UE Artificial Intelligence

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Contents

- discussion of the last exercise sheet
- brief discussion of the new exercise sheet

A2.2 - Logic

If the unicorn is magical or goes sailing on rainbows, then it can plant rainbow seeds. If the unicorn is mythical, then it is immortal and goes sailing on rainbows, but if it is not mythical, then it is just a mortal mammal. If the unicorn is either immortal or a mammal, then it is horned. The unicorn is magical if it is horned.

A2.2 - Logic

If the unicorn is ***magical*** *or goes* ***sailing*** *on rainbows, then it can* ***plant*** *rainbow seeds. If the unicorn is* ***mythical****, then it is im****mortal*** *and goes* ***sailing*** *on rainbows, but if it is not* ***mythical****, then it is just a* ***mortal mammal****. If the unicorn is either im****mortal*** *or a* ***mammal****, then it is* ***horned****. The unicorn is* ***magical*** *if it is* ***horned****.*

A2.2 - Logic

If the unicorn is ***magical*** *or goes* ***sailing*** *on rainbows, then it can* ***plant*** *rainbow seeds.*

$$\text{magical} \vee \text{sailing} \rightarrow \text{plant}$$

If the unicorn is ***mythical****, then it is im****mortal*** *and goes* ***sailing*** *on rainbows, but if it is not* ***mythical****, then it is just a* ***mortal mammal****. If the unicorn is either im****mortal*** *or a* ***mammal****, then it is* ***horned****. The unicorn is* ***magical*** *if it is* ***horned****.*

A2.2 - Logic

If the unicorn is ***mythical****, then it is im****mortal*** *and goes* ***sailing*** *on rainbows, ...*

$$\text{magical} \vee \text{sailing} \rightarrow \text{plant}$$
$$\text{mythical} \rightarrow \neg\text{mortal} \wedge \text{sailing}$$

..., but if it is not ***mythical****, then it is just a* ***mortal mammal****. If the unicorn is either im****mortal*** *or a* ***mammal****, then it is* ***horned****. The unicorn is* ***magical*** *if it is* ***horned****.*

A2.2 - Logic

*..., but if it is not **mythical**, then it is just a **mortal mammal**.*

$$
\begin{aligned}
\text{magical} \lor \text{sailing} &\rightarrow \text{plant} \\
\text{mythical} &\rightarrow \neg\text{mortal} \land \text{sailing} \\
\neg\text{mythical} &\rightarrow \text{mortal} \land \text{mammal}
\end{aligned}
$$

*If the unicorn is either im**mortal** or a **mammal**, then it is **horned**. The unicorn is **magical** if it is **horned**.*

A2.2 - Logic

*If the unicorn is either im**mortal** or a **mammal**, then it is **horned***

$$
\begin{aligned}
\text{magical} \lor \text{sailing} &\rightarrow \text{plant} \\
\text{mythical} &\rightarrow \neg\text{mortal} \land \text{sailing} \\
\neg\text{mythical} &\rightarrow \text{mortal} \land \text{mammal} \\
\neg\text{mortal} \lor \text{mammal} &\rightarrow \text{horned}
\end{aligned}
$$

*The unicorn is **magical** if it is **horned**.*

A2.2 - Logic

*The unicorn is **magical** if it is **horned**.*

$$
\begin{aligned}
\text{magical} \vee \text{sailing} &\rightarrow \text{plant} \\
\text{mythical} &\rightarrow \neg\text{mortal} \wedge \text{sailing} \\
\neg\text{mythical} &\rightarrow \text{mortal} \wedge \text{mammal} \\
\neg\text{mortal} \vee \text{mammal} &\rightarrow \text{horned} \\
\text{horned} &\rightarrow \text{magical}
\end{aligned}
$$

A2.2 - Logic

$$
\begin{aligned}
\text{magical} \lor \text{sailing} &\rightarrow \text{plant} \\
\text{mythical} &\rightarrow \neg\text{mortal} \land \text{sailing} \\
\neg\text{mythical} &\rightarrow \text{mortal} \land \text{mammal} \\
\neg\text{mortal} \lor \text{mammal} &\rightarrow \text{horned} \\
\text{horned} &\rightarrow \text{magical}
\end{aligned}
$$

Choice of Inference Method

- Can we use forward or backward chaining?

