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A Survey in Fuzzy Logic: An Introduction

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Abstract— Fuzzy Logic was initiated in 1965 [1], [2], [3], by Lotfi A. Zadeh professor for computer science at the University of California in Berkeley. A fuzzy set is defined by a function that maps objects in a domain of concern to the membership value in the set. Fuzzy Logic provides a different way to approach a control or classification problem. Basically, Fuzzy Logic (FL) is a multivalve logic that allows intermediate values to be defined between conventional evaluations like true/false, yes/no, high/low, etc. Notions like rather tall or very fast can be formulated mathematically and processed by computers, in order to apply a more human-like way of thinking in the programming of computers [4]. Fuzzy Logic has emerged as a a profitable tool for the controlling and steering of of systems and complex industrial processes, as well as for household and entertainment electronics, as well as for other expert systems and applications like the classification of SAR data. By studying all its tools and application areas we concluded that even after getting so much criticism in its initial stage now FUZZY LOGIC is a new emerging technology with very bright future, which is further expanding its area of application. Its operation field is so much wide that it can be applied to control any type of operation even to control our daily life appliances and instruments. In it there is no need to do so much calculations and operations and also its results are so much accurate that they can be applied directly to a given task. Success of fuzzy logic in a wide range of applications has inspired much interest in fuzzy logic among the scientists and engineers. Fuzzy Logic provides a more efficient and resourceful way to solve Control Systems.

Key words: Fuzzy Logic, Set, Crisp Set etc

I. INTRODUCTION

After being mostly viewed as a controversial technology for two decades, fuzzy logic has finally been accepted as an emerging technology since the late 1980's.This is largely due to a wide array of successful applications from consumer products to industrial process control to automotive applications. Before engage in an in-depth discussion of technical issues concerning fuzzy logic, however, we must first place this paradigm in perspective. For this we first clarify two meanings of the term "Fuzzy Logic".

The term fuzzy logic has been used in two different senses. In a narrow sense, fuzzy logic refers to a logical system that generalizes classical two-valued logic for reasoning under uncertainty. In a broad sense, fuzzy logic refers to all of the theories & technologies that employ fuzzy sets, which are classes with unsharp boundaries.

Fuzzy Logic was initiated in 1965 [5], [6], [7], by Lotfi A. Zadeh, professor for computer science at the University of California in Berkeley. Basically, Fuzzy Logic (FL) is a multivalued logic that allows intermediate values to be defined between conventional evaluations like true/false, yes/no, high/low, etc. Notions like rather tall or very fast can be formulated mathematically and processed by computers, in order to apply a more human-like way of thinking in the programming of computers [8]. Fuzzy systems are an alternative to traditional notions of set membership and logic that has its origins in ancient Greek philosophy. The precision of mathematics owes its success in large part to the efforts of Aristotle and the philosophers who preceded him. In their efforts to devise a concise theory of logic, and later mathematics, the so-called"Laws of Thought" were posited [9]. One of these, the"Law of the Excluded Middle," states that every proposition must either be true or false. Even when Parmenides proposed the first version of this law (around 400 B.C.) there were strong and immediate objections: for example, Heraclitus proposed that things could be simultaneously true and not true. It was Plato who laid the foundation for what would become fuzzy logic, indicating that there was a third region (beyond True and False) where these opposites"tumbled about." Other, more modern philosophers echoed his sentiments, notably Hegel, Marx, and Engels. But it was Lukasiewicz who first proposed a systematic alternative to the bi–valued logic of Aristotle [10]. Even in the present time some Greeks are still outstanding examples for fussiness and fuzziness, (note: the connection to logic got lost somewhere during the last 2 millenniums [11]. Fuzzy Logic has emerged as a a profitable tool for the controlling and steering of of systems and complex industrial processes, as well as for household and entertainment electronics, as well as for other expert systems and applications like the classification of SAR data.

II. BIRTH OF FUZZY

The idea of fuzzy sets was born in July, 1964. Lofti A. Zadeh is a well-respected professor in the department of Electrical engineering and Computer science at University of California, Berkeley. In the fifties, professor Zadeh believed that all real-world problems could be solved with efficient, analytical methods and /or fast electronic computer. In this direction, he has made significant contributions in the development of system theory (e.g. the state variable approach to the solution of simultaneous differential equations) and computer science. In early 1960's he began to feel that traditional system analysis techniques were too precise for many complex real-world problems. So, in 1964 he gave a new theory generally known as "Fuzzy Set Theory".

The concept of fuzzy sets encountered sharp criticism from the academic community. Some rejected it because of the name without knowing the content in detail and others rejected because of the theory's emphasis on imprecision.

III. CONCEPT OF SET

One of the most important methods in mathematics is the theory of set. A collection of objects is basic both in our

daily life and mathematics. The set theory is regarded as a tool of thoughts.

For example- Tea set, set of color, class of math, cricket team etc.

A. Sets:

It is a well-defined collection of objects or a collection of distinct objects. According to set theories sets are of two types:

B. Crisp Set:

This set is also known as *classical set which* is defined in a well-known theory named *Classical set theory*.

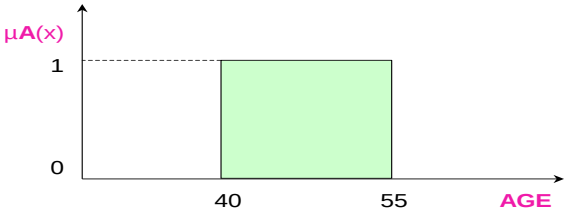
A classical or crisp set is defined by a characteristic function μA(x).

e.g.

