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Autonomous Environment Control System using Fuzzy Logic

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Abstract—This research work presents an autonomous system for premises environment control using fuzzy logic. This proposed design of control system has four inputs: luminance intensity, luminance mode, temperature and humidity. There are six controlling outputs for luminance controller, air conditioner, ceiling fan, air-cooler fan, water-pump and heating unit. This design model can be applied for indoor and outdoor environments like office, work place, home, commercial areas and streets. This application of fuzzy logic would contribute in minimizing the energy wastages. Fuzzy rules are formulated, applied and tested using MATLAB simulation.

Index Terms— autonomous environment control system, fuzzy logic environment control, luminance intensity, temperature and humidity level control system.

1 Introduction

THERE are focused considerations for controlling environment suitable to its living beings for not only easiness but also providing comfort to increase working capacities with fresh mind. It would save and enhance energy resources also. There have been criticalities for limitations of energy resources including ever increasing requirements for energy utilizations. There are wastages of energy during its utilizations even in needlessness specifically in deregulated environments [1]. It can be overcome through proper scheduling but it involves hazards. An appropriate solution is to make autonomous and controlled systems according to the requirements. The proposed system is based on fuzzy logic. Fuzzy Logic is suitable for uncertainties issues. The non-probabilistic problems are dealt with fuzzy logic [3]. There are different fuzzy inference system and defuzzification techniques were reported [2], [6]. However this research provides comprehensive application of fuzzy Logic for the particular appliances together involving the automation of light controller, air conditioner, heating unit ceiling fan and air-water-cooler controlling luminance, temperature and humidity. It would also save the energy cost. The feelings of temperature vary with the different levels of humidity. Humidity is the amount of water vapor in the air. In high humidity living beings feel the atmosphere very hot in summer because it reduces the effectiveness of sweating to cool the body by reducing the evaporation of perspiration from the skin. At normal temperature with wet atmosphere, it would be felt cool by living beings because water vapors absorb energy rapidly [5]. Air-cooler appliance works on this phenomenon. It includes air-cooler fan and water pump. It is something like window fan [7]. The phenomenon is also implemented for other appliances to save energies. By decreasing or increasing humidity there is less energy required for controlling temperature and making appropriate luminance according to the specifications to minimize energy wastages and discomfort. The frame work of this paper comprises, design and structure of the proposed autonomous environment control system in section 2, section 3 gives the design algorithm of autonomous environment control system, section 4 describes simulation results and discussion whereas Section 5 gives conclusion and future work.

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2 Design and Structure of The Proposed Autonomous Environment Control System

There are included Fuzzyfier, Inference Kernel connected with Knowledgebase and Defuzzifier in the proposed fuzzy logic system. The Knowledgebase contains Database, Rule base and Membership Functions.

The fuzzifier converts the Crisp values into Linguistics values. The linguistics values are manipulated for inference engine [4]. The kernel of the system provides the output according to the Rule Selector. The Rule Selector selects rules according to the Knowledgebase. Knowledgebase comprises of Database, Rule base and Membership Functions [3]. Rule base is built up carefully considering all possible effective situations. There have been incorporated four input variables: Luminance Intensity, Luminance Mode, Temperature and Humidity. There are six outputs controlling appliances: Luminance Controller, Air Conditioner, Ceiling Fan, Air-Cooler Fan, Water

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Pump and Heating Unit. There have been considered sixty rules for the effective situations focusing energy saving. There are used sixty operators for the rule selector. Luminance mode can be set according to the requirement. However there are proposed Time Oriented Luminance Intensity Mode Specifications for three types of premises including indoor and outdoor environments.

The feelings of hotness depend upon temperature and humidity. During low temperatures, the heating systems work for long enough to convert the climate into dry resulting discomfort. At normal temperature heating system remains off while there wet climate effects cool.

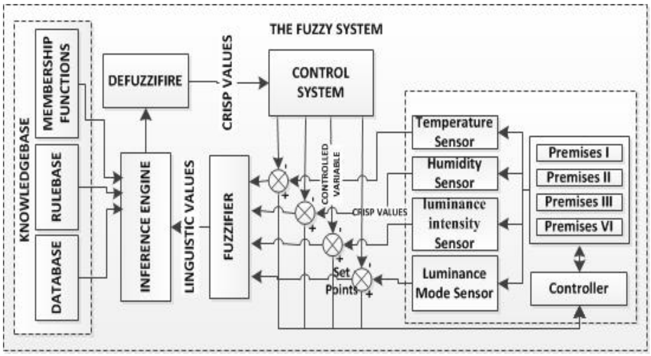

Fig.1. Block diagram of the proposed system to control the environment in different premises using fuzzy logic.

