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Autonomous Room Air Cooler Using Fuzzy Logic Control System

M. Abbas, M. Saleem Khan, Fareeha Zafar

Abstract— This research paper describes the design and implementation of an autonomous room air cooler using fuzzy rule based control system. The rule base receives two crisp input values from temperature and humidity sensors, divides the universe of discourse into regions with each region containing two fuzzy variables, fires the rules, and gives the output singleton values corresponding to each output variable. Three defuzzifiers are used to control the actuators; cooler fan, water pump and room exhaust fan. The results obtained from the simulation were found correct according to the design model. This research work will increase the capability of fuzzy logic control systems in process automation with potential benefits. MATLAB-simulation is used to achieve the designed goal.

Index Terms— Fuzzy Logic Control, Inference Engine, MATLAB simulation and Rule Selection.

1 Introduction

MODERN processing systems are heavily dependent on automatic control systems. The control automation has become essential for machines and processes to run successfully for the achievement of consistent operation, better quality, reduced operating costs, and greater safety.

The control system design, development and implementation need the specification of plants, machines or processes to be controlled. A control system consists of controller and plant, and requires an actuator to interface the plant and controller. The behaviour and performance of a control system depend on the interaction of all the elements. The dynamical control systems design, modeling and simulation in local and distributed environment need to express the behaviour of quantitative control system of multi-input and multi-output variables control environment to establish the relation between actions and consequences of the control strategies [1].

Computational Intelligence (CI) is a field of intelligent information processing related with different branches of computer sciences and engineering. The fuzzy systems are one paradigm of CI. The contemporary technologies in the area of control and autonomous processing are benefited using fuzzy sets [2].

The user based processing capability is an important aspect of fuzzy systems taken into account in any design consideration of human centric computing systems. The human centricity plays a vital role in the areas of intelligent data analysis and system modeling [3]. The elements of fuzzy sets belong to varying degrees of membership or belongingness. Fuzzy sets offer an important and unique feature of information granules. A membership function quantifies different degrees of membership. The higher the degree of membership A (x), the stronger is the level of belongingness of this element to A. Fuzzy sets provide an ultimate mechanism of communication between humans and computing environment [4].

The fuzzy logic and fuzzy set theory deal with non-probabilistic uncertainties issues. The fuzzy control system is based on the theory of fuzzy sets and fuzzy logic [5]. Previously a large number of fuzzy inference systems and defuzzification techniques were reported. These systems/techniques with less computational overhead are useful to obtain crisp output. The crisp output values are based on linguistic rules applied in inference engine and defuzzification techniques [6]-[7].

The efficient industrial control with new techniques of fuzzy algorithm based on active rule selection mechanism to achieve less sampling time ranging from milliseconds in pressure control, and higher sampling time in case of temperature control of larger installations of industrial furnaces has been proposed [8].

The development of an air condition control system based on fuzzy logic with two inputs and one output using temperature and humidity sensors for feedback control, and three control elements for heating, cooling, and humidity, and formulated fuzzy rules for temperature and humidity has been achieved. To control the room temperature, the controller reads the room temperature after every sampling period [9].

This proposed design work of Autonomous Room Cooling System is the application of fuzzy logic control system consisting of two input variables: Temperature and Humidity, and three output variables: Cooler fan speed, Water pump speed and Exhaust fan speed, used in a processing plant of room cooler to maintain the

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required cooling environment. The basic structure of the proposed model is described in Section 2. Section 3 gives the simplified design algorithm of fuzzy logic for room air cooler system. Section 4 describes the simulation results of this system. Conclusion and future work is given in Section 5.

2 BASIC STRUCTURE OF THE PROPOSED MODEL

The basic structure of the proposed model of autonomous water room cooler consists of room air cooler with fuzzy logic control system. The room cooler mounted in a room has cooler fan, a water pump to spread water on its boundary walls of grass roots or wooden shreds. A room exhaust fan, humidity and temperature sensors used to monitor the environment of room are mounted in the room. The sensors with amplification and voltage adjustment unit are connected with the two fuzzifiers of the fuzzy logic control system. Three outputs of defuzzifiers: cooler fan speed control, water pump speed control and room exhaust fan speed control are connected through actuators.

