Investigation and Implementation of Genetic Algorithm for Speed Control of DC Motor Based on PID Controller

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Abstract: In this study, a singular tuning technique for the parameters of PID controller based pace manipulates of DC motor using Genetic Algorithm (GA) is proposed. The principle advantage of the proposed approach is that the mathematical version of the machine beneath manipulate isn't always required, so it's miles useful in lots of industrial methods that haven't any obvious or complex model. This approach permits determining the great values of PID parameters for a unique overshoot, upward thrust time and settling time, The DC motor with the designed PID controller is modeled and the simulation outcomes are acquired. The received consequences are in comparison with those of conventional Ziegler Nichols (ZN), GA based integral Absolute of the Error (IAE) index and GA based Means of the Squared Error (MSE) index strategies. The assessment indicates effectiveness of the proposed tuning approach as it offers a higher performance and satisfies the required control traits.

Key words: DC motor, PID, genetic algorithm, propose objective function, MSE, IAE

INTRODUCTION

The DC motor is a movement energizing, which modification over into electrical power to turning oversee. The DC motor are regularly reasonable as a major aspect of industry and designing, for occasion, electric fueled trains, metallic moving vegetation, circle power, robotized controller and in various oversee programming on this way, its oversee is basic for manage of DC motor, ordinary controller, for instance, PI and PID controller have been for the greatest segment connected as a piece of writing. The Dc motor have for quite a while been the fundamental methodology for electric balance DC development is exact as a SISO (single-enter single-yield) device having torques/pace characteristics perfect with most extreme mechanical weights. The velocity oversee systems for a DC motor aren't as huge amounts of troublesome and bounty less remarkable than those of AC autos and rate can be without an issue cleaned. Starting late, brush less dc motor, deception motor and synchronous vehicles have duplicated enormous use in electric equalization. in this way the rate control of dc motor has pulled in top notch exam and a few procedures have ventured forward. Relative, central, assistant PID controllers were completely utilized for velocity (speed) control and change control of the DC motor device. Goal of this study

to plot a control machine making utilization of hereditary calculation with in perspective of non linearity viable of mechanical assembly. Genetic arrangement of tenets. Then again fast GA is a stochastic figuring in perspective of guidelines of capacity devotion and innate. Hereditary calculation (GA) are a stochastic overall request approach that imitates the strategy of trademark improvement. In this study using Genetic Algorithms (gasoline) to accomplish the tuning procedure of the controller will the result in best controller being surveyed for the relationship without be unsuccessful. Tuning of PID controller parameters is to choose the parameters that satisfy the required traits of the controlled framework. Among the customary tuning methods, the Ziegler-Nichols (ZN) methodology is the most extreme truely comprehended methodology (Ziegler and Nichols, 1942; Meshram and Kanojiya, 2012). It is solid contrary to the gadget form insecurity and valuable for a couple of mechanical bundles. Be that as it can, it doesn't supply a phenomenal tuning, since it guarantees an intemperate overshoot in the machine response (Meshram and Kanojiya, 2012). To embellish the execution of the ordinary tuning procedures, exceptional vigilant systems have been included (Kim et al., 2008). Variable of this study, an as of late tuning technique for PID controller parameters in gentle of speed control of DC motor utilizing

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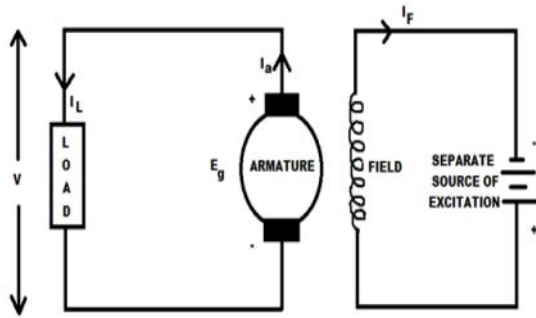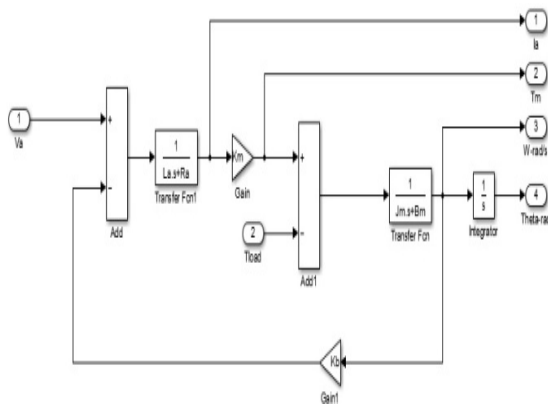
Fig. 1: SE DC motor

