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Fuzzification Of Fuzzy Logic And Fuzzy Sets With An Overview Of Fuzzy Set Operations And Applications

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Abstract: ***This paper deals with Fuzzy logic an idea which is easy to understand. Fuzzy logic provides an alternative way to represent linguistic and subjective attributes of the real world in computing. The cause for selection of fuzzy logic model in this revision is that the system uses fuzzy logic model enables to provide useful results depending on uncertain verbal knowledge just like logic of human being. The value of fuzzy logic model usage here is to reach a general solution by doing only incomplete experiments. It takes long time to use the other methods for such problem. The fuzzy logic provides the quickest way out to the problem prevents to lose. It is a outline of multiple-valued logic which has other than two truth values. It uses the concept of level of membership. In Boolean logic, the truth standards may be only 0 or 1, but in fuzzy logic, they will be any real number between 0 and 1 i.e. the truth values will vary between true and false. Fuzzification which comprises of the development of transforming hard values into grades of membership for linguistic terms of fuzzy sets and Fuzzy set is a set that allows its members to have various degrees of membership within 0 and 1 i.e. within true and false. Fuzzy system is based on a logical system which is much closer to human thinking and natural language.***

I. INTRODUCTION

The control systems are usually explained by numerical models which follow the randomly determined models, law of physics or arithmetical logic models. The problem with such models is how to solve the given difficulty to a suitable mathematical model. No doubt, all such troubles are overcome by today's extremely developed computer technology, but these systems are still too complex to manage. Hence, to make simpler the impossibility, uncertainty and indistinctness during the modeling, the concept of fuzzy logic comes into account. In recent years, the applications of fuzzy logic have been improved significantly. Fuzzy logic can deal with information that is arising from computational observation, understanding and cognition. In computing problems, it provides addition of unclear human evaluation.
It also provides an outstanding means for several criteria variance resolution and preferable estimation options. From definite and unbalanced information, it addresses the solutions to that distinct level as the result is made by human, while the other approaches need definite and correct equations to form the behaviors of real world. Thousands of researchers and engineers are producing and rights, granted to inventors for search papers on fuzzy logic. Fuzzy logic is really useful for number of people concerned in biomedical, agricultural, mechanical, electrical, computer software etc. for development and research [2].

II. FUZZY LOGIC

In mathematics, variables frequently take numerical values, but in fuzzy logic applications, non-numeric values i.e. typescript are used to eased advance the rules and to facts expressions.
Fuzzy logic has two different meanings [1]:

- In narrow sense, fuzzy logic is an addition of multivalve logic.
- In broad sense, fuzzy logic is almost the same with the fuzzy set theory. Fuzzy logic projected various methods for deducing doubtful, shortened and incorrect knowledge. It compacts with calculation which is inaccurate or imperfect rather than fixed, correct and precise. The advantages of fuzzy logic are as follows [3]:
  - Adaptable, instinctive rule base design.
  - Based on natural language, therefore easy to use.
  - Model non-linear function of perverted complexity.

- Uncomplicated implementation and simple computations.
- Several input signals can be handled easily.
- Increase toughness.

A computational standard that is based on how humans think.

- Fuzzy Logic looks at the world in indefinite terms, in much the same way that our brain takes in information, then responds with specific actions.
- The human brain can reason with doubts, indistinctness, and judgments. Computers can only manipulate specific valuations. Fuzzy logic is an effort to combine the two techniques.
- "Fuzzy" – a inappropriate name, has resulted in the mistaken suspicion that Fuzzy Logic is somehow less demanding than conventional logic.
- Planned to deal with analysis that is expected rather than accurate.
- In contrast with "crisp logic", where binary sets have binary logic, fuzzy logic variables may have a reality value that ranges between 0 and 1.
- Can include linguistic variables, like: high, low, hot, cold, and very.

III. FUZZIFICATION

The fuzzification comprises the method of transforming crisp values into grades of membership for linguistic terms of fuzzy sets. The relationship function is used to connect a grade to each pertaining to language term.

Example

For the fuzzification of the car speed value $\boldsymbol{x_0 = 70\ km/h}$ the two membership functions $\boldsymbol{\mu A}$ and $\boldsymbol{\mu B}$ from Figure 1 can be used, which characterize a low and a medium speed fuzzy set, respectively. The given speed value of $\boldsymbol{x_0 = 70\ km/h}$ belongs with a grade of $\boldsymbol{\mu A\ (x_0) = 0.75}$ to the fuzzy set 'low' and with a grade of $\boldsymbol{\mu B\ (x_0) = 0.75}$ to the fuzzy set 'medium'.

