Fuzzy Logic Based Air Conditioning System

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Abstract: In this paper, a fuzzy logic based Air Conditioning System (FBACS) is an efficient room temperature controller system which based on fuzzy logic controller. The system is a smart which provide the control on both room temperature and the humidity of a room in efficient and effective manner so that it provide not only healthy atmosphere as per medical guidelines, but also provide many beneficial things such as saving electrical energy i.e. less power consumption, increases air conditioner efficiency, environment friendly, good for health, and economic. So, main objective of this paper is to design a system, which provide well atmosphere and also economic for person as well as for nature. A FBACS is designed to improve the system efficiency based on controlled input such as selected temperature, temperature difference and dew point. At the output side the compressor speed and fan speed will be controlled by the controlled input variables. The efficient FBACS maintain the proper comfort or artificial environmental conditions with the minimum possible energy consumption.

Keywords: temperature; speed, fuzzy logic control.

I. Introduction

A smart room temperature controller system is basically same as a refrigerator without the insulated box. It uses the evaporation of a refrigerant, like Freon to provide cooling. The mechanics of the Freon evaporation cycle are the same in a refrigerator. The compressor compresses cool Freon gas, causing it to become hot, high-pressure Freon gas [1-4]. This hot gas runs through a set of coils so it can dissipate its heat, and it condenses into a liquid. The Freon liquid runs through an expansion valve, and in the process it evaporates to become cold a low- pressure Freon gas. This cold gas runs through a set of coils that allow the gas to absorb heat and cool down the air inside the building. The cooling level of the air conditioner system is base on the compressor speed and the fan speed [5]. But it is waste of energy if the compressor and fan is always run in a certain speed to provide the cooling level. With add in controller system, the speed of compressor and fan can be autonomous according to the room temperature setting [6].

The basic level of warmth required for a healthy and well-dressed person is 18°C. This standard is recognized by the World Health Organization. Here are some basic benchmarks for indoor temperatures:

> 24°C - cardiovascular risk,
18-21°C - comfortable temperature, 18°C -
minimum for comfort
12-16°C - respiratory risk
<12°C - cardiovascular risk

Here our emphasized should not so much on luxurious life because it makes human body lazy and decreases its immune power so always keeps in mind and should always give the first priority to those things which provide healthy and fit life in economic range and have minimum disgusting effect to natural environment. So, It is better to design a system, which provide healthy atmosphere and also economic for person as well as for nature.

The objective of this system is to design an intelligent controller that used the fuzzy logic controller technique to control room temperature based on outputs control. This system will control the speed of compressor and fan to save the energy.

MATLAB Fuzzy logic Toolbox is used to design fuzzy logic controller. Basically, the Fuzzy Logic controller consists of four basic components: fuzzification, a knowledge base, inference engine, and a defuzzification interface as shown in Figure 1. Each component of the fuzzy logic controlled system affects the effectiveness of the fuzzy controller in economic as well as betterment for health point of view [7-9]. In the fuzzification interface, a measurement of inputs and a transformation, which converts input data into suitable linguistic variables, are performed which mimic human decision making [10-15]. The results obtained by fuzzy logic depend on fuzzy inference rules and fuzzy implication operators. The knowledge base provides necessary information for linguistic control rules and the information for fuzzification and defuzzification. In the defuzzification interface, an actual control action is obtained from the results of fuzzy inference engine [16].

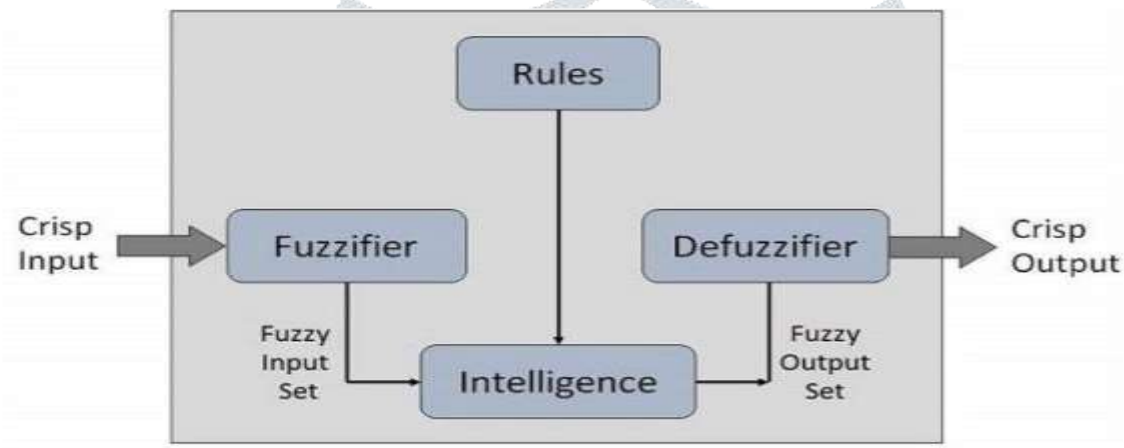
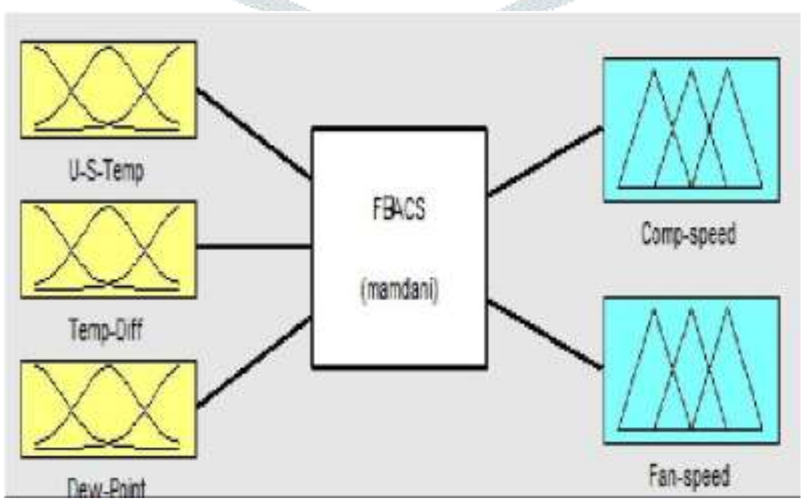