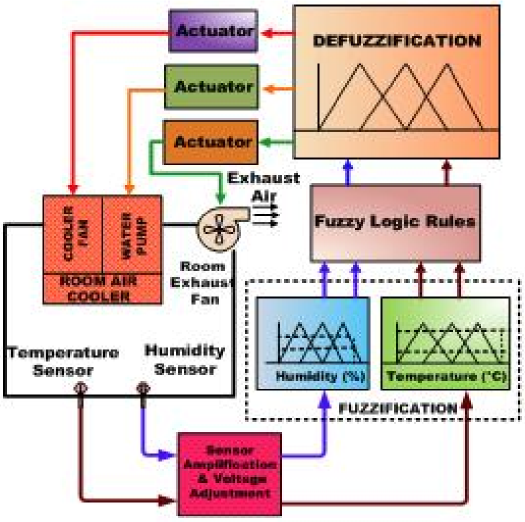

Fig.1. Block diagram of Autonomous Room Air Cooler System

3 SIMPLIFIED DESIGN ALGORITHM OF FUZZY LOGIC FOR ROOM AIR COOLER SYSTEM

This simplified design algorithm is used to design the fuzzifier, inference engine, rule base and defuzzifier for the autonomous room air cooling system according to the control strategy of the processing plant to achieve the quantity and quality of the desire needs to maintain the room environment.

This design work uses five triangular membership functions equally determined over a scale range of 0°C to 40°C for the temperature input and 0% to 100% relative humidity inputs. The five fuzzy membership functions for temperature input are termed as: cold 0-10°C, cool 0-20°C, normal 10-30°C, warm 20-40°C, and hot 30-40°C. As for humidity input, the five fuzzy membership functions are: dry 0%-25%, not too dry 0%-50%, moist 25%-75%, not too wet 50%-100%, and wet range 75%-100%.This fuzzy logic model aims to determine the amplitude of the voltage signal 0-5v to be sent to the three actuators for: Cooler fan speed, water pump speed and room exhaust fan speed to maintain a constant and desired environment. Here no time constrain is applied. Three outputs of this proposed system are: Cooler fan speed, water pump speed and room exhaust fan speed. Each output variable consists of five membership functions: Stop 0-5, Low 0-50, Medium 40-60, Fast 50-90 and Very Fast 90-100.

3.1 Fuzzifier

The set points of fuzzifiers use the data of two input variables, “Temperature” and, “Humidity”. Their occupied region description, membership functions and range are given in TABLE 1 and TABLE 2.

TABLE 1
MEMBERSHIP FUNCTIONS AND RANGES OF INPUT VARIABLE TEMPERATURE

Membership Function (MF)	Ranges	Region Occupied
Cold	0-10	1
Cool	0-20	1-2
Normal	10-30	2-3
Warm	20-40	3-4
Hot	30-40	4

TABLE 2
MEMBERSHIP FUNCTIONS AND RANGES OF INPUT VARIABLE HUMIDITY

Membership Function (MF)	Ranges	Region Occupied
Dry	0-25	1
Not Too Dry	0-50	1-2
Moist	25-75	2-3
Not Too Wet	50-100	3-4
Wet	75-100	4

For each input variable, five membership functions are used as shown in Fig. 2 and in Fig. 3.

The five membership functions, “Cold”, “Cool”, “Normal”, “Warm”, “Hot” are used to show the various ranges of input fuzzy variable “TEMPERATURE” in a plot consisting of four regions as shown in Fig. 2.

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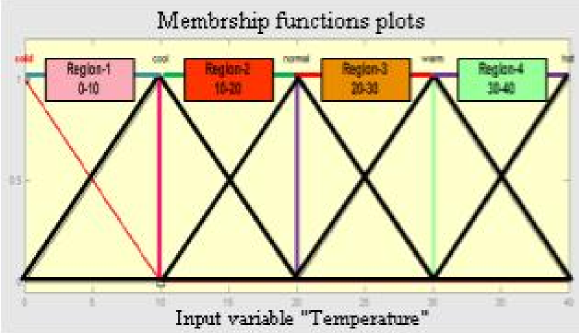

Fig.2. Plot of membership functions for input variable, "TEMPERATURE"

The five membership functions, "Dry", "Not Too Dry", "Moist", "Not Too Wet", "Wet" are used to show the various ranges of input fuzzy variable "HUMIDITY" in a plot also consisting of four regions as shown in Fig. 3

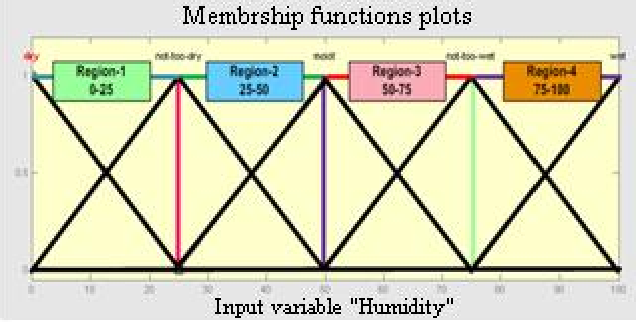

Fig.3. Plot of membership functions for input variable, "HUMIDITY"

The linguistic values are the mapping values of the fuzzy input variables with the membership functions occupied in the regions [10]. As we are using two variables, therefore four linguistic values are shown in Fig.4. The mapping of input fuzzy variables with the functions in four regions is listed in TABLE 3.

