Control of DC motor Using Fuzzy Sliding Mode Control and Imperialist Competitive Algorithm

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Abstract— Wide amplitude, DC motor's speed and their facile control cause its great application in industries. Generally the DC motors gain speed by armature voltage control or field control. In this paper, by using a combination of Fuzzy Sliding Mode methods and Imperialist CompetitiveAlgorithms, The results of this simulation have been mentioned in the conclusion. It seems that the results be acceptable results.

Index Terms— Nonlinear control,Optimal,classical PID controller,Imperialist CompetitiveAlgorithm

1 INTRODUCTION

There are variety methods for DC motors control that are presented since now. The presented methods for DC motors control are divided generally in three groups. Classic methods such as PID and PI controllers [1,2].Modern methods (adaptation-optimum…) [3, 4, 5] .Artificial methods such as neural networks and fuzzy [6, 7] Theory are the presented methods for DC motors speed control.
The design method in linear control comprise based on main application the wide span ' of frequency, linear controller has a weak application, because it can't compensate the nonlinear system effect completely.

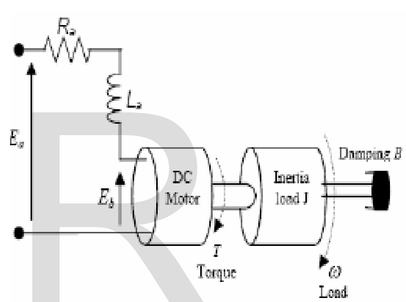

Figure 1: The structure of a DC motor

2. MODEL OF DC MOTOR

The direct current motors are different kinds and several methods are presented for controlling of their speed. In this essay DC motor was chosen for speed control and by controlling the supply voltage was controlled it in nominal less speed.
The electric circuit of the armature and the free body diagram of the rotor are shown in fig. 1

$$V_t = R_a I_a + L_a \frac{dI_a}{dt} + E_a \quad (1)$$

$$T = J\frac{d\omega}{dt} + B\omega - T_i \quad (2)$$

$$T = K_T I_a \quad (3)$$

$$E_a = K_a \omega \quad (4)$$

$$\frac{d\omega}{dt} = \varphi \quad (5)$$

With the following physical parameters:
Ea: The input terminal voltage (source), (v);
Eb: The back emf, (v);
Ra: The armature resistance, (ohm);
Ia: The armature current (Amp);
La: The armature inductance, (H);
J: The moment inertial of the motor rotor and load,(Kg.m2/s2);
T: The motor torque, (Nm)
w : The speed of the shaft and the load (angularvelocity),(Rad/s);

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f : The shaft position, (Rad);
B: The damping ratio of the mechanical system, (Nms);
T k: The torque factor constant, (Nm/Amp);
B k: The motor constant (v-s/rad).
Block diagram of a DC motor is shown in fig. 2 [8].

