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Moving from Binary Logic to Fuzzy Logic: Towards Real Life Cases

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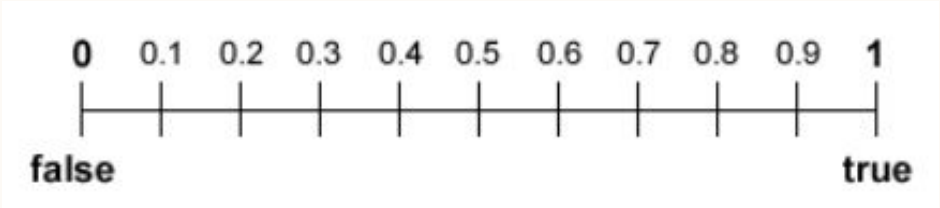
Fuzzy logic

Fuzzy logic is a form of many-valued logic; it deals with reasoning that is approximate rather than fixed and exact. In contrast with traditional logic theory, where binary sets have two-valued logic: true or false, fuzzy logic variables may have a truth value that ranges in degree.



History of Fuzzy Logic

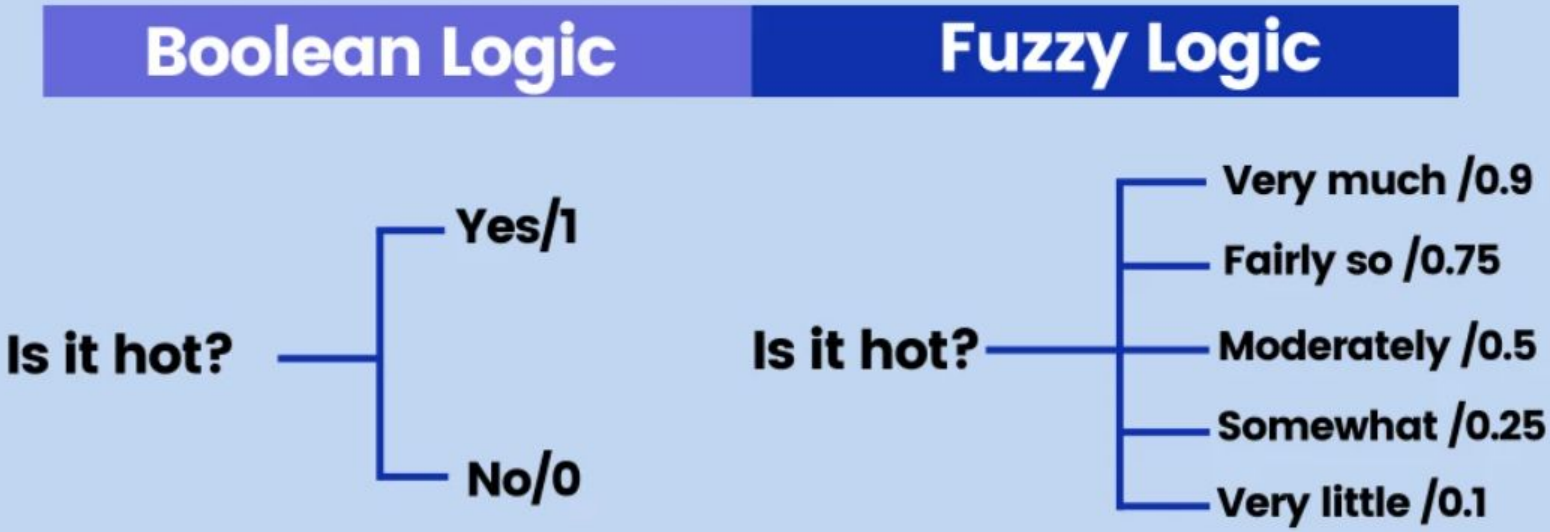
Dr. Lotfi A. Zadeh invented fuzzy logic in the 1960s. It goes beyond simple "true" or "false" logic by introducing the idea of "fuzzy sets," which allow for degrees of membership. This flexible approach is used in various fields, including control systems and artificial intelligence, to handle uncertainty and make more human-like decisions. It has become a crucial tool in modern technology and remains extensively utilized today.

What is Fuzzy Logic used for?

