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Control of DC Motor by SFS/PID Approach and A Comparative Study

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ABSTRACT

The velocity control of DC motor is an essential case as less settling time and overshoot are desired. This work presents control of DC motor with tuning of proportional-integral-derivative (PID) controller by Stochastic Fractal Search (SFS) algorithm. Fractal Search is a metahuristic algorithm stimulated by the natural phenomenon of growth using the concept of fractal. Stochastic rules like; Gaussian walks are used to change the iteration process to generate random fractals. Here, integral of product between squared time and absolute error (ISTAE) has been used as an objective function. Comparison of proposed SFS/PID approach has also been shown with other existing approaches; such as PSO/PID and IWO/PID. It has been observed that SFS/PID approach gives no overshoot and other parameters such as; settling time and rise time are also comparable with other existing approaches.

Keywords: DC motor, PID, SFS, ISTAE.

I. INTRODUCTION

PID controllers are broadly used in industrial plants due to their robustness and ease of implementation. Adding some zeros to closed loop transfer function using differential controller, improves the transient response, and adding some poles to it using integral controller, decreases the steady state error [1, 2]. PID controllers can be tuned by different ways such as; Ziegler Nichols, Cohen-coon tuning and Z-N step response, etc. But, all of these classical methods have some limitations [3].

Now days, some evolutionary algorithms are also available for tuning the parameters of PID controller [4]. Particle Swarm Optimization (PSO) and Invasive Weed Optimization (IWO) algorithms are already available in the literature to tune the parameters of PID controller for control of DC motor [5-10].

In the present work, SFS algorithm has been used to tune the parameters of PID controller for control of DC motor. In SFS, given an initial particle positioned at the origin, other particles are then created randomly around that point, and cause diffusion. Besides efficient exploration of the search space, SFS uses Gaussian random methods in updating processes which introduce diversification properties in SFS algorithm [11-14]. The comparison of proposed SFS/PID approach has also been shown with PSO/PID and IWO/PID approaches.

II. BASIC CONCEPTS OF DC MOTOR

DC motor generates torque directly from DC power supplied to the motor by using internal communication, stationary permanent or electromagnets, and rotating electrical magnets. Like all electric motors or generators, torque is produced by the principle of Lorentz force. Advantages of a brushed DC motor include low initial cost, high reliability and simple control of motor speed. The basic model of DC motor is shown in Fig. 1.

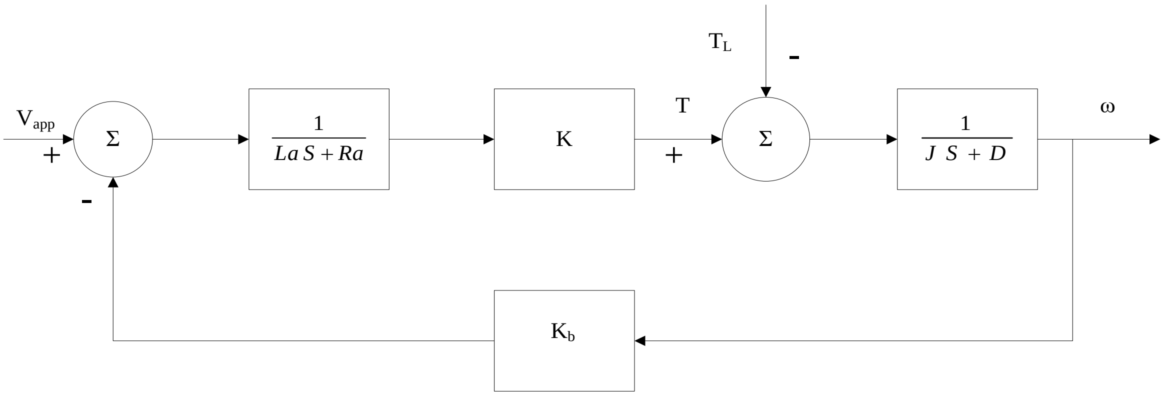

Fig. 1: Model of DC motor

In Table 1, the parameters of the motor used in present simulation have been given [7].

