Inference-based agents in the wumpus world

A wumpus-world agent using propositional logic:

\[
\begin{align*}
\neg P_{1,1} & \\
\neg W_{1,1} & \\
B_{x,y} & \Leftrightarrow (P_{x,y+1} \vee P_{x,y-1} \vee P_{x+1,y}) \\
S_{x,y} & \Leftrightarrow (W_{x,y+1} \vee W_{x,y-1} \vee W_{x+1,y} \vee W_{x-1,y}) \\
W_{1,1} & \vee W_{1,2} \vee \ldots \vee W_{4,4} \\
\neg W_{1,1} & \vee \neg W_{1,2} \\
\neg W_{1,1} & \vee \neg W_{1,3} \\
\ldots & 
\end{align*}
\]

\[\Rightarrow\] 64 distinct proposition symbols, 155 sentences

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**function** PL-WUMPUS-AGENT (percept) **returns** an action

**inputs:** percept, a list \([\text{stench}, \text{breeze}, \text{glitter}]\)

**static:** KB, initially containing the "physics" of the wumpus world

\(x, y, \text{orientation}, \) the agent’s position (init. [1,1]) and orient. (init. right)

\(\text{visited}, \) an array indicating which squares have been visited, initially false

\(\text{action}, \) the agent’s most recent action, initially null

\(\text{plan}, \) an action sequence, initially empty

**update** \(x,y,\text{orientation}, \text{visited}\), based on action

if stench then TELL(KB, \(S_{x,y}\)) else TELL(KB, \(\neg S_{x,y}\))

if breeze then TELL(KB, \(B_{x,y}\)) else TELL(KB, \(\neg B_{x,y}\))

if glitter then action := grab
else if plan is nonempty then action := POP(plan)
else if for some fringe square \([i,j], \text{ASK}(KB, (\neg P_{i,j} \land \neg W_{i,j})) \text{ is true or} \)
for some fringe square \([i,j], \text{ASK}(KB, (P_{i,j} \lor W_{i,j})) \text{ is false then do} \)

\(\text{plan} \leftarrow A^*-\text{GRAPH-SEARCH}((\text{ROUTE-}\text{PB}(x,y, \text{orientation}, [i,j, \text{visited}]))\)

action := POP(plan)
else action := a randomly chosen move

**return** action
Expressiveness limitation of propositional logic

- KB contains "physics" sentences for every single square

- For every time $t$ and every location $[x,y]$, $L_{k,y} \land \text{FacingRight}^t \land \text{Forward}^t \Rightarrow L_{x+1,y}$

- Rapid proliferation of clauses

Circuit-based agents

- Particular type of reflex agent with state
- Percepts are inputs to a sequential circuit built of gates and registers (to store truth values for a single proposition).
- Circuit will be evaluated according to data-flow (compare to and-or graphs)
Circuit-based agents

Summary

- Logical agents apply inference to a knowledge base to derive new information and make decisions
- Basic concepts of logic:
  - syntax: formal structure of sentences
  - semantics: truth of sentences wrt models
  - entailment: necessary truth of one sentence given another
  - inference: deriving sentences from other sentences
  - soundness: derivations produce only entailed sentences
  - completeness: derivations can produce all entailed sentences
- Wumpus world requires the ability to represent partial and negated information, reason by cases, etc.
- Resolution is complete for propositional logic
  Forward, backward chaining are linear-time, complete for Horn clauses
- Propositional logic lacks expressive power