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Comparison of Fuzzy Logic and Neuro Fuzzy Algorithms for Air Conditioning System

Arshdeep Kaur, Amrit Kaur

***Abstract*— This paper provides the design for air conditioning system using fuzzy logic as well as neuro-fuzzy method. Inputs taken for the air conditioning system are from temperature and humidity sensors and the output is to control the compressor speed. The simulation results of both systems using fuzzy logic and neuro-fuzzy are shown as well as compared to signify better of the two.**

***Index Terms*— air conditioning system, fuzzy logic control, neuro-fuzzy, rule base.**

I. INTRODUCTION

Nowadays, air conditioning systems are commonly found in homes and in public enclosed spaces to create a comfortable environment [1]. Air conditioning has developed to be an integrated industry including environment, energy, machinery, electronics, and automatic control technology, so that its several major trends of development would be health, environmental protection, energy saving, intelligence and diversity. Air conditioning is not only a name of the product, but by using the ideas and methods of air conditioning to create comfort and natural living environment while at the same time reduce the ravages of nature and achieve the real sense harmony of human and nature to maximum extent [2].Air conditioning system is a control system that have complex interactions between physical variables and is too nonlinear.

Conventional design methods require the development of a mathematical model of the control system and then use of this model to construct the controller that is described by the differential equations. Mathematical model is an abstraction and cannot perfectly represent all possible dynamics of any physical process. Even if a relatively accurate model of a dynamic system can be developed, it is often too complex to use for development of controller, especially for many conventional design procedures as they require restrictive assumptions for the plant, e.g. linearity. As opposed to conventional control design, fuzzy logic control focus on gaining an intuitive understanding of how to best control the process or plant [3].

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Arshdeep Kaur, Pursuing M.Tech., University College Of Engineering, Patiala (Punjab), India (Email: arshdeep_24@yahoo.in)

Amrit Kaur, Assistant Professor, Punjabi University, Patiala (Punjab), India (Email: amrit_aks@yahoo.ca)

Fuzzy logic control appears very useful when linearity and time invariance of the controlled process cannot be assumed, when the process lacks a well posed mathematical model, or when human understanding of the process is very different from its model [4]. Fuzzy logic control provides a formal methodology for representing, manipulating and implementing a human's experience based knowledge about how to control a system [3]. Fuzzy logic uses human knowledge and expertise to deal with uncertainties in the process of control [5].

Fuzzy controller block diagram is shown in Fig.1. It has four main parts: (i) Fuzzification interface, simply modifies and converts inputs into suitable linguistic values so that can be compared to the rules in the rule base. (ii) Rule base, holds the knowledge in the form of a set of rules, of how best to control the system. (iii) Inference mechanism, evaluates which control rules are relevant at current time and then decides what the input to the plant should be. (iv) Defuzzification interface, converts the conclusions reached by the inference mechanism into crisp ones.

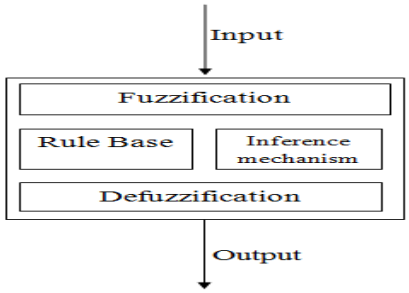

Fig.1. Block diagram of Fuzzy controller

The affectivity of the fuzzy models representing non linear input-output relationships depends on the fuzzy partition of the input output spaces. Therefore, the tuning of membership functions becomes an important issue in fuzzy modeling. Since this tuning task can be viewed as an optimization problem neural networks offer a possibility to solve this problem [6]. A neuro-fuzzy system is a fuzzy system that uses a learning algorithm derived from or inspired by neural network theory to determine its parameters by processing data samples.

The rest of the paper is organized as follows: Section 2 gives the fuzzy logic control algorithm and Section 3 neuro-fuzzy algorithm for air conditioning system. Section 4 provides the results. Section 5 Conclusion.

II. FUZZY LOGIC CONTROL ALGORITHM

Fuzzy logic control based air conditioning system consists of two inputs from temperature and humidity sensors, which gives the measure of the temperature and humidity of the room. Based on these inputs, an output signal is sent to control the compressor speed. The scale over which membership functions are described is 0ºC- 45ºC for temperature and 0%-100% for humidity. Each of the inputs have four triangular membership functions which are shown in Fig.2. and Fig.3. The output also have four membership functions namely "off", "slow", "medium", "fast". The rule base for the design is shown in Table 1.e.g.: "IF Temperature is *very low* AND Humidity is *dry* THEN Compressor speed is *off*"

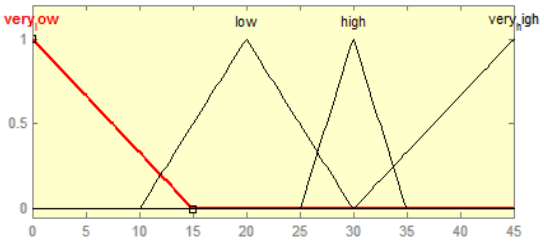

Fig.2. Temperature membership functions

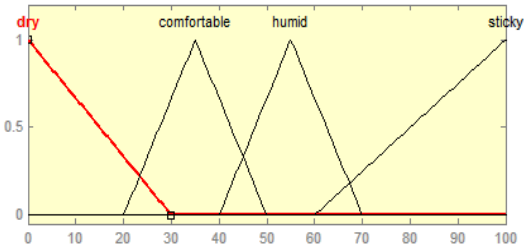

Fig.3. Humidity membership functions

Table1. Fuzzy rules for the design.

