REAL-LIFE APPLICATIONS OF FUZZY LOGIC

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Accepted: 07.04.2022 **Published**: 01.05.2022

Keywords: Fuzzy, Boolean, Uncertainty in Fuzzy Environments, Fuzzy Set, Defuzzification.

Abstract

The theory of fuzzy logic is based on the notion of relative graded membership, as inspired by the processes of human perception and cognition. Lotfi A. Zadeh published his first famous research paper on fuzzy sets in 1965. Fuzzy logic can deal with information arising from computational perception and cognition, that is, uncertain, imprecise, vague, partially true, or without sharp boundaries. Fuzzy logic allows for the inclusion of vague human assessments in computing problems. Also, it provides an effective means for conflict resolution of multiple criteria and better assessment of options. New computing methods based on fuzzy logic can be used in the development of intelligent systems for decision making, identification, pattern recognition, optimization, and control. Fuzzy logic is extremely useful for many people involved in research and development including 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.

Paper Identification

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Introduction

Computers mainly use Boolean Logic to determine the result of scenarios. As per the Boolean Logic, value 1 refers to True, and 0 means False. The term Fuzzy refers to something unclear or vague. The computer cannot easily understand such cases. Thus, it cannot produce an exact result of True or False. But a Fuzzy Logic algorithm makes systems more intelligent and helps them understand the problems where there may be other answers than true or false. Lotfi Zadeh was the first to describe the term Fuzzy Logic in 1965. He thought that as humans cannot answer every question with a Yes or No, traditional computers are also not capable of processing unclear data. These uncertainties can be:

- Definitely yes
- Possibly yes
- Can't say
- Possibly no
- Definitely no

How Fuzzy Logic Works?

Let's try to understand the Fuzzy Logic with the help of the following example.

Problem – Is it cold outside?

Boolean Logic

- Yes
- No

Fuzzy Logic

- Very cold
- Little cold
- Moderately cold
- Not at all

As you can see, Fuzzy Logic addresses the problem better, such as very cold, moderately cold, or not cold. These answers are displayed with the help of values between 0 and 1.

So, in cases where an accurate answer cannot be provided, Fuzzy Logic provides satisfactory reasoning. A Fuzzy Logic, coupled with a good algorithm takes into account all the available data and then comes up with the best possible solution.

Let's take a look at another example:

Problem – Is the fuel tank full?

Boolean Logic

- Yes
- No

Fuzzy Logic

- Full
- Almost full
- Half Full
- Almost empty
- Empty

In the example above, we can see that Fuzzy Logic is a better way to answer the question as a fuel tank is mostly neither full nor empty.

Advantages of Fuzzy Logic Systems

Some benefits of Fuzzy Logic systems are:

- A robust system that works with vague inputs
- Acceptable input types are imprecise, distorted or uncertain data
- The feedback sensor can be reprogrammed if it stops working
- The Fuzzy Logic algorithms do not occupy a huge memory space
- Fuzzy Logic systems are used to solve complex problems
- Systems with a simple structure

Characteristics of Fuzzy Logic

Following are the characteristics of fuzzy logic:

1. This concept is flexible and we can easily understand and implement it.
2. It is used for helping the minimization of the logics created by the human.
3. It is the best method for finding the solution of those problems which are suitable for approximate or uncertain reasoning.
4. It always offers two values, which denote the two possible solutions for a problem and statement.
5. It allows users to build or create the functions which are non-linear of arbitrary complexity.
6. In fuzzy logic, everything is a matter of degree.
7. In the Fuzzy logic, any system which is logical can be easily fuzzified.

Architecture of a Fuzzy Logic System

In the architecture of the Fuzzy Logic system, each component plays an important role. The architecture consists of the different four components which are given below.

1. Rule Base
2. Fuzzification
3. Inference Engine
4. Defuzzification

1. Rule Base

Rule Base is a component used for storing the set of rules and the If-Then conditions given by the experts are used for controlling the decision-making systems. There are so many updates that come in the Fuzzy theory recently, which offers effective methods for designing and tuning of fuzzy controllers. These

updates or developments decreases the number of fuzzy set of rules.

