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A Review: Some Application on Fuzzy Logic

S.Chitra[1] and S.Jackson[2]

[1] Research Scholar (Reg No:19212232092010), [2]Assistant Professor,

PG and Research Department of Mathematics,

V.O Chidambaram College,Tuticorin-8,

(Affiliated to Manonmaniam Sundaranar University, Abishekapatti, Tirunelveli-627012, Tamil Nadu, India)

[1]chithra.mat@voccollege.ac.in, [2]jacks.mat@voccollege.ac.in

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ABSTRACT: The idea of relative graded membership, which draws inspiration from human sight and reasoning, forms the foundation of fuzzy logic theory. In 1965, Lotfi A. Zadeh released the first version of his groundbreaking study on fuzzy sets. When it comes to information from computational awareness and cognition, fuzzy logic can handle data that is ambiguous, imprecise, hazy, partly true, or lacking in clear limits. Fuzzy logic permits the incorporation of hazy human judgements in computational issues. Additionally, it offers a useful way to resolve disputes involving several factors and improve choice evaluation. Fuzzy logic-based new computing techniques can be used to create clever decision-making, identification, pattern-recognition, optimization, and management systems. Engineers (electrical, mechanical, civil, chemical, aerospace, agricultural, biomedical, computer, environmental, geological, industrial, and mechatronics), mathematicians, computer software developers and researchers, natural scientists (biology, chemistry, earth science, and physics), medical researchers, and social scientists (economics, management, political science, and psychoanalysis) all find fuzzy logic to be of great use in research and development. In fact, many technical and scientific works use fuzzy logic, which was once considered to be a mysterious mathematical curiosity.

1.Introduction on Fuzzy Logic

The idea of relative graded membership, which draws inspiration from human sight and reasoning, forms the foundation of fuzzy logic theory. In 1965, Lotfi A. Zadeh released the first version of his groundbreaking study on fuzzy sets. When it comes to information from computational awareness and cognition, fuzzy logic can handle data that is ambiguous, imprecise, hazy, partly true, or lacking in clear limits. Fuzzy logic permits the incorporation of hazy human judgements in computational issues. Additionally, it offers a useful way to resolve disputes involving several factors and improve choice evaluation. Fuzzy logic-based new computing techniques can be used to create clever decision-making, identification, pattern-recognition, optimization, and management systems. Engineers (electrical, mechanical, civil, chemical, aerospace, agricultural, biomedical, computer, environmental, geological, industrial,

and mechatronics), mathematicians, computer software developers and researchers, natural scientists (biology, chemistry, earth science, and physics), medical researchers, and social scientists (economics, management, political science, and psychoanalysis) all find fuzzy logic to be of great use in research and development. In fact, many technical and scientific works use fuzzy logic, which was once considered to be a mysterious mathematical curiosity.

Fuzzy logic has a wide range of applications, including facial pattern recognition, air conditioners, washing machines, vacuum cleaners, transmission systems, control of subway systems, unmanned helicopters, knowledge-based systems for multi-objective optimization of power systems, weather forecasting systems, models for new product pricing or project risk assessment, medical diagnosis and treatment plans, and stock trading. Numerous industries, including control systems engineering, image processing, power engineering, industrial automation, robotics, consumer electronics, and optimization, have successfully used fuzzy logic. Scientific fields that had been dormant for a while have received a new lease on life thanks to this branch of mathematics. Fuzzy logic is the subject of thousands of research and development projects, patents, and academic papers.

In Zadeh's report on the effects of fuzzy logic, as of March 4, 2013, there were 26 research journals on fuzzy logic theory or applications, 89,365 publications in the INSPEC database, 22,657 publications in the Math Sci Net database, 16,898 patent applications and patents issued related to fuzzy logic in the USA, and 7149 applications and patents related to fuzzy log. There are more and more useful uses being developed every day. In order to progress the theory and applications of fuzzy logic and soft computing, Zadeh established the Berkeley Initiative in Soft Computing (BISC), a renowned study facility at the University of California, Berkeley. This special issue's goal is to convey the developments in fuzzy logic's many practical uses and commercial goods across a wide range of industries. Although fuzzy logic has numerous applications, those who are not acquainted with intelligent systems are unaware of how it can be used in the various products that are presently on the market. The definition of the term "fuzzy" in engineering and science is still ambiguous for many individuals.

