

# Fuzzy Logic : Examining its Real-World Applications Through Literature

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**Abstract:** *It's been claimed that mathematics is the art of all arts and the science of all sciences. Most mathematical ideas and procedures have applications in a variety of other disciplines, including engineering, robotics, physics, etc. Among them are terms like fuzzy logic. This expression is spreading beyond mathematics and appearing in other disciplines such as engineering, medicine, robotics, etc., as well as in households. This paper presents the idea of fuzzy logic and its applications in many domains. This study serves as an example of how fuzzy logic is used in the fields of political science, chemical science, medicine, agriculture, operations research, and environmental science. This paper illustrates the three main stages of the fuzzy logic technique: fuzzification, rule or inference, and defuzzification. The findings demonstrated that fuzzy logic is a more versatile approach than mathematical logic, with applications across a wide range of domains.*

**Keywords:** Fuzzy Algorithms, Fuzzy Optimization.

## I. INTRODUCTION

A wide variety of academics from many disciplines and eras have studied fuzzy logic, a mathematical concept. A significant shift has been brought about via fuzzy logic. Fuzzy logic has made a lot of things simpler, saving people time, money, and effort. Lotti Zadeh initially introduced fuzzy logic in 1965. Before Zadeh, a number of academics made significant contributions to this field of study, including Plato, Hegel, Marx, Lukasiewicz, and others [1]. In boolean logic, there are just two potential outcomes: true or false (0 or 1). Some of them provided three valued logic, while others provided four or five.

Fuzzy sets and fuzzy logic are the definitions of mathematics given by Lotti Zadeh in his book "Fuzzy Sets". Before fuzzy logic was invented, mathematicians could only conclude that a given number was either 0 or 1. But this range has been expanded to include the actual integers (0, 1) using fuzzy logic. This essay defines fuzzy logic and provides an outline of its many applications. This research shows how fuzzy logic may be used in a variety of ways to enhance conceptual understanding.

## II. CONCEPT OF FUZZY LOGIC

Boolean logic accepts just two values: true or false (0 or 1). This one may be used to talk about high or low. Since there is no meaning sent between them, it disproves the notion of a medium. This might be accomplished with fuzzy logic, a more complex idea that takes values [0, 1]. This concept makes it possible to talk about very low and very high as well as low, high, and medium. So, it's larger-scale Boolean logic.

Unknown or inadequately clear is referred regarded be fuzzy. When using fuzzy logic, a proposition might have a median truth value, be true, or be false. It is intended to address the concept of partial truth. The degree of truth is represented by the membership function. A membership function on a set X is any function from X to a real unit interval [0, 1]. Values between 0 and 1 indicate partially true values, whereas values between 0 and 1 represent erroneous values. One of the numerous advantages of fuzzy logic is that it mirrors human thought processes. Linguistic variables are used to simplify this.

### III. FUZZY LOGIC CONTROL

The fuzzy logic controller operates in three stages. The first stage is fuzzification. As a result, a clear variable becomes fuzzy. In the second step, the If Then format is used to define the rules and operate the inference system. The third step is defuzzification. After that, this hazy output is converted back into a sharp variable [2].

Fuzzification + Inference system Defuzzification

#### Application of Fuzzy Logic

Based on fuzzy sets and fuzzy logic, fuzzy mathematics is an extension of classical mathematics. Fuzzy logic is a broad concept. It has uses in a variety of fields outside of mathematics. This research looks at a few areas where fuzzy logic has been used successfully. Below is an overview of few of them:

#### In chemical science

Fuzzy logic has been used in chemical research. Davidson and Hayward [3] looked at a number of situations where fuzzy logic was used. Almary's study employed a fuzzy control system to apply current to several anodes in order to protect a long subterranean conduit and minimize the amount of power needed to do so [3]. The study claims that he constructed a fuzzy control system using 126 rules and modified the output membership functions to get the intended outcomes. Adroer et al. found that fuzzy error, or the difference between the planned and actual pH, was helpful in controlling the pH of flowing waste water [3]. Using a fuzzy method, Adroer et al. found that a small mixer with a brief dwell time might provide sufficient pH control. Thus, the study highlights the important contribution fuzzy logic has made to the field of chemical science.

#### In Healthcare Industry

In the medical area, fuzzy logic has been used. Despite being seen as a branch of science, biomedicine is really an artistic endeavor. As human knowledge, experience, and talents constitute the foundation for both sickness diagnosis and therapy. Inherent nonlinearity, temporal variability, and temporal delay are features of biological systems. To regulate blood pressure in patients with open hearts, a real-time fuzzy control drug delivery system was tried in the 1980s [10]. Davidson and Hayward's study [3] states that Warren et al. suggested a decision support system based on fuzzy approach for automating the acceptance of clinical practice recommendations. The study shows that test report probability estimates may be considered as membership values in fuzzy techniques and utilized as such in fuzzy inference models, instead of providing confirmation of the presence or absence of a disease. The study so indicates the important role fuzzy logic plays in the medical field.

