Simulation of the Fuzzy logic controller for Air Conditioner

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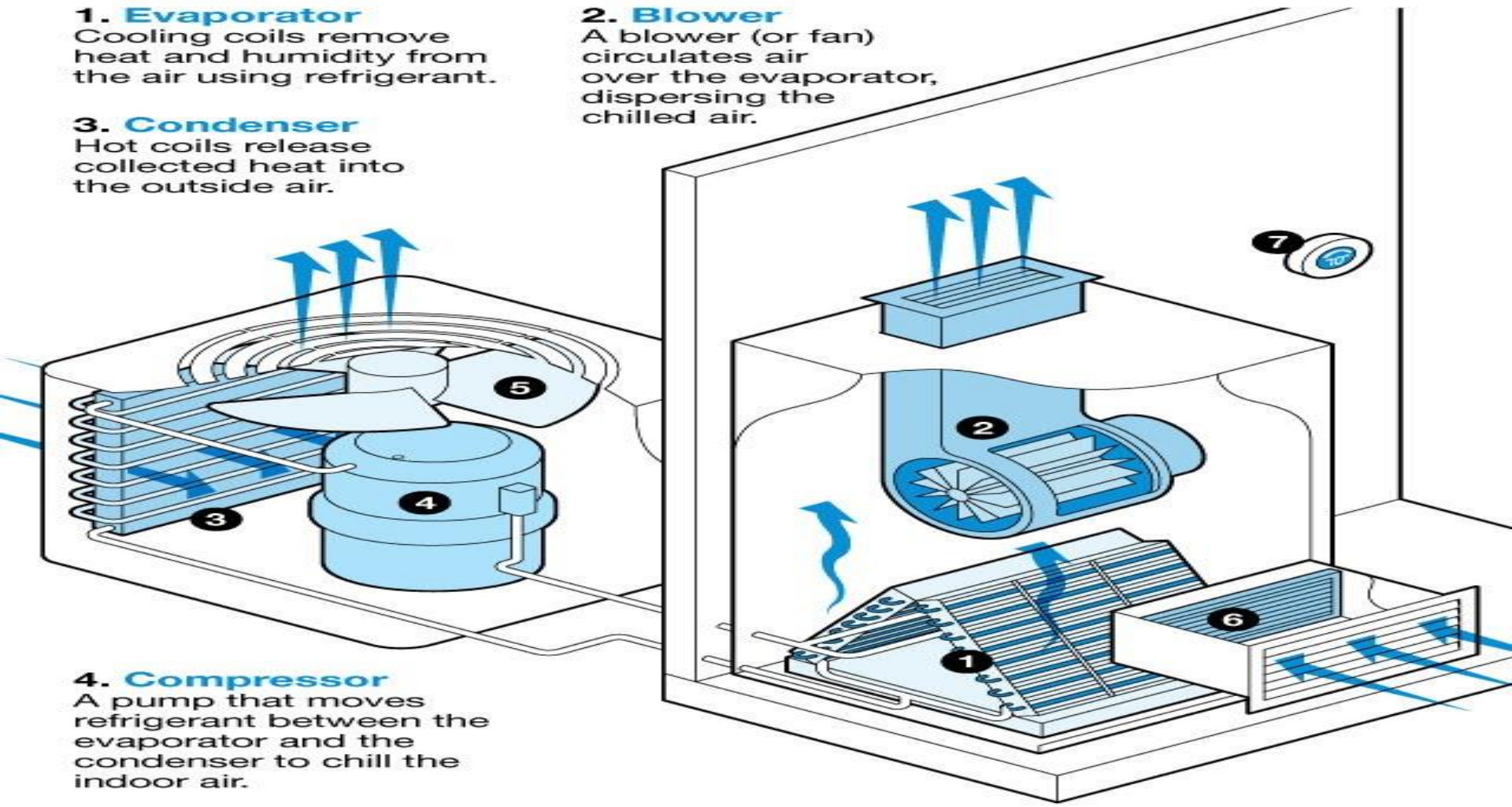
14BEE0112

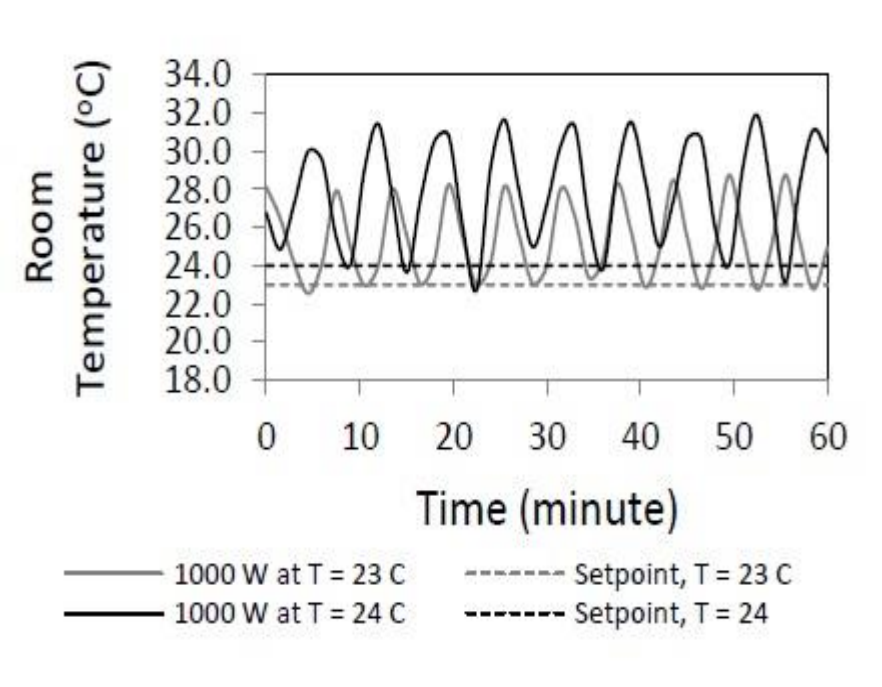
Working of Air Conditioner



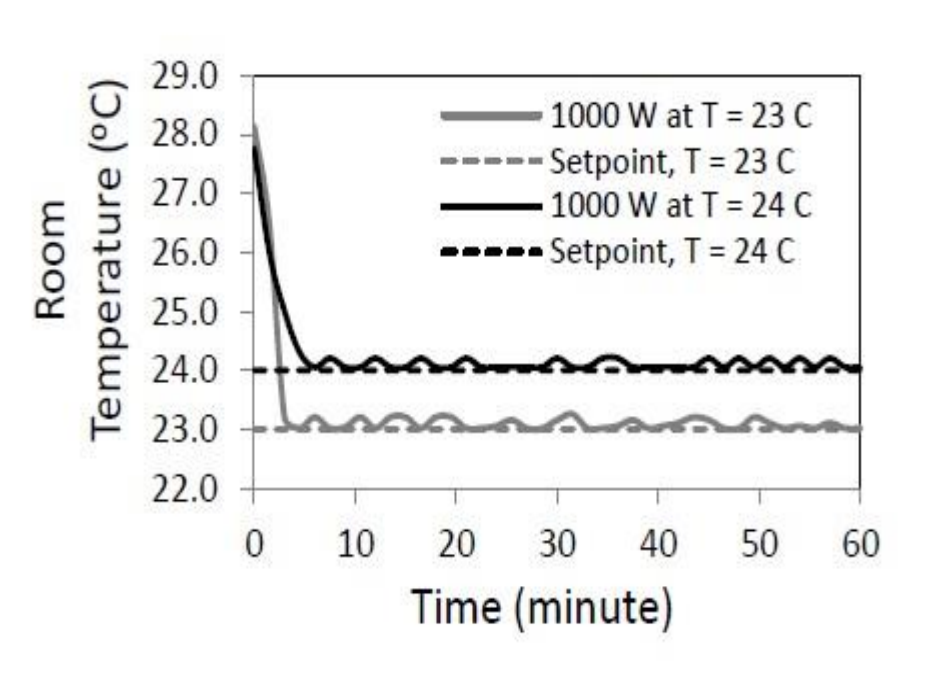
Why use Fuzzy Logic Controller

- Complex interactions between user preferences, actual room temperature and humidity level are very difficult to model mathematically. Hence, PID controllers can't be used.
  - Lots of dynamics
  - Non linear
  - If a model can be created then it is too difficult to form a controller
- Human comfort
- Achieving thermal comfort with minimum energy consumption.
  - Hence, Variable compressor speeds are needed to increase energy efficiency with better temperature control.
  - The usage of on/off controller consumes large energy as the compressor is working at the maximum speeds, and it turns on and off when it achieves the temperature setting, causing high-energy usage.
- Tuning fuzzy logic controller is faster or easier than tuning PID controller.

