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A Historical View Of Fuzzy Mathematics And Its Applications

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Abstract

In this paper, we present a historical and chronological overview of the development of fuzzy mathematics, give the concept of Crisp Set vs Fuzzy Set and applications of fuzzy set theory in different fields. Uncertainty is one one of the major human problem. Fuzzy Models are utilitarian mode give more accurate results than the Traditional ones. Here we study the history and development of the Fuzziness.

Keyword: Uncertainty, Crisp set, Fuzzy set, membership function, Fuzzy Logic

Introduction

The most appropriate theory for dealing with uncertainty in the theory of Fuzzy Sets developed by Zadeh [**1**] in 1965. Pawlak introduced rough set theory [**2**] in 1982, which is another significant approach to modelling vagueness. This theory has been successfully applied to many field such as machine learning, data mining, data analysis, medicine etc. The notion of fuzziness spread to nearly all mathematical disciplines: fuzzy arithmetic, fuzzy logic, fuzzy probability, fuzzy relations, fuzzy topology, etc fuzzy set theory has its strength in modelling, interfacing humans with computers and modelling certain uncertainties. Traditional mathematics is the language of precision. Statements are either true or false. But, in reality there are few things that are truly simply true or false. Life is full of shades of grey. Capturing these shades of grey has been problematic using traditional mathematics. Mathematics can model the uncertainty itself but rarely incorporates it into the model. In this paper, we will discuss the Crisp Set vs Fuzzy Set. and application of fuzzy mathematics in different fields.

The Origin Of Fuzzy Mathematics

Crisp Set is a collection of well-defined objects. In a classical set (or crisp set), the objects in the set are called elements or members of the set. An element x belonging to a set A is defined as $x \in A$, an element that is not a member in A is noted *as* $x \notin A$. A characteristic function

$\chi_A(x)$ for a set A is defined as:

$$\chi_A(x) = \begin{cases} 1 & for\ x \in A \\ 0 & for\ x \notin A \end{cases}$$

In crisp sets the characteristic function takes a value of 1 or 0. For Example, Let X be the set of all real numbers between 0 and 10 and let A = [5; 9] be the subset of X of real numbers between 5 and 9. This results in the following figure:

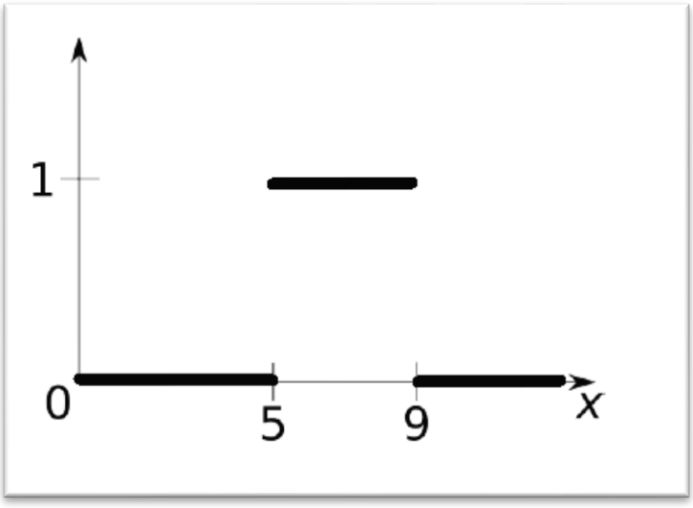

Figure 1

Collection of men is a set but collection of "Tall men" is not a set as the collection is not well defined. The meaning of the word "Tall" is fuzzy.

In 1965, Zadeh introduced Fuzzy set theory which is a generalization of a Crisp set theory. Let X is a collection of objects then fuzzy set *A* is defined as

$A = \{(x, \mu_A(x)) \mid x \in X\}$

Where $\mu_A(x)$ is a membership function belongs to the interval [0, 1]. For example, Let us consider as above, X be the set of real numbers between 1 and 10 then the fuzzy set A, a set of real numbers close to 7 will be given by the figure as:

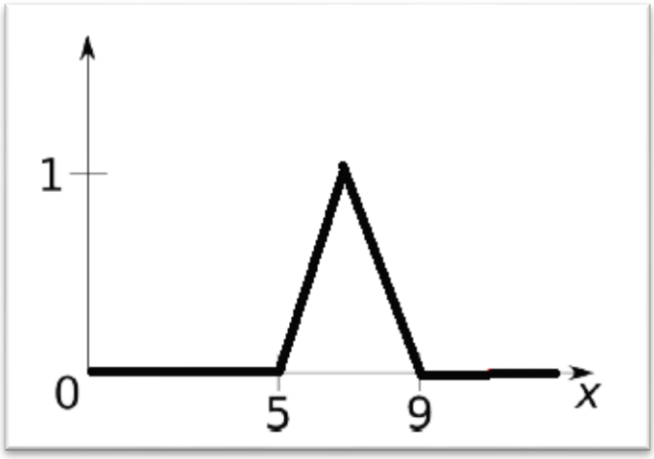

Figure 2

Fuzzy set theory and crisp set theory has equivalent operations such as equality, union and intersection etc.