Figure 1: Basic Configuration of Fuzzy Logic Controller

II. Methodology

The Mamdani techniques will be used in this system consists of three control inputs and two control outputs as shown in Figure 2. To simplify this system, only two outputs will be considered in terms of the speed of compressor and fan changing with the difference input temperature.



a. Input of the system

Figure 2: Fuzzy based air conditioner system

Input 1 is set as the user decides temperature; it is divided into 5 membership functions, where two types of membership function are used such as trapmf (trapezoidal membership function) and trimf (trigonometric membership function) consists of five membership function in which two are trapmf type (Very Cool and Very Hot) and three are trimf (Cool, Medium and Hot) as shown in Figure 3. User select temperature holds users preferred temperature received by remote/front control unit. The control unit allows user to set temperature on a continuous dial over full range of 22°C to 28 °C.

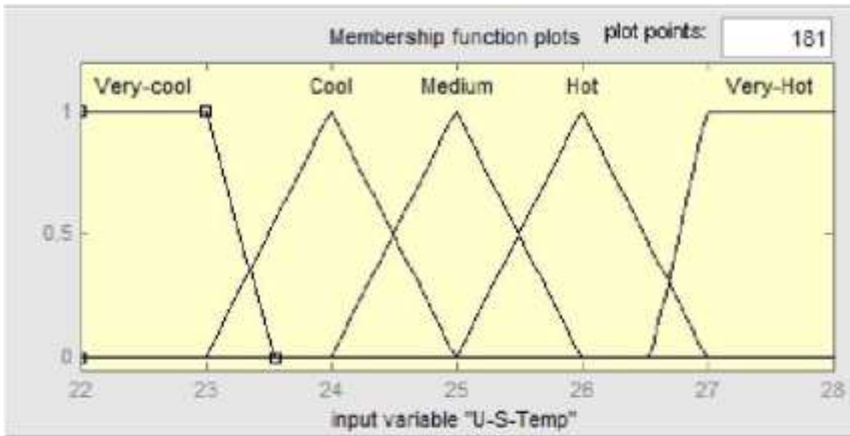


Figure 3: Membership function of user selected temperature

Input 2 is the temperature difference which is divided into 5 membership functions (Negative Large, Negative Small, Zero, Positive Small and Positive Large) in which Negative Large and Positive Large are trepazoidal type and other three are trigonometric type as shown in Figure 4. Temperature difference gives information on difference between actual room temperature as received by electronic thermostat and user selected temperature.

[Temperature Difference = Actual Room Temperature – User Selected Temperature]

The thermostat range should be wide enough to take care of climatic and regional weather conditions fluctuation. In the case of "Utter Pradesh" the range is between 0° C to 50° C, which constraints temperature difference between -15° C to 15° C.

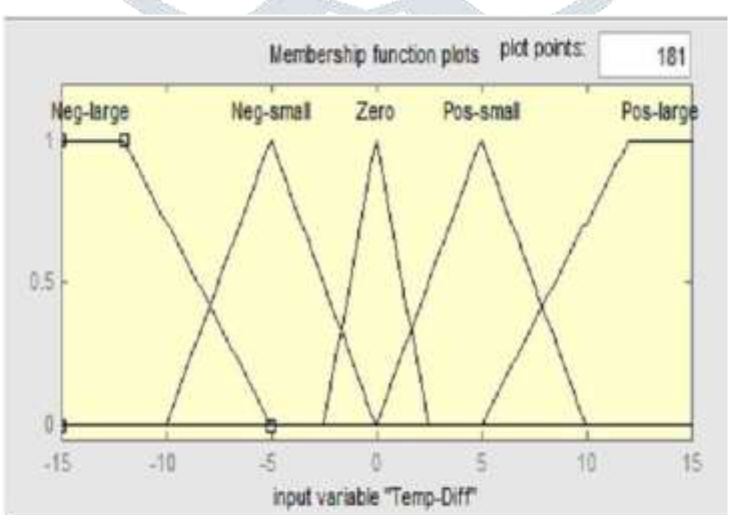


Figure 4: Membership function of temperature difference

Input 3 is the dew point detection which is divided into 3 membership functions, the outlook for the system is shown in Figure 5. Dew point detection gives information about dew point temperature inside the room as received by electronic dew point sensor. Dew point is a direct measure of moisture content of air and is independent of temperature. Table 1, shows Human perception versus dew point [17]