TABLE 3
LINGUISTIC VALUES OF FUZZIFIERS OUTPUTS IN ALL REGIONS

Input Variables	Linguistic Fuzzifiers Outputs	Region 1	Region 2	Region 3	Region 4
Temperature	f_1	$f_1[1]$	$f_1[2]$	$f_1[3]$	$f_1[4]$
	f_2	$f_1[2]$	$f_1[3]$	$f_1[4]$	$f_1[5]$
Humidity	f_3	$f_2[1]$	$f_2[2]$	$f_2[3]$	$f_2[4]$
	f_4	$f_2[2]$	$f_2[3]$	$f_2[4]$	$f_2[5]$

TABLE 4
RULE MAPPING FOR REGIONS OCCUPIED

Case No.	Regions Occupied		Rules
	Temperature Input variable 1	Humidity Input variable 2	$f_n[m]$= Membership value, where n=No. of input variable, m=No. of membership func-
1	1	1	$R_1 = f_1 \wedge f_3 = f_1[1] \wedge f_2[1]$ $R_2 = f_1 \wedge f_4 = f_1[1] \wedge f_2[2]$ $R_3 = f_2 \wedge f_3 = f_1[2] \wedge f_2[1]$ $R_4 = f_2 \wedge f_4 = f_1[2] \wedge f_2[2]$
2	1	2	$R_1 = f_1 \wedge f_3 = f_1[1] \wedge f_2[2]$ $R_2 = f_1 \wedge f_4 = f_1[1] \wedge f_2[3]$ $R_3 = f_2 \wedge f_3 = f_1[2] \wedge f_2[2]$ $R_4 = f_2 \wedge f_4 = f_1[2] \wedge f_2[3]$
3	1	3	$R_1 = f_1 \wedge f_3 = f_1[1] \wedge f_2[3]$ $R_2 = f_1 \wedge f_4 = f_1[1] \wedge f_2[4]$ $R_3 = f_2 \wedge f_3 = f_1[2] \wedge f_2[3]$ $R_4 = f_2 \wedge f_4 = f_1[2] \wedge f_2[4]$
4	1	4	$R_1 = f_1 \wedge f_3 = f_1[1] \wedge f_2[4]$ $R_2 = f_1 \wedge f_4 = f_1[1] \wedge f_2[5]$ $R_3 = f_2 \wedge f_3 = f_1[2] \wedge f_2[4]$ $R_4 = f_2 \wedge f_4 = f_1[2] \wedge f_2[5]$
5	2	1	$R_1 = f_1 \wedge f_3 = f_1[2] \wedge f_2[1]$ $R_2 = f_1 \wedge f_4 = f_1[2] \wedge f_2[2]$ $R_3 = f_2 \wedge f_3 = f_1[3] \wedge f_2[1]$ $R_4 = f_2 \wedge f_4 = f_1[3] \wedge f_2[2]$
6	2	2	$R_1 = f_1 \wedge f_3 = f_1[2] \wedge f_2[2]$ $R_2 = f_1 \wedge f_4 = f_1[2] \wedge f_2[3]$ $R_3 = f_2 \wedge f_3 = f_1[3] \wedge f_2[2]$ $R_4 = f_2 \wedge f_4 = f_1[3] \wedge f_2[3]$
7	2	3	$R_1 = f_1 \wedge f_3 = f_1[2] \wedge f_2[3]$ $R_2 = f_1 \wedge f_4 = f_1[2] \wedge f_2[4]$ $R_3 = f_2 \wedge f_3 = f_1[3] \wedge f_2[3]$ $R_4 = f_2 \wedge f_4 = f_1[3] \wedge f_2[4]$
8	2	4	$R_1 = f_1 \wedge f_3 = f_1[2] \wedge f_2[4]$ $R_2 = f_1 \wedge f_4 = f_1[2] \wedge f_2[5]$ $R_3 = f_2 \wedge f_3 = f_1[3] \wedge f_2[4]$ $R_4 = f_2 \wedge f_4 = f_1[3] \wedge f_2[5]$
9	3	1	$R_1 = f_1 \wedge f_3 = f_1[3] \wedge f_2[1]$ $R_2 = f_1 \wedge f_4 = f_1[3] \wedge f_2[2]$ $R_3 = f_2 \wedge f_3 = f_1[4] \wedge f_2[1]$ $R_4 = f_2 \wedge f_4 = f_1[4] \wedge f_2[2]$
10.	3	2	$R_1 = f_1 \wedge f_3 = f_1[3] \wedge f_2[2]$ $R_2 = f_1 \wedge f_4 = f_1[3] \wedge f_2[3]$ $R_3 = f_2 \wedge f_3 = f_1[4] \wedge f_2[2]$ $R_4 = f_2 \wedge f_4 = f_1[4] \wedge f_2[3]$
11.	3	3	$R_1 = f_1 \wedge f_3 = f_1[3] \wedge f_2[3]$ $R_2 = f_1 \wedge f_4 = f_1[3] \wedge f_2[4]$ $R_3 = f_2 \wedge f_3 = f_1[4] \wedge f_2[3]$ $R_4 = f_2 \wedge f_4 = f_1[4] \wedge f_2[4]$
12.	3	4	$R_1 = f_1 \wedge f_3 = f_1[3] \wedge f_2[4]$ $R_2 = f_1 \wedge f_4 = f_1[3] \wedge f_2[5]$ $R_3 = f_2 \wedge f_3 = f_1[4] \wedge f_2[4]$ $R_4 = f_2 \wedge f_4 = f_1[4] \wedge f_2[5]$
13.	4	1	$R_1 = f_1 \wedge f_3 = f_1[4] \wedge f_2[1]$ $R_2 = f_1 \wedge f_4 = f_1[4] \wedge f_2[2]$ $R_3 = f_2 \wedge f_3 = f_1[5] \wedge f_2[1]$ $R_4 = f_2 \wedge f_4 = f_1[5] \wedge f_2[2]$

