Speed control of DC Motor by using Fuzzy Logic

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Abstract This paper presents an introduction to fuzzy logic and its application in speed control of dc motor. Lotfi Zadeh, a professor at the university of California at Berkley who conceived the concept of fuzzy logic, and presented not as a control methodology ,but as a way of processing the data by allowing partial set membership rather than crisp set membership or non-membership.This approach to set theory was not applied to control system until the 70's due to insufficient small computer capability prior to that time. Prof zadeh reasoned that people do not require precise, numerical information input, and yet they are capable of highly adaptive control. If feedback controllers could be programmed to accept noisy, imprecise input, they would be much more effective and perhaps easier to implement.

Keywords: fuzzy logic controllers, dc motor control, set theory

I INTRODUCTION TO FUZZY LOGIC

Fuzzy logic is a problem-solving control system methodology that lends itself to implementation in systems ranging from simple, small, embedded microcontrollers to large, networked, multi-channel PC or workstation-based data acquisition and control systems. It can be implemented in hardware, software, or a combination of both. Fuzzy logic provides a simple way to arrive at a definite conclusion based upon vague, ambiguous, imprecise, noisy, or missing input information. Fuzzy logic 's approach to control problems mimics how a person would make decisions, only much faster. Human thinking and decisions are based on 'yes'/'no' reasoning, or 1'/ 0" logic. Accordingly Boolean logic was developed, and Expert System principles were formulated based on Boolean logic.

II FUZZY CONTROL

In general, a control system based on AI is defined as intelligent control. A fuzzy control system essentially embeds the experience and intuition of a human plant operator, and sometimes those of a designer and/or researcher of a plant. The design of a conventional control system is normally based on the mathematical model of a plant. If an accurate model is available with known parameters, it can be analyzed, for example by abode or Nyquist plot, and a controller can be designed for the specified performance. Such a procedure is tedious and time testing, although CAD programs are available for such design. Unfortunately, for complex process, such a cement plants, nuclear reactors, and the like reasonably good mathematical model is difficult to find. On the other hand, the plant operator may have good experience for controlling the process. Power electronics system models are often ill-defined. Even if a plant model is multi variable, complex, and non-linear, such as the dynamic d-q model of an ac machine.

III.FUZZY ASSOCIATED MATRIX (FAM)

Fuzzy Associated Matrix is used to imply the fuzzy rules of the learning rate and momentum parameter .Fuzzy controllers will get the two parameters at the same time evaluate the error and change in the error coefficient. The change in error is the difference between the actual error and last error calculated.

Fuzzy sets are:

1.High Positive(HP)

2.Low positive(LP)

3.zero(z)

5.Low Negative(LN)

E\CE	**HP(-2)**	**LP(-1)**	**Z(0)**	**LN(1)**	**HN(2)**
HP(-2)	**HP**	**LP**	**LP**	**LN**	**Z**
LP(-1)	**HP**	**HP**	**HP**	**Z**	**LN**
Z(0)	**HP**	**HP**	**Z**	**LN**	**HN**
LN(1)	**HP**	**Z**	**LN**	**LN**	**HN**
HN(2)	**Z**	**LP**	**LN**	**HN**	**HN**

6.High Negative(HN)

N=number of fuzzy sets={HP,LP,Z,LN.HN}=5

Number of numerical values=n=N/2-0.5=2

n value ranges between +2 to -2

From this numerical base fuzzy matrix the rule matrix can be drawn as follows

IV DEFUZZIFICATION

Defuzzification is the process of producing a quantifiable result in fuzzy logic, given fuzzy sets and corresponding membership degrees. It is typically needed in fuzzy control systems. These will have a number of rules that transform a number of variables into a fuzzy result, that is, the result is described in terms of membership in fuzzy sets. For example, rules designed to decide how much pressure to apply might result in "Decrease Pressure (15%), Maintain

Pressure (34%), and Increase Pressure (72%)". Defuzzification is interpreting the membership degrees of the fuzzy sets into a specific decision or real value.

The simplest but least useful defuzzification method is to choose the set with the highest membership, in this case, "Increase Pressure" since it has a 72% membership, and ignore the others, and convert this 72% to some number. The problem with this approach is that it loses information. The rules that called for decreasing or maintaining pressure might as well have not been there in this case.

