ISSN: 2277-3754
ISO 9001:2008 Certified
International Journal of Engineering and Innovative Technology (IJEIT)
Volume 2, Issue 9, March 2013

Comparison of Mamdani Fuzzy Model and Neuro Fuzzy Model for Load Sensor

Monika, Amrit Kaur

Abstract*— Development of Load sensor is done in this paper, the input output of the load sensor is taken from the optical fiber sensor and the inputs are load and displacement and output is voltage. Load sensor is implemented by using two models i.e. mamdani fuzzy model and neuro fuzzy model and both the models are simulated using MATLAB, Fuzzy logic Toolbox and the results of the two models are compared.

***Index terms* —Fuzzy Logic, Load Sensor, Mamdani, Neuro Fuzzy.**

I. INTRODUCTION

Neuro-fuzzy approach combines two powerful computing disciplines neural networks and fuzzy set theory. Neural networks are well known for its ability to learn and adapt to unknown or changing environment to achieve better performance [1]. Fuzzy logic was first proposed in 1965 as a way to imprecise data by Lofti Zadeh, professor at University of California [2]. Fuzzy set theory is used because of its effectiveness in handling linguistic information and incorporates human knowledge which deals with imprecision and uncertainty and the relation between input and output variables. However, the neural networks have the capability of identification of a system which can be extracted from the input output data. This learning capability of neural network can be combined with control capability of a fuzzy logic system [1]. A Load sensor is a sensor that converts a load or force acting on it into an electronic signal. This electronic signal can be a voltage change, current change or frequency change depending on the type of load cell and circuitry used [3]. Load sensors can be simulated by Neuro- fuzzy model .Load sensors are being used in different type of structures e.g. bridges, wind mills, roofs of sport centers, blades of helicopters, airplane wings etc through the use of embedded or surface bonded sensors . In the case of wind mill blades, optical fiber sensors based on fiber brag grating is embedded in composite material(GFRP & CFRP) used in wind mill blade to monitor the load on wind mill blade[4]. The data acquired using load sensors are typically not directly usable as they suffer from three problems: (a) Noise because of inaccuracy in hardware sensing and transmission and unfavorable environmental conditions and limited battery power further exaggerates this problem. (b) Missing values usually occur due to packet loss and node failure.(c) Incompleteness, since sensors sample continuous physical phenomena at discrete time intervals. All these problems seriously impact the quality of data obtained from such sensors. The aim of the industry, indeed, is to manufacture tiny, cheap sensors that can be deployed everywhere and disposed when depleted. Consequently, noise, imprecision and inaccuracies are inevitable in these cheap sensors. It is extremely important that data from these sensors be reliable since actions are usually taken based on their readings [3].Nowadays, optical fiber sensors have been commercialized. Optical fiber sensors have certain advantages such as: Immunity to electromagnetic interference (EMI), Light weight and small size, High sensitivity, large bandwidth and Easy in implementing multiplexed or distributed sensors. Strain, temperature and pressure are the most widely studied and measured and the fiber grating sensor represents the most widely studied technology for optical fiber sensors. Fiber-optic gyroscopes and fiber-optic current sensors are good examples of rather mature and commercialized optical fiber sensor technologies. Today, some success has been found in the commercialization of optic technology [5]. In this paper, load sensor is implemented by using mamdani and neuro fuzzy models and then comparison of results from both the models is done. The rest of the paper is organized as follows: Section 2 Gives the mamdani fuzzy model for load sensor. Section 3 gives the Neuro-fuzzy model for load senor. Section 4 provide Results and section 5 is give the Conclusion of this paper.

II. DEVELOPMENT OF MAMDANI FUZZY MODEL

Load sensor is first developed using mamdani fuzzy model. It consists of two inputs namely as load and displacement for load sensor. Based on these inputs, output namely as voltage is generated. The load and displacement are taken to be in ranges from 1162 to 1960 gm and 95 to 107 mm respectively.

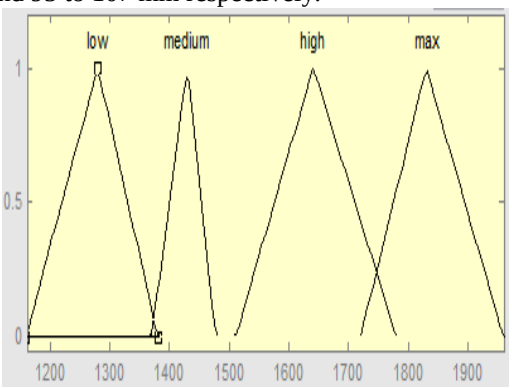

Fig.1. Load Membership Functions

Each of these inputs has four triangular membership functions as shown in Fig. 1 and 2. The output i.e. voltage

ISSN: 2277-3754
ISO 9001:2008 Certified
International Journal of Engineering and Innovative Technology (IJEIT)
Volume 2, Issue 9, March 2013

is taken in the range from 2.2 to 3.4 V and have four triangular membership functions as shown in Fig. 3. The rules included for the model is described in TABLE I.