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Case No.	Regions Occupied		Rules	
	Temperature Input variable 1	Humidity Input variable 2	$f_n[m]$= Membership value, where n=No. of input variable, m=No. of membership func-	
14.	4	2	$R_1 = f_1 \wedge f_3 =$	$f_1[4] \wedge f_2[2]$
			$R_2 = f_1 \wedge f_4 =$	$f_1[4] \wedge f_2[3]$
			$R_3 = f_2 \wedge f_3 =$	$f_1[5] \wedge f_2[2]$
			$R_4 = f_2 \wedge f_4 =$	$f_1[5] \wedge f_2[3]$
15.	4	3	$R_1 = f_1 \wedge f_3 =$	$f_1[4] \wedge f_2[3]$
			$R_2 = f_1 \wedge f_4 =$	$f_1[4] \wedge f_2[4]$
			$R_3 = f_2 \wedge f_3 =$	$f_1[5] \wedge f_2[3]$
			$R_4 = f_2 \wedge f_4 =$	$f_1[5] \wedge f_2[4]$
16.	4	4	$R_1 = f_1 \wedge f_3 =$	$f_1[4] \wedge f_2[4]$
			$R_2 = f_1 \wedge f_4 =$	$f_1[4] \wedge f_2[5]$
			$R_3 = f_2 \wedge f_3 =$	$f_1[5] \wedge f_2[4]$
			$R_4 = f_2 \wedge f_4 =$	$f_1[5] \wedge f_2[5]$

Fuzzifier converts the input crisp value into the linguistic fuzzy values. The output of fuzzifier gives the linguistic values of fuzzy set. For the two input variables, two fuzzifiers are used which are shown in Table 5.

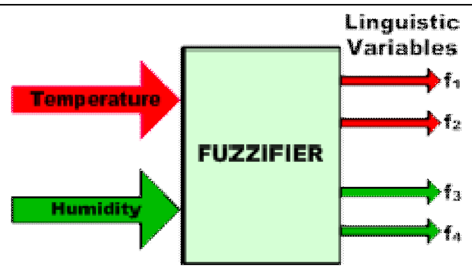

Fig.4 Fuzzifier Block

Each fuzzifier consists of : a multiplier: which converts the input voltage range 0-5volt into the crisp value 0-40 for temperature by multiplying the input with 10, and the crisp value 0-100 for humidity by multiplying the input with 25, comparators; used to decide the region occupied by the input variable value, subtractors; used to find the difference of crisp value from the end value of each region, multiplexer; using the address information from the region selection and inputs from the four subtractors, multiplex the four values because this system is designed for the four predefined regions, divider; used to divide the difference value in each selected region by 10 to find the mapping value of membership function with the input variable value of temperature in that region, and to find the mapping value of membership function for input variable value of humidity, divide the difference value in each selected region by 25, a second fuzzy set subtractor; used to find the active value of the second fuzzy set by subtracting the first active fuzzy set value from 1. The general internal hardware structural scheme of a fuzzifier for four regions is shown in Fig. 5 & Fig. 6 and the results of fuzzification are shown in TABLE 5 for mathematical analysis [11].

