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Design of Hybrid Fuzzy Pid Controller for Dc Servo Motor
Part 1: Design of hybrid fuzzy PID controller

Bui Thi Hai Linh[1], Tran Thi Hai Yen[2]
[1,2] *Thai Nguyen University ofTechnology,Thai Nguyen City, Vietnam*

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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 this part 1, the paper present the design of hybrid fuzzy PID controller.

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II. DESIGN OF THE HYBRID FUZZY PID CONTROLLER

Fuzzy hybrid system abbreviated as Fuzzy-PID is a control system in which the control device consists of two components: classical control component and fuzzy control component.

There are two common structures of hybrid fuzzy controller

FLC is paralleled with classical PID

The hybrid Fuzyy-PID controller can be set up based on two signals, the error e(t) and its derivative e'(t). The fuzzy controller has very good performance in the large error region, where with its nonlinearity it is possible to produce very fast dynamic response. When the process of the system approaches the set point (deviation e(t) and its derivative e'(t) is approximately equal to 0) the role of the Fuzzy Logic Controller (FLC) is limited so the controller works like a normal PID regulator. Figure 1 shows the idea of setting up hybrid Fuzzy-PID which combination of fuzzy controller and their impact partition

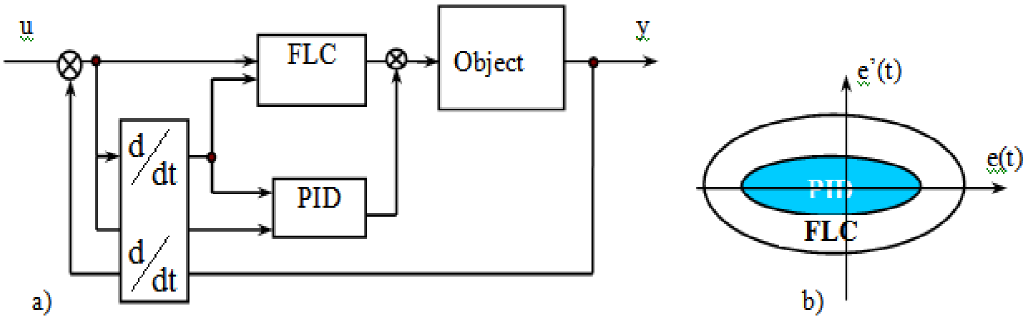

Figure 1: a) Fuzzy control principle; b) Areas of action of the controllers

The conversion between FLC and PID active regions can be done by using fuzzy locking or by using FLC itself. If the conversion uses FLC, in addition to being the FLC regulator, it also monitors the system's behavior to perform the conversion. The action conversion between FLC and PID can be done by following simple rule:

if |e(t)| is big positive and |ė(t)| big positive then u là FLC (1)

if |e(t)| small positive and |ė(t)| small positive then u là PID (2)

FLC as a fuzzy key switch

To perform fuzzy conversion between the FLC levels and the PID converter, one can set up multiple PID regulators i (i = 1,2 ... n) each of which is selected to optimize the quality according to a specific method. somehow to produce a good feature in a limited region of the input variable as shown in the Figure 2. These regulators share the same input information and their effect depends on the input value. In this case, the transformation rule can be written in the fuzzy system as follows:

If (state of the system) is Ei then (control signal) = ui

Where i = 1, 2,..., n; Ei is the language variable of the input signal, ui is the function with the parameters of the control action. If at each tuning region, the control action is due to the PID regulator with:

$$u_i = K_{Pi}e + K_{Ii}\int_0^t e(t)dt + K_{Di}\frac{de}{dt} \qquad (i = 1, 2, \dots n) \qquad (3)$$

Thus, the coefficients of the PIDi regulator depend on the input signals, more generally on the state of the system. If we consider the coefficients K_{Pi}, K_{Di}, and K_{Ii} as the defuzzification results according to the center-average method from three functional fuzzy systems:

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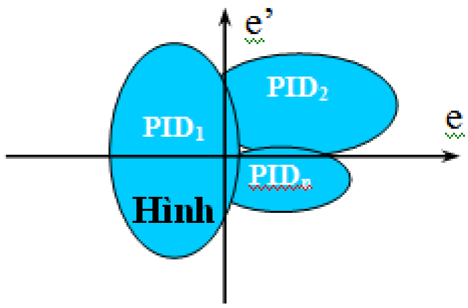

Functional fuzzy system calculates the coefficient KP with the rule system:

Ru(i): if E is Eiand DE is DEithen $K_P = K_{Pi}$ (3)

Functional fuzzy system calculates coefficient KD with the rule system:

Ru(i): if E is Eiand DE is DEithen $K_D = K_{Di}$ (4)

Functional fuzzy system to calculate coefficient KI with the rule system:

Ru(i): if E is Eiand DE is DEithen $K_I = K_{Ii}$ (5)

The theory research on hybrid fuzzy control system is mentioned above. A proposal of a hybrid fuzzy control structure for the problem of motor speed stability, based on the distribution of the working area between the fuzzy controller and the classic PID controller through the switching as shown in the Figure 3.

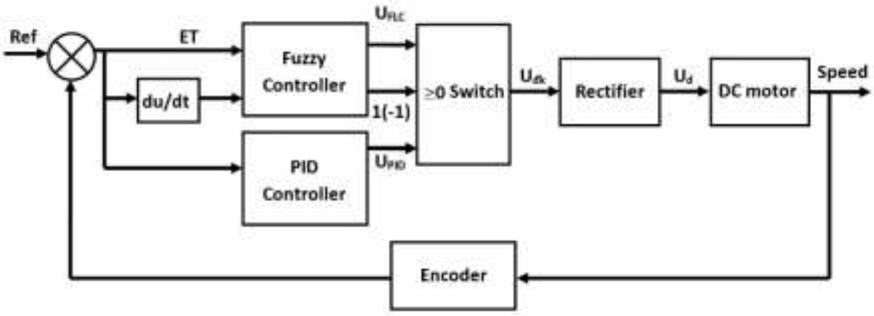

Figure 3: The Hybrid fuzzy PID controller structure for DC motor speed loop control using commutationSwitch

CONCLUSION

In this paper, the author presented an overview of the hybrid fuzzy control system, the design method of the hybrid fuzzy controller and proposed a hybrid fuzzy control structure for the problem of stabilizing the DC motor speed as described which proposed in this paper, in the next study will discuss about the hybrid fuzzy control system for DC motors.

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