Fig. 2: Simulink modeling of DC motor

the Genetic calculation (GA) strategy is proposed. The objective limit of the proposed GA is imprinted in perspective of the required oversee components of the machine in classes. The machine is indicating using matlab/simulink and the copy impacts are gotten and differentiated and individuals of customary Ziegler Nichols (ZN), GA based essential supreme of the mistake (IAE) composition and GA based Mean of the Squared blunder (MSE) record strategies. The connection exhibits the ampleness of the proposed tuning approach as it offers an unrivaled execution and satisfies the foreordained control characteristics. Resultant updates at the step response conduct of pace control of the DC motor gadget are showed up for two examples.

The DC motor model: Recall the independently energized the DC motor force device thru armature control (Namazove and Basturk, 2010; Nasri *et al.*, 2007). The voltage connected to the armature of the motor is balanced and now not the use of a converting the voltage connected to concern. Figure 1 indicates under a separately excited DC motor proportionate model. That is

making in with the aid of using matlab/simulink as shown in Fig. 2. On this character case in the course of the delivery furnished a one at a time to armature winding and field winding. The primary a unique or wonderful form in those varieties of dc motor is with the precept motive of the field winding in does now not go with the flow the armature contemporary-day because of the fact; the sector winding is agitated from a separate out of doors source of dc current. DC motors gives splendid manager of the rate for vehicles need of their maximum vital parameters collectively with pace, feature and acceleration and so on (Mohammed, 2011). The force of parameters are given in appendix:

$$V_a(t) = R_a i_a(t) + L_a \frac{di_a(t)}{dt} + e_b(t) \qquad (1)$$

$$\frac{\omega(s)}{V_a(s)} = \frac{k_m}{L_a J_m S^2 + (R_a J_m + L_a B_m)S^2 + (R_a B_m + K_b K_T)S} \qquad (2)$$

$$\frac{\theta(s)}{V_a(s)} = \frac{k_m}{L_a J_m S^3 + (R_a J_m + L_a B_m)S^2 + (R_a B_m + K_b K_T)S} \qquad (3)$$

Where:
R_a = Armature resistance
L_a = Armature inductance
I_a = Armature current (A)
V_a = Armature voltage
E_b = Back emf
ω = Angular-speed
Tm = Motor torque
θ = Angular position of rotor pipe
J_m = Rotor inertia
B_m = Iscous friction coefficient
K_m = Motor torque constant
K_b = Back emf constant

Design of PID controller: The PID Controller is a key oversee circle of input contraption and is broadly utilized as a part of control machine. The nonlinear capacities of a DC motor such on record that dispersion and innovation can disgrace general execution of the established controllers (Johnson and Lorenz, 2009). Controllers utilize 3 essential types of parameter or modes: (P) Proportional, (I) Indispensable and subordinate (D). Even however, corresponding and urgent control is utilized as unmarried oversee approach and a by-item control utilized is that it enhances the short lived reaction of the machine. On this study its miles actualizing to control the rate of DC motor which on apex of is demonstrated in Fig. 3. It is working in view of the rate bungles among the genuine speed and reference pace is
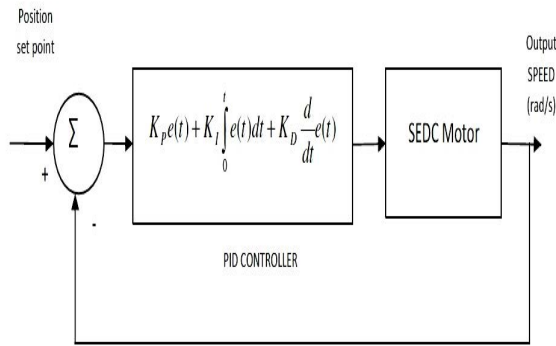
Fig. 3: PID controller with system