Similarly at warmer temperatures dry humidity demands comfort. Such situations indicate deregulations that result in not only discomfort but energy wastages also. The proposed system deals with such scenarios. It can be applied for different types of premises including office, workplace, study, display, sleep, candlelight and street modes whether the premises contain or don't contain all the appliances together. It would control luminance, temperature and humidity.

3 Design Algorithm Of Autonomous Environment Control System

The system is designed for five appliances. It takes four inputs namely luminance intensity, luminance mode, temperature and humidity. The membership functions with their respective ranges for input variables are shown in the Table I.

TABLE I.

Membership Functions of Input Variables: Luminance Intensity, Luminance Mode, Temperature and Humidity

Luminance Intensity (cd)	MF Range	Luminance Mode	MF Range	Temperature (°C)	MF Range	Humidity (RH)	MF Range
Dark	0-33	Sleep/Off	0-33	Cold	0-15	Wet	0-33
Low	0-66	Candle Light/Safety	0-66	Cool	0-30	Normal	0-66
				Nominal	15-45		
Normal	33-100	Normal Working	33-100	Warm	30-60	Dry	33-100
				Very Warm	45-80		
Bright	66-100	Work/Study /Display	66-100	Hot	60-100	Very Dry	66-100
				Very Hot	80-100		

There are six output variables to adjust and controle an environment for the five appliances. The membership functions for light control and air conditioner are represented in Table II.

TABLE II.

Membership Functions of Output Variables: Luminance Controller and Air Conditioner

Luminance Controller	MF Range	Air Conditioner	MF Range
Off	0-30	Off	0-20
Low	0-60	Fan Mod	0-40
Medium	30-90	Low	20-60
High	60-100	Medium	40-80
		High	60-100
		Very High	80-100

The membership functions for output variables: ceiling fan, air-water fan, water pump and heating unit are shown in the Table III.

TABLE III.

Membership Functions of Output Variables: Ceiling Fan, Air-Cooler Fan, Water Pump and Heating Unit

Ceiling Fan	MF Range	Air-Cooler Fan	MF Range	Water Pump	MF Range	Heating Unit	MF Range
Off	0-30	Off	0-50	Off	0-50	High	0-50
Low	0-60	Low	0-100	Low	0-100	Low	0-100
Medium	30-100	High	50-100	High	50-100	Off	50-100
High	60-100						

Table IV shows the rule base for input luminance intensity, luminance mode and corresponding output for luminance controller.

TABLE IV.

Rule Base for Light Intensity Control

Rule No.	Input		Output
	Luminance Mode	Luminance Intensity	Luminance Controller
1	Sleep/Off	Dark	Off
2		Low	Off
3		Normal	Off
4		Bright	Off
5	Candle light/Safety	Dark	Low
6		Low	Off
7		Normal	Off
8		Bright	Off
9	Normal working	Dark	Medium
10		Low	Medium
11		Normal	Off
12		Bright	Off
13	Work/Study / Display	Dark	High
14		Low	High
15		Normal	Medium
16		Bright	Off

Luminance intensity would be used to adjust the luminance of the premises according to the requirement and the type of the premises. The requirments can be set with respect to the type of the premeses with time oriented scheduling in terms of luminance mode. A model scheduling has been drawn for offic or work environmrnt and given in the Table V.

TABLE V.

TIME ORIENTED LUMINANCE MODE SPECIFICATIONS FOR OFFICE OR WORK PREMISES

Time Oriented Mode Specifications for Work Place Premises		
Time	**Scale**	**Luminance Mode**
Arrival	07:00-09:00	Normal Daily Working
Working Hours	09:00-17:00	Work/Study /Display
Closing	17:00-18:00	Normal Daily Working
Evacuation	18:00-18:30	Candle light/Safety
Work Place Closed	18:30-07:00	Sleep/Off

For home premises a modulation for luminance control mode is represented in Table VI.

TABLE VI.

