ISSN:0975-9646

Arshdeep Kaur et al, / (IJCSIT) International Journal of Computer Science and Information Technologies, Vol. 3 (2) , 2012,3593-3596

Comparison of Mamdani Fuzzy Model and Neuro Fuzzy Model for Air Conditioning System

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***Abstract*— Air conditioning system is developed using mamdani fuzzy model and neuro fuzzy model. It is two input one output system where inputs being the temperature and humidity measured from their respective sensors and the output being the signal that controls the compressor speed. Both the models are simulated using MATLAB Fuzzy logic Toolbox and their results are compared.**

***Keywords*— air conditioning, mamdani, fuzzy logic, neuro-fuzzy.**

I. INTRODUCTION

Control automation has become essential for machine and processes, to achieve consistent operation, better quality, reduced operating costs, and greater safety [1]. Various control systems are used in many industry sectors, e.g. temperature control, humidity control, flow control etc. Air conditioning systems are also control systems that are integral part of almost every institution. These systems are found in auditoriums, indoor stadiums, conference halls, even in homes and offices.

The answer to the question why use fuzzy logic for control is that fuzzy logic can be used for controlling a process that is too non-linear or too ill-understood to use conventional control designs. Fuzzy logic enables control engineers to easily implement control strategies used by human operators [2]. Conventional design methods require the development of mathematical model of the control system and then use of this model to construct the controller that is described by the differential equations [3]. Air conditioning systems are difficult to model mathematically due to complex interactions of multiple inputs and outputs. Fuzzy logic appears useful when a process lacks a well posed mathematical model [4]. It is one of the most useful approaches for utilizing the qualitative knowledge of a system to design a controller. Fuzzy logic techniques represent a means of both collecting human knowledge and expertise and dealing with uncertainties in the process of control [5].

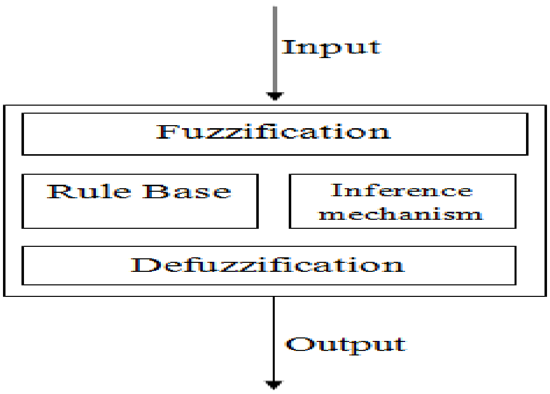

Fig. 1 Block diagram of fuzzy controller

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 output should be. (iv) Defuzzification interface, converts the conclusions reached by the inference mechanism into crisp ones.

One of the major problems of the fuzzy logic control is the difficulty of choice and membership functions for a given problem [6]. The quality of the fuzzy logic controller can be drastically affected by the choice of membership functions. Thus methods for tuning fuzzy logic controllers are necessary. A combination of neural networks and fuzzy logic offers the possibility of solving tuning problems and design difficulties of fuzzy logic [7]. Neuro-fuzzy system combines the learning capabilities of the neural networks and the control capabilities of a fuzzy logic system. It is a system that uses a learning algorithm to determine its parameters by processing data samples. Fig. 2 shows architecture of neuro-fuzzy system. First layer of neurons represent the input variables, second layer represents the input membership functions, third layer represents the rule base, fourth layer represents the output membership functions and fifth layer represents the output variables.