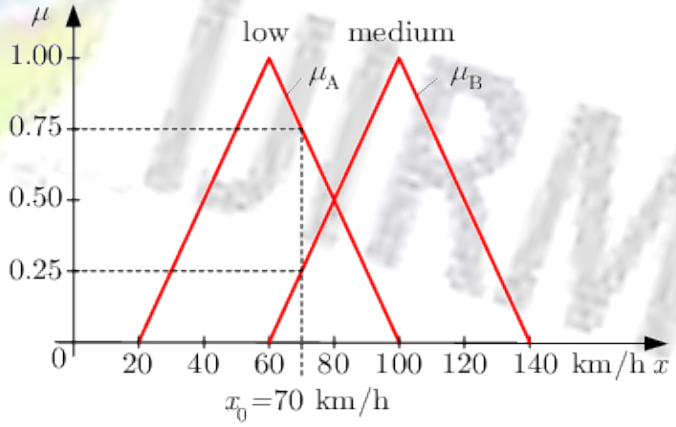

Fig 1: Fuzzification of a car speed

IV. FUZZY SETS

Fuzzy set is a set that permits its members to have a variety of degrees of membership within 0 and 1 i.e. within true and false. In other words, a set without crisp is a fuzzy set. A fuzzy set contains fundamentals which have partial grades of membership [5]. Hard values are those values which do not have visibly defined boundaries - for example, much longer than, tall, many, younger, etc. are true only to a assured degree as well as simulated to a certain degree. By contrast, fuzzy standards are the values which have stridently defined values. Hence fuzzy sets do not contain any doubtful or incomprehensive values.

In standard set theory, any given element can be totally excludes or entirely includes i.e. an element either belong or does not belong to the set. While in fuzzy set theory, it allows regular membership assessment of fundamentals in a set which is explained with the membership purpose esteemed aid in the real unit interval 0, 1. Generally used example for fuzzy set theory is the set of tall people.

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The curve shown in fig: 2 is designated by μ and is known as a association function. This arch varies from not tall to tall. If the set of people has a well definite (sharp edged) boundary, then the set is recognized as classical set. Figure 2 shows sharp-edged (non-fuzzy) membership purpose for tall. If the pointed distinct boundary for tall people is 6 feet, then people have height more than 6 feet are measured tall. But in real people, if one person height is compared with another person, constant membership function is used. Figure 3 shows continuous-edged (fuzzy) membership function for tall. The curve formed by this relationship function varies smoothly involving not tall and tall.