Let F and G are two fuzzy sets and μ_F and μ_G are their membership functions. The Union F ∪ G is defined by any one of the following membership functions:

$$\mu_{F\ U\ G}(x) = max.\{\mu_F(x), \mu_G(x)\}$$
$$\mu_{F\ U\ G}(x) = \ \mu_F(x) + \mu_G(x) - \mu_F(x).\mu_G(x)$$
$$\mu_{F\ U\ G}(x) = min.\{1, \mu_F(x), \mu_G(x)\}$$

The Intersection F ∩ G is defined by any one of the following membership functions:

$$\mu_{F\cap G}(x) = min.\{\mu_F(x), \mu_G(x)\}$$
$$\mu_{F\cap G}(x) = \ \mu_F(x).\mu_G(x)$$
$$\mu_{F\cap G}(x) = max.\{0, \mu_F(x) + \mu_G(x) - 1\}$$

The complementary membership function of F is defined as $\mu_{F'} = 1 - \mu_F$

And complementary membership function of above function is given by bold lines in the figure below:

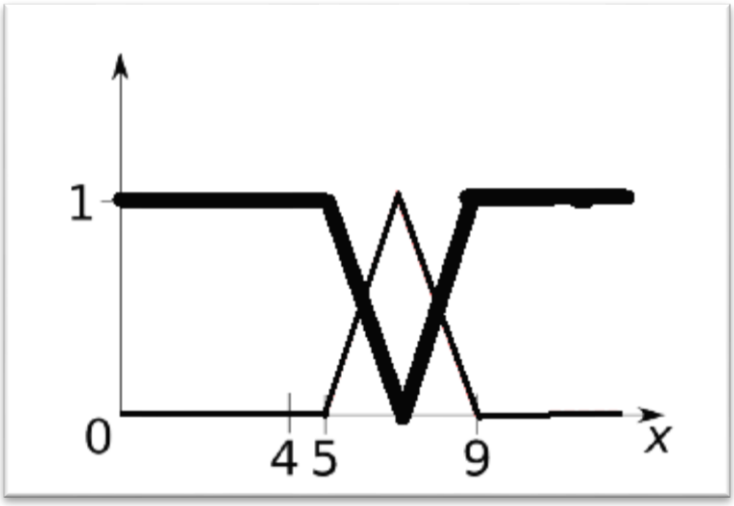

Figure 3

Consider an example, Let$\{F_i : 1 \leq i \leq 7\}$ be the set of flats where i = number of rooms in a flat. Then the fuzzy set "Comfortable type of flat for a 3-person family" is defined as

A = $\{(F_1, 0.2), (F_2, 0.8), (F_3, 1), (F_4, 0.9), (F_5, 0.6), (F_6, 0.3), (F_7, 0.2)\}$

In fuzzy set theory, we use linguistic variables whose values are not numbers but words or sentences.For example, age is linguistic variable whose values can be taken as young, very young, old, very old.

Applications of Fuzzy Mathematics

Many Problems have solution with the help of fuzzy theory which could not be obtained by Traditional method. With the help of fuzzy mathematics ,researchers solve many problems in many fields like artificial intelligence, computer science, control engineering, decision theory, expert systems, logic, management science, operations research, pattern recognition, and robotic etc. Theoretical advances have been made in many directions like Fuzzy linear programming is a generalization of LPP , Fuzzy algebra is a generalization of algebra, Fuzzy clustering theory is a generalization of clustering theory etc. In addition, the transition from fuzzy set theory to fuzzy technology has been achieved by providing numerous software and hardware tools that considerably improve the design of fuzzy systems and make them more applicable in practice. In 1965, Zadeh gave the concept of Fuzzy relations which are fuzzy subsets of X x Y, that is, mappings from X to Y.

Fuzzy logic is a form of multi-valued logic derived from fuzzy set theory to deal with reasoning that is approximate rather than precise.

The area in which primarily fuzzy set theory is known and attractive to many scientists, students and practitioners was certainly fuzzy control. With the help of fuzzy logic , the phenomenon of uncertainty will have to be modelled so that artificial intelligence will be useful in capturing human thinking and perception. In a crisp model, the determination of the optimal districting can be performed by using integer programming algorithms. If the problem is of reasonable size, heuristic versions have to be used. But In 1984, Fabian and Stoica and Zimmermann and Pollatschek gave the concept of fuzzy integer programming which is used to reduce the number of possible districting to a reasonable size by eliminating non feasible and dominated covers.

Fuzzy languages such as LPL,FLIP, Fuzzy planne are based on LPI, FORTAN, LISP etc. In 1978, Zadeh developed PRUF which is a representing language for natural languages and is based on possibility theory. PRUF is used to translate a set of premises expressed in a natural language into fuzzy expressions and apply the rules of fuzzy logic or approximation reasoning. This yields the other expression which can be translated with the help of PRUF into natural languages.

Expert system, a computer program

We use fuzzy set theory in expert system as it increase efficiency and decreasing answer time.

The fuzzy pattern recognition used in medical diagnosis ,earthquake engineering and in intelligence. The "violation" of any constraint in Classical LPP makes the solution infeasible . Thus each and every constraints are of equal weight age. But this conclusion is not hold true in recent years as fuzzy linear programming model is developed for this pupose. In contrast to classical linear programming, “fuzzy linear programming" is *not* a uniquely defined type of model many variations are possible, depending on the assumptions or features of the real situation to be modelled. In 1985, Murayama et al for , improved fuel consumption rate designed a fuzzy controller for a marine diesel engine..

Another application of Fuzzy Logic, this concept was used on the high-speed train in Sendai, to improve the economy, comfort, and precision of the ride. It has also been used in recognition of hand written symbols in Sony pocket computers, flight aid for helicopters, controlling of subway systems in order to improve driving comfort, precision of halting, and power economy, improved fuel consumption for automobiles, single-button control for washing machines, automatic motor control for vacuum cleaners.

Conclusion

Thus we see that Fuzzy set theory is very much interesting and useful for solving the day to day problems. It helps to take decision making in a critical situation.

In this study some applications of fuzzy logic method in medical area were described. Some work should be done to apply the soft computing techniques such as fuzzy logic, neural network, genetic algorithms, learning and expert systems in order to developing intelligent systems in diagnosis and therapy of integrated western and eastern medicine. Fuzzy set theory has remarkable contribution to applications in many fields.

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