These individuals must comprehend when and how fuzzy reasoning can be applied. M. S. Dattathreya and colleagues show a new fuzzy deterministic non controller type (FDNCT) system and an FDNCT inference method in their paper, "Detection and elimination of a possible fire in engine and battery compartments of hybrid electric cars" (FIA). A hybrid electric vehicle's intelligent system uses the FDNCT to identify and put out possible flames in the engine and battery areas. Additionally, they compare the simulation outcomes of the FIA and singleton inference algorithms for spotting possible fires and deciding what to do to put them out. R. Dixit and H. Singh's article "Comparison of detection and classification algorithms using boolean and fuzzy techniques" compares different logic analysis techniques and presents findings for a fictitious target categorization scenario. They evaluate the outcomes of Boolean, Multi-Quantization Boolean, and Fuzzy techniques and demonstrate how pre-processing can fairly maintain result confidence. The writers of "BDD, BNN, and FPGA on fuzzy techniques for rapid system analysis," R. Dixit and H. Singh, examine methods for streamlining data analysis of big multivariate military sensing systems. A fuzzy multi-criteria strategy for estimating the requirement of vertical handoffs is designed and implemented by the writers of

"A fuzzy pre-processing module for optimising the access network selection in wireless networks" by F. Kaleem et al. Their approach establishes the ideal moment for vertical handoff while taking into account the continuity, quality, and happiness of the present service being used. In “A soft computing approach to crack detection and impact source identification with field-programmable gate array implementation” by A. M. Dixit and H. Singh, the authors present a fuzzy inference system to automate crack detection and impact source identification (CDISI) and present their work on a microchip for automated CDISI. In “Analysis of adaptive fuzzy technique for multiple crack diagnosis of faulty plate using vibration signatures” by A. K. Dash, the author proposes a method for multi crack detection of structure using a fuzzy Gaussian technique. In “Effect of road traffic noise pollution on human work efficiency in government offices, private organizations, and commercial business centres in Agartala City using fuzzy expert system: a case study” by D. Pal and D. Bhattacharya, the authors examine the reduction in human work efficiency due to growing road traffic noise pollution. Using fuzzy logic, they monitor and model disturbances from vehicular road traffic and the effect on personal work performance.

In their article "A Hybrid approach to failure analysis using stochastic Petri nets and ranking generalised fuzzy numbers," authors A. D. Torshizi and J. Parvizian introduce a novel failure analysis strategy that combines the adaptability of fuzzy logic with the structural characteristics of stochastic Petri nets. There are numerous commercial uses for this method. The writers of "Excluded-mean-variance neural decision analyser for qualitative group decision making" by K.-Y. Song et al. present a novel mean-variance neural method for group decision making in unclear circumstances. The authors present a case study using the excluded-mean variance method to demonstrate how this approach can enhance the efficiency of qualitative decision making by giving the decision maker a new cognitive tool to support their thinking. The author of "Warren, McCain, and Obama needed fuzzy sets at presidential forum," A. M. G. Solo, demonstrates how the moderator and presidential candidates in a presidential forum required fuzzy logic to appropriately pose and respond to a discussion question. The author demonstrates how asking and responding to questions about describing vague linguistic words correctly requires knowledge of fuzzy logic. Then A. M. G. Solo makes a distinction between qualitative meanings and quantitative definitions of linguistically imprecise words, as well as between clear-cut quantitative definitions and fuzzy quantitative definitions. The writers explain their fuzzy expert system for assessing intellectual capital in "A fuzzy rule-based expert system for evaluating intellectual capital" by M. H. F. Zarandi et al. This helps managers comprehend and assess the degree to which each creative commodity is produced.

First, a little background. My 1965 article on fuzzy sets was inspired by my belief that the theories in use at the time did not adequately address the sharpness (fuzziness) of class boundaries, an ubiquitous feature of reality. Without these tools, it is challenging to create accurate simulations of biological and human-centered systems. I assumed that the scientific communities in these and allied areas would embrace fuzzy set theory. What I did not anticipate was that, formany years after the debut of fuzzy set theory, its main applications would be in the realms of engineering systems and consumer products. The first significant real-life applications of fuzzy set theory and fuzzy logic began to appear in the late seventies and early

eighties. Among such applications were fuzzy logic-controlled cement kilns and production of steel. The first consumer product was Matsushita's shower head, 1986. Soon, many others followed, among them home appliances, photographic equipment, and automobile transmissions. A major real-life application was Sendai's fuzzy logic control system which began to operate in 1987 and was and is a striking success. In the field of medical instrumentation, a notable real life application is Omron's fuzzy- logic-based and widely used

blood pressure meter. The past two decades have witnessed a significant change in the nature of applications of fuzzy logic. Non engineering applications have grown in number, visibility, and importance. Among such applications are applications in medicine, social sciences, policy sciences, fraud detection systems, assessment of credit-worthiness systems, and economics.

