OPTIMIZE WASH TIME OF WASHING MACHINE USING FUZZY LOGIC

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ABSTRACT

Washing machines are a common feature today in our 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.

Keywords: Fuzzy Logic, Washing Machine, Optimization

1. INTRODUCTION

This paper aims at presenting the idea of controlling the washing time using fuzzy logic control. 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.

2. 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.

3. 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 analysed 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.

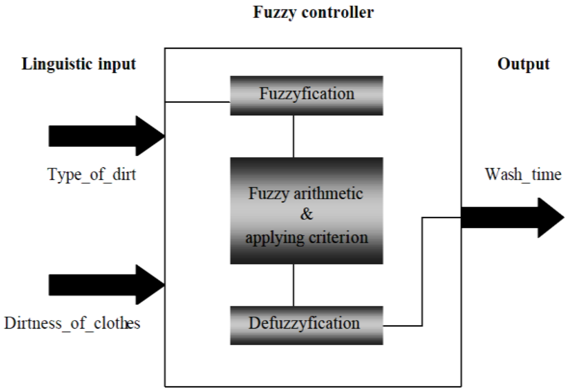


Figure 1 The shape of the membership function.

4. DETAILS ABOUT THE SET APPLIED

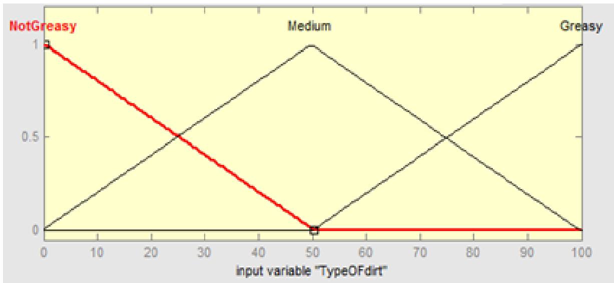
Before the details of the fuzzy controller are dealt with, the range of possible values for the input and output variables are determined. These (in language of Fuzzy Set theory) are the membership functions used to map the real world measurement values to the fuzzy values, so that the operations can be applied on them. Values of the input variables degree_of_dirt and type_of_dirt are normalized range -1 to 100) over the domain of optical sensor (see figure 2).

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.

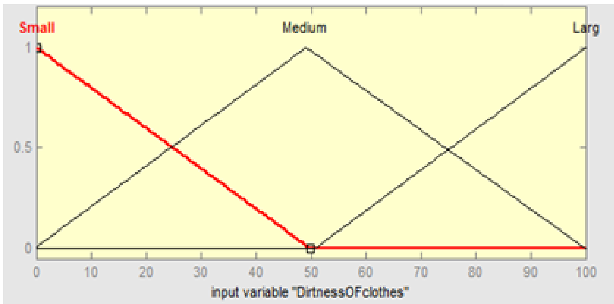
The sets of rules used here to derive the output are:

1. If dirtness_of_clothes is Large and type_of_dirt is Greasy then wash_time is VeryLong;
2. If dirtness_of_clothes is Medium and type_of_dirt is Greasy then wash_time is Long;
3. If dirtness_of_clothes is Small and type_of_dirt is Greasy then wash_time is Long;
4. If dirtness_of_clothes is Large and type_of_dirt is Medium then wash_time is Long;
5. If dirtness_of_clothes is Medium and type_of_dirt is Medium then wash_time is Medium;
6. If dirtness_of_clothes is Small and type_of_dirt is Medium then wash_time is Medium;
7. If dirtness_of_clothes is Large and type_of_dirt is NotGreasy then wash_time is Medium;
8. If dirtness_of_clothes is Medium and type_of_dirt is NotGreasy then wash_time is Short;
9. If dirtness_of_clothes is Small and type_of_dirt is NotGreasy then wash_time is VeryShort