Table 1: Human perception versus dew point [17]

Dew Point°C	Dew Point°F	Human Perception[1]	Relative Humidity at 90°F(32°C)
>Higher than 26°C	> Higher than 80°F	Severely high, Even deadly for Asthma related illnesses	72% and higher
24-25°C	75-80°F	Extremely uncomfortable, fairly opp	62%-71%
21-24°C	70-74°F	Very Humid, quite uncomfortable	52% - 61%
18-21°C	65-69°F	Somewhat uncomfortable for most people at upper age	44% - 51%
16-18°C	60-64°F	OK for most, but all perceive the humidity at upper age	37–43%
13–16 °C	55–59 °F	Comfertable	31–36%
10–12 °C	50–54 °F	Very comfortable	26–30%
< 10 °C	< 50 °F	A bit dry for some	25% and lower

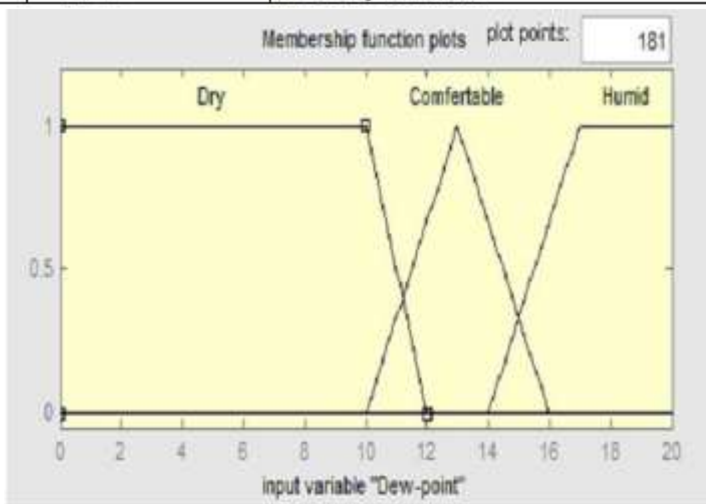


Figure 5: Membership function of dew point

b. Output of the system

Output 1 is the compressor speed which is divided into 6 membership function, the outlook for the system is shown in Figure 6. The range of this output is 0 to 100 which means the percentage speed of the compressor.

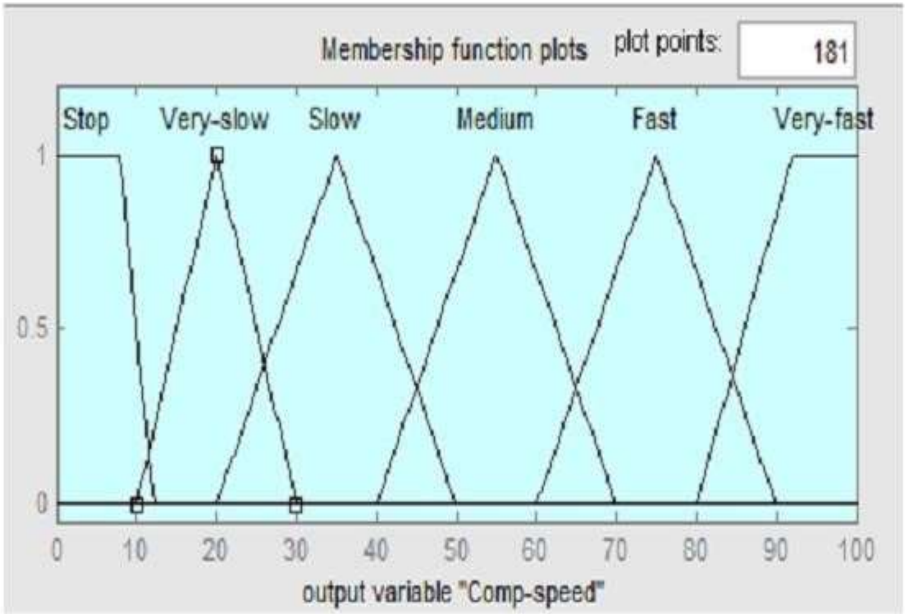


Figure 6: membership function of compressor speed

Output 2 is the fan speed which is divided into 5 membership function the outlook for the system is shown in Figure 7. The range of this output is 0 to 100 which means the speed percentage of the fan.