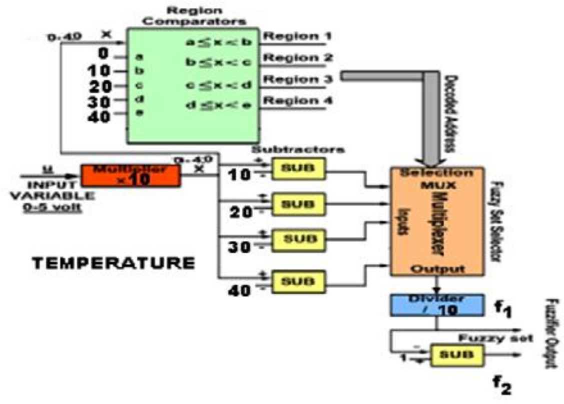

Fig. 5 Internal Hardware Structural Scheme for Four Regions "TEMPERATURE"

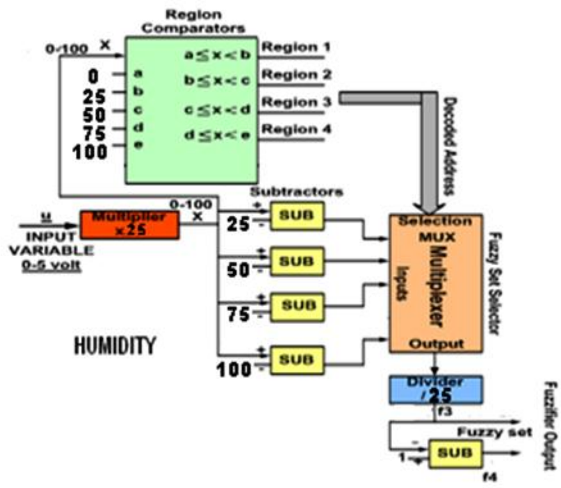

Fig. 6 Internal Hardware Structural Scheme for Four Regions "HUMIDITY"

TABLE 5
RESULTS OF FUZZIFICATION

Input Variables	Input Voltage (u)	Values	Region Selection	Fuzzy Set Calculation
Temperature	2.8 volts	x=10u=28	$20 \le x < 30$	$f_1=(30-28)/10=0.2$
			Region-3	$f_2=1-f_1=1-0.2=0.8$
Humidity	1.6 volts	x=25u=40	$25 \le x < 50$	$f_3=(50-40)/25=0.4$
			Region-2	$f_4=1-f_3=1-0.4=0.6$

3.2 Inference Engine

The inference engine consists of four AND operators, these are not the logical ANDs but select minimum value input for the output. This inference engine accepts four inputs from fuzzifier and applies the min-max composition to obtain the output R values. The min-max inference

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method uses min-AND operation between the four inputs. Fig. 7 shows this type of inference process.

Number of active rules = m^n, where m = maximum number of overlapped fuzzy sets and n = number of inputs. For this design, m = 5 and n = 2, so the total number of active rules are 25. The total number of rules is equal to the product of number of functions accompanied by the input variables in their working range [12]. The two input variables described here consisted of five membership functions. Thus, 5 x 5 = 25 rules were required which are shown in TABLE 6.

TABLE 6
TOTAL NUMBER OF RULES

INPUTS		OUTPUTS		
Temperature (°C)	Humidity %	Speed of Cooler Fan	Speed of Water Pump	Speed of Room Exhaust Fan
Cold	Dry	Stop	Low	Stop
Cold	Not Too Dry	Stop	Low	Slow
Cold	Moist	Stop	Low	Slow
Cold	Not Too Wet	Stop	Low	Slow
Cold	Wet	Low	Stop	Medium
Cool	Dry	Stop	Medium	Stop
Cool	Not Too Dry	Stop	Low	Slow
Cool	Moist	Stop	Low	Medium
Cool	Not Too Wet	Low	Low	Medium
Cool	Wet	Low	Stop	Medium
Normal	Dry	Low	Medium	Stop
Normal	Not Too Dry	Low	Medium	Slow
Normal	Moist	Medium	Medium	Slow
Normal	Not Too Wet	Medium	Low	Medium
Normal	Wet	High	Stop	Fast
Warm	Dry	High	High	Stop
Warm	Not Too Dry	High	High	Slow
Warm	Moist	High	High	Medium
Warm	Not Too Wet	High	Medium	Slow
Warm	Wet	Very High	Low	Stop
Hot	Dry	High	Very High	Stop
Hot	Not Too Dry	Very High	Very High	Slow
Hot	Moist	Very High	High	Medium
Hot	Not Too Wet	Very High	Medium	Medium
Hot	Wet	Very High	Low	Fast

In this case only 4 rules are required for the particular values of two variables because each value of two variables in a region corresponds to mapping of two functions. The corresponding mapping values of $f_1[3]$, $f_1[4]$, $f_2[2]$, $f_2[3]$ were used to establish the 4 rules. Here $f_1[3]$ means the corresponding mapping value of membership function "Normal" of temperature in region-3 and the similar definitions are for the others [13].

