Fuzzy Set Theory and Its Application for analysis on Earthquakes

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Abstract- *This paper explain the basic properties of the fuzzy sets and their application for the analysis of the deterioration caused by different earthquakes in different parts of the world based on the immensity and the focal point distance. The aim of investigation was to model the conventional notion of the fuzzy theory in the logic based framework.*

Keywords- membership function, methodology of fuzzy mathematics, fuzzy rule, focal point, magnitude

I. INTRODUCTION

The fuzzy principle states that everything is a concerns of degree. It will be its more known "leitmotiv". All propositions obtain, a truth value between 1 (true) and 0 (false), comprehensive. The allocation of these utmost values will only be given in the case of logical truths or falsehoods or strong inductions. In 1965, Lofti A. Zadeh was introduced Fuzzy set theory. It is a conception of the classical set theory. Fuzzy logic representations establish on the fuzzy set theory try to catch the way humans represent and objective with real world knowledge in the face of uncertainty. Uncertainty could arise due to ambiguity, vagueness, chance or incomplete knowledge. [1]

Fuzzy Set Theory means the notion of a fuzzy set provides a convenient point of departure for the construction of a conceptual frame-work which parallels in many respects the framework used in the case of ordinary sets, but is more general than the latter and, potentially, may prove to have a much wider scope of applicability, particularly in the fields of pattern classification and information processing. Essentially, such a framework provides a natural way of dealing with problems in which the source of imprecision is the absence of sharply defined criteria of class membership rather than the presence of random variables. A simple example of fuzzy mathematical structure is a fuzzy set. A fuzzy set can be explained mathematically by assigning to each possible individual in the universe of discourse, a value representing its grade of membership in the fuzzy set. This category equals to the degree to which that individual is similar or compatible with the concept represented by fuzzy set. In other words, fuzzy set supports a flexible sense of membership of elements to a set.[11][12]

II. MEMBERSHIP FUNCTION

A membership function for a fuzzy set A on the universe of discourse X is defined as $\mu A: X \rightarrow [0, 1]$, where each element of X is mapped to a value between 0 and 1. This value, called membership value or degree of membership, quantifies the grade of membership of the element in X to the fuzzy set A. Membership functions allow us to graphically represent a fuzzy set. The x axis represents the universe of discourse, whereas the y axis represents the degrees of membership in the [0, 1] interval. Simple functions are used to build membership functions. Because we are defining fuzzy concepts, using more complex functions does not add more precision. [10]

- Triangular function: defined by a lower limit a, an upper limit b, and a value m, where a < m < b.[2]

$$\mu_A(x) = \begin{cases} 0, & x \le a \\ \dfrac{x-a}{m-a}, & a<x\le m \\ \dfrac{b-x}{b-m}, & m<x<b \\ 0, & x\ge b \end{cases}$$

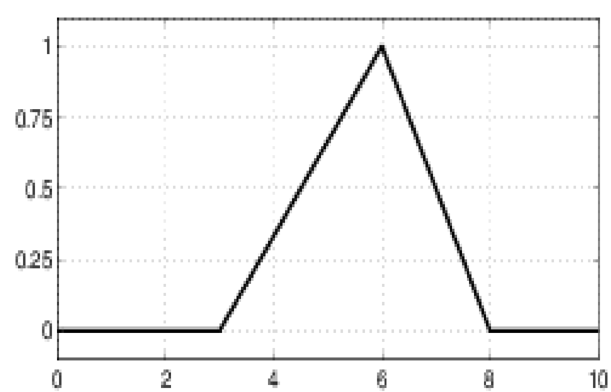
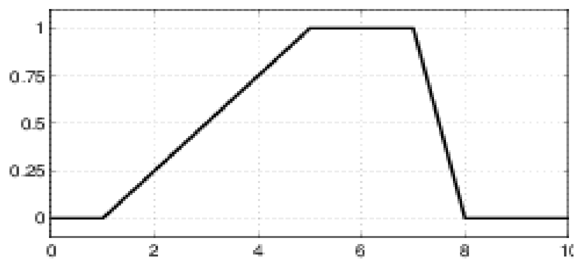


Figure 1. Graph of Triangular function

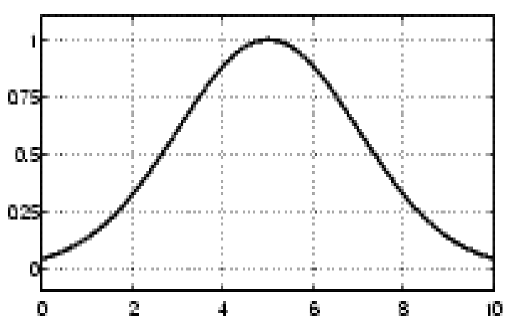
- Trapezoidal function: defined by a lower limit a, an upper limit d, a lower support limit b, and an upper support limit c, where a < b < c < d.[7]



$$\mu_A(x) = \begin{cases} 0, & (x < a) \text{ or } (x > d) \\ \frac{x-a}{b-a}, & a \le x \le b \\ 1, & b \le x \le c \\ \frac{d-x}{d-c}, & c \le x \le d \end{cases}$$

