IJNRD.ORG ISSN : 2456-4184
INTERNATIONAL JOURNAL OF NOVEL RESEARCH AND DEVELOPMENT (IJNRD) | IJNRD.ORG
An International Open Access, Peer-reviewed, Refereed Journal

A Study on Methodology of Fuzzy Logic

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Abstract: The Fuzzy Logic is the advancement of Binary Logic in the field of Computer Science / Computer Application which was initiated during 1960's by Mathematician Lotfi Zadeh. In Binary Logic, only Trueand False values play an important role in decision making, whereas the Fuzzy Logic has several decision making capabilities in addition to true or false values. Fuzzy Logic protocols are defined to make system behave like how humans think. Fuzzy Logic is applied on Fuzzy sets with appropriate syntax and semantic codes. This Logic is useful for modeling complex problems, wherein the inputs will be random in nature.

Keywords: Fuzzy sets, Logic, Random Inputs, Protocols.

I INTRODUCTION

The Fuzzy Logic is a multi valued Logic which allow multiple concurrent truth values and is an heuristic approach in arriving at the conclusion. The Fuzzy systems adopt if then rules and are more dynamic in producing optimum results. Fuzzy Logic algorithms require less hardware when compared with Boolean or Binary Logic. The components of Fuzzy Logic includes Fuzzification, Fuzzy rules, Inference method and Defuzzification, Fuzzification process will have fuzzifier which map real crisp input to a fuzzy function. Fuzzy rules are applied to fuzzy values and the inference component simulates human decisions by performing approximate reasoning and the defuzzification component converts the processed fuzzy values into crisp output values. The steps in designing fuzzy logic control [FLC] are identification of variables, subset configuration, obtaining membership function, formulating fuzzy rule base configuration, fuzzification, combining fuzzy outputs and defuzzification. The merits of using fuzzy logic control are – developing a FLC is cheaper, robust, customizable, accurate to human thinking capability, more reliable and efficient. The demerits of FLC are requires lot of data, useful in case of historical data, needs high human expertise and regular updating of rules is necessary. Fuzzy systems are implemented where the usage of classical set theory and binary logic is impossible. A fuzzy control system is capable to analyze analog input values in the form of logical variables that are continuous values between 0 and 1.The fuzzy logic are used in several areas such as speech recognition, facial recognition, aircrafts applications, satellite applications , automotive industry , managing traffic in highway systems, in maintaining shift schedules in organizations, controlling speed of vehicles, helps in decision making in business, applicable in defense sector, in government service agencies, counting and supply of notes (currencies) in banking sectors. FLC also fits to monitor the working of washing machines, microwave ovens, vacuum cleaners, waste water treatment plant, optimization in cheese industry, milkoptimization in milk industry, in controlling ships using auto pilot mechanism, security appliances, in railways - train schedules can be managed and many more.

The respite of this paper is organized as follows. Section II is Literature Reviews. Section III will be Fuzzy Logic methodology by discussing its architecture. Section IV presents the Conclusion.

II LITERATURE REVIEW

This section reveals a brief knowledge about the research papers on Fuzzy Logic.[1] In the paper "A Paper on Fuzzy Logic & it's Applications" author discusses Fuzzy Logic and its applications. Fuzzy Logic is an extension of binary logic that handles imprecise data and uncertainty. It allows intermediate values between fully true and fully false. Fuzzy Logic resembles how humans

