COMMONSENSE KNOWLEDGE

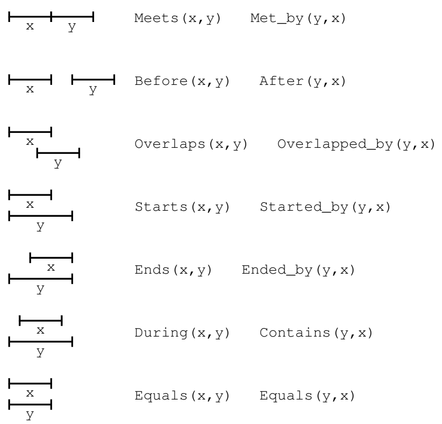
What is commonsense knowledge?

- Throughout, we have talked to "domain knowledge", knowledge about the situation an agent finds itself in.
- It seems to be relatively easy to program tn agent with good detailed knowledge about domains.
- (Dealing with the volume of knowledge is another question.)
- However, it is much harder to give agents the kind of general knowledge about the world that children have.
- (Perhaps because agents don't get to spend as much time learning about the world by interacting with it that children do.)
- Such knowledge is necessary, though, if we want to build general intelligent agents.

- Typical pieces of commonsense knowledge
  - Two blocks can't be in the same place.
  - Liquid comes out of a cup if you tilt it.
  - Water makes things wet.
  - You can't drive through walls.
  - If you let go of something it falls.
- "What any fool knows"
- AI has looked for compact representations of this.
- Maybe we just need to type it all in.

Time

- Lots of ways of representing time:
  - discrete
  - continuous
  - unidirectional
  - bidirectional
  - linear
  - branching
- Formal tools for many of these.
- Consider Allen's interval calculus.



- These map into logic

  $\forall x, y \cdot Meets(x, y) \equiv (end(x) = start(y))$

  $\forall x, y \cdot Before(x, y) \equiv \exists z(Meets(x, z) \wedge Meets(z, y))$
- And the rest can be defined in a similar manner.
- Then we can describe temporal aspects about the world:

$$\begin{array}{l} \forall y \cdot Occurs(Flow, y) \Rightarrow \\ \quad \exists x, z \cdot Occurs(Turn, x) \wedge Occurs(Turn, y) \\ \quad \wedge Overlaps(x, y) \wedge Overlaps(y, z) \end{array}$$

- We can then:
  - Use a theorem prover to reason about the world.
  - Use a STRIPS planner to decide what to do.

Taxonomic knowledge

- Often we find that commonsense knowledge comes in the form of taxonomies.
- All Ps are Qs.
- We can represent this as logic.

$$\begin{array}{rcl} & & Laser\_printer(snoopy) \\ \forall x \cdot Laser\_printer(x) & \Rightarrow & Printer(x) \\ \forall X \cdot Printer(x) & \Rightarrow & Office\_machine(x) \end{array}$$

- We can infer $\forall x \cdot Laser\_printer(x) \Rightarrow Office\_machine(x)$
- We can inherit properties from superclass to subclass.

Semantic Networks

- Taxonomic reasoning can be more efficient not in logic.
- Developed by Quillian in 1968, for *semantic memory*.
- Models the "associations" between ideas that people maintain.
- Semantic net is a *labelled graph*.
  - nodes in graph represent *objects*, *concepts*, or *situations*;
  - arcs in graph represent *relationships between objects*.

Key types of arc:

- $x \xrightarrow{subset} y$

  "x is a kind of y" ($\subset$)

  Example: $penguin \xrightarrow{subset} bird$
- $x \xrightarrow{member} y$

  "x is a y"

  Example: $opus \xrightarrow{member} penguin$
- $x \xrightarrow{R} y$

  "x is R-related to y"

  Example: $bill \xrightarrow{friend} opus$
- Inference is then by traversing arcs.

- *Binary* relations are easy and natural to represent.
- Others kinds of relation are harder.
- Unary relations (properties).

  Example: "Opus is small".
- Three place relations.

  Example: "Opus brings tequila to the party."
- Some binary relations are problematic . . .

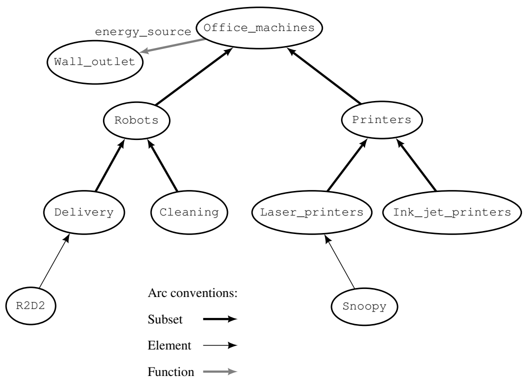
  "Opus is larger than Bill."

- *Quantified* statements are very hard for semantic nets.