$R_1 = f_1 \wedge f_3 = f_1[3] \wedge f_2[2] = 0.2 \wedge 0.4 = 0.2$
$R_2 = f_1 \wedge f_4 = f_1[3] \wedge f_2[3] = 0.2 \wedge 0.6 = 0.2$
$R_3 = f_2 \wedge f_3 = f_1[4] \wedge f_2[2] = 0.8 \wedge 0.4 = 0.4$
$R_4 = f_2 \wedge f_4 = f_1[4] \wedge f_2[3] = 0.8 \wedge 0.6 = 0.6$

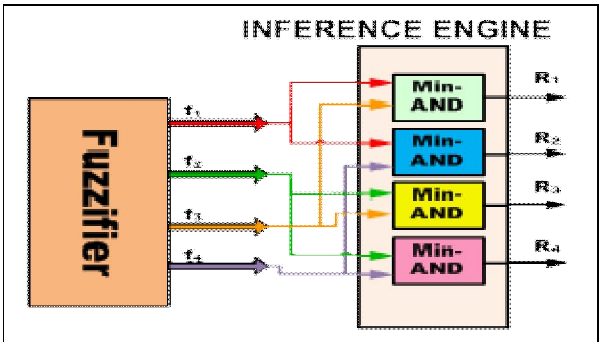

Fig. 7 Block Diagram of Inference Engine

3.3. Rule Selector

The rule selector receives two crisp values of temperature and humidity. It gives singleton values of output functions under algorithm rules applied on design model.

For two variables, four rules are needed to find the corresponding singleton values S_1, S_2, S_3 and S_4 for each variable according to these rules are listed in Table 7.

TABLE 7
ILLUSTRATION OF RULES APPLIED MODEL

Rule No.	INPUTS		SINGLETON VALUES OF OUTPUTS			Singleton Values
	Temperature	Humidity	Speed of Cooler Fan	Speed of Water Pump	Speed of Room Exhaust Fan	
1.	Normal	Not Too Dry	Low = 0.25	Medium=0.50	Slow=0.25	S_1
2.	Normal	Moist	Medium = 0.50	Medium=0.50	Slow=0.25	S_2
3.	Warm	Not Too Dry	High = 0.70	High=0.70	Slow=0.25	S_3
4.	Warm	Moist	High = 0.70	High=0.70	Medium=0.50	S_4

The rule base accepts two crisp input values, distributes the universe of discourse into regions with each region containing two fuzzy variables, fires the rules, and gives the output singleton values corresponding to each output variable. Fig. 8 shows the main block diagram of the Rule Base.

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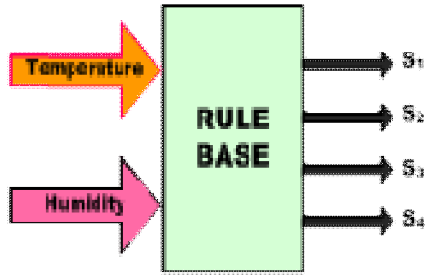

Fig. 8 Rule Base

3.4 Deffuzifier

In this system, three defuzzifiers control the actuators; speed of cooler fan, speed of water pump, speed of room exhaust fan. The membership functions of the three output variables are shown in Fig. 9 to Fig. 11, and the detail of each plot is given in TABLE 8.

TABLE 8
OUTPUT VARIABLES MEMBERSHIP FUNCTIONS

MFs	Range	Speed of Cooler Fan	Speed of Water Pump	Speed of Room Exhaust Fan
MF1	0-5	Stop	Stop	Stop
MF2	0-50	Low	Low	Slow
MF3	40-60	Medium	Medium	Medium
MF4	50-90	High	High	Fast
MF5	70-100	Very High	Very High	Very Fast

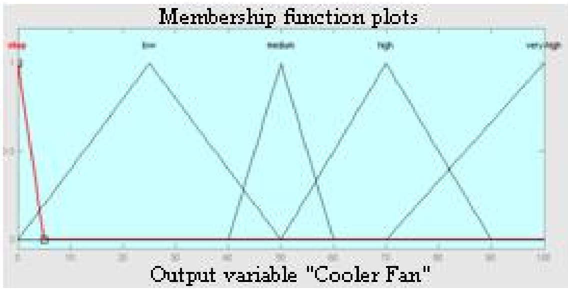

Fig. 9 Plot of Membership Functions for Output Variable, "Cooler Fan Speed"