Table 1: Parameters of DC Motor

Ra	0.4 ohm
La	2.7 H
J	0.0004 kg.m^2
D	0.0022 N.m.sec/rad
K	15e-3 kg.m/A
K_b	0.05 V.sec

Now, for control of DC motor, building an ideal PID controller is practically impossible. The objective of this work is to achieve response/speed of DC motor close to the ideal/set point state. Figure 2 shows the equivalent circuit of DC motor with a PID controller.

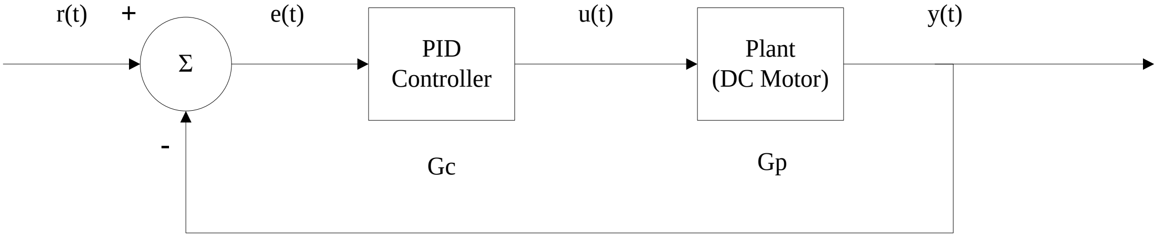

Fig. 2: Equivalent circuit of DC motor with PID controller

III. PROBLEM FORMULATION

The DC motor has a PID controller, given by:

$$PID = K_P + \frac{K_I}{S} + K_D S \tag{1}$$

Now, the objective is to obtain the unknown parameters of PID controller in (1) for control of speed of DC motor to ideal/set point state. For this, the fitness/objective function taken is based on integral of product between squared time (ISTAE) and absolute value of the output velocity of the DC motor, given by:

$$ISTAE = \int_0^{t_{sim}=10} t^2 |\Delta w|\, dt \tag{2}$$

The simulink model representation of ISTAE is shown in Fig. 3.

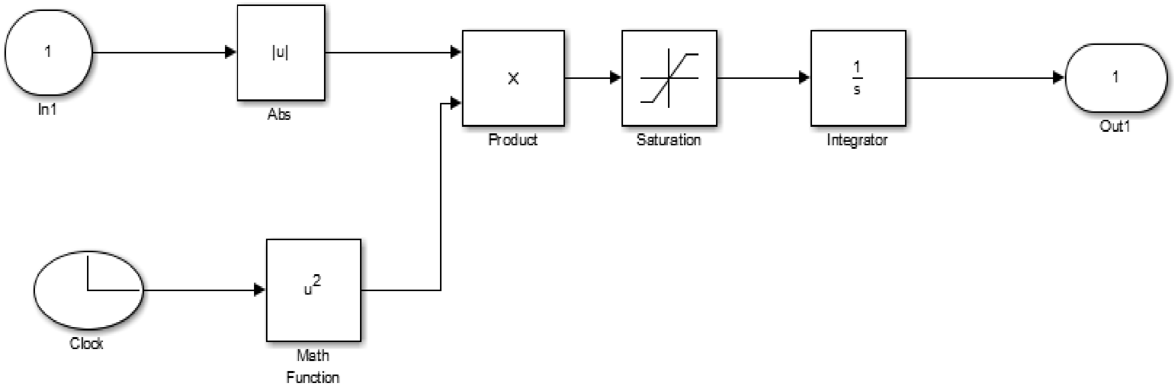

Fig. 3: Simulink model representation of ISTAE

Figure 4 shows the complete simulink model of DC motor with PID controller in which ISTAE as fitness function has been taken.