Particularly worthy of note is the path-breaking work of Professor Rafik Aliev on application of fuzzy logic to decision making in the realm of economics. Once his work is understood, it is certain to have a major impact on economic theories. Underlying real-life applications of fuzzy logic is a key idea. Almost all real-life applications of fuzzy logic involve the use of linguistic variables. A linguistic variable is a variable whose values are words rather than numbers. The concept of a linguistic variable was introduced in my 1973 paper. In science, there is a deep-seated tradition of according much more respect for numbers than for words. In fact, scientific progress is commonly equated to progression from the use of words to the use of numbers. My counter traditional suggestion to use words in place of numbers made me an object of severe criticism and derision from prominent members of the scientific community. The point which I was trying to make was not understood. Underlying the concept of a linguistic variable is a fact which is widely unrecognized—a fact which relates to the concept of precision. Precision has two distinct meanings precision in value and precision in meaning. The first meaning is traditional. The second meaning is not. The second meaning is rooted in fuzzy logic. Example. Consider the proposition, p: Robert is young. So far as Robert's age is concerned, p is imprecise in value, but so far as meaning is concerned, p is precise in meaning if tall is interpreted as a

fuzzy set with a specified membership function. More concretely, when in fuzzy logic a word represents the value of a variable, the word is precisiated by treating it as a specified fuzzy set. This is the key idea which underlies the concept of a linguistic variable, an idea which opens the door to exploitation of tolerance for imprecision. There is a price for accuracy. The use of language helps to cut costs when there is a certain amount of tolerance for imprecision. Another crucial benefit of using words is that they help build more accurate representations of reality. This is what my vocal detractors did not like. Undoubtedly, there is a moral here. A final remark about the process of word-based computation (CWW). The foundation of CWW is the idea of a language variable. CWW opens the way to building of mathematical solutions of computational issues which are expressed in natural language. In the upcoming years, CWW is probably going to play an even bigger part in the creation and growth of practical uses of fuzzy logic.

2.Uses of Fuzzy Logic and its Application

2.1 Fuzzy Logic in the Field of Medicine

The healthcare sector makes significant use of fuzzy reasoning. Though considered a subset of science, biomedicine is more of a craft than a science. because it employs human expertise, knowledge, and abilities in the diagnosis and treatment of illness. Biological systems are by their very nature complex, time-varying, and time-delayed. A real-time drug distribution technique for open-heart patients that is regulated by fuzzy logic was created in 1980 to assist patients' blood pressure levels. Warren et al. showed a decision support system that automated the use of clinical practise guiding principles based on the fuzzy logic technique, which was again given in the research by Hayward and Davidson [2]. The research demonstrated that test findings generated probable estimates rather than conclusive evidence of the absence or presence of illness, and that in the fuzzy method, probable guesses can be managed with the help of membership values and utilised as such in the interpretation model. As a result, the research shows how fuzzy logic has had a significant impact on the health sector.

2.2 Fuzzy Logic in the Field of Chemical Sectors

Chemical science has used fuzzy logic in some cases. Numerous examples that used fuzzy logic were taken into consideration by Hayward and Davidson [2]. In Almardy's research, a fuzzy control system was employed to help apply current to series-connected anodes in order to protect a long underground pipeline while also reducing the amount of electricity needed to do so [4]. The study showed that for this he set up 126 rules fuzzy control system and ensured the output by adjusting the output membership functions. In the management of flowing waste water pH, Adroer et al. identified the fuzzy error, which was the difference between the intended and real pH[2]. His methods revealed that a small mixer with a shorter residence period can be offered for an adequate pH control. Consequently, the research revealed that flexible logic significantly advances chemistry science.

2.3 Fuzzy Logic in the Field of Agriculture

N. Ganesanand Philomine Roseline T [3] studied the uses of fuzzy logic in agriculture. The paper characterizes employing fuzzy logic in weed management, disease management, and pest management and to develop a professional system for several crops and to scrutinize and study soil. The paper "Design and development of Fuzzy Expert System for Integrated Disease management in Finger Millets" identified syndromes as moderately resistant, highly resistant,

immune, resistant, highly susceptible and susceptible. The professional system uses defuzzification and fuzzification process which is traditionally done only by experienced farmers or agricultural scholars. The paper "Integrated pest management system using the fuzzy expert system" showed fuzzy logic approach-based on three inputs on pests like damages to pests, dimensions of pests, number of pests. A fuzzy-based system "Development and design of the professional system for potato crop" studied the condition of soil development with fuzzy membership function. Thus the study presented that the fuzzy logic approach had an immense contribution to agriculture.