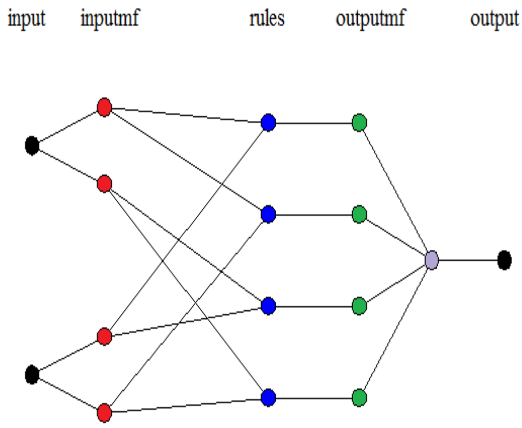

Fig. 2 architecture of neuro fuzzy system

The rest of the paper is organized as follows: Section II gives mamdani fuzzy model. Section III gives neuro-fuzzy model. Section IV provides the results and section V conclusion.

II. MAMDANI FUZZY MODEL

Air conditioning system is first developed using mamdani fuzzy model. It consists of two inputs from temperature and humidity sensors providing the temperature and humidity of the room. The system has one output that controls the compressor speed. The temperature and humidity are taken to be in ranges of 0ºC to 45ºC and 0% to 100 % respectively. Each of the inputs has four triangular membership functions as shown in Fig. 3 and 4. The output i.e. compressor speed is taken in percentage in range from 0% to 100% and have four triangular membership functions shown in Fig. 5. The rules included for the air conditioning system are described in TABLE I.

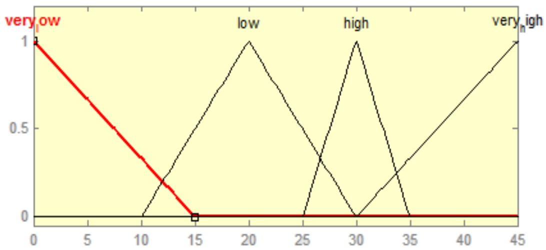

Fig. 3 Temperature membership functions

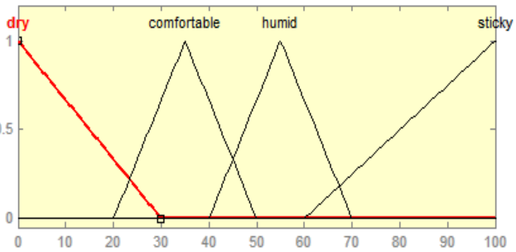

Fig. 4 Humidity membership functions

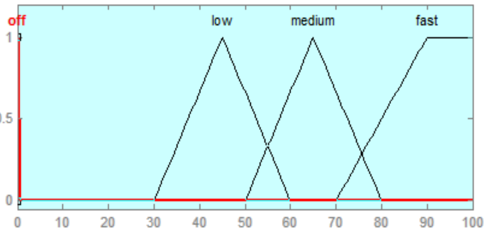

Fig. 5 Compressor speed membership functions

TABLE I
MAMDANI RULE BASE 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 MODEL

Neuro-fuzzy model for air conditioning system is developed using ANFIS Edit GUI. Fuzzy inference system (FIS) of two inputs and one output is generated. The two inputs take the name input1 and input2 which corresponds to temperature and humidity of the room respectively and each have four triangular membership functions. The output corresponds to compressor speed has sixteen membership functions which are of constant nature. This generated FIS is trained for a input-output data set gathered from technical expertise. Then the membership functions of input1 take the scale of 10ºC-40ºC and membership functions of input2 take the scale of 15%-85% as shown in Fig. 6 and 7. Neuro-fuzzy architecture for the system is shown in Fig. 8. The rule base for neuro-fuzzy model that is generated by the GUI is given in TABLE II.

