

# A Study on Fuzzy Logic and its Applications

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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 True and 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, cheese optimization in cheese industry, milk optimization 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, "Importance of Fuzzy Logic and Application Areas in Engineering Research", authors have discussed about how Fuzzy Logic is efficient in solving non-linear problems with high complexity and has the capability to handle real world problems. The paper discuss about identifying colon malignant growth, intense leukemia and other diseases wherein microarray DNA dataset is used to identify diseases with the help of Fuzzy logic. The authors have elaborates about how

Fuzzy logic is utilized in area of defense to recognize underwater target recognition, target tracking etc. In finance and Banking, Fuzzy systems are helping in decision making. In manufacturing and production quality control and process management are taken care by Fuzzy system. In machine learning and pattern recognition, classification, clustering, optimization are done using Fuzzy logic, In Transportation industry, Fuzzy based systems are adopted, In medical science for diagnosis of diseases and in industrial sectors Fuzzy systems are adopted. The advantages of Fuzzy systems are high precision, similar as human reasoning. Demerits include low speed, lack of real time response. The Fuzzy systems can be included in text mining, object recognition, image classification, image retrieval and optimization. [2]In the paper “Application of Fuzzy Logic in Transport Planning”, authors have described about solving complex traffic and transportation engineering problems using Fuzzy logic. The trip generation, Trip distribution, Modal split (Modes of transport), Route choice, traffic assignment wherein the paper briefs about Deterministic Link Travel time, Actual link travel time, Fuzzy sets for perceived link travel time such as travel time is normal, link is congested, link has incident, link has construction & special events. The paper discusses about Fuzzy shortest path(FSP) Algorithm which has the steps of converting Fuzzy graph to crisp graph, find shortest path in graph G, calculating membership, Fuzzy traffic assignment. The paper gives a clear picture of accepting crisp input vector and producing a crisp scalar output. [3]In the paper “ Fuzzy Logic and its Applications in some Area: A Mini review”, the authors have discussed about Fuzzy set notation proposed by Lotfi.A.Zadeh in 1965.Fuzzy logic can be applied in the field of commerce wherein it is a trusted model in evaluation and Quantification in E-commerce. Fuzzy systems are adopted in the area of environment. The FWPI(Fuzzy water pollution index) indicates that if the value of this index is higher, then higher is the concentration of pollutants. Fuzzy logic in the field of chemical engineering system to analyse safety, piping risk assessment, combustion process, food produce etc. In the field of physics, statistics, medical, computers, Engineering, agricultural. [4]In the paper “ International journal of Statistics and Applied Mathematics ”,author has described about mathematical logic and it is relevant in many branches.

In the concept of fuzzy logic Boolean logic accepts only two values true or false (0 or 1).This paper reviews a few areas where fuzzy logic has been applied successfully. Some of them are, In chemical science, in this the fuzzy technique implemented by engineers through this the fuzzy logic has great contribution in chemical science, In Healthcare industry here the biomedical system are used and to regulate the blood pressure in case of open heart patients a real time fuzzy control drug delivery system has been tried, In Agriculture here the paper “Design and development of fuzzy expert system for integrated disease management in finger millets”, It identified diseases as Immune, highly resistant. Next In the field of Political science here in the paper “Selection of candidate by political parties using fuzzy logic” the five factors are considered to select a candidate that is behavior, age, character, publicity and education, In operations research here the main aim is to maximize profit and to minimize cost of production or cost of transportation etc., In Household here many have appliances are being upgraded using fuzzy logic to get the optimal result, In environment science here it has been successfully used in detection of natural tragedies like flood and in environment change etc, Finally through this paper it presents a brief outline of fuzzy logic and its applications in many fields. [5]In the paper “Fuzzy Logic expert system for evaluating the activity of university teachers”, authors have described about the traditional methods of dealing with affiliation and logic. The application of fuzzy logic as a simple method for deciding on an clear evaluation of institution of higher education teachers based on ambiguity, imprecision, or lack of input era information. There are followers of the idea that the two terms actually refer were Artificial Intelligence and Intelligent computing. A taxonomy of intelligent system is shown and the sources of uncertainty, ways to express uncertainty, Reasoning techniques, Possibility theory, the importance of using fuzzy logic system, the description of the concept of fuzzy logic , Mandami model has described briefly and also about the usage of the Mandami model, Mandami inference(Max-Min) with a single rule and also it includes with the Mandami inference with multiple rules, it also describes about the defuzzification. The concept of software implementation of fuzzy algorithms are used. The block diagram of the fuzzy system for evaluating the research activity. Finally

