Design of Fuzzy Logic Controller for Detection ofQuality of Milk

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ABSTRACT
In India, co-operative based milk collection centerin ruralarea collect milk from farmers. Aquantity of milk tested for its quality using traditional test equipments.The fear of unhygienic conditions and milk contamination occurs mostly due to delay in testing.Possibility of human error in calculation of milk quality and quantity is also one of the threats.Therefore, a cost effective electronic system is essential at dairies.In this paper, Fuzzy logic is employed on different parameters of themilk such as FAT, Water concentration, SNS (Solid non FAT), protein and lactose for the identification ofquality of milk. (FIS) implemented by employing the data sets collected from several milk industries wherein the milk is tested using sophisticated instruments.This model is further simulated in Simulink. In hardware design,ultrasonic sensors used for FATs measurement, water concentration is measured by IR sensor to formulate the SNF (solid non FAT), Lactose and Protein. The model has shownthe different contents in milk as well asthe overall quality of milk on LCD display.

Keywords
Fuzzy Interference system, Membership Function, Rule base, simulink.

1. INTRODUCTION
Since all the primary parameters calculate with traditional instruments and with the standard formula. The quality of milk determined with fixed restriction.However, the paper aims to emphasize on the quality of milk; therefore, fuzzy logic is found to be a best solution. A human-like imprecise reasoning, ability to reason approximately and judge under uncertain conditions is the foundation. FLC was originally seen as a wayofusing simple linguistic rules to implement an effectivecontroller.There are four input membership functions i.e. Fat, protein, lactose and water content. For which Low, Normal, High and Very high linguistic descriptorswere chosen.

Applying themin-max process, the representative values for each singleton in each output are defuzzified by computing a weighted average method. Fuzzy logic controller after evaluation, implemented in Simulink, is a data flow graphical programming language tool for modeling, simulating and analyzing multi-domain dynamic systems.The results are verified by inputting the different values. However, finally the hardware for the detection of quality of milk is designed using

anATmega16A microcontroller. It consists of multiple sensors,LCD display & keypad as main elements.

2. LITERATURE REVIEW
United States Code of Federal Regulations (USCFR) defined that"the lacteal secretion, practically free from colostrums, obtained by the complete milking of one or more healthy cows, which contains not less than 8.25% of milk solids-non-fat and not less than 3.25% of milk fat".Biochemical processes produce milk and a minimum amount of solids-non-fats and fats to get a milk of acceptable quality.To ensure the quality of milk, several tests are available. The Kjeldahl method is widely applied in food science and technology and is the official standard reference method for measuring Protein. Röse-Gottlieb method, Soxhlet Extraction method, Babcock method, Gerber method, gas chromatographic method is used for Fat measurement. Review of several papers is summarized in Table-1 as shownbelow.

Table-1: Summery of literature review

Content	Sensors / Methodology	Ref.
Expert sys.	Milk Analyzing and billing, Optical biosensor, Dynamic temperature sensor, Passive PH sensor, diagnose Subclinical mastitis, High intensity elect. Field for milk Quality enhancement	1,2,3,4 ,5,6
Fuzzy Logic & Neural Network	fuzzy temperature controller, FAT detection, PID and Fuzzy Logic in Temperature Control,Mamdani Fuzzy Logic Controller, Fuzzy Logic Control System on a Freescale 68HCS12controller,Review : fuzzy logic constrained for embedded control systems implemented using general-purpose microcontrollersestimation of fat contents in milk via ANFIS	7,8,9,1 0,11,1 2,13,1 4

3. FUZZY LOGIC FORQUALITY OF MILK
Fuzzy logic is a well known method applied for control, classification and decision support systems. The fuzzy logic applied here to detect the quality of milk. Four input membership functions used forFat, protein, lactose and water contain.These fundamental components are calculated once the water containsand a value of FAT is determined, SNF and Water concentration can be calculated by using following formula.

SNF measurement

SNF% =100 – (Water + Fat)%

SNF measurement

Protein% = 0.367* SNF

SNF measurement

Lactose = 0.55* SNF

Membership for FAT realized withLow, Normal, High and Very highlinguistic descriptors.To describe the Protein,

Lactose and Water concentration input membershipterms Low, Normal, andHighare chosen.The terms Rejected, Moderate, Good, and Excellentare selected to describe the output in the form of Quality of Milk.

The rules map the input membership function values to the output membership functions,generate the set of rules.

