A Review Study of Fuzzy Controllers and Its Application in Decision Mapping

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Abstract

Fuzzy logic is an approach to variable processing that allows for multiple possible truth values to be processed through the same variable. Fuzzy logic attempts to solve problems with an open, imprecise spectrum of data and heuristics that makes it possible to obtain an array of accurate conclusions. The complexity of product design in industry has been continuously increasing. More factors are required to be considered simultaneously before a decision about the new product could be determined. For this reason, decision-making process costs much more time and it may even be impossible to determine the optimal decision by normal calculations. Therefore, Fuzzy Inference System based on Fuzzy Logic is introduced as a quick decision- making tool to arrive at a good decision within much shorter time. This thesis focuses on studying the features of membership functions in Mamdani-type fuzzy inference process. It is aimed at making the black box of fuzzy inference system to be transparent by adjusting the membership functions to control the relations between input and output variables. Systematic trial and error is implemented based on the Fuzzy Logic Toolbox from MATLAB, and conclusions developed from experiments help eliminate the uncertainties of membership functions, so that the inference process turns to be more precise and reliable.
Keywords: Fuzzy Logic, Fuzzy Controllers, Decision Making, MATLAB.

I. INTRODUCTION

Soft computing, as opposed to traditional hard computing approaches, takes use of tolerance for change, ambiguity, and partial truth to improve traction, durability, and the cost of developing solutions as compared to the former. Instead of emphasising precise answers, fuzzy logic aids in the resolution of obstacles by emphasising approximations rather than perfect reasoning and reasoning. In contrast to Crisp Logic variables (such as Binary Logic), which can only have two potential truth values of true or false, Fuzzy Logic variables may have any truth value between zero and one, allowing them to be anywhere between 0 and 1. Rather than a categorical yes or no, the membership values of fuzzy logic, also known as truth values, convey an extent to which a statement is true or false. if the statement is between

the range of 0 to 1, with 0 being completely inaccurate and 1 being completely accurate, then the statement is true to some extent. A significant increase in the number of Fuzzy Logic applications has occurred in recent years, because of the fuzzy logic concept's resemblance to human speech and intuition, as has the variety of Fuzzy Logic applications.

The most common use of ambiguous logic is the vague conclusion, which is the topic of this dissertation. The fuzzy conclusion employs a series of if-then rules and confusing logical functions to go from the entering space to the exit space. We use human terms directly to express if-then statements since they are ambiguous in their entirety. To establish if-then rules, all of these fuzzy sets must be initially generated using member functions.

The relevance of member functions in finding input-output connections, as well as the construction of member functions for ideal linear and classical nonlinear inference systems, are the principal topics of this thesis. Mamdani-type inference systems are also discussed. The method here is to use MATLAB's fuzzy logic toolbox to apply tests and errors. Each condition in the experimental systems of unclear Mamdani conclusion will remain the same, except for the form, amount and overlap ratio of the member function between the nearby Single Output MFs, one input The vague Mamdani inference system will be first investigated to extract the characteristics of the member functions in the changing input-output curves, as it is the simplest model. As a second step, the two-entry exit conclusion system will be addressed to summaries the consistent impact of member operation on both SISO's and TISO conclusions systems. A technique for incorporating weight into a single multi-entry output system will be presented, with practical application aimed at validating the applicability of the results.

II. REVIEW OF RELATED WORKS

Fuzzy logic is used in various applications, including approximate reasoning, granulation of information, and information technology with words. Artificial systems based on knowledge can benefit from vague logic, which is a framework of conclusions that allows people to apply their reasoning skills to them. In addition, it provides a high level of calculation allowing the translation of language strategies into actions.

In the field of neural networks, a new computer tool with learning and adaptation skills is being developed, while fuzzy logic is used to reproduce certain perceptual and linguistic characteristics related to human knowledge to give it more mathematical power. Cognitive uncertainty requires the use of unclear logical theory to provide a mechanism of conclusions, and computational neural networks have many attractive traits such as learning, adaptability, fault tolerance, parallelism, and generalization.