A common and useful defuzzification technique is **Centre of Gravity (COG) Defuzzificztion**. First, the results of the rules must be added together in some way. The most typical fuzzy set membership function has the graph of a triangle. Now, if this triangle were to be cut in a straight horizontal line somewhere between the top and the bottom, and the top portion were to be removed, the remaining portion forms a trapezoid. The first step of defuzzification typically "chops off" parts of the graphs to form trapezoids (or other shapes if the initial shapes were not triangles). For example, if the output has "Decrease Pressure (15%)", then this triangle will be cut 15% the way up from the bottom. In the most common technique, all of these trapezoids are then superimposed one upon another, forming a single geometric shape. Then, the centroid of this shape, called the *fuzzy centroid*, is calculated. The *x* coordinate of the centroid is the defuzzified value.

V SPEED CONTROL OF DC MOTOR

The above speed control system is low cost and suitable for learning at home where being rigorously, mathematically correct is not required. It is important to be aware that this speed controller is only an experimental controller to get familiar with the fuzzy logic concept. It is not what engineers call a rigorous, technically correct application of fuzzy logic. 1. Determine the control system input. Examples: The temperature is the input for your home air conditioner control system. Speed of the car is the input for your cruise control. In our case, input is the speed in Rpm of the DC motor, for which we are going to regulate the speed. See Figure 3 above. Speed error between the speed measured and the target speed of 2,420 Rpm is determined in the program. Speed error may be positive or negative. We measure the DC output voltage from the generator. This voltage is proportional to speed. This speed-proportional voltage is applied to an analog input channel of our fuzzy logic controller, where the analog to digital converter and the personal computer, including appropriate software, measure it.

RULES:

Translate the above into plain English rules (called "linguistic" rules by Dr. Zadeh). These Rules will appear in the BASIC computer program as "If-Then" statements:

Rule 1: If the motor is running too slow, then speed it up.

Rule 2: If motor speed is about right, then not much change is needed.

Rule 3: If motor speed is too fast, then slow it down.

The next three steps use a charting technique that will lead to a computer program. The purpose of the computer Program is to determine the voltage to send to the speed controlled motor. Associate the above inputs and outputs as causes and effect with a Rules Chart, as in Figure shown, below. The chart is made with triangles, the use of which will be explained. Triangles are used, but other shapes, such as bell curves, could also be used. Triangles work just fine and are easy to work with. Width of the triangles can vary. Narrow triangles provide tight control when operating conditions are in their area. Wide triangles provide looser control. Narrow triangles are usually used in the center, at the set point (the target speed). For our example, there are three triangles, as can be seen in

Figure below (three rules, hence three triangles).

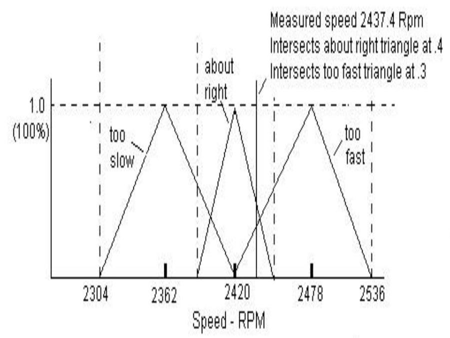

Figure 5. Speed above target value

The above shown figure is derived from the previously discussed Rules and Results in the following regarding voltage to the speed controller:

a. If speed is about right then not much change needed in voltage to the speed controller.
b. If speed is too slow then increase voltage to the speed controller to Speed up.
c. If speed is too fast then decrease voltage to the speed controller to slow down.

The vertical line intersects the about right triangle at .4 and the Too fast Triangle at .3. This is determined by the ratio of sides of congruent triangles from Plane Geometry. The next step is to draw "effect" (output determining) triangles with their height "h" determined by the values obtained in Step, above. The triangles to be drawn are determined by the rules in Step 6. Since the vertical 2,437.4 Rpm speed line does not intersect the too slow triangle, we do not draw the Speed up triangle. We draw the Not much change and the Slowdown triangles because the vertical speed line intersects the about right and Too fast triangles. These "effect" triangles will be used to determine controller output that is the voltage **to send to the speed control transistor.** The result is affected by the widths we have given the triangles and will be calculated. See Figure above. The Not much change triangle has a height of .4 and the Slowdown triangle has a height of .3, because these were the intersect points for their matching "cause" triangles; see Figure above.

CONCLSION

In this paper we have given the introduction of the fuzzy logic and also the Advantages compared with the conventional control methods. Mainly we have explained how the fuzzy logic is used in the speed control of the DC motor.

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