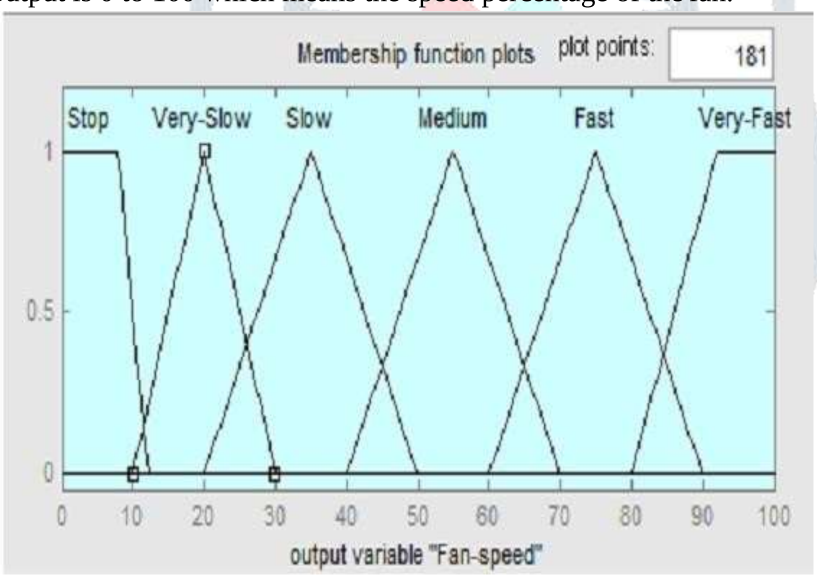


Figure 7: membership function of fan speed

c. Rules for the system

There is a combination of compressor speed and fan speed in order to control the room temperature according to the designed room temperature. The examples of the rules are shown as below:

1. If (U-S-Temp is Very-Cool) and (Temp-Diff is Neg-large) and (Dew-Point is Dry) then (Comp-speed is Stop) (Fan-speed is Stop) (1)
2. If (U-S-Temp is Cool) and (Temp-Diff is Neg-large) and (Dew-Point is Dry) then (Comp-speed is Stop) (Fan-speed is Stop) (1)
3. If (U-S-Temp is Medium) and (Temp-Diff is Neg-large) and (Dew-Point is Dry) then (Comp-speed is Stop) (Fan-speed is Stop) (1)
4. If (U-S-Temp is Hot) and (Temp-Diff is Neg-large) and (Dew-Point is Dry) then (Comp-speed is Stop) (Fan speed is Stop)

(1)

5. If (U-S-Temp is Very-Hot) and (Temp-Diff is Neg-large) and (Dew-Point is Dry) then (Comp-speed is Stop) (Fan-speed is Stop) (1)
6. If (U-S-Temp is Very-Cool) and (Temp-Diff is Neg-large) and (Dew-Point is Comfortable) then (Comp- speed is Stop) (Fan-speed is Stop) (1)
7. If (U-S-Temp is Cool) and (Temp-Diff is Neg-large) and (Dew-Point is Comfortable) then (Comp-speed is Stop) (Fan-speed is Stop) (1)
8. If (U-S-Temp is Medium) and (Temp-Diff is Neg-large) and (Dew-Point is Comfortable) then (Comp- speed is Stop) (Fan-speed is Stop) (1)
9. If (U-S-Temp is Hot) and (Temp-Diff is Neg-large) and (Dew-Point is Comfortable) then (Comp-speed is Stop) (Fan-speed is Stop) (1)
10. If (U-S-Temp is Very-Hot) and (Temp-Diff is Neg-large) and (Dew-Point is Comfortable) then (Comp- speed is Stop) (Fan-speed is Stop) (1)
11. If (U-S-Temp is Very-Cool) and (Temp-Diff is Neg-large) and (Dew-Point is Humid) then (Comp-speed is Stop) (Fan-speed is Very-slow) (1)
12. If (U-S-Temp is Cool) and (Temp-Diff is Neg-large) and (Dew-Point is Humid) then (Comp-speed is Stop) (Fan-speed is Very-slow) (1)
13. If (U-S-Temp is Medium) and (Temp-Diff is Neg-large) and (Dew-Point is Humid) then (Comp-speed is Stop) (Fan-speed is Very-slow) (1)
14. If (U-S-Temp is Hot) and (Temp-Diff is Neg-large) and (Dew-Point is Humid) then (Comp-speed is Stop) (Fan-speed is Very-slow) (1)
15. If (U-S-Temp is Very-Hot) and (Temp-Diff is Neg-large) and (Dew-Point is Humid) then (Comp-speed is Stop) (Fan-speed is Very-slow) (1)
16. If (U-S-Temp is Very-Cool) and (Temp-Diff is Neg-small) and (Dew-Point is Dry) then (Comp-speed is Stop)(Fan-speed is Stop) (1)
17. If (U-S-Temp is Cool) and (Temp-Diff is Neg-small) and (Dew-Point is Dry) then (Comp-speed is Stop)(Fan-speed is Stop) (1)
18. If (U-S-Temp is Medium) and (Temp-Diff is Neg-small) and (Dew-Point is Dry) then (Comp-speed is Stop)(Fan-speed is Stop) (1)
19. If (U-S-Temp is Hot) and (Temp-Diff is Neg-small) and (Dew-Point is Dry) then (Comp-speed is Stop)(Fan-speed is Stop) (1)
20. If (U-S-Temp is Very-Hot) and (Temp-Diff is Neg-small) and (Dew-Point is Dry) then (Comp-speed is Stop)(Fan-speed is Stop) (1)
21. If (U-S-Temp is Very-Cool) and (Temp-Diff is Neg-small) and (Dew-Point is Comfortable) then (Comp- speed is Stop)(Fan-speed is Stop) (1)
22. If (U-S-Temp is Cool) and (Temp-Diff is Neg-small) and (Dew-Point is Comfortable) then (Comp-speed is Stop)(Fan-speed is Stop) (1)
23. If (U-S-Temp is Medium) and (Temp-Diff is Neg-small) and (Dew-Point is Comfortable) then (Comp- speed is Stop)(Fan-speed is Stop) (1)
24. If (U-S-Temp is Hot) and (Temp-Diff is Neg-small) and (Dew-Point is Comfortable) then (Comp-speed is Stop)(Fan-speed is Stop) (1)
25. If (U-S-Temp is Very-Hot) and (Temp-Diff is Neg-small) and (Dew-Point is Comfortable) then (Comp- speed is Stop)(Fan-speed is Stop) (1)
26. If (U-S-Temp is Very-Cool) and (Temp-Diff is Neg-small) and (Dew-Point is Humid) then (Comp-speed is Stop)(Fan-speed is Slow) (1)
27. If (U-S-Temp is Cool) and (Temp-Diff is Neg-small) and (Dew-Point is Humid) then (Comp-speed is Stop)(Fan-speed is Slow) (1)
28. If (U-S-Temp is Medium) and (Temp-Diff is Neg-small) and (Dew-Point is Humid) then (Comp-speed is Stop)(Fan-speed is Slow) (1)
29. If (U-S-Temp is Hot) and (Temp-Diff is Neg-small) and (Dew-Point is Humid) then (Comp-speed is Stop)(Fan-speed is Slow) (1)
30. If (U-S-Temp is Very-Hot) and (Temp-Diff is Neg-small) and (Dew-Point is Humid) then (Comp-speed is Stop)(Fan-speed is Slow) (1)
31. If (U-S-Temp is Very-Cool) and (Temp-Diff is Zero) and (Dew-Point is Dry) then (Comp-speed is Stop)(Fan-speed is Stop) (1)
32. If (U-S-Temp is Cool) and (Temp-Diff is Zero) and (Dew-Point is Dry) then (Comp-speed is Stop)(Fan- speed is Stop) (1)
33. If (U-S-Temp is Medium) and (Temp-Diff is Zero) and (Dew-Point is Dry) then (Comp-speed is Stop)(Fan- speed is Stop) (1)