Weihua Su et al. (2021) The right choice of the renewable energy project (REP) is crucial to maximizing the benefits of regional resources and optimizing the energy consumption structure. The choice of REP is a difficult multi-criteria group decision-making issue (MCGDM) with many aspects affecting such as the economy, society, and the environment. This research offers an MCGDM framework of a social network based on social network analysis (SNA) and hesitantly probabilistically fuzzy sets to handle this challenge (HPFS).

Finally, a dual feedback method is provided, including modification of opinion and weight adjustment to increase the level of consensus of the group. In this institution, an MCGDM social network structure is proposed for rep selection, and the SNA technique is used for the first time for rep selection. After that, a case study is offered by China's Zhejiang province to demonstrate the logic and effectiveness of the framework. The findings suggest that the proposed hesitant potential trust function can better reflect the trusting relationships of decision-makers and characterize the trust transmission process, which is important for MCGDM issues such as rep selection.

Linos Nchena et al. (2020) Finally, the purpose of this study is to examine Artificial Intelligence and determine whether it can be applied to a real problem. A vague logic control system (FLC) is described in order to control and maintain the speed of a motor vehicle. The vehicle controller is responsible for creating a throttle or braking force. This force is injected into the car's engine, as a result, the vehicle accelerates in the right way. A smooth, flat road requires average throttle and braking performance. When two different models are used to test and validate the proposed

response, the results shall be analyzed. Both models use FLC controllers, with the first using an FLC controller and the second using an analog integrator controller (PI). When moving from actual to programmed speed, the PI controller has been shown to be less smooth than the FLC controller. When it came time to demonstrate its independence from the model, the FLC passed with flying colors. It was divided into two different models to demonstrate that the results achieved are based on unclear rules and not on the specific model. This experiment successfully showed how an FLC controller system can adjust the speed of the motor vehicle better than a PI controller system compared to a PI controller system.

Fuzzy logic in the medicine

Since Lotfi Zadeh's important paper in 1965, It is common for fuzzy sets to be utilised in a wide range of fields where uncertainty is an issue. An great example is medicine, which often straddles the line between science and art: Medical diagnosis is plagued by ambiguity, linguistic uncertainty, hesitancy, uncertain measurement, natural variance, and subjectivity.

Schuh et al., [2005] Patients' medical records and medical systems have been cited as examples of imprecise logic being applied to medical systems. Yue et al. [2007] studied the immune system's defence of the human body based on the immunity algorithm utilising a flow chart and a hazy cognitive map (FCM).

Christian et al., [2008] In this paper, we provide an investigation into ambiguous logic, confounding sets and linkages in medical research, as well as an explanation of the GlucoNotify patient glucose data management, hazy automation proposal for ARDS medicines. Yataka Hata and colleagues [2009] have brought together medical diagnosis and health management in a single publication. Khanale and Ambilwade [2011] proposed a vague logical tester for the maintenance of normoglycemic for a type I diabetic patient.

Djam et al., [2011] established a decision support system for diagnosing TB and shown that

ambiguous logic for medical diagnosis is an excellent technique to assist novice clinicians obtain the final diagnosis of tuberculosis more quickly and efficiently.

Soundarajan et al., [2012] have designed a vague rules-based system TB diagnostic tool for the identification and treatment of tuberculosis Rule extraction approaches are utilised to updatethese ambiguous rules in order to more accurately diagnose tuberculosis. In addition to being well-suited to the needs of pulmonologists, this technique, which provides TB categories, also speeds up the diagnostic procedure.

The most prevalent types of arthritis are osteoarthritis and rheumatoid arthritis, although many people are unaware that they have either condition because they do not seek treatment. As a result, it is critical to have an early diagnosis and treatment for the kind of arthritis that ispresent, as well as any accompanying machine issues. Based on the findings of Mirzamansoor Bad et al. (2012), it has been shown for the first time that a fuzzy logic controller (FLC) may be utilised to effectively use Zadeh's "hazy whole theory" as a tool for dealing with uncertainty and insecurity.

