Design of Fuzzy Inference System for Autonomous Air Conditioner

Komal B. Uplenchwar
M.Tech (Electronics)
B. D. College Of Engineering
Sevagram, Wardha

V. R. Ingle
Department of Electronics
B. D. College Of Engineering,
Sevagram,Wardha.

ABSTRACT
Design of an autonomous air conditioner using fuzzy rule based system is proposed in this literature.An air conditioning system, presently involves frequent starting and stopping of the compressor for desired temperature.However,thedesired temperature in the room is depends on number of factors such as occupancy,change in temperature and humidity of the environment throughout the day. Therefore, intelligent system using multiple sensors is proposed which measures theuser temperature, temperature difference, occupancy and humidity inside the room. These inputparameters are then used tocontrol three parameters listed as compressor speed, fan speed and fin direction which involved in decision making. Data driven neuro-fuzzy system is employed to get the crisp values of different controlling parameters.

Keywords
Multiple regression, linguistic variables Fuzzy inference system, fuzzy logic controller.

1. INTRODUCTION
Desired temperature in the room is depends on number of factors such as occupancy, change in temperature and humidity of the surroundings. Present air conditioning system involves frequent starting and stopping of the compressor for desired temperature.However, frequently changing the comfortable level of temperature by means of remote control is monotonous. Hence to attain thecomfortable level of cooling byassessing the environmental factor is the main concern.Therefore,an autonomous air conditioner using fuzzy rule based control system is projected.

Fuzzy Logic is a practical alternative for challenging control applications. It provides a convenient method for constructing nonlinear controllers via the use of heuristic information. Such heuristic information is recorded in rules, describing the control process. Fuzzy Logic emulates the human decision making process, and provides a user-friendly formalism for representing and implementing high-performance control.Fuzzy Logic controller forms the base of the Fuzzy Control system. It basically consists of the heuristics rules those define the parameters. It consists of:

- Data Base:It normalizes the input crisp values and contains the fuzzy partitions of the input and output space.
- Fuzzy Rule Base:It contains the type of fuzzy rules and the source and derivation of the fuzzy control rules.
- Fuzzy Inference Machine: The basic function is to compute the overall output of the control output variable based on the individual contribution of each rule in the fuzzy rule base.
- Defuzzification: It converts the set of modified control out-put values into single point-wise (crisp) values and denormalizes the output onto its physical domain.

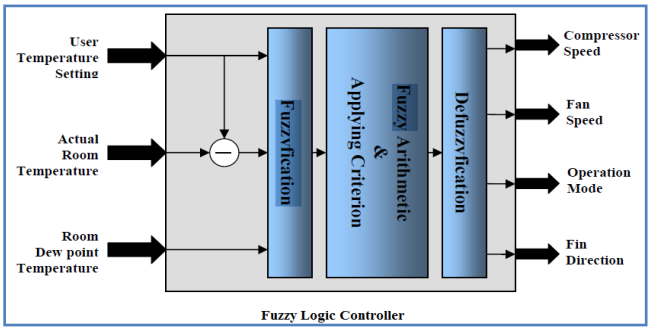


Fig.1: Fuzzy logic based controller design

The user based processing capability is an important aspect of fuzzy systems and thustargetingthe human comfort fordesign consideration. The multiple inputs to the model are temperature difference, humidity, occupancy, time of day anduser temperature. However, compressor speeds, blower speeds and direction of blower blades are considered as output parameters.

2. LITERATURE ANALYSIS
A fuzzy logic system has been designed [1] by dividing the universe of discourse into different regionscontaining two fuzzy variables. The rule base receives two crisp input values from temperature and humidity sensors. The rules firewith the singleton output.Defuzzifiers control the actuators; cooler fan, water pump and room exhaust fan. Designed system provided the results effectively in agreement with the simulation results during the testing of various parts of the control system. The algorithmic design approach makes the system efficient and absolutely under control. Another designed suggested for room cooler,accumulate the control management without the complexity in a processing plant, whichsustains the required cooling environment. [2] Air-Conditioner would assess the environmental factors like temperature and humidity. It resultedin providing the comfortable levels of cooling and optimized electricity consumption.