through this paper it brief about the model of fuzzy logic applied to the evaluation of university professors. [6]In the paper “Fuzzy Logic Control System and its Applications”, authors have described about computerized process control system. In the present competitive scenario the fuzzy logic system are being adopted by the automotive manufactures for the improvement of quality and reduction of development time and the cost as well. It was introduced by Dr.Lotfi Zadeh of a professor at the university of California at Berkley in the 1960’s as a means to model the uncertainty of natural language. In this the process of “Fuzzification” as a methodology to generalize any specific theory from a crisp (discrete) to a continous (fuzzy) form. The birth and the evolution of fuzzy logic is narrated by the pioneer zadeh, Next the fuzzy expert system are used in fuzzy logic instead of Boolean logic. They are used in several broad areas, including Linear and non Linear conrol, pattern recognition ,Financial systems and also the operation of fuzzy logic is described in the paper, The basic principles of fuzzy control system, Two approaches of control system has been elaborated through different approaches like algorithmic optimization and heuristic approach. Fuzzy reasoning or logic operations in this the description of fuzzy set theory is defined. and also the usage of fuzzy logic system is described, Applications of fuzzy logic is described. Finally through this paper it briefs about the overview of fuzzy logic control system and its application.

### III METHODOLOGY

Fuzzy logic system requires a stream of processing architecture. This includes Rule base, Fuzzifier, Defuzzifier and Inference engine. Fuzzy logic is a technique to embody human like thinkings into a control system. Fuzzy logic is used in the aerospace field for altitude control of spacecraft and satellites. Fuzzy logic can emulate human deductive thinking, that is the process people use to infer conclusions from what they know. Fuzzy logic is implemented using fuzzy rules, which are if-then statements that convey the connection between input variables and output variables in a fuzzy way. The output of a Fuzzy logic system is a Fuzzy set, which is a set of membership degrees for each possible output value. Fuzzy logic provides very valuable flexibility for reasoning. 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 heuristic that makes it possible to obtain an array of accurate conclusions. The architecture of the Fuzzy logic system is exposed in Figure 1. A typical fuzzy system can be split into four main parts they are, Rule base, Fuzzification, Inference engine, Defuzzification. The first step of a fuzzy logic system is Rule base, which contains rules given by experts and the IF-THEN conditions that guide decision making system, on the basis of linguistic information. Recent developments in fuzzy theory provide several efficient methods for fuzzy controller design and tuning. The majority of these developments decrease the number of Fuzzy rules.

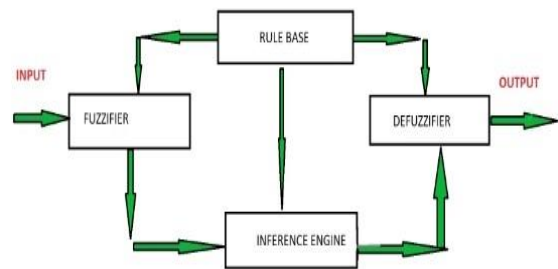


Figure 1.Fuzzy Logic Architecture[7]

Fuzzification is the phase in which the input gets converted to Fuzzy sets. A sharp input is essentially a precise input that is measured by a sensors and passed to the control system for processing, such as: Temperature, pressure, speed, etc.

The Inference Engine determines the match level of the current fuzzy input for each rule and decides which rule to trigger based on the input fields. Trigered rules are bound to control actions.

Defuzzification is used to convert the fuzzy sets obtained by the inference engine into explicit values. Several defuzzification methods are available, and the most suitable method for a particular expert system is used to reduce errors. Because fuzzy logic resembles human thinking and decision-making, it offers highly efficient solutions to complex problems in all areas of life.

### V CONCLUSION

In addition to exploring the Fuzzy logic system and its applications, the paper discussed some of the techniques and areas where the Fuzzy logic system is being developed. It is based on the concept of

membership function and the implementation is done using fuzzy rules. Fuzzy logic is an effective tool for solving various computing problems in the world. The problem solving technique is very transparent and flexible to scale and minimize requirements according to the application needs. In this context, the paper provides the detailed overview of fuzzy system implementation and acceptance in various industries and organizations. Fuzzy logic in business, politics, environment, chemistry, physics, statistics, medical, computer science, engineering, agriculture, etc. Finally, the application scope of Fuzzy logic will increase due to technological advancement and digital transformation.

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