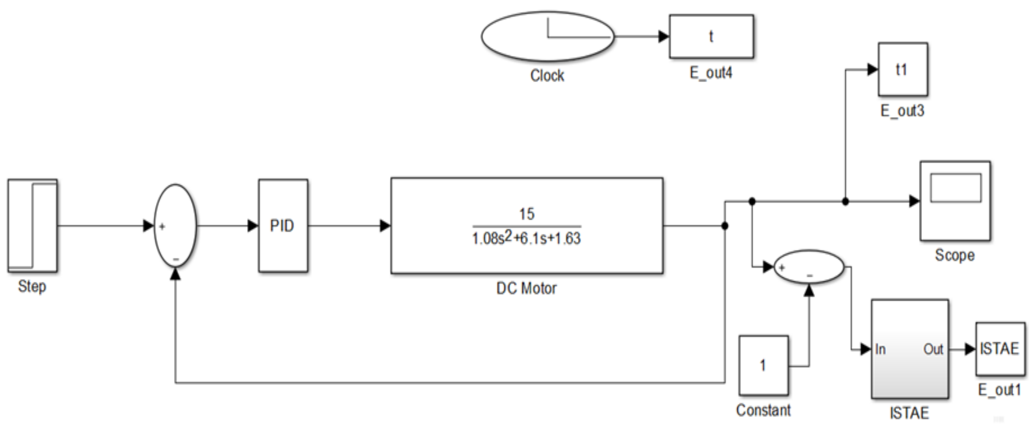

Fig. 4: Complete simulink model of DC motor with PID controller and ISTAE as Fitness Function

IV. SFS ALGORITHM

In SFS, diffusion property is generally observed in random fractals, to discover the search space. Stochastic rules like Gaussian walks are used to change the iteration process to create random fractals. In this process, few best particles from the diffusing process are considered, and the rest of the particles are discarded. The flow chart of SFS algorithm is shown in Fig. 5.

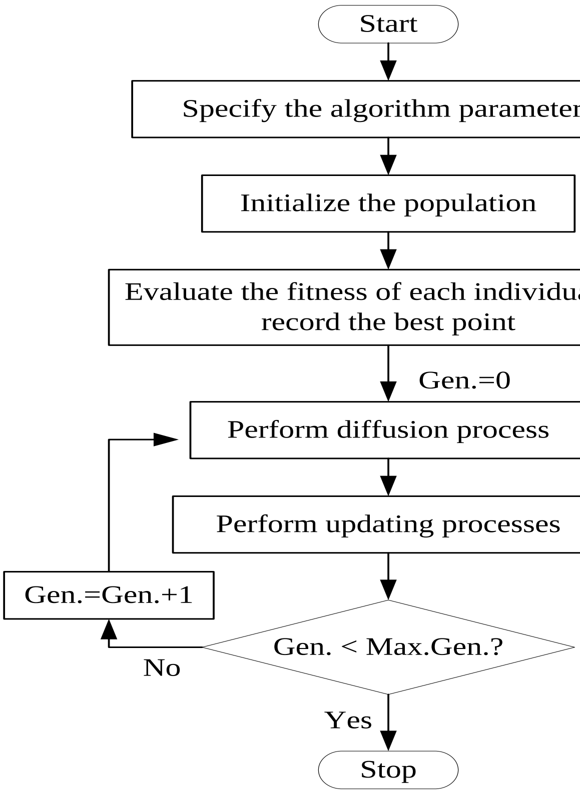

Fig. 5: Flow chart of SFS Algorithm

V. SIMULATION RESULTS AND DISCUSSIONS

The SFS algorithm has been run in Matlab for the simulink model shown in Fig. 4 and obtained parameters of PID controller are given in Table 2. For comparison of SFS with PSO and IWO, the parameters of PID obtained by IWO and PSO have also been given in Table 2.

Table 2: Optimal Parameters of PID for DC Motor obtained by SFS, IWO and PSO

Algorithm	**K_p**	**K_I**	**K_D**
SFS (Proposed)	1.8586	0.2870	0.3081
IWO	1.5782	0.4372	0.0481
PSO	1.5234	1.3801	0.0159

A comparison of speed of DC motor without and with PID controller tuned by SFS is shown in Fig. 6. It can be seen in Fig. 6 that, the speed of DC motor approaches to set point immediately without any overshoot with the PID controller tuned by SFS.

