AIFA: Fuzzy Inference System

11/03/2024

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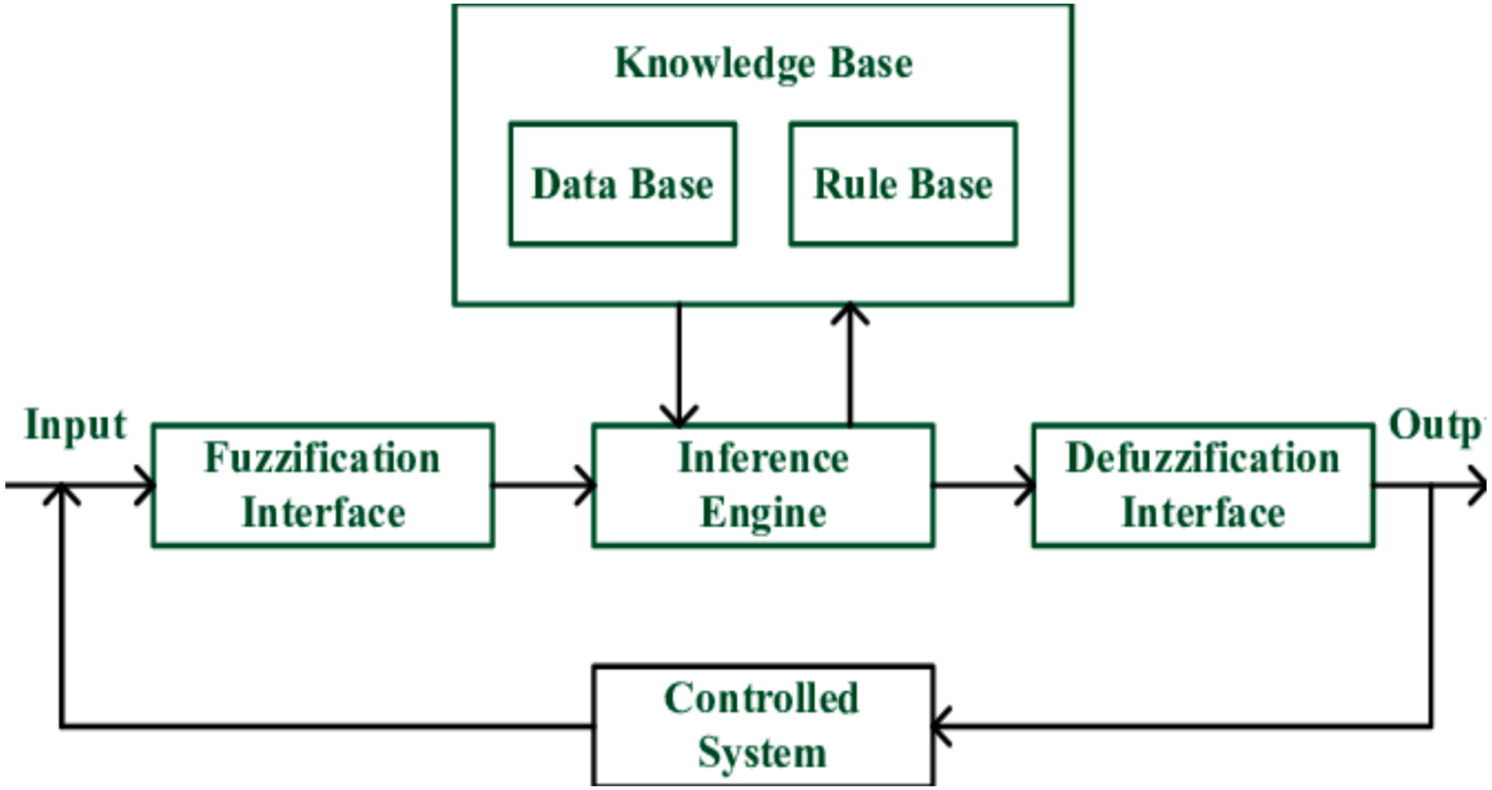
Fuzzy Inference System

- Rule Base: Contains IF-THEN Rules
- Fuzzification: Convert crisp inputs to Fuzzy set
- Inference engine: determines matching degree of current input
- Defuzzification: Convert fuzzy values to crisp values

Fuzzy Inference System



Fuzzification

- Why do we need Fuzzification?
  - Rules are Fuzzy

- Converting a crisp value such as height = 5 ft 6 inches to a membership value of a fuzzy set, such as medium or tall

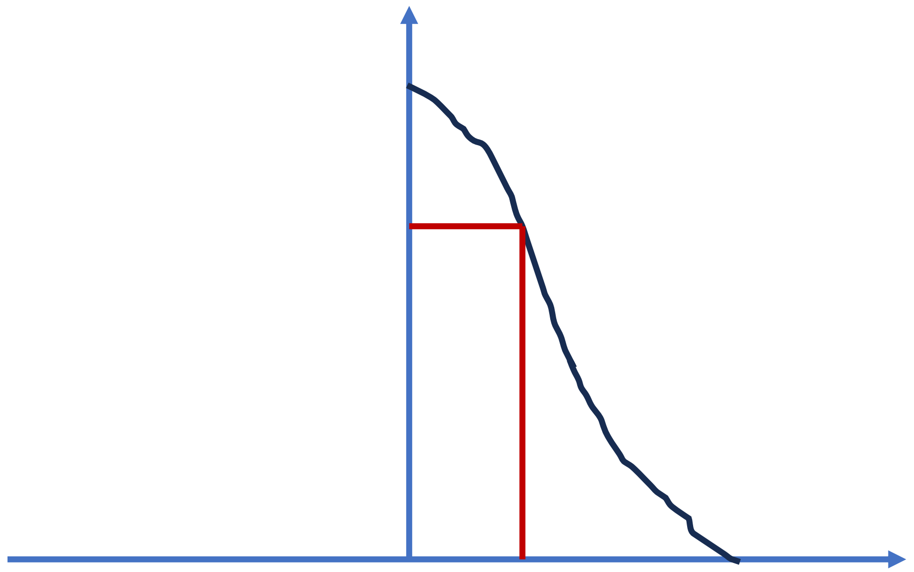
- Different ways of fuzzification – experimental/subjective