Temperature fluctuations FLC vs. Conventional Controller

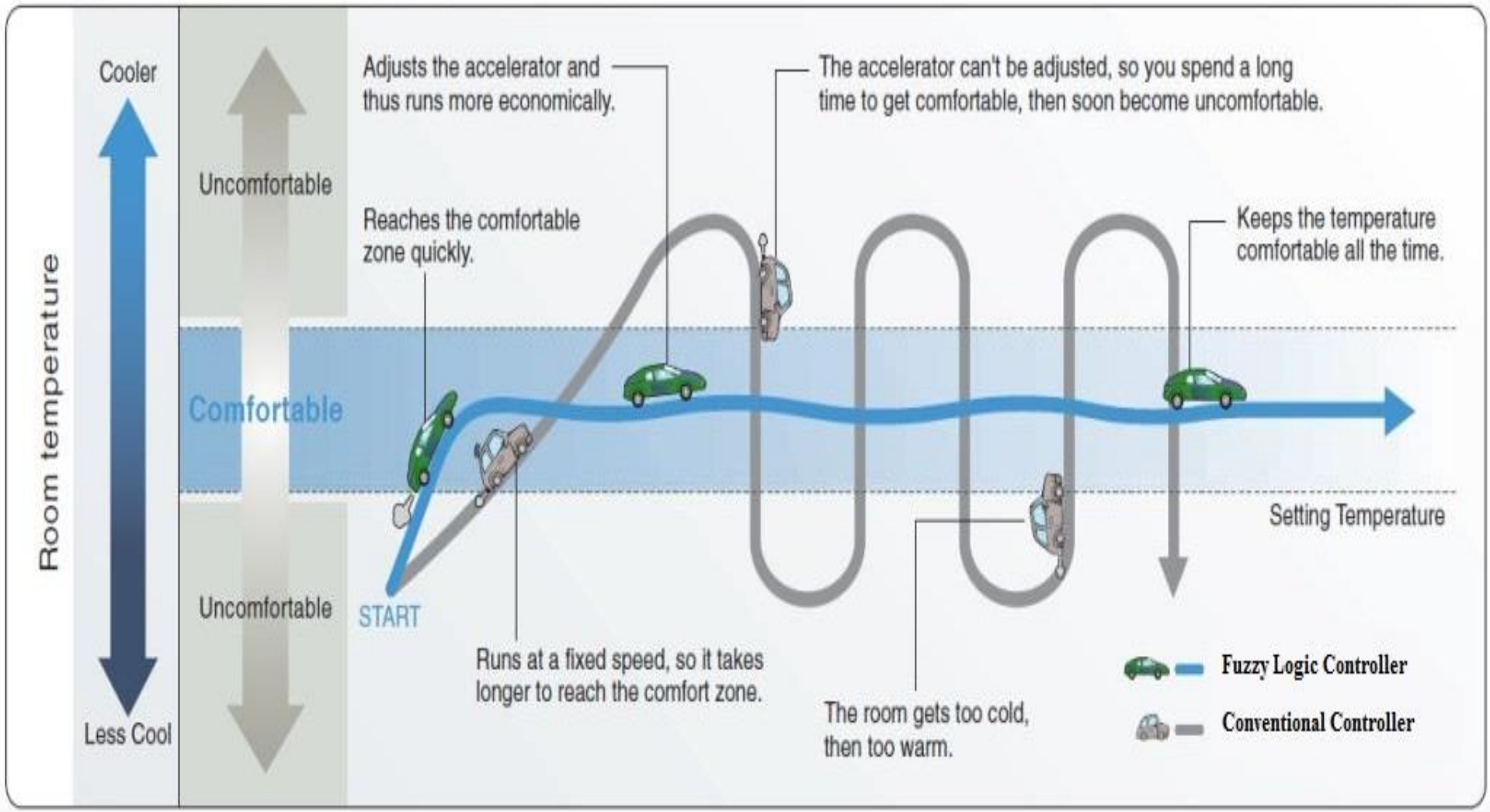


Conventional Controller

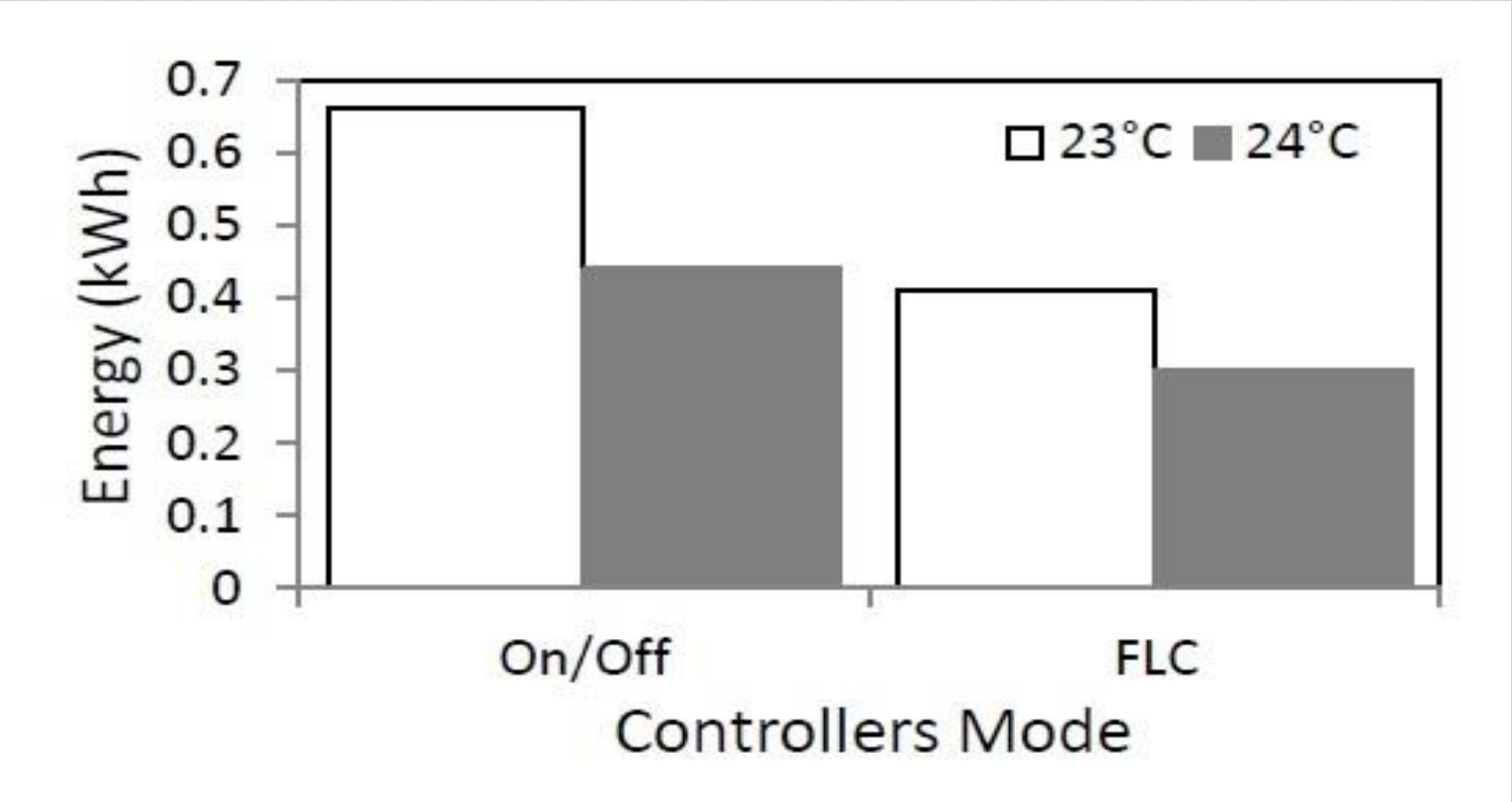


Fuzzy Logic Controller

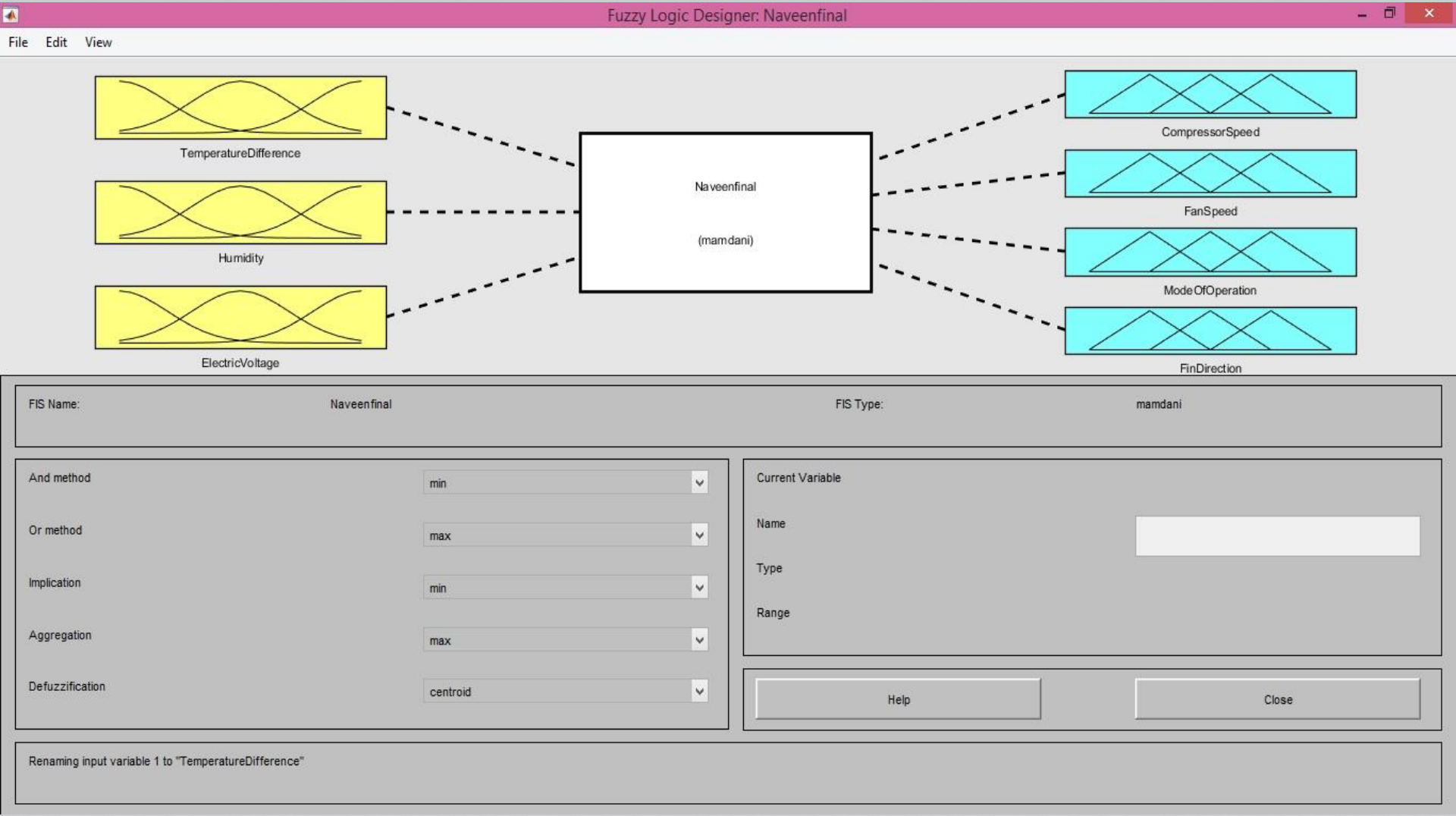
Analogy


Cooler
Less Cool
Room temperature
Uncomfortable
Comfortable
Uncomfortable
Adjusts the accelerator and thus runs more economically.
The accelerator can't be adjusted, so you spend a long time to get comfortable, then soon become uncomfortable.
Reaches the comfortable zone quickly.
Keeps the temperature comfortable all the time.
Setting Temperature
START
Runs at a fixed speed, so it takes longer to reach the comfort zone.
The room gets too cold, then too warm.
Fuzzy Logic Controller
Conventional Controller

