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# Simulating Matlab Rules in Fuzzy Controller Based Washing Machine

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**Abstract**
*Fuzzy logic enables designers to control complex systems more effectively than traditional approaches. As it provides a simple way to arrive at definite conclusion upon ambiguous, imprecise or noisy information. In this paper we have proposed the design of fuzzy logic controller having three inputs to give correct spin period of washing machine. The objective is to save lot of time, electricity and water for washing the cloth. The paper describes the procedure that can be used to get a suitable spin period for different cloths. The proposed FLC is simulated using Fuzzy Logic Toolbox of MATLAB. The result is used to calculate the spin period for different type of input conditions The process is based entirely on the principle of taking non-precise inputs from the sensors subjecting them to fuzzy arithmetic and obtaining a crisp value of spin period.*
**Keywords:** *FIS Editor, Fuzzy Logic Controller, Matlab, Rules of the system, Response Surface of the Input Output relations*

## 1. Introduction

Washing machines are common house hold items and to have a washing machine that efficiently controls the wash time is vital. Conventional, proportional, integral and differential [PID] controllers have proven to be less capable in such control situations. In recent years there has been a growing interest in applying Fuzzy logic for control. A washing machine is a machine to wash laundry, such as clothing and sheets. Washing entails immersing, dipping, rubbing, or scrubbing in water usually accompanied by detergent, or bleach. The simplest machines may simply agitate clothes in water while switched on; automatic machines may fill, empty, wash, spin, and heat in a cycle. Most washing machines remove substantial amounts of water from the laundry at the end of a wash cycle, but do not completely dry it.

Washing by hand involves soaking, beating, scrubbing, and rinsing dirty textiles. Water for the laundry would be hand carried, heated on a fire for washing, and then poured into the tub. That made the warm soapy water precious; it would be reused, first to wash the least soiled clothing, then to wash progressively dirtier laundry. Removal of soap and water from the clothing after washing was originally a separate process. First soap would be rinsed out with clear water. After rinsing, the soaking wet clothing would be formed into a roll and twisted by hand to extract water. The entire process often occupied an entire day of hard work, plus drying and ironing.

After the World War II, numerous appliance manufacturers were given permission to undertake the research and development of washers during the war years. Many took the opportunity to develop automatic machines, realizing that these represented the future for the industry.A large number of manufacturers introduced automatic machines (mainly of the top-loading type) in the late 1940s and early 1950s. An improved front-loading automatic model, *the Bendix Deluxe* was introduced in 1947. General Electric also introduced its first top loading automatic model in 1947. This machine had many of the features that are incorporated into modern machines. Several manufacturers produced semi-automatic machines, requiring the user to

intervene at one or two points in the wash cycle. A common semi-automatic type included two tubs: one with an agitator or impeller for washing, plus another smaller tub for water extraction or centrifugal rinsing.

**Fuzzy logic:** In 1965 the concept of fuzzy logic was first conceived by Professor Lofti A. Zadeh University of California Berkely[1]. Fuzzy logic is used to monitor non linear systems which are difficult to deal mathematically. The non-probabilistic, uncertainties issues are monitored by fuzzy logic and fuzzy set theory[2]. The development of fuzzy logic theory now stimulated alternative ways to solve automatic control problems.

Based on these basic ideas of fuzzy logic Mamdani and Assilian proposed fuzzy controllers which describe human control in linguistic form. Consequently the first applications of fuzzy control replaced a human operator[4]. Fuzzy logic controllers for Gas Heater was designed using behavioral modeling and then these modules are connected via structural VHDL to control "valve angle" [5].

For about 20 years, contributions on fuzzy control were presented at conferences and in the control literature, but the field of fuzzy control did not obtain high attention for a longer period. It is only recently about 1990 that the interest in fuzzy control has increased strongly because of successes and advertisement of applications in Japanese consumer products such as washing machines and camcorders. Moreover, successful fuzzy control of industrial processes, such as, e.g., a cement kiln in Denmark in train operation, or simulations for ship steering [3]. Since then, a controversial discussion has been going on concerning the merits of fuzzy control versus conventional control.

**Fuzzy logic Controller for Washing Machine:** In 2007, the fuzzy inference is used for determining wash time. In this design MF used was triangular; the inputs of fuzzy Controller were Change of turbidity and turbidity, the output was Washing Time [6].

In 2009, Pritesh Lohani, proposed "An improved Controller Microchip for washing machine" that comprises three inputs and one output [8].

In 2011, Manish Agarwal, proposed the fuzzy logic control for washing machine having two inputs and one output with the fuzzy inference engine which provides 9 rules for the FLC [7].