Fuzzy logic in bioinformatics

As we go through the information age, computers and computing have an impact on every area of our everyday lives. Information is gathered and distributed by people all over the world via theusage of the Internet. It is predicted that there will be rain based on a series of advanced computer models. In the stock market, electronic trading is quite common. An airplane's whole design is designed on a computer before the first component of the aircraft is manufactured. It was the rising use of computers and computing in biological and medical research that led tothe birth of the field of bioinformatics.

Bioinformatics is a term that is often used in science and technology but has not yet been defined. Until the precise boundaries of this new area can be defined, it will take many years before they can be determined. "Research, development, or application of computational tools and approaches to expand the use and benefit from biomedical and health data, including those that must be acquired, represented, described, or stored for analysis or visualisation," according to an unofficial definition provided by the National Institutes of Health (NIH) in the United States.NIH describes computational biology as "the development and use of analytical and theoretical data approaches, mathematical modelling, and computer simulation tools in the study of biological, behavioural, and social systems," which is a closely related area. Technology (engineering) plays an important role in the development of tools and infrastructures in both bioinformatics and computational biology, although bioinformatics is more concerned with science (biology) in the formulation of hypotheses about the nature of things than computationalbiology.

Cordon et al., [2004] have studied and analyzed the DNA sequence using genetically inconclusive systems. Das and Dey [2004] introduced a novel approach for local alignment of DNA sequences.

the Paul and Konar [2005] Direct comparison approaches have been developed to

accomplish global and local alignment between the two sequences. An alternate scoring system based on an undefined idea was also offered by the researchers.

Chen et.al., [2006] Utilizing the problem's area structure, we've suggested a partitioning strategy based on the ant-colony optimization algorithm that has greatly improved solution time and quality.

Chang et al., [2006] have used fuzzy logic to create a fuzzy PAM matrix, and then used fuzzy arithmetic to estimate the fitness function of the genetic process. The findings of their research prove to be vague logic useful in addressing the problem of uncertainties and were successfully applied to the alignment of protein sequencing.

Yue and Tang [2007] have implemented the division and aligning three sequences to minimise memory use from n3 to one (n2). Dynamic programming was employed to make certain that everything was perfectly aligned.

Nasser et al., [2007] combination dynamic programming and fuzzy logic technique has been used to align various sequences over time. Some criteria were base quality, overlap duration and vacuum penalty in determining the best possible subcommittee alignment.

Naznin et al., [2009] In order to align diverse sequences, we developed an iterative progressivealignment strategy that employs unique approaches to both construct guiding trees for random sequences and adjust sequences inside guide trees in order to align varied sequences. Different tactics were used to achieve the major goal of this research, which was to provide efficient algorithms in terms of memory and time requirements.

Fuzzy matrices

IVFMs (interactive fuzzy matrices) are a relatively new concept that was developed to cope with the inherent ambiguity that exists in so much of our daily lives. The ability to customise the fuzzymatrices used in the space further boosts the versatility of the instrument. Many of the real-world difficulties we face in the medical, engineering, and management sectors, as well as in the social sciences, include the use of data that is not necessarily exact, dependable, or predefined, as is often the case. When dealing with this kind of uncertainty, it is usual practise to use probabilities, fuzzy sets, and intuitive fuzzy set ideas, among other techniques.

Yang et al. [2009].has shown that none of the aforementioned concerns have their own set of special tools, and to remedy this, he developed a concept known as "soft set theory," which contains a collection of custom tools for dealing with a wide range of uncertainties. The "fuzzy soft set" has been studied theoretically by Maji et al. [2001]. The space-rated fuzzy soft set was recently presented.

Shyamal and Pal [2006] suggested the idea of IVF as a generalisation of the fuzzy uterus, by extending max.min functions to fuzzy algebra and extending max.min functions to fuzzy algebra, respectively. The knowledge a physician has about a patient, as well as his or her understanding of medical interactions in general, is widely regarded to be equivocal

[**Adlassnig,1986**]. Uncertain medical information may be represented as inconclusive sets in hazy set theory, which allows for the representation of the diagnostic process as a series of inconclusive sets.

Using fuzzy sets in medical research**, Zadeh [1969] and Sanchez [1979]** recommended the development of a fully formed connection modelling framework for symptoms and disorders, which they described as follows: This notion of an intuitive fuzzy set has been around since the work of **Andreev [1986,]** who first proposed it., vague set theory has been used in medicine to solve problems (IFS).