μA(x) = {0, 1}

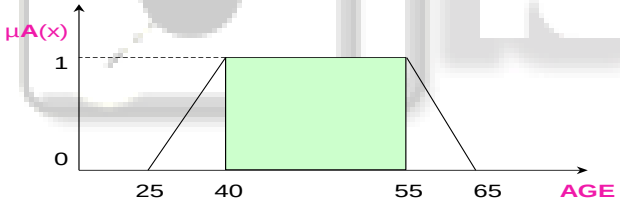
μA(x) = {1} if 40<=x<=55

μA(x) = {0}, otherwise



C. Fuzzy Set:

This set is defined by another well known theory as *fuzzy set theory*. This theory defines fuzzy set as it is a class of objects with a continuum of grade of membership. The transition from membership to non-membership in a subset of reference set is gradual rather than abrupt.



IV. Operations on Fuzzy Sets

We can introduce basic operations on fuzzy sets. Similar to the operations on crisp sets we also want to intersect, unify and negate fuzzy sets. In his very first paper about fuzzy sets [1], L. A. Zadeh suggested the minimum operator for the intersection and the maximum operator for the union of two fuzzy sets. It can be shown that these operators coincide with the crisp unification and intersection if we only consider the membership degrees 0 and 1. For example, if A is a fuzzy interval between 5 and 8 and B be a fuzzy number about 4 as shown in the Figure1 below.

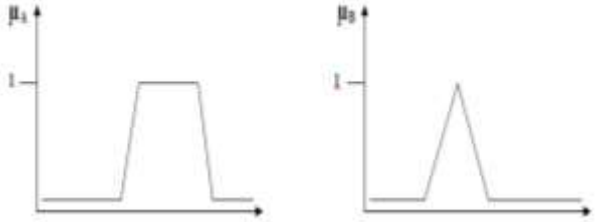


Fig. 1: Example Fuzzy Set

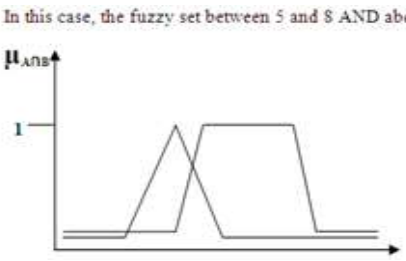


Fig. 2: Example Fuzzy AND

Set between 5 and 8 OR about 4 is shown in the next figure the NEGATION of the Fuzzy set A is shown below

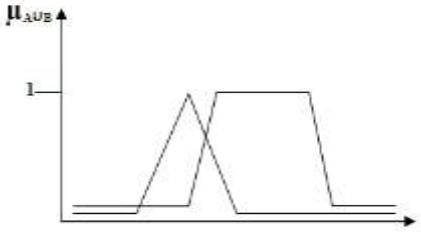


Fig. 3: Example Fuzzy AND

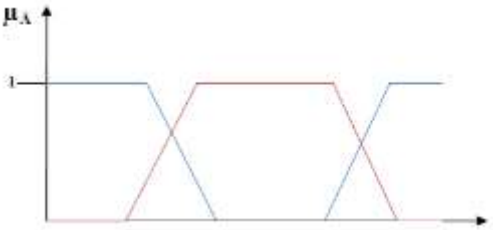


Fig. 4: Example Fuzzy NAGATION

Fuzzy classifies are one application of fuzzy theory Traditional representation of logic

V. Advantages of Fuzzy Based Systems

Fuzzy logic is a better way of dealing with:

- Imprecise knowledge.
- Incomplete information.
- Complex and non-linear systems.
- No need for rigorous mathematical treatment.
- Better way of dealing with linguistic expression.
- Can be blended with conventional control techniques.
- Based on natural languages

VI. About Fuzzy Logic

There have been several about fuzzy logic

Some of them are discussed below:

- Fuzzy logic is a clever disguise of the probability theory.
- Fuzzy Logic and Probability are competing technologies. Only one of them can be used to solve a given problem.
- The behavior of a fuzzy logic system is fuzzy non-deterministic.
- Fuzzy Logic in the narrow sense is basically a kid of multi-valued logic.
- Fuzzy Logic is a model-less approach and therefore does not require a good understanding of the problem.

- Fuzzy Logic is no more than a table look up technique.
- Fuzzy Logic is ill-founded, not rigorous, and lead to potential disasters.
- Fuzzy Logic Controllers can't be shown to be stable.

VII. APPLICATIONS

The working era of fuzzy logic is very wide that's why its application area is very large. Some of its applications in different fields are quoted below as:

- Consumer Products: Cameras and Camcorders, Washing Machines, Refrigerators, Vacuum Cleaners.
- Automotive & Power Generation: Power Train and Transmission Control, Engine Control.
- Industrial Process Control: Cement Kiln, Incineration plant, Refining, Distillation and other Chemical Processes. Robotics & Manufacturing:
- Electrical Discharge Machine

VIII. CONCLUSION

By studying all its tools and application areas we concluded that even after getting so much criticism in its initial stage now fuzzy logic is a new emerging technology with very bright future, which is further expanding its area of application. Its operation field is so much wide that it can be applied to control any type of operation even to control our daily life appliances and instruments. In it there is no need to do so much calculations and operations and also its results are so much accurate that they can be applied directly to a given task. Success of fuzzy logic in a wide range of applications has inspired much interest in fuzzy logic among the scientists and engineers. Fuzzy Logic has emerged as a profitable tool for the controlling and steering of systems and complex industrial processes, as well as for household and entertainment electronics, as well as for other expert systems and applications like the classification of SAR data.Fuzzy logic provides an alternative way to represent linguistic and subjective attributes of the real world in computing. It is able to be applied to control systems and other applications in order to improve the efficiency and simplicity of the design process.

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