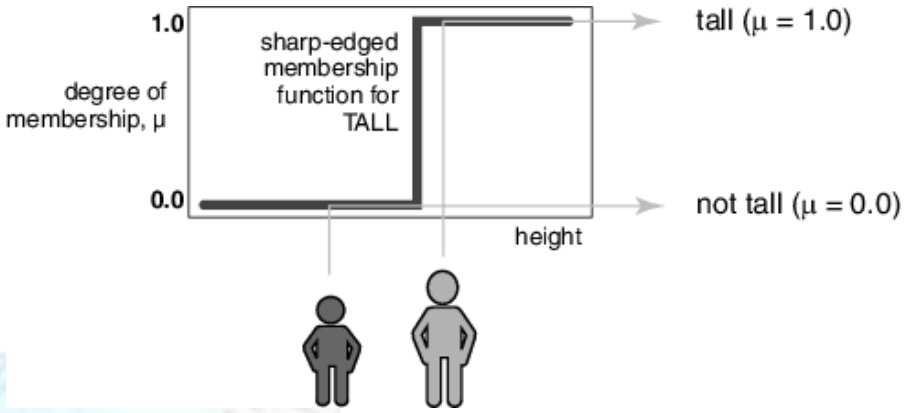

Fig 2: Sharp-edged(non-fuzzy) membership function for tall

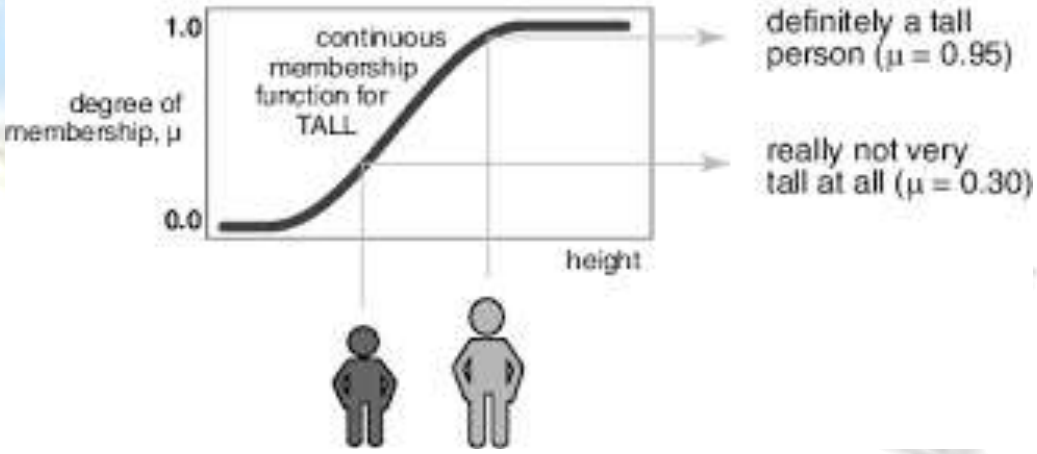

Fig 3: Continuous-edged (fuzzy) membership function for tall

V. FUZZY SET OPERATIONS

Process on fuzzy set is called fuzzy set operation. These operations are done on fuzzy sets and fuzzy associations and are generalized form of crisp set operation. The standard fuzzy set function is most extensively used operation. There are the following three fundamental operations of fuzzy set [10]:

- Fuzzy complements.
- Fuzzy intersections.
- Fuzzy unions

Let the fuzzy sets be A and B, such that A,B∈U , x is an element in the universe U

- **Union**: The union (combination) of two fuzzy sets (A∪B) is defined as- ( ) max(( ), ( )) A B A B φ x = φ x φ x ∪.
- **Intersection**: The intersection of two fuzzy sets (A∩B) is defined as- ( ) min(( ), ( )) A B A B φ x = φ x φ x ∩.
- **Complement**: The complement of the fuzzy sets is defined asFor fuzzy set A: ( ) 1 (( )) not A A φ x = − φ x For fuzzy set B: ( ) 1 (( )) not B B φ x = − φ x.

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VI. FUZZY LOGIC SYSTEM

In 1972, Professor Toshire Terano planned the world's earliest working group on fuzzy logic systems. Fuzzy system is based on a consistent system which is much earlier to human thinking and natural language. It has good stability, fast response, less complexity and small overshoot than conventional systems. It has outstanding performance in dealing with difficult, imperfectly defined, time varying and non linear systems. Figure 4 shows fuzzy logic system. Following are the basic required elements of fuzzy logic system [8], [9]:

6.1) Fuzzifier

The most important element of fuzzy logic system is fuzzifier. It is used in fuzzy logic space for mapping any crisp value into correct fuzzy value i.e. it is dependable for converting the hard input into a fuzzy input which is used by the inference engine. It performs various functions such as:

- Measures input variables
- Scale mapping
- Fuzzification

6.2) Fuzzy Rule Base

Fuzzy rule support is the main part of fuzzy system which is completed up of fuzzy rules. Fuzzy rules are in the form of IFTHEN statement. There are many other components in the system which helps in implementing the fuzzy rules in an suitable manner. Fuzzy rule support vary from application to application.

6.3) Inference Engine

Inference engine is an non-natural intelligence tool. It takes fuzzy inputs from the fuzzifier and processes the fuzzy system on the fuzzy inputs.

6.4) Defuzzifier

Defuzzifier is in charge for converting the fuzzy value into the final hard output value. According to the productivity variable membership function, defuzzification is performed.

