

Other Approaches to Knowledge Representation

Semantic Networks, Frames, and Ontologies

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December 30, 2024

Introduction to Knowledge Representation

- ▶ Knowledge representation (KR) is critical for AI systems.
- ▶ It structures knowledge in a machine-readable form for reasoning and problem-solving.
- ▶ Common approaches include **semantic networks**, **frames**, and **ontologies**.

What are Semantic Networks?

- ▶ Graph-based representation of knowledge.
- ▶ **Nodes** represent concepts or entities.
- ▶ **Edges** represent relationships between concepts (e.g., "is-a," "has-a").
- ▶ **Inheritance**: allows concepts to share properties.

Example:

$[\text{Dog}] \xrightarrow{\text{is-a}} [\text{Animal}]$ $[\text{Dog}] \xrightarrow{\text{has-a}} [\text{Tail}]$

Semantic Networks Example

Statements:

Jerry is a cat.

Jerry is a mammal

Jerry is owned by Priya.

Jerry is white color

All Mammals are animal.

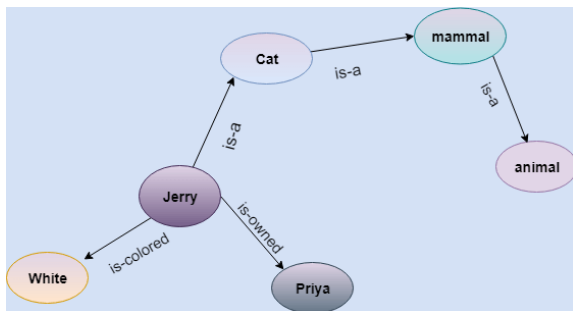


Figure: An example of a Semantic Network.

Semantic Networks Example

Example :

Tom is a cat.
Tom caught a bird.
Tom is owned by John.
Tom is ginger in colour.
Cats like cream.
The cat sat on the mat.
A cat is a mammal.
A bird is an animal.
All mammals are animals.
Mammals have fur.

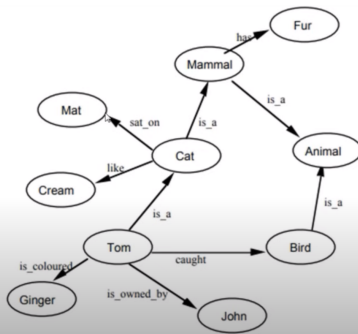


Figure: An example of a Semantic Network.

Pros and Cons of Semantic Networks

Advantages:

- ▶ Intuitive and flexible for relational knowledge.
- ▶ Easy to visualize and understand.
- ▶ Inherits properties from parent concepts.

Disadvantages:

- ▶ Lack of formal semantics.
- ▶ Difficult to represent complex relationships (causal, temporal).
- ▶ Limited reasoning capabilities.

What are Frames?

- ▶ Structured representation using **slots** and **values**.
- ▶ A frame is like a data structure or object with attributes (slots).
- ▶ **Inheritance** of slots from higher-level frames.

Example:

- ▶ Frame: **Dog**
 - ▶ Type: Animal
 - ▶ Legs: 4
 - ▶ Fur: Yes
 - ▶ Habitat: Domestic
 - ▶ Sound: Bark

Pros and Cons of Frames

Advantages:

- ▶ Structured and detailed representation of objects.
- ▶ Supports default values and inheritance.
- ▶ Easy to extend and update.

Disadvantages:

- ▶ Can become cumbersome with large numbers of frames.
- ▶ More rigid structure compared to semantic networks.
- ▶ Complexity increases with deeply nested inheritance.

What is Ontological-Based Representation?

- ▶ **Ontology**: Formal representation of a domain's concepts and relationships.
- ▶ Defines **classes**, **instances**, and **relations** between concepts.
- ▶ Supports **logical reasoning** and **axioms** (rules).

Example:

- ▶ Class: Animal
 - ▶ has-a: Leg
 - ▶ has-a: Heart
 - ▶ is-a: Mammal
 - ▶ is-a: Bird
- ▶ Class: Mammal
 - ▶ has-a: Fur
 - ▶ gives-birth: Yes
- ▶ Class: Bird
 - ▶ has-wings: Yes
 - ▶ lays-eggs: Yes

Pros and Cons of Ontologies

Advantages:

- ▶ Rich formalism supports automated reasoning.
- ▶ Interoperability across systems.
- ▶ Highly expressive for complex knowledge domains.

Disadvantages:

- ▶ Complex and resource-intensive to build and maintain.
- ▶ Ambiguity in domain interpretation.
- ▶ Scalability challenges as the ontology grows.

Comparison: Semantic Networks, Frames, and Ontologies

Feature	Semantic Networks	Frames	Ontologies
Structure	Graph of nodes and edges	Data structures with slots	Formal classes, instances, relations
Inheritance	Yes, limited inheritance	Yes, supports default values	Yes, with logical reasoning
Formalism	Informal, not strict	More structured, but informal	Very formal, with axioms and rules
Expressiveness	Limited to relationships and hierarchies	Can represent complex objects and relationships	Highly expressive, supports complex reasoning
Use Cases	Simple conceptual relationships	Structured objects in a domain	Detailed and logical domain modeling
Reasoning	Limited, mostly hierarchical	Limited, depends on the structure	Advanced reasoning with formal rules and axioms

Conclusion

- ▶ **Semantic Networks:** Best for simple relationships and hierarchical knowledge.
- ▶ **Frames:** Useful for representing detailed objects and their attributes.
- ▶ **Ontologies:** Formal and powerful for large-scale, complex domains requiring reasoning.