This paper aims at presenting the idea of controlling the spin period using fuzzy logic control. The paper describes the procedure that can be used to get suitable spin period for different types of cloths (Cotton, Woolen, Silk) dirtiness of clothes and Mass of cloths. The process is based entirely on the principle of taking non-precise inputs from sensors, subjecting them to fuzzy arithmetic and obtaining a crisp value of the spin period. It is quite clear that from the paper itself that this method can be used in practice to further automate the washing machines.

## 2. Proposed Design

When one uses a washing machine, the person generally select the length of spin period based on the amount of clothes he/she wish to wash and the type and degree of dirt cloths have. Unfortunately, there is no easy way to formulate a precise mathematical relationship between volume of clothes and dirt and the length of spin period required.

Consequently, this problem has remained unsolved until very recently. Conventionally, people simply set spin period by hand and from personal trial and error experience. Washing machines were not as automatic as they could be. The users of washing machines have been facing the problem of selecting the length of spin period based on the type of clothes, type of dirt, dirtiness of clothes and amount of clothes.

Most of the people find it very difficult to decide that which cloth needs what amount of spin period To overcome these problems, Fuzzy based washing machine have the sensor based program which checks for the extents of dirt and grease, amount of detergent and water to add which accordingly adjust the spin priod. In this paper, we have introduced three input variables and one output fuzzy logic controller to get correct spin period.

## 3. Principles of washing machine

To understand how a washing machine cleans, we must understand the components of washing machines

**Important parts of the washing machine:**

Water inlet control valve, Water pump, Tube (washer drum), Agitator, Motor, Door safety sensor, Detergent drawer, Drain pipe, Controller, Mechanical programmer.

### 3.1 Wash Sensor (Optical sensor)

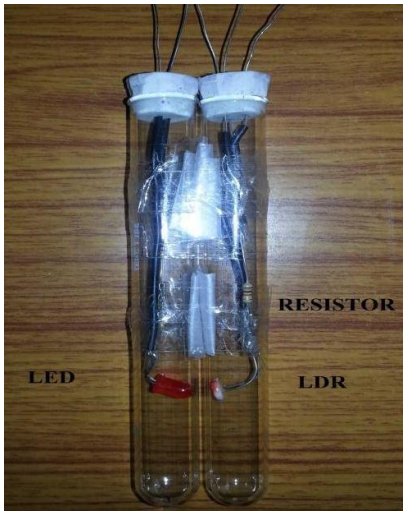


**Figure 1:** Wash Sensor (Optical sensor)

An optical sensor is a device that converts light rays into electronic signals. It measures the physical quantity of light and translates it into a form read by the instrument. The features of an optical sensor are its ability to measure the changes from one or more light beams.

A washing machine includes an optical sensor for detecting a light permeability of detergent solution and rinse water in a washer tank. The optical sensor includes a light emitting element and a light receiving element. A microprocessor (Fuzzy Controller) is provided for controlling a luminous intensity of the light emitted from the light emitting element.

### 3.2 How Wash sensor work

The working of the sensors is not a matter of concern. We assume that we have these inputs at our hand.

**3.2.1 The degree of dirt** is determined by the transparency of the wash water. The dirtier the clothes, less transparent the water being analyzed by the sensors is.

**3.2.2 Type of dirt** determines the quality of dirt. Greasy cloths, for example, take longer for water transparency to reach transparency because grease is less soluble in water than other forms of dirt. Type of dirt is determined by the **time of saturation**.

**3.2.3 Saturation** is a point, at which there is no more appreciable change in the color of the water.

**Unfortunately**, there is no easy way to formulate a precise mathematical relationship between **volume of clothes** and **dirt** and the **length of spin period** required. Because the input/output relationship is not clear, the design of a washing machine controller has not in the past lent itself to traditional methods of control design. We address this design problem using fuzzy logic.

Fuzzy logic has been used because a fuzzy logic controlled washing machine controller gives the correct spin period even though a precise model of the input/output relationship is not available.

## 4. Proposed Design

The proposed Fuzzy Logic Controller for washing machine consists of three Linguistic Inputs i.e.

1. Type of Dirt
2. Dirtiness of cloths
3. Mass of cloths

All the above Linguistic Inputs control the one Linguistic output i.e. spin period

The proposed Fuzzy Logic Controller inference engine is designed using rules for spin period. The rules formed in this research are derived from the common sense and purely based on experience from a typical home use. Every Linguistic inputs and outputs has a set of membership functions. The MF used for all LIs and LOs is triangular MF.