34. If (U-S-Temp is Hot) and (Temp-Diff is Zero) and (Dew-Point is Dry) then (Comp-speed is Stop)(Fan- speed is Stop) (1)
35. If (U-S-Temp is Very-Hot) and (Temp-Diff is Zero) and (Dew-Point is Dry) then (Comp-speed is Stop)(Fan-speed is Stop) (1)
36. If (U-S-Temp is Very-Cool) and (Temp-Diff is Zero) and (Dew-Point is Comfortable) then (Comp-speed is Stop)(Fan-speed is Stop) (1)
37. If (U-S-Temp is Cool) and (Temp-Diff is Zero) and (Dew-Point is Comfortable) then (Comp-speed is Stop)(Fan-speed is Stop) (1)
38. If (U-S-Temp is Medium) and (Temp-Diff is Zero) and (Dew-Point is Comfortable) then (Comp-speed is Stop)(Fan-speed is Stop) (1)
39. If (U-S-Temp is Hot) and (Temp-Diff is Zero) and (Dew-Point is Comfortable) then (Comp-speed is Stop)(Fan-speed is Stop) (1)
40. If (U-S-Temp is Very-Hot) and (Temp-Diff is Zero) and (Dew-Point is Comfortable) then (Comp-speed is Stop)(Fan-speed is Stop) (1)
41. If (U-S-Temp is Very-Cool) and (Temp-Diff is Zero) and (Dew-Point is Humid) then (Comp-speed is Stop)(Fan-speed is Slow) (1)
42. If (U-S-Temp is Cool) and (Temp-Diff is Zero) and (Dew-Point is Humid) then (Comp-speed is Stop)(Fan- speed is Slow) (1)
43. If (U-S-Temp is Medium) and (Temp-Diff is Zero) and (Dew-Point is Humid) then (Comp-speed is Stop)(Fan-speed is Slow) (1)
44. If (U-S-Temp is Hot) and (Temp-Diff is Zero) and (Dew-Point is Humid) then (Comp-speed is Stop)(Fan- speed is Slow) (1)
45. If (U-S-Temp is Very-Hot) and (Temp-Diff is Zero) and (Dew-Point is Humid) then (Comp-speed is Stop)(Fan-speed is Slow) (1)
46. If (U-S-Temp is Very-Cool) and (Temp-Diff is Pos-small) and (Dew-Point is Dry) then (Comp-speed is Very-slow)(Fan-speed is Slow) (1)
47. If (U-S-Temp is Cool) and (Temp-Diff is Pos-small) and (Dew-Point is Dry) then (Comp-speed is Slow)(Fan-speed is Medium) (1)
48. If (U-S-Temp is Medium) and (Temp-Diff is Pos-small) and (Dew-Point is Dry) then (Comp-speed is Medium)(Fan-speed is Medium) (1)
49. If (U-S-Temp is Hot) and (Temp-Diff is Pos-small) and (Dew-Point is Dry) then (Comp-speed is Medium)(Fan-speed is Fast) (1)
50. If (U-S-Temp is Very-Hot) and (Temp-Diff is Pos-small) and (Dew-Point is Dry) then (Comp-speed is Fast)(Fan-speed is Fast) (1)
51. If (U-S-Temp is Very-Cool) and (Temp-Diff is Pos-small) and (Dew-Point is Comfortable) then (Comp- speed is Slow)(Fan-speed is Medium) (1)
52. If (U-S-Temp is Cool) and (Temp-Diff is Pos-small) and (Dew-Point is Comfortable) then (Comp-speed is Slow)(Fan-speed is Medium) (1)
53. If (U-S-Temp is Medium) and (Temp-Diff is Pos-small) and (Dew-Point is Comfortable) then (Comp- speed is Medium)(Fan-speed is Medium) (1)
54. If (U-S-Temp is Hot) and (Temp-Diff is Pos-small) and (Dew-Point is Comfortable) then (Comp-speed is Medium)(Fan-speed is Fast) (1)
55. If (U-S-Temp is Very-Hot) and (Temp-Diff is Pos-small) and (Dew-Point is Comfortable) then (Comp- speed is Fast)(Fan-speed is Fast) (1)
56. If (U-S-Temp is Very-Cool) and (Temp-Diff is Pos-small) and (Dew-Point is Humid) then (Comp-speed is Slow)(Fan-speed is Very-fast) (1)
57. If (U-S-Temp is Cool) and (Temp-Diff is Pos-small) and (Dew-Point is Humid) then (Comp-speed is Slow)(Fan-speed is Fast) (1)
58. If (U-S-Temp is Medium) and (Temp-Diff is Pos-small) and (Dew-Point is Humid) then (Comp-speed is Medium)(Fan-speed is Fast) (1)
59. If (U-S-Temp is Hot) and (Temp-Diff is Pos-small) and (Dew-Point is Humid) then (Comp-speed is Fast)(Fan-speed is Fast) (1)
60. If (U-S-Temp is Very-Hot) and (Temp-Diff is Pos-small) and (Dew-Point is Humid) then (Comp-speed is Very-fast)(Fan-speed is Very-fast) (1)
61. If (U-S-Temp is Very-Cool) and (Temp-Diff is Pos-large) and (Dew-Point is Dry) then (Comp-speed is Fast)(Fan-speed is Very-fast) (1)
62. If (U-S-Temp is Cool) and (Temp-Diff is Pos-large) and (Dew-Point is Dry) then (Comp-speed is Fast)(Fan-speed is Very-fast) (1)
63. If (U-S-Temp is Medium) and (Temp-Diff is Pos-large) and (Dew-Point is Dry) then (Comp-speed is Fast)(Fan-speed is

