AI Notes

Logical Representation

Description:

- Uses formal logic to represent facts and relationships.
- Provides a declarative and precise way to encode knowledge.
- Knowledge is expressed as propositions, rules, and relationships.
- Involves inference mechanisms for deducing new information.

Types:

- **Propositional Logic**: Represents simple true/false statements.
    - Example: Rain → Wet(Grass) (If it rains, the grass will be wet).
- **First-Order Logic (Predicate Logic)**: Includes objects, relations, and quantifiers.
    - Example: ∀x (Bird(x) → CanFly(x)) (All birds can fly).

Strengths:

- Rigor and clarity.
- Well-suited for reasoning and problem-solving.

Weaknesses:

- Computationally expensive for large-scale systems.
- Difficult to handle uncertainty.

Semantic Networks

Description:

- Represents knowledge as a graph of nodes (concepts) and edges (relationships).
- Nodes represent objects, concepts, or classes, while edges define their relationships.
- Often used for representing hierarchical knowledge.

Example:

- Animal → Bird → Penguin
- Bird → CanFly
- Penguin → CannotFly

Strengths:

- Intuitive and visually interpretable.
- Efficient for representing hierarchical relationships.

Weaknesses:

- Limited in representing procedural knowledge.
- Lacks precision for complex relationships.

Frame-Based Representation

Description:

- Represents knowledge as structures (frames) that describe objects, events, or situations.
- Frames contain **slots** (attributes or properties) and **values** (data or references to other frames).
- Similar to object-oriented programming.

Example:

Frame: Dog

- Slots:
    - Type: Mammal
    - Legs: 4
    - Sound: Bark

Strengths:

- Supports default values and inheritance.
- Organizes knowledge in a modular way.

Weaknesses:

- Limited reasoning capabilities.
- Inefficient for highly dynamic systems.

Ontological Representation

Description:

- Uses **ontologies** to define concepts, their properties, and relationships formally.
- Ontologies are structured frameworks for domain knowledge.
- Often used in semantic web and natural language processing.

Example:

Ontology: Library

- Classes: Books, Authors, Members
- Relationships: Writes(Book, Author), Borrows(Book, Member)

Strengths:

- Provides a shared vocabulary and precise definitions.
- Facilitates interoperability and reasoning.

Weaknesses:

- Time-consuming to design.
- Complex for dynamic knowledge.

Procedural Representation

Description:

- Represents knowledge as a set of procedures or instructions.
- Encodes "how-to" knowledge for performing tasks.

Example:

- Procedure to bake a cake:
    1. Preheat oven.
    2. Mix ingredients.
    3. Pour into a pan and bake

Strengths:

- Directly executable.
- Useful for encoding actions and dynamic processes.

Weaknesses:

- Lacks generality.
- Cannot easily represent declarative knowledge.

Knowledge Reasoning (Inference)

Reasoning is the process of thinking about things in a logical way to make decisions, solve problems, or understand something better

AI systems use reasoning techniques to draw new conclusions from known knowledge. This includes:

- Deductive reasoning: Drawing specific conclusions from general rules.
- Inductive reasoning: Generalizing from specific instances or data.
- Abductive reasoning: Inferring the most likely explanation for a set of observations.
- Probabilistic reasoning: Managing uncertainty through statistical models (e.g., Bayesian inference).

1. Deductive Reasoning:

Description:

- Derives specific conclusions from general facts or rules.
- Based on logic, where if the premises are true, the conclusion must also be true.

Example:

- Rule: All birds can fly.
- Fact: A sparrow is a bird.
- Conclusion: A sparrow can fly.

2.Inductive Reasoning

Description:

- Draws generalized conclusions from specific observations.
- The conclusion is probable but not guaranteed.

Example:

- Observation: Every swan I have seen is white.
- Conclusion: All swans are white.

3.Abductive Reasoning

This reasoning involves making the best guess based on the information available, often used when we don't have complete information.

Example:

- Observation: The ground is wet.
- Possible Explanation: It might have rained.

4.Probabilistic reasoning

Description:

- Deals with uncertainty by assigning probabilities to conclusions.
- Instead of providing definite conclusions, it evaluates the likelihood of different outcomes based on available evidence and prior knowledge

Example:

- Observation: The patient has a fever and cough.
- Conclusion: There is a 70% chance they have the flu.

5.Analogical Reasoning

Analogical reasoning solves new problems by drawing analogies from similar, previously solved problems.

Example:

- Known: A plane flies because it has wings like a bird.
- Inference: A new drone with wings can also fly.

6.Non-monotonic Reasoning

Non-monotonic reasoning allows for conclusions to be revised or withdrawn when new information becomes available, unlike traditional logic where conclusions remain fixed.

Example in Human Thinking:

- You believe that all the stores are closed because it's late.
- But then you see one store's lights on.
- You revise your belief to say that one store might still be open.

Propositional logic

Propositional logic (also called propositional calculus) is a branch of logic that deals with **propositions** and their relationships using logical connectives.

Key Components:

- **Propositions**: Statements that are either true (T) or false (F).
- **Logical Connectives**:
    - **AND (∧)**: True only if both propositions are true.
    - **OR (∨)**: True if at least one proposition is true.
    - **NOT (¬)**: Negates the truth value of the proposition.
    - **IMPLIES (→)**: True except when the first is true and the second is false.
    - **BICONDITIONAL (↔)**: True if both propositions have the same truth value.

Tautology

A **tautology** is a compound statement that is always **true** regardless of the truth values of its components.

Example:

- Proposition: P ∨ ¬P

P	¬P	P ∨ ¬P
T	F	T
F	T	T

Contradiction

A **contradiction** is a compound statement that is always **false** regardless of the truth values of its components.

Example:

- Proposition: P ∧ ¬P

P	¬P	P ∧ ¬P
T	F	F
F	T	F

Contingency

A **contingency** is a compound statement that is **neither always true nor always false**. Its truth value depends on the truth values of its components.

Example:

- Proposition: P ∨ Q

P	Q	P ∨ Q
T	T	T
T	F	T
F	T	T
F	F	F

Predicate Logic

Predicate logic, also called **first-order logic (FOL)**, extends propositional logic by including:

1. **Quantifiers** (universal and existential).
2. **Predicates** (functions or relations applied to arguments).

It allows reasoning about objects and their properties, as well as the relationships between objects, making it more expressive than propositional logic.

Key Components of Predicate Logic

1.Constants:

- Represent specific objects or entities.
- Example: a,b,c (e.g., John, Earth).

2.Variables:

- Represent arbitrary objects in the domain.
- Example: x,y,z

3.Predicates:

- Represent properties or relations.
- Example: Likes(John,IceCream), Greater(x,y)

4.Quantifiers:

- **Universal Quantifier (∀)**: "For all."
    - Example: ∀x(P(x)) "For all x, P(x) is true."
- **Existential Quantifier (∃)**: "There exists."
    - Example: ∃x(P(x)): There exists at least one x for which P(x) is true."

5.Logical Connectives:

- AND (∧), OR (∨), NOT (¬), IMPLIES (→)(then), EQUIVALENT (↔).