think and reason with vague or ambiguous concepts. It uses fuzzy sets and fuzzy rules instead of crisp binary sets and Boolean logic. The paper outlines the main components of a Fuzzy Logic system: Rule base - contains the IF-THEN fuzzy rules that guide decision making. Fuzzification - converts crisp inputs into fuzzy sets. Inference engine - determines which rules are triggered based on the input. Defuzzification - converts fuzzy outputs into crisp values. Fuzzy Logic can be applied in various fields like : Chemical engineering for process control and optimization, Transportation systems for traffic management, Business for decision making and evaluation, Medicine for disease diagnosis, Evaluation of performance. In summary, Fuzzy Logic provides a simple yet effective way to deal with imprecise data and knowledge. It allows building expert-like systems that can make decisions like humans. The paper discusses the methodology and architecture of Fuzzy Logic systems and outlines some of their applications. [2] In the paper"A Self-Organized Method for a Hierarchical Fuzzy Logic System Based on a Fuzzy Autoencoder",authors have proposes a novel design of a hierarchical fuzzy system based on a self-organized fuzzy partition and fuzzy autoencoder. The initial rule set of the system is empty and all fuzzy sets and rules are generated by a self-organized fuzzy partition algorithm. An improved box plot data standardization method is adopted to process the data which can better represent the input data distribution and improve accuracy. A fuzzy autoencoder is used to train the hierarchical fuzzy system layer by layer which can ensure the effectiveness of hidden layer variables and provide interpretability. Compared to traditional fuzzy logic systems, the hierarchical fuzzy system reduces the total number of rules and complexity. The hierarchical self-organized fuzzy system performs better in regression accuracy than the self-organized fuzzy system. The paper discusses interpretability of self-organized fuzzy systems and analyzes indexes for assessing interpretability. A fuzzy autoencoder is used as a way to realize layer-by-layer training of the hierarchical fuzzy system. The fuzzy autoencoder consists of a fuzzy encoder and decoder which are trained using gradient descent. The fuzzy sets for the hierarchical fuzzy system are generated using the proposed fuzzy set self-organized method. Experimental results on three regression datasets show that the hierarchical fuzzy system improves the accuracy of regression prediction compared to classical fuzzy logic systems and other fuzzy systems. [3]In the paper "An Integrated Fuzzy Logic System under Microsoft Azure using Simpful", the authors proposes a cloud-based fuzzy logic system using Microsoft Azure and the Simpful library for real-time human monitoring applications. They developed two types of fuzzy inference systems: Mamdani and TSK. The key objectives were: Create a cloud-based framework to handle uncertain data processing issues for making decisions in healthcare scenarios. Implement a cloud-based fuzzy system for non-invasive human health monitoring in real time. The authors collected real-time data using a wearable wrist pulse oximeter sensor. They then classified the data using a cloud-based fuzzy logic system on Microsoft Azure. The experimental results show that: The Mamdani fuzzy inference system required 0.456 seconds less processing time compared to the TSK fuzzy inference system. The detection accuracy of the Mamdani system was 6.82% higher than the TSK system. In conclusion, the cloud-based fuzzy system approach can effectively handle large volumes of data from multiple users for real-time human monitoring applications. The openness of the architecture also allows for easy updating of knowledge base without requiring hardware changes.[4] In the paper "Students' Grading System by Fuzzy approach" the author proposes a decision support system to measure student learning outcomes in a Digital Electronics course using fuzzy logic. Outcome Based Education has been implemented by many universities where assessment methods are important. Fuzzy logic has been widely used in education for tasks like learning style prediction and measuring education quality. The researchers applied fuzzy logic to assess student learning outcomes in the Digital Electronics course. Two Program Learning Outcomes (PLOs) were evaluated - PLO 1 on professional ethics and PLO 2 on knowledge and problem solving skills. For PLO 1 assessment, traditional assessment, fuzzy logic with triangle membership function, and fuzzy logic with Gaussian membership function were used. The results showed that the choice of parameters significantly impacted the outcome. Similarly for PLO 2 assessment, the three methods produced different results. However, the researchers could not determine which method was best. The choice of assessment method still depends on the lecturer. But fuzzy logic assessment proves to be an alternative decision support system for measuring student learning outcomes. The researchers concluded that fuzzy logic assessment works well, and recommend using Gaussian membership function and centroid fuzzification process. [5] In the paper "Decision Support System of Student Learning Outcomes Assessment on Digital Electronic Subject using Fuzzy Logic" author approach to evaluate students' performance based on their scores in different exams. The traditional grading system only looks at the total marks scored, but this fuzzy approach considers other factors like students' perseverance and consistency in improving over time. Fuzzy logic can handle imprecise data and qualitative aspects like "excellent", "good" performance, which is more natural than just numerical scores. The inputs are students' scores in Test 1, Test 2, Midterm and Endterm exams. These scores are fuzzified using triangular membership functions. The fuzzy rules are then used to calculate an overall performance score based on how well the student has persevered and improved from one exam to the next. The performance score is then defuzzified to assign a grade to the student. This considers factors beyond just the total marks scored. The approach was implemented in MATLAB using fuzzy

