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Design of Hybrid Fuzzy Pid Controller for Dc Servo Motor
Part 2: The hybrid fuzzy PID controller applied for a DC motor

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ABSTRACT: The controlling speed for DC motors, especially in industry, is always associated with the production technology process and it greatly determines the quality of the products. Depending on the nature and requirements of the process, it requires appropriate control methods. This paper given a designs of speed controlling for a DC servo system based on a newly developed fuzzy system, which is very powerful and has brought about many unexpected achievements in the field of fuzzy logic control. The basic advantage of fuzzy control over classical control methods is that it is possible to synthesize the controller without knowing the exact characteristics of the object in advance. In fact, in order to make full use of the advantages of each type of fuzzy controller and classical controller, people often use systems that combine two types of traditional and fuzzy controllers to create a controller which is the new fuzzy controller. In this paper, we present the hybrid fuzzy PID controller for controlling the speed of DC servo motors.
To achieve the goal we organize into 3 main contents as follows: Part 1: Design of hybrid fuzzy PID controller; Part 2: The hybrid fuzzy pid controller for a dc motor; Part 3: The simulation of the hybrid fuzzy pid controller for dc servo motor.

KEYWORDS:DC servo motors , fuzzy controller, fuzzy PID, Fuzzy logic,…

I. INTRODUCTION

DC servo motors are popularly used as prime movers in computers, numerically controlled machinery, or other applications where starts and stops are made quickly and accurately. Servo motors have lightweight, low-inertia armatures that respond quickly to excitation-voltage changes.

The speed of DC motor can be adjusted to a great extent so as to provide easy control and high performance. There are several conventional and numeric controller types intended for controlling the DC motor speed at its executing various tasks: PID Controller, Fuzzy Logic Controller (FLC) [1]; or the combination between them: PID-Particle Swarm Optimization, PID-Neural Networks, PID-Genetic Algorithm. One of the problems which might cause unsuccessful attempts for designing a proper controller would be the time-varying nature of parameters [2-6], unknown the parameters of the plants and variables which might be changed while working with the speed systems. One of the best suggested solutions to solve this problem would be use of the new Fuzzy PID Controller call hybrid fuzzy PID controller [7-11]. The hybrid fuzzy PID controller is not sensitive to change and yet would have a fair response to the system variations.The new Fuzzy PID Controller which is computationally efficient analytic scheme suitable for a real-time closed-loop digital control implementation [12-14]. Numerous computer simulations are included to demonstrate the effectiveness of the controller not only in linear but also in nonlinear systems. The better response can be achieved by the hybrid fuzzy PID Controller in comparison with classical methods in terms of shorter settling time, less overshoot and more stability. Thus, the hybrid fuzzy PID controller is adopted in this paper which is very flexibility to control the speed of the DC servo motor.
In the part 1, we already design a hybrid fuzzy PID controller, and proposed a control structure for a DC motor system using the hybrid fuzzy controller which is presented. In the part 2, continuing to study and design hybrid fuzzy control structure for motors of speed stability in control.

II. THE HYBRID FUZZY PID CONTROLLER APPLIED FOR A DC MOTOR

Based on the proposed structure in part 1, which is the basis of theoretical research on hybrid fuzzy control system. The control structure of two loops to stabilize the speed of the DC motor is built in this section. The simulation structure of the DC motor speed stability control system with hybrid fuzzy algorithm on Matlab Simulink software is presented as shown in Figure 3.