Rules	Temperature	Humidity	Compressor speed
1.	Very Low	Dry	Off
2.	Very Low	Comfortable	Off
3.	Very Low	Humid	Off
4.	Very Low	Sticky	Low
5.	Low	Dry	Off
6.	Low	Comfortable	Off
7.	Low	Humid	Low
8.	Low	Sticky	Medium
9.	High	Dry	Low
10.	High	Comfortable	Medium
11.	High	Humid	Fast
12.	High	Sticky	Fast
13.	Very High	Dry	Medium
14.	Very High	Comfortable	Fast
15.	Very High	Humid	Fast
16.	Very High	Sticky	Fast

III. NEURO-FUZZY ALGORITHM

The design proposed for air conditioning system using fuzzy logic then can be trained using the learning algorithms of neural networks to make it adaptive. Fuzzy logic controlled air conditioning system is trained using ANFIS Toolbox of MATLAB for a data set which was gathered from technical expertise. On training the given fuzzy inference system, the input temperature takes the name 'input1' and is changed to the range from 10ºC to 40ºC with membership functions as shown in Fig.4. Similarly, input humidity takes the name 'input2' and have membership functions in the range of 15% to 85% as shown in Fig.5. The name of output compressor speed changes to 'output' and takes sixteen membership functions instead of four over the range of 0 to 100. The rule base for the system also changes accordingly as shown in Table 2. The Fuzzy system structure in form of neural networks formed by ANFIS is shown in Fig.6.

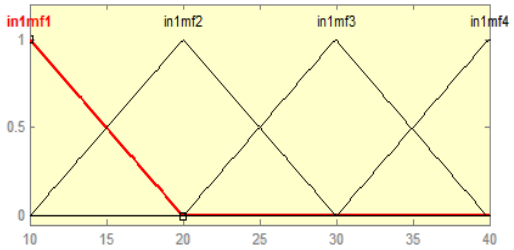

Fig.4. Input1 membership functions

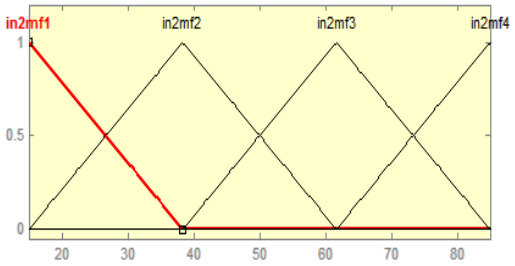

Fig.5. Input2 membership functions

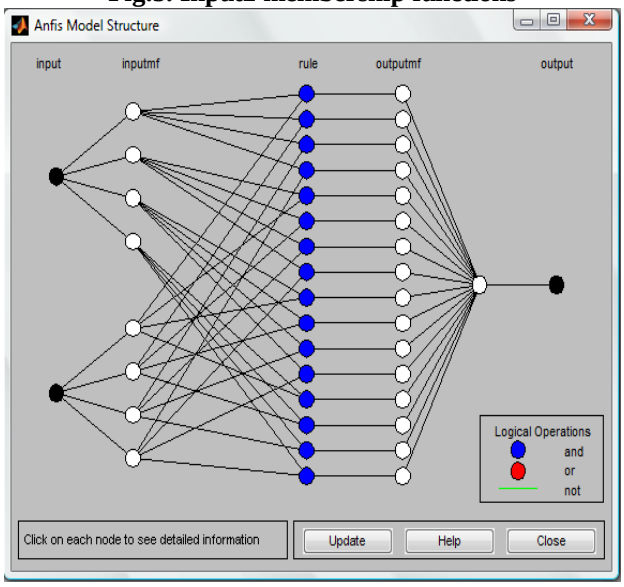

Fig.6. ANFIS structure

Table2. ANFIS rules for the design

Rules	Input1	Input2	Output
1.	In1mf1	In2mf1	Out1mf1
2.	In1mf1	In2mf2	Out1mf2
3.	In1mf1	In2mf3	Out1mf3
4.	In1mf1	In2mf4	Out1mf4
5.	In1mf2	In2mf1	Out1mf5
6.	In1mf2	In2mf2	Out1mf6
7.	In1mf2	In2mf3	Out1mf7
8.	In1mf2	In2mf4	Out1mf8
9.	In1mf3	In2mf1	Out1mf9
10.	In1mf3	In2mf2	Out1mf10
11.	In1mf3	In2mf3	Out1mf11
12.	In1mf3	In2mf4	Out1mf12
13.	In1mf4	In2mf1	Out1mf13
14.	In1mf4	In2mf2	Out1mf14
15.	In1mf4	In2mf3	Out1mf15
16.	In1mf4	In2mf4	Out1mf16

IV. EXPERIMENTAL RESULTS

Following are the curves obtained after simulation of fuzzy logic control based air conditioning system using MATLAB (as shown in Figs.7, 8, 9).