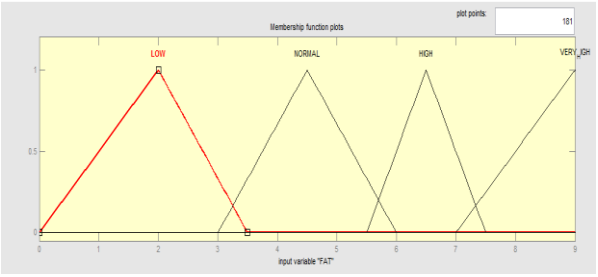

Figure 1:Membership Functions for Fat

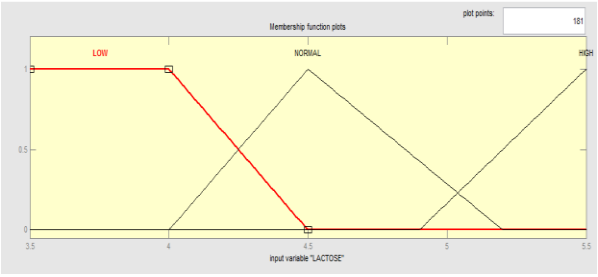

Figure 2: Membership Functions for Lactose

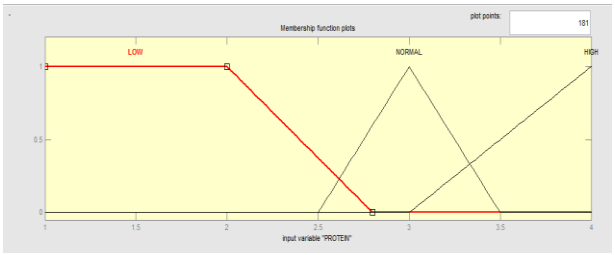

Figure 3:Membership Functions for Protein

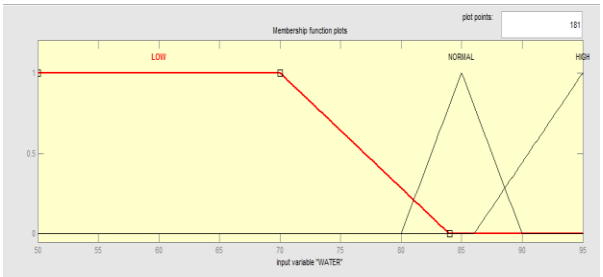

Figure 4:Membership Functions for Water contain

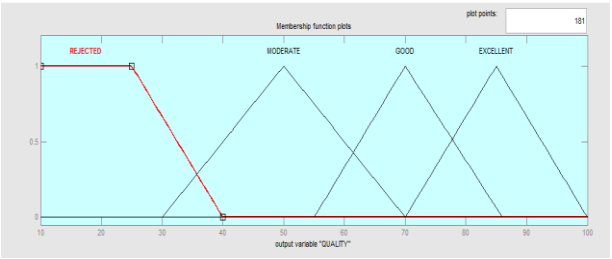

Figure 5:Membership Functions for Quality of Milk

After evaluation of all rules, the output membership function truth value for each particular output isexamined and the maximum value for each singleton is taken as the representative value. These min-max process represented values for each singleton in each output are thendefuzzified by computing a weighted average method.

4. PROTOTYPE MODEL IN SIMULINK

Simulink model is build up throughFIS designed in fuzzy platform. Thefour inputs are given through CONSTANT block and fuzzy logic controller through VECTOR CONCATENATE. It concatenate input signals of same data type to create contiguous output signal. Output of FLC is given to INTERVAL TEST block. The Interval Test Dynamic block outputs TRUE if the input is between the values of the external signals. Output of Interval Test Dynamic block is displayed the Quality of milk. The system implementation and corresponding rule viewer is shown in the following figures.

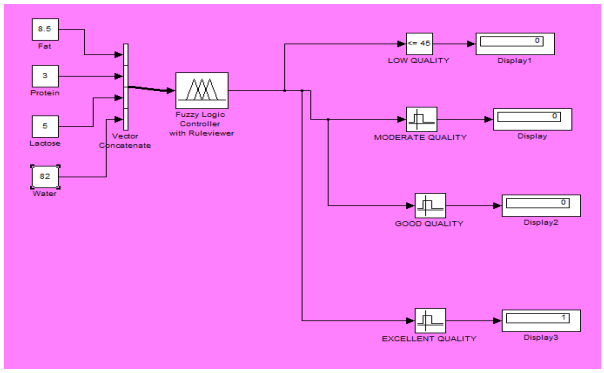

Figure 6: Simulink model

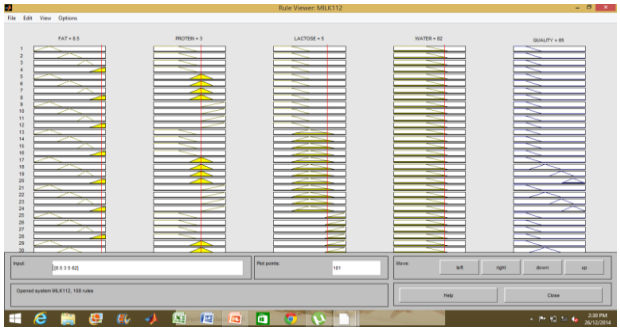

Figure 7:Simulink model rule Viewer

5. REALIZATIONOF FLC USING ATMEGA16A CONTROLLER

This system mainly consists of following component.

