USED OF FUZZY TOOL OR PID FOR SPEED CONTROL OF SEPRATELY EXCITED DC MOTOR

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ABSTRACT
DC motor has been widely utilized as a part of much mechanical provision for their exact, basic and nonstop control attributes. We have different controller for control dc motor speed with the help of PID& FUZZY TOOLS sliding mode using software Matlab and experiment set up. The
brushless dc motor extensively used for control system and industrial application because small in size, high efficiency and high torque density. Design PID controller to get fast step response. The PID controller gives very good response and the controller further tuned to decrease overshoot and steady state error. In industries PID controller are better than other controller. PID controller is not difficult to tune and modest. PID control technique is unable to balance out the nonlinear plants or in the vicinity of limited however high instabilities. This thesis an extensive study to control speed of dc motor by different Controller like PID or FUZZY Sliding mode in Matlab simulation as well as experimental Study on dcmotor. The system identification technique is used to get the accurate transfer function of dc motor system identification is the technique where we give some input to the motor and get output corresponding input and output we get the process model with measured and simulation mode through is model get the best fit percentage result after find the transfer function of plant we have design the different controller to control the speed/position of the motor. We have design PID controller or FUZZY controller for high accuracy speed control.

Keywords – PID Controller, Fuzzy Controller, DC Motor, Fuzzy Tools

INTRODUCTION
A dc motor is a machine or device which converts d.c power into mechanical power. Its operation is based on the principle that when a current carrying conductor is placed in a magnetic field, the conductor experiences a mechanical force. The direction of force is given by Fleming’s left hand rule and magnitude is given by $F=Bl$ newtons, where “$B$” is magnetic flux density, “$i$” is the current flowing through the conductor and “$l$” is the length of the conductor. The output of the motor is a mechanical output that is the output is a rotational motion of the rotor due to this force. A shaft is connected to the rotor and the shaft rotates. The speed of rotation depends on various factors. Eg….The speed control can be done by controlling those factors.
The voltage equation of a dc motor is given by-
\[ V = I_a R_a + E_b \]
where \( I_a \) is the armature current, \( R_a \) is the armature resistance and \( E_b \) is the back EMF. From this equation we have -
\[ E_b = V - I_a R_a \]
\[ P_{OZ}/60A = V - I_a R \]
\[ N = (V - I_a R_a) \times (60A/P_{OZ}) \]
\[ N = [(V - I_a R_a)/\Phi] \times (60A/PZ) \]
\[ N = [(V - I_a R_a)/\Phi] \times K, \quad \text{where } K \text{ is a constant.} \]
\[ N \propto (V - I_a R_a)/\Phi \]

From the above equation, it is cleared that the speed of the motor can be controlled by controlling or varying any of the three parameters Terminal voltage “\( V \)”, Flux linkage \( \Phi \) and \( I_a R_a \) drop in the armature winding. If we connect an inductor of certain definite value in series with the armature winding than the armature current approximately becomes constant and therefore the speed can be varied by varying the armature resistance only. If we control “\( V \)” the method is called voltage control method, if we control the voltage drop “\( I_a R_a \)” or armature resistance “\( R_a \)” it is called armature control method and if we control the flux “\( \Phi \)” then it is called flux control method.

**FUZZY SET THEORY & FUZZY CONTROLLER**

Fuzzy theory was initiated by Lotfi A. Zadeh in 1965 as an extension of the classical control theory. According to him classical control theory put too much emphasis on precision and therefore could not the complex systems. Later he formalized the ideas into the paper “Fuzzy set.” Fuzzy sets are sets whose elements have degrees of membership.
Fuzzy systems are knowledge based or rule based systems. The heart of a fuzzy system is a knowledge base consisting of the so-called If-Then rules. A fuzzy If-Then statement in which some words are characterized by continuous membership functions. After defining the fuzzy sets and assigning their membership functions, rules must be written to describe the action to be taken for each combination of control variables. These rules will relate the input variables to the output variable using If-Then statements which allow decisions to be made.