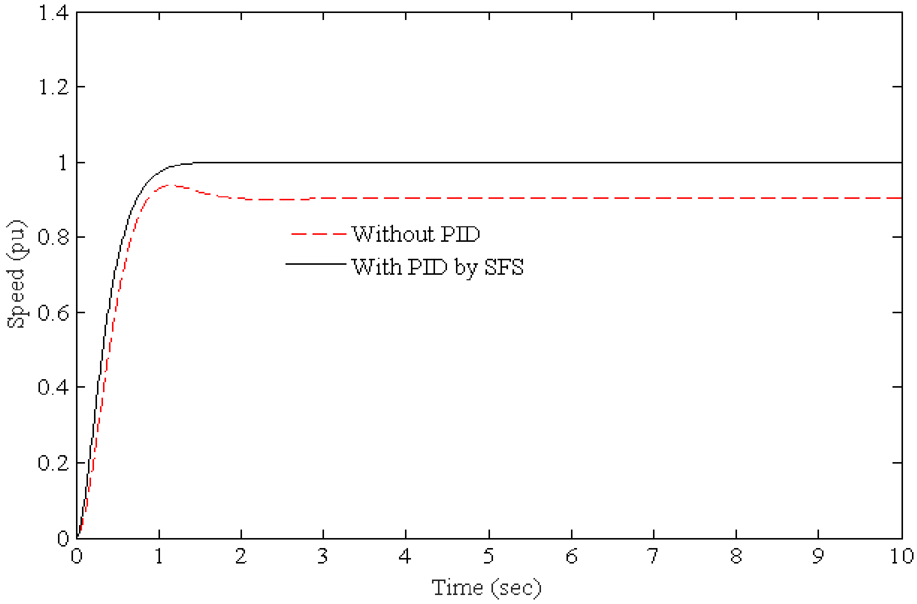

Fig.6: Comparison of Speed of DC motor without and with PID Controller

To show the effectiveness of the proposed SFS/PID approach, the comparison has also been shown with existing PSO/PID and IWO/PID approaches [7], as shown in Fig. 7. It can be seen in Fig. 7 that, SFS/PID approach gives no overshoot in comparison to existing approaches.

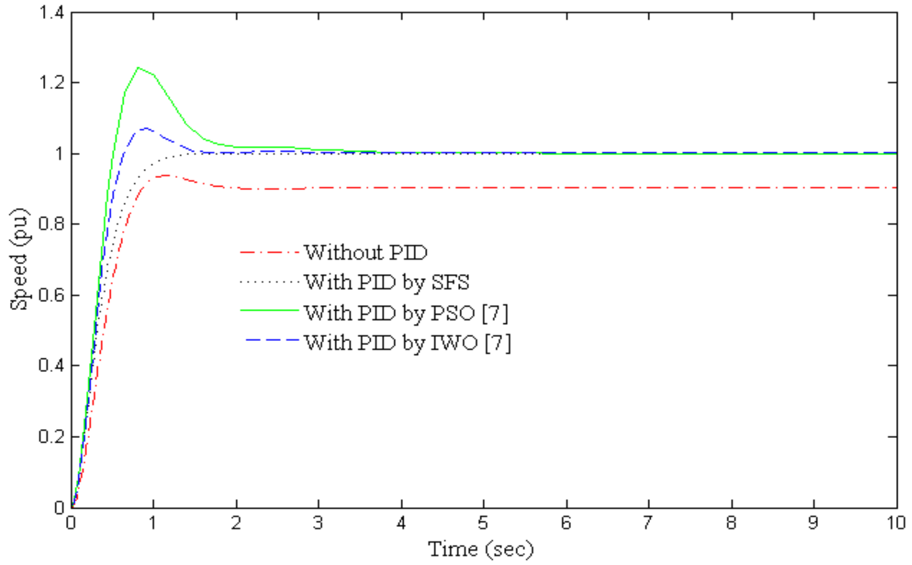

Fig. 7: Comparison of Speed of DC Motor with various Approaches

In Table 3, a comparative study of the transient response parameters; such as Overshoot, Rise time and Settling time have also been given.