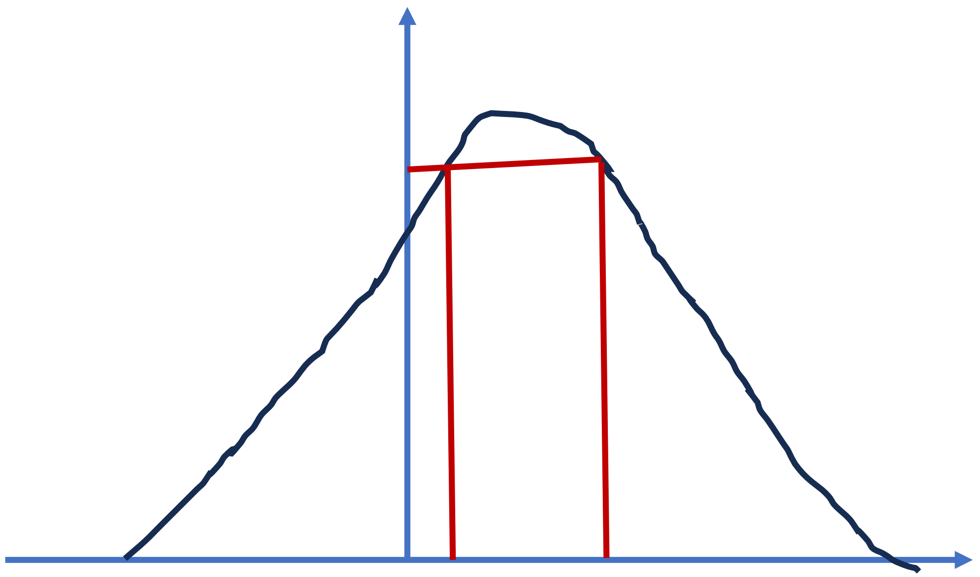
- Fuzzified value serves as input to the fuzzy rules

Defuzzification

- Converting a fuzzy term such as small shift
- To a crisp value such as 5 degrees
- Different methods --- such as COG (Centre of Gravity)

Defuzzification





AIFA: Reasoning Under Uncertainty

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Handling uncertain knowledge

- $\forall_p symptom(p, Toothache) \rightarrow disease(p, Cavity)$
  - Not correct – toothache can be caused in many other cases

- $\forall_p symptom(p, Toothache) \rightarrow$
  - $disease(p, Cavity) \vee$
  - $disease(p, GumDisease) \vee$
  - …

Reasons for using probability

- Specification becomes too large
  - Difficult to get complete list of antecedents or consequents

- Theoretical ignorance
  - The complete set of antecedents not known

- Practical ignorance
  - The truth of antecedents not known

Reasons for using probability

- Probability that X is fat = 0.2

- If X is fat then X has coronary heart disease = 0.7

- P[X has CHD] = 0.2*0.7 + 0.8*Z

Probability Basics

- **Joint Probability**
  - P(A = a, C = c): joint probability that random variables A and C will take values a and c respectively

- **Conditional Probability**
  - P(A = a | C = c): conditional probability that A will take the value a, given that C has taken value c
  - $P(A|C) = \frac{P(A,C)}{P(C)}$

Bayes Theorem

- Bayes theorem:
    - $P(C|A) = \frac{P(A|C)P(C)}{P(A)}$
    - P(C) known as the **prior probability** for class C
    - P(C | A) known as the **posterior probability**

Example of Bayes Theorem

- Given:
    - A doctor knows that meningitis (M) causes stiff neck (S) 50% of the time
        - $P(S|M) = 0.50$
    - Prior probability of any patient having meningitis is 1/50,000
        - $P(M) = \frac{1}{50000}$
    - Prior probability of any patient having stiff neck is 1/20
        - $P(S) = \frac{1}{20}$
- If a patient has stiff neck, what's the probability he/she has meningitis?
    - $P(M|S)$

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- If a patient has stiff neck, what's the probability he/she has meningitis?
  - $P(M|S)$
  - $P(M|S) = \frac{P(S|M).P(M)}{P(S)} = \frac{0.50 \times \frac{1}{50000}}{\frac{1}{20}} = 0.0002$

Probability Distribution

- Describes joint probability distribution over a set of variables
- A set of random variables $Y_1, Y_2, \dots, Y_n$
  - Each Y_i *can take on the set of possible values* $V(Y_i)$

- Joint space of set of variables:
  - $V(Y_1) \times V(Y_2) \times V(Y_3) \ldots \times V(Y_n)$

- Each item in joint space corresponds to one of the possible assignments of values $< Y_1 = y_1, Y_2 = y_2, \dots, Y_n = y_n >$

- Probability distribution over this joint space is called joint probability distribution

Thank You