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Comparison of Mamdani-Type and Sugeno-Type Fuzzy Inference Systems for Air Conditioning System

Arshdeep Kaur, Amrit Kaur

Abstract:- Fuzzy inference systems are developed for air conditioning system using Mamdani-type and Sugeno-type fuzzy models. The results of the two fuzzy inference systems (FIS) are compared. This paper outlines the basic difference between the Mamdani-type FIS and Sugeno-type FIS. It also shows which one is a better choice of the two FIS for air conditioning system.

Index Terms:- Air Conditioning, Fuzzy Inference System (FIS), Fuzzy Logic, Mamdani.

I. INTRODUCTION

After being mostly viewed as a controversial technology for two decades, fuzzy logic has finally been accepted as an emerging technology since the late 1980s. This is largely due to a wide array of successful applications ranging from consumer products, to industrial process control, to automotive applications [1]. Fuzzy logic is closer in spirit to human thinking and natural language than conventional logical systems [2]. Classical control theory is based on the mathematical models that describe the physical plant under consideration. The essence of fuzzy control is to build a model of human expert who is capable of controlling the plant without thinking in terms of mathematical model [3].Fuzzy systems are very useful in two general contexts: (1) in situations involving highly complex systems whose behaviors are not well understood, and (2) in situations where an approximate, but fast, solution is warranted [4].

Fuzzy logic was put forward earliest in 1965 by L.A. Zadeh. One of the primary applications of fuzzy logic was subway system in Sendai city of Japan. The applied result showed that fuzzy logic control was superior to traditional control. But finding out the correct rule set and determining the essence and range of fuzzy variables is time consuming work. Such as in subway system of Sendai, to obtain correct input sets, the engineers spent several months. Similarly, in central air conditioning system field today, there is a long way to find out a mature expert fuzzy control model which must need plenty of project experience [5]. Air conditioning is not only a name of the product, but by using ideas and methods of air conditioning to create comfort and natural living environment while at same time reduce the ravages of nature and achieve real sense harmony of human and nature to maximum extent [6]. Nowadays, air conditioning systems are commonly found in homes and offices, and in almost all public enclosed spaces. The rest of the paper is organized as follows: Section II, gives the difference between Mamdani-type and Sugeno-type FIS. Section III, shows the development of Mamdani-type FIS. Section IV, shows the development of Sugeno-type FIS. Section V, gives results and discussions and section VI conclusions.

II. MAMDANI-TYPE FIS VS. SUGENO-TYPE FIS

Mamdani method is widely accepted for capturing expert knowledge. It allows us to describe the expertise in more intuitive, more human-like manner. However, Mamdani-type FIS entails a substantial computational burden. On the other hand, Sugeno method is computationally efficient and works well with optimization and adaptive techniques, which makes it very attractive in control problems, particularly for dynamic non linear systems. These adaptive techniques can be used to customize the membership functions so that fuzzy system best models the data.

The most fundamental difference between Mamdani-type FIS and Sugeno-type FIS is the way the crisp output is generated from the fuzzy inputs. While Mamdani-type FIS uses the technique of defuzzification of a fuzzy output, Sugeno-type FIS uses weighted average to compute the crisp output. The expressive power and interpretability of Mamdani output is lost in the Sugeno FIS since the consequents of the rules are not fuzzy [7]. But Sugeno has better processing time since the weighted average replace the time consuming defuzzification process. Due to the interpretable and intuitive nature of the rule base, Mamdani-type FIS is widely used in particular for decision support application. Other differences are that Mamdani FIS has output membership functions whereas Sugeno FIS has no output membership functions. Mamdani FIS is less flexible in system design in comparison to Sugeno FIS as latter can be integrated with ANFIS tool to optimize the outputs.

III. DEVELOPMENT OF MAMDANI-TYPE FIS

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 Figs.1 and 2. The output i.e. compressor speed is

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Arshdeep Kaur, University College of Engineering, Punjabi University, Patiala, India, 09872560605., (e-mail: arshdeep_24@yahoo.in).

Amrit Kaur, University College of Engineering, Punjabi University, Patiala, India, 09417606040, (e-mail: amrit_aks@yahoo.ca).

taken in percentage in range from 0% to 100% and have four triangular membership functions shown in Fig. 3. The rules included for the air conditioning system are described in Table I.