Table 3: Comparison of Transient Response Parameters of SFS, IWO and PSO tuned PID Controller for DC Motor

Over Shoot (%)			Setteling Time (sec)			Rise Time (sec)		
SFS	IWO	PSO	SFS	IWO	PSO	SFS	IWO	PSO
0	6.98	24.2	1.97	1.25	1.8	0.497	0.419	0.356

It can be seen in Table 3 that, the SFS/PID approach gives no overshoot in comparison to other existing approaches and the Rise time and Settling time are also comparable.

VI. CONCLUSIONS

The present work deals with speed control of DC motor with tuning of PID controller by SFS algorithm. Fractal Search is a metahuristic algorithm which uses the concept of fractal. The ISTAE has been used as an objective/fitness function. Comparison of proposed SFS/PID approach has also been shown with other existing approaches; such as PSO/PID and IWO/PID. The simulation results reveal that SFS/PID approach gives no overshoot and other parameters such as; settling time and rise time are also comparable with existing approaches. The work has been carried out in MATLAB/SIMULINK environment.

REFERENCES

[1]. M.Y. Chew, A. Menozzi, F. Holcomb “On the comparison of the performance of emerging and conventional control techniques for DC motor velocity and position control”, IEEE, 1992.

[2]. A.E. Bryson, Y.C. Ho, “Applied optimal control”, Hemisphere, 1975.

[3]. N.Thomas "Position Control of DC Motor Using Genetic Algorithm Based PID Controller", Proceeding of the world congress on engineering 2009, Vol II WCE2009, 2009, UK.

[4]. K.H. Ang, G. Chong, Y. Li, “PID control system analysis, design, and technology”, IEEE Trans. Control System Technology, vol. 13, p. 559 – 576, Jul. 2005.

[5]. H. Y. Fukuyama, “Fundamentals of Particle Swarm Optimization Techniques”, Chapter 5, pp. 1-5.

[6]. S.R. Yuhui S and R. Eberhart, “Empirical study of PSO”, IEEE, Proceedings of the 1999 Congress on Evolutionary Computation, Vol.3, September 1999, pp. 6-9.

[7]. M. Khalilpuor, N. Razmjooy, H. Hosseini, P. Moallem-“Optimal Control of DC motor using Invasive Weed Optimization (IWO) Algorithm”, Majlesi conference on Electrical Engineering, August 2011.

[8]. A. Akbarzadeh and M. Sadeghi, "Parameter Study in Plastic Injection Modeling Process Using Statistical Methods and IWO Algorithm". International Journal of Modeling and Optimization, Vol. 1, No. 2, June 2011.

[9]. A Rubaai., R Kotaru., Online identification and control of a DC motor using learning adaptation of neural networks, IEEE Trans. Industry Application, Vol. 36, p. 935 – 942, 2000.

[10]. F. J. Lin, K. K. Shyu, Y. S. Lin, Variable structure adaptive control for PM synchronous servo motor drive, IEE Proc. IEE B: Elect. Power Applicat, vol. 146, Mar., p. 173 – 185, 1999.

[11]. H. Salimi , “Stochastic Fractal Search: a powerful metahuristic algorithm”, *Knowledge-based System*, Elsevier, Vol. 75, pp 1-18, 2015.

[12]. S. Padhy, S. Panda, "A hybrid stochastic fractal search technique based cascade PI-PD controller for automatic generation control of multi-source power system in presence of plug in electric vehicles", *CAAI Transactions on Intelligence Technology*, 2017.

[13]. H. H. Hoos and T. Stiitzle "*Stochastic locals search foundation and application*", Elsevier, 2005.

[14]. M. Sohal, A. Singh and R.S. Virk, "A Framework For Optimizing Distributed Database Queries Based On Stochastic Fractal Search", Int. J. Comp. Sc. and Mob. Computing (JCSMC), Vol. 4, No.6, pp. 544-551, 2015.