Design of Fuzzy Logic controller for Washing Machine with More Features
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ABSTRACT
In any of the control application controller design is the most important part. The controller can be conventional in nature or can be intelligent in nature. The paper describes a study of design of fuzzy logic controller for washing machine with more features. The objective is to save a lot of time, electricity and water for washing the cloth. The proposed FLC is simulated using fuzzy logic toolbox of MATLAB. The result is used to calculate the wash time, washing strength, washing speed and amount of detergent for different type of input conditions.

Keywords—FIS Editor, Fuzzy Logic Controller, MATLAB, Surface Viewer.

I. INTRODUCTION
Washing machines are one in every of the foremost common home appliances found these days. The essence of such a machine is to cut back the labor and effectively offer cleaner garments [4]. To prove the cleanliness of garments, the washing machine makers are motivated towards a fully automatic sensing element operated machines which may completely sense the quantity of wash load, the quantity of dirtiness of the garments and also the style of material within the current wash cycle to directly predict the wash time needed. The wash sensing element may be an easy optical sensing element employed to determine the physical measure of light, passed through a glass tube, which may then be reborn to electrical signals to predict the quantity of dirtiness [1].

There are two types of washing machines i.e., semi-automatic and fully-automatic. Now the electronic appliances manufacturer companies are working on the sensor based fully-automatic washing machines according to requirement of washing machine users. Because the users of washing machines have been facing the problem of selecting the length of wash time, washing speed based on the type of clothes, turbidity. Most of the people find it very difficult to decide that which cloth needs what amount of detergent and what amount of washing time. To overcome these problems fully-automatic washing machines based on fuzzy logic offers the advantage of performance, simplicity and less cost. Fuzzy based washing machine have the sensor based program which can sense wash load, water level, type of fabric, type of dirt and dirtiness of clothes to decide the ideal time for washing, number of rinses and spin period as per the information picked by the sensor systems to the machine.

Fuzzy logic was introduced by Professor Lotfi A. Zadeh in 1965. Fuzzy logic is another form of artificial intelligence (AI), a branch of engineering that deals with the development of computer program based on the study of human intelligence and nature of human thinking. Fuzzy logic has recently been applied in process control, modeling, estimation, identification, diagnostics, stock market prediction, agriculture, military science, and so on. The fuzzy logic approach is mainly based on making decisions with imprecise, vague, and inaccurate information [3].

Fuzzy logic controller and its applications: fuzzy logic controller for Gas heater was designed using behavioral modeling and these modules are connected via structural VHDL to control “valve angle” [2].

The Fuzzy logic controller for liquid level control was designed using MATLAB for controlling “valve” and compared with the PID controller significantly reduced overshoots and steady state error [2].

Fuzzy logic controller for washing machine: In 2011, the fuzzy interference is used for determining wash time. In this design MF used was triangular; the inputs of the fuzzy controller were turbidity and change of turbidity, the output was washing time [7]. In 2009, pritesh lohani, proposed “An improved controller microchip for washing machine”, the inputs of the fuzzy controller were types of dirt, dirtiness of clothes and mass of clothes and the output was washing time. With the above information, a new FLC for washing machine is
designed with three inputs and four outputs with 27 rules [8].

II. PRINCIPLES OF WASHING MACHINE

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

Water inlet control valve, water pump, washer drum, agitator, motor, door safety sensor, detergent drawer, drain pipe, controller and Mechanical programmer are the important parts of a washing machine [1].

An optical sensor is a device that converts light rays into electronic signals. It measures the physical quantity of light and translates it into form read by the instrument. The features of an optical sensor are its ability to measure the change from one or more light beams [5].

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.

Unfortunately, there is no easy way to formulate a precise mathematical relationship between turbidity and volume of clothes and length of wash time 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 controller.

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

III. PROPOSED DESIGN OF FLC FOR WASHING MACHINE

A. Fuzzy system constraint

The input variables of the fuzzy controller are turbidity E, turbidity rate change ΔE and the types of cloth H. Output variables are washing time U1, washing speed U2, Amount of detergent U3.

The input quantities are described as different fuzzy sets:

- Turbidity: small (NM), medium (NO), large (PM).
- The turbidity change rate: small (NM), medium (NO), large (PM).
- Types of cloth: wool (NM), chemical fiber (NO), cotton (PM).

The output quantities are also represented by different fuzzy sets, washing time is described by five fuzzy sets:

- Washing time: shorter (NM), short (NS), medium (NO), long (PS), longest (PM).
- Washing strength: lighter (L), light (ML), medium (MO), strong (MS), strongest (s).
- Washing speed: lowest (NM), lower (NS), medium (N), higher (PS), highest (PM).
- Amount of detergent: little (L), less (ML), normal (MO), more (MS), much (S).