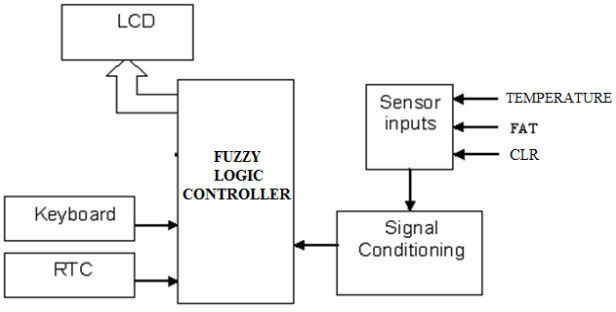

Fig.8: Block diagram of system

Sensors:Includes sensor for measuring Fat and Water containin the milk. Fat measured by ultrasonic sensor. As liquid found in different nature, theultrasonic propagation through medium getdifferentattenuation which varies the speed and intensity level.When an ultrasonic wave passed through milk, velocity and attenuation coefficient willchanges accordingly.

Water contain is measured by IR sensor. Infrared sensor is an electronic sensor that measures infrared (IR) light radiating from objects in its field of view. It detects changes in the amount of infrared radiation impinging upon it, which varies depending on the temperature and surface characteristics of the objects in front of the sensor. The sensor converts the resulting change in the incoming infrared radiation into a change in the output voltage.

Signal Conditioning: Signal conditioning circuit convert sensors output into standard format suitable for microcontroller. Analog to digital converter is used as a Signal conditioning circuit. The analog output of sensor is given to on-chip Analog to Digital Converter (ADC) of microcontroller.

ATmega16A Microcontroller:A low-power CMOS 8-bit microcontroller based on the AVR enhanced RISC architecture.Executing powerful instructions in a single clock cycle, the ATmega16A achieves throughputs approaching 1 MIPS per MHz allowing the system to optimize power consumption versus processing speed. The particular chip used in this research, featuring 16K Bytes of In-System Self-programmable Flash program memory, 512 Bytes EEPROM, 1K Byte Internal SRAM.It also includes two serial communications interfaces (SCI) for RS-232 communications, three serial peripheral interfaces (SPI) for communication with supported devices, Four PWM Channels, 8-channel, 10-bit analog-to-digital (A/D) converters. All these features are used in the implementation of the fuzzy logic controller.

LCD and keyboard: LCD and keyboard are connected to the microcontroller to display the result and to enter the data respectively.

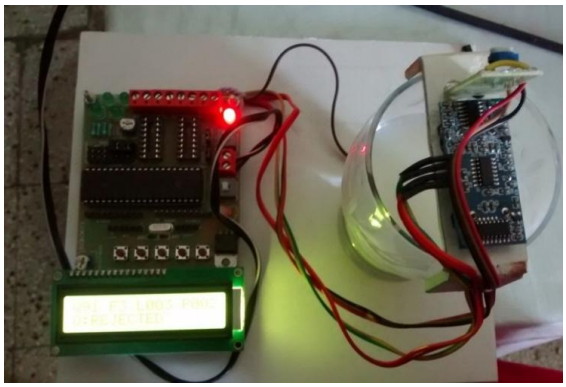

Fig. 7: Experimental setup

Fig. 8: LCD display

6. RESULT

The system supplied with the contentof milk such as fat, protein, lactose, water, and the output i.e. Quality of milk is displayed with linguistic variableson LCD. Five samples are tested on the system, which gives result as follows-

Table2: Test Result of System

Sample No.	Fat	Protein	Lac	Water	Quality of milk
1.	3	2	4	91	Rejected
2.	6	2.9	5.1	86	Moderate
3.	5.5	3.5	5	86	Moderate
4.	4	3.2	4.8	88	Moderate
5.	7.4	3.1	4.5	85	Good

7. CONCLUSION

Fuzzy logic based system for the detection of milk quality is designed. This instrument is not only able to selectively measure content of milk like fat, protein, lactose and water, but also can determine the milk quality grade (Rejected, Moderate, Good, Excellent).FLC based design system is cost effective solution to the existing costlier milk analyzers.The system utilized without sink sensor and because ofits rapid responseunhygienic conditions or milk contamination is avoided. Fear of Human error in calculation of milk quality and quantity is also prevented.

8. REFERENCES

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