Very-fast) (1)

64. If (U-S-Temp is Hot) and (Temp-Diff is Pos-large) and (Dew-Point is Dry) then (Comp-speed is Very- fast)(Fan-speed is Very-fast) (1)
65. If (U-S-Temp is Very-Hot) and (Temp-Diff is Pos-large) and (Dew-Point is Dry) then (Comp-speed is Very-fast)(Fan-speed is Very-fast) (1)
66. If (U-S-Temp is Very-Cool) and (Temp-Diff is Pos-large) and (Dew-Point is Comfortable) then (Comp- speed is Fast)(Fan-speed is Fast) (1)
67. If (U-S-Temp is Cool) and (Temp-Diff is Pos-large) and (Dew-Point is Comfortable) then (Comp-speed is Fast) (Fan-speed is Fast) (1)
68. If (U-S-Temp is Medium) and (Temp-Diff is Pos-large) and (Dew-Point is Comfortable) then (Comp-speed is Fast) (Fan-speed is Fast) (1)
69. If (U-S-Temp is Hot) and (Temp-Diff is Pos-large) and (Dew-Point is Comfortable) then (Comp-speed is Very-fast) (Fan-speed is Fast) (1)
70. If (U-S-Temp is Very-Hot) and (Temp-Diff is Pos-large) and (Dew-Point is Comfortable) then (Comp- speed is Very-fast) (Fan-speed is Fast) (1)
71. If (U-S-Temp is Very-Cool) and (Temp-Diff is Pos-large) and (Dew-Point is Humid) then (Comp-speed is Fast) (Fan-speed is Very-fast) (1)
72. If (U-S-Temp is Cool) and (Temp-Diff is Pos-large) and (Dew-Point is Humid) then (Comp-speed is Fast) (Fan-speed is Very-fast) (1)
73. If (U-S-Temp is Medium) and (Temp-Diff is Pos-large) and (Dew-Point is Humid) then (Comp-speed is Fast) (Fan-speed is Very-fast) (1)
74. If (U-S-Temp is Hot) and (Temp-Diff is Pos-large) and (Dew-Point is Humid) then (Comp-speed is Very- fast) (Fan-speed is Very-fast) (1)
75. If (U-S-Temp is Very-Hot) and (Temp-Diff is Pos-large) and (Dew-Point is Humid) then (Comp-speed is Very-fast) (Fan-speed is Very-fast) (1)

III. Result

After adding rules to the system, the result can be obtained from "Rule Viewer" in MATLAB FIS tools as shown in Figure 8 that tells about changes in Compressor speed and Fan speed as changes occur in any input parameters.