Power Consumptions

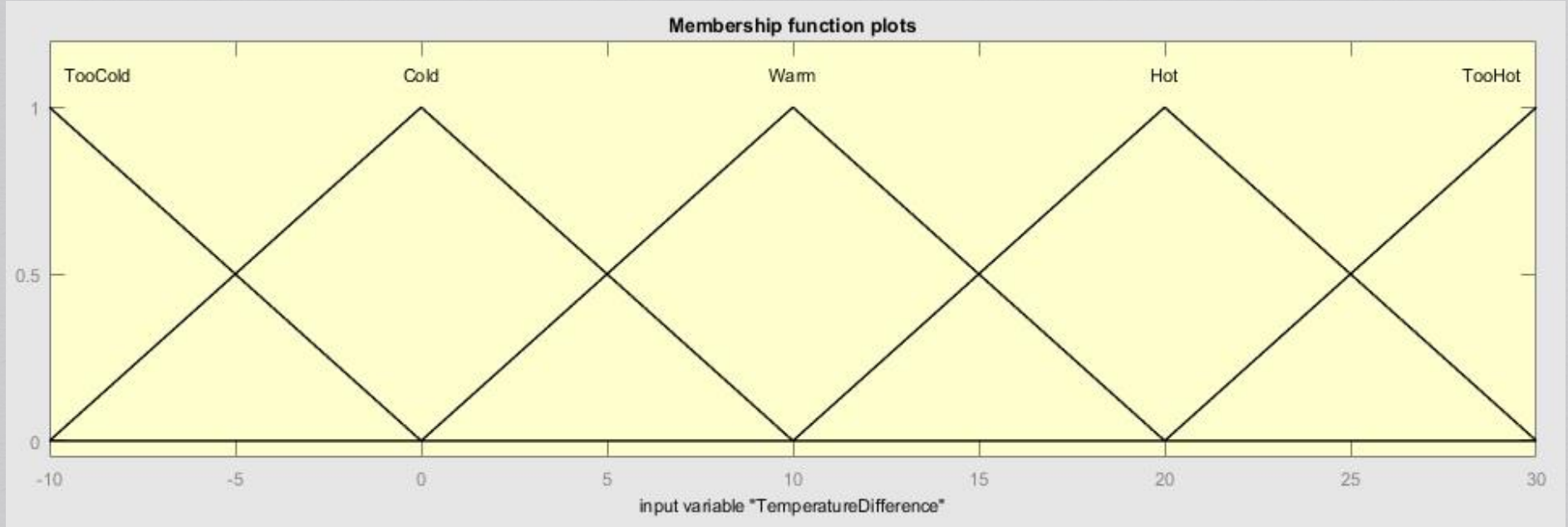


Inputs and their membership functions



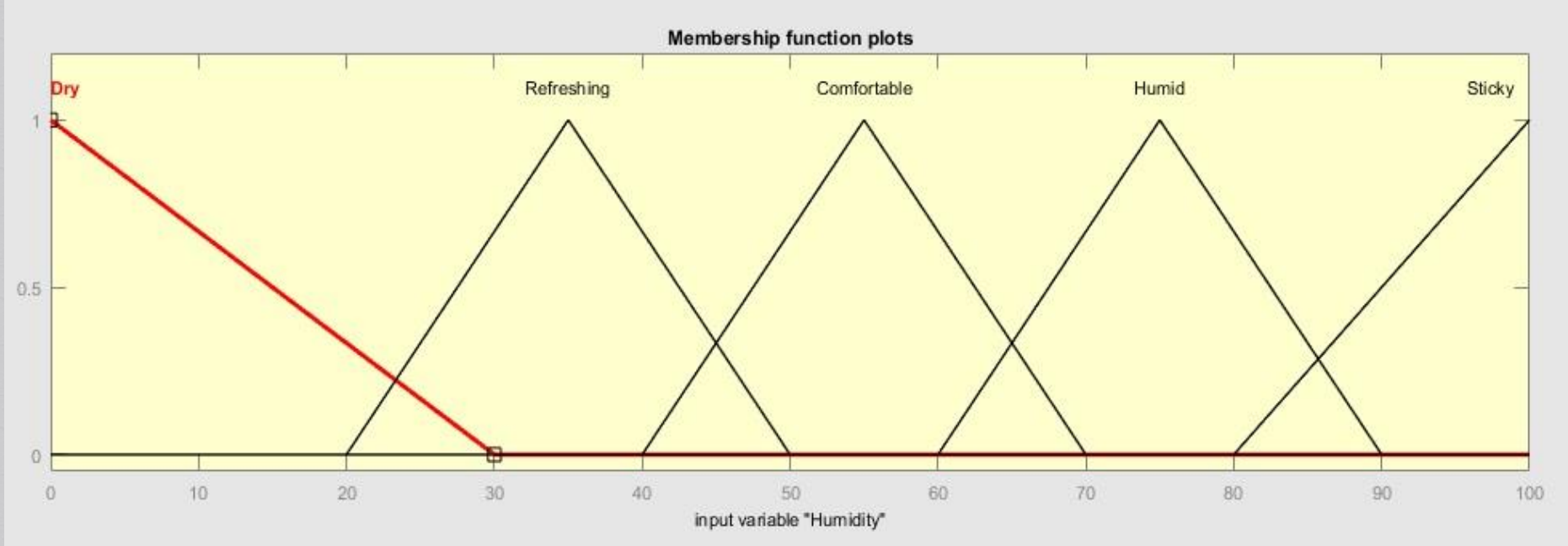
Temperature Difference

Temperature Difference represents the difference between the set temperature (which is set by the user) and the room temperature. The value being too much negative is depicted as TooCold, negative as Cold, Positive as warm and so on.



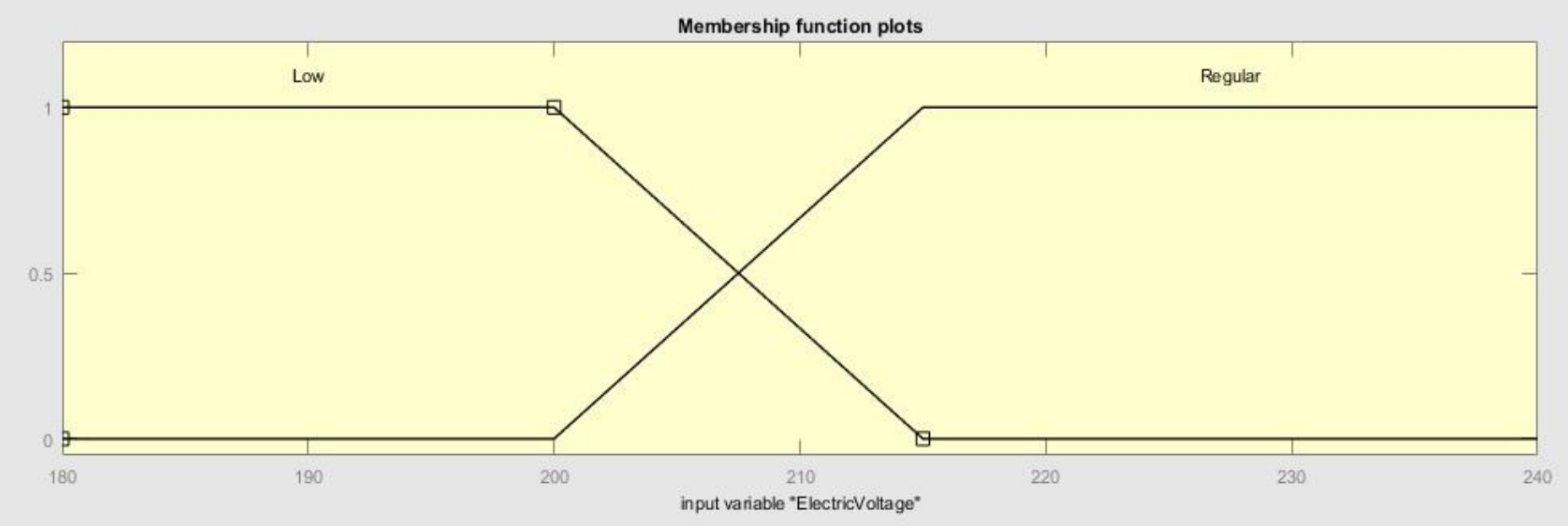
Humidity

Humidity is represented as the percentage relative humidity.



Electric Voltage

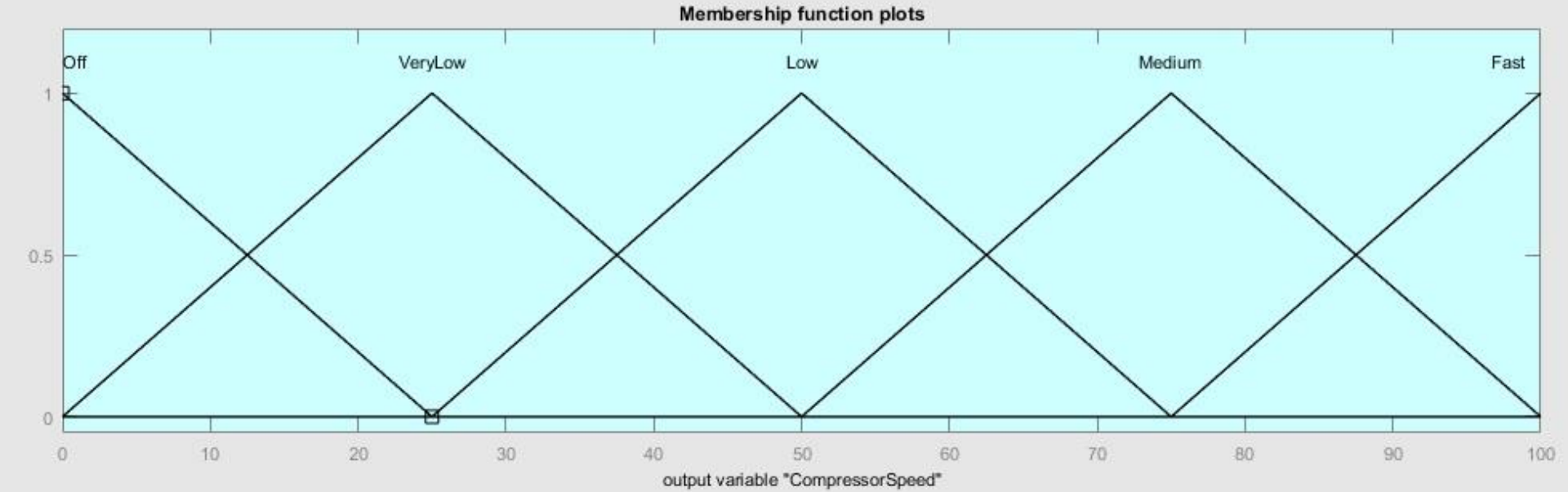
Electric voltage describes the information about alternating voltage that the air conditioner is receiving. Sometimes, the equipment may receive voltage than the average volts it receives, hence, it should still work optimally.