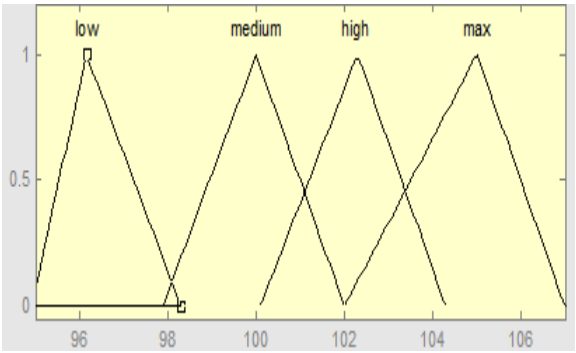

Fig. 2 Displacement Membership Functions

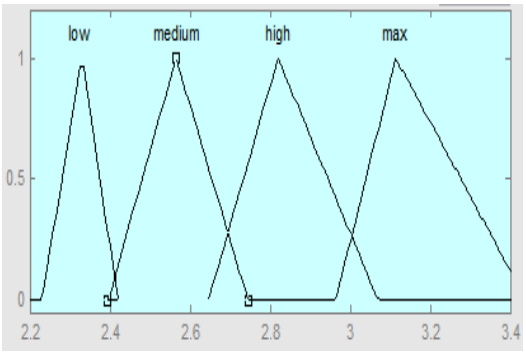

Fig. 3 Voltage Membership Functions

Table I. Mamdani Rule Base for the Load Sensor

Rules	Load	Displacement	Voltage
1	Low	Maximum	Maximum
2	Medium	High	Maximum
3	Low	High	Maximum
4	High	Low	Low
5	Medium	Maximum	Low
6	Maximum	Low	Low
7	High	Low	Medium
8	Medium	Medium	High

III. DEVELOPMENT OF NEURO-FUZZY MODEL

The design proposed for load sensor using fuzzy logic then can be trained using the learning algorithms of neural networks to make it adaptive. Fuzzy logic for load sensor 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 load takes the name "Input1" and is changed to the range from 1200 to 1800 gm with membership functions as shown in Fig.4. Similarly, input displacement takes the name "Input2" and has membership functions in the range of 0 to 100 mm as shown in Fig.5. The output load sensor can only be either constant or linear in neuro fuzzy, so four membership functions for the output are "low", "med", "high" and "max" which are constant and are shown in Table II. The output in Neuro fuzzy can only be in the range of 0-1. Neuro-fuzzy architecture for the system is shown in Fig. 6.

