

# Dynamic Modeling for Washing Machines with Fuzzy logic

**Khin Thandar Myint, Tha Pyay Win**  
University of Computer Studies, Pakokku  
rapjac43@gmail.com, Thapyay14@gmail.com

## Abstract

*Washing machines, the most important utility, are a common feature today in the world household. A customer can derive the capacities of a washing machine so that the customer saves the efforts including brushing, agitating and washing the cloth. Different types of cloth need different amount of washing time which depends directly on the type of dirt, amount of dirt, cloth quantity etc. The washing machines that are used today (the one not using fuzzy logic control) serve all the purpose of washing mechanism which cloth needs what amount of agitation time is a business which has not been dealt with properly. In most cases, either the user is compelled to give all the cloth same agitation or is provided with a restricted amount of control. This paper aims at presenting the idea of controlling the washing time and water level using fuzzy logic control.*

## 1. Introduction

Fuzzy logic is a rule-based decision process that seeks to solve problems where the system is difficult to model and where ambiguity or vagueness is abundant between two extremes. This logic allows the system to be defined by logic equations rather than complex differential equations and incorporates ways of thinking, which allows modeling complex systems using human knowledge and experience [7]. It can offer several advantages over other problem-solving techniques, such as quicker development time, increased maintainability better performances less expensive hardware and more robustness. In fact, fuzzy logic was originally thought to be better suited for “softer sciences” such as statistics, psychology, sociology, etc [1]. On a mathematical level, fuzzy logic abandons the strict bivalent logic of true and false, one and zero, on and off [6].

Thus the use of fuzzy logic for washing machine control system seems to be promising. These are certain difficulties in modeling and simulating complex real world control system development. Fuzzy control provides a formal methodology for representing, manipulating and implementing a

heuristic knowledge about how to control the system [5]. In order to apply the fuzzy logic in a real world application, a fuzzy logic control system for the determination of the washing time and water level of a washing machine is proposed in this paper. The effectiveness of the fuzzy logic controller in controlling washing machine automation conditions is considered to simulate in this paper. It is designed to work under the window environment.

The system has a number of facilities for easy user manipulation and also analysis of the performances of the fuzzy. In choosing the fuzzy logic controller to control the washing machine, wash-time and water-level are determined according to the input. The user can set up own fuzzy control rules and use the default rules as given. There is also an option for the user to configure the membership functions as desired.

## 2. Related work

The work related to the proposed paper are presented here. Manish Agarwal presents the about of solving the washing machine control problem using fuzzy logic controller which takes two inputs, processes the information and outputs a wash time [2]. Caro Lucas, Rasoul M.Milasi, and Babak N.Araabi use two techniques for washing machine control system. Firstly, neuro fuzzy algorithm has been used for modeling the washing machine. Next, the brain emotional learning based intelligent controller is applied to the model of washing machine. The results show the proposed controller has satisfactory control performance [3].

There are several of defuzzification methods [4] and, the center of average defuzzification techniques is also used to obtain real crisp output in this system.

$$\mu^{crisp} = \frac{\sum_i b_i \int \mu_{premise(i)}}{\sum_i \int \mu_{premise(i)}}$$

where,  $\sum$  = denotes the algebraic sum  
 $b_i$  = area of membership function  
 $\int \mu_{premise}$  = center of membership function

### 3. Background theory

#### 3.1. Introduction

In this section, the explanation of a simple fuzzy logic controller, fuzzy controlled washing machine system, input and output membership function, fuzzy rule bases, inference engine and defuzzification method are represented in details.

#### 3.2. A simple fuzzy logic controller

In this paper, a fuzzy control using linguistic control rules is implemented. There are three steps of procedures in fuzzy logic control. Firstly, it is fuzzification that translates a numeric value for the input into a linguistic value. Then, inference mechanism performs the process according to the fuzzy rules in the rule-base to produce fuzzy set. Finally, defuzzification takes the fuzzy output of the rules and generates a “crisp” value.

#### 3.3. Fuzzy controlled washing machine system

The implementation of an intelligent washing machine automation system using fuzzy logic technology has the capability of mimicking human intelligence for controlling washing machine. Fuzzy controllers are very simple conceptually. It consists of an input stage, a processing stage and an output stage. The input stage maps manually to the appropriate membership functions and truth values. The processing stage involves each appropriate rule and generates a result for each, then combines the results of the rules. Finally, the output stage converts the combined result back into a specific control output value.

In this paper, a fuzzy logic controller was designed for isolated five-main characteristics of clothes: quantity, degree-of-dirt, type-of-dirt, detergent and thickness.

In this Figure 1. shows fuzzy washing machine controller, five fuzzy input variables are chosen. This system will accept quantity, degree-of-dirt, type-of-dirt, detergent and thickness 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 conclusions can be made by matching rule-base built by data and  $\mu_{premise}$  value by making fuzzification.