The X-axis of all the MF graphs represents the LI values which are obtained from the sensors and it ranges from 0 to 1 up to first whereas the Y-axis of

all MF graph denotes the degree of membership function.

**Fuzzy controller:-**

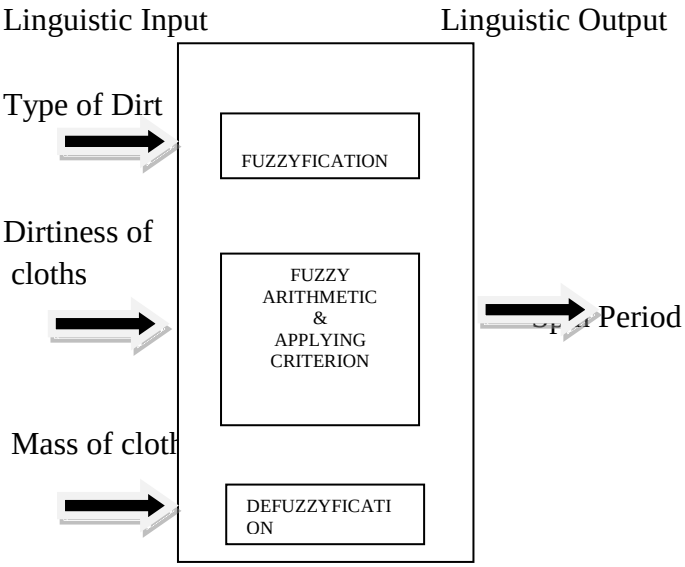


**Figure 2:** FLC for Washing machine

Fuzzy Logic Controller for Washing Machine consists of mainly three blocks i.e. Fuzzifier, Fuzzy Rule select and defuzzifier

In a conventional washing machine the time of each run is set by the user if insufficient time is set for a given load of cloths they are not properly washed if the spin time is overly long the time and energy wasted and machine as well as the cloths are unnecessarily worn out.

Once the washing machine is loaded with dirty laundry it begins to calculate how dirty the laundry is and how long it would take to wash it. If machine takes ten minutes to wash cloths it calculate how dirty the laundry is if the load is 100% dirty then it adds two minutes per piece of dirty laundry to the wash cycle that would have taken ten minutes originally. if the laundry is 50% dirty then it would add 50% of two minutes . this means a minute to the ten minute wash cycle. if the laundry is greasy then an additional two minutes are added to the cycle if the laundry is dirty and greasy then the machine factors in 4 additional minutes to the entire load.

A Fuzzy machine would also have to take into account the amount of soap it would require for dirty cloths, greasy cloths, and dirty and greasy cloths this require complex calculations which the machine is programmed to do. The machine would also require drawing sufficient water accommodate all the calculations in to a wash cycle.

The operating time of washing machine depends on two properties of each given load of cloths

a) It depends of how dirty the cloths are
b) It depends on the type of soil

The degree of dirtiness is measured by a special sensor Via the degree of water transparency. The less transparent the water , the dirtier the cloths and the type of soil is determined by measuring the time needed after the machine has started, to reach a state in which the water transparency remains constant this time is called saturation time and is different for different types of soil.

**5. Details about the set applied**

**Fuzzification:** Fuzzification is the first step in the fuzzy inferencing process. This involves a domain transformation where crisp inputs are transformed into fuzzy inputs. Crisp inputs are exact inputs measured by sensors and passed into the control system for processing, such as temperature, pressure, etc.. Each crisp input that is to be processed by the FIU has its own group of membership functions or sets to which they are transformed. This group of membership functions exists within a universe of discourse that holds all relevant values that the crisp input can possess. The following shows the structure of membership functions within a universe of discourse for a crisp input.

where: degree of membership: degree to which a crisp value is compatible to a membership function, value from 0 to 1, also known as truth value or fuzzy input.

MF: defines a fuzzy set by mapping crisp values from its domain to the sets associated degree of membership.

crisp inputs: distinct or exact inputs to a certain system variable, usually measured parameters external from the control system, e.g. 6 Volts.

label: descriptive name used to identify a membership function.

scope: or domain, the width of the membership function, the range of concepts, usually numbers, over which a membership function is mapped.

universe of discourse: range of all possible value or concepts, applicable to a system variable. and When designing the number of membership functions for an input variable, labels must initially be determined for the membership functions.