2. Fuzzification

Fuzzification is a module or component for transforming the system inputs, i.e., it converts the crisp number into fuzzy steps. The crisp numbers are those inputs which are measured by the sensors and then fuzzification passed them into the control systems for further processing. This component divides the input signals into following five states in any Fuzzy Logic system:

- Large Positive (LP)
- Medium Positive (MP)
- Small (S)
- Medium Negative (MN)
- Large negative (LN)

3. Inference Engine

This component is a main component in any Fuzzy Logic system (FLS), because all the information is processed in the Inference Engine. It allows users to find the matching degree between the current fuzzy input and the rules. After the matching degree, this system determines which rule is to be added according to the given input field. When all rules are fired, then they are combined for developing the control actions.

4. Defuzzification

Defuzzification is a module or component, which takes the fuzzy set inputs generated by the Inference Engine, and then transforms them into a crisp value. It is the last step in the process of a fuzzy logic system. The crisp value is a type of value which is acceptable by the user. Various techniques are present to do this, but the user has to select the best one for reducing the errors.

Real-Life Applications of Fuzzy Logic

The Fuzzy Logic can be used in a variety of industries, including domestic goods, automotive systems, environment control, etc. Some of them are:

- It is used to control the altitude of aircraft, satellites, and spaceships.
- It is used in automotive systems to monitor and control the traffic and speed.
- Large companies used it for personal evaluation and decision making support systems.
- The chemical industry uses Fuzzy Logic for processes like controlling the pH.
- Fuzzy Logic, coupled with technologies like Natural language processing and Artificial Intelligence, can enhance the capabilities of systems.
- It is extensively used in systems to automate vehicle control.
- The purpose of using Fuzzy Logic is to make decisions like a human in case of unclear data, but faster. Thus, making it suitable for Neural Networks.

Fields where fuzzy logic are applied

Aerospace

In aerospace, fuzzy logic is used in the following areas −

- Altitude control of spacecraft
- Satellite altitude control
- Flow and mixture regulation in aircraft deicing vehicles

Business

In business, fuzzy logic is used in the following areas −

- Decision-making support systems
- Personnel evaluation in a large company

Defence

In defence, fuzzy logic is used in the following areas −

- Underwater target recognition
- Automatic target recognition of thermal infrared images
- Naval decision support aids
- Control of a hypervelocity interceptor
- Fuzzy set modelling of NATO decision making

Electronics

In electronics, fuzzy logic is used in the following areas −

- Control of automatic exposure in video cameras

- Humidity in a clean room
- Air conditioning systems
- Washing machine timing
- Microwave ovens
- Vacuum cleaners

Marine

In the marine field, fuzzy logic is used in the following areas −

- Autopilot for ships
- Optimal route selection
- Control of autonomous underwater vehicles
- Ship steering

Future Work

Fuzzy logic has been successfully used in numerous fields such as control systems engineering, image processing, power engineering, industrial automation, robotics, consumer electronics, and optimization. This branch of mathematics has instilled new life into scientific fields that have been dormant for a long time. Thousands of researchers are working with fuzzy logic and producing patents and research papers. According to Zadeh's report on the impact of fuzzy logic as of March 4, 2013, there are 26 research journals on theory or applications of fuzzy logic, there are 89,365 publications on theory or applications of fuzzy logic in the INSPEC database.

Fuzzy-logic-based computing technologies help to create intelligent systems for decision making, identification, pattern recognition, optimization, and control. Engineers, mathematicians, software developers, natural scientists, medical researchers, and business analysts can benefit greatly from fuzzy logic.

Conclusion

During the study of various articles and research paper, it is required the fuzzy logic is one of the most accurate technique for processing data and obtained fruitful results. The objectives of the present study were to make a review, that, how the fuzzy logic is useful in various fields regarding solving problems, and benefits for the human health and wealth. Fuzzy Logic functions like the human brain, making it a necessity in expert systems, artificial intelligence, and neural networks. When vague data is input, the AI-based Fuzzy Logic system might be your best friend in finding the solution. This method focuses on what the system should do rather than trying to model how it works. One can concentrate on solving the problem rather than trying to model the system mathematically, if that is even possible. On the other hand the fuzzy approach requires a sufficient expert knowledge for the formulation of the rule base, the combination of the sets and the defuzzification. In General, the employment of fuzzy logic might be helpful, for very complex processes, when there is no simple mathematical model.

RÉFÉRENCIAS

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