toolboxes. The results showed that students with similar total scores could get different grades based on their performance and perseverance. So in summary, the key idea is that the proposed fuzzy logic approach evaluates students' performance in a more holistic way that considers not just their scores but also qualitative factors like their perseverance and consistency in improving over time. This gives a more nuanced assessment of students compared to the traditional grading system. [6] In the paper, "Fuzzy logic expert system for evaluating the activity of University Teachers", authors have discussed about how the use of fuzzy logic expert systems for evaluating the activity of university teachers. Fuzzy logic can handle imprecise information and uncertainty, which is useful for evaluating academics. The authors developed a fuzzy logic model in Matlab using Mamdani fuzzy inference. The model was tested and validated using a graphical interface that gives results according to minimum criteria. Fuzzy logic offers advantages like being easy to understand, flexible, tolerant of imprecise data, and able to model complex functions. The fuzzy logic model allows formally modeling vague knowledge stored in rule bases. It can implement human experience through the inference rules. In summary, using fuzzy logic for evaluating university teachers offers advantages such as simplicity, flexibility, tolerance of imprecise data, accurate modeling of complex functions, utilization of expert knowledge, and compatibility with the con-ventional evaluation approaches.

III METHODOLOGY

A fuzzy logic system requires a specific processing architecture consisting of several components: a rule base, a fuzzifier, a defuzzifier, and an inference engine. Fuzzy logic is a technique used to incorporate human-like thinking into control systems. It has practical applications in the aerospace field, such as altitude control for spacecraft and satellites. By emulating human deductive thinking, fuzzy logic allows for the inference of conclusions based on available knowledge. This is achieved through the use of fuzzy rules, which are if-then statements that establish connections between input and output variables in a fuzzy manner. The output of a fuzzy logic system is a fuzzy set, which represents the membership degrees for each possible output value. Fuzzy logic provides flexibility in reasoning and processing by allowing for multiple truth values to be considered for the same variable. It is particularly useful in solving problems that involve imprecise and open-ended data, enabling the generation of a range of accurate conclusions. The architecture of a fuzzy logic system is illustrated in Figure 1. It typically consists of four main components: the rule base, fuzzification, the inference engine, and defuzzification. The rule base contains expert-provided rules and IF-THEN conditions that guide the decision-making process based on linguistic information. Recent advancements in fuzzy theory have led to the development of efficient methods for designing and tuning fuzzy controllers, often resulting in a reduced number of fuzzy rules.

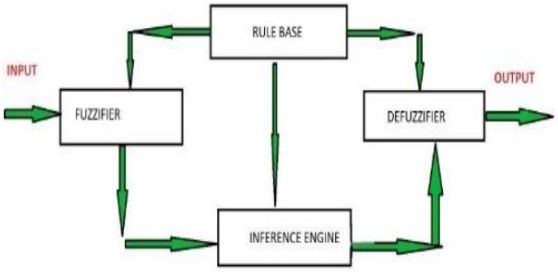

Figure 1. Fuzzy Logic Architecture[6]

Fuzzification is the process of converting the input into Fuzzy sets. A sharp input refers to a precise input that is measured by sensors and sent to the control system for processing, such as temperature, pressure, speed, and so on. The Inference Engine determines the level of match between the current fuzzy input and each rule, and based on the input fields, it decides which rule to trigger. The triggered rules are associated with control actions.

Defuzzification is employed to convert the fuzzy sets obtained from the inference engine into explicit values. There are various defuzzification methods available, and the most appropriate method is selected for a specific expert system to minimize errors. Fuzzy logic, due to its resemblance to human thinking and decision-making, provides highly efficient solutions to complex problems across various domains of life.

V CONCLUSION

The paper discusses the Fuzzy logic system and its applications. It also explores the techniques and areas where the system is currently being developed. The Fuzzy logic system is based on the concept of membership function and implements fuzzy rules. It proves to be an effective tool for solving various computing problems. The problem-solving technique is transparent and flexible, allowing for scalability and customization based on specific application needs. The paper provides a comprehensive overview of the implementation and acceptance of fuzzy systems in various industries and organizations. Fuzzy logic finds applications in business, politics, environment, chemistry, physics, statistics, medical, computer science, engineering, agriculture, and more. As technology advances and digital transformation continues, the application scope of Fuzzy logic is expected to grow.

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