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Development of Fuzzy Model for Load Sensor

Vandna kamboj, Amrit Kaur
University College of Engineering, Punjabi University, Patiala, Punjab- 147002, India

Abstract — Load sensor is developed using mamdani type fuzzy model. It is two input one output model. Inputs taken for the load sensor are load and displacement and voltage is taken as output. The model is simulated using MATLAB Fuzzy Logic Toolbox and simulation results are shown in this paper.

Index Terms **—Fiber Bragg Grating sensor, Fuzzy logic, Load sensor, Mamdani, Windmill blades.**

I. INTRODUCTION

In recent years, there have been efforts for developing load-bearing structures that include health-monitoring systems. These systems represent an important aspect in the maintenance of different types of structures (e.g., bridges, roofs of sport centers, blades of helicopters or of wind power plants, airplane wings, etc.) through the use of embedded or surface bonded sensors [1]. Now days, more and more fiber reinforced composites are used in manufacture of structures [2]. Fiber-optic sensors used for sensing a device offer many advantages over their electrical counterparts—these include their electromagnetic immunity, light weight and minimal intrusiveness when embedded in load-bearing structures. Fiber optic sensor based on Fiber Bragg Grating technology is found to be more suitable for strain sensing because FBG sensors, owe to small size, good repeatability, stable performance in product quality, have become the focus of research of fiber intelligent sensors [2][3]. In comparison with conventional strain gauges, the FBG sensors are unsusceptible to EMI and have no EM emission. They are intrinsically safe and have unique optical multiplexing potential [3]. Fiber Bragg Grating sensors are very compatible with new structural materials like glass and carbon fiber reinforced composites used in highly stressed construction e.g. in airplanes and in wind power plants etc. The heavy load bearing structures undergoes a lot of strain on it. Due to this, structure suffers from cracks and delimitation leading to weakening in its strength and degrading its load bearing capacity. Hence to avoid this condition, we need to monitor the health of structure, but we need to face many challenges. The major challenges include monitoring of structures like loads, wind dynamics, strains, temperature gradient etc.

Recently, there has been a growing interest in wind energy as it has outstanding advantages: ample, renewable, wide distribution, cheap, reducing toxic gas emission. The wind turbine systems with larger blades are preferred to harvest more energy as the size of the wind turbine blades is directly related to their capacity of energy generation, and cost efficiency. Thus, the blade has become larger and slender [4].

Recently, computational intelligence (CI) has provided a number of successful solutions for various industrial problems with similar characteristics. The area of CI is an evolving collection of methodologies aiming to exploit the tolerance for imprecision and uncertainty to achieve robustness, tractability and low costs. Fuzzy logic (FL), one of the main components of CI [2]. Fuzzy logic was fist proposed in 1965 as a way to imprecise data by Lofti Zadeh, professor at University of California. Fuzzy logic is methodology to represent and implement human's knowledge about how to control a system [5]. In fuzzy logic, knowledge can be captured in terms of rules and linguistic variables [6]. Fuzzy systems are extremely versatile because, by appropriate tuning of their configuration parameters, they can approximate with arbitrary precision any nonlinear input output mapping. Fuzzy inference process, i.e. the numerical interpretation of the linguistic information, requires a very small computation effort [3].

Fuzzy systems are very useful in two general contexts: (1) in situation involving highly complex system whose behaviors are not well understood and (2) in situation where an approximate, but fast solution is warranted [7] In this paper, we use fuzzy logic to implement algorithm for load sensor with two inputs load and displacement and one output voltage. The input load is taken from Fiber Bragg Grating sensor embedded on the wind mill blades. The rest of the paper is organized as follows: Section 2 gives the mamdani type fuzzy logic algorithm for load sensor. Section 3 provides the results and section 4 reports the conclusion of this paper.