Turksen [1986] Atanassov and Gargov [1989] established the notion of the space-rated intuitive fuzzy set (IVIFS), which is an extension of the fuzzy set IVFS. One of the most notable features of IVFS and IVIFS is the fact that the function membership and function without membership have interval values rather than precise integers.

III. METHODOLOGY

Part 1: Membership functions in SIO systems may now be adjusted (SISO) systems

This thesis starts with the simplest model, the Single-Input Single-Output Mamdani Fuzzy Inference System, to study the influence of the membership function on fuzzy inference performance. Except for the details of the membership function, several SISO Mamdani fuzzy inference systems are constructed based on the same assumptions and limitations, using MATLAB's Fuzzy Logic Toolbox. There is a long number of issues relating to the function of membership that are not yet known.

(a). One input variable may be described by how many different model functions (MFs).

(b). A single output variable may be described by how many MFs?(c). how are MFs for input variables affected by their shapes?

(d). How does the form of the MFs for the output variable influence the inference system?

(e). In what ways does the proportion of overlap between neighbouring input MFs affect the finaloutput result?

(f). Do nearby output MFs have an affect on the overall result?

It is vital to take into account all of these variables in order to ensure that the input-outputconnection is properly balanced.

Assumptions and Expectation

This thesis will not address all of these issues, but they must be addressed to prevent disrupting the fuzzy inference process, which is why many other concerns will not be considered. This is why preconditions and assumptions are necessary before delving into membership function's fundamental rules.

(1) As a general rule of thumb, the range of [0,10] for both input and output variables is used to analyse the properties of MF. Using a rate range of 0 to 10, the input and output values are converted to numbers, with a larger number often representing a preferred option. Thus, in order to avoid the differences in the layouts of MF curves that might arise from various areas of discussion, this requirement must be met.

(2) The monotonicity of the input-output relation is used as a criteria for the performance of fuzzy inference models. Defuzzification should provide an output with a positive connection to the input. A rising curve indicating the input-output relationship is predicted as typical system performance in the SISO fuzzy inference model covered in this chapter. The maximum input value is where the input-output curve's peak should be positioned.

(3) The remainder of the qualities of MFs are established as presuppositions in this thesis. Constraining all MFs that represent the same input or output variable to have similar geometrical properties and translating them such that the range [0, 10] is filled in is necessary to provide a monotonic input-output relation. The MFs are all convex and normal.

(4) When it comes to the relationship between input and output variables, if-then rules may always make a substantial contribution. Rule completeness and symmetry are necessary for the fuzzy inference models so that rules do not conflict.

IV. CONCLUSION

Several instances and techniques for introducing weight effects into the MISO Mamdani fuzzy inference model are discussed as well as a number of case studies. However, doing so at the expense of a more intricate arrangement of membership functions for output variables makes it possible to construct a MISO fuzzy inference system that responds correctly to weights and has sufficient linear performance supports the prior findings by examining and supporting an ethical challenge connected to the design of an automotive engine's timing system, which is based on a real-world case study from the literature. Despite the fact that the MISO fuzzy inference model with weight influence from input variables employs triangular input MFs and rectangular output MFs, the model is unable to construct an input-output link with consistent linearity due to the usage of triangle input MFs. Utilizing the MISO inference model, we were able to increase its linear performance while also providing dependable recommendations based on a previously learned feature of the membership function that we previously learned about. Fuzzy logic systems provide two other very important advantages. They can use existing linguistic knowledge very successfully, and they treat uncertainty in an appropriate manner. The basic goal of this paper was to classify and analyse results in the application of fuzzy logic when modelling complex traffic and transportation processes. The results obtained show that fuzzy set theory and fuzzy logic present a promising mathematical approach to model complex traffic and transportation processes that are characterized by subjectivity, ambiguity, uncertainty and imprecision. As already noted, the benefits from the fuzzy logic will be more accurately assessed as the number of successful practical applications of the fuzzy logic in traffic control and transportation planning increases.

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