Table II. Membership functions of Voltage

Voltage	Constant value
Low	0
Medium	0.33
High	0.66
Max	1

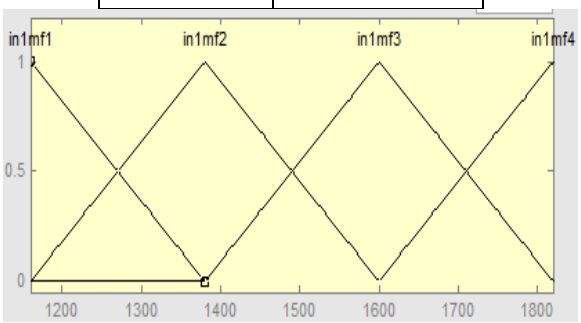

Fig. 4 Input 1 Membership Functions

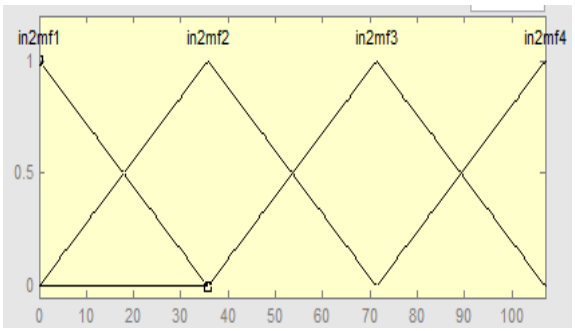

Fig. 5 Input 2 Membership Functions

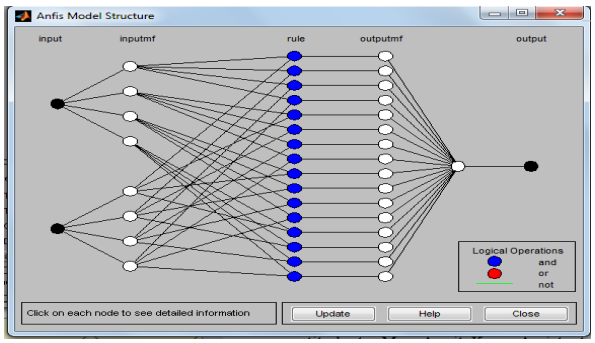

Fig.6 Structure of ANFIS

IV. RESULTS AND DISCUSSIONS

Following are the curves obtained after simulation of mamdani fuzzy logic based load sensor using MATLAB (as shown in Figs. 7, 8, 9). The above are the results for the mamdani type fuzzy model based load sensor having two inputs load and displacement and one output voltage.

ISSN: 2277-3754
ISO 9001:2008 Certified
International Journal of Engineering and Innovative Technology (IJEIT)
Volume 2, Issue 9, March 2013

Results showed that voltage is decreasing as load on the sensor is increased. This gives the loading capability of the sensor. Also, as the displacement increasing, the voltage is also increasing.

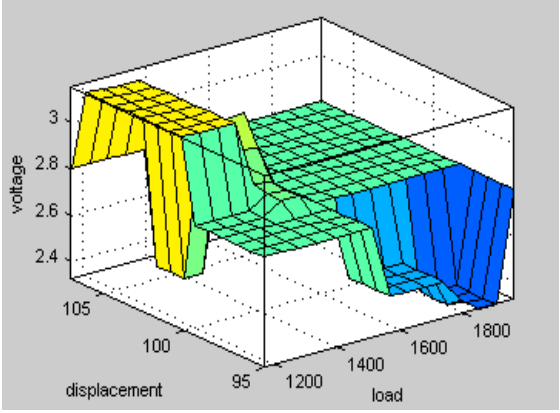

Fig. 7 Surface Viewer Using Mamdani Fuzzy Model

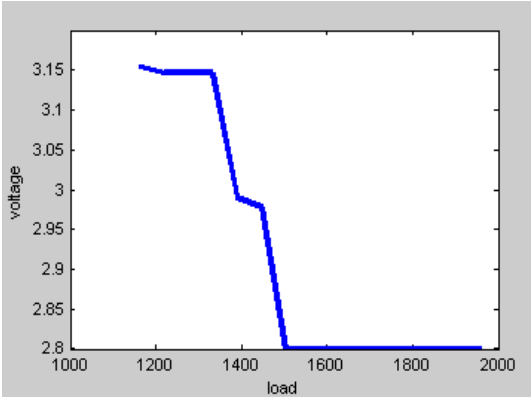

Fig. 8 Relationship between voltages with load For mamdani fuzzy model.

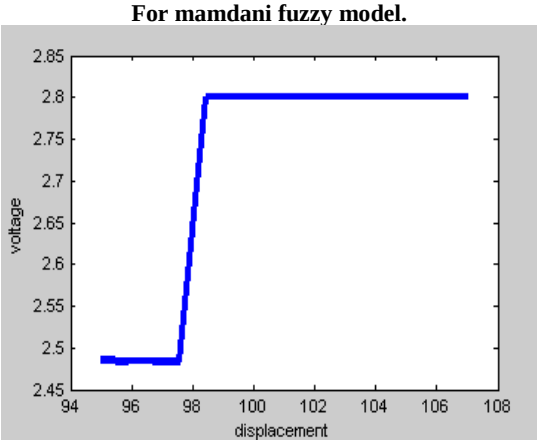

Fig.9 Relationship between Voltages with Displacement for Mamdani Fuzzy Model

Following are the curves obtained after simulation of ANFIS model based load sensor using MATLAB (as shown in Figs. 10, 11, 12).