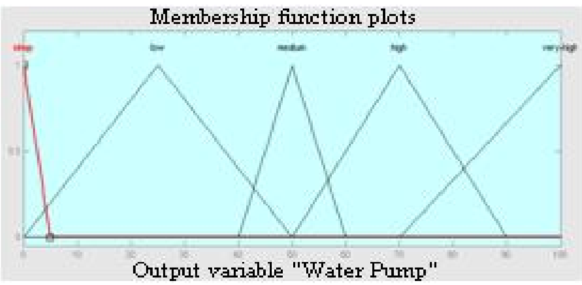

Fig.10. Plot of Membership Functions for Output Variable, "Water Pump Speed"

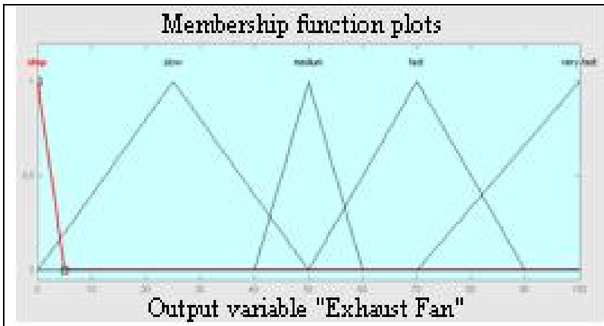

Fig.11. Plot of Membership Functions for Output Variable,

The defuzzification process provides the crisp value outputs after estimating its inputs [14]. In this system 8 inputs are given to each of three defuzzifiers. Four values of R_1, R_2, R_3, R_4 from the outputs of inference engine and four values S_1, S_2, S_3, S_4 from the rule selector are shown in Fig. 10. Each defuzzifier estimates the crisp value output according to the center of average (C.O.A) method using the mathematical expression, $\Sigma S_i * R_i / \Sigma R_i$, where i = 1 to 4. Each output variable membership function plot consists of five functions with the same range values for simplification.

Fig.12 shows the design arrangement of a defuzzifier. One defuzzifier consists of : one adder for ΣR_i, four multipliers for the product of $S_i * R_i$, one adder for $\Sigma S_i * R_i$, and one divider for $\Sigma S_i * R_i / \Sigma R_i$. Finally a defuzzifier gives the estimated crisp value output.

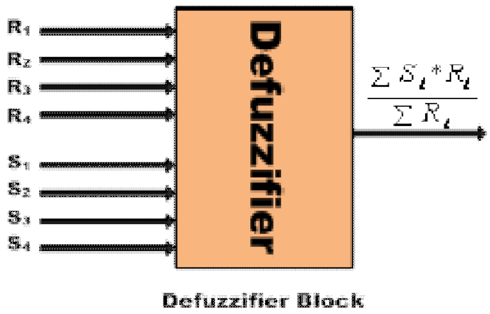

Fig.12 Defuzzifier Block

4. RESULTS AND DISCUSSION

The designed values for three outputs; cooler fan speed, water pump speed and room exhaust fan speed are given in the Tables 9-11. According to the results of inference engine

$$\Sigma R_i = R_1+R_2+R_3+R_4 = 0.2+0.2+0.4+0.6 = 1.4$$

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TABLE 9
DESIGNED VALUE FOR COOLER FAN SPEED

i	S_i	R_i	$S_i * R_i$
1	0.25	0.2	0.05
2	0.50	0.2	0.10
3	0.70	0.4	0.28
4	0.70	0.6	0.42

$\Sigma S_i * R_i = 0.85$ and $\Sigma S_i * R_i / \Sigma R_i = 0.85/1.4 = 0.6071$
= 60.71% of Cooler Fan Speed

TABLE 10
DESIGNED VALUE FOR WATER PUMP SPEED

i	S_i	R_i	$S_i * R_i$
1	0.50	0.2	0.10
2	0.50	0.2	0.10
3	0.70	0.4	0.28
4	0.70	0.6	0.42

$\Sigma S_i * R_i = 0.90$ and $\Sigma S_i * R_i / \Sigma R_i = 0.90 / 1.4 = 0.6428$

=64.28 % of Water Pump Speed

TABLE 11
DESIGNED VALUE FOR EXHAUST FAN SPEED

i	S_i	R_i	$S_i * R_i$
1	0.25	0.2	0.05
2	0.25	0.2	0.05
3	0.25	0.4	0.10
4	0.50	0.6	0.30

$\Sigma S_i * R_i = 0.50$ and $\Sigma S_i * R_i / \Sigma R_i = 0.50 / 1.4 = 0.3571$
= 35.71 % of Exhaust Fan Speed.

Using mathematical expression $\Sigma S_i * R_i / \Sigma R_i$ the crisp values for output variables were determined and the results were found according to the MATLAB simulation as shown in Fig.13. These results are compared in TABLE 13 and found correct according to the design model. MATLAB simulation was adapted according to the arrangement of membership functions for four rules as given in TABLE 12.