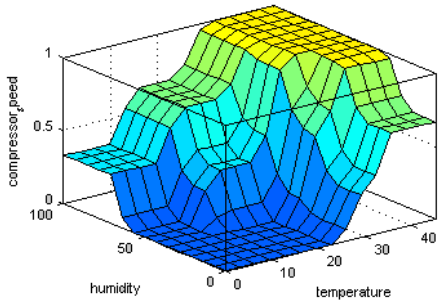

Fig.7. Surface view using fuzzy logic control algorithm

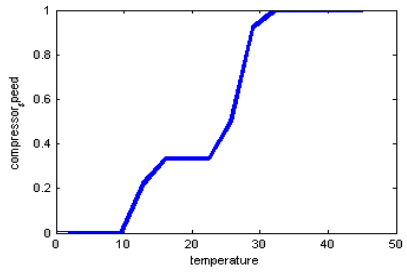

Fig.8. Compressor speed with Temperature

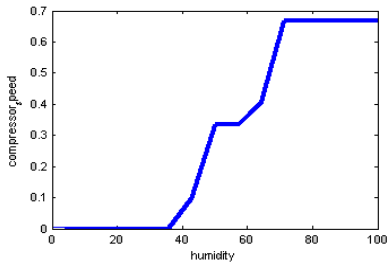

Fig.9. Compressor Speed with Humidity

Figs.10, 11, 12 shows the simulations of the neuro-fuzzy control based air conditioning system:

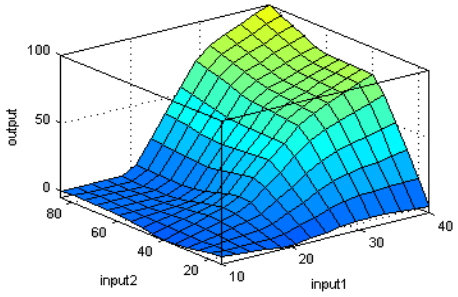

Fig.10. Surface view using neuro-fuzzy algorithm

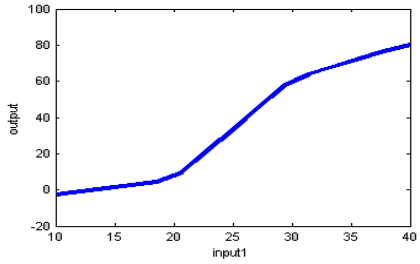

Fig.11. Output with Input1 (Temperature)

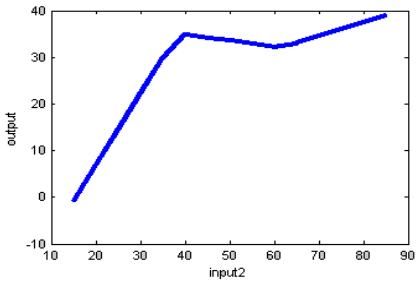

Fig.12. Output with Input2 (Humidity)

From these simulation results it is evident that neuro-fuzzy algorithm gives a better control than fuzzy logic algorithm. In fuzzy logic control based design, the compressor speed remains constant for temperature range from 30ºC onwards but in neuro-fuzzy based design the output increases consistently with temperature. Hence compressor speed is changing with every change in input temperature so this will save energy more than fuzzy logic design as at temperature of 30ºC the compressor is working at its 100% capacity in fuzzy logic design whereas in neuro-fuzzy design the compressor is working at it's approximately 60% capacity which shows

definite reduction in energy consumption. The same can be observed for humidity.

V. CONCLUSION

Neuro-fuzzy algorithm is definitely superior to fuzzy logic algorithm as it inherits adaptability and learning. It can be concluded from the simulations that neuro-fuzzy control makes the system adaptive to the room environment and weather. Even the control provided by the neuro-fuzzy is much better than fuzzy logic. In comparison to fuzzy algorithm, neuro-fuzzy algorithm makes the air conditioning system energy efficient.

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AUTHOR PROFILE

Arshdeep Kaur is pursuing M.TECH. final year in department of Electronics and Communication Engineering at University College of Engineering, Punjabi University, Patiala. She has done her B.TECH. in trade electronics and communication engineering from University College of Engineering, Punjabi University, Patiala. She has presented many papers in national and international conferences. Her topic of research is fuzzy logic, neuro-fuzzy, genetic algorithm and its applicability to industrial sector.

Amrit Kaur is Assistant Professor at University College of Engineering, Punjabi University, Patiala. She has received her M.TECH. degree from Punjab University, Chandigarh in 2005.She has eight years of teaching experience. Her areas of interest are control engineering, fuzzy logic, neuro fuzzy, MATLAB. She has to her credit many papers in international journals and national and international conferences.