The proposed fuzzy logic controller interference engine is designed using 27 rules for wash time, washing speed, amount of detergent, washing strength. 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 function.

The X-axis of all the membership function graphs represents the linguistic input values which are obtained from the sensors and the Y-axis of all the membership function graphs denotes the degree of membership function. Fuzzification is the first step in the fuzzy interfacing process. This involves a domain transformed where crisp inputs are transformed into fuzzy inputs.
structure of membership functions within a universe of discourse for a crisp input.

B. Fuzzy rules

In the fuzzy control of the smart washing machine control system, according to the prior data conclude by expert’s experience, control of the washing time, washing speed, washing strength and amount of detergent and can be divided into 27 kinds of rules.

Rule 1

IF (the turbidity change rate is small) and (turbidity is small) and (type of cloth is wool) THEN (wash time is shortest) and (washing strength is lightest) and (washing speed is very low) and (amount of detergent is very less).

Rule 2

IF (the turbidity change rate is small) and (turbidity is small) and (type of cloth is fiber) THEN (wash time is shortest) and (washing strength is lightest) and (washing speed is very low) and (amount of detergent is very less).

Rule 27

IF (the turbidity change rate is large) and (turbidity is large) and (type of cloth is cotton) THEN (wash time is longest) and (washing strength is strongest) and (washing speed is very high) and (amount of detergent is much).

<table>
<thead>
<tr>
<th>TABLE 1.</th>
<th>Fuzzy Rules</th>
</tr>
</thead>
<tbody>
<tr>
<td>ΔE</td>
<td>small</td>
</tr>
<tr>
<td>wool</td>
<td>fiber</td>
</tr>
<tr>
<td>Washing time</td>
<td>shortest</td>
</tr>
<tr>
<td>Washing strength</td>
<td>lightest</td>
</tr>
<tr>
<td>Washing speed</td>
<td>lowest</td>
</tr>
<tr>
<td>Amount of detergent</td>
<td>little</td>
</tr>
</tbody>
</table>

| washing time | shorter | shorter | mediu | shorter | mediu | shorter | medi | um |
| Washing strength | lighter | lighter | mediu | lighter | mediu | lighter | medi | um |
| Washing speed | lower | lower | mediu | lower | mediu | lower | medi | um |
| Amount of detergent | less | less | normal | less | norma | l | normal | less |

| Large | Washing time | mediu | longer | longer | mediu | longer | longe | st |
| Washing strength | mediu | stronger | stronger | mediu | strong | est | medi | um |
| Washing speed | mediu | higher | higher | mediu | higher | highes | t | medi | um |
| Amount of detergent | normal | more | more | normal | more | much | normal | much |
IV. DEFUZZIFICATION

Defuzzification process is used to understand the membership degrees of the fuzzy sets in some precise real value. There are some kinds of methods are used for defuzzification. Here the centroid method is used for defuzzification to get a scalar output value for the actual duration of the wash time, washing strength, washing speed, amount of detergent.

V. RESULTS

By the use of fuzzy logic controller we have been able to obtain the washing speed, wash time, washing strength and amount of detergent for different type of cloths and different type of turbidity.
Here the sensors sense the input values and using the above model the inputs are fuzzified 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.

![Fig. 9. Response surface of the input output relationship](image)

The fig. 9 shows the relation between inputs turbidity and rate of change of turbidity output washing time, similar we have been obtain the relation between the inputs type of cloths, turbidity and rate of change of turbidity and outputs washing speed, washing strength and amount of detergent.

Here we take different values of inputs and get the outputs according to inputs. For example if we take the turbidity 15, rate of change of turbidity is 5, and type of cloth 20 then the outputs washing time is 17.4, washing speed 348, amount of detergent 29, washing strength 17.4 and some other output response with respect to input shows in table 2.

<table>
<thead>
<tr>
<th>Inputs</th>
<th>Outputs</th>
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<tbody>
<tr>
<td>Turbidity</td>
<td>Rate of change of turbidity</td>
</tr>
<tr>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>5</td>
<td>15</td>
</tr>
<tr>
<td>25</td>
<td>15</td>
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VI. CONCLUSIONS

In this paper fuzzy logic toolbox is used to create and edit fuzzy interference system within the framework of MATLAB. By the use of fuzzy logic we have been able to achieve wash time, washing strength, washing speed, amount of detergent for different type of cloths, turbidity and rate of change of turbidity.

Due to this adjustment of output parameter cloths will come out cleaner and it will also make the whole washing process economical by reducing amount of detergent, electricity, time.

References