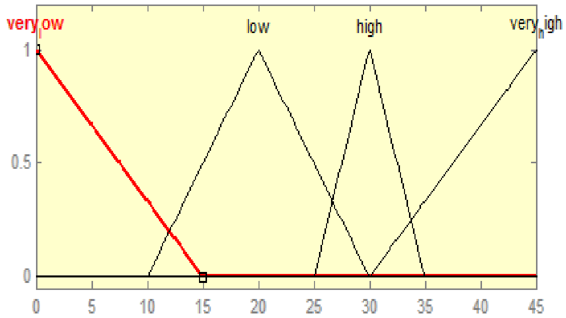

Fig.1. Temperature membership functions

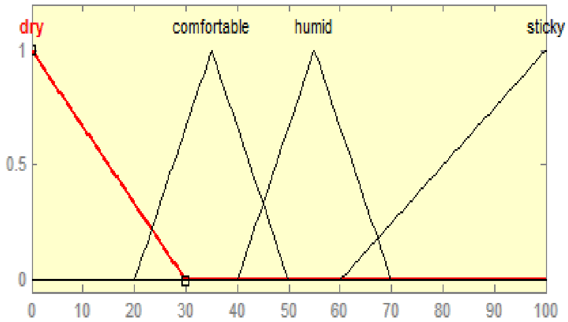

Fig.2. Humidity membership functions

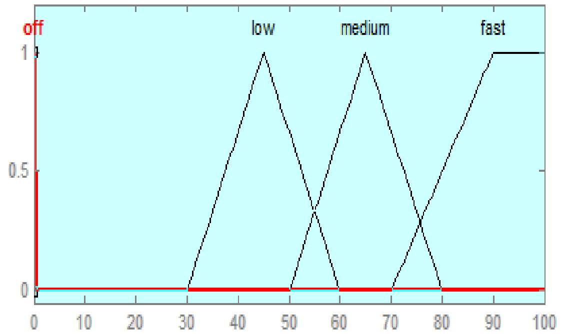

Fig.3. Compressor speed membership functions

Table I. Rule base of Mamdani-type FIS

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. DEVELOPMENT OF SUGENO-TYPE FIS

For development of air conditioning system using Sugeno-type model, the initial steps are same as Mamdani-type model. It also takes inputs from temperature and humidity sensors and produces an output signal that controls the compressor speed. Inputs temperature and humidity have four triangular membership functions over the range of 0ºC to 45ºC and 0% to 100% respectively (as already shown in Figs. 1 and 2). The output compressor speed can only be either constant or linear in this FIS, so four membership functions for the output are “off”, “low”, “medium” and “fast” which are constant and are shown in Table II. The output in Sugeno-type FIS can only be in range of 0-1. The rule base for Sugeno-type FIS is same as for Mamdani-type FIS as shown in Table I.

Table II. Compressor speed membership functions

Compressor speed	Constant value
Off	0
Low	0.3333
Medium	0.6667
Fast	1

V. RESULTS AND DISCUSSIONS

The plots obtained after simulating Mamdani-type of FIS for air conditioning system are shown in Figs.4, 5 and 6.

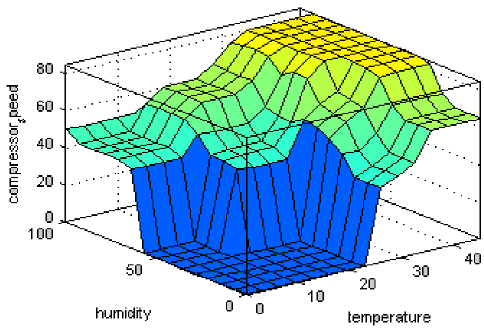

Fig.4. Surface view of Mamdani-type FIS

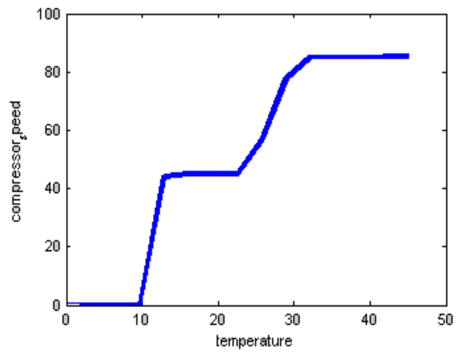

Fig.5. Compressor speed with temperature

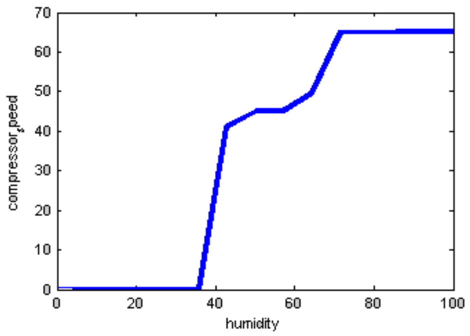

Fig.6. Compressor speed with humidity

Following are the plots obtained after simulating the Sugeno-type FIS for air conditioning system (as shown in Fig. 7, 8 and 9):