2.4 fuzzy logic in traffic signals:

In the-condensed traffic, with the growing number of cars, it requires regularly progressing and more intricate explanation of the traffic situation that includes traffic signal control. The controlling and monitoring of traffic in the city is a crucial task due to the capability to handle control of roads. There have been numerous studies [4,5] focusing on various approaches to predicting and modeling traffic behavior. The fuzzy logic control system provides an improved solution than conservative traffic-dependent control. For instance, humans would think in the following way to control traffic condition at a junction: “if the traffic is dense on the northern or southern lanes and the traffic on the western or eastern lanes is lesser, then at such a situation the traffic lights must remain green for a longer time for northern and southern lanes.” Such necessity can now be simply put up in the fuzzy logic controller.

2.5 fuzzy logic in the field of land science

Many models in soil studies are interdisciplinary, requiring mathematical models that are built in the hard sciences and which are then linked with connections and subjective rule based models used in the less exact or soft sciences. The resulting complex models are often difficult to interpret and may not possibly reflect the soil or soil processes of the real world. In soil science, the fuzzy set theory is prominently used for classification. The purpose of classification is to ease a complicated system, represented with the aid of some sets of data, into explicitly defined classes. In soil science, we often hear of classification such as 'very deep soil', 'deep soil' or 'shallow soil'. Thus study shows that soil classification can be done using fuzzy logic.

2.6 fuzzy logic in transportation problem

In operations research, we talk about the problems which are related to optimization. Operations research proves helpful in maximizing profit and in minimizing the cost of

production or transportation cost etc. Fuzzy logic can be useful in operations research too. By using the fuzzy logic cost of transportation can be minimize. Mamdani and Pappis (1977) [1] have used fuzzy logic in operation research effectively. The study shows fuzzy logic to the governor a juncture of two one way streets. Kalie and Teodorovic(1996) used fuzzy logic to decide the transportation mode so that travel cost and time gets minimized [1]. Thus fuzzy logic has prodigious influence towards operations research.

2.7 Fuzzy Logic in the Field of Petroleum Production

Petroleum production and exploration business prosper with in-depth understanding and knowledge of the subsurface. Technological advancement has aided in providing the industry with a lot of information about the petroleum reservoir; though, a lot of uncertainties are still

present as of the nature of the sub surface. The industry has attempted to report this problem in diverse ways; unfortunately, the classical methods have failed to provide proper guidance to management decisions in making use of these reservoirs. The application of fuzzy logic comes across various extents of engineering. Decision-makers solve problems on a day-to-day basis

with the aid of quantitative information obtained. Therefore, solving real-life and industrial problems requires quantitative information. Fuzzy logic aids to guarantee quality and precision avoids uncertainty and inconsistency. Additional areas where fuzzy logic is being used largely in this domain are simulation treatment, completion, and drilling, and reservoir characterization.

2.8 fuzzy logic in household activities:

These days, a lot of home-use appliances are being upgraded with the aid of fuzzy logic to save money and time. Fuzzy logic is used in a lot of appliances like an air conditioner, vacuum cleaner, washing machine, etc. Tiryaki and Kazan's dishwasher which made used fuzzy logic and Alhanjouri and Alhaddad's optimized wash time of washing machine using fuzzy logic are the important studies that are based on the fuzzy logic. After which many researchers have worked on this so that they can achieve reduced wash time and the reduced consumption of water and time. The paper "Washing machine using fuzzy logic" [6] shows the use of fuzzy logic for the washing machine. The study represents that four input variables and five output variables are set up together with eighty-one rules to define the relationship among these variables. Some other researchers made use of sensors in washing machines for linguistic inputs that are mass of clothes, dirt type, clothes type, etc. These control the linguistic output that is rinse time, spin time, wash time, etc. The study showed fuzzy logic being used in air coolers and air conditioners also. The paper "Application of Fuzzy Logic in Daily Life" [1] shows that the design of the room cooler might have multiple inputs and output variables. The paper measured dual input variables: humidity and temperature and three output variables: cooler fan speed, exhaust fan speed, and water pump speed. By making use of this, fuzzy

logic was employed to get the optimum result. Hence fuzzy logic has a tremendous contribution to the household too.

