AI2 Module 4
Tutorial 3

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1 Logical Agents: Extending the expressive Power

In the lecture we showed that FOL already gives a more succinct representation of the Wumpus World than propositional logic. We also introduced an even more succinct representation by representing squares as pairs $\langle i, j \rangle$, introducing the binary adjacency predicate $Adj(p, q)$, and by avoiding disjunctions in rules, e.g., $\forall p.S(p) \Leftrightarrow \exists q.Adj(p, q) \wedge W(q)$.

1.1 Definition for Predicates

Complete the following definition for the predicates. Put your definitions in clause normal form. You may use the predicate = which represents equality:

a) $\forall i.\forall j.\forall q.\ Adj(\langle i, j \rangle, q) \Leftrightarrow ...$

b) $\forall p.\ B(p) \Leftrightarrow ...$

1.2 Interrogating a FOL KB

We showed how the query $\text{Ask}(KB, OK(3, 1))$ can be answered using resolution. In the following we assume that any arithmetic evaluation is built-in. Try to complete the following inference to refute $OK(3, 1)$ based on the representation introduced above. Fill in the gaps.

[1]In case of any question, do not hesitate to contact `jzimmer@mathweb.org`.

(0)	$\Rightarrow OK(\langle 3,1\rangle)$	
(1)	$W(\langle i,j\rangle) \wedge OK(\langle i,j\rangle) \Rightarrow$	
(2)	$S(p) \Rightarrow Adj(p, a(p))$	
(3)	$\Rightarrow S(\langle 2,1\rangle)$	
(4)	$S(p) \Rightarrow W(a(p))$	
(5)	$Adj(\langle i,j\rangle, q) \Rightarrow ...$	Diagnostic rule from 1.1.(a)
(6)	$(x = y_1 \vee x = y_2 \vee x = y_3 \vee x = y_4) \wedge W(x)$ $\Rightarrow (W(y_1) \vee W(y_2) \vee W(y_3) \vee W(y_4))$	
(7)	$W(\langle 1,1\rangle) \Rightarrow$	
(8)	$W(\langle 2,0\rangle) \Rightarrow$	
(9)	$W(\langle 2,2\rangle) \Rightarrow$	
(10)	...	by (2) & (3)
(11)	$\Rightarrow (a(\langle 2,1\rangle) = \langle 1,1\rangle \vee a(\langle 2,1\rangle) = \langle 3,1\rangle \vee$ $a(\langle 2,1\rangle) = \langle 2,2\rangle \vee a(\langle 2,1\rangle) = \langle 2,0\rangle)$	by (5) & (10)
(12)	...	by (3) & (4)
(13)	$\Rightarrow W(\langle 1,1\rangle) \vee W(\langle 3,1\rangle) \vee W(\langle 2,2\rangle) \vee W(\langle 2,0\rangle)$	by (6),(11)&(12)
(14)	...	by (7)–(9) & (13)
(15)	$\Rightarrow$	by (14), (1) & (0)

2 The Situation Calculus and the Wumpus World

We discussed the frame problem and showed how it can be fixed by adding frame axioms. Use the following predicates and functions:

- $At(sq, s)$ means that the agent is at square sq in situation s.
- $Heading(dir, s)$ means that the agent is facing in direction dir in situation s.
- $Next(sq1, dir, sq2)$ means that square $sq2$ is adjacent to square $sq1$ in direction dir.
- $Result(act, s)$ is the situation resulting from executing the action act in situation s.
- $Turn(x)$ is the action of turning x where $x \in \{left, right\}$.
- $Newdir(dir1, x, dir2)$ means that $dir2$ is the new direction the agent will face if it is facing in direction $dir1$ and turns $x \in \{left, right\}$.
- $Wumpus(sq, s)$ means that that the Wumpus is in square sq in situation s.

In the following we assume that the action *Shoot* only has an effect in directly adjacent squares.
a) Formalise an effect axiom for the Wumpus World that best describes the action $Turn(x)$.
b) Formalise an effect axiom that best describes the *Shoot* action in the Wumpus World.
c) Formalise a frame axiom that best describes the *Shoot* action in the Wumpus World.