Knowledge Representation

• Q1: How can we map human knowledge?
• Q2: How can we convert our maps to machine readable form?

Types of Knowledge

Deep Knowledge

• Derived from formal coursework or instruction
• Available in the public domain
• Sources include books, journals, articles, etc.
• Represents the collective learning of society or its subsets

Shallow Knowledge

• Derived from individual learning and experience
• Local and not widely available
• Sources include industry and organizational experience, encoded in individual minds or manuals
• Represents the level of attainment achieved by an individual or organization
• Comes in the form of heuristics or rules
Knowledge Representation

Modes of Representing Knowledge

- Individual Objects/Concepts
  - OAV Triplets
  - Frames
  - Logic Statements

- Objects and their Relations
  - Neural Networks (model based)
  - Semantic networks
  - Rule-based systems

Representing Individual Objects/Concepts

OAV Triplets

Object ---- Attribute(s) ---- Value(s)

Pete Jones has an Income is $50,000

Frames

- Frames provide slots for any attribute associated with an object, as well as slots for procedural commands (e.g., pointers, procedures, etc.)
Frames (cont.)

<table>
<thead>
<tr>
<th>DOG</th>
<th>type</th>
<th>Beagle</th>
</tr>
</thead>
<tbody>
<tr>
<td># legs</td>
<td>Default = 4</td>
<td></td>
</tr>
<tr>
<td>age</td>
<td>15 months</td>
<td></td>
</tr>
<tr>
<td>health</td>
<td>go to frame &quot;health&quot;</td>
<td></td>
</tr>
</tbody>
</table>

Predicate Calculus

- Concepts are basic building block
- Predicate describes an attribute about an object, or a relationship between objects
  - E.g., mammal (dog)
- Used in Prolog

Representing Related Objects/Concepts

Neural Networks

- Crudely represents human brain neuron firing
- Is useful for pattern matching and classification
- Drawback is that it is a "black box"
Knowledge Representation

Neural nets (cont.)

\[
\begin{align*}
&x_1, \ldots, x_n \\
&\text{w}_1, \ldots, \text{w}_n \\
&\text{PE} \\
&\text{OUTPUT } (Y) \\
&Y = f_{hl} (\sum \text{w}_i x_i - \theta) \\
&Y = 1 \text{ for class 1} \\
&-1 \text{ for class 2}
\end{align*}
\]

Propositional Logic

- Propositions are the basic building block
- Propositions may be linked
- Propositions may be deduced from other propositions
- Drawbacks: restricted to manipulating whole propositions and bound by rules of logical inference

Propositional Logic (cont.)

- Conventions
  - Given that X is true and Y is true, and Z is false
  - \( \gg X \text{ AND } Y \text{ is true, } X \text{ AND } Z \text{ is false, } Y \text{ and } Z \text{ is false} \)
  - \( \gg X \text{ OR } Z \text{ is true, } Y \text{ OR } Z \text{ is true} \)
  - \( \gg \text{NOT } Z \text{ is true} \)
- Example
  - \( X = \text{The door is open} \)
  - \( Y = \text{The window is shut} \)
  - \( Z = \text{The Martians have landed} \)

Semantic Network

- Represents several objects and attributes
- Networks of OAV triplets
- Represents associations between nodes
Knowledge Representation

Semantic Network (cont.)

Knowledge Representation

Semantic Network (cont2)

• Exercise: Produce semantic nets for the assigned exercises and your final project.

Rule-based (production) Systems

• Premise (IF) followed by conclusion (THEN)
• Made up of clauses containing AV pairs
• Advantages are:
  • Easy to construct
  • Make sense to user and developer
  • Compatible with the computer
  • Easier to update, validate and maintain

Components of Rules

• Premises & conclusions made of clauses
• May be several clauses within a single rule
  • Premise clauses may be connected via AND (OR not recommended)
  • Conclusion clauses may be connected via AND (not OR)
  • AND = conjunctive. OR = disjunctive
**Components of Clauses**

- Each clause built on OAV triplet
  - E.g. IF the student's GRE score is 1350 or higher, THEN admit
  - (IF) object is student, attribute is GRE score, value 1350
  - (THEN) object is student, attribute is admission status, value is yes

**Properties of Clauses**

- Clauses are proved true or false
- Until a clause is tested its value is "not yet known"

**Rule Components (cont.2)**

- E.g. 1:
  - IF nose = runny
  - THEN take decongestant

- E.g. 2:
  - IF nose = runny
  - AND temperature = high
  - AND eyes = bloodshot
  - THEN disease = flu
  - AND drink fluids
  - AND take aspirin

**Producing Causal Maps of Problem Spaces**
### Mapping Problem Spaces

- Problems can be mapped as:
  - Initial Conditions -- Interm. States -- Goal
- Maps are different for different problem types

### Problem Types

- Goal-driven
- Data-driven

### Characteristics of Goal-driven Problems

- Many initial conditions
- Only a few outcome states
- E.g., classification or diagnostic problems

### Classification Type Problem Space
Knowledge Representation

Characteristics of Data-driven Problems

- Few initial conditions, constraints or values
- Many possible outcome states
- E.g., design or planning problems

Design/Planning Problem Space

Summary

- Mapping the problem space makes writing rules (or whatever) MUCH easier....
- Exercise: Map assigned exercises and final project using this method.

end...