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- Is "$\neg$mythical $\rightarrow$ mortal $\wedge$ mammal" a Horn clause?

Choice of Inference Method

- Can we use forward or backward chaining?
- Is "$\neg$mythical $\rightarrow$ mortal $\wedge$ mammal" a Horn clause?

$$\neg\text{mythical} \rightarrow \text{mortal} \wedge \text{mammal} \equiv$$
$$\text{mythical} \vee (\text{mortal} \wedge \text{mammal}) \equiv$$
$$(\text{mythical} \vee \text{mortal}) \wedge (\text{mythical} \vee \text{mammal})$$

Choice of Inference Method

- Can we use forward or backward chaining?
- Is "$\neg$mythical $\rightarrow$ mortal $\wedge$ mammal" a Horn clause?

  $\neg \text{mythical} \rightarrow \text{mortal} \wedge \text{mammal} \equiv$
  $\text{mythical} \vee (\text{mortal} \wedge \text{mammal}) \equiv$
  $(\text{mythical} \vee \text{mortal}) \wedge (\text{mythical} \vee \text{mammal})$

- Not a Horn clause, we have to use **resolution**!

Bring the clauses of our KB into CNF

magical $\vee$ **sailing** $\rightarrow$ **plant**

mythical $\rightarrow \neg$mortal $\wedge$ sailing

$\neg$mythical $\rightarrow$ mortal $\wedge$ mammal

$\neg$mortal $\vee$ mammal $\rightarrow$ horned

horned $\rightarrow$ magical

Bring the clauses of our KB into CNF

$(\neg \text{magical} \lor \text{plant}) \land (\neg \text{sailing} \lor \text{plant})$

$\textbf{mythical} \rightarrow \neg \textbf{mortal} \land \textbf{sailing}$

$\neg \text{mythical} \rightarrow \text{mortal} \land \text{mammal}$

$\neg \text{mortal} \lor \text{mammal} \rightarrow \text{horned}$

$\text{horned} \rightarrow \text{magical}$

Bring the clauses of our KB into CNF

$(\neg \text{magical} \lor \text{plant}) \land (\neg \text{sailing} \lor \text{plant})$

$(\neg \text{mythical} \lor \neg \text{mortal}) \land (\neg \text{mythical} \lor \text{sailing})$

$\neg \mathbf{mythical} \rightarrow \mathbf{mortal} \land \mathbf{mammal}$

$\neg \text{mortal} \lor \text{mammal} \rightarrow \text{horned}$

$\text{horned} \rightarrow \text{magical}$

Bring the clauses of our KB into CNF

$(\neg \text{magical} \lor \text{plant}) \land (\neg \text{sailing} \lor \text{plant})$

$(\neg \text{mythical} \lor \neg \text{mortal}) \land (\neg \text{mythical} \lor \text{sailing})$

$(\text{mythical} \lor \text{mortal}) \land (\text{mythical} \lor \text{mammal})$

$\boldsymbol{\neg \textbf{mortal} \lor \textbf{mammal} \rightarrow \textbf{horned}}$

$\text{horned} \rightarrow \text{magical}$

Bring the clauses of our KB into CNF

$(\neg \text{magical} \lor \text{plant}) \land (\neg \text{sailing} \lor \text{plant})$

$(\neg \text{mythical} \lor \neg \text{mortal}) \land (\neg \text{mythical} \lor \text{sailing})$

$(\text{mythical} \lor \text{mortal}) \land (\text{mythical} \lor \text{mammal})$

$(\text{mortal} \lor \text{horned}) \land (\neg \text{mammal} \lor \text{horned})$

