into mechanical energy. Motor can be divided into two categories:

1. Alternating current (AC) motor
2. Direct current (DC) motor

Voltage supplied is responsible for speed of the dc motor. Voltage is decreased, the speed is reduced and when the voltage is allowed to increase the speed of the motor rises.

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In case of the constant voltage supplies or batteries this speed control is achieved by making use of the speed controllers. The speed controllers function by allowing variable voltage to the motors and thus controlling their speeds. The speed controllers have very quick response and they can switch the voltage supply ON-OFF very fast therefore making an average voltage supplied to motor as mandatory [2]. This process is known to be pulse width modulation. There are many forms of the speed controllers are available now-a-days and each having their own pros and cons. Speed controllers used in this project are as follows

a) Pole placement controller.
b) PID controller.
c) Fuzzy logic controllers22

2. PROBLEM STATEMNT

GA based PID controller has slower steady state response along less undershoot / overshoot during transition phase.

When the PID tuning was carried out based on the genetic algorithm, the results obtained were far better than those obtained from the conventional ways of tuning. PID tuning values that can be obtained by making use of the conventional ways and methods provides good starting values but these values needed to be improved. Gain of the PID controller is fully related to the initial population of the range thus selected [3]. The response was found to be quite satisfying and was around the required when the well-designed GA tuned PID controller was put into action. Tuning was observed to be well-versed and effective when, K_I in the range of 0.001 to 0.55, while KP was between 10 to 30 and KD was within 0.001-0.5. If the initial population is increased, generations required for converging to some optimum value may be increased but the added advantage will be the broader range of requirements may be dealt with.

Mathematical relationship between the input voltage and angular position the shaft of the DC motor may be derived using the laws of physics. DC Servo motor in case of point of control system, can be assumed to be SISO plant [5]. Thus all the complications and impediment which have anything to do with multi-input system are just eradicated. Field coils in DC servo motors are exactly parallel with the armature. Armature current and field coil current are not dependent on each other.

$$E_a(s) = R_a I_a(s) + L_a s I_a(s) + E_b(s)$$

$$T_m(s) = K_t I_a(s)$$

$$E_b(s) = K_b s\theta(s)$$

$$T_m(s) = (J_m s^2 + D_m s)\theta(s)$$

2
3

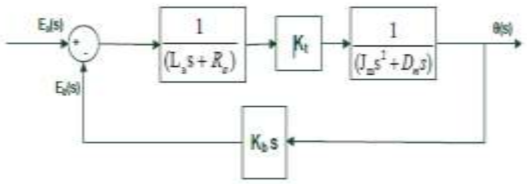

Fig 1:-Schematic Diagram of a DC Servo motor

3. GENATIC ALGORITHM

The primary goal of the Genetic algorithm (GA) is to find the most suitable and optimized solution of the problem. The genetic algorithm as in is based upon an assortment of solutions possible for the presented problem. And As this term Genetic is taken from biological sciences, another term is taken from its reference and its "population". The assortment of the other alternative possible solutions to the chosen problem is known to be "population". Any on solution of this assortment, or individual of population is called chromosome. And the individual singular character in this chromosome is called genes. To reach more precise possible solution than the one obtained earlier, a new iteration is to be carried out and the evolution of the new generation in each of the next iteration of GA takes place. [4].

Fraction of the individuals present in the population which are to be substituted in one generation to the next and so on is known to be generation gap. Upon this basis, the GA approach has been further classified into two categories.

1. Conventional GA
2. Steady State Algorithm GA

4. GENATIC ALGORITHM TUNED BY PID

The main objective of genetic algorithm is to find out the optimal values of PID controller to optimize the system transient response. For this purpose genetic algorithm considers the objective function maximization.

The objective function delivers a means for calculating the performance of the PID controller according to the determined gain parameters, which allows any expert to design the optimized PID controller. Genes are the gain parameters of the controller K_P, K_I, and $K_D$when they are applied to the PID controller. Every chromosome is composed of all the needed genes to complete the trial solution. Fitness of each chromosome is determined using error principle, which then decides the selection of chromosome for succeeding generation [5].

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For every generation, fitness function is used for the population evaluation. Fitness function can be taken as the inverse of error function. Error is evaluated by comparison of actual and required location of closed loop pole.
It can be written as

ETs =error in settling time
ETd=error in peak time,
Eon and Eof = errors in the location of real poles.

In this, variables α, β γ, δ and λ represents the weight age factors. Adjustment of these variables, in PID controller parameters can give us the required value of closed loop response. After evaluating fitness, the fittest of the solutions are selected which undergo the crossover process for getting offspring.
Modification of any random value can be done to get mutation. This induces a minor change in solution. Using these imitation methods, for reproduction, the entire population is replaced by the offspring, best solution and good solution neighbors. Keep on continue the process of calculation, reproduction, for a number of generations until better solution is obtained.

The summary is as follows,

Begin the population; while preset termination condition not fulfilled;

- Determine all these solutions with help of fitness function. It can be the inverse of error function.
- Highly fit solutions should be selected.
- Combine them as parents and execute crossover operation to produce offspring.
- Execute mutation by marginally changing some arbitrary solution.
- Produce some solutions in the surroundings of good solutions by taking their average.
- Save best solution.
- Replace all population with offspring, best solution and good solution neighbors.

