



# A Novel Approach for Designing FKBC Based Washing Machine Controller

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## Abstract

*Washing machines are a common feature today in the Indian household. The most important utility a customer can derive from a washing machine is that he saves the effort he/she had to put in brushing, agitating and washing the cloth. Most of the people wouldn't have noticed (but can reason out very well) that different type of cloth need different amount of washing time which depends directly on the type of dirt, amount of dirt, cloth quality etc. The washing machines that are used today (the one not using fuzzy logic control) serves all the purpose of washing, but which cloth needs what amount of agitation time is a business which has not been dealt with properly. In most of the cases either the user is compelled to give all the cloth same agitation or is provided with a restricted amount of control. The thing is that the washing machines used are not as automatic as they should be and can be. This paper aims at presenting the idea of controlling the washing time using fuzzy Knowledge Based Control (FKBC). The paper describes the procedure that can be used to get a suitable washing time for different cloths. 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 the washing time. It is quite clear from the paper itself that this method can be used in practice to further automate the washing machines. Never the less, this method, though with much larger number of input parameters and further complex situations, is being used by the giants like LG and Samsung.*

**Key Words:** fuzzy Knowledge Based Control (FKBC); MATLAB; Membership Functions; Fuzzification; De-fuzzification

## Problem Definition

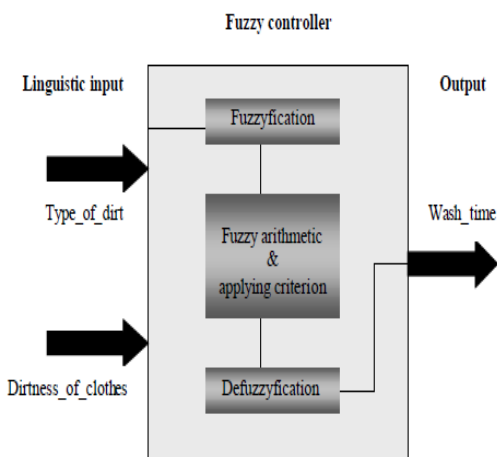
When one uses a washing machine, the person generally select the length of wash time based on the amount of clothes he/she wish to wash and the type and degree of dirt cloths have. To automate this process, we use sensors to detect these parameters (i.e. volume of clothes, degree and type of dirt). The wash time is then determined from this data. Unfortunately, there is no easy way to formulate a precise mathematical relationship between volume of clothes and dirt and the length of wash time required. Consequently, this problem has remained unsolved until very recently. Conventionally, people simply set wash times by hand and from personal trial and error experience. Washing machines were not as automatic as they could be. The sensor system provides external input signals into the machine from which decisions can be made. It is the controller's responsibility to make the decisions and to signal the outside world by some form of output. 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 wash time even though a precise model of the input/output relationship is not available.

## Details about the Problem

The problem in this paper has been simplified by using only two variables. The two inputs are:

1. Degree of dirt
2. Type of dirt

Figure 1 shows the basic approach to the problem. The fuzzy controller takes two inputs (as stated for simplification), processes the information and outputs a wash time. How to get these two inputs can be left to the sensors (optical, electrical or any type). The working of the sensors is not a matter of concern in this paper. We assume that we have these inputs at our hand. Anyway the two stated points need a bit of introduction which follows. 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. On the other hand, type of dirt is determined by the time of saturation, the time it takes to reach saturation. Saturation is a point, at which there is no more appreciable change in the color of the water. Degree of dirt determines how much dirty a cloth is. Where as 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. Thus a fairly straight forward sensor system can provide us the necessary input for our fuzzy controller.



**Figure 1: Basic block diagram of the process**

### Details about the set applied

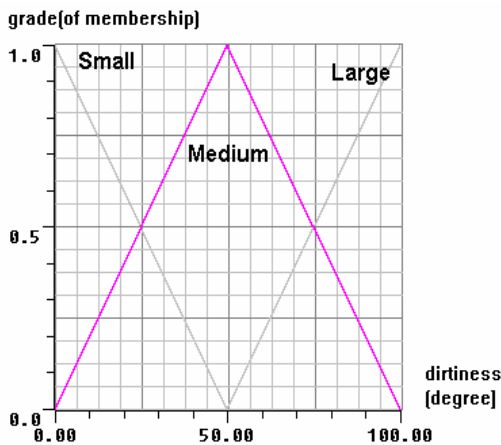
Before the details of the fuzzy controller are dealt with, the range of possible values for the input and output variables are determined. These (in language of Fuzzy Set theory) are the membership functions used to map the real world measurement values to the fuzzy values, so that the operations can be applied on them. Figure 2 shows the labels of input and output variables and their associated membership functions. Values of the input variables degree\_of\_dirt and type\_of\_dirt are normalized range -1 to 100) over the domain of optical sensor.