Time Oriented Luminance Intensity Mode Specifications for Home premises

Time	Scale	Luminance Mode
early morning	04:00-06:00	Candle light/Safety
morning	06:00-10:00	Sleep/Off
noon	10:00-14:00	Sleep/Off
after noon	14:00-17:00	Sleep/Off
evening	17:00-20:00	Normal Working
night	20:00-23:00	Study/Display
late night	23:00-04:00	Sleep/Off

Controling light in the outdoor environments is manupulated with the dierect daylight luminance. It can be implimented by both time oriented and the luminance sensor. However the lator is convinient. Table VII presents both ways.

TABLE VII.

TIME ORIENTED LUMINANCE INTENSITY MODE SPECIFICATIONS FOR OUTDOOR PREMISES

Time	Scale	Luminance Mode
Evening to Morning	18:00-06:00 (< 200 Cd)	Normal Working
Morning to Evening	06:00-18:00 (> 200 Cd)	Sleep/Off

Table VIII presents rule base for inputs: temperature and humidity to controle output variables: ceiling fan, air-cooler fan its water pump, air conditioner and heating unit. Rules 17 to 24 are formulated for low temperatures when heating unit is critical while cooling appliances remain off.

TABLE VIII

RULE BASE FOR TEMPERATURE AND HUMIDITY CONTROL IN THE PREMISES

Rule No.	Inputs: Temperature	Inputs: Humidity	Outputs: Ceiling Fan	Outputs: Air-Cooler-Fan	Outputs: Water-Pump	Outputs: Air-Conditioner	Outputs: Heating Unit
Rule Base for Temperature and Humidity Control in Indoor Premises at Low Temeratures When Heating Unit Might Be On							
17	Cold	Wet	Off	Off	Off	Off	High
18	Cold	Normal	Off	Off	Off	Off	High
19	Cold	Dry	Off	Off	Off	Off	Low
20	Cool	Wet	Off	Off	Off	Off	High
21	Cool	Normal	Off	Off	Off	Off	Low
22	Cool	Dry	Off	Off	Off	Off	Low
23	Nominal	Wet	Off	Off	Off	Off	Low
24	Nominal	Normal	Off	Off	Off	Off	Off
Rule Base for Temperature and Humidity Control in Indoor Premises Containing Air-Cooler and Ceiling Fan							
25	Warm	Wet	Off	Off	Off	None	Off
26	Warm	Normal	Low	Off	Off	None	Off
27	Very Worm	Normal	Medium	Off	Off	None	Off
28	Hot	Normal	High	Off	Off	None	Off
29	Hot	Dry	Medium	Low	Low	None	Off
30	Hot	Very dry	Low	High	High	None	Off
31	Very Hot	Normal	Low	Low	Low	None	Off
32	Very Hot	Dry	Medium	High	High	None	Off
33	Very Hot	Very Dry	High	High	High	None	Off
Rule Base for Temperature and Humidity Control in Indoor Premises Containing Air-Conditioner							
34	Warm	Wet	None	None	None	Off	Off
35	Warm	Normal	None	None	None	Fan Mod	Off
36	Very Warm	Normal	None	None	None	Fan Mod	Off
37	Hot	Normal	None	None	None	Low	Off
38	Hot	Dry	None	None	None	Medium	Off
39	Hot	Very dry	None	None	None	High	Off
40	Very Hot	Normal	None	None	None	Medium	Off
41	Very Hot	Dry	None	None	None	High	Off
42	Very Hot	Very Dry	None	None	None	Very High	Off
Rule Base for Temperature and Humidity Control in Indoor Premises Containing CeilingFan							
43	Warm	Wet	Off	None	None	None	Off
44	Warm	Normal	Low	None	None	None	Off
45	Very Warm	Normal	Medium	None	None	None	Off
46	Hot	Normal	Medium	None	None	None	Off
47	Hot	Dry	Medium	None	None	None	Off
48	Hot	Very dry	Low	None	None	None	Off
49	Very Hot	Normal	High	None	None	None	Off
50	Very Hot	Dry	High	None	None	None	Off
51	Very Hot	Very Dry	Medium	None	None	None	Off
Rule Base for Temperature and Humidity Control in Indoor Premises Containing Air-Cooler							
52	Warm	Wet	None	Off	Off	None	Off
53	Warm	Normal	None	Low	Off	None	Off
54	Very Warm	Normal	None	High	Off	None	Off
55	Hot	Normal	None	Low	Low	None	Off
56	Hot	Dry	None	High	Low	None	Off
57	Hot	Very dry	None	Low	High	None	Off
58	Very Hot	Normal	None	High	Low	None	Off
59	Very Hot	Dry	None	High	High	None	Off
60	Very Hot	Very Dry	None	High	High	None	Off