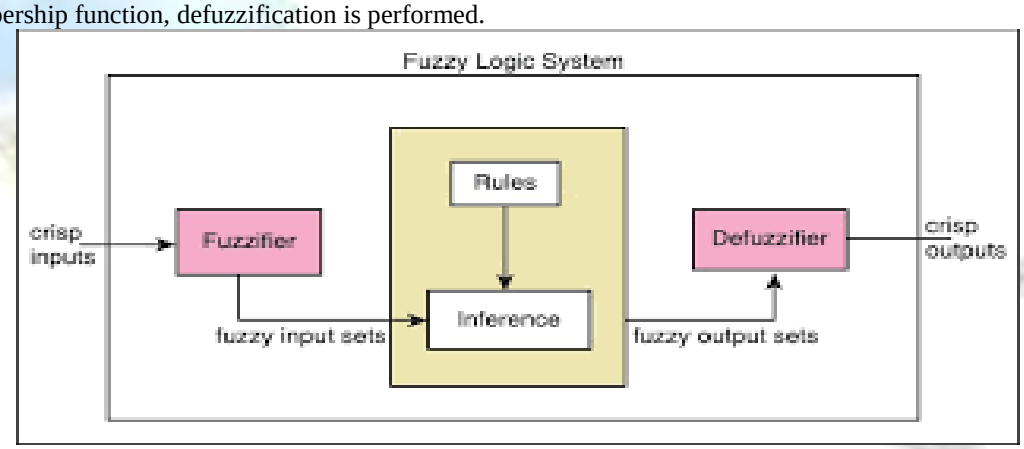

Fig 4: Fuzzy logic system International Journal of Computer Applications

VII. BENEFITS OF FUZZY LOGIC SYSTEM OVER CONVENTIONAL CONTROL SYSTEM

Fuzzy logic enables a human being to easily border with an automated system. In fuzzy logic system, fuzzy rules are defined that are in the form of natural language. Hence, fuzzy system has an ability to correspond directly with the user [1], [4].
(a) Conventional control theory, (b) Logic theory . The association points between them are given below:

- Conventional control system is not easy to identify with as compared to fuzzy logic system.
- Conventional control system requires plant modeling and sensory information to create control actions, while fuzzy logic organizer needs only fuzzy rules for controlling actions.
- An algorithm for the conventional controller is hard to develop, while fuzzy logic algorithms are undemanding and easy to generate.
- From the above points it is clear that the difficulty of conventional control system is additional as compared to fuzzy logic system.

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VIII. FUZZY INFERENCE SYSTEM

Fuzzy assumption system is a method in which the values are interprets in the input vector and according to the user defined rules; the values are passing on to the output vector. With the assistance of MATLAB fuzzy logic toolbox, rules set, membership functions can be definite and the performance of the fuzzy inference structure can be analyzed. Figure 5 shows the fuzzy inference system [1].

Fuzzy logic toolbox is a collected works of graphical tools or command-line functions. With the help of these tools and functions, fuzzy inference system can turn out and edit within the MATLAB framework. In fuzzy logic toolbox, there are five basic graphical user interface (GUI) tools for editing, construction, and observing fuzzy interference system which are given below [6], [7], [11]:

- Fuzzy Inference System (FIS) Editor.
- Membership Function Editor.
- Rule Editor.
- Rule Viewer.
- Surface Viewer.