Outputs and their membership functions

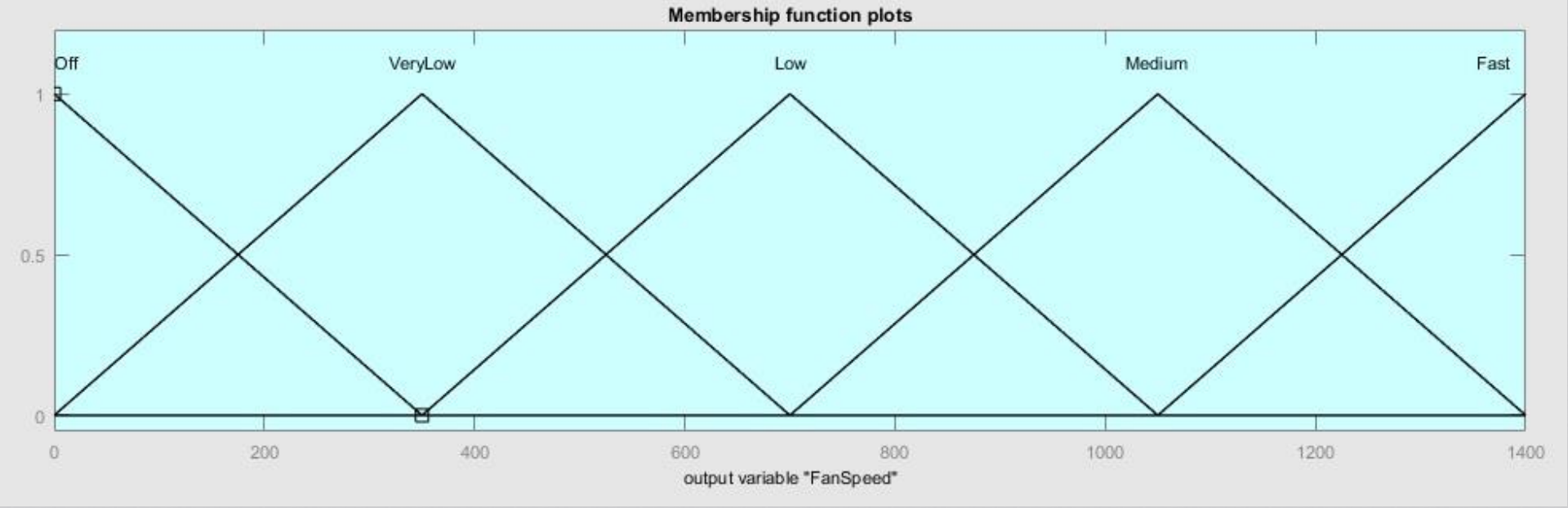
Compressor Speed

Compressor Speed determines the speed with which the compresses the coolant which determines the pressure of the coolant in the system and hence the temperature of the room. Compressor Speed is usually the trade secret of every AC manufacturer. Hence, it is depicted as percentage of rated rpm.



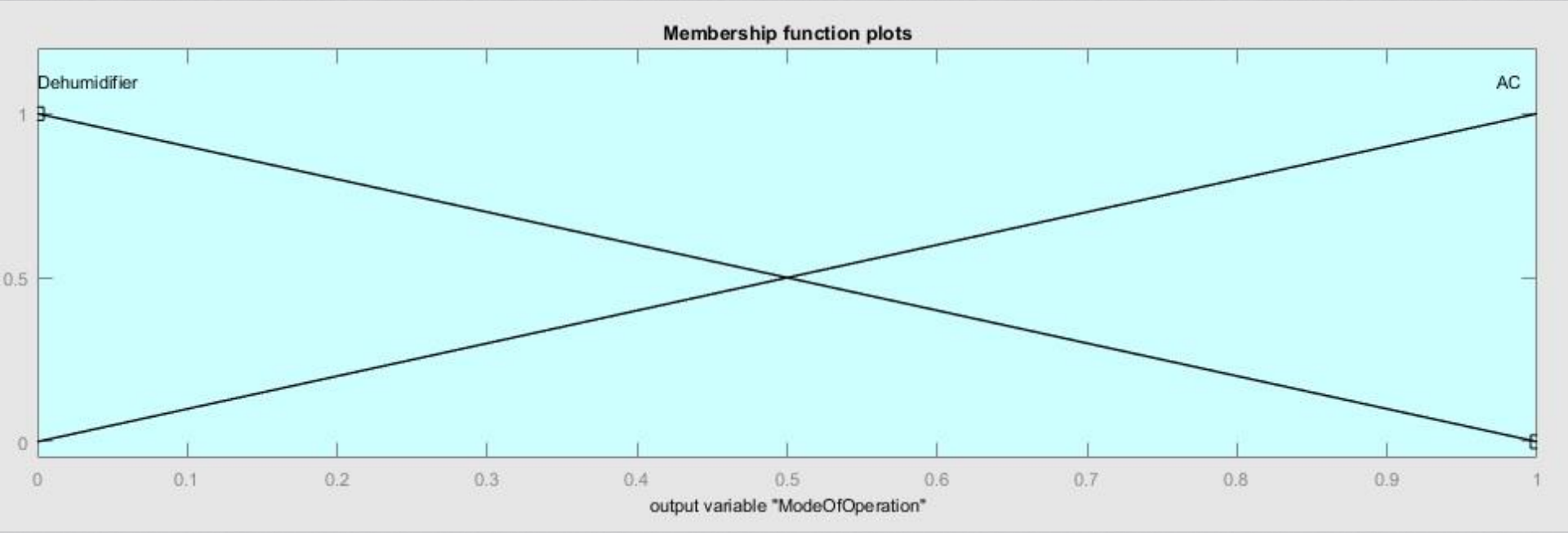
Fan Speed

Compressor Speed determines the speed with which the fan in the indoor unit blows the cool air in the room. The range of fan speed is 1400 rpm which is the speed of motor in the LG Split Indoor AC.



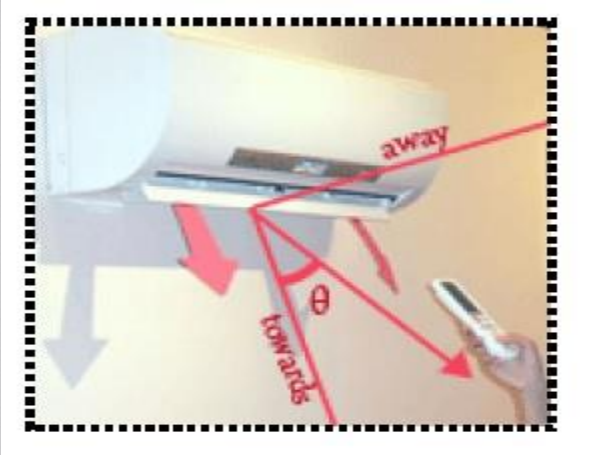
Mode of Operation

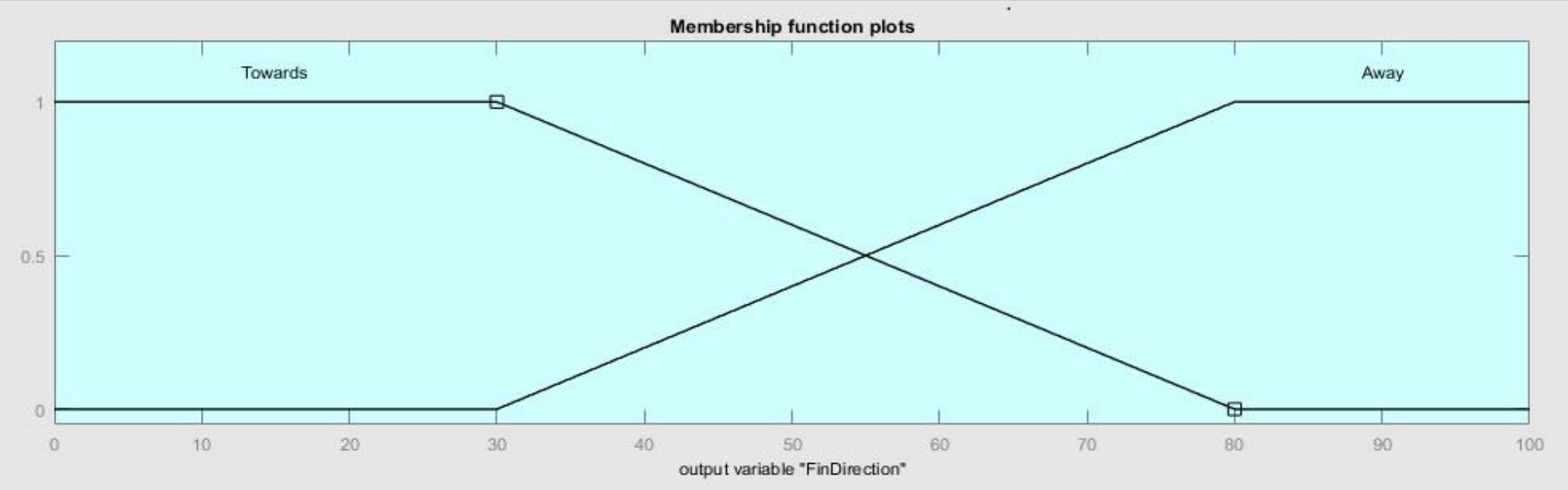
Mode of operation decides whether air conditioner will work like a dehumidifier only or normal.



Fin Direction

Fin directions directs air from air condition towards or away from occupants. Assuming top mounted air condition, $\theta = 0^{o}$ can be considered as towards and $\theta = 90^{o}$ as away from occupants in the room.



