Using Fuzzy Logic Control in Micro-Controller System

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Abstract

Fuzzy logic is a powerful way problem solving with a myriad of in embedded control and information processing and provide a remarkably simple way to draw finite solution from vague, imprecise information. Fuzzy sets allow representing the membership functions as a possibility distribution for the possibility of multiple solutions and offer heuristic solutions to real- world problem. In this paper, fuzzy logic is based on principle of non-precise inputs from the sensors a subjecting them to fuzzy arithmetic and obtaining a crisp values of the processing. The washing machines not using fuzzy logic control that are used to serves all the purpose of washing but which cloth need what amount of agitation time is a business which has not dealt with properly. This paper describes the procedure that can be used to get a suitable washing time for different clothes by using fuzzy logic control (FLC). The most utility is that the customer saves effort to put in brushing, agitating and washing the clothes.

Keywords: fuzzy logic, FLC, washing machines.

1. Introduction

Fuzzy logic (FL) is a multivalued logic, which allows intermediate values to be defined between conventional evaluations like true/false, yes/no, high/low, etc. Notions like rather tall or very fast can be formulated mathematically and processed by computers in order to apply a more human-like way of thinking in the programming of computers [9].

Fuzzy logic in washing machines the easy to use and gaining popularity [1], [7], [10]. These machines offer the advantages of performance, productivity, simplicity and less cost. Sensors continually monitor varying conditions inside the machines and accordingly adjust operations for the best wash result. As there is no standard for fuzzy logic, different machines perform in different manners. Several manufactures in the automatic are using fuzzy to improve technology and reduce development time. Typically, fuzzy logic control the washing machine process, water intake, water temperature, wash time, rinse performance and spin speed.

Fuzzy logic approach requires a sufficient expert knowledge for the formulation of the rule base, the combination of the sets and the defuzzification. This paper is organized as follows: In section 2, related work and problem issues is explained. In section3, described the theory background in detail. In section 4 proposed the implementation of the fuzzy logic control system and section 5 presented the implementation result. In section 6, the general conclusion is formulated.

2. Related Work and Problem Issues

Some earlier works that have used and we can find fuzzy logic in other domestic things such as shower head, rice cookers, and vacuum cleaners, and just about everywhere. The first industrial application of fuzzy logic was in the area of fuzzy controllers. These results were not much notice in the West, but they certainly were in Japan. The Japanese caught the idea and applied it in an automatic-drive fuzzy control system for subway trains in Sendai City. The final product was extremely successful and was generally praised as superior to other comparable system based on classical control [6].

K.M.Passino and S.Yurkovich proposed “Fuzzy Control”. They described the design of a fuzzy controller requires specification of all the fuzzy sets and their membership functions defined for each input and output variable, complication of an appropriate and complete set of heuristic control rules that operates on these fuzzy sets and determination of the method of choosing a crisp output action based on the fuzzy result generated by the control rules [8].

The most users who used to washing machines and other domestic things do not understand the behaviors and effect of fuzzy logic washing machines. Therefore, users are necessary to know behaviors and types of fuzzy logic control of washing machines.

3. Background Theory

Fuzzy logic resembles human decision making with its ability to work from approximately data and find precise solution. In order to design a fuzzy logic control system one has to be describe the operation linguistically. In other words, one has

to identify the inputs and outputs using linguistic variables:

(1) identify the inputs and outputs using linguistic variables;
(2) assign membership function to the variables;
(3) build a rule-base;
(4) generate a crisp control action (defuzzification).

These linguistic variables, membership function and the rule-base system are created from the experience of a skilled operator. The inference mechanism (or inference engine) has two basic tasks:

(1) determining the extent to which each rule is relevant to the current situation as characterized by inputs (it is called matching)
(2) drawing conclusion using the current inputs and the information in the rule-base (it is called this task an 'inference step').

The rule-base consists of a collection of rules of the type: *IF (premise) then (conclusion)*. The premises are conditional expression that operates on the contents of the rule-base. The *fuzzy inference engine* is a natural algorithm in the case of using fuzzy rules. The linguistic quantification used to specify a set of rules (a rule-base) that captures the expert's knowledge about how to control the plant. Two standard forms for IF-THEN rules are multi-input multi-output (MIMO) and multi-input single output (MISO). The inputs are combined logically using the AND operator to produce output response values for all expected inputs.

In this paper, defuzzification to get a real value from fuzzy output, one approach is a weight average method fuzzy logic provides a different way to approach a control or classification problem. This method focuses on what the system should do rather than trying to model how it works.