Fig. 4: Step input of uncontrolled DC motor drive system

Table 1: Special effects of increasing the pid controller parameters

Parameters	Rise time	Over shoot	Settling time	Steady state error
K_p	Reduce	Increase	Little change	Reduce
K_I	Reduce	Increase	Increase	Reduce
K_D	little change	Reduce	Reduce	little

assigned as data to a PID controller. The PID controller relying upon changes the blunder their yields, to control the strategy enter such that the slip-up is reduction. Complete in arrangement roughly the thought and tuning of PID controllers is given in underneath (Othman, 2009). General type of the Transfer capacity of a the PID controller is indicated as (Mashakbeh, 2000):

$$G(S) = K_P + K_I \frac{1}{S} + K_D S \qquad (4)$$

Where:

e = Error signal
K_p = Proportional constant
K_i = Integral constant
K_d = Derivative constant

$$u(t) = K_P e(t) + KI \int_0^t e(t) + K_D \frac{de(t)}{dt} \qquad (5)$$

MATERIALS AND METHODS

Tuning methodology

Conventional PID controller tuning method: In this two strategies for determination parameters of PID controller known as Ziegler-Nichols tuning methods. Remembering the final objective to choose the parameters of the normal PID controller using sensitive figuring tuning as a part of a MATLAB is made. The step response of uncontrolled the DC motor is showed up in Fig. 4. It is clear that the uncontrolled DC motor has a sensible step response since the settling time is exceptionally poor and not appropriate working condition second of the reference speed. At that point applying PID controller whose velocity might be researched utilizing the Proportional (KP) Integral (KI) and Derivative (KD) addition of the PID controller. Since, traditional controllers PID are neglecting to control the drive when load parameters be additionally changed The most essential point of this study is to break down the
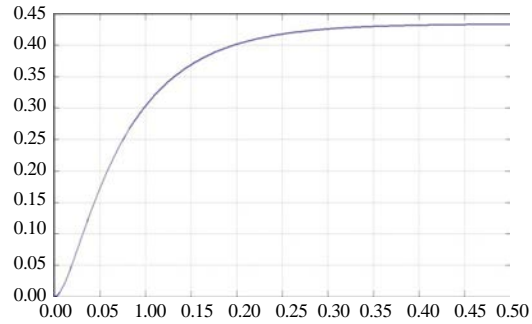
execution of Genetic Algorithms (Gas) for improve PID controllers parameters for rate control of the DC motor and specify their advantages over the traditional tuning methodologies. The emphasis point is resolved, the digression line is drawn Table 1.