2.9 fuzzy logic in the field of natural science

Fuzzy logic finds its application in Environment science too.It has been effectively used in detecting natural tragedies like a flood, earthquakes, etc. A review of the paper "Prediction of flood detection system Fuzzy logic approach"[6] showed that the fuzzy logic model developed with the help of If-Then rules for predicting flood detection based on Mamdani approach is tremendously useful. In this paper water level and climate conditions are used as input and

control action is used as output and a total of twenty-five rules are set up for the process of prediction of the flood. Due to fuzzy logic now it is possible to make vehicles safer, better, and efficient to save the climate. Thus fuzzy logic has tremendous inputs in environment science too.

2.10 Fuzzy Logic in Machines

Researchers have attempted to apply methods of the fuzzy system in various areas of application. One of them is to optimize machining by applying a fuzzy system. The execution of the fuzzy system substantiated to be largely useful in case of highly complex or very nonlinear processes, in the absence of any simple mathematical model or which

the needed for processing by expert's knowledge. Machining data play a vital role in the effective consumption of machine tools and thus meaningfully impacts the overall costs of

manufacturing. Execution of a fuzzy logic model to be used for the metal cutting operation to advance a computerized database of machining systems that could be a great help to the process planner for the establishment of the strategy for selecting machining data for a specific machining process.

Concept related to fuzzy logic:

Support of a fuzzy set

1. Empty fuzzy set.
2. Fuzzy singleton
3. Center of Fuzzy set:
4. Crossover point of a fuzzy set
5. Height of a fuzzy set
6. Normal fuzzy set
7. α-cut of a fuzzy set A

We will explain these concepts with following example.

EXAMPLE:

Let U={1,2,3,…,10} Several = 0.5/3+0.8/4+1/5+1/6+0.8/7+0.5/8 (3.3)

Support of fuzzy set "Several" is the set of integers {3, 4, 5 6, 7, 8}.

Centre of fuzzy set "Several" is the mean of 5 & 6 (i.e.5.5) where its maximum value is finite. Crossover point of fuzzy set "Several" is 3and 8.

Height of fuzzy set "Several" is 1. Therefore "Several" is the normal fuzzy set.

If α = 0.8 then the α-cut of fuzzy set "Several" is the crisp set {4, 7}.

REFERENCES:

1. Priyanka Kausha, Neeraj Mohan, Parvinder Sandhu S, (2010) ,Relevancy of Fuzzy Concept in Mathematics.International Journal of Innovation, Management, and Technology,l(3), 312-315.
2. Kathole, A. B., Katti, J., Dhabliya, D., Deshpande, V., Rajawat, A. S., Goyal, S. B., . . . Suciu, G. (2022). Energy-aware UAV based on blockchain model using IoE application in 6G network-driven cybertwin. Energies, 15(21) doi:10.3390/en15218304
3. Keerthi, R. S., Dhabliya, D., Elangovan, P., Borodin, K., Parmar, J., & Patel, S. K. (2021). Tunable high-gain and multiband microstrip antenna based on liquid/copper split-ring

resonator superstrates for C/X band communication. Physica B: Condensed Matter, 618 doi:10.1016/j.physb.2021.413203

4. Kothandaraman, D., Praveena, N., Varadarajkumar, K., Madhav Rao, B., Dhabliya, D., Satla, S., & Abera, W. (2022). Intelligent forecasting of air quality and pollution prediction using machine learning. Adsorption Science and Technology, 2022 doi:10.1155/2022/5086622
5. Kumar, A., Dhabliya, D., Agarwal, P., Aneja, N., Dadheech, P., Jamal, S. S., & Antwi, O. A. (2022). Cyber-internet security framework to conquer energy-related attacks on the internet of things with machine learning techniques. Computational Intelligence and Neuroscience, 2022 doi:10.1155/2022/8803586
6. Hayward, Davidson, (2003), Fuzzy Logic Application, Analyst.128, 1304-1306.
7. Philomena Roseline TN, Ganesan, Clarence Tauro JM, (2015) A study of Applications of Fuzzy Logic in Various Domains of Agricultural Sciences. International Journal of Computer Applications (0975 -8887),15-18.
8. G. C. D'Ans and D. C. Gazis,(1976) "Optimal control of oversaturated store-and-forward transportation networks," Transportation Science, vol. 10, no. 1, pp. 1–19.
9. R. Boettger and Siemens,(1971) "Optimal coordination of traffic signals in street networks," in Proceedings of the 5th International Symposium on the Theory of Traffic Flow and Transportation, Berkeley, Calif, USA.
10. Mustafa Demetgul, Osman Ulkir, Tayyab Waqar, (2014) Washing Machine using Fuzzy Logic, Automation. Control and Intelligent Systems, 2(3), 27-32.