$\textbf{horned} \rightarrow \textbf{magical}$

Bring the clauses of our KB into CNF

$(\neg \text{magical} \lor \text{plant}) \land (\neg \text{sailing} \lor \text{plant})$

$(\neg \text{mythical} \lor \neg \text{mortal}) \land (\neg \text{mythical} \lor \text{sailing})$

$(\text{mythical} \lor \text{mortal}) \land (\text{mythical} \lor \text{mammal})$

$(\text{mortal} \lor \text{horned}) \land (\neg \text{mammal} \lor \text{horned})$

$\neg \text{horned} \lor \text{magical}$

CNF of KB

$$
\begin{aligned}
\neg\text{magical} \lor \text{plant} && (1)\\
\neg\text{sailing} \lor \text{plant} && (2)\\
\neg\text{mythical} \lor \neg\text{mortal} && (3)\\
\neg\text{mythical} \lor \text{sailing} && (4)\\
\text{mythical} \lor \text{mortal} && (5)\\
\text{mythical} \lor \text{mammal} && (6)\\
\text{mortal} \lor \text{horned} && (7)\\
\neg\text{mammal} \lor \text{horned} && (8)\\
\neg\text{horned} \lor \text{magical} && (9)
\end{aligned}
$$

Proof: The unicorn goes sailing on rainbows

Proof: The unicorn goes sailing on rainbows

- It is not possible to prove that the unicorn goes sailing on rainbows.
- Informal explanation: You would need to know if the unicorn is mythical, but we do not know. (or, you could also do an exhaustive search and find no contradictions using resolution)

$$
\begin{aligned}
\text{magical} \vee \text{sailing} &\rightarrow \text{plant} \\
\textbf{mythical} &\rightarrow \neg\textbf{mortal} \wedge \textbf{sailing} \\
\neg\text{mythical} &\rightarrow \text{mortal} \wedge \text{mammal} \\
\neg\text{mortal} \vee \text{mammal} &\rightarrow \text{horned} \\
\text{horned} &\rightarrow \text{magical}
\end{aligned}
$$

Reminder: Resolution rule

$$\frac{a \vee b, \quad \neg a \vee c}{b \vee c}$$

Proof: The unicorn can place rainbow seeds

$$\neg\text{magical} \lor \text{plant} \tag{1}$$

$$\neg\text{sailing} \lor \text{plant} \tag{2}$$

$$\neg\text{mythical} \lor \neg\text{mortal} \tag{3}$$

$$\neg\text{mythical} \lor \text{sailing} \tag{4}$$

$$\text{mythical} \lor \text{mortal} \tag{5}$$

$$\text{mythical} \lor \text{mammal} \tag{6}$$

$$\text{mortal} \lor \text{horned} \tag{7}$$

$$\neg\text{mammal} \lor \text{horned} \tag{8}$$

$$\neg\text{horned} \lor \text{magical} \tag{9}$$

Proof: The unicorn can place rainbow seeds

$$\neg\text{magical} \vee \text{plant} \tag{1}$$
$$\neg\text{sailing} \vee \text{plant} \tag{2}$$
$$\neg\text{mythical} \vee \neg\text{mortal} \tag{3}$$
$$\neg\text{mythical} \vee \text{sailing} \tag{4}$$
$$\text{mythical} \vee \text{mortal} \tag{5}$$
$$\text{mythical} \vee \text{mammal} \tag{6}$$
$$\text{mortal} \vee \text{horned} \tag{7}$$
$$\neg\text{mammal} \vee \text{horned} \tag{8}$$
$$\neg\text{horned} \vee \text{magical} \tag{9}$$
$$\neg\text{plant} \tag{10}$$

Proof: The unicorn can place rainbow seeds

$$\neg\text{magical} \lor \text{plant} \quad (1)$$
$$\neg\text{sailing} \lor \text{plant} \quad (2)$$
$$\neg\text{mythical} \lor \neg\text{mortal} \quad (3)$$
