AI3001

Knowledge Representation and Reasoning

Week 09

Adil Sheraz

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Outline

- Semantic Nets
- Representation – Semantic Nets
- Distinctions – Semantic Nets
- Example – Semantic Nets
- Components of a SN
- SN in KRR
- Reasoning in SN
- Frame Representation
- Conclusion

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Semantic Nets

- The main idea behind semantic nets is that the meaning of a concept comes from the ways in which it is connected to other concepts.
- In a semantic net, information is represented as a set of nodes connected to each other by a set of labeled arcs, which represent relationships among the nodes.

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Semantic Nets

- A Semantic Network is a foundational method in Knowledge Representation and Reasoning, providing a structured way to capture and infer relationships between concepts.
- By using nodes and edges, semantic nets enable machines to store, understand, and manipulate knowledge in a way that is intuitive and closely aligned with human reasoning.
- It is used in artificial intelligence and cognitive science to represent and reason about knowledge.
- Pre-build libraries available to create and use semantic network.

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Semantic Nets

- A fragment of a typical semantic net is shown below:
- This network contains examples of both the *isa* and *instance* relations.
- We can use inheritance to derive the additional relations

has-part(Pee-Wee-Reese, Nose)

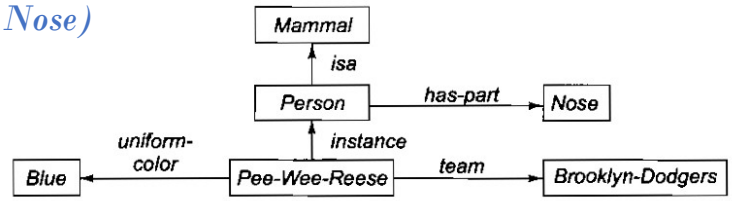

Fig. 9.1 *A Semantic Network*

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Representation – Semantic Nets

- Semantic nets are a natural way to represent relationships that would appear as ground instances of binary predicates in predicate logic:

  isa(Person, Mammal)
  instance(Pee-Wee-Reese, Person)
  team(Pee-Wee-Reese, Brooklyn-Dodgers)
  uniform-color(Pee-Wee-Reese, Blue)

- We can also express predicates of other arities, from the semantic nets, using some very general purpose predicates, such as ***isa*** and ***instance***, for example:

  man(Marcus),

  could be re-written as:

  instance(Man, Marcus)

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Representation – Semantic Nets

- Three or more place predicates can also be converted to binary form by creating one new object representing the entire predicate statement and then introducing binary predicates to describe the relationship to this new object of each original argument.
- Example:

  score(Cubs, Dodgers, 5-3)

  - This can be represented in a semantic net by creating a node to represent the specific game and then relating each of the three pieces of information to it.

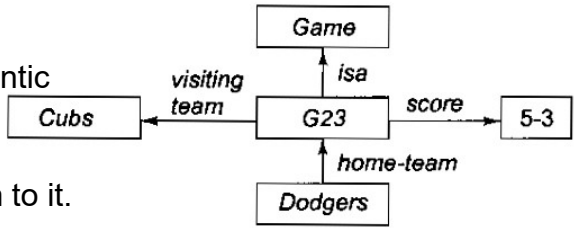

Fig. 9.2 *A Semantic Net for an n-Place Predicate*

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Representation – Semantic Nets

- It is a useful way to represent a declarative sentence.
- Example:

  John gave the book to Mary

  - could be represented by the network shown.
  - In fact, several of the earliest uses of semantic nets were in English-understanding programs.

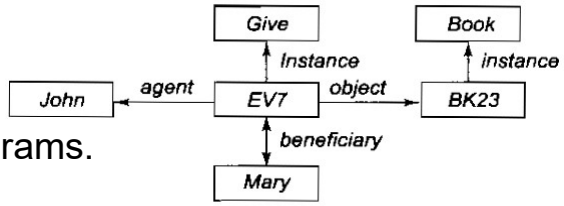

Fig. 9.3 *A Semantic Net Representing a Sentence*

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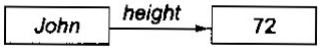
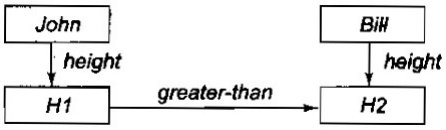
Distinctions – Semantic Nets

- There should be a difference between a link that defines a new entity and the one that relates two existing entities, consider a net:



- Both nodes represent objects that exist independently of their relationship to each other.
- Now suppose we want to represent the fact that John is taller than Bill, using the net:



- The nodes H1 and H2 are new concepts representing John's height and Bill's height, respectively. They are defined by their relationships to the nodes John and Bill.