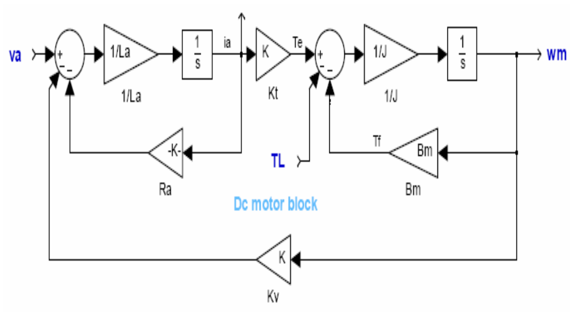

Figure 2.The block diagram of a DC motor

At first we control the DC motor by PID controller in fig.3

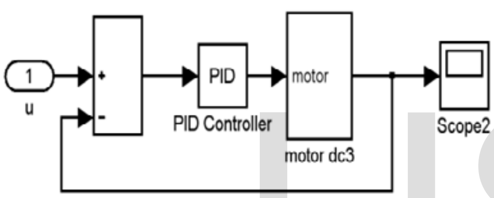

Figure 3.The block diagram of a PID controller dc motor

The results are based on fig.4

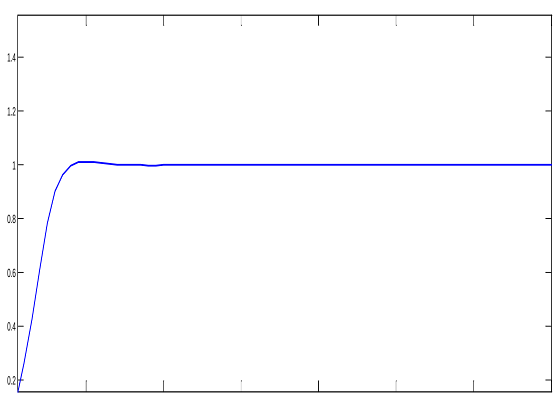

Figure 4.Simulated results PID controller of DC motor

The step response is proportionately a good response. Now with this controller we examine the step response of DC motor with uncertainly.(fig 5)

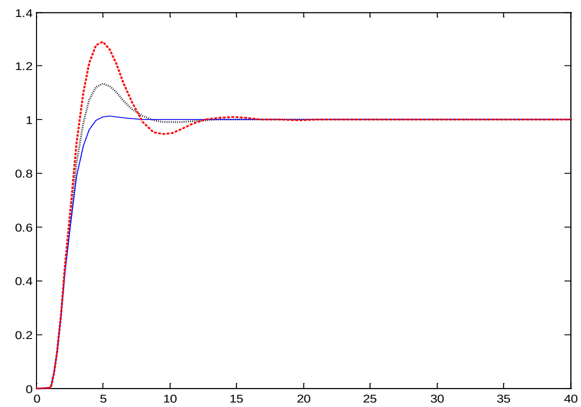

Figure 5.Simulated results PID controller of DC motor with uncertainties

You can see that the system's response to uncertain motor is not proper response.

3. Sliding Mode Controller

Nonlinear system control that its model isn't clear carefully works with tow methods:
(1).Robust control methods.
(2).Adaptive control methods.
In control view, uncertainly in modeling is divided in two main kinds:
(1).Non certainly in existent Parameters in model
(2).Estimating the lower step for system and being UN modeled dynamics in the estimating model.
Sliding control is one of the designed modes for robust control that make access to system desired application estimating system in model.
The major idea of this method is the controlling of nonlinear first grade system is easier than n grade system control in spite of uncertainly.
But this function maybe cause the control law with more energy that is not practicable implement station.Sliding mode is really compromise between modeling and suitable operation with inaccurate design.
We consider the non linear system model in this rule:

$$X^n = f(x) + b(x)u \quad (6)$$

That F(x) is nonlinear function, its high boundary characterized as X function.B(x) is a continuous function that its high and low boundaries characterized by X function.

The good of finding X is in this way that in g(x)F(x) function we can follow the desirable mode in spite of uncertainly.

$$\tilde{X} = X - X_d = [\tilde{X}, \tilde{X}', \ldots, \tilde{X}^{n-1}] \quad (7)$$

In ideal state

$$\tilde{X} = 0 \quad (8)$$

Sliding surface equation defines as below:

$$s = e' + \alpha_1 e + \alpha_2 \int e\, dt \quad (9)$$

Because of the signals of control that gain with this designing method has limited energy, it is necessary to:

$$X_d(0) = X(0) \quad (10)$$

In other word:

$$S(X,t) \equiv 0 \quad (11)$$

$$\frac{1}{2}\frac{dS^2}{dt} \leq -\eta|S| \quad (12)$$

In designing, the control low on S(t) continuously is noticed cause we should concentrate to carelessness in model in sliding surface and reduced the chattering effect.
We can write the system's dynamics when in some situation they are in sliding state.

$$S' = 0 \quad (13)$$

The gained control signals for this system are as below:

$$U = k_1 \times out_{fuzzy} * S \quad (14)$$

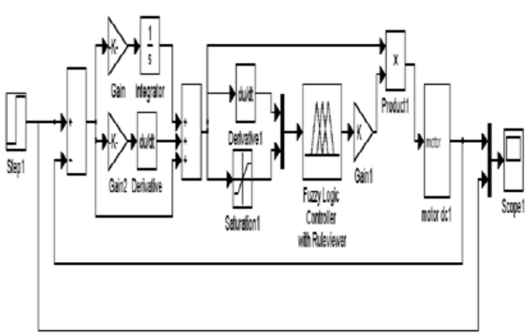

Figure6.simulink block diagram of FSMC

Fuzzy controls are designed based on created sliding surface and sliding surface changes.
All of the fuzzy rules collection came in Table II

