Fuzzy Logic

Artificial Intelligence

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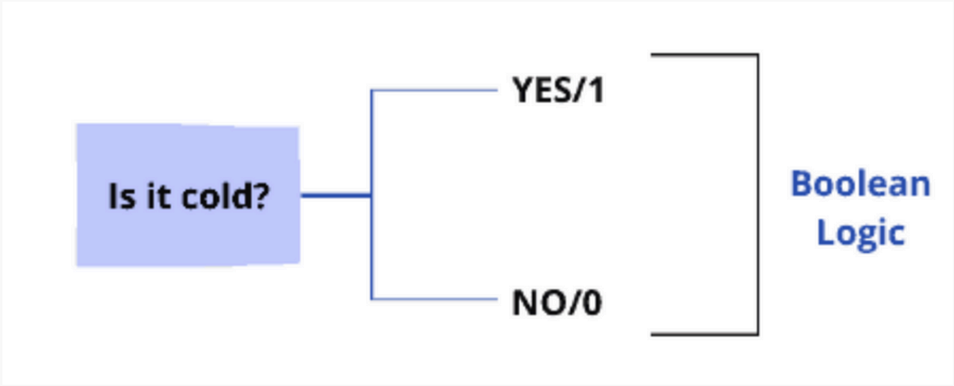
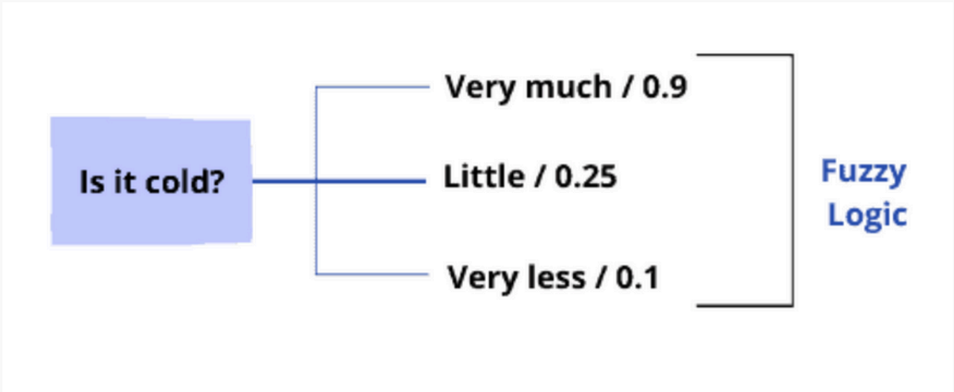
Introduction

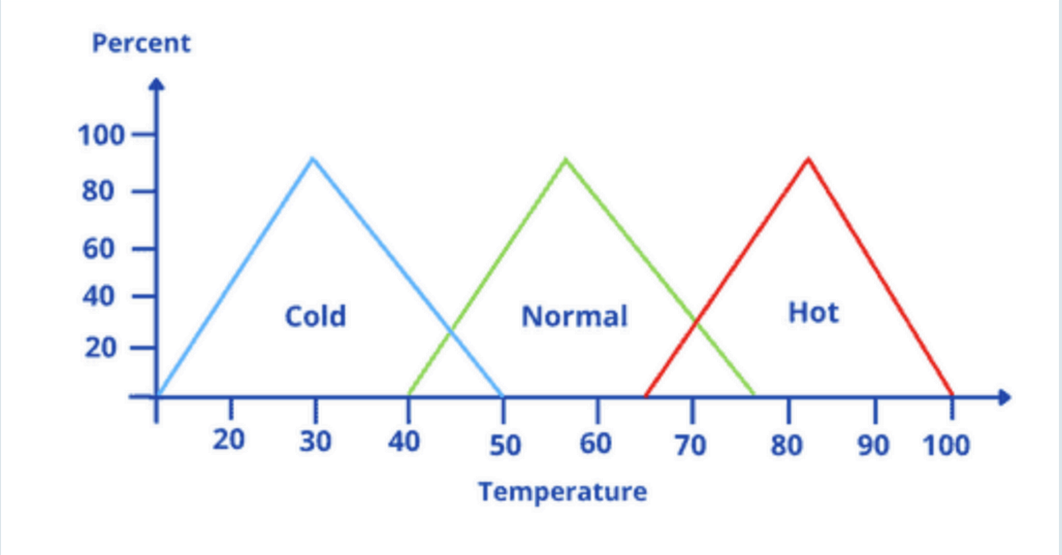
- Form of **many-valued logic** that deals with approximate reasoning rather then fixed and exact values
- Concept of **partial truth** with values ranging between 0 and 1
- **Membership function,** which defines the degree of membership of an input value to a certain set or category