4. Implementation of the Fuzzy Logic Control System

This paper has been simplified by using only three variables. These three inputs are (1) dirtiness of clothes; (2) type of dirt and (3) type of clothes. The fuzzy controller takes three inputs process the information and outputs the wash time. The person generally select the length of wash time to wash based on the amount of clothes wish to wash and type and degree of dirt clothes have. To automate this process we use sensors to detect these parameters (i.e. type of clothes, type of dirt and dirtiness of clothes). The wash time is then determined from this data. Unfortunately, there is no easy way to formulate a precise mathematical relationship between lengths of wash time required. The sensor system provides external input signal into the machine from which decision can be made. Input/output relationship is not clear the design of a fuzzy logic controller has not in the past lent itself to traditional methods of control design. The working of these sensors is not a matter of concern in this paper. It is assumed that input is sensed by visual interpreter.

Three inputs variables are converted to linguistic variables characterized by their membership functions. This is the process of *fuzzification*, which is equivalent to a crude quantization [4], [5]. The appropriate number of quantization levels are set equal to five and three respectively. The system flow diagram of the process is shown in Fig. 1.

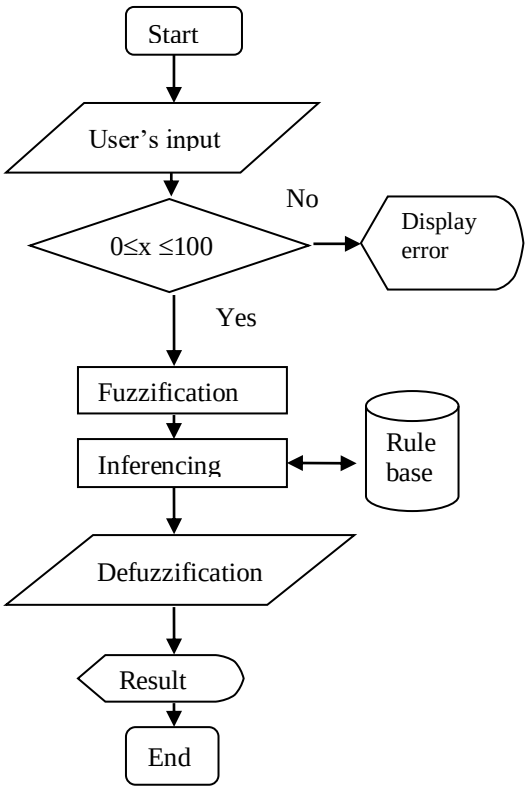

Fig.1 .System flow of the process

4.1 Linguistic variables and their membership functions

Variables whose values are words or sentences in natural or artificial languages are called linguistic variables. To specify rules for the rule-base, the expert will use a "linguistic description"; hence, linguistic expressions are needed for the inputs and outputs. Fuzzy sets and fuzzy logic are used to heuristically quantify the meaning of linguistic variables that are specified by the expert. The concept of a fuzzy set is introduced by first defining a "membership function".

The linguistic variables for dirtiness of clothes are called: zero (Z), small (S), medium (M),

large (L), very large (VL). They have membership functions μ(x) as shown in Fig.2.

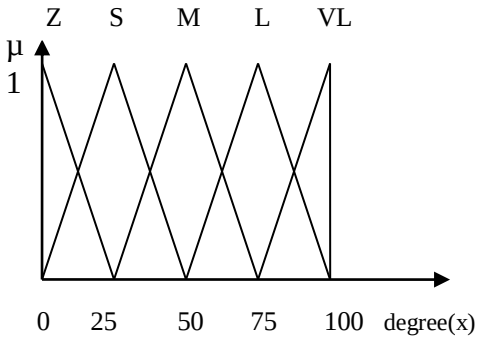

Fig.2 Membership functions for dirtiness of clothes

Similarly, the linguistic variables for type of dirt are called: not greasy (NG), small greasy (SG), medium (M), greasy (G), large greasy (LG). They have membership functions μ(x) as shown in Fig. 3.

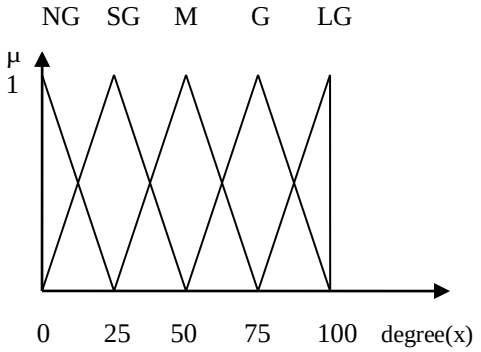

Fig. 3 Membership functions for type of dirt

Similarly, the linguistic variables for type of dirt are called: thick (TK), medium (M), thin (TN). They have membership functions μ(x) as shown in Fig. 4.