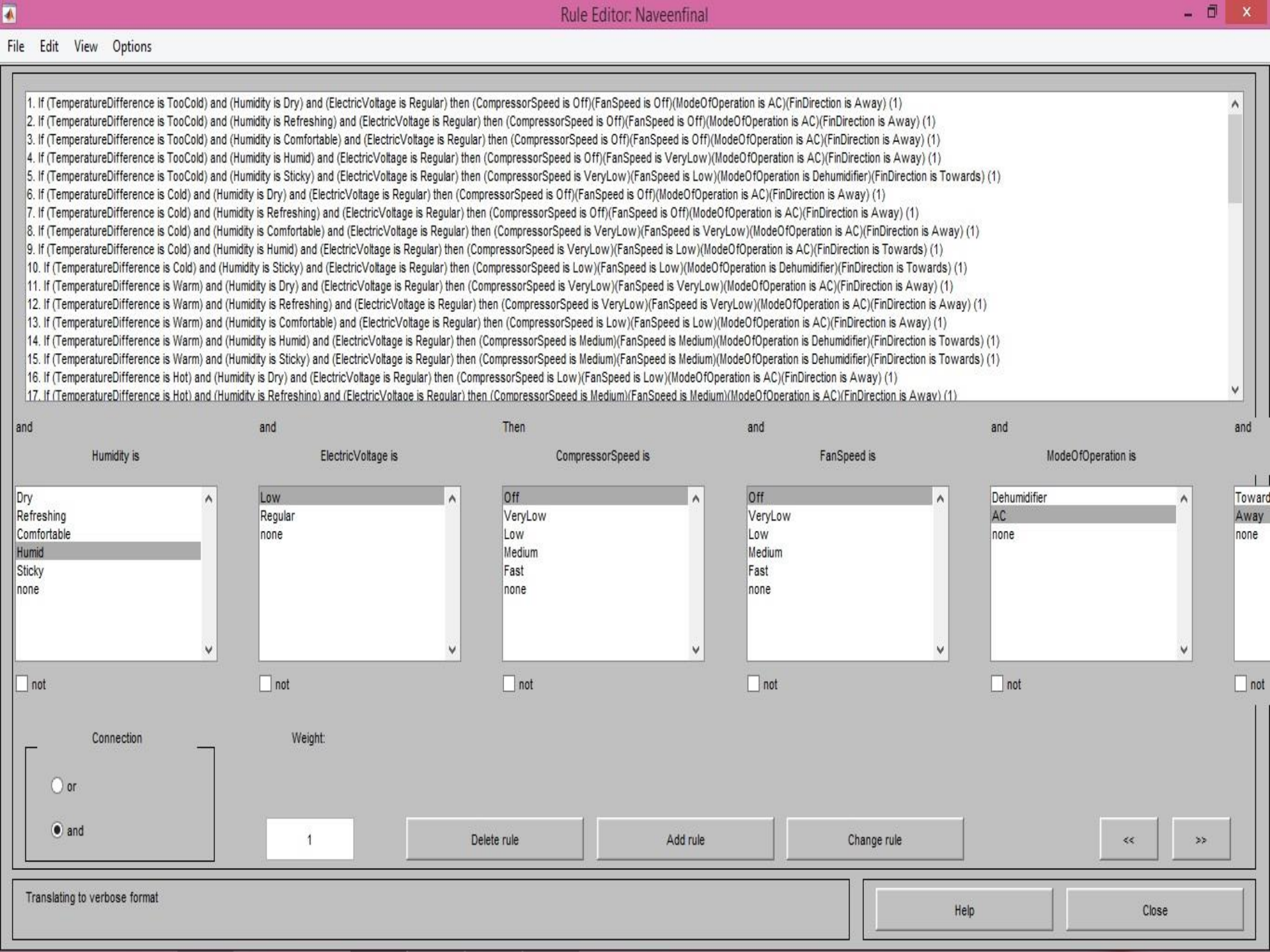


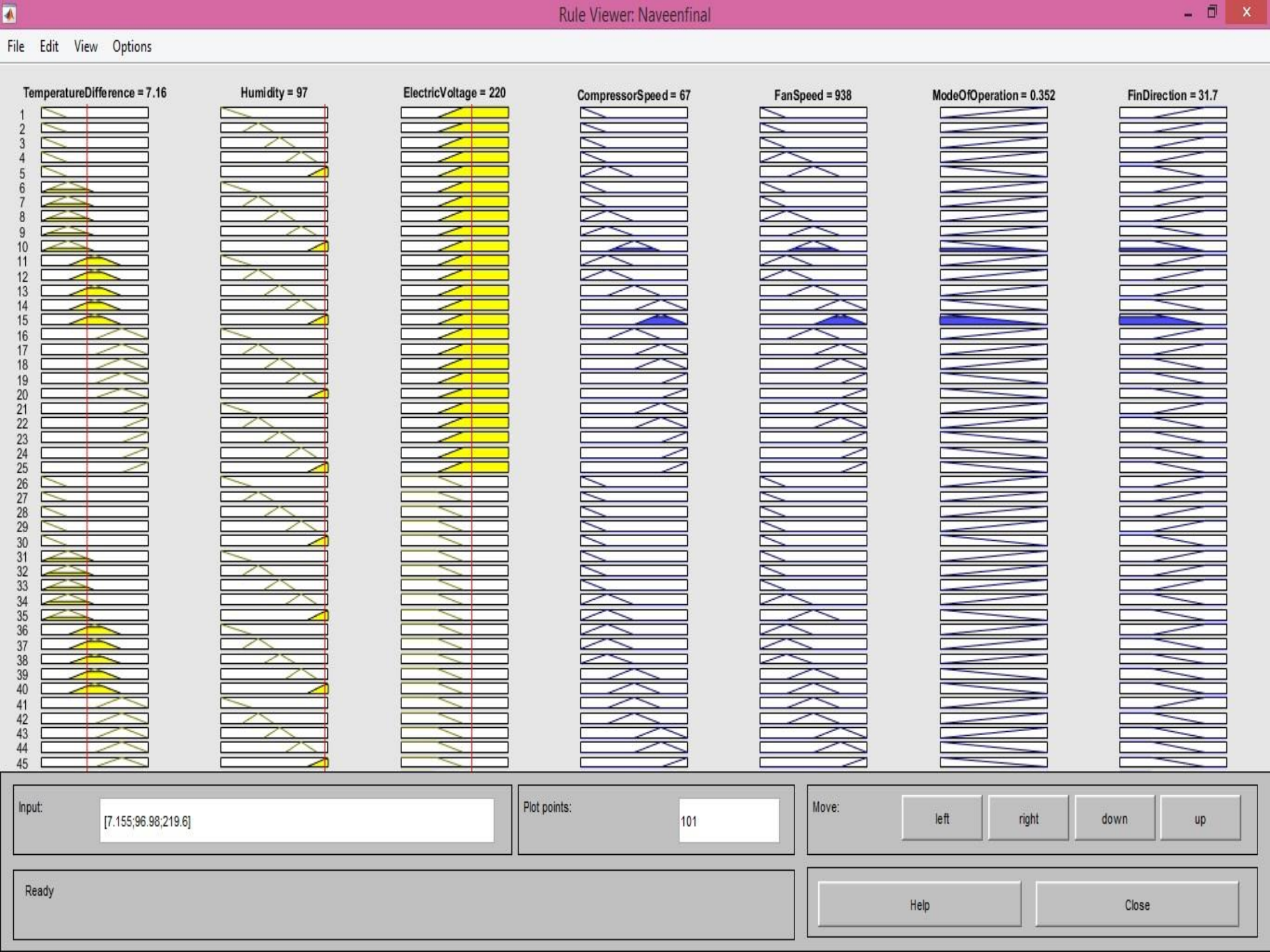
Fuzzy Rule Base

	A	B	C	D	E	F	G	H
1	**Electric voltage**	**Temperature**	**Humidity**		**Compressor Speed**	**Fan Speed**	**Fin Direction**	**Mode of operation**
2	Regular	Too Cold	Dry		Off	Off	Away	AC
3	Regular	Too Cold	Refreshing		Off	Off	Away	AC
4	Regular	Too Cold	Comfortable		Off	Off	Away	AC
5	Regular	Too Cold	Humid		Off	Very Low	Away	AC
6	Regular	Too Cold	Sticky		Very Low	Low	Towards	Dehumidifier
7	Regular	Cold	Dry		Off	Off	Away	AC
8	Regular	Cold	Refreshing		Off	Off	Away	AC
9	Regular	Cold	Comfortable		Very Low	Very Low	Away	AC
10	Regular	Cold	Humid		Very Low	Low	Towards	AC
11	Regular	Cold	Sticky		Low	Low	Towards	Dehumidifier
12	Regular	Warm	Dry		Very Low	Very Low	Away	AC
13	Regular	Warm	Refreshing		Very Low	Very Low	Away	AC
14	Regular	Warm	Comfortable		Low	Low	Away	AC
15	Regular	Warm	Humid		Medium	Medium	Towards	Dehumidifier
16	Regular	Warm	Sticky		Medium	Medium	Towards	Dehumidifier
17	Regular	Hot	Dry		Low	Low	Away	AC
18	Regular	Hot	Refreshing		Medium	Medium	Away	AC
19	Regular	Hot	Comfortable		Medium	Medium	Towards	AC
20	Regular	Hot	Humid		Fast	Fast	Towards	Dehumidifier
21	Regular	Hot	Sticky		Fast	Fast	Towards	Dehumidifier
22	Regular	Too Hot	Dry		Medium	Medium	Away	AC
23	Regular	Too Hot	Refreshing		Medium	Medium	Towards	AC
24	Regular	Too Hot	Comfortable		Fast	Fast	Towards	Dehumidifier
25	Regular	Too Hot	Humid		Fast	Fast	Towards	Dehumidifier
26	Regular	Too Hot	Sticky		Fast	Fast	Towards	Dehumidifier