Table2. Fuzzy Rule

dS / S	NB	NS	ZE	PS	PB
N	B	B	M	S	B
Z	B	M	S	M	B
P	B	S	M	B	B

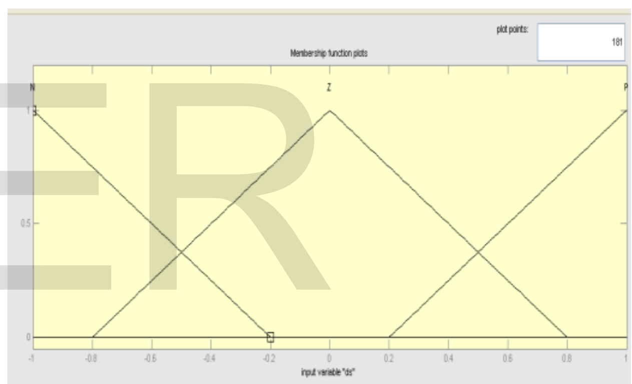

Figure 7.Membership functions for (ds/dt) normalized inputs

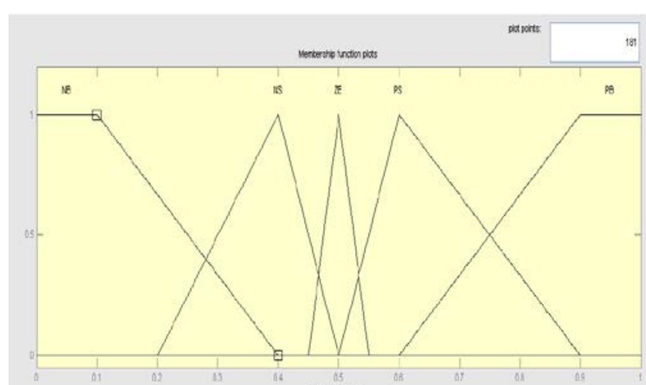

Figure 8.Membership functions for (ds/dt) normalized inputs

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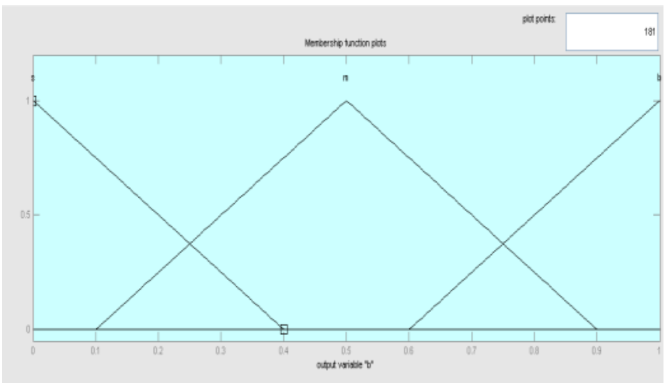

Figure 9.Membership functions for (out fuzzy) normalized outputs

4. BRIEF DESCRIPTION OF IMPERIALISTCOMPETITIVE ALGORITHM

Imperialism is the policy of extending the power and rule of a government beyond its own boundaries. A country may attempt to dominate others by direct rule or by less obvious means such as a control of markets for goods or raw materials. The latter is often called neocolonialism [6]. Imperialist Competitive Algorithm (ICA) [5] is a novel global search heuristic that uses imperialism and imperialistic competition process as a source of inspiration. Figure 1 shows the pseudo code for this algorithm. Like other evolutionary ones, this algorithm starts with an initial population. In his algorithm any individual of the population is called a country. Some of the best countries in the population are selected to be the imperialist states and all the other countries form the colonies of these imperialists. All the colonies of initial population are divided among the mentioned imperialists based on their power which are inversely proportional to their cost. After dividing all colonies among imperialists and

Creating the initial empires, these colonies start moving toward their relevant imperialist country. This movement is a simple model of assimilation policy that was perused by some imperialist states [10]. Figure 2 shows the movement of a colony towards the imperialist. In this movement, θ and x are random numbers with uniform distribution and d

Is the distance between colony and the imperialist.