Adding the intelligence in Air-Conditioning system, increases adaptively in the cooling process.Temperature difference, occupancy, time of day, user temperature, dew point are the inputs to model and Compressor speed, fan speed, mode of operation and fin direction are the output to model.The analysis clearly maps out advantage of fuzzy logic in dealing with problems that are difficult to study analytically yet are easy to solve intuitively in terms of linguistic variables[3].The Programmable logic controller (PLC) applied to realize the fuzzy controlled air conditioning system. The keyboard is used to simulate temperature, the DIP Switch (DSW) used to simulate humidity, and the stepping motor is used to simulate compressor. The feedback signal through PLC is transferred to computer for fuzzy control. Finally, the control signal from

computer is transferred to PLC to control speed of stepping motor for simulating the operation of compressor. The system can change the speed for different loads as well as adjust the compressor at any time.With this system, the temperature and humidity provided by the air conditioning system remain at comfortable levels and reduce the air conditioning load to achieve the objective of energy savings.A fuzzy control system is used, and an operation of air-conditioning system is simulated. The designed system shows the capability for full control of speed variation of compressor for any required range of temperature and humidity. The controller is optimally designed by considering an integrated objective function, which balances the requirements of comfort and energy efficiency [4].

Fuzzy inference systemsfor air conditioning system proposed using Mamdani-type and Sugeno-type fuzzy models. Thepaper outlines the basic difference between the Mamdani-type FIS and Sugeno-type FIS. The difference shows the fullcapacityof Sugeno-type FIS air conditioning system compared withMamdani-type FIS. Although the designing of both the FIS observed to be same but the output membership functions of Sugeno-type can only be either constant or linear[5].The MC68HC12 microcontroller features support Fuzzy Logic, introduces in Fuzzy Logic and intelligent control[6]. Fuzzy control mechanism for air-condition system, combines the fuzzy control and multi-point sensing technology. Therein an intelligent fuzzy controller for air-condition with Zigbee sensors is used to provide the comfort and energy-saving benefit. Another design of an intelligent Fuzzy controller for air-condition with Zigbee sensors is used to provide the comfort and energy-saving benefit. Although traditional control system (shorten as TCS) and the proposed fuzzy control system (named as FCS) have a common goal of temperature control, they differ from each other in temperature switch decision made during the each ambient temperature phases[7].The proposed model consists of two fuzzy logic controllers to control temperature and humidity respectively. The first controller accepts two input values- the current temperature as detected by temperature sensor and its deviation from user set-temperature, and controls the speed of heat-fan and cool-fan accordingly. When the current temperature in the room reaches set point, it serves as one of the input for second fuzzy logic controller that controls the humidity. The algorithmic design approach makes the system efficient and absolutely under control. The analysis clearly maps out advantage of fuzzy logic in dealing with problems that are difficult to study analytically yet are easy to solve intuitively in terms of linguistic variables [8].

3. FUZZY INFERENCE SYSTEM

The input and output ranges for every parameters are considered for different ratings of air conditioners. By applying the multiple linear regressions on input/output set aregression function is derived. A database of input/output combination is created for data driven modeling. The user based processing capability is an important aspect of fuzzy systems and thustargetingthe human comfort fordesign consideration. The multiple inputs to the model are temperature difference, humidity, occupancy, time of day anduser temperature. However, compressor speeds, blower speeds and direction of blower blades are considered as output parameters.