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Rules 25 to 33 cover the premises containing all the appliances except heating unit. Rules 34 to 42 are for the premises that contain air conditioner and rules 43 to 51 reserve for just ceiling fan. Rules 52 to 60 cover the crticalities for air cooler including its water pump.

Plots of membership functions for input fuzzy variables are given in Fig. 2, Fig. 3, Fig. 4 and Fig. 5. The four membership functions Dark(1), Low(2), Normal(3) and Bright(4) are used to represent various ranges of input variable luminance intensity in Fig. 2.

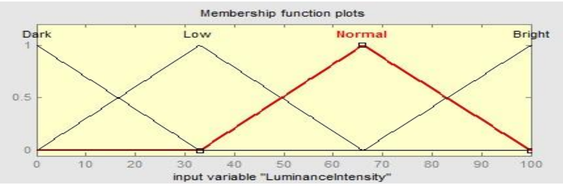

Fig. 2. Plot of membership functions for input fuzzy variable Luminance Intensity

The four membership functions Sleep / Off (1), Candle light/Safety (2), Normal daily Working (3) and Study/Display (4) are used to represent various ranges of input variable luminance intensity mode in Fig. 3.

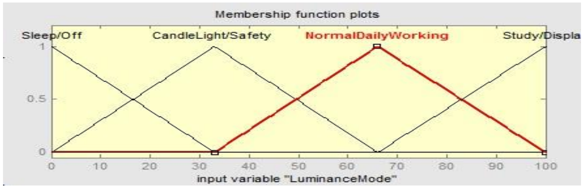

Fig. 3. Plot of membership functions for input fuzzy variable Luminance Mode

The seven membership functions Cold (1) Cool (2), Normal(3), Warm(4), Very Warm (5), Hot (6) and Very Hot(7) are used to represent input variable Temperature in Fig. 4 containing six regions.

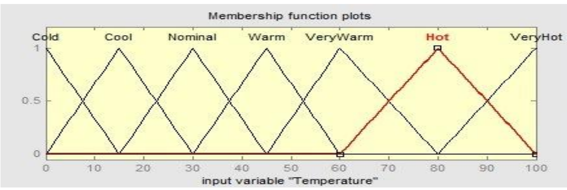

Fig. 4. Plot of membership functions for input fuzzy variable Temperature with their respective ranges

The four membership functions Wet (1) Nominal (2), Dry(3) and Very Dry(4) used to represent input variable Humidity in Fig. 5. It consists of three regions.

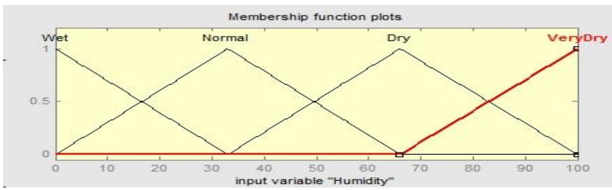

Fig. 5. Plot of membership functions for Humidity with the ranges

The four membership functions Off(1), Low(2), Medium(3) and High(4) luminance are used to represent fuzzy output variable Light Controller in Fig. 6. It contains three regions.

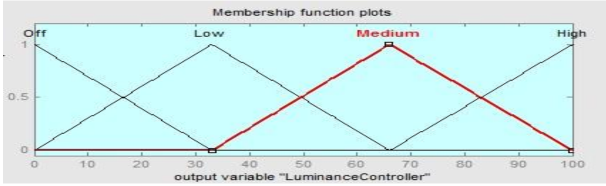

Fig. 6. Plot of membership functions for output Luminance Controller with their respective ranges

There are used six membership functions Very High (1) High(2), Medium(3), Low(4), Fan Mode (5) and Off (6) to represent output controlling variable for Air Conditioner in Fig. 7 containing five regions.

