AI Knowledge Representation: Semantic Nets & Conceptual Dependency

🎯 Learning Objectives:

By the end of this 60-minute lesson, students will be able to:

- Define and explain the core principles of **Semantic Nets**.
- Illustrate the structure and components of a Semantic Net with examples.
- Define and explain the core principles of **Conceptual Dependency (CD)** theory.
- Translate simple sentences into their Conceptual Dependency representations.
- Compare and contrast Semantic Nets and Conceptual Dependency, identifying their strengths and weaknesses in different AI applications.

⏱️ Time Allotment:

60 minutes

📚 Materials:

- Whiteboard or projector
- Markers or pens
- Handout with example sentences for CD (optional)
- Computer with internet access for visual aids (optional)

👩‍🏫 Lesson Procedure:

Part 1: Introduction to Knowledge Representation (5 minutes)

- **What is Knowledge Representation (KR)?** Briefly discuss why AI systems need to represent knowledge (understanding, reasoning, problem-solving).
- **Why different methods?** Introduce the idea that different types of knowledge and reasoning require different representation techniques.

Part 2: Semantic Nets (20 minutes)

- **Definition:** Explain Semantic Nets as a graphical representation of knowledge, consisting of **nodes** (concepts, objects) and **links/arcs** (relationships between nodes).
- **Components:**
  - **Nodes:** Represent entities (e.g., "Dog," "Animal," "Fido").
  - **Links:** Represent relationships (e.g., "is-a," "has-a," "can").
- **Example 1: Simple Hierarchy:** Draw a basic hierarchy like "Dog is-a Mammal," "Mammal is-a Animal."

    - *Discussion:* How does this represent inheritance?
- **Example 2: Properties:** Add properties like "Fido has-a Tail," "Fido is-a Dog."
- **Strengths:** Intuitive, good for hierarchical relationships, easy to visualize.
- **Weaknesses:** Ambiguity in link interpretation, difficulty representing complex logical statements, lack of standard semantics.

Part 3: Conceptual Dependency (CD) (25 minutes)

- **Definition:** Introduce CD as a theory developed by Roger Schank, aiming to represent the meaning of natural language sentences using a small set of primitive actions and states. Focus on the underlying conceptual meaning rather than surface syntax.
- **Core Idea:** All actions can be reduced to a few primitive acts.
- **Key Primitive Acts (Illustrate with examples):**
    - **ATRANS:** Transfer of an abstract relationship (e.g., "give," "take," "buy").
        - *Example:* "John gave Mary a book." → John ATRANS book to Mary.
    - **PTRANS:** Transfer of physical location (e.g., "go," "move," "run").
        - *Example:* "Mary went to the store." → Mary PTRANS to store.
    - **MTRANS:** Transfer of mental information (e.g., "tell," "ask," "learn").
        - *Example:* "John told Mary a story." → John MTRANS story to Mary.
    - **PROPEL:** Application of physical force (e.g., "push," "pull," "throw").
        - *Example:* "The boy hit the ball." → Boy PROPEL ball.
    - **INGEST:** Taking something into the body (e.g., "eat," "drink," "breathe").
        - *Example:* "She ate an apple." → She INGEST apple.
    - **EXPEL:** Expelling something from the body (e.g., "cry," "speak," "vomit").
        - *Example:* "He cried." → He EXPEL tears.
    - **MBUILD:** Building new information from old (e.g., "decide," "conclude").
    - **DO:** An unspecified action.
- **Conceptual Categories:** Introduce Actor, Object, Recipient, Source, Destination, Instrument.
- **Example Translation:** Work through a more complex sentence like "John ate the apple with a spoon."
    - *Breakdown:* John INGEST apple (instrument: spoon).
- **Strengths:** Reduces ambiguity, captures underlying meaning, useful for natural language understanding and generation, inference.
- **Weaknesses:** Limited set of primitives might be insufficient for all nuances, complex to represent, less intuitive than semantic nets for some.

Part 4: Comparison & Use Cases (8 minutes)

- **Semantic Nets:** Good for representing static, hierarchical knowledge, ontologies,

"is-a" and "has-a" relationships.
- **Conceptual Dependency:** Excellent for representing dynamic actions, events, and the meaning of natural language sentences, especially for inference and summarization.
- **Scenario Discussion:** When would you use one over the other? (e.g., a knowledge base for animals vs. a chatbot understanding user requests).

Part 5: Conclusion & Q&A (7 minutes)

- **Recap:** Briefly summarize the key takeaways for Semantic Nets and Conceptual Dependency.
- **Future Directions:** Mention other KR techniques (frames, rules, logic).
- **Q&A:** Open the floor for questions.

📝 Assessment:

- **Informal:** Observe student participation in discussions and their ability to answer questions.
- **Quick Check:** Ask students to provide one example of a Semantic Net relationship and one simple sentence translated into CD.

🏠 Homework/Further Reading:

- Find two sentences and try to represent them using Conceptual Dependency primitives.
- Research "Frames" as another knowledge representation technique.