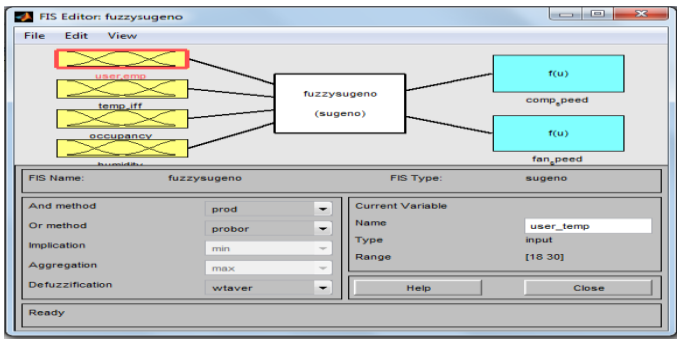
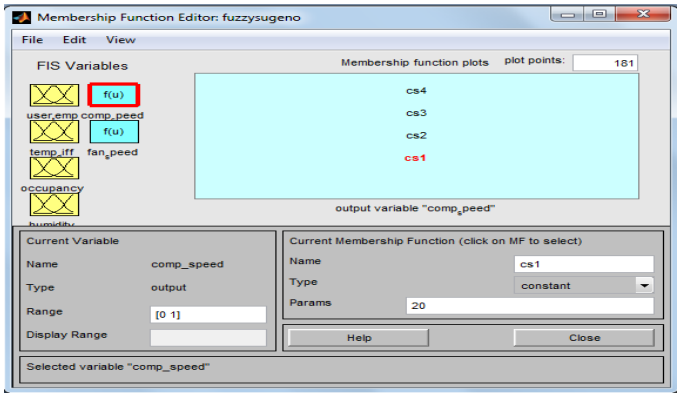


Fig.2: Fuzzy Inference System design

The outputs variables i.e. Compressor Speed (Sc) and blower Speed (Sf) of the Fuzzy Controller are shown as follows:



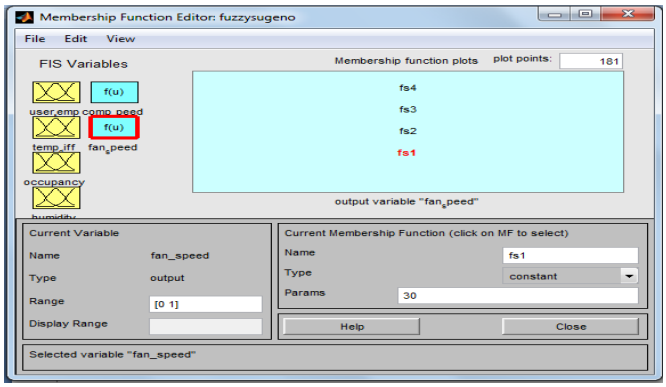


Fig.3: Outputs Variables

4. ADAPTIVE NEURO-FUZZY INFERENCE SYSTEM

ANFIS is a hybrid AI technique, which combines best features of Fuzzy Logic and parallel processing neural networks. It possesses fast convergence and has more accuracy than back propagation neural network. The algorithm used to give the output values based on Neuro-Fuzzy technique. The steps of the proposed algorithm are shown in the form of the flowchart in Fig. 4.

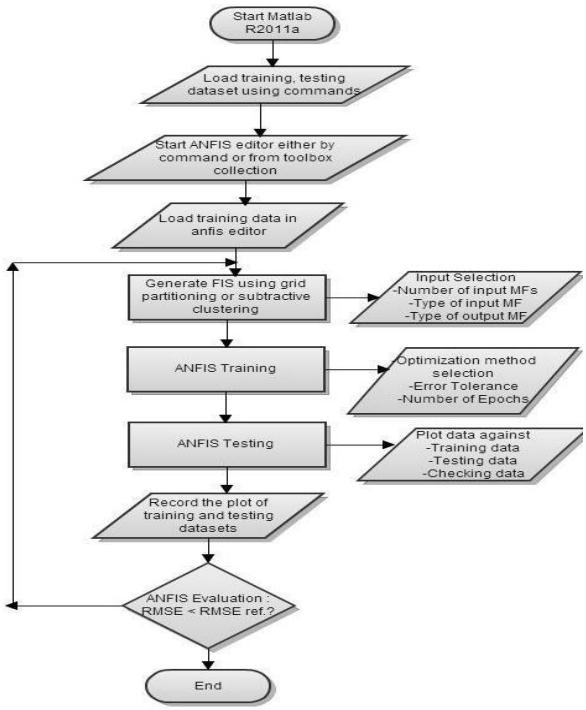


Fig.4: Algorithm of ANFIS

ANFIS takes multiple inputs to the system and gives only one output. Therefore, two different systems are designed which give two outputs for compressor speed and fan speed.