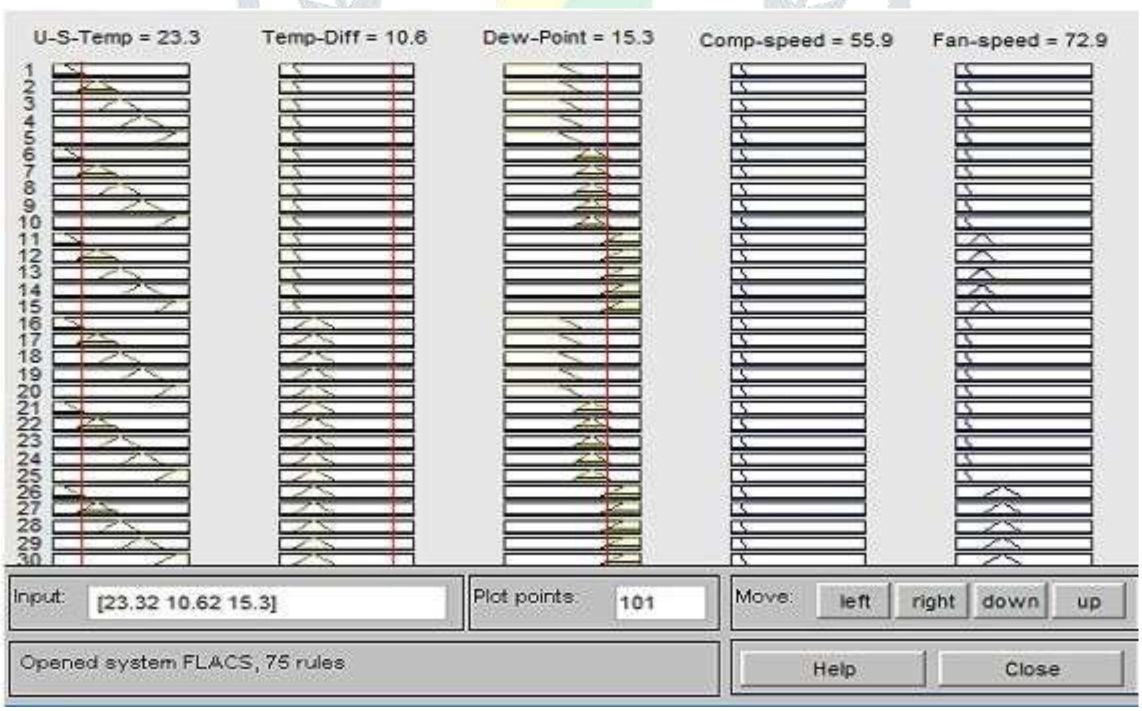


Figure 8: Rule viewer in MATLAB

Based on the results, the speed of compressor and fan is slow when the user selected temperature is low and temperature difference is Negative Large, this is because the room temperature is lower than the user setting temperature. The speed of compressor and fan is increase when the user temperature is low and temperature difference is Large. These results show that the function of air conditioner to achieve room temperature that is set by user. Figure 9 and 10 shows the surface viewer of the system, which shows the 3D figure taking three input parameter on different-different axis gives the changes in output showing as a 3D surface depicted by variation and height of color. This shows that if output changes by changing the value of input combination. So if input parameter adjusted in right manner as required or needed than it gives reasonable output, which would be effective and efficient for every user. While Figure 11 shows the pseudo color for surface viewer.