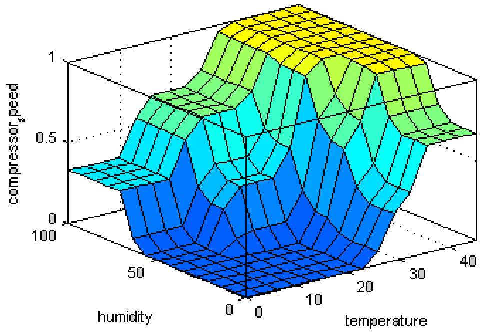

Fig.7. Surface view of Sugeno-type FIS

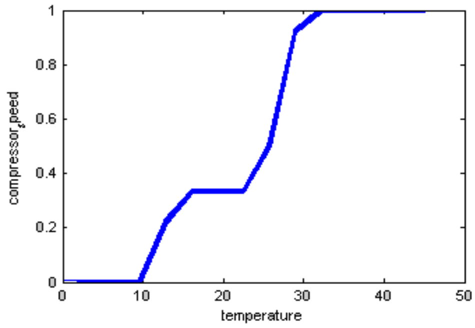

Fig.8. Compressor speed with temperature

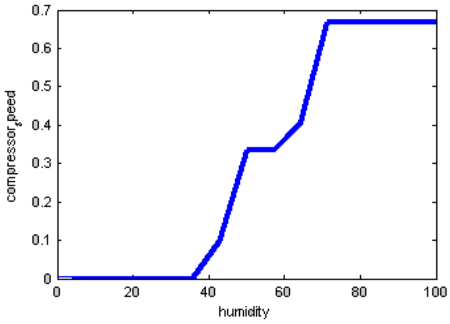

Fig.9. Compressor speed with humidity

The results obtained show that for the given application of air conditioning system Mamdani-type FIS and Sugeno-type FIS works similarly. The only difference noticed is that in Sugeno-type FIS air conditioning system works upto its full capacity whereas in Mamdani-type FIS it does not work upto full capacity.

VI. Conclusion

It can be concluded from this paper that for air conditioning system Mamdani-type FIS and Sugeno-type FIS performs similarly but by using Sugeno-type FIS model it allows the air conditioning system to work at its full capacity. Although the designing of both the FIS is same but the output membership functions of Sugeno-type can only be either constant or linear and also the crisp output is generated in different ways for both the FIS. Sugeno-type FIS has an advantage that it can integrated with neural networks and genetic algorithm or other optimization techniques so that the controller can adapt to individual user, environment and weather.

VII. Acknowledgment

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References

[1] J. Yen and R. Langari, *Fuzzy Logic*. Pearson Education, 2004.

[2] K.P. Mohandas and S. Karimulla, "Fuzzy and Neuro-fuzzy modeling and control of non linear systems", Second International Conference on Electrical and Electronics, 2001.

[3] G. S. Sandhu and K. S. Rattan, "Design of a neuro-fuzzy controller", IEEE International Conference on Systems, Man, Cybern., 1997.

[4] T. J. Ross, *Fuzzy Logic with Engineering Applications*. John Wiley and sons, 2010.

[5] M. Du, T. Fan, W. Su, H. Li, "Design of a new practical expert fuzzy controller in central air conditioning control system", IEEE Pacific-Asia Workshop on Computational Intelligence and Industrial Application, 2008

[6] S. Li, J. Liu, J. Liu, "Design on the central air-conditioning controller based on LabVIEW", ICCASM IEEE proc., 2010.

[7] A. Haman, N. D. Geogranas, "Comparison of Mamdani and Sugeno Fuzzy Inference Systems for Evaluating the Quality of Experienceof Hapto-Audio-Visual Applications", HAVE 2008 – IEEE International Workshop on Haptic Audio Visual Environments and their Applications, 2008

[8] 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.

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.