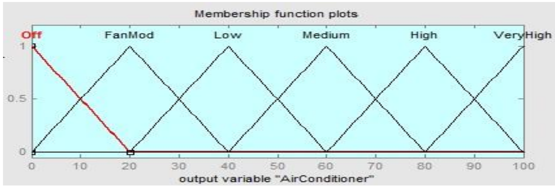

Fig. 7. Plot of membership functions for output variable Air conditioner with their respective ranges

There are used four membership functions High(1) Medium(2), Low(3) and Off(4) to represent output controlling variable for Ceiling Fan in Fig. 8 consisting three regions. The third region is critical at high humidity.

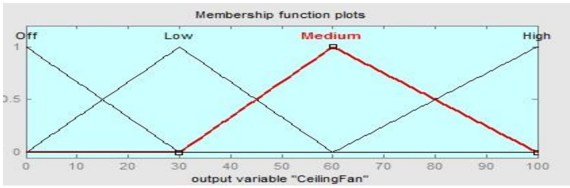

Fig. 8. Plot of membership functions for fuzzy output variable Ceiling Fan with their respective ranges

Although the rang values of Air-cooler Fan, Water Pump and Heating Unit are taken according to the requirment, however these are same. Therefore the shape of of the plot of membership functions for output variable Air-cooler Fan, its Water Pump and Heating Unit are occued same in this proposed design and are shown in Fig. 9.

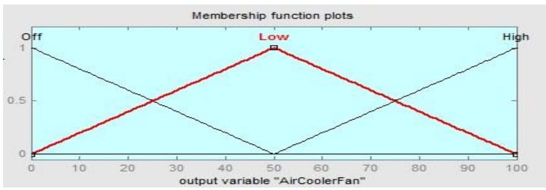

Fig. 9. Plot of membership functions for output variable Air-Cooler Fan, its Water Pump and Heating Unit with their respective ranges

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There are used three membership functions High (1) Low (2) and Off (3) to represent output controlling variable for Air Water Fan, its Water Pump and Heating Unit in Fig. 9 consisting of two regions.

The Fuzzy Fier will convert the three input crisp values into six output linguistic values. There are sixty rules are fired for the values of one set of variables. A total of 60 rules have been generated. The inference engine consists of sixty operators. The rule selector receives four input values luminance intensity, luminance mode, temperature and humidity. It provides singleton values of output functions under algorithm rules applied on this design model. The Defuzzifier converts the output values into crisp values to control the environment.

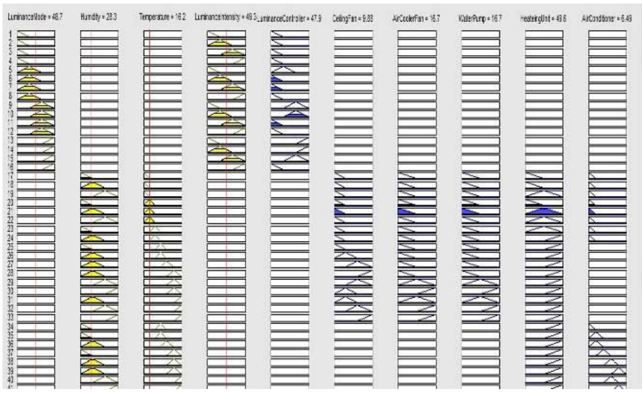

Fig. 10. MATLAB rule viewer and simulations result for autonomous environment control system

The rule viewer represents output variations for different values of input variables according to the rule base.

4 Simulation Results and Discussion

The surface view of the plots of output variables luminance controller, air conditioner, ceiling fan, air-cooler fan, water pump and heating unit on input variables luminance intensity, luminance mode, temperature and humidity has been drawn according to the design scheme of the rule base. The plots in Fig. 11 indicate the inter dependencies of the effects of temperature and humidity on controlling units.

Fig. 11(a). shows that luminance intensity and luminance mode is directly proportional to the light controller. It means energy can be saved only through proper scheduling and does not by other than light resource.

Fig. 11(b). describe that ceiling fan directly proportional to temperature in most of the ranges of the membership functions while ceiling fan is not directly proportional to humidity in all the ranges of the membership functions. It shows that energy would be less consumed in the situations when ceiling fan is not depending on temperature and humidity.

Fig. 11(c). indicates the plot of air-cooler fan on temperature and humidity while energy would be saved in the situations when air-cooler fan is not depending on temperature and humidity.