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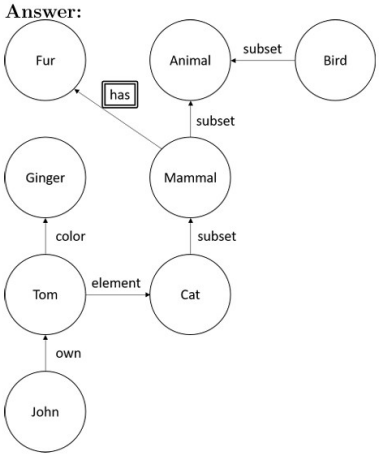
Semantic Nets – Example

- Draw the semantic network that represents the data given below:
  - Mammals have fur.
  - All mammals are animals.
  - A bird is an animal.
  - A cat is a mammal.
  - Tom is a cat.
  - Tom is owned by John.
  - Tom is ginger in color.

Answer:



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Components of a Semantic Network

- Concepts (Nodes): Represent entities, objects, or concepts in the domain of interest.
  - For example, in a network about animals, concepts might include "Cat," "Dog," or "Mammal."
- Relationships (Edges): Represent the types of connections or associations between concepts. Common relationships include:
  - "is-a": Represents subclass relationships (e.g., "Cat" is-a "Mammal").
  - "part-of": Represents part-whole relationships (e.g., "Wheel" part-of "Car").
  - "has-property": Represents attributes or properties (e.g., "Bird" has-property "Can fly").
  - "instance-of": Represents specific instances of a general category (e.g., "Tom" instance-of "Cat").

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Semantic Networks Aid in KRR

- Graphical Structure
  - The visual representation makes it easier to understand complex interconnections between concepts.
- Hierarchical Relationships
  - By using relationships like "is-a," semantic networks can create taxonomies or hierarchies that organize knowledge into general and specific categories.
- Property Inheritance
  - Concepts inherit properties from higher-level concepts in the hierarchy. For example, if "Bird" has the property "Can fly," all instances of "Bird" like "Sparrow" and "Eagle" inherit this property unless exceptions are defined.

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Semantic Networks Aid in KRR

- Associative Memory
  - Semantic networks resemble human associative memory, making them effective for modeling cognitive processes.
- Knowledge Maintenance and Management
  - It is easy to extend and change a template of property or part and the same reasoning process can be maintained.
- Standard and Implementation Support
  - There are different parallel frameworks available for semantic network.

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Semantic Networks and Reasoning

- Inference
  - Drawing new conclusions from existing facts using the relationships.
- Pathfinding
  - Algorithms can traverse the network to find connections between concepts, such as finding all animals that "can fly" by following paths in the network.
- Spreading Activation
  - A process used in AI and cognitive models where activating one concept in the network spreads to related concepts, simulating associative thinking.
- Human-Readable Structure
  - The graphical representation is intuitive and aligns with human understanding.

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Semantic Networks and Reasoning

- Support for Inheritance
  - Properties and relationships can be inherited through "is-a" relationships, which simplifies knowledge maintenance.
- Query via Knowledge Base
  - Semantic networks can be queried using languages like SPARQL, making it easy to extract and infer information.

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Frame Representation

- A frame is a record-like structure consisting of a collection of attributes and values to describe an entity in the world.
- Frames are the AI data structure that divides knowledge into substructures by representing stereotypical situations. It consists of a collection of slots and slot values.
- These slots may be of any type and sizes. Slots have names and values which are called facets.
- **Facets:** The various aspects of a slot are known as Facets. Facets are features of frames that enable us to put constraints on the frames.

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Frame Representation

- Ex- Frame for a book

A frame abc

Slots	Filters
Title	Artificial Intelligence
Author	Peter Norvig
Edition	Third Edition
Year	1996
Page	1152

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Frame Representation

- Example
  - Let's suppose we are taking an entity, Peter. Peter is an engineer as a profession, and his age is 25, he lives in city London, and the country is England. So following is the frame representation for this:

Slots	Filter
Name	Peter
Profession	Doctor
Age	25
Marital status	Single
Weight	78

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Frame Representation – Advantages

- The frame knowledge representation makes the programming easier by grouping the related data.
- The frame representation is comparably flexible and used by many applications in AI.
- It is very easy to add slots for new attributes and relations.
- It is easy to include default data and to search for missing values.
- Frame representation is easy to understand and visualize.

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Frame Representation – Dis-advantages

- In the frame system, the inference mechanism is not be easily processed.
- The inference mechanism cannot be smoothly proceeded by frame representation.
- Frame representation has a much more generalized approach.

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Conclusion

- Semantic Network is an important Knowledge Representation scheme and there are several parallel implementation framework exists for it.

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