Boolean Logic vs Fuzzy logic

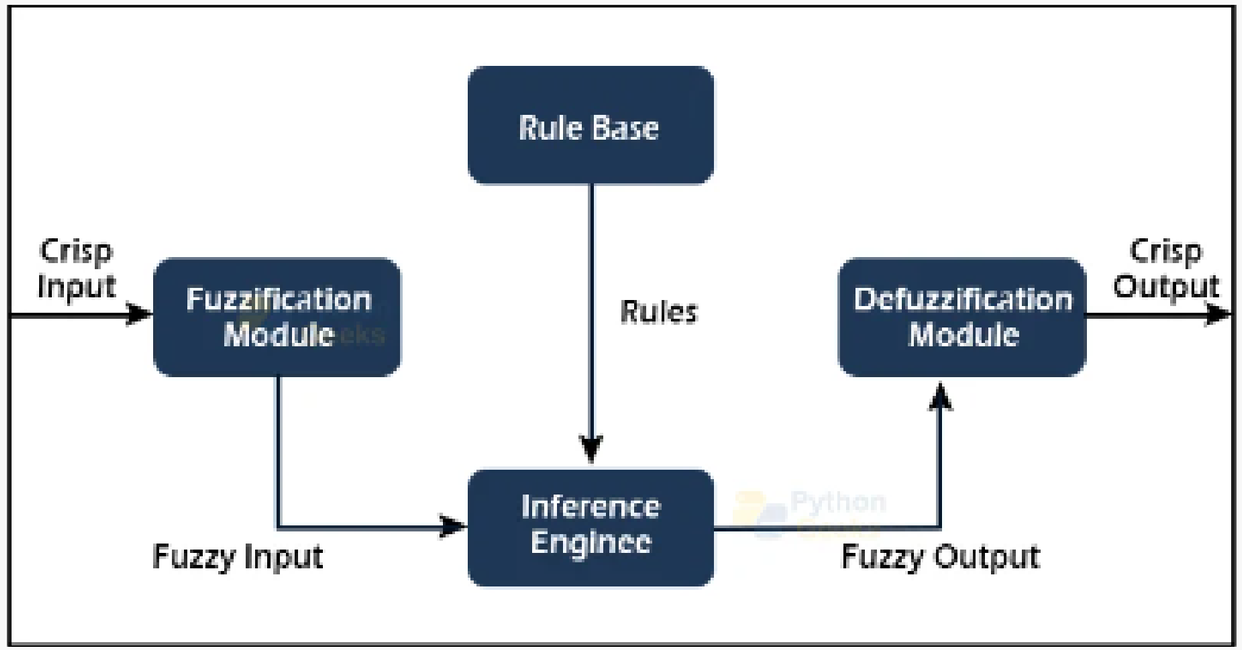




Triangular Membership function



Architecture



Rule Base

- Contains IF-THEN rules and conditions from experts
- Guides decision-making using linguistic information

Fuzzification

- Converts crisp inputs (exact measurements) into fuzzy sets
- Applies triangular membership functions to input data

Inference Engine

- Matches fuzzy inputs with rules
- Determines which rules to activate based on input
- Combines activated rules to form control actions

Defuzzification

- Converts fuzzy sets from the inference engine into crisp values
- Use of Centroid Method (Center of Gravity)