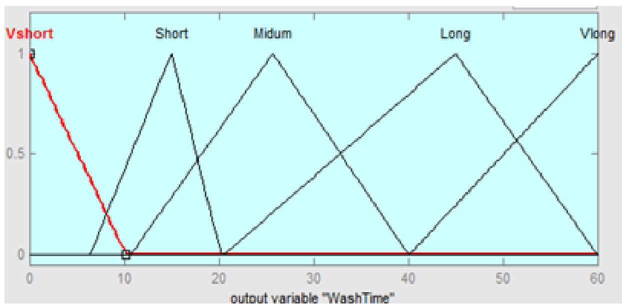
The rules too have been defined in imprecise sense and hence they too are not crisp but fuzzy values. (See figure 3) The two input parameters after being read from the sensors are fuzzified as per the membership function of the respective variables. These in additions with the membership function curve are utilized to come to a solution (using some criteria). At last the crisp value of the wash_time is obtained as an answer.



(a)



(b)



(c)

Figure 2 (a) A membership for input variable Type_of_dirt.
(b) A membership for input variable Dirtness_of_colthes.
(c) A memberships for output Wash_ Time.

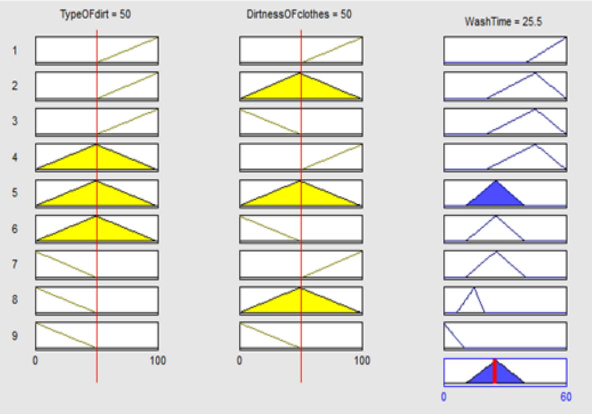


Figure 3 Rules of the system.

In this paper we use a FUZZY TOOLBOX in MATLAB software program to present our model system. This tool allowed us to justify inputs and outputs depend on our own design. So in (figure 2,a and b) you can see that we apply triangular membership for input permeates and we get the resulted output as seen in (figure 2, c).

5. 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 Fuzzy Interface Unit. This is the fundamental unit in which the application interface encodes controller information.

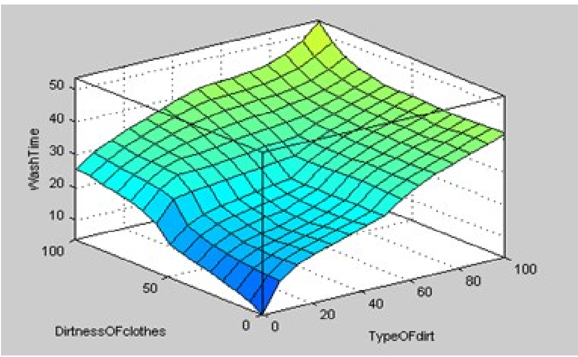


Figure 4 Response surface of the input output relations.

The results (the above plot) shows the way the machine will response in different conditions. For example, if we take type_of_dirt and dirtness value both to be 100, the wash_time which the model output is equivalent to 60 mins. This is quite convincing and appropriate

6. Model and Calculation

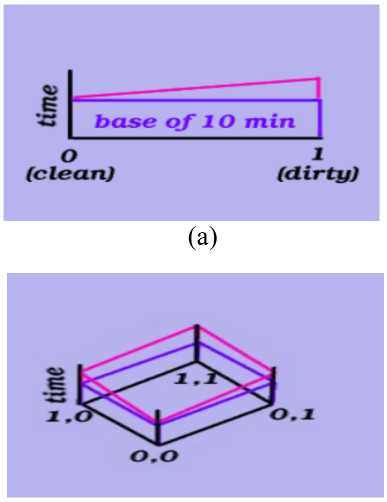
Like a real fuzzy washing machine would, our model first tests how dirty the laundry is. Once it knows how dirty the laundry is, it can easily calculate how long it should wash it. To calculate this it uses the graph below:

First it always takes a base of 10 minutes. It does this so that people are happy with its work even if they put completely clean laundry in to wash. It then calculates to what degree it is dirty. If it is 100% dirty it adds two minutes per piece of laundry. Of course a real washing machine would just do these calculations in the end, but our model does it for each individual piece so you can keep track of what is going on easier.