  Examples:

  - "every dog has bitten a postman"
  - "every dog has bitten every postman"
- *Partitioned* semantic nets can represent these.
- Of course, expressions like this are very easy to represent in first order logic.

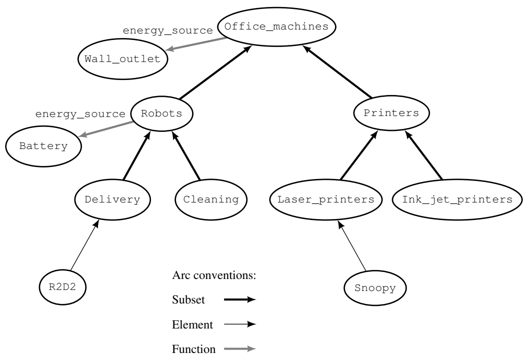
- Example semantic net:



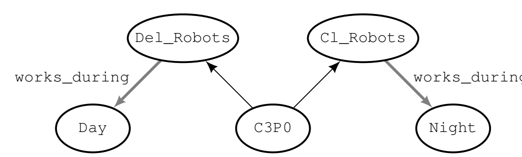
Default reasoning

- Reasoning about inheritance is a classic type of *default* reasoning.
- We make an assumption which may later turn out to be wrong.
- This provides us with one way to write commonsense knowledge compactly.
- Can write down the properties of superclasses and let subclasses inherit them.
- Thus, we don't need to represent the fact that Snoopy and R2D2 connect to wall outlets.

- We can also deal with inheritance conflicts:



- However, coming up with general mechanisms for resolving these conflicts is hard.
- When does C3P0 work?



- Can add priorities/preferences to deal with this.

Frames

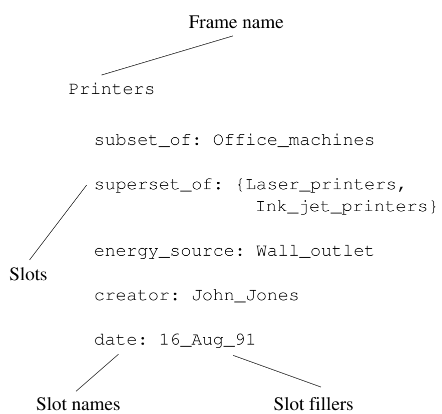
- Frames are a kind of *structured* knowledge representation mechanism.
- All information relevant to a particular concept is stored in *frame* which resembles C `struct`, PASCAL `record`, Java object...
- Each frame has a number of *slots*.
- Each slot may be *filled* by:
  – a value;
  – a pointer to another frame;
  – a procedure.
- Slots may have *default values* associated with them.
- Frames = OO!

- Frames are typically used to represent the *properties* of objects, and the relationships between them.
- Frames may represent:
  – *generic concepts* (cf classes) or
  – *specific items* (cf objects).
- Most important kind of link between frames:

is-a

- Facilitates reasoning about object properties.
- Allows *default values* to be *inherited*.

- Example frame system:



- How to reason with frame systems?
- Easy to answer questions such as
  is x a y?
  Simply follow the *is-a* links.
- Example: Is snoopy a laser printer.
- (Problem of *multiple inheritance* — Nixon diamond.)
- Also useful for *default* reasoning.
  Simply *inherit* all default values that are not explicitly provided.
- Example: Does snoopy the printer have a wall outlet?

- *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
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,
         Waiter gets tip
```


- Scripts developed by Roger Schank for *understanding stories*.
- Used to help *understand language*.
- Scripts provide *context* information without which sentences cannot be understood:
  - sentences are not unconstrained sequences of words;
  - stories are not unconstrained sequences of sentences.
- 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.

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* — lack precise meaning, or *semantics*.
- Inference procedures poorly defined & justified.
- The *syntax* of KR scheme is *irrelevant*.
- *Logic* generalises these schemes... and that is both an advantage and a disadvantage.

- Logic has a(nother) problem, it is inherently *monotonic*
- Once we have:

  $$\Delta \vdash \phi$$

  then

  $$\Delta \cup \{\psi\} \vdash \phi$$

  whatever ψ may be.
- So, once we know that C3P0 is a delivery robot, and so works during the day nothing can refute this ...
- ...even when we are told that as a night delivery robot he works at night.

- Trying to make logic *nonmonotonic* has consumed a lot of work over the last 20 years.
- One of the best solutions (there is no one best solution) is the use of *argumentation*.
- We establish whether ϕ holds by looking at the reasons (arguments) that support it:

  $$(\{a, a \Rightarrow b, b \Rightarrow c\}, c)$$

- We deal with conflict between deductions through the notion of *acceptability*
- Acceptable arguments are ones not attacked, or ones whose attackers are defeated.

Summary

- This lecture introduced the idea of commonsense knowledge in AI.
- It then briefly surveyed representations of time and taxonomic knowledge, before talking about the general problem of nonmonotonic reasoning.
- Finally the lecture mentioned argumentation as a general approach to nonmonotonic reasoning.