Fuzzy logic finds application in various domains where dealing with imprecise and uncertain information is crucial. It is used in:

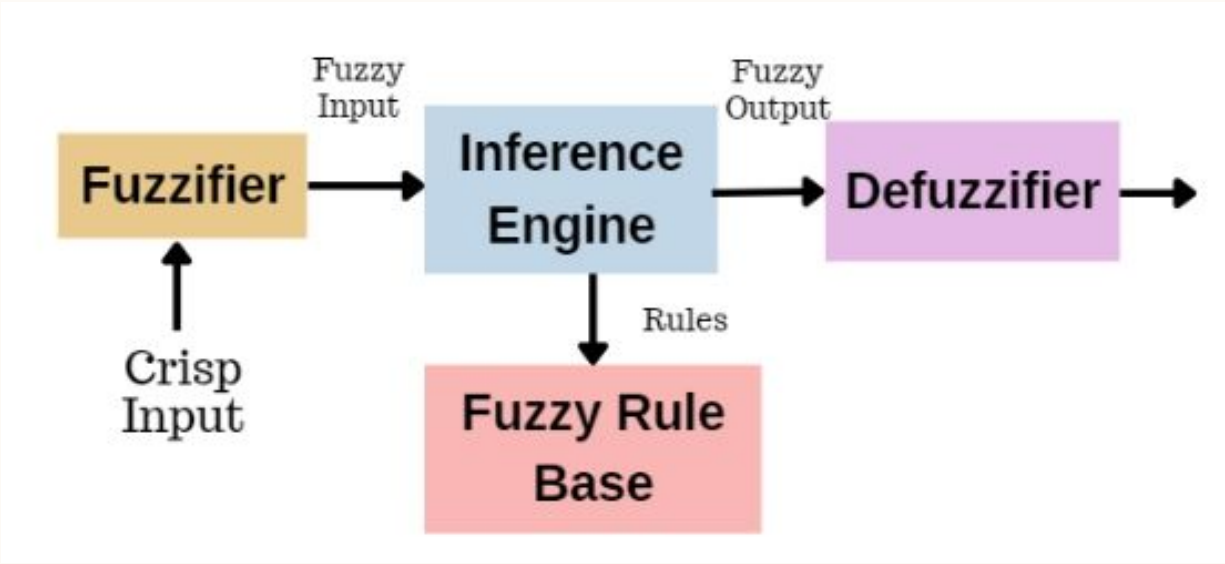
- Control systems,
- Decision-making processes,
- Pattern recognition,
- Artificial intelligence, and
- Natural language processing to enable more flexible and reasoning.

Boolean Logic vs. Fuzzy Logic



Architecture of Fuzzy Logic

The architecture of fuzzy logic consists mainly of four parts. Below diagram shows the architecture of fuzzy logic.



Architecture of Fuzzy Logic

Fuzzifier: The fuzzifier allows mapping of crisp inputs to fuzzy sets. This helps in representing the degree to which the inputs belong. For example, a pressure sensor may maps the pressure reading to the fuzzy set “high” with a membership value of 0.9.

Inference Engine: The inference engine allows making the decisions which are based on the fuzzy sets that are generated by the fuzzifier. It uses fuzzy rules to make decisions.

Architecture of Fuzzy Logic

De-fuzzifier: The de-fuzzifier allows to convert the fuzzy output sets into crisp outputs. These outputs can further be used for decision making.

User Interface: The user interface allows the users to interact with the system that uses fuzzy logic. Users can specify inputs and then view outputs.

Binary Logic in Programming

```
bool speed;
get the speed
if ( speed == 0) {
        //  speed is slow
}
else {
        //  speed is fast
}
```

Fuzzy Logic in Programming

```
float speed;
get the speed
if ((speed >= 0.0)&&(speed < 0.25)) {
        //  speed is slowest
}
else if ((speed >= 0.25)&&(speed < 0.5))
{
        //  speed is slow
}
else if ((speed >= 0.5)&&(speed < 0.75))
{
        //  speed is fast
}
else // speed >= 0.75 && speed < 1.0
{
        //  speed is fastest
}
```

Fuzzy Logic in Control Systems

Fuzzy logic is widely used for heating and cooling systems, industrial processes, vehicles, and robots. It gives you a flexible and easy way to show complicated control relationships and deal with uncertainty in the system being controlled.