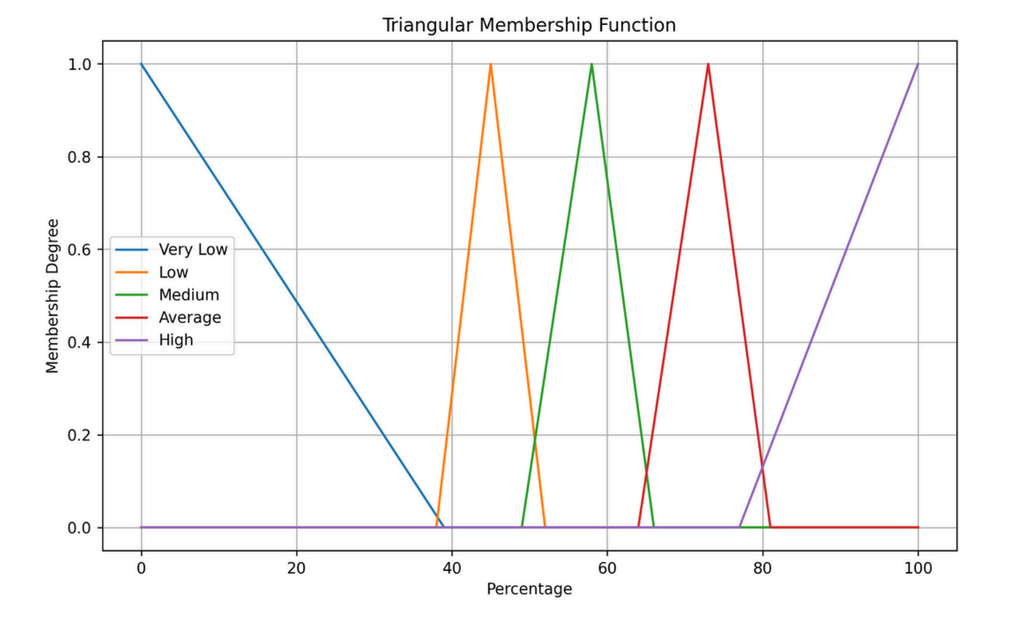
$$\text{Crisp Output} = \Sigma(\mu(x)x) / \Sigma(\mu(x))$$

where $\mu(x)$ = Membership degree at value x

About the project

- Fuzzy logic for classifying students' exam percentage into grades
- **Four categories**: Distiniction, 1st Div, 2nd Div, Pass
- Regular Grading System:
  - 79.8% - 1st Division
  - 80.1%- Distinction
- Unfair?
- Fuzzy logic can solve this problem.