5. PROPOSED METHODOLOGY

Fuzzy logic is using for improve the performance of the required response from the actual response. By implement fuzzy logic rule we have been achieved the required response near about to actual response.

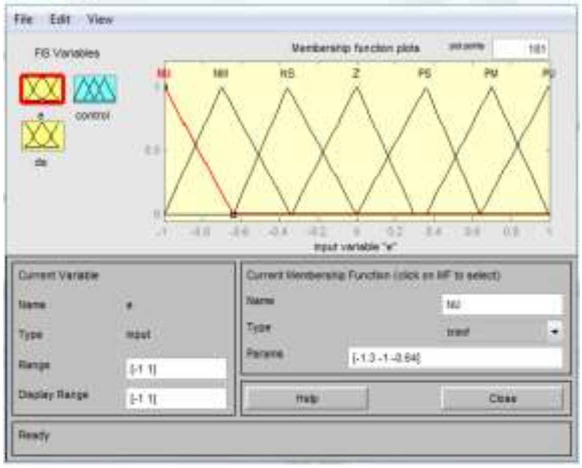

Fig 2:- First input fuzzy rule

According to Figure 2 input e is a range of -1 to 1. It is showing the limit of first input in fuzzy rule file.

According to figure 3, second input range is -1 to 1.

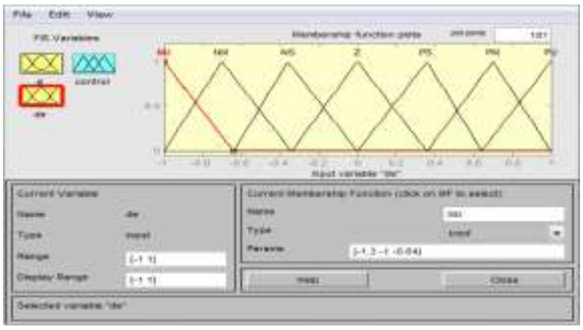

Fig 3: - Fuzzy rule file for second input

Fuzzy logic rules give the better actual response with comparison of required response for the DC motor.

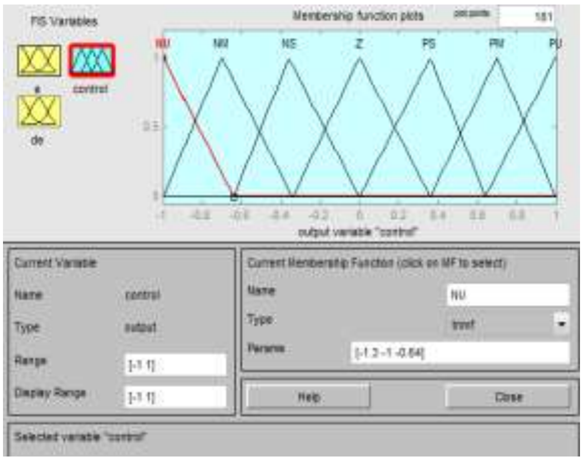

Figure 4:- Output fuzzy logic rules waveform

According to figure 4 output rules are shown. The range is from -1 to 1 .The values of NU, NM, NS,Z, PS, PM, PU are given according to image number 4 .

	NU	NM	NS	Z	PS	PM	PU
NU	NU	NU	NU	NM	NM	NS	Z
NM	NU	NU	NM	NM	NS	Z	PS
NS	NU	NM	NM	NS	Z	PS	PS
Z	NM	NS	NS	Z	PS	PS	PM
PS	NS	NS	Z	PS	PS	PM	PU
PM	NS	Z	PS	PM	PM	PU	PU
PU	Z	PS	PM	PM	PU	PU	PU

Table 1:- Fuzzy Logic rules for the design

6. RESULTS

Figure 5 is showing the comparison of actual response with respect to required respoce.According the grahs it is showing that our required response is touching to actula response . that means it is better then the PID controller .

Fig 5:- comparison of actual response and required response

Figure 6 is showing the required response for the DC servo motor .

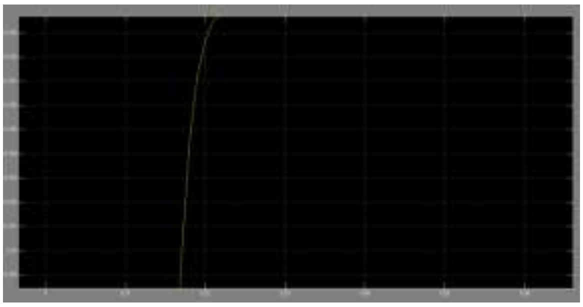

Figure 6:- DC servo motor desired response

Figure 7 is showing the actual response after apply the fuzzy logic rules.

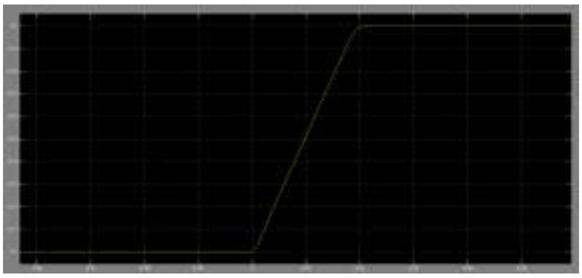

Figure 7 :- Actual response for DC servo motor

7:- CONCLUSION

Fuzzy logic is improving the results of actual response to required response .In the previous work required response is not touching the graph of actual response. Actual response graph overshoot goes up to 2.00 and desired response is going to 2.004.

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