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Development of Constant Sugeno Type Fuzzy Inference System for Load Sensor

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Abstract — ***This paper presents implementation of Load sensor using constant sugeno type fuzzy inference system. It is two input one output model. Inputs taken for the load sensor are load and displacement and output is voltage. The model is simulated using MATLAB Fuzzy Logic Toolbox and simulation results are shown in this paper.***

Index Terms — **Constant sugeno type fuzzy inference system, Fiber Bragg grating sensor, Fuzzy logic, Load sensor, 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(FBG) 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. FBG sensors are used to monitor the health of structures. 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 first 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 constant sugeno type fuzzy logic algorithm for load sensor. Section 3 provides the results and section 4 reports the conclusion of this paper.

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II. FUZZY LOGIC ALGORITHM

Load sensor is developed using constant sugeno fuzzy inference system. It consists of two inputs load and displacement from sensor. Based on these inputs, output i.e. voltage is generated. The load and displacement are taken to be in ranges of 1162-1960 gm and 95-107 mm respectively. Each of these inputs has four triangular membership functions as shown in Fig. 1 and 2. The output i.e. voltage have four triangular membership functions namely "low", "medium", "high", "maximum" and constant in nature. The rules included for the load sensor are described in TABLE I.

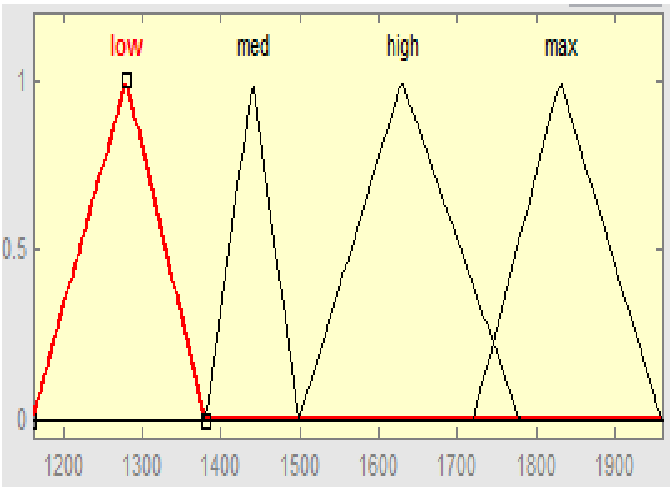

Fig. 1 Load membership functions

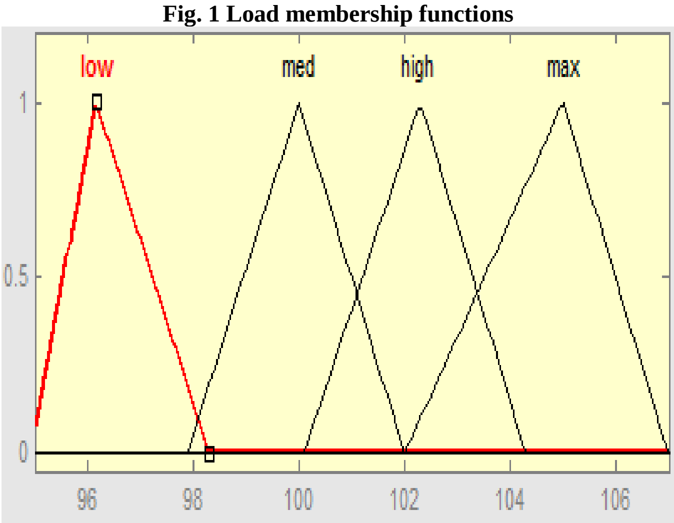

Fig. 2 Displacement membership functions

TABLE I: SUGENO RULE BASE FOR THE SENSOR

Sr. No.	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. RESULT AND DISCUSSIONS

The plot obtained after simulation of sugeno type fuzzy inference system (FIS) based load sensor using MATLAB GUI toolbox (as shown in Figs. 3, 4, 5).

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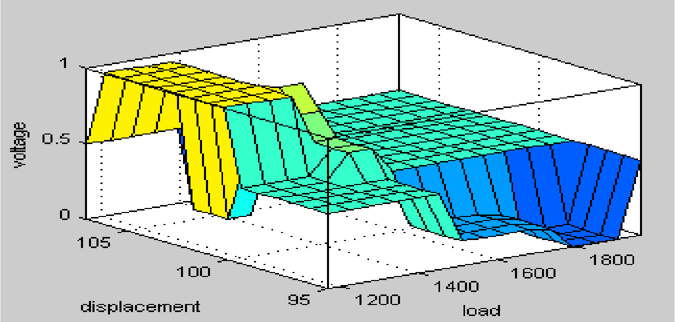

Fig. 3 Surface view of sugeno type FIS

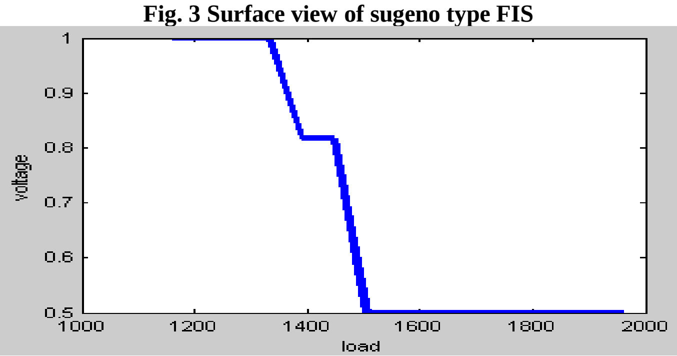

Fig. 4 Voltage with load

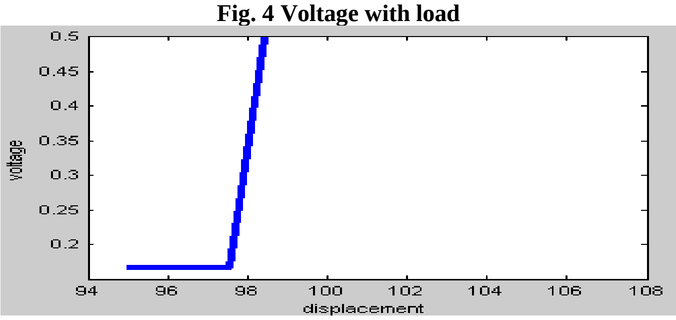

Fig. 5 Voltage with displacement

The results obtained shows that for the constant sugeno type fuzzy inference system based load sensor, output voltage is decreasing as load on the sensor is increased and as displacement is increased, voltage is also increased. This gives the loading capability of the sensor.

IV. CONCLUSION

In this paper, the development of load sensor using constant sugeno type fuzzy model having two inputs as load and displacement and one output i.e. voltage is done. It is shown that how voltage is changed when load on composite materials is changed. Sugeno-type FIS has an advantage that it can integrated with neural networks and genetic algorithm or other optimization techniques so that the sensor can adapt to individual user, environment and weather.

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