Membership Function

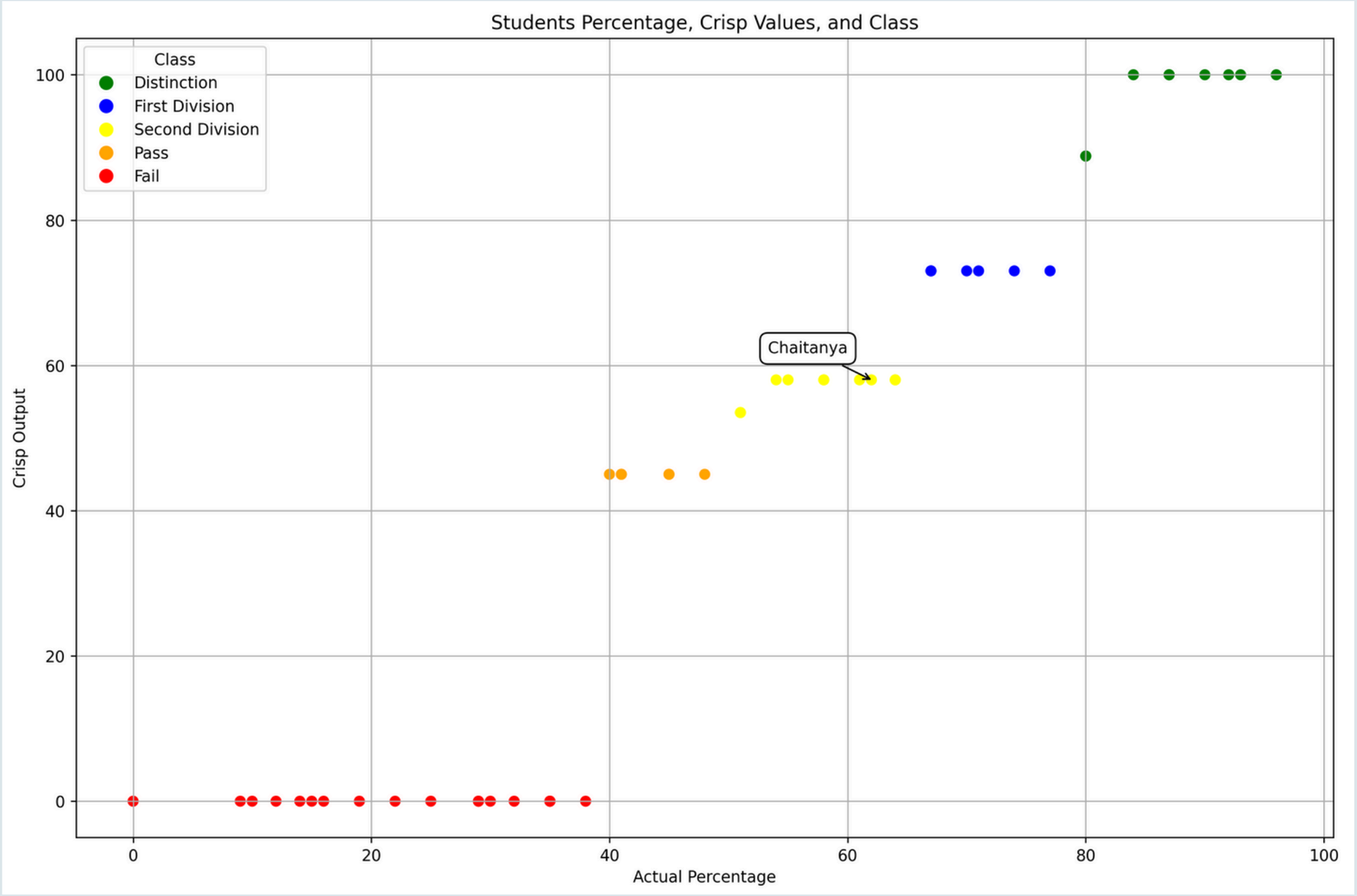


Rules

- **Rule 1-** (0,39): Very Low ---> Fail
- **Rule 1**- (38, 45, 52): High ---> Pass
- **Rule 2**- (49, 58, 66): Average---> 2nd Division
- **Rule 3**- (64, 73, 81): Medium ----> 1st Division
- **Rule 4**- (77,100): Low ---> Distinction

- If a value lies in intersection of multiple functions, apply multiple rules.

Project Output



Testing

```
Test Percentage: 16
Expected Crisp Output: 13
Computed Crisp Output: 13.0

Test Percentage: 39
Expected Crisp Output: 45
Computed Crisp Output: 45.0

Test Percentage: 60
Expected Crisp Output: 58
Computed Crisp Output: 58.0

Test Percentage: 78
Expected Crisp Output: 73
Computed Crisp Output: 75.62101694915255

Test Percentage: 79.8
Expected Crisp Output: 73
Computed Crisp Output: 83.11663551401867

Test Percentage: 97
Expected Crisp Output: 92.33
Computed Crisp Output: 92.33
```

Advantages

- Works with imprecise, distorted, or noisy inputs
- Simple and Understandable to build
- Based on straightforward set theory reasoning
- Provides efficient solutions resembling human decision-making
- Requires little data and memory

Disadvantages

- Various methods lead to ambiguity and lack of systematic approaches.
- Hard to prove characteristics due to lack of mathematical descriptions.
- Often compromises accuracy by handling both precise and imprecise data.

Some other applications

AI

Smart Home Devices, Facial Recognition Systems, Voice Assistants

Automotive

Speed and traffic control

Business Evaluation

Decision-making support and personnel evaluation

Chemical Industry

Controlling pH, drying and distillation process

Control Systems

Temperature Control, Camera Auto-focus, Robotic Control

Aerospace

Altitude control of spacecraft and satellites

Thank you