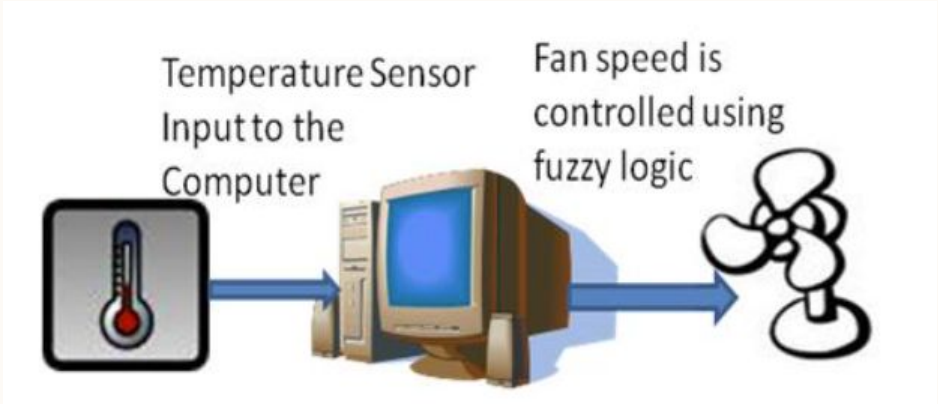
Fuzzy Logic in Control Systems

- Heater/ cooler system
- Vacuum cleaner
- Washing machine devices

Fuzzy Logic in Control Systems

The temperature sensor measures the temperature values of the rooms. The obtained values are taken and then given to the fuzzifier.

The fuzzifier assigns linguistic variables for each measured value and the rate of change of measured value.



Fuzzy Logic in Control Systems

For example, if the measured value is 40^0C and above, then the room is too hot

If the measured value is between 30^0C to 40^0C, the room is quite hot

If the measured value is 22 to 28^0C, the room is moderate

If the measured value is 10 to 20^0C, the room is cold

If the measured value is below 10, the room is too cold.

Fuzzy Logic in Control Systems

The next step involves the functioning of the knowledge base which contains the information of these member functions as well as the rule base.

For example,

if Room is too hot

then set the fan speed to High

If Room is too cold

then set the fan speed to less than Low.

Fuzzy Logic in Control Systems

The next step involves converting this linguistic output variable into numerical variables or logical variables used to drive the fan motor driver.

The final step involves controlling the fan speed by giving proper input to the fan motor driver.

Fuzzy Logic vs. Neural Networks

Fuzzy logic is a reasoning method for handling imprecise data with linguistic variables and rules, while neural networks are brain-inspired computational models used for pattern recognition and data learning.

Fuzzy Logic in Data Mining

Fuzzy logic in data mining deals with data that might be uncertain or not precise. This helps data mining algorithms find better patterns and make accurate decisions, especially when the data is unclear or incomplete. Fuzzy logic is helpful for tasks such as grouping similar data, organizing things into categories, and discovering valuable rules in the data. It is excellent when dealing with complex or messy information.

Fuzzy Logic Applications in AI

Fuzzy logic has a wide range of applications across many fields, including:

Image processing: It is used for image enhancement, noise reduction, and edge detection tasks. It provides a means of representing uncertainty in the image data and making decisions about how to process the image based on it.

Fuzzy Logic Applications in AI

Decision-making systems: It is used for job candidate evaluation, credit scoring, and customer segmentation tasks. It gives a flexible, easy-to-understand way to show uncertainty in the data and make decisions based on that uncertainty.

Medicine and health care systems: Fuzzy logic is used in medical diagnosis and treatment planning. For example, it can diagnose diseases based on symptoms and medical history and determine the best course of treatment based on the patient's condition and available treatments.

Fuzzy Logic Applications in AI

Natural language processing (NLP): Fuzzy logic is used in natural language processing for tasks such as sentiment analysis and text classification. It shows uncertainty in the meaning of natural language text and makes decisions based on this uncertainty.

Fuzzy logic is used in Natural Language Processing

Sentiment analysis: Fuzzy logic can be used in sentiment analysis to determine the sentiment of a text, such as whether it is positive, negative, or neutral. The use of fuzzy logic allows uncertainty in interpreting the sentiment, which is common in NLP problems.

Text classification: Fuzzy logic can categorize text into predefined categories, such as news articles, product reviews, or social media posts. The use of fuzzy logic allows for uncertainty in text classification, which is common in NLP problems.

Fuzzy logic is used in NLP

Word sense disambiguation: Fuzzy logic can be used in word sense disambiguation to determine the correct sense of a word in a given context. The use of fuzzy logic allows uncertainty in interpreting the word sense, which is common in NLP problems.

Text summarization: Fuzzy logic can be used in text summarization to generate a summary of a text that retains the most crucial information. The use of fuzzy logic allows uncertainty in selecting essential data, which is common in NLP problems.

Fuzzy string matching: is a technique of finding strings that match a given string partially and not precisely.

Hybrid Intelligent Systems with Fuzzy logic

Hybrid Intelligent Systems combine more than one intelligent systems.

For example combining neural network with fuzzy logic will provide neuro – fuzzy system.

Also, combine fuzzy logic with genetic algorithm and IoT systems with sensors and control.

THANK YOU