Let A be a fuzzy set named “numbers closed to zero.” Then a possible membership function for A is \( \mu_A(x) = e^{-x^2} \), Where \( x \in A \). According to this membership function, the number 0 and 2 belong to the fuzzy set to degrees of \( e^0 = 1 \) and \( e^{-4} \), respectively. So the construction of fuzzy set depends on two things:

1. The identification of suitable universe of discourse.
2. The specification of an approximate MF’s. As MF’s are subjective, which means MF’s are specified for each fuzzy set.

FL requires some numerical parameters in order to operate such as what is considered significant error and significant rate-of-change-of-error, but exact values of these numbers are usually not critical unless very responsive performance is required in which case empirical tuning would determine them. For example, a simple temperature control system could use a single temperature feedback sensor whose data is subtracted from the command signal to compute "error" and then time-differentiated to yield the error slope or rate-of-change-of-error, hereafter called "error-dot". Error might have units of degs F and a small error considered to be 2F while a large error is 5F. The "error-dot" might then have units of degs/min with a small error-dot being 5F/min and a large one being 15F/min. These values don't have to be symmetrical and can be "tweaked" once the system is operating in order to optimize performance.
Fuzzy logic has rapidly become one of the most successful of today's technologies for developing sophisticated control systems. The reason for which is very simple. Fuzzy logic addresses such applications perfectly as it resembles human decision making with an ability to generate precise solutions from certain or approximate information. It fills an important gap in engineering design methods left vacant by purely mathematical approaches (e.g. linear control design), and purely logic-based approaches (e.g. expert systems) in system design. Other approaches require accurate equations to model real-world behaviors; fuzzy logic can accommodate the ambiguities of real-world human language and logic. It provides both an intuitive method for describing systems in human terms and automates the conversion of those system specifications into effective models.

**FUZZIFICATION**

The first step in designing a fuzzy controller is to decide which state variables represent the system dynamic performance must be taken as the input signal to the controller. Fuzzy logic uses linguistic variables instead of numerical variables. The process of converting a numerical variable (real number or crisp variables) into a linguistic variable (fuzzy number) is called
fuzzification. This is achieved with the different types of fuzzifiers. There are generally three types of fuzzifiers, which are used for the fuzzification process; they are

1. Singleton fuzzifier
2. Gaussian fuzzifier
3. Trapezoidal or triangular fuzzifier

**RULE BASE**

A decision making logic which is, simulating a human decision process, inters fuzzy control action from the knowledge of the control rules and linguistic variable definitions. The rules are in “If Then” format and formally the If side is called the conditions and the Then side is called the conclusion. The computer is able to execute the rules and compute a control signal depending on the measured inputs error (e) and change in error (de). In a rule based controller the control strategy is stored in a more or less natural language. A rule base controller is easy to understand and easy to maintain for a non-specialist end user and an equivalent controller could be implemented using conventional techniques.

**INFERENCCE ENGINE**

Inference engine is defined as the Software code which processes the rules, cases, objects or other type of knowledge and expertise based on the facts of a given situation. When there is a problem to be solved that involves logic rather than fencing skills, we take a series of inference steps that may include deduction, association, recognition, and decision making. An inference engine is an information processing system (such as a computer program) that systematically employs inference steps similar to that of a human brain.

**DEFUZZIFICATION**

The reverse of fuzzification is called defuzzification. Defuzzification is the method of converting the linguistic variables or fuzzy values into crisp values. The use of Fuzzy Logic Controller
(FLC) produces required output in a linguistic variable (fuzzy number). According to real world requirements, the linguistic variables have to be transformed to crisp output. There are many defuzzification methods but the most common methods are as follows:

- a) Center of gravity (COG)
- b) Bisector of area (BOA)
- c) Mean of maximum (MOM)
- (a) Center Of Gravity (COG)

For discrete sets COG is called center of gravity for singletons (COGS) where the crisp control value is the abscissa of the center of gravity of the fuzzy set is calculated as follows:

\[
 u_{COGS} = \frac{\sum_i \mu_c(x_i)x_i}{\sum_i \mu_c(x_i)}
\]

Where \( x_i \) is a point in the universe of the conclusion (i=1, 2, 3…) and \( \mu_c(x_i) \) is the membership value of the resulting conclusion set. For continuous sets summations are replaced by integrals.

