Artificial intelligence

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Knowledge Representation and Reasoning

(Concept Map / Infographic Style)

1. Logic

- **Propositional Logic** (📜 *Symbol: P, Q, ¬, ∧, ∨*)
- **Predicate Logic** (🔤 *Symbols: ∀, ∃, variables*)
  Visual: Split branch with "P→Q" and "F(x,y)"

2. Rules

- **If-Then** (🔄 *Flowchart arrow: "If rain, then wet"*)

3. Semantic Net

- **Graph** (🕸️ *Nodes: "Cat", "Animal"; Edges: "Is-a"*)

4. Frame

- **Slots & Filters** (📋 *Table: "Car" frame with slots like "Color: Red"*)

5. Script

- **Sequential Actions** (🎬 *Filmstrip: "Restaurant script: order → eat → pay"*)

6. Key Aspects (⚖️ *Balanced icons*)

- **Syntax** (🔠 *Structure: "Grammar rules"*)
- **Semantics** (💡 *Meaning: Lightbulb over "dog = animal"*)

Probability

$$\Downarrow$$

Calculate the likelihood

of a certain event

Probability

$$P(x) = \frac{\text{\# possibilities that satisfy condition}}{\text{total \# of possibilities}}$$

Ex

Flipping a coin

Prob. of Tails $= 0.5 = 50\%$

$$P(T) = \frac{1}{2}$$

$$P(H) = \frac{1}{2}$$

Probability

$$P(x) = \frac{\text{\# possibilities that satisfy condition}}{\text{total \# of possibilities}}$$

Rules

1) $0 \leq P(x) \leq 1$

2) $P(A) + P(B) + P(C) + \ldots = 1$

3) $P(A) + \underbrace{P(A)^c}_{\textit{Complement}} = 1$

Axioms of Probability: The Foundation of Probability Theory

Probability theory is built on **axioms**—fundamental rules that are assumed to be true without proof. These axioms were formalized by the Russian mathematician **Andrey Kolmogorov** in 1933 and serve as the backbone of modern probability theory.

The Three Basic Axioms of Probability

1. Non-Negativity & Less than or equal to 1

> **The probability of any event is always ≥ 0.**

- Mathematical Form:

$$0 \leq P(\omega) \leq 1$$

- **Example:**
  - Probability of getting **Heads (H)** in a coin toss:

$$P(H) = 0.5 \quad (\text{which is} \geq 0)$$

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2. Normalization (Unit Measure)

> **The probability of the entire sample space (S) is 1 (100%).**

- Mathematical Form:

$$P(S) = 1$$

- **Example:**
  - Rolling a fair die: The probability of getting **1, 2, 3, 4, 5, or 6** must sum to 1:

$$P(1) + P(2) + \cdots + P(6) = 1$$

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3. Additivity (Finite or Countable Additivity)

> **For mutually exclusive events (events that cannot occur together), probabilities add up.**

- Mathematical Form:

$$P(A \cup B) = P(A) + P(B) \quad (\text{if } A \cap B = \emptyset)$$

- **Example:**
  - Probability of rolling a **1 or 2** on a fair die:

$$P(1 \cup 2) = P(1) + P(2) = \frac{1}{6} + \frac{1}{6} = \frac{1}{3}$$

Bayes' Theorem

$$P(A|B) = \frac{P(B|A) \cdot P(A)}{P(B)}$$

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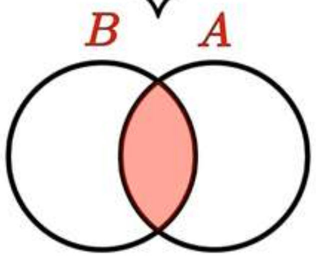
$$P(A|B) = \frac{P(B|A) \cdot P(A)}{P(B)}$$

$$P(A|B) = \frac{P(A \cap B)}{P(B)} = \frac{P(B|A) \cdot P(A)}{P(B)}$$

$$P(B \cap A)$$

$$\Downarrow$$



$$P(A) \cdot P(B|A) = \frac{P(A \cap B)}{\cancel{P(A)}} \cdot \cancel{P(A)}$$

$$P(B|A) \cdot P(A) = P(A \cap B)$$

$$P(A \cap B) = P(B \cap A)$$

Ex You've been planning a picnic for your family. You're trying to decide whether to postpone due to rain. The chance of rain on any day is 15%. The morning of the picnic, it's cloudy. The prob. of it being cloudy is 25% and on days where it rains, it's cloudy in the morning 80% of the time.

Should you postpone the picnic?

$P(\text{rain}) = 0.15$

$P(\text{cloudy}) = 0.25$

$P(\text{cloudy}|\text{rain}) = 0.80$

$$P(A|B) = \frac{P(B|A) \cdot P(A)}{P(B)}$$

$$P(\text{rain}|\text{cloudy}) = \frac{P(\text{cloudy}|\text{rain}) \cdot P(\text{rain})}{P(\text{cloudy})}$$

$$= \frac{0.8 \cdot 0.15}{0.25}$$

$$\boxed{P(\text{rain}|\text{cloudy}) = 0.48}$$