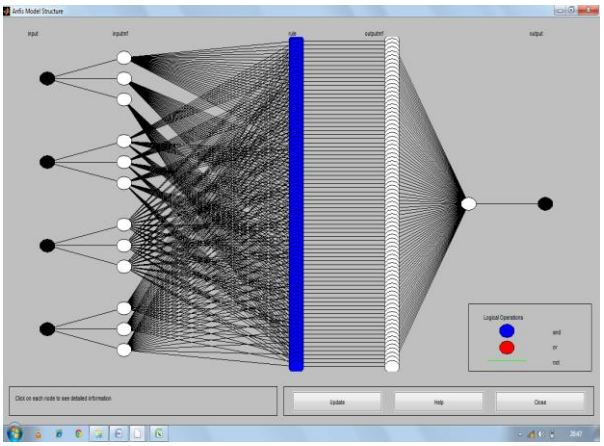


Fig.5: FIS Structure for fan speed

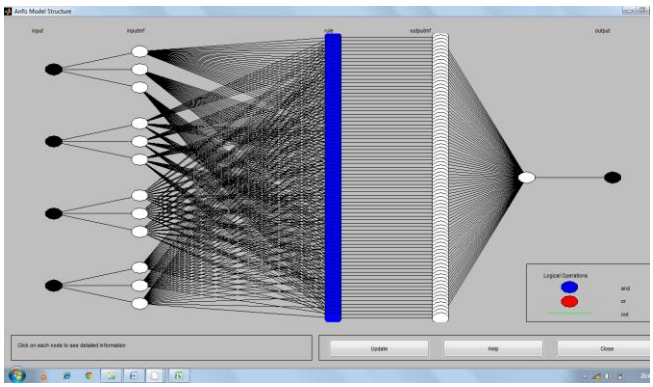


Fig.6: FIS Structure Compressor speed

5. COMPARISION BETWEEN TWO MODELS

The test sample for both the models are given as- [usertemp. =24 ;temp.diff. =10^0C ; humidity =70]

Table 1: Soft computing O/P Vs Statistical O/P

Desired output	Multiple Reg.	FUZZY LOGIC	ANFIS	Linguistic variable
Compressor speed	55	42.7	54.9	CS2
Fan speed	64	50	63.3	FS2

The result shows the accuracy of ANFIS model and therefore the numeric values in terms of outputs are calculated by means of designed ANFIS model for the realization of the hardware.

6. AUTONOMOUS AIR CONDITIONER

The different controlling points derived for output variables are used to maintain the human comfort. A general purpose kit, AVR (40 pin)Rapid Robot controller board is used to realize the FLC. The block diagram of the same is shown in the following fig.

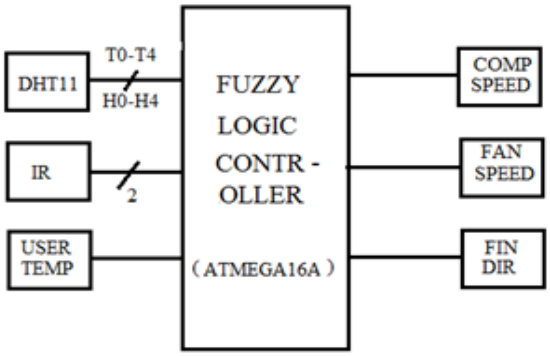


Fig.7: Realization of FLC using ATMEGA 16 A

Several features are specified below-

- 5 Switches including reset
- 3 Switches on interrupt pins
- Power on/off toggle switch
- Motor on/off toggle switch
- 16MHz crystal for maximum speed
- Onboard LCD connector compatible to HD44780 LCD Modules.
- PWM pins connected to motor drivers for speed control of motors.
- Full Speed/PWM Speed control selection jumpers
- 4 ADC/Standard servo compatible connectors.