Figure 2. Graph of Trapezoidal function

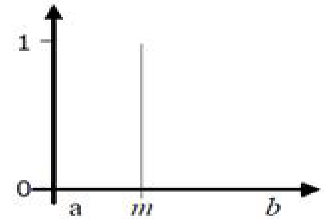
- Gaussian Function: defined by a lower limit a, an upper limit d, a lower support limit b, and an upper support limit c, where k > 0[7][1]



$$G(x) = \exp\left[\frac{-(x-m)^2}{2\sigma^2}\right]$$

Figure 3. Graph of Gaussian functions

Singleton Function: It takes the value 0 in all the universe of discourse except in the point m, where it takes the value 1.[1][7]



$$SG(X) = \begin{cases} 0 & IF \quad X \neq M \\ 1 & IF \quad X = M \end{cases}$$

Figure 4. Graph of singleton function

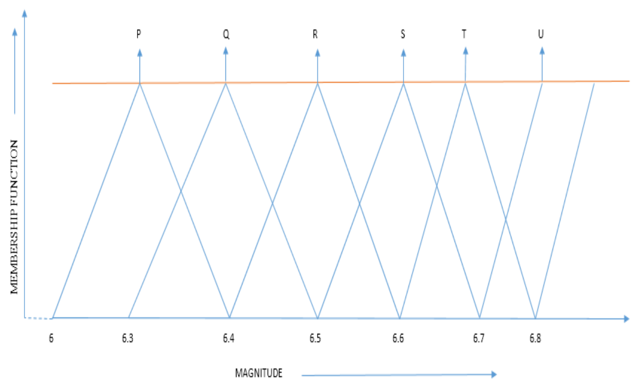
III. REAL VALUES OF EARTHQUAKE

The following table represents the data of the earthquakes that happened in the different parts of the world in the year 2018 along with their magnitude and the epicenter distance: [12]

DATE	MAGNITUDE	FOCAL POINT AND PLACE
10/28/2018	5.5	16km SE of Comandau, Romania
10/25/2018	6.8	33km SW of Mouzaki, Greece
10/22/2018	6.5	223km SW of Port Hardy, Canada
10/22/2018	6.8	197km SW of Port Hardy, Canada
10/22/2018	6.6	218km SW of Port Hardy, Canada
10/20/2018	4	15km NNE of Amarillo, Texas
10/16/2018	6.4	167km E of Tadine, New Caledonia
10/16/2018	6.3	170km ESE of Tadine, New Caledonia
10/13/2018	6.7	269km NW of Ozernovskiy, Russia
10/10/2018	6.5	154km S of Severo-Kuril'sk, Russia
10/10/2018	7	120km E of Kimbe, Papua New Guinea
10/10/2018	6	40km NNE of Cungapmimbo, Indonesia
10/7/2018	5.9	21km WNW of Ti Port-de-Paix, Haiti
9/30/2018	6.7	263km NNE of Ndoi Island, Fiji

IV. TRIANGULAR FUNCTION

In this paper, I have used the triangular function for the calculation of membership function corresponding to the magnitude as well as the focal point distance of the earthquake for the data given in the above table. With the help of this membership function we have prepared the following two graphs. The first one shows the magnitude on x- axis and membership function on y- axis.

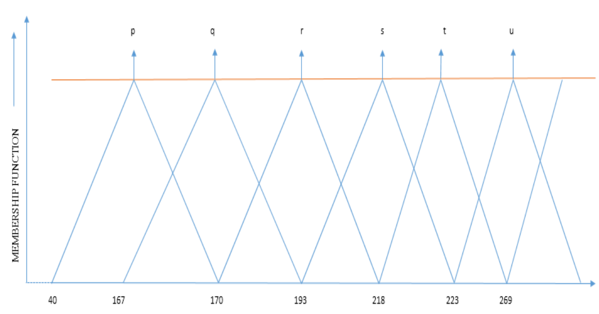


In the above graph the symbols mean---

P-LOW Q-NEARLY LOW R-ALMOST MEDIUM S-MEDIUM T-NEARLY HIGH U-HIGH

The above graph represents the variation of magnitude of the earthquake and membership function. The magnitude of value 6 or less than 6 is taken as low value. As the magnitude increases the variations have seen by the letters marked on the peaks of the curves. The magnitude of 6.8 or above is taken as high value.

The second graph represents the focal points distance (km) on x- axis and the membership function on y- axis. The effects was seen by earthquakes of different magnitudes and having different focal point distances are shown in the graphs given below:



In the above graph the symbols mean--- p-little close q-close r-very near s-firmly near t-near u-far

The above graph represents the variation of focal point distance of the earthquake and the membership function. The focal point distance of value 40 km or less than 40 km is taken as little close value. As the focal point distance increases the variations have seen by the letters marked on the peaks of the curves. The distance of 269 km or above is taken as far value. [2]

V. CONCLUSION

From the first graph which represents magnitude on x- axis and on membership function on y- axis and the second graph which represents the focal point distance on x- axis and the membership function on y- axis. I concluded that if the magnitude is low and the focal point distance is little close then the deterioration caused by the earthquake is low. But with a higher value in the magnitude and the focal point distance the deterioration caused by the earthquake also increases.

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