TABLE 12
ARRANGEMENT OF MEMBERSHIP FUNCTIONS FOR SIMULATION

Rule No.	INPUTS		OUTPUTS		
	Temperature	Humidity	Speed of Cooler Fan	Speed of Water Pump	Speed of Room Exhaust Fan
1	Normal	Not Too Dry	Low	Medium	Slow
2	Normal	Moist	Medium	Medium	Slow
3	Warm	Not Too Dry	High	High	Slow
4	Warm	Moist	High	High	Medium

In Fig. 13 the same values of input variables, Temperature = 28, and Humidity = 40 are shown. Various values of input and output variables match the dependency scheme of the system design. The simulated values were checked using MATLAB-Rule viewer as shown in Fig. 13.

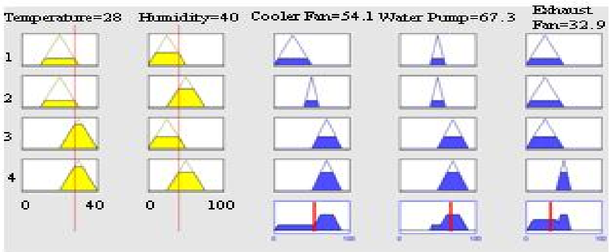

Fig.13. MATLAB-Rule Viewer

The correctness of results shows the validity of the simplified design work for processing system using fuzzy control system.

TABLE 13
COMPARISON OF SIMULATED AND CALCULATED RESULT

Result	Speed of Cooler Fan	Speed of Water Pump	Speed of Room Exhaust Fan
Design Values	60.7	64.28	35.71
MATLAB Simulation	54.1	67.3	32.9
% error	10.8	4.6	7.8

4.1. Simulation Graphs Discussion

This system was simulated for the given range of input variables. The given value of: Temperature = 28 lies in region 3 of the range 20-30 and Humidity = 40 lies in region 2 of the range 25-50. The four rules were applied for MATLAB simulation according to this range scheme. In this design model, the speed of cooler fan depends upon the selected value of temperature sensor, water pump and exhaust fan speeds depend on the value of humidity. The simulated and calculated results are according to the reliance scheme.

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Fig. 14 shows that the cooler fan speed is directly proportional to temperature and it does not depend upon the humidity. Fig. 15 represents that the water pump speed is inversely proportional to humidity and it does not depend upon the temperature. Fig. 16 shows that the exhaust fan speed is directly proportional to humidity.

5. CONCLUSION AND FUTURE WORK

Design model of autonomous room air cooler fuzzy logic processing control system provided the results effectively in agreement with the simulation results during the testing of various parts of the control system. The algorithmic design approach makes the system efficient and absolutely under control. This work builds up the control management without the complexity in a processing plant of room cooler to sustain the required cooling environment. The utility of the proposed system in such processing plants is being carried out and in future it will help to design the advanced control system for the various industrial applications in environment monitoring and management systems using state of the art FPGAs based Microelectronics Chips.

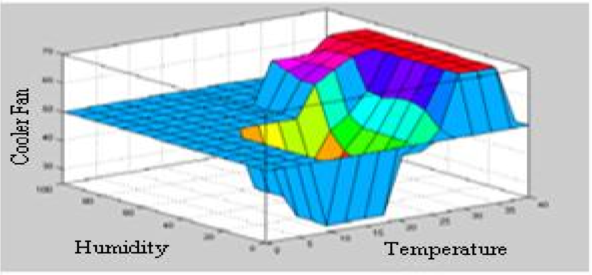

Fig.14 Plot between Temperature-Humidity & Cooler Fan Speed

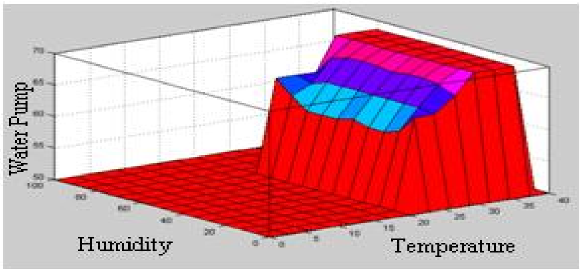

Fig.15. Plot between Temperature-Humidity & Water Pump Speed

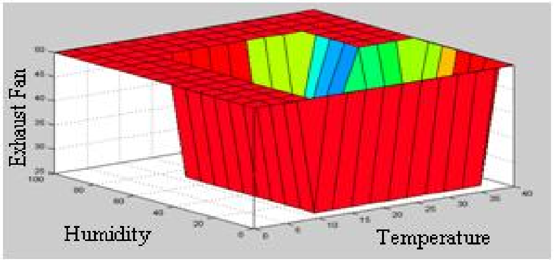

Fig.16. Plot between Temperature-Humidity & Room Exhaust Fan Speed

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