So if you now add a piece which is only 50% dirty, it will add 50% of 2 minutes; it adds 1 minute instead of 2 minutes to the base of 10 minutes.

Our washer, however, doesn't only check for dirt but also for grease. Laundry which is greasy has to be washed longer too. Since the laundry can be greasy and dirty at the same time, we have to put them on the same graph. When we do this, we get a graph as shown in figure 5.

On the graph in figure 5 (b), you can see once more the base of ten minutes. The point 0,0 is where the laundry is completely clean; non-dirty and non-greasy. The point 0,1 is where the laundry is non-greasy, but dirty. The point 1,0 is where it is greasy but not dirty and 1,1 is greasy and dirty. The washing machine adds 2 minutes per piece for 100% dirty or 100% greasy and 4 minutes for 100% dirty and greasy.



(a)

(b)

Figure 5 (a) Choosing base time as reference.
(b) Relation between base time and the system inputs

So now if you have a piece of laundry which is 100% dirty and 50% greasy, you first go to the point 0,1 (100% dirty) and then go halfway towards point 1,1. If the cube would contain more information, you could now see that the washer has to wash it for 3 minutes more than the base of 10 minutes.

After all our calculations we built the interface model for make test for these data. This interface allows any designers to adjust the optimal time needed for a number of clothes that could be cleaned (figure 6).

On the other hand this application can work with our internet access. You can enter only the piece of dirty clothes with different degree of dirtiness. When you put a new piece the result or output (wash time) updated. We must refer to important point that we do optimize to get more performance, productivity, simplicity, and less cost.

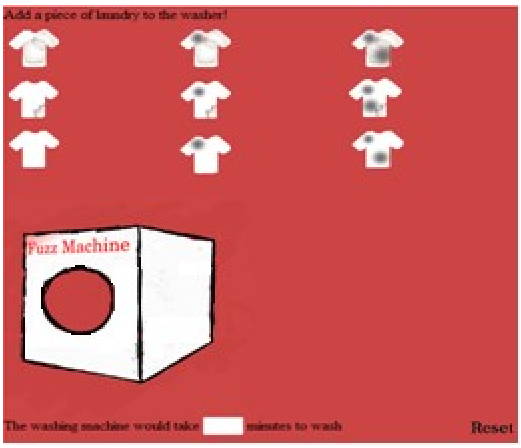


Figure 6 Model interface for testing wash time

7. SUMMARY

By the use of fuzzy logic control 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. Also we do interface to validate our model. This interface makes the system easy to deal with it for user and any interested in this sector of engineering.

8. 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

[1] Bart Kosko, *Fuzzy Thinking: The New Science of Fuzzy Logic,* Hyperion Year of Publication, 1993.

[2] Bart Kosko, *in Heaven in a Chip: Fuzzy Visions of Science & Society in the Digital Age*, New York: Three Rivers Press, 2000.

[3] Masao Mukaidono, *Fuzzy Logic for Beginners*, Singapore: World Scientific, 2001.

[4] Timothy J. Ross, *Fuzzy Logic with Engineering Applications*, 3rd edition, John Wiley & Sons, 2010

[5] Bart Kosko, *Fuzzy Logic,* Scientific American journal, July 1993.

[6] Badami et al., *Fuzzy Logic Control Method for Reducing Water Consumption in a Machine for Washing*, General Electric Company, Schenectady, NY, 1992.

[7] Fuzzynet technical case studies (http://www.aptronix.com), access date; May 24, 2010.

[8] Fuzzy logic, (http://mathematica.ludibunda.ch/fuzzy-logic6.html), access date: April 6, 2013.

[9] Technical manual of washing machines, *Samsung electronics,* at (http://www.samsungelectronics.com.my/washing_machine/tech_info/index.html), access date: April 6, 2013.

[10] Weijing Zhang, Applications Engineer, *Aptronics Incorporated*, Copyright © 1992 by Aptronix Inc.