COMP210: Artificial Intelligence

Lecture 14. Semantic Networks and Frames

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Overview

- The last lecture looked in detail at using rules for knowledge representation.
- While rules have been widely used, there are several other important approaches to knowledge representation.
- Three of these are
  - *Structured objects*
    - *semantic nets.*
    - *frames;*
  - *logic;*
- This lecture covers the first two of these.

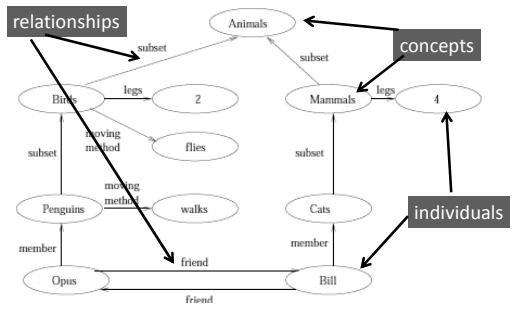
Structured Objects

- Structured objects are:
  - Knowledge representation formalisms whose components are essentially similar to the nodes and arcs found in graphs.
  - In contrast to production rules and formal logic.
  - An attempt to incorporate certain desirable features of human memory organisation (association) into knowledge representations.

Semantic Networks

- Developed by Quillian in 1968, as a model for human memory
  - *semantic memory.*
- Models the "associations" between ideas and concepts that people maintain.
- Semantic net is a *labelled graph.*
  - nodes in graph represent *objects, concepts,* or *situations/events;*
  - arcs in graph represent *relationships* between these things.

Semantic Networks

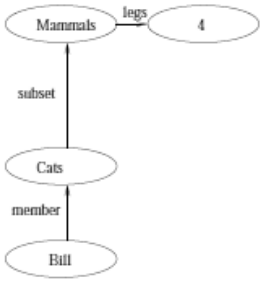


Important Arc Types

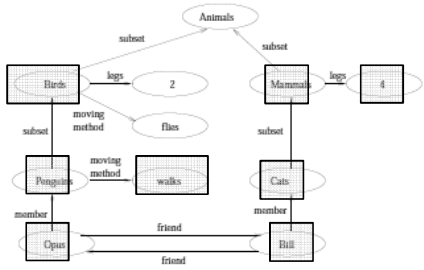
- Subset
  - X is a kind of Y
  - Penguin subset Bird: Concept to Concept
- Member
  - X is a Y: X is an instance of Y
  - Opus member Penguin: Individual to Concept
- R-relation
  - X relation-name Y
  - Opus is a friend of Bill; Lou is a parent of Ian. Individual to Individual

Inheritance

- Inheritance is one of the main kind of reasoning done in semantic nets
- The subset relation is often used to link a class and its superclass.
- Some links (e.g. legs) are inherited along subset paths
- The semantics of a semantic net can be relatively informal or very formal
- Often defined at the implementation level



Example

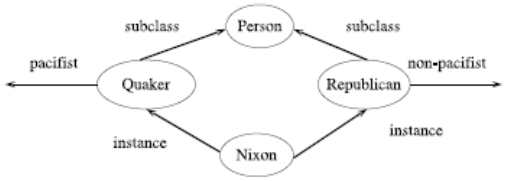


Bill has four legs ***Opus is a Bird*** ***Opus walks***

Multiple Inheritance

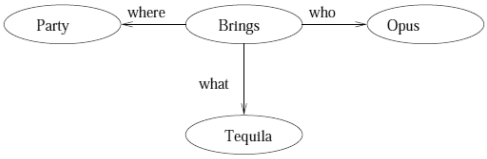
- A node can have any number of superclasses that contain it, enabling a node to inherit properties from multiple parent nodes and their ancestors in the network. It can cause conflicting inheritance.

Nixon Diamond

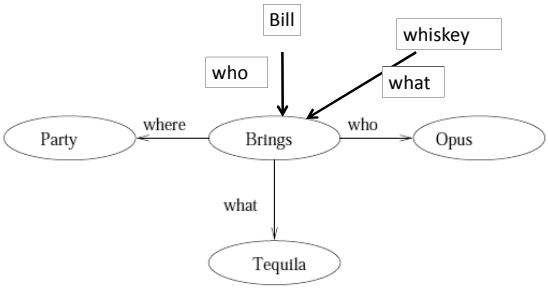


Problems with Semantic Nets

- Binary relations are easy to represent. Others are harder.
- Example: "Opus brings tequila to the party."



But now Bill brings Whisky

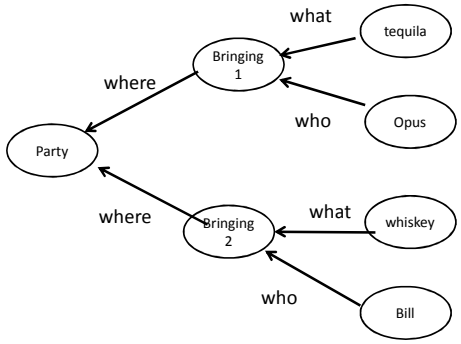


Cannot tell who brought what!

