Biological Vision and Applications
Module 07-01: Knowledge Representation

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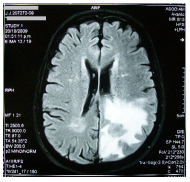
Knowledge required for visual interpretation

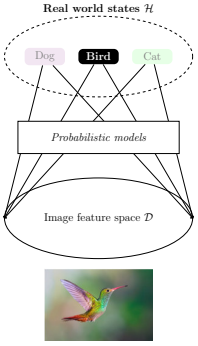
Explicit and implicit knowledge

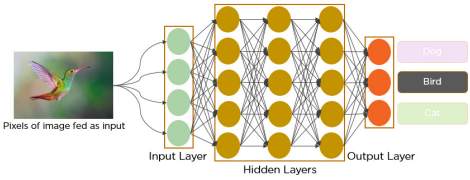


- Domain Knowledge (Ontology)
  - Example: What makes a lesion different ?
  - Declarative: can be stated explicitly
  - Exists independent of processing structure
  - can be shared
- Knowledge about (image) processing
  - Example: How to extract the edges from an image?
  - Procedural: implicit
  - Encoded as algorithms, neural networks, etc.
  - Strictly private to the processing structure
- The relation between the two
  - How to use them together in a problem

Dual representation of knowledge

Same knowledge can be represented either in declarative or in procedural way

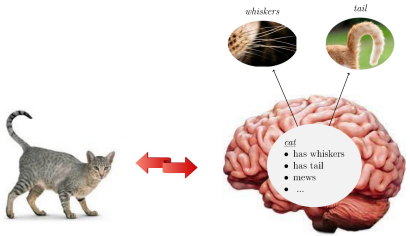




Declarative
Model based approach

Procedural
Data driven approach

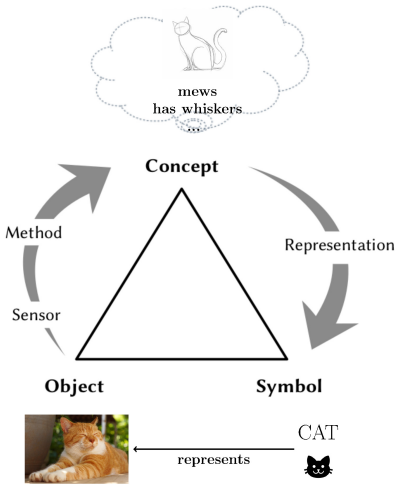
Representational Theory of Mind (RTM)



- A concept is a mental model of something
  - A real-world thing
  - An internal mental state of the agent
- A name is associated with a concept
  - For reference while manipulation
- Knowledge is
  - A collection of named concepts
  - A set of sentences (propositions) that relate the concepts
    - Named concepts: cat, tail
    - Proposition: A cat has a tail

Symbolic representation

The semiotics triangle



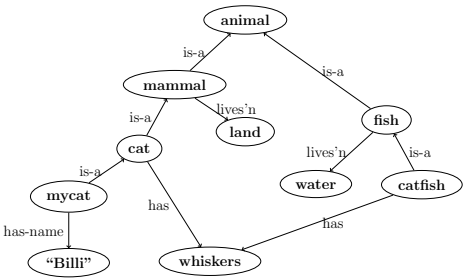
- Objects (things): That exist
- Concepts: Mental representations (models)
- Representation: Symbol to represent a concept (text, icon, speech)

Semantic Network

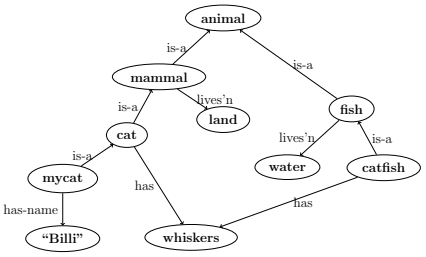
Compact knowledge representation

- Knowledge is a set of statements
  - A mammal is an animal
  - A cat is a mammal
  - A cat has whiskers
  - A mammal lives on land
  - A fish is an animal
  - A catfish is a fish
  - A catfish has whiskers
  - A fish lives in water
  - Mycat is a cat
  - Mycat has a name “Billi”

- Equivalently, knowledge is a graph (semantic network)