Fuzzy Rule Base

	A	B	C	D	E	F	G	H
30	**Electric voltage**	**Temperature**	**Humidity**		**Compressor Speed**	**Fan Speed**	**Fin Direction**	**Mode of operation**
31	Low	Too Cold	Dry		Off	Off	Away	AC
32	Low	Too Cold	Refreshing		Off	Off	Away	AC
33	Low	Too Cold	Comfortable		Off	Off	Away	AC
34	Low	Too Cold	Humid		Off	Off	Away	AC
35	Low	Too Cold	Sticky		Off	Low	Towards	Dehumidifier
36	Low	Cold	Dry		Off	Off	Away	AC
37	Low	Cold	Refreshing		Off	Off	Away	AC
38	Low	Cold	Comfortable		Off	Off	Away	AC
39	Low	Cold	Humid		Very Low	Very Low	Towards	AC
40	Low	Cold	Sticky		Very Low	Low	Towards	Dehumidifier
41	Low	Warm	Dry		Very Low	Very Low	Away	AC
42	Low	Warm	Refreshing		Very Low	Very Low	Towards	AC
43	Low	Warm	Comfortable		Very Low	Very Low	Towards	AC
44	Low	Warm	Humid		Low	Low	Towards	Dehumidifier
45	Low	Warm	Sticky		Low	Low	Towards	Dehumidifier
46	Low	Hot	Dry		Low	Low	Away	AC
47	Low	Hot	Refreshing		Low	Low	Towards	AC
48	Low	Hot	Comfortable		Medium	Medium	Towards	AC
49	Low	Hot	Humid		Medium	Medium	Towards	Dehumidifier
50	Low	Hot	Sticky		Fast	Fast	Towards	Dehumidifier
51	Low	Too Hot	Dry		Medium	Medium	Towards	AC
52	Low	Too Hot	Refreshing		Medium	Medium	Towards	AC
53	Low	Too Hot	Comfortable		Medium	Medium	Towards	Dehumidifier
54	Low	Too Hot	Humid		Fast	Fast	Towards	Dehumidifier
55	Low	Too Hot	Sticky		Fast	Fast	Towards	Dehumidifier


Rule Editor: Naveenfinal
File Edit View Options
1. If (TemperatureDifference is TooCold) and (Humidity is Dry) and (ElectricVoltage is Regular) then (CompressorSpeed is Off)(FanSpeed is Off)(ModeOfOperation is AC)(FinDirection is Away) (1)
2. If (TemperatureDifference is TooCold) and (Humidity is Refreshing) and (ElectricVoltage is Regular) then (CompressorSpeed is Off)(FanSpeed is Off)(ModeOfOperation is AC)(FinDirection is Away) (1)
3. If (TemperatureDifference is TooCold) and (Humidity is Comfortable) and (ElectricVoltage is Regular) then (CompressorSpeed is Off)(FanSpeed is Off)(ModeOfOperation is AC)(FinDirection is Away) (1)
4. If (TemperatureDifference is TooCold) and (Humidity is Humid) and (ElectricVoltage is Regular) then (CompressorSpeed is Off)(FanSpeed is VeryLow)(ModeOfOperation is AC)(FinDirection is Away) (1)
5. If (TemperatureDifference is TooCold) and (Humidity is Sticky) and (ElectricVoltage is Regular) then (CompressorSpeed is VeryLow)(FanSpeed is Low)(ModeOfOperation is Dehumidifier)(FinDirection is Towards) (1)
6. If (TemperatureDifference is Cold) and (Humidity is Dry) and (ElectricVoltage is Regular) then (CompressorSpeed is Off)(FanSpeed is Off)(ModeOfOperation is AC)(FinDirection is Away) (1)
7. If (TemperatureDifference is Cold) and (Humidity is Refreshing) and (ElectricVoltage is Regular) then (CompressorSpeed is Off)(FanSpeed is Off)(ModeOfOperation is AC)(FinDirection is Away) (1)
8. If (TemperatureDifference is Cold) and (Humidity is Comfortable) and (ElectricVoltage is Regular) then (CompressorSpeed is VeryLow)(FanSpeed is VeryLow)(ModeOfOperation is AC)(FinDirection is Away) (1)
9. If (TemperatureDifference is Cold) and (Humidity is Humid) and (ElectricVoltage is Regular) then (CompressorSpeed is VeryLow)(FanSpeed is Low)(ModeOfOperation is AC)(FinDirection is Towards) (1)
10. If (TemperatureDifference is Cold) and (Humidity is Sticky) and (ElectricVoltage is Regular) then (CompressorSpeed is Low)(FanSpeed is Low)(ModeOfOperation is Dehumidifier)(FinDirection is Towards) (1)
11. If (TemperatureDifference is Warm) and (Humidity is Dry) and (ElectricVoltage is Regular) then (CompressorSpeed is VeryLow)(FanSpeed is VeryLow)(ModeOfOperation is AC)(FinDirection is Away) (1)
12. If (TemperatureDifference is Warm) and (Humidity is Refreshing) and (ElectricVoltage is Regular) then (CompressorSpeed is VeryLow)(FanSpeed is VeryLow)(ModeOfOperation is AC)(FinDirection is Away) (1)
13. If (TemperatureDifference is Warm) and (Humidity is Comfortable) and (ElectricVoltage is Regular) then (CompressorSpeed is Low)(FanSpeed is Low)(ModeOfOperation is AC)(FinDirection is Away) (1)
14. If (TemperatureDifference is Warm) and (Humidity is Humid) and (ElectricVoltage is Regular) then (CompressorSpeed is Medium)(FanSpeed is Medium)(ModeOfOperation is Dehumidifier)(FinDirection is Towards) (1)
15. If (TemperatureDifference is Warm) and (Humidity is Sticky) and (ElectricVoltage is Regular) then (CompressorSpeed is Medium)(FanSpeed is Medium)(ModeOfOperation is Dehumidifier)(FinDirection is Towards) (1)
16. If (TemperatureDifference is Hot) and (Humidity is Dry) and (ElectricVoltage is Regular) then (CompressorSpeed is Low)(FanSpeed is Low)(ModeOfOperation is AC)(FinDirection is Away) (1)
17. If (TemperatureDifference is Hot) and (Humidity is Refreshing) and (ElectricVoltage is Regular) then (CompressorSpeed is Medium)(FanSpeed is Medium)(ModeOfOperation is AC)(FinDirection is Away) (1)
and
Humidity is
Dry
Refreshing
Comfortable
Humid
Sticky
none
not
and
ElectricVoltage is
Low
Regular
none
not
Then
CompressorSpeed is
Off
VeryLow
Low
Medium
Fast
none
not
and
FanSpeed is
Off
VeryLow
Low
Medium
Fast
none
not
and
ModeOfOperation is
Dehumidifier
AC
none
not
and
Toward
Away
none
not
Connection
or
and
Weight:
1
Delete rule
Add rule
Change rule
<<
>>
Translating to verbose format
Help
Close


Rule Viewer: Naveenfinal
File Edit View Options
TemperatureDifference = 7.16
Humidity = 97
ElectricVoltage = 220
CompressorSpeed = 67
FanSpeed = 938
ModeOfOperation = 0.352
FinDirection = 31.7
Input:
[7.155;96.98;219.6]
Plot points:
101
Move:
left
right
down
up
Ready
Help
Close