Fig. 11(d). is the plot of water pump on temperature and humidity showing that it works smoothly in medium-low temperatures and high humidity while it is directly proportional to the humidity in high temperatures.

Fig. 11(e). indicates that energy is to be saved from heating unit having small values in high humidity with low temperature.

Fig. 11(f). depicts that energy is saving by reducing air conditioner in low temperatures.

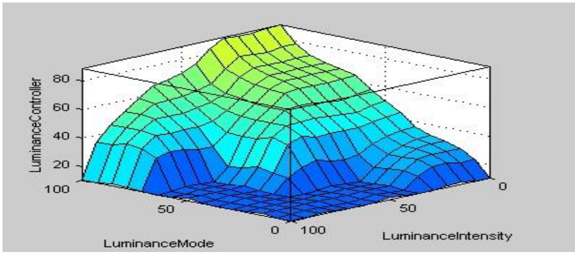

Fig. 11(a). Plot view of luminance mode, luminance intensity on luminance controller.

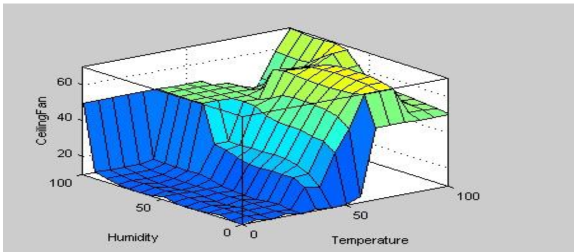

Fig. 11(b) Plot view of ceiling fan on temperature and humidity.

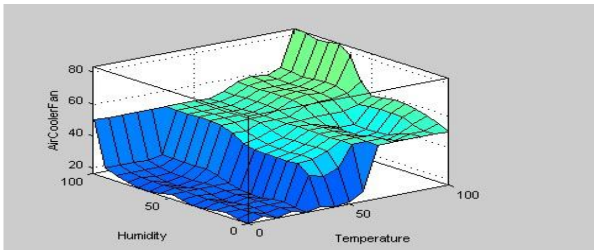

Fig. 11(c) Plot view of air-cooler fan on temperature and humidity.

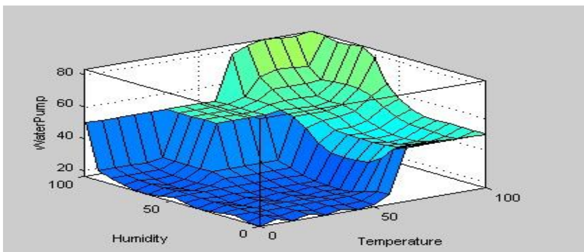

Fig. 11(d) Plot view of water pump on temperature and humidity.

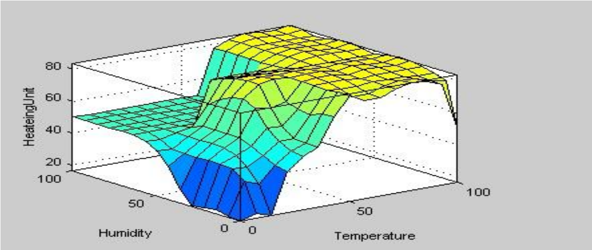

Fig. 11(e) Plot view of heating unit fan on temperature and humidity.

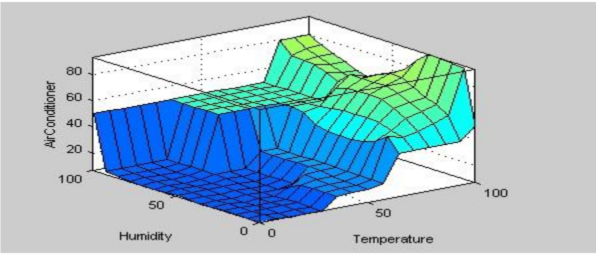

Fig. 11(f) Plot view of air conditioner on temperature and humidity.

5 Conclusion And Future Work

The simulated results show the effectiveness of the Autonomous Environment Control System. It automates the appliances and contributes in better utilization of energy. The proposed system is suitable for deregulation environments also. It works from low humidity to high humidity, low temperature to high temperature and dark luminance to bright maintaining environment pleasant to the user satisfaction and comfort. It would enhance working capacities also.

For future work neural network simulation of Autonomous Environment Control System would be manipulated including more appliances.

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