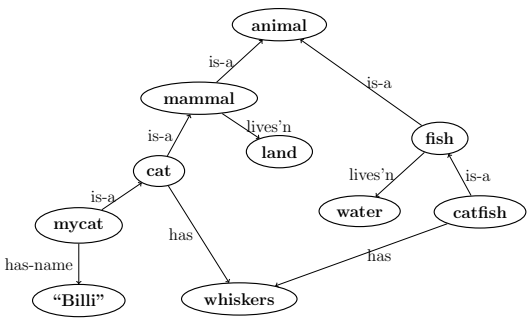
Semantics of "Semantic Network"



- A set of propositions
  - Each describes a property of a concept
- Structure: $< subject, predicate, object >$
  - Examples:
    - cat has whiskers
    - mycat has-name "Billi"
- A concept can be a class, or an instance
  - Example: cat, mycat
- A value can be a concept, or a literal
  - Example: whiskers, "Billi"

Reasoning with Semantic Network

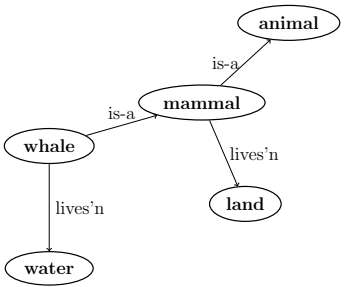
Axioms lead to semantics



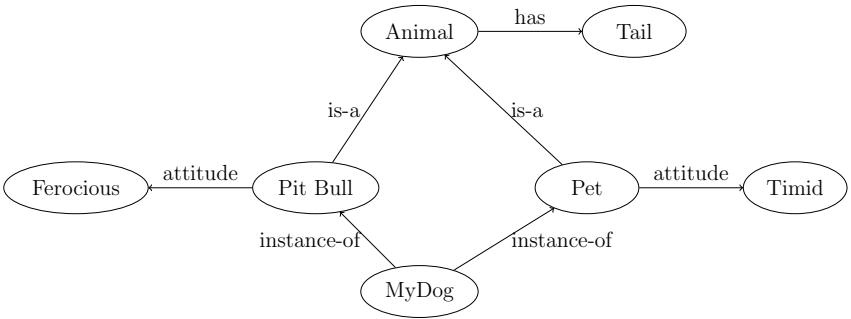
- Requires underlying axioms, e.g.
  - Property inheritance
    - If *a* "is-a" *b*, then *a* inherits properties of *b*
  - "is-a" is transitive
    - If *a* is-a *b*, and *b* is-a *c*, then *a* is a *c* too
  - These axioms make a semantic network efficient (compact)
  - There can be other domain-specific rules

Flexibility with "Semantic Network"

- No restrictions on properties / values to be associated to a concept
- There can be exceptions. e.g.
  - Whale is a mammal, but lives in water
- Axioms need to be redefined
  - If *a* "is-a" *b*, then
    a inherits properties of *b*
    unless overruled



Multiple inheritance



MyDog has a tail

What's about MyDog's attitude ?

Properties of Semantic Network

- A semantic network is extremely flexible
  - An informal description of a domain (in it's basic form)
- Semantics is imposed with axioms / constraints
- Many variants have been proposed
  - Definitional network
    - Expresses class-subclass relations
    - ... and properties that distinguish sibling subclasses
    - Cat *is-a* mammal; cat *has* whiskers
  - Implication Network
    - Expresses causal relations
    - Banana *causes* yellow color
  - Hybrid networks combine more than one of paradigms

Sowa. Semantic Networks

Resource Description Framework (RDF)

W3C Recommendation – for representing interconnected data on the web

- Data (resources) can be distributed over the web
  - Knowledge is an interconnection (relations) of this distributed data
- Each resource is identified with a IRI
- Follows semantic network model
  - An RDF graph is a set of RDF sentences ⟨ subject, predicate, object ⟩
- A predicate is also a "resource"
  - A predicate in one sentence can be a subject or an object in another
  - ⟨ hasWeightInKg, is-a, healthParameter ⟩. ⟨ Ramu, hasWeightInKg, 80 ⟩
- Reification: A statement is also a "resource"
  - I said "cat is an animal"
  - S1: ⟨ cat, is-a, animal ⟩. S2: ⟨ I, said, S1 ⟩
- Some axioms are inbuilt – additional semantics can be defined with RDF Schema
- Notations: XML, N3, Turtle, ...

SPARQL Query Language

- To make query on RDF Graphs
- Syntactically similar to SQL
- Implemented with “triple-store” databases
  - Apache Jena / TDB
  - Optimized for storing triplets
- Query on distributed knowledge
  - Distributed knowledge centrally indexed
  - Distributed query processing (distributed index)
- Resources:
  - W3School tutorials
  - W3C Documents

Quiz

Quiz 07-01

End of Module 07-01