![Fig. 2 - Illustration of centre of gravity method](image)

**FUZZY LOGIC CONTROLLER**

The input to the Self-tuning Fuzzy PID Controller are speed error "e(t)" and Change-in-speed error "de(t)". The input shown in figure are described by
\(e(t) = w_r(t) - w_a(t)\)
\(de(t) = e(t) - e(t-1)\)

Using fuzzy control rules on-line, PID parameters “\(K_P\)”, “\(K_I\)”, “\(K_D\)” are adjusted, which constitute a self-tuning fuzzy PID controller as shown in Figure 15.

![Fig. 3 - The structure of self-tuning fuzzy PID controller](image)

PID parameters fuzzy self-tuning is to find the fuzzy relationship between the three parameters of PID and "e" and "de", and according to the principle of fuzzy control, to modify the three parameters in order to meet different requirements for control parameters when "e" and "de" are different, and to make the control object a good dynamic and static performance.

In order to improve the performance of FLC, the rules and membership functions are adjusted. The membership functions are adjusted by making the area of membership functions near ZE region narrower to produce finer control resolution. On the other hand, making the area far from ZE region wider gives faster control response. Also the performance can be improved by changing the severity of rules. An experiment to study the effect of rise time \((Tr)\), maximum overshoot \((Mp)\) and steady-state error \((SSE)\) when varying \(K_p\), \(K_i\) and \(K_d\) was conducted. The results of the experiment were used to develop 25-rules for the FLC of \(K_p\), \(K_i\) and \(K_d\).
SIMULATION MODEL AND RESULTS

Fig 4 - Simulink Model for Speed Control of Separately Excited DC motor using self tuned fuzzy PID controller

Fig 5 - Simulink model of fuzzy-PID controller
9.2 OUTPUT RESPONSE

Fig. 7 - speed response of fuzzy pid controller
FIG 8 - Error Vs time response of fuzzy tuned PID controlled DC motor

Fig 9 - Change of speed Vs time response of fuzzy tuned PID controlled DC motor
The three parameters ‘$K_P$’, ‘$K_I$’, ‘$K_D$’ of conventional PID control need to be constantly adjusted online in order to achieve better control performance. Fuzzy self-tuning PID parameters controller can automatically adjust PID parameters in accordance with the speed error and the rate of change of speed error, so it has better self-adaptive capacity. Fuzzy PID parameter controller has smaller overshoot and less rising and settling time than conventional PID controller and has better dynamic response properties and steady-state properties. Steady state error in case of self tuned fuzzy PID is less compared to conventional PID controller. Fuzzy PID controller can reduce system non-linearities but conventional PID controller cannot.
CONCLUSION
In this project we have studied about different method for speed control of DC motor. The steady state operation and its various torque-speeds, torque-current characteristics of DC motor are studied. We have also studied basic definition and terminology of fuzzy logic and fuzzy set. This project introduces a design method of two inputs and three outputs self-tuning fuzzy PID controller and make use of MATLAB fuzzy toolbox to design fuzzy controller. The fuzzy controller adjusted the proportional, integral and derivate (K_P, K_I, K_D) gains of the PID controller according to speed error and change in speed error. From the simulation results it is concluded that, compared with the conventional PID controller, self-tuning PID controller has a better performance in both transient and steady state response. The self-tuning FLC has better dynamic response curve, shorter response time, small overshoot, small steady state error (SSE), high steady precision compared to the conventional PID controller. Conventional PID controller...
cannot remove system non linearities but fuzzy based PID controller can reduced it to minimum resulting in a very smooth and superfine control strategy.

REFERENCES