RESULTS AND DISCUSSION

GA-based optimization: The genetic algorithmis a methodology for handling both unconstrained and constrained issues that rely on upon characteristic inclination. A Genetic Algorithm (GAs) is a chase and progression methodology which framework by duplicating the formative ethics and chromosomal diversion of the precepts in trademark genetic qualities (Fig. 5). A GA begins its request with a discretionary game plan of game plans if all else fails coded in parallel strings. Every plan is going on a health which is in a straight line related to the objective limit of the request and change issues. The Genetic count is consistently assembled of two strategies. The essential methodology is the choice of individuals for the formation of the bleeding edge and second process is the control of the particular individual to shape the front line by change and half breed strategies. The wellness capacity is the imperative part of to use in the hereditary calculation (Gas). The most key step in applying GA tuning technique is to pick the objective work that is used to survey the wellness estimation of each chromosome (Liu *et al.*, 2002). In this study, three target capacities are used and their execution is taken a gander at. The primary relies on upon Integral Absolute Error (IAE) list, the second relies on upon Mean of the Squared Error (MSE) record, besides, the most recent one is recommend (objective function) target limit, two equation. Equation 6 and 7 under neath
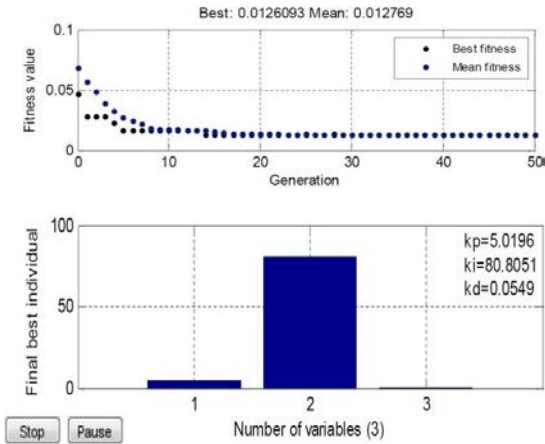
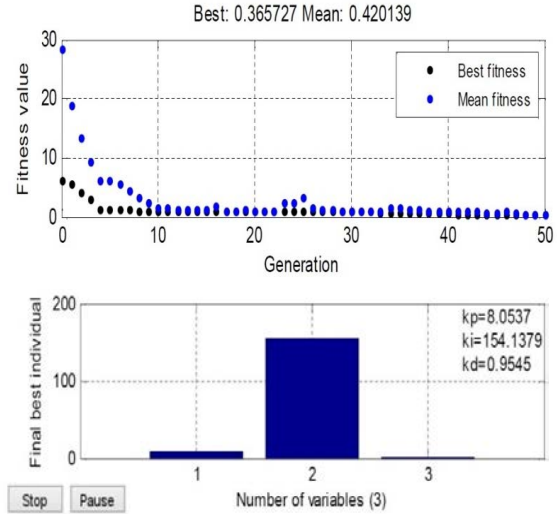Fig. 5: GA optimization progression based objective function (IAE) index

Fig. 6: GA optimization progression based objective function (MSE) performance index
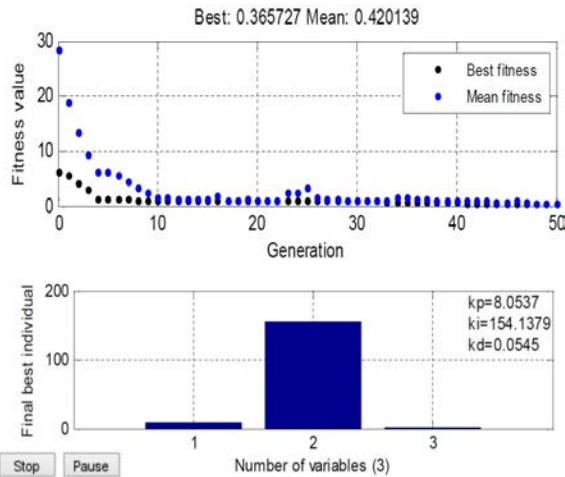

Fig. 7: GA optimization process based the proposed objective function

Table 2: Setings of GA parameters values

Parameters	Values
Lower bound [KP, KI, KD]	[0, 0 ,0]
Upper bound [KP, KI, KD]	[500, 500, 500]
Populations	25
Generations	50
Population type	Double vector
Ranges of PID parameters	0-500
Crossover fraction	0.8
Mutation rate	0.01
Elite count	5
Selection function	Tournament
Plot function individual	Best fitness, best

target limit is called conventional techniques and numerical proclamation (Eq. 18) objective is propose target limit. In this study in target work besides orchestrate through the MATLAB coding. The parameters of Gas in this study are set as in Table 2. The GA headway process based IAE file and MSE file are showed up in Fig. 6 and 7, exclusively. For each case, the controller parameters are determined. The goal capacity (wellness capacity) is given as:

$$IAE = \int_0^T |e(t)| dt \qquad (6)$$

$$MSE = \frac{1}{t} e\big((t) \big)^2 dt \qquad (7)$$

$$\Big(F_{OBJECTIVE} = |OS\% - 5| + \mu \big(|T_s - 0.05| + |T_r - 0.01| \big) + |T_r - 0.01| v + \|T_r - 0.01\| \Big) \qquad (8)$$

Where:

F	=	Proposed objective function
OS%	=	Overshoot
T_s	=	Settling time
T_r	=	Rise time
m and n	=	Weights factor

The constants m and n are weights calculate moreover are taken as (m = 100, n = 150). The parameters of GAs in this study are set as in Table 3. The GA improvement process based IAE document, MSE record and proposed record are showed up result in Fig. 6-8 independently. For each case, the PID controller parameters are determined.