7. CONCLUSION

An autonomous air conditioner using fuzzy rule based system is designed using microcontroller. From the experiment results, it is observed that the ANFIS gives the better result compare to fuzzy logic. Since ANFIS is self designed scheme whereas fuzzy logic is a user designed method. As the ANFIS defined the data oriented membership function and the rules to provide the output with minimum tolerance error. Because of themultiple sensors and the concept of ANFIS, the required output value for human comfort temperature is achieved successfully.

8. REFERENCES

[1] M. Abbas, M. Saleem Khan, Fareeha Zafar, "Autonomous Room Air Cooler Using Fuzzy Logic Control System" International Journal of Scientific & Engineering Research Volume 2, Issue 5, May-2011 ISSN 2229-5518.

[2] Sanjit Kumar Dash, GouravmoyMohanty, AbhishekMohanty. " Intelligent Air Conditioning System using Fuzzy Logic" International Journal of Scientific & Engineering Research Volume 3, Issue 12, December-2012 1 ISSN 2229-5518.

[3] Po-Jen Chengand, Chin-Hsing Cheng, Tzai-Shiang Chang "Variant-Frequency Fuzzy Controller for Air Conditioning Driver by Programmable LogicController" Proceedings of 2011 8th Asian Control Conference (ASCC) Kaohsiung, Taiwan, May 15-18, 2011.

[4] ArshdeepKaur, AmritKaur. "Comparison of Mamdani-Type and Sugeno-Type Fuzzy Inference Systems for Air Conditioning System". International Journal of Soft Computing and Engineering (IJSCE) ISSN: 2231-2307, Volume-2, Issue-2, May 2012.

[5] Zainah Md. Zain', NorRulHasma Abdullah and Abdul HalimMohdHanafi. "Microcontroller-Based Energy Saving Control for Air - Conditioning System Using Fuzzy Logic Approaching: An Overview" 2006 IEEE.

[6] M. Mongkolwongrojn and V. Sarawit, "Implementation of Fuzzy Logic for Air - Conditioning Systems". http://2005.iccas.org/submission/paper/upload/1ICCAS-2005 _Fuzzy_.pdf.

[7] J. M. Moon,,I. Y. cho and R. V. D. Ree, "Better Controls To Improve Air- Conditioning System Efficiency",//www.digitalscroll.com/digitalweb/english/better-controls.htm.

[8] M.C.G. Alerge "Fuzzy Diagnose Based System for Air QualitySurveillance",Available at:http://citeseer.ist.psu.edu/cache/papers/cs/28975/;www.iai.csic.eszSzuserszSzgpazSzpostscriptzSzContaminacionMelbourneOl.pdf/fuzzy-diagnose-microcontroller-based.pdf

[9] M. Mongkolwongrojn and V. Sarawit, "Implementation of Fuzzy Logic for Air - Conditioning Systems". Available at: http:// 2005.iccas.org/submission/paper/upload/1ICCAS-2005 element belongs to a set, on a scale from 00 to FF Fuzzy_.pdf.

[10] P. J. Cheng, C. H. Cheng, Y. C. Lin, "Design of Intelligent Controller for Air-Conditioning System Using DSP", Journal of Information and Optimization Sciences. Vol. 29, No. 5, pp. 907-922, 2008.

[11] M. S. I. Md., S. Z. Sarker, K. A. A. Rafi, M. Othman, "Development of a fuzzy logic controller algorithm for air conditioning system", ICSE Proceedings,2006.