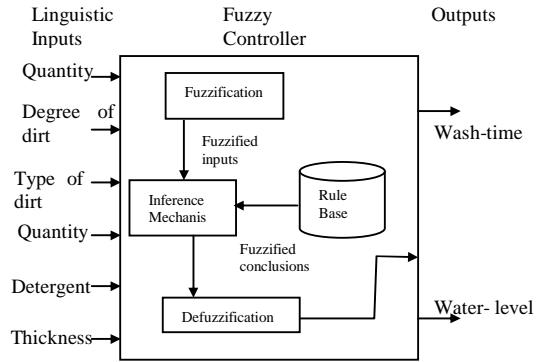


Figure 1. Fuzzy washing machine controller

Consequently, these fuzzy conclusions can be defuzzification to set output value by means defuzzification method, center of average (CA).

#### 3.4. Input and output membership function

For the washing machine control, the input for each output is not related, so the system is implemented with three inputs for each output. The following Table 1 shows the fuzzy variables of “quantity”, “degree-of-dirt”, “type-of-dirt” and “wash-time” of the system. The notations in Table 1 are used to shorten these variables.

Table 1. Linguistic variables of input and output

Fuzzy set						
Quantity	Sym- bol	Degree- of-dirt	Sym- bol	Type-of- dirt	Sym- bol	Wash- Time
Small Quantity	SQ	Small	SM	Not Greasy	NG	Very Short
Medium Quantity	MQ	Medium	ME	Medium Greasy	MG	Short
Large Quantity	LQ	Large	LA	Very Greasy	VG	Medium
						Long
						Very Long

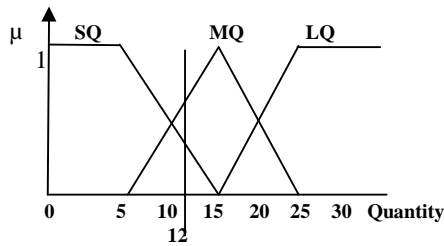
The graphical representation of membership function of the linguistic variable is presented in Figure 1 in which y-axis is the degree of the membership of each of the fuzzy variable. For the output fuzzy variable, the universes of discourse are the length of wash-time.

For the washing machine control, the following Table 2 shows the fuzzy variables of “Quantity”, “Detergent”, “thickness” and “water-level” of the system. The notations in Table 2 are used to shorten these variables.

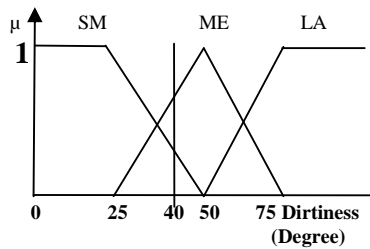
Table 2. Linguistic variables of input and output

Fuzzy set						
Quantity	Sym- bol	Deter- gent	Sym- bol	Thick- ness	Sym- bol	Water- Level
Small Quantity	SQ	Small	S	Light	LIG	Least
Medium Quantity	MQ	Medium	M	Mediu m	ME D	Little
Large Quantity	LQ	Large	L	Heavy	HEA	Many
						More
						Most

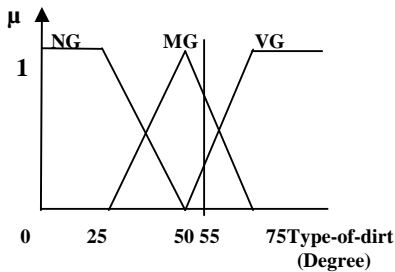
For example, the quantity value and degree-of-dirt value are assigned with 12 and 40 as shown in Figure 2. (a) and (b) respectively. Additionally, type-of-dirt is also used with 50 and then the membership degrees are calculated by L- function and triangular-function and the results are represented  $\mu$  values. At the present, the quantity is included in both (SQ, MQ). Similarly, degree-of-dirt and type-of-dirt are also contained in the range of (SM, ME) and (MG, VG). Finally, the membership values of this experimentation are 0.6, 0.4, 0.3 and 0.2 according to the quantity of 12, degree of 40 and degree of 50, respectively.



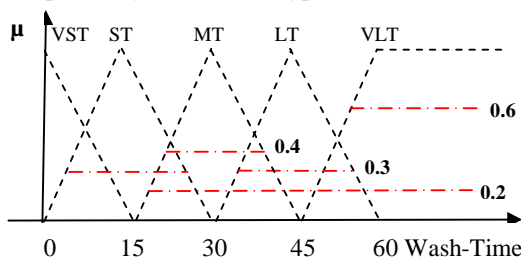
(a) Input Fuzzy Variable 1: Quantity



(b) Input fuzzy variable 2: Degree-of-dirt



(c) Input fuzzy variable 3: Type-of-dirt



(d) Output Fuzzy Variable 1: Wash-time

Figure 2. Graphical representation of membership functions of the fuzzy logic controller

### 3.5. Fuzzy Rule Bases

Fuzzy rules can be defined according to the values of outputs from wash-time and water-level. In wash-time table, table rows are represented by quantity and columns are represented by degree-of-dirt and type-of-dirt. Fuzzy rules for wash-time are achieved in this rule table. For example, if Quantity is SQ and Degree-of-Dirt is SM and Type-of-Dirt is NG then Wash-Time is VST. Similarly, if Quantity is MQ and Degree-of-Dirt is ME and Type-of-Dirt is MG then Wash-Time is VLT. Finally, if Quantity is LQ and Degree-of-Dirt is ME and Type-of-Dirt is NG and Wash-Time is LT. The total rules are taken from the above procedure.