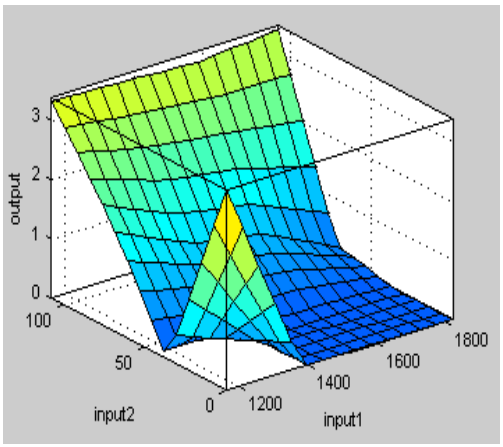

Fig. 10 Surface Viewer Using Neuro Fuzzy Model

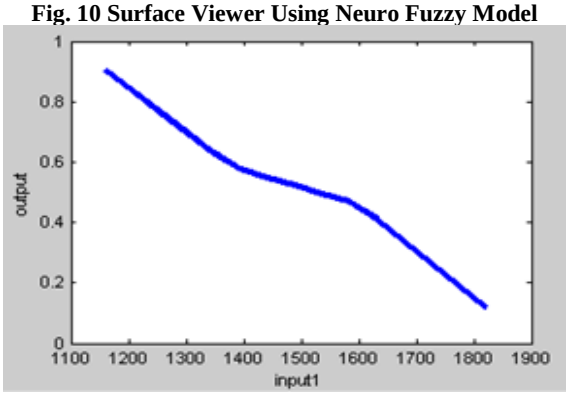

Fig. 11 Relationship between Output (Voltage) With Input1 (Load) For Neuro Fuzzy Model.

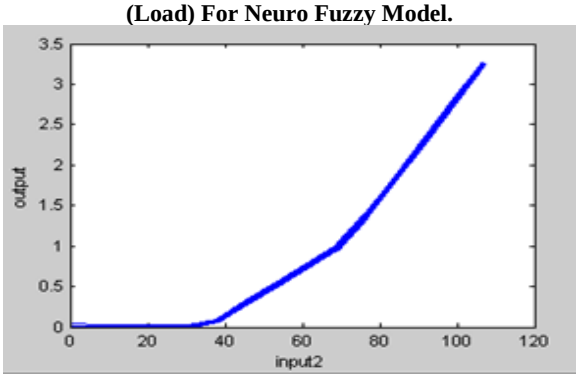

Fig. 12 Relationship between Output (Voltage) With Input2 (Displacement) For Neuro Fuzzy Model.

The results obtained shows that neuro-fuzzy model provide better results than mamdani fuzzy model for load sensor system. From the curves that in mamdani model voltage becomes constant after 1500 of load whereas in neuro-fuzzy model voltage is continuously decreasing with the increase in load, hence is nearly linear. Also graph of displacement is better in ANFIS as compared to mamdani. Therefore ANFIS is much better than mamdani.

V. CONCLUSION

As evident from the results, neuro-fuzzy model is definitely superior to mamdani fuzzy model for the load sensor. As it inherits adaptability and learning. In the

ISSN: 2277-3754
ISO 9001:2008 Certified
International Journal of Engineering and Innovative Technology (IJEIT)
Volume 2, Issue 9, March 2013

Mamdani fuzzy model the relationship between input and output is non linear. But in the case of neuro-fuzzy model the relationship between input and output is linear. The performance of neuro fuzzy model can be still improved by training the neural networks with more number of input and output combinations.

ACKNOWLEDGMENT

Monika, author wishes to express her sincere gratitude to **Mrs. Amrit Kaur**, Assistant Professor, University College of Engineering, Punjabi University, Patiala for guiding her throughout the current research work.

REFERENCES

[1] K.P Mohandas and S.Karimulla, "fuzzy and neuro-fuzzy modeling and control of non linear system," second international conference on electrical and electronics, 2001.

[2] T. J. Ross, "Fuzzy Logic with Engineering Applications", John wiley and sons, 2010.

[3] Alfredo Petrosino and Antonino Staiano, "A Neuro fuzzy Approach for Sensor Network Data cleaning" Italian Workshop on Neural Networks (WIRN), pp. 140-147, 2007.

[4] Gaizka Durana, Marlene Kirchhof, Michael Luber, Idurre Sáez de Ocáriz, Hans Poisel, Joseba Zubia, and Carmen Vázquez, "Use of a Novel Fiber Optical Strain Sensor for Monitoring the Vertical Deflection of an Aircraft Flap,"IEEE SENSORS JOURNAL, VOL. 9, NO. 10, OCTOBER 2009.

[5] Byoungho Lee, "Review of the present status of optical fiber sensors" Science Direct Journal on Optical Fiber Technology, Vol 9, pp. 57-79, April 2003.

AUTHOR BIOGRAPHY

Monika 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. Her topic of research is fuzzy logic, Neuro-fuzzy and its applicability to industrial sector.

Amrit Kaur is Assistant Professor at University College of Engineering, Punjabi University, and Patiala. She has received her M.TECH. Degree from Punjab University, Chandigarh in 2005.She has nine 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.