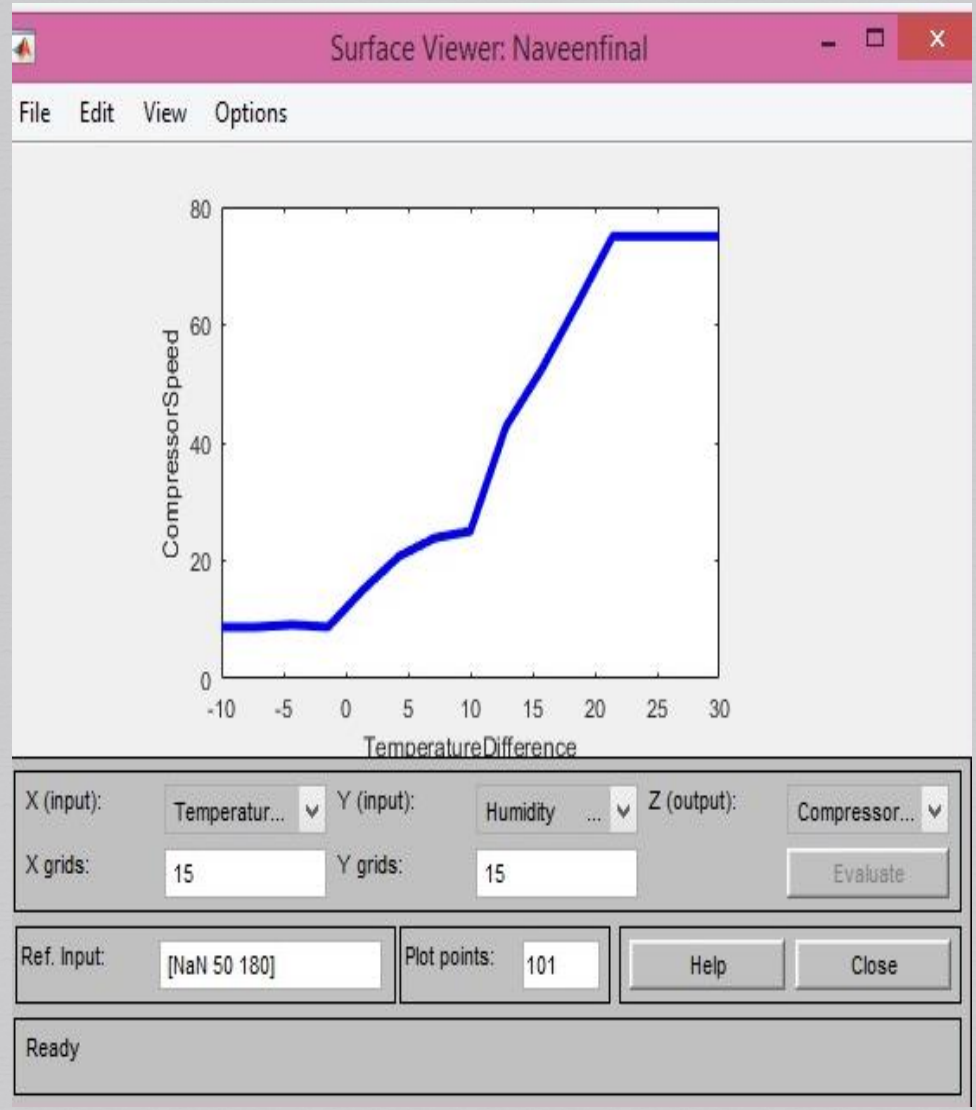
Example

- On 29th October, 2017, Vellore's temperature was **23 °C** and relative humidity was **97%**. We desire a temperature of **16 °C.** Assuming the regular supply of voltage at **220 Volts**.
- **Output:**
  Compressor Speed: 66.6% of rated rpm
  Fan Speed: 933 rpm
  Fin Direction: Towards at 28.62°
  Mode Of Operation: Dehumidifier

Conclusion

- Depending upon value of the inputs i.e. Electric Voltage, temperature and humidity, the fuzzy controller changes the speed of the compressor and the fan along with the direction of fin as well as the changes it's mode of operation working as an AC or as a dehumidifier.
- It just makes use of the linguistic expressions without needing any mathematical model.
- It can be easily tuned.

Results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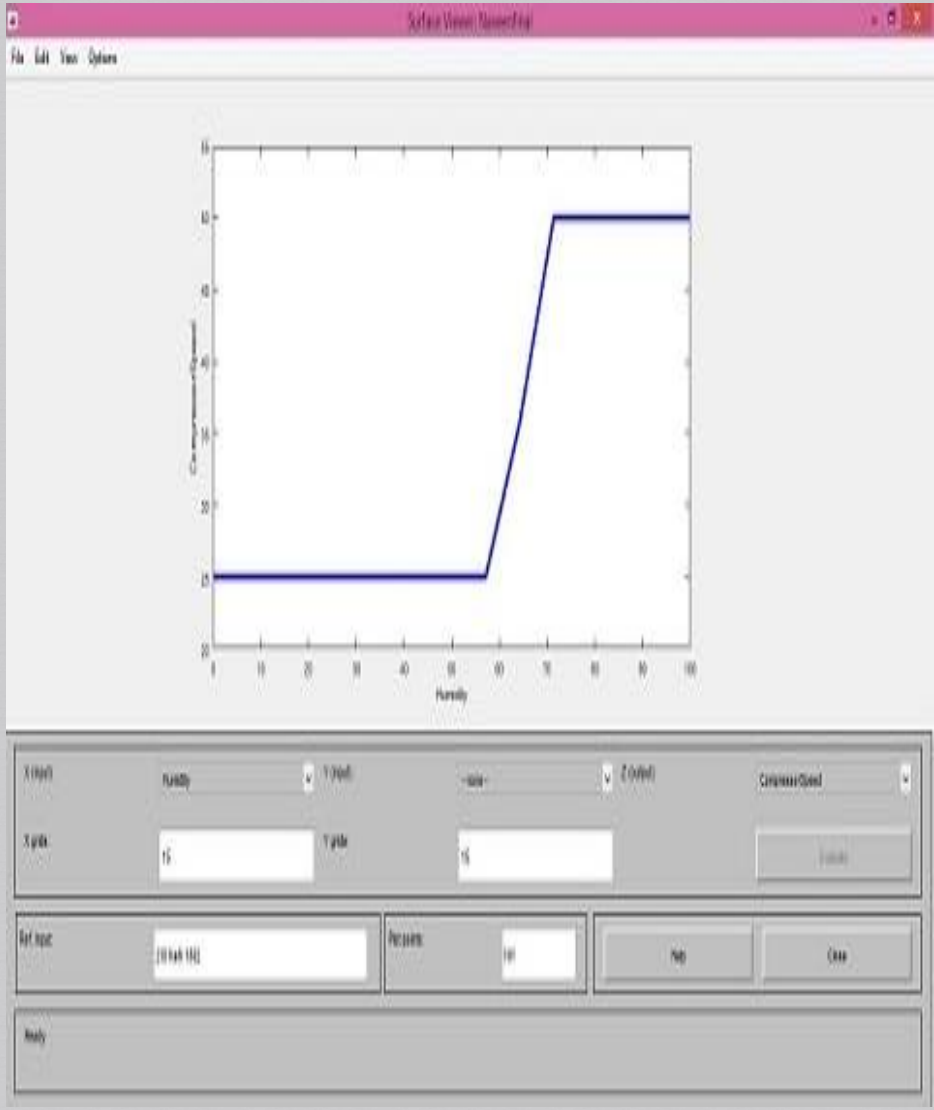
File Edit View Options
CompressorSpeed
TemperatureDifference
X (input): Temperatur...
Y (input): Humidity
Z (output): Compressor...
X grids: 15
Y grids: 15
Evaluate
Ref. Input: [NaN 50 180]
Plot points: 101
Help
Close
Ready



References

- **Indoor Temperature Control and Energy Saving Potential of Split Unit Air Conditioning System using Fuzzy Logic Controller**
  Henry N., *Member, IAENG,* Afiq A. Dahlan, Affandi M. Nasib, Azhar A. Aziz, *Member, IAENG* and Sumeru
- **Air Conditioning System with Fuzzy Logic and Neuro-Fuzzy Algorithm**
  Rajani Kumari; Sandeep Kumar and Vivek Kumar Sharma
- **Developing of Fuzzy Logic Controller for Air Condition System**
  Sameh Mohamed Sobhy; Wael Mohamed Khedr