Table 3. Fuzzy Rule Matrix For Wash-Time Degree-of-Dirt/ Type-of-Dirt

		SM/NG	SM/MG	SM/VG	ME/NG	ME/MG	ME/VG	LA/NG	LA/MG	LA/VG
Q U A N T I T Y	SQ	VST	ST	MT	ST	LT	LT	MT	MT	VLT
	MQ	MT	MT	LT	MT	VLT	VLT	LT	LT	VLT
	LQ	LT	LT	VLT	LT	VLT	VLT	VLT	VLT	VLT

Output  $\Rightarrow$  Wash-Time

Table 4. Fuzzy Rule Matrix for Water-Level Detergent/Thickness

		S/LIG	S/MED	S/HEA	M/LIG	M/MED	M/HEA	L/LIG	L/MED
L W A T E R L E V E L	USQ	LT	LI	MY	MY	ME	ME	MT	MT
	TMQ	LI	MY	MY	ME	ME	MT	MT	MT
	YLQ	MY	MY	ME	ME	MT	MT	MT	MT

Output  $\Rightarrow$  Water-Level

In water-level table, table rows are represented by quantity and columns are also represented by detergent and thickness. Fuzzy rules for water-level are achieved in this rule table. For example, if Quantity is SQ and Detergent is S and Thickness is LIG then Water-Level is LT. Similarly, if Quantity is MQ and Detergent is M and Thickness is MED then Water-Level is ME. Finally, if Quantity is MQ and Detergent is L and Thickness is LIG then Water-Level is MT and so on.

### 3.6. Inference Engine and Defuzzification

In the washing machine fuzzy control system, the max-min implication technique, area of a trapezium method and area of triangle method are

used. Using this technique, the final output membership function for each rule is the fuzzy set assigned to that output by clipping the degree of truth values of the membership degree of each output fuzzy variable is determined, all the rules that are being fired are then combined and actual crisp output is obtained through defuzzification.

#### 4. Experimental Results

Washing Machine control simulation is implemented by using fuzzy logic. At the starting of the operation for the washing machine, the water-level is gradually increased to adjust the wash-time to comfort the clothes from tearing and short life. In this system, it has sixty minutes maximum washing time and the water-level has maximum 100 litres.



Figure 3. The result form of the system with the input variables

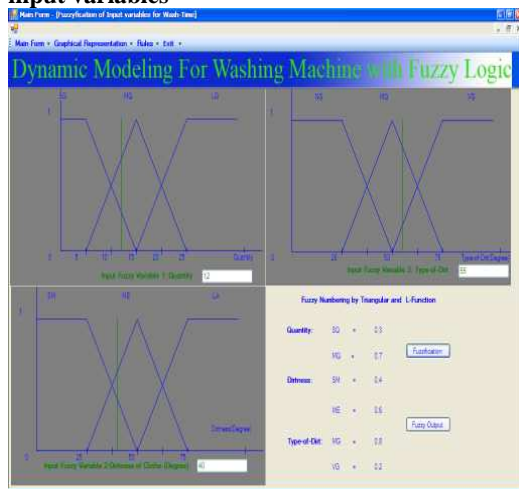


Figure 4. The graph form of the input membership function

During the operation, additional adjusting may encounter. When update of input values comes across, the wash-time and water-level will be increased or decreased to adjust the operation according to the new update of inputs.

When the wash-time is long, the water-level will operate more and when wash-time reaches zero, the water-level will zero.

#### 5. Conclusion

The purpose of this paper is to be automatically control of the washing machine's wash-time and water-level according to the inputs quantity, degree-of-dirt, type-of-dirt, detergent and thickness. Fuzzy logic controlled washing machine was accomplished to control time consumption. The fuzzy logic controller is better than fixed time controller because it makes use of linguistic variables rules and these linguistic variables can be naturally represented by fuzzy sets and logical connectives of these sets which are consistent with natural languages of human use. That is the advantages of fuzzy logic control system.

#### 7.Limitations and Further Extension

A more fully automatic washing machine is straightforward to design using fuzzy logic technology. The process is entirely based on the principle of taking non-precise inputs from the sensors, subjecting them to fuzzy arithmetic and obtaining a crisp value of the washing time. The working of the sensors is not a matter in this simulating system. Moreover, the design process mimics human intuition, which adds to the ease of development and future maintenance. Although this particular example controls only the wash-time and water-level of a washing machine, the design process can be extended without undue complications to other control variables such as spin speed. The formulation and implementation of membership functions rules are similar to that shown for wash-time and and water-level.

#### 8. References

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