***Rules:-***

***Table** : Rule for Fuzzy Wash Time control*

| RULE NUMBER | LINGUISTIC INPUTS | | | LINGUISTIC OUTPUT |
|---|---|---|---|---|
| | **Type of Dirt** | **Dirtiness of Cloth** | Mass **of Clothes** | **Spin period** |
| 1 | Not Greasy | Small | Light | Veryshort |
| 2 | Not Greasy | Small | Medium | Short |
| 3 | Not Greasy | Small | Heavy | Medium |
| 4 | Not Greasy | Medium | Light | Medium |
| 5 | Not Greasy | Medium | Medium | Medium |
| 6 | Not Greasy | Medium | Heavy | Long |
| 7 | Not Greasy | Large | Light | Medium |
| 8 | Not Greasy | Large | Medium | Medium |
| 9 | Not Greasy | Large | Heavy | Long |
| 10 | Medium | Small | Light | Short |
| 11 | Medium | Small | Medium | Medium |
| 12 | Medium | Small | Heavy | Long |
| 13 | Medium | Medium | Light | Medium |
| 14 | Medium | Medium | Medium | Long |
| 15 | Medium | Medium | Heavy | Long |
| 16 | Medium | Large | Light | Short |
| 17 | Medium | Large | Medium | Long |
| 18 | Medium | Large | Heavy | Long |
| 19 | Greasy | Small | Light | Short |
| 20 | Greasy | Small | Medium | Medium |
| 21 | Greasy | Small | Heavy | Long |
| 22 | Greasy | Medium | Light | Medium |
| 23 | Greasy | Medium | Medium | Long |
| 24 | Greasy | Medium | Heavy | Very Long |
| 25 | Greasy | Large | Light | Medium |
| 26 | Greasy | Large | Medium | Long |
| 27 | Greasy | Large | Heavy | Very Long |

The rules obtained can be read in terms of IF and THEN statements as shown in below.

**Rule 1:**

IF (Type of Dirt is not Greasy) and (Dirtiness of Cloth is Small ) and (Mass of Cloth is Light) THEN (spin period is Short).

**Rule2:**

IF (Type of Dirt is not Greasy) and (Dirtiness of Cloth is Small) and (Mass of Cloth is Heavy) THEN (spin period is Very Long).

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**Rule 27:**

IF (Type of Dirt is not Greasy) and (Dirtiness of Cloth is Large) and (Mass of Cloth is Heavy) THEN (spin period is Very Long).

The rules too have been defined in imprecise sense and hence they too are not crisp but fuzzy values The three input parameters after being read from the sensors are fuzzified as per the membership function of the respective variable these in additions with the membership function curve are utilized to come to a solution (using some criteria).

At last the crisp value of the spin period is obtained as an answer.