II. MAMDANI FUZZY MODEL

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

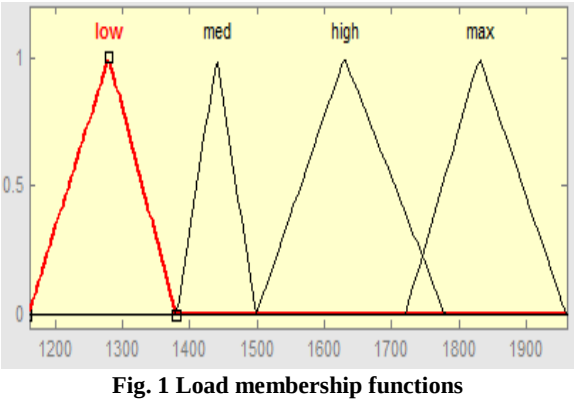

Fig. 1 Load membership functions

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

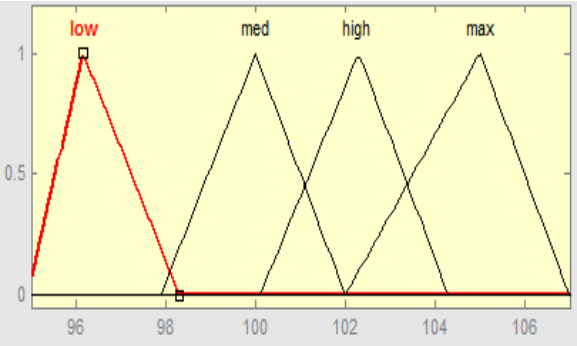

Fig. 2 Displacement membership functions

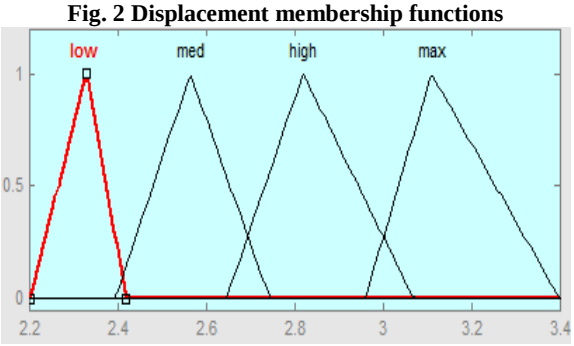

Fig. 3 Voltage membership functions

TABLE I: MAMDANI RULE BASE FOR THE 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. EXPERIMENTAL RESULT

Following are the curves obtained after simulation of mamdani type fuzzy logic based load sensor using MATLAB (as shown in Figs. 4,5,6).

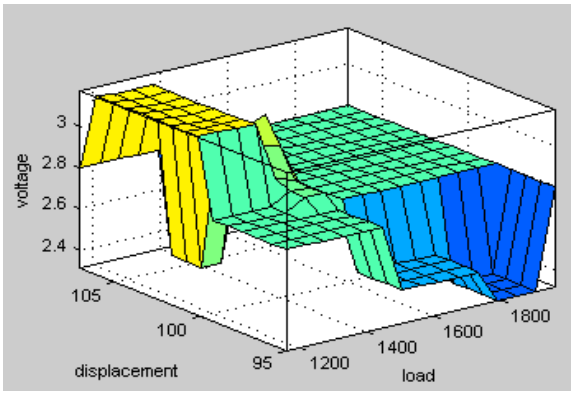

Fig. 4 Surface view using mamdani fuzzy logic algorithm

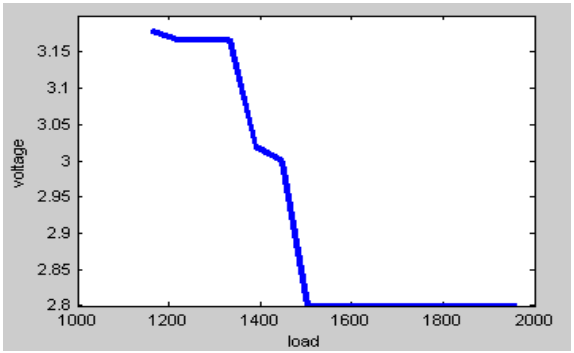

Fig. 5 Voltage with load

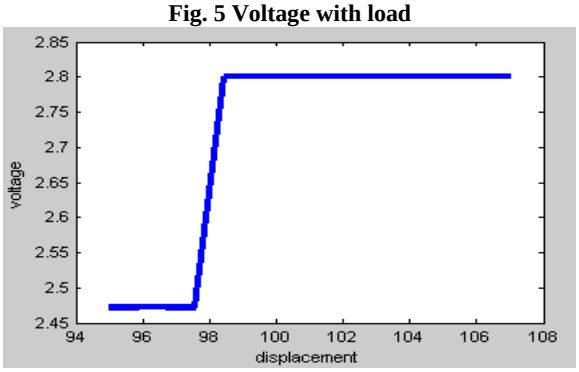

Fig. 6 Voltage with displacement

The above experimental results are for the mamdani type fuzzy model based load sensor having two inputs load and displacement and one output voltage. Results show 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.

IV. CONCLUSION

In this paper, the implementation of load sensor using mamdani type fuzzy model with two inputs load and displacement and one output i.e. voltage is done. It is shown that how voltage is changed when load on composite materials of windmill blades is changed. The input–output behavior of a fuzzy logic based load sensor is programmable using linguistic information in the form of IF (pre conditions) THEN (post conditions) rules i.e. 8 rules is used here, describing an approximate or qualitative knowledge of an observed process or causal relations and there is no need of mathematical models.

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AUTHOR BIOGRAPHY

Vandna Kamboj 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 Rayat Bahra college of Engineering and Biotechnology, Punjab Technical University, Jalandhar. Topic of research is fuzzy logic 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.