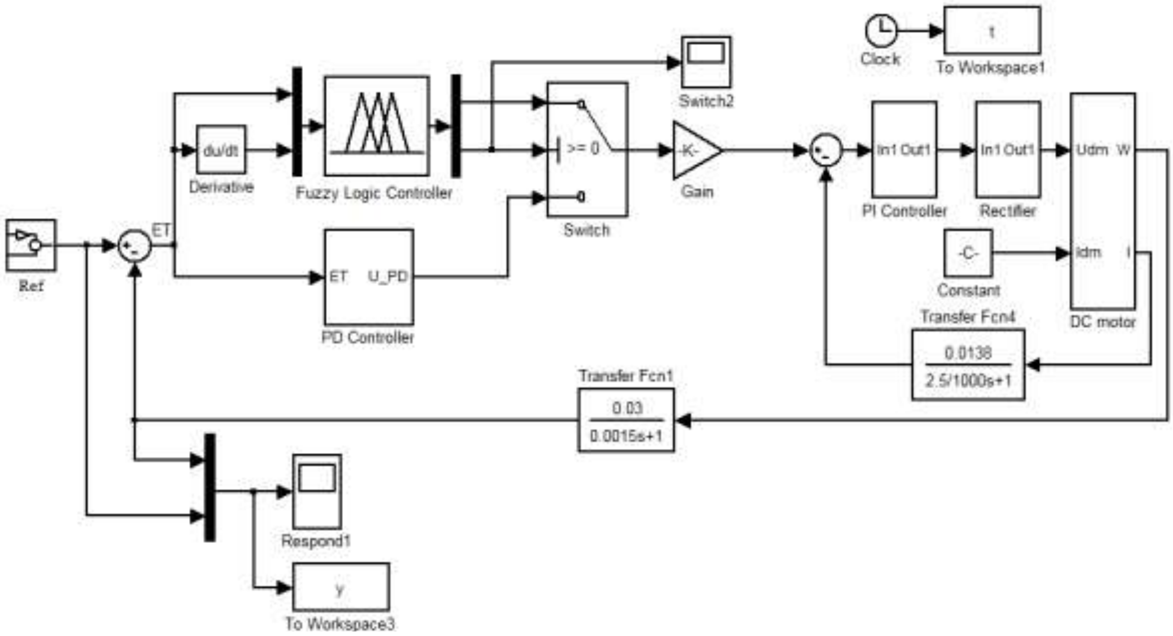

Figure 3: Structural diagram of simulation of hybrid fuzzy PID system for DC motor on Matlab Simulink

In the hybrid fuzzy PID simulation structure Figure 3 is the combination of the fuzzy controller and the classical PI controller for the speed stable loop. In which, the PI controller has a range of operation when the ET error and DET deviation have small absolute values, while the fuzzy controller has a range of operation when the ET error and DET deviation are small. has a large absolute value. Through the switch switch with two inputs will decide when to allow which controller to work. Thus, in addition to the main function of the fuzzy controller, which is to synthesize the control signal for the speed loop of the DC motor, it also performs the second function of outputting the comparison signal to the switching switch, helping to The switch can open and close flexibly to coordinate between the two dimming controllers and the PI controllers during the working process.

The Hybrid Fuzzy PID Controller algorithm for speed loop is presented in this paper which of input/output language variables as follows:

Figure 4:The input and output language variables for fuzzy controller

➢**The first input language variable:** error ET = [-5 5] (V).

+ ET ≤ -4: BigNegative (AL);

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+ ET ≈ -2.5: Small Negative (AN);
+ ET ≈ 0: Zero (K);
+ ET ≈ 2.5: Small Positive (DN);
+ ET ≥ 4: Big Positive (DL).

Figure 5: The membership function for the input language variable ET

➢ **The second input language variable :** derivative error DET = [-100 100] (V/s).

+ ET ≤ -80: Big Negative (AL);
+ ET ≈ -50: Small Negative (AN);
+ ET ≈ 0: Zero (K);
+ ET ≈ 50: Small Positive (DN);
+ ET ≥ 80: Big Positive (DL).

Figure 6: The membership function for the input language variable DET

➢**The first output language variable**: Two-state switching signal

+ ET ≈ -1: Negative (A);
+ ET ≈1: Positive (D).

Figure 7: The membership function for the output language variables switch between PI controller and fuzzy controller

➢ The second output language variable: Control signal Uđk = [0 10] (V).

+ ET ≈ 0: Zero (K);

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+ ET ≈ 3: Small (N);
+ ET ≈ 5: Medium (V);
+ ET ≈ 7: Large (L);
+ ET ≈ 10: Very Large (RL).

Figure 8: The membership function for the output language variable Switch switches between two PI controllers and fuzzy controllers

➢ **Rule table for fuzzy controller**

Figure 9: Setting the control law for fuzzy controller

The construction of a control rule table for fuzzy controllers in the hybrid fuzzy controller structure is based on control thinking between the relationship between the input error ET and the deviation derivative DET, while taking into account the function of the fuzzy controller. The second function of the fuzzy controller is to open and close the switch for the PI controller to work or the fuzzy controller to work.

U_{fk} / Switch		ET				
		AL	AN	K	DN	DL
DET	AL	K/D	K/D	N/A	V/D	V/D
	AN	K/D	N/D	V/A	V/D	L/D
	K	N/D	N/A	V/A	L/A	L/D
	DN	N/D	N/D	L/A	L/D	RL/D
	DL	N/D	V/D	L/A	RL/D	RL/D

Figure 10: Control rule table for fuzzy controller

PI controller parameters in hybrid fuzzy controller: Kp = 32.5; KI =1.5

CONCLUSION

In this section, the paper has presented the control structure of a DC motor when combining two classical and fuzzy regulators into motor speed control. To make understandable clarify the superiority of the proposed hybrid fuzzy PID controller which is the speed stability control problem with the influencing noise factor. The author has implemented a system simulation structure to compare the simulation results between the classical PID controller (specifically, the P controller) and the proposed hybrid fuzzy PID controller for the speed loop in stability control problem for DC motor. Simulation results will be mentioned in next study: The simulation of the hybrid fuzzy pid controller for dc servo motor.

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