Binary Relations

- Any relation can be rewritten as a set of Binary relations
- Bringing-1(Opus,tequilla,party-1)
- Bringing-2(Bill,whisky,party-2)
- Make the event a think and make one binary relation ***per role***
  - who(bringing-1,Opus); who(bringing-2,Bill)
  - what(bringing-1,tequila); what(bringing-2, whiskey)
  - where(bringing-1,party); where(bringing-2,party)

Now we can see who brought what



Other Problems are Harder

- Negation
  - Opus and Dirk are not friends
    - Can just assume an absence of a link
- Cancellation
  - Property inherited from a distant superclass cancelled at a lower level
    - Birds fly, penguins don't
- Disjunction
  - Opus either drinks tea or coffee
- Quantification
  - "every dog has bitten a postman"
  - "every dog has bitten every postman"

Advantages of Semantic Nets

- Easy to visualise
- Flexible: Relationships can be arbitrarily defined by the knowledge engineer
- Formal definitions of semantic networks have been developed.
- Related knowledge is easily clustered.
- Efficient in space requirements
- Objects represented only once
- Inference reduced to search

Disadvantages of Semantic Nets

- Inheritance (particularly from multiple sources and when exceptions in inheritance are required) can cause problems.
- Facts placed inappropriately cause problems.
- No standards about node and arc values
- Limited expressiveness: may require a number of specially coded procedures

Frames

- Development of semantic nets
- Desire to exploit the powerful mechanism of inheritance
- Observation: things of a given type participate in the same set of relationships
- A lot of information is available by default – it is the exceptions that are interesting

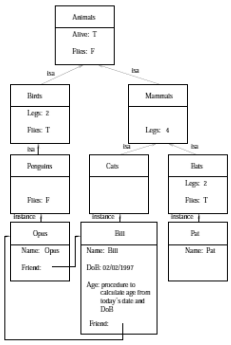
Frames

- Frames — semantic net with *properties and methods*
  - Devised by Marvin Minsky, 1974.
- Incorporates certain valuable human thinking characteristics:
- Expectations, assumptions, stereotypes, exceptions.
- The essence of this form of knowledge is that we represent the typical case *and exceptions, rather* than give *definitions.*
- Hierarchical structure, similar to class hierarchies

How Frames are Organised

- A frame can represent a specific individual, or a general concept
- Each frame has
  - A name
  - Slots (attributes) which have values
    - *Binary relations entity-attribure-value*
  - a specific value
  - a default value (what is typical)
  - an inherited value (default from superclass)
  - a pointer to another frame (relation between concepts and individuals
  - a procedure that gives the value (e.g. calculation from other slots)

Example frame system



Reasoning

- How do we reason with frame systems?
- Easy to answer questions such as
  - *is x a y?*
  - Simply follow the instance and/or is-a links.
  - Example: Is Opus a bird?
- Also useful for *default reasoning.*
  - Simply inherit all default values if there is no specific value
  - How many legs does Opus have?

How Frames are Organised

- In the higher levels of the frame hierarchy, typical knowledge about the class is stored.
- In the lower levels, the value in a slot may be a specific value, to overrule the value which would otherwise be inherited from a higher frame.
- An instance of an object is joined to its class by an instance relationship.
- A class is joined to its superclass by an is-a relationship.

Scripts

- Scripts are a variant of frames, for representing stereotypical sequences of events.
- A script is thus a frame with a set of prescribed slots, for example:
  - Some initial conditions;
  - Some final conditions;
  - Some state description;
  - Some actions; and
  - Some actors
- The structure of the script is heavily domain dependent.

Example Script

```
SCRIPT
Name: RESTAURANT
Roles: Customer, Waiter, Cook, Cashier
Entry condition: Customer is hungry
Props: Food, table, money, menu, tip
Events:
 1/ Customer enters restaurant
 2/ Customer goes to table
 3/ Waiter brings menu
 4/ Customer orders food
 5/ Waiter brings food
 6/ Customer eats food
...
10/ Customer leaves restaurant

Main concept: 6
Results: Customer not hungry,
         Customer has less money,
         Restaurant has more money
```

Why Scripts

- Scripts developed by Roger Schank for *understanding stories.*
- Scripts provide *context information* without which sentences cannot be understood:
  - sentences are not unconstrained sequences of words;
  - stories are not unconstrained sequences of sentences.
  - people leave out large amounts of assumed detail out
    - E.g. Who brought the menu? Even if not stated can be inferred from the script.
- Schank developed SAM (Script Applier Mechanism) that *could fill in gaps in stories.*
- Also able to "explain" elements of stories, e.g., people get upset or angry when story deviates from script.
  - Bob went into the restaurant and waited. He got angry. Why? The waiter did not bring the menu

Frame Advantages

- Fairly intuitive for many applications
- Similar to human knowledge organisation
- Suitable for causal knowledge
- Easy to include default information and detect missing values
- Easier to understand than logic or rules
- Very flexible

Frame Disadvantages

- No standards (slot-filler values)
- More of a general methodology than a specific representation:
- Frame for a class-room will be different for a professor and for a maintenance worker
- No associated reasoning/inference mechanisms

Problems with Frames & Semantic Nets

- Both frames and semantic nets are essentially *arbitrary.*
- Both are useful for representing certain sorts of knowledge.
- But both are essentially *ad hoc — they lack precise* meaning, or *semantics.*
- Inference procedures poorly defined & justified, and often special purpose
- The *syntax of KR scheme is irrelevant.*
- *Logic generalises these schemes.*

Currently

- Many of the ideas of frames are now expressed in ontologies
- Ontologies use description logics to provide semantics

Summary

- We have liked at two (once) popular means of structuring information
- In recent years people have moved attempted to be more principled and formal
  - Simply working on special cases and limited domains is no longer enough
- We will consider these developments in the context of logic based approaches