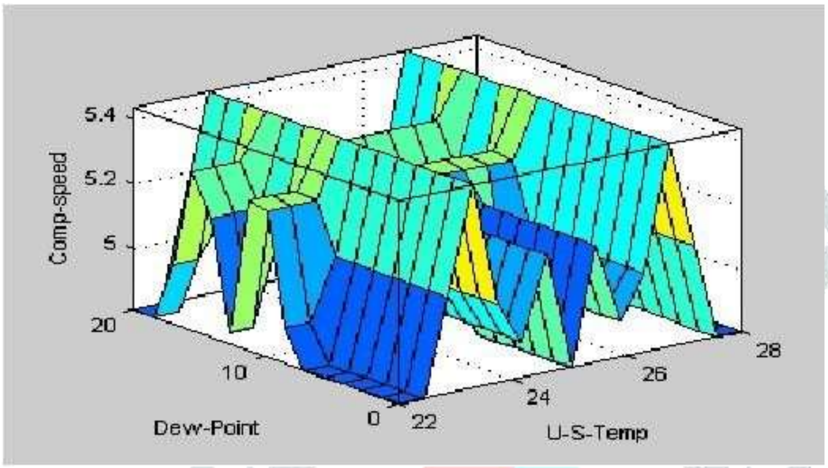


Figure 9: Surface viewer of the system

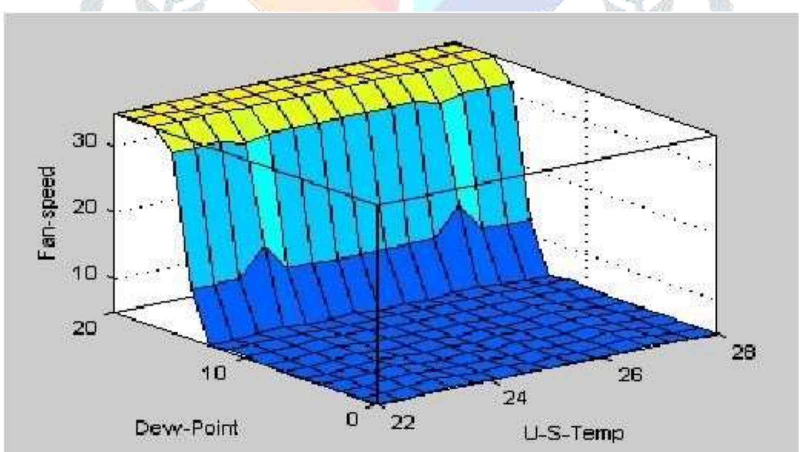


Figure 10: Surface viewer of the system

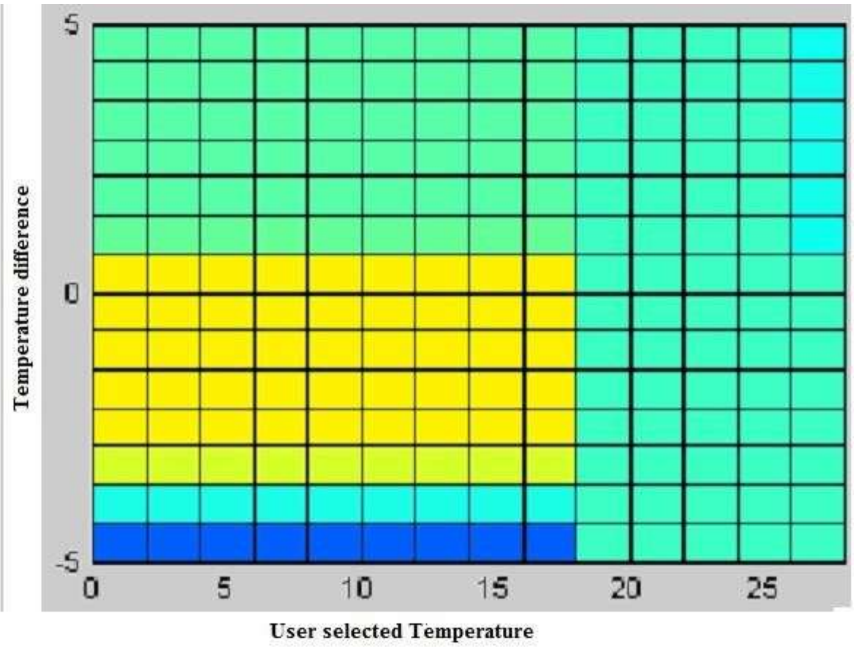


Figure 14: Pseudo Color for surface viewer

IV. Discussion and conclusion

Air conditioning systems are most demanding and essential in most of our daily lives. Expectations for such systems have been increased exponentially to apply these systems in varying safe, suitable and comfort situations and environments. An environment which is comfortable and safe is often not so easy to define, it is very difficult task, generally depends on people to people and place to place. If we focus particular place like Uttar Pradesh in India, It is seen that it is generally affected by varying seasonal occurred in Uttar Pradesh as well as in all over India, so from time to time it depends on contradictory factors.

Fuzzy based Air Conditioner System; using Fuzzy logic control provides an effective and economic approach to solve this type of problems. FBACS incorporated in the various latest model systems (automobiles designed by Japanese auto makers) provide proof that temperature control in diverse environments can be solved. The key to a good solution lies in detailed analysis of factors affecting the control target and the kinds of sensors and sensing techniques used to detect these factors. For an engineer, an ideal machine would be one in which human requests area automatically interpreted and responded to by adjusting itself appropriately to variations in the environment. Fuzzy logic can help make this ideal a reality. At the least, it makes the effort easier.

The FBACS had been design to control the temperature according to the room environment. Every input (user temperature and temperature difference) and output (compressor speed and fan speed) consists of several membership functions to increase the performance of the system. MATLAB Fuzzy Logic Toolbox is used for system design because the other Fuzzy logic based temperature controller involves a lot of calculation and independent algorithm. So avoiding lengthy and difficult process, as compared Fuzzy logic is simple and suits very much to handle such type of problem which contains Fuzzy values.

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