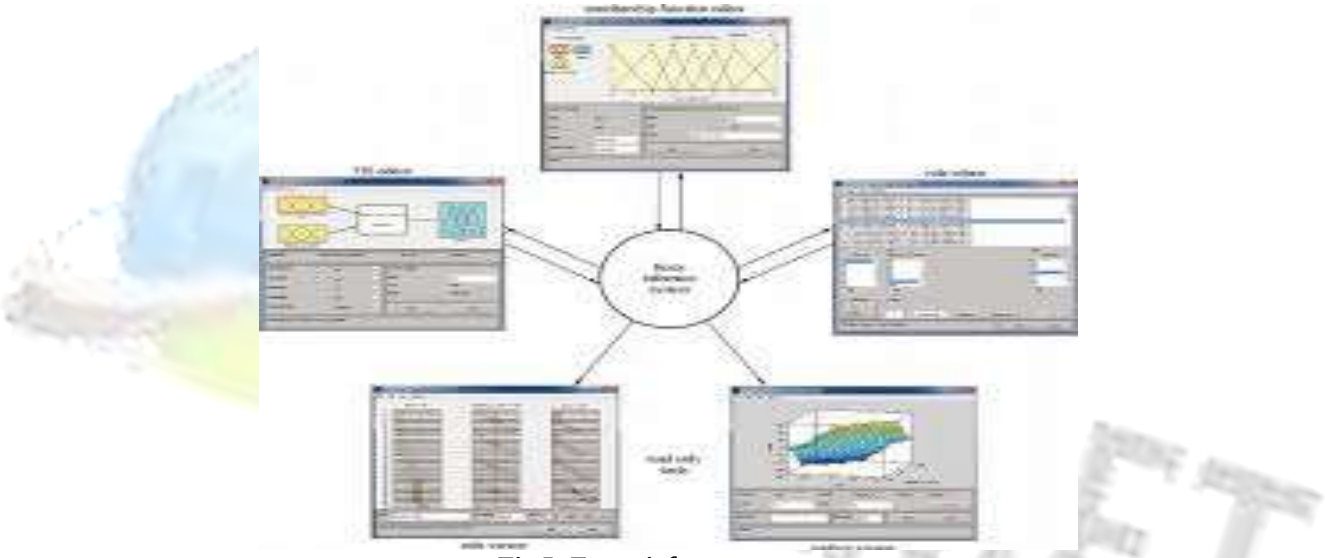

Fig 5: Fuzzy inference system

FIS editor is used to make a new fuzzy inference system from score. The FIS editor window is opened by typing "fuzzy" on control window. It displays general information about fuzzy inference system. The most common and easy methodology is the Mamdani's fuzzy deduction method. Membership function editor is used to exhibit and edit all of the membership functions disturbed with all input and output variables for the whole fuzzy inference system. Rule editor makes the user to identify or transform the rules for the fuzzy logic system. Rule viewer displays a roadmap of the entire fuzzy inference system. The associated GUI tools can be open in the menu bar of rule viewer. After the conclusion of design, in the surface viewer window, a three dimensional curve (surface) of a structure is obtained. It is possible to see, edit and save the intended surface.

IX. APPLICATIONS

Areas in which fuzzy logic has been productively applied are often quite real. Other applications which have benefited all the way through the use of fuzzy systems theory have been information retrieval systems, a navigation system for mechanical cars, a predicative fuzzy-logic controller for mechanical operation of trains, laboratory water level controllers, controllers for robot arc-welders, feature-definition controllers for robot vision, graphics controllers for automatic police sketchers, and further more. Expert systems have been the most understandable recipients of the profit of fuzzy logic, since their area is frequently inherently fuzzy. Examples of expert systems with fuzzy logic essential to their control are decision-

support systems, monetary planners, analytical systems for a meteorological expert system in China for determining areas in which to establish rubber tree orchards.

9.1) Fuzzy Based Water Quality Estimator

There are several ways of scheming the quality of drinking water. Basically, there are dissimilar indicators which can be used as parameters to calculate approximately the water quality. These indicators are given certain ranges by the dissimilar government and the private authorities. Water quality can be described by detailed microbiological, substance and substantial attributes of water. These attributes are usually maintained in a advantageous range, predefined by upper and/or lower limits [12]. So, in this study, the intake water quality is being estimated by using the fuzzy technique.

As fuzzy logic can be seen as an addition of classical logic, with a theoretical framework suitable for the management of problems possessing essential subjectivity and with the linguistic terms, it's suitable for the problem.

X. CONCLUSION

This paper presents a complete description of fuzzy logic which clears that fuzzy logic is an alternating way to signify linguistic and subjective attributes of the real world. In order to get better the effectiveness and effortlessness of the design process, fuzzy logic can be practical to various control systems and other applications. The comparison points between fuzzy logic system and conventional system which is described in this piece of writing concludes that fuzzy logic systems are simple, easy to recognize and have less difficulty than other controlling systems.

This paper makes the readers to have a wide understanding of fuzzy logic and its advantages, fuzzy sets, fuzzy set operations, fuzzy logic system, fuzzy inference system (FIS) and a variety of application based on fuzzy logic for further purpose of investigation and aware the engineers and educators how to develop the applications of fuzzy logic and modernize the conventional control systems by using fuzzy rules.

Meanwhile, this paper can also activate the further investigations related to the integration of fuzzy logic controller with soft computing techniques. In the present work, the method has been found competent of estimating the quality of drinking water. The obtained results appear to be a practical resemblance with the desired results. The estimation system existing here can be considered as a step towards water quality estimation, which can productively be applied by taking other parameters into concern. Moreover, when compared with the existing system, it's found to be extra capable and is giving improved results.

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