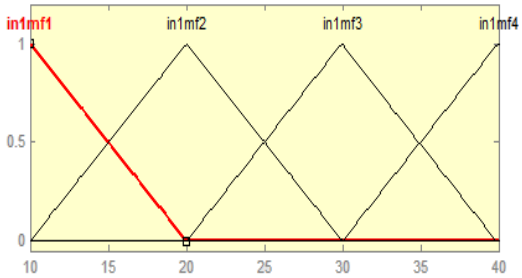

Fig.6 Input1 membership functions

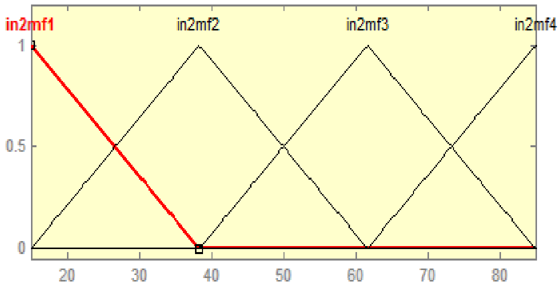

Fig.7 Input2 membership functions

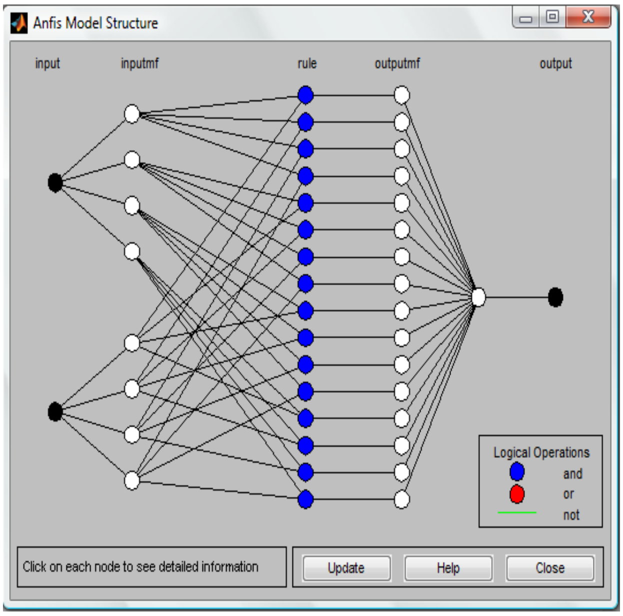

Fig.8 ANFIS structure

TABLE II
ANFIS RULE BASE 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

IV. EXPERIMENTAL RESULTS

The results for both the designs using mamdani fuzzy model and neuro-fuzzy model for air conditioning system are obtained using MATLAB Fuzzy logic Toolbox. Following are the curves of the air conditioning system using mamdani fuzzy model (shown in Figs. 9, 10, 11).

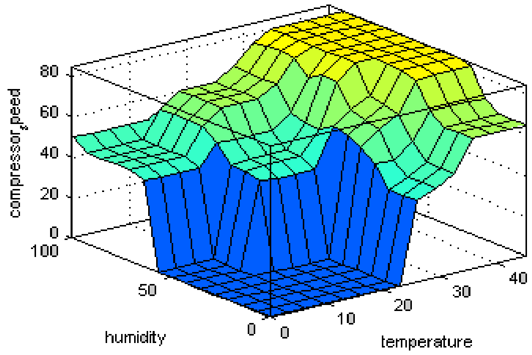

Fig. 9 Surface view using mamdani fuzzy model

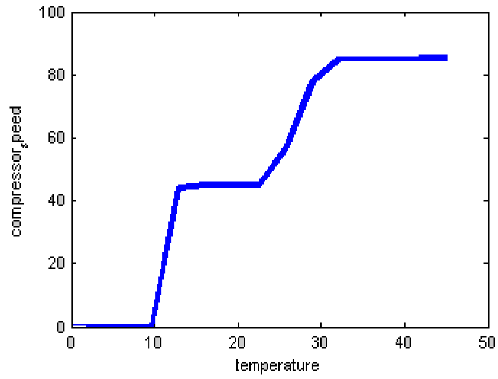

Fig. 10 Compressor speed with Temperature

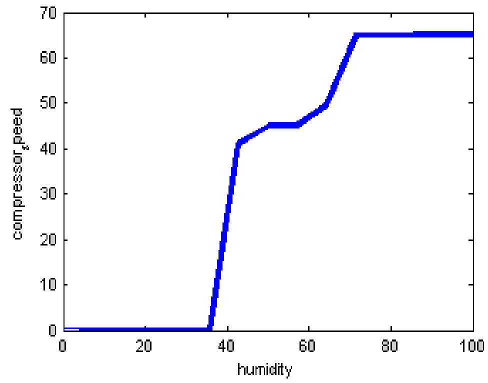

Fig. 11 Compressor speed with Humidity

Figs. 12, 13, 14 show the result obtained using neuro fuzzy model of air conditioning system:

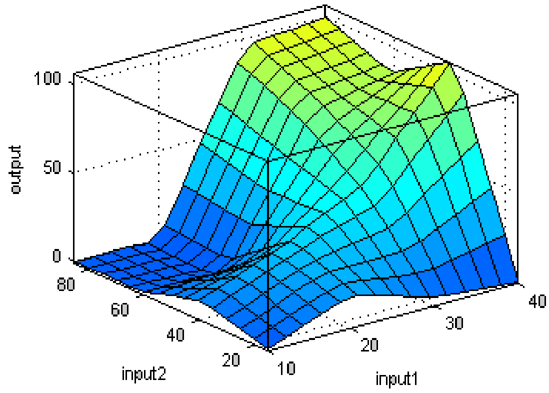

Fig. 12 Surface view using neuro-fuzzy model

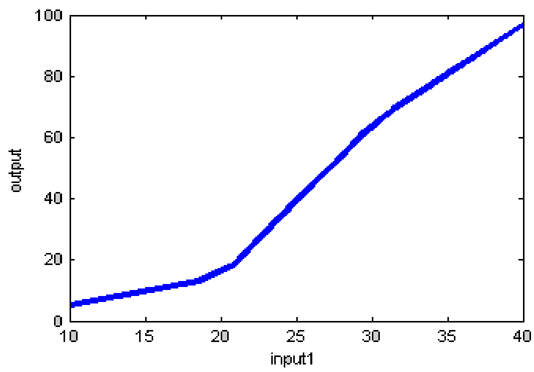

Fig. 13 Output with Input1 (temperature)

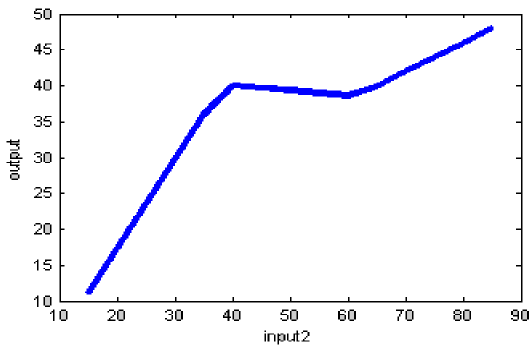

Fig. 14 Output with Input2 (humidity)

The results obtained shows that neuro-fuzzy model provides a better control than mamdani fuzzy model for air conditioning system. As can be seen from the curves, that in mamdani fuzzy model compressor speed becomes constant after 30ºC of temperature whereas in neuro-fuzzy model compressor speed is continuously increasing with the increase in temperature, hence is nearly linear. Neuro-fuzzy model also helps in reduction of energy consumption as at 30ºC of temperature compressor is working at nearly 60% of its capacity in neuro fuzzy model opposed to that of 80% in mamdani fuzzy model. Furthermore, in mamdani fuzzy model the compressor never works at it full capacity nor even at highest of temperature whereas in neuro-fuzzy model compressor nearly reaches its full capacity at highest of temperatures.

V. Conclusions

As evident from the results, neuro-fuzzy model is a better choice than mamdani fuzzy model for air conditioning system. Neuro-fuzzy model inherits adaptability and learning, has a better control and is even energy efficient in comparison to mamdani fuzzy model. The performance of neuro-fuzzy model can still be improved by training the neural networks with more number of input and output combinations.

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