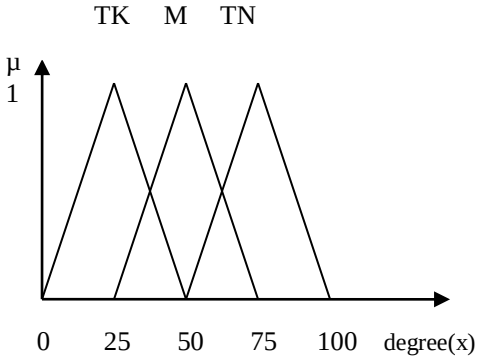

Fig. 4 Membership functions for type of clothes

The appropriate number of quantization levels for output wash time is five and the linguistic variables are called: very short (VS), short (S), medium (M), long (L), very long (VL). They have membership functions μ(x) as shown in Fig. 5.

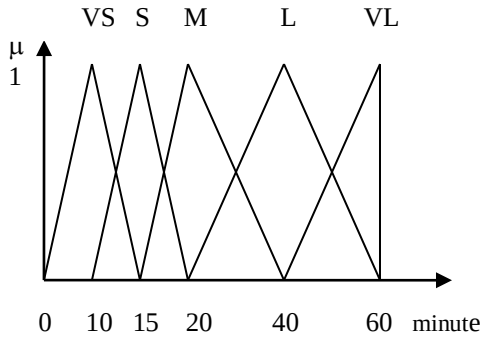

Fig. 5 Membership functions for output wash time

For simplicity, use triangular membership functions of the output are chosen to be the same as the membership functions of the input parameters dirtiness of clothes, type of dirt and type of clothes. The fuzzy law can be expressed by fuzzy rules which are constructed as a *rule-base* table. Fuzzy rules for each inputs x according to the rule-base table as it is shown in Fig. 6, 7 and 8. An example is as follows:

If dirtiness of clothes is medium and type of dirt is greasy and type of clothes is thin then output wash time is medium

Type of clothes = 'TN'

Dirtiness of clothes

Type of dirt	VS	S	M	L	VL
NG	VS	VS	VS	VS	S
SG	VS	VS	S	S	M
M	S	S	M	M	L
G	S	S	M	L	L
L	S	M	L	L	VL

Fig. 6 Fuzzy rule-base table for output wash time

Type of clothes = 'M'

Dirtiness of clothes

Type of dirt	VS	S	M	L	VL
NG	VS	S	S	S	M
SG	S	S	M	M	L
M	S	S	M	L	L
G	S	S	M	L	VL
L	S	M	L	VL	VL

Fig. 7 Fuzzy rule-base table for output wash time

Type of clothes = 'TK'

Dirtiness of clothes

Type of dirt	VS	S	M	L	VL
NG	S	S	S	S	M
SG	S	S	M	M	M
M	S	M	M	L	L
G	M	L	L	VL	VL
L	L	L	VL	VL	VL

Fig. 8 Fuzzy rule-base table for output wash time

The linguistic variables are then mapped into real values by the *defuzzification* operation. The weighted average method is formed by weighting each membership function in the output by its respective maximum membership value. This corresponds to taking the mean or median of the membership function of the variable. The fuzzy weight average defuzzification method has been used:

$$z^* = \frac{\sum \mu_C(\bar{z}).\bar{z}}{\sum \mu_C(\bar{z})} \qquad (1)$$

Where

z* = crisp value of output wash time

$\sum$ = denotes the algebraic sum

$\bar{z}$ = is the centric of each symmetric membership function

μ_c = the membership function value

5. Implementation Result

This system will accept dirtiness of clothes, type of dirt and type of clothes as the input values to make fuzzification. After that related fuzzy set values and membership values can be achieved and viewed in the graphically forms as well as text format as required. By minimizing previous membership value, $\mu_{premise}$ values, as a result are achieved. In the view of inference mechanism, fuzzy conclusion can be made by matching with rule-base built by data and $\mu_{premise}$ value by making fuzzification. Consequently, this fuzzy conclusion can be defuzzification to set crisp value by means of weight average defuzzification method. Implementation results of the system can get as follow:

-The input 1 "Type of dirt" is 40 degree, the fuzzy sets are small greasy and medium.

-The input 2 "Type of clothes" is 30 degree, the fuzzy sets are thick and medium.

- The input 3 "Dirtiness of clothes" is 40 degree, the fuzzy sets are small and medium.

-The crisp values are fuzzified and there are 8 rules in inference engine.

-Weight Average method is used for defuzzification, and then the output is Wash time =16 minutes

6. Conclusions

In this paper there are only three inputs and one output for fuzzy logic control of washing machines. The universe of discourse of the inputs and output cannot be changed by user. Values of the input variables dirtiness of clothes, type of dirt and type of clothes are normalized range 0 to 100 over the domain of optical sensor. The conventional method requires the human interruption to decide upon what should be the wash for different clothes. In other words, this situation analysis ability has been incorporated in the machine which makes the machine much more automatic and represents the decision taking power of the new arrangement. Though the analysis in this paper has been very crud but this clearly depicts the advantages of adding the fuzzy logic controller in the washing machines.

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