The decision which the fuzzy controller makes is derived from the rules which are stored in the database. These are stored in a set of rules. Basically the rules are if-then statements that are intuitive and easy to understand, since they are nothing but common English statements. Rules used in this paper are derived from common sense, data taken from typical home use, and experimentation in a controlled environment. The sets of rules used here to derive the output are:

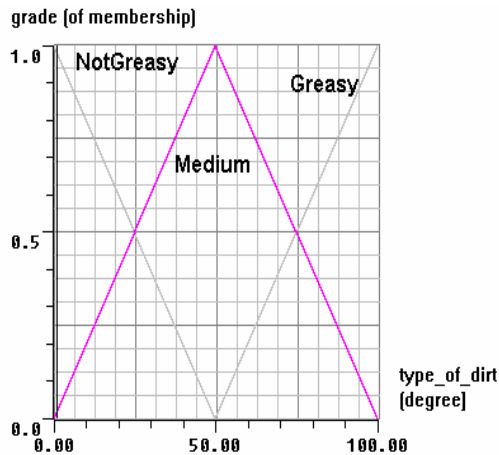
1. If dirtiness\_of\_clothes is Large and type\_of\_dirt is Greasy, then  
 wash\_time is Very Long;
2. If dirtiness\_of\_clothes is Medium and type\_of\_dirt is Greasy then wash\_time is Long;
3. If dirtiness\_of\_clothes is Small and type\_of\_dirt is Greasy then wash\_time is Long;
4. If dirtiness\_of\_clothes is Large and type\_of\_dirt is Medium then wash\_time is Long;
5. If dirtiness\_of\_clothes is Medium and type\_of\_dirt is Medium then wash\_time is Medium;
6. If dirtiness\_of\_clothes is Small and type\_of\_dirt is Medium then wash\_time is Medium;

7. If dirtiness\_of\_clothes is Large and type\_of\_dirt is NotGreasy then wash\_time is Medium;
8. If dirtiness\_of\_clothes is Medium and type\_of\_dirt is NotGreasy then wash\_time is Short;
9. If dirtiness\_of\_clothes is Small and type\_of\_dirt is NotGreasy then wash\_time is Very Short

These rules have been shown as membership functions in figure 2.



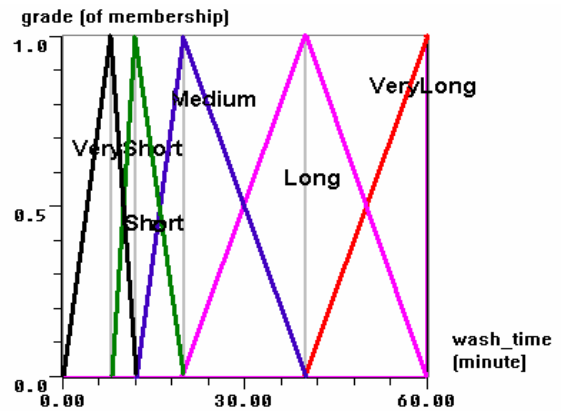
**Figure 2a: Membership function for dirtiness\_of\_clothes**



**Figure 2b: Membership Function of type\_of\_dirt**

The rules too have been defined in imprecise sense and hence they too are not crisp but fuzzy values.

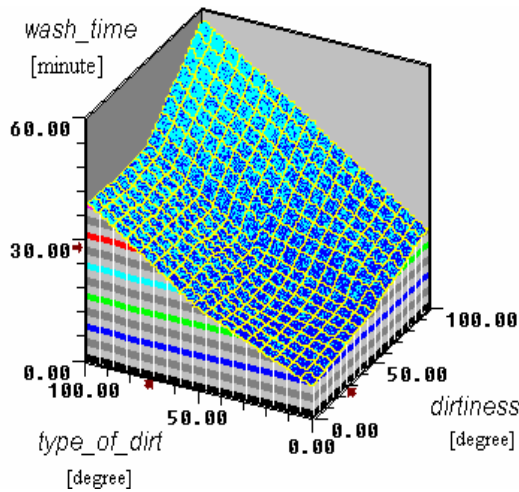
The two input parameters after being read from the sensors are fuzzified as per the membership function of the respective variables. These in additions with the membership function curve are utilized to come to a solution (using some criteria). At last the crisp value of the wash\_time is obtained as an answer.



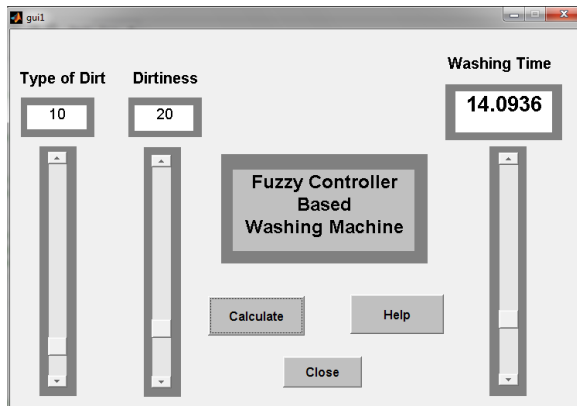
**Figure 3: Labels and membership functions for output variable wash\_time**

**Results and discussion**

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 wash time is obtained. Figure 4 shows the response surface of the input - output relations as determined by FIU. FIU stands for Fuzzy Interface Unit. This is the fundamental unit in which the application interface FIDE encodes controller information.



**Figure 4: Input/Output response surfaces**



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 value both to be 100, the wash\_time which the model output is equivalent to 60 mins. This is quite convincing and appropriate.

**GUI**

**Conclusion**

By the use of fuzzy Knowledge Based Control (FKBC), we have been able to obtain a wash time for different type of dirt and different degree of dirt. The conventional method required the human interruption to decide upon what should be the wash 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. Though the analysis in this paper has been very crude, but this clearly depicts the advantage of adding the fuzzy logic controller in the conventional washing machine.

**Future Directions**

A more fully automatic washing machine is straightforward to design using fuzzy logic technology. 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 of a washing machine, the design process can be extended without undue complications to other control variables such as water level and spin speed. The formulation and implementation of membership functions and rules is similar to that shown for wash time.

**References:**

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- [3.] Weijing Zhang, Applications Engineer, Apronics Incorporated, Copyright © 1992 by Apronix Inc.