$X \sim U(0, \beta \times d)$

$\theta \sim U(\gamma, \gamma)$

β and γ are arbitrary numbers that modify the area that colonies randomly search around the imperialist. In our implementation β and γ are 2 and π/4 (Rad) respectively.

1) Select some random points on the function and initialize the empires.
2) Move the colonies toward their relevant imperialist (Assimilating).
3) If there is a colony in an empire which has lower cost than that of imperialist, exchange the positions of that colony and the imperialist.
4) Compute the total cost of all empires (Related to the power of both imperialist and its colonies).
5) Pick the weakest colony (colonies) from the weakest empire and give it (them) to the empire that has the most likelihood to possess it (Imperialistic competition).
6) Eliminate the powerless empires.
7) If there is just one empire, stop, if not go to 2.

Fig. 10. Pseudo code for the proposed algorithm

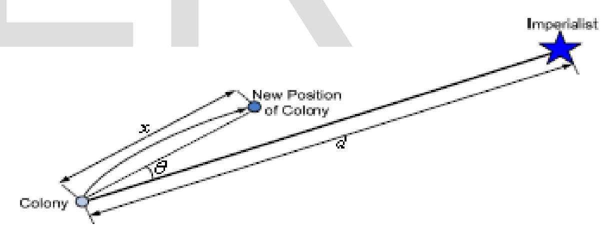

Fig11. Motion of colonies toward their relevant imperialist.

The total power of an empire depends on both the power of the imperialist country and the power of its colonies. In this algorithm, this fact is modeled by defining the total power of an empire by thepower of imperialist state plus a percentage of the mean power of its colonies. Any empire that is not able to succeed in imperialist competition and can not increase its power (or at least prevent decreasing its power) will be eliminated. The imperialistic competition will gradually result in an increase in the power of great empires and a decrease in the power of weaker ones. Weak

empires will lose their power gradually and ultimately they will collapse. The movement of colonies toward their relevant imperialists along with competition among empires and also collapse mechanism will hopefully cause all the countries to converge to a state in which there exist just one empire in the world and all the other countries are its colonies. In this ideal new world colonies have the same position and power as the imperialist.

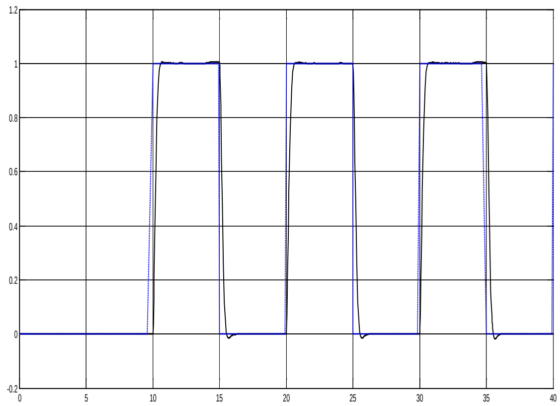

Figure 12.Simulatedpulseresults FSMC of DC motor

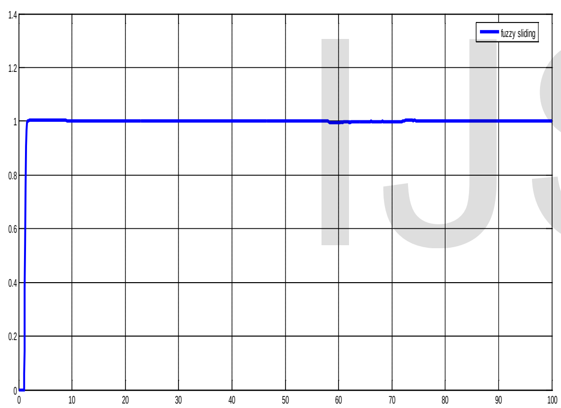

Figure 13.Simulated step results FSMC of DC motor

5. Conclusion

In this paper, a robust control system with the fuzzy sliding mode controller and the additional compensator is presented for a DC motor position control. According to the simulation results, the FSMC controllers can provide the properties of insensitivity and robustness to uncertainties and external disturbances, and response of the DC motor for FSMC controllers against uncertainties and external disturbance is the same Fuzzy sliding mode controller gives a better response to system than the fuzzy and classical PID controllers. Ifα_1, α_2, k_1 control parameters set suitably

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