#### In Agriculture

Researchers Philomine Roseline T. and N. Ganesan [4] examined the use of fuzzy logic in agriculture. In this work, fuzzy logic is used to build expert systems for various crops, examine and analyze soil, and control pests, illnesses, and weeds. The diseases that were identified in the research paper "Design and development of fuzzy expert system for integrated disease management in finger millets" fell into one of the following categories: immune, highly susceptible, immune, resistant, moderately resistant, and resistant. The expert system reasoned through possibilities using the fuzzification and defuzzification methods, which are restricted to use by experienced farmers or agricultural experts. Three pest-related inputs in the fuzzy logic method were found during the analysis of the paper "Integrated pest management system using fuzzy expert system": the number, size, and damage of the pests. The fuzzy membership function was used by the fuzzy-based expert system "Design and development of expert system for potato crop" to assess the soil condition. As a result, the study shows how widely the fuzzy logic approach is used in agriculture.

#### In Political Science

Political science is the study of selecting candidates for public office, forecasting election results, etc. These concepts may be examined using fuzzy logic. The research "Selection of candidate by political parties using fuzzy logic" [9] considers the following five criteria: behavior, age, character, publicity, and education. The study presented in this article shows that there are no hard rules or mathematical formulae that can provide an exact answer. Fuzzy logic thus

serves this function nicely. The article "Election results prediction system based on fuzzy logic" [5] predicts election results using three phases of fuzzy logic. The study shows that, for the research project, nine elements were selected as input variables and one as an outcome variable. Next, a MATLAB toolbox known as the fuzzy logic toolbox is used, and 91 rules are constructed for the fuzzy system. Additionally, the study shows that the outcome is given as a percentage, showing the different winning probabilities. Thus, fuzzy logic has also significantly advanced political science.

### **In Operations Research**

Optimization-related issues are studied in operations research. Profits are increased and expenses related to manufacturing, transportation, and other activities are reduced with the use of operations research. It is quite useful to use fuzzy logic in operations research. The use of fugitive logic might reduce transportation expenses. Pappis and Mamdani (1977) [2] effectively combined fuzzy logic with operation research approaches. The research demonstrates how to manage an intersection of two one-way lanes using fuzzy logic. Fuzzy logic was utilized by Teodorovic and Kalie (1996) to identify the method of transportation that would have the lowest cost and fastest trip time [2]. Using fuzzy logic to regulate traffic is quite beneficial. Fuzzy logic was utilized by Jarkko and Esko (2003) to reduce the possibility of accidents and wait times at traffic lights [2]. The paper illustrates the use of fuzzy logic in operations research in this way. Fuzzy logic is thus crucial to operations research.

### **In Household**

Many home appliances are being improved these days using fuzzy logic to save costs and time. Fuzzy logic systems are used in many home appliances, such as washing machines, air conditioners, and vacuum cleaners. The fuzzy logic dish washer by Tiryaki and Kazan and the fuzzy logic washing machine optimizer by Alhanjouri and Alhaddad are the two main works based on fuzzy logic. Other researchers then focused on this to reduce the time and water required for cleaning. The study of the article "Washing machine using fuzzy logic" [7] demonstrates the usage of fuzzy logic in washing machines. Eighty-one rules are used, according to the study, to determine the relationship between four input variables, five output variables, and their configuration. Other researchers collected verbal inputs on garment type, kind of filth, amount of laundry, etc. using sensors found in washing machines. These control language output, including how long the wash, spin, and rinse cycles last. The study shows how fuzzy logic may be used to air conditioners and air coolers. The examination of the paper "Application of Fuzzy Logic in Daily Life" [2] indicated that the design of the room cooler may make use of a number of input and output values. The research included two input factors, temperature and humidity, and three output variables, exhaust fan speed, water pump speed, and cooler fan speed. To obtain the best result with them, fuzzy logic was used. Thus, fuzzy logic is also quite useful at home.

### **In Environment Science**

Fuzzy logic may also be used to environmental studies. Among other things, it has proven useful in predicting natural catastrophes like floods and changes in the environment. The benefits of using a fuzzy logic model with If-Then rules for flood detection system prediction based on the Mamdani method were shown in a review of the paper "Prediction of flood detection system fuzzy logic approach" [8]. The inputs and outputs in this article are the water level, the climate, and control measures. The flood prediction procedure is governed by a total of twenty-five regulations. To save the environment, automobiles may now be made safer, more efficient, and more efficient thanks to fuzzy logic. Thus, fuzzy logic has also significantly advanced environmental studies.

## **III. CONCLUSION**

Boolean or two valued logic is expanded by fuzzy logic. Fuzzification, inference systems, and defuzzification are the three primary methods utilized in this. It is conveniently taught utilizing fuzzified teaching approaches. Therefore, utilizing multivalued fuzzy logic as opposed to two-valued logic makes sense. An overview of fuzzy logic and its applicability in various disciplines is presented in this article. This article presents an overview of fuzzy logic and its applications; much more is explored than is offered here. However, there are currently numerous realized and discovered applications for it. There are still many items that need to be located. The idea of fuzzy logic and its

applications in chemical research, the healthcare industry, and agriculture are covered in this study. in the realms of ecology, home, operations, and political science. As a consequence, fuzzy logic has proved valuable in many other domains beyond mathematics.

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