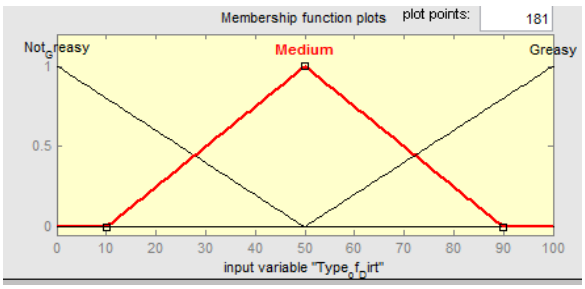


**Fig: 3(a)** A membership for input variable Type of Dirt

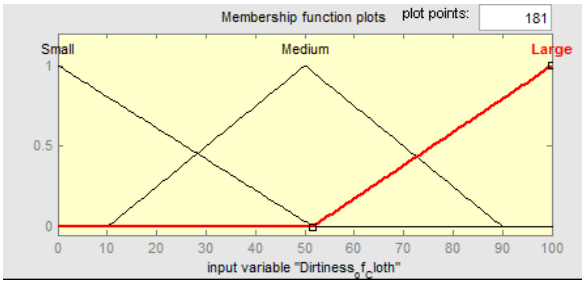


**Fig: 3(b)** A membershipfor inputvariable Dirtiness of Cloth

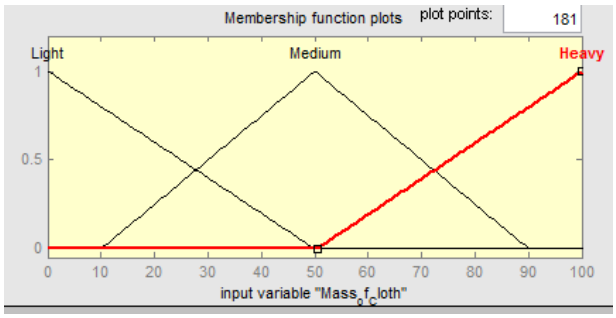


**Fig: 3(c)** A membership for input variable Mass of Cloth

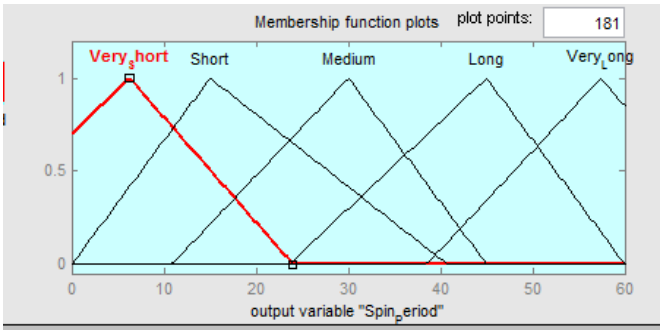


**Fig: 3(d)** A membership for Output variable Spin Time

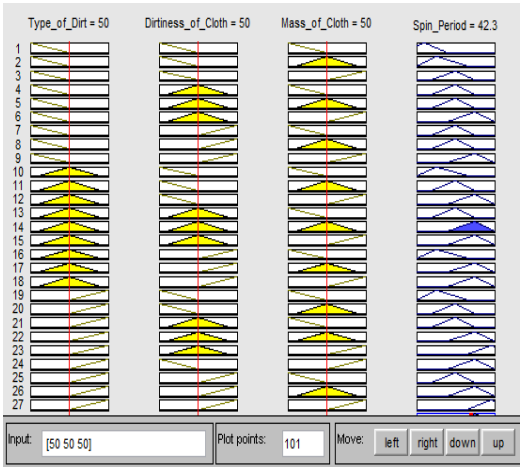


**Fig 4 :-** Rules of the System

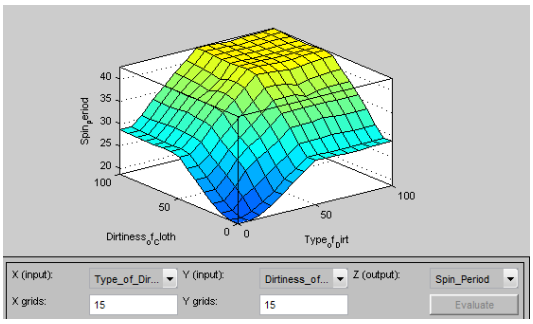


**Fig 5(a):-** 5 Response surface of the input output relations

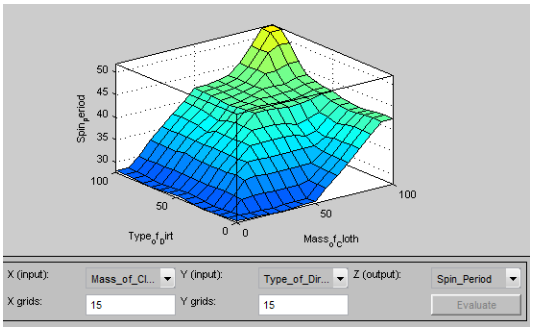


**Fig 5(b):-** 5 Response surface of the input output relations

**Defuzzification:** The result obtained from fuzzy inference technique is then processed to produce a quantifiable result i.e. the total time it takes to spin the clothes (Spin Time).

Defuzzification process is used to interpret the membership degrees of the fuzzy sets in some specific real value (i.e. in crisp value opposite to that Fuzzification do). Centroid method is used for defuzzification to get a scalar output value for the actual duration of the spin cycle from the output function obtained.

$$\text{Spin Period} = \bar{X}(centroid) = \frac{\sum_{1}^{60} x\mu(x)}{\sum_{1}^{60} \mu(x)}$$

$$= 42.3 \text{ minutes.}$$

## 6. Conclusion

By the use of fuzzy logic control we have been able to obtain a Spin period for different type of dirt and different degree of dirt and different Mass of cloths. The conventional method required human interruption to decide upon what should be the spin time for different cloths. 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.

Here the sensors sense the input values and using the above Model the inputs are fuzzyfied and then by using simple if-else rules and other simple fuzzy set operations the output fuzzy function is obtained and using the criteria the output value for spin period is obtained. Figure 5. shows the response surface of

the input output relations as determined by fuzzy interface unit. This is the fundamental unit in which the application interface FIDE encodes controller information.

The results (the above plot) shows the way the machine will response in different conditions. For example, if we take type of dirt and dirtiness of cloth value as 50, the spin period which the model output is equivalent to 42.3 mins. This is quite convincing and appropriate.

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