This study in aim characteristic a committed software program the usage of programming language "'C" on for this trouble in MATLAB. The variety of KP, KI and KD is desired between (0-500), respectively. Values of KP, KI and KD are plotted through the wonderful objective feature in Fig. 5 and 6 and in the end suggest
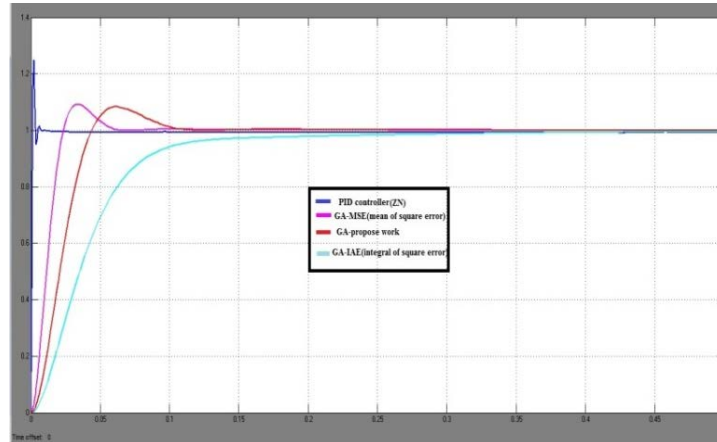
Fig. 8: Step input of controlled DC motor drive system

Table 3: Performance comparison of parameters with pid and ga Tuning method

		Genetic algorithm		
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Parameters	Conventional PID	IAE objective function	MSE objective function	The proposed objective function
KP	14.7312	5.0196	8.0537	8.0537
KI	105.15	80.8051	154.1379	154.1379
KD	0.547	0.0549	0.0545	0.9545
Rise time (sec)	0.00622	0.0663	0.0499	0.0291
Settling time (sec)	0.0837	0.116	0.117	0.0952
Overshoot (%)	47.4	0	2.22	8.33
Peak	1.41	1.02	0.995	1.08

goal feature/fitness function. Figure 7 shows the dissimilarity of the health of the tremendous explanation with technology, somewhere great clarification is its smooth as which offers minimum upward push time, settling time overshoot and nearly 0 regular US errors in the energy of the quality answer in every technology till it reaches a most capability rate may be recognized to the choice method followed that is to say aggregate of match selection by way of way of way of Elitism manner.

CONCLUSION

It is perfect final result that the customary PID controller is not getting the proper final result however by means of the transformative Computation procedures to the most brilliant tuning of the PID controller lead to a fitting close circle response for the plan underneath perception. Appraisal of the result as revealed and proposes in Table 3 and Fig. 8. This study gives a fresh out of the plastic new tuning method for pace control of the DC motor with hereditary calculation (GA) based the PID controller.

Objective of this examination paper of PID parameters (KP, KD, KI) upgrade through the hereditary calculation based absolutely particular target work however not top notch final result then we're stoop novel propose target trademark/wellness work, the gotten extraordinary result by utilizing this change way with the goal that you can get rise time, settling time overshoots and almost zero enduring state blunder. The reenactment results represent in Fig. 8. That gives supplementary more beneficial presentation when contrasted with customary controller for the deliberate framework.

APPENDIX

$Ra = 11.2\,\Omega$, $La = 0.1215$ H, $= 1.28$ Nm/A, $K_b = 1.28$ V s/rad
DC motor, separately-excited, 5Hp, 240 V, 1500 rpm,
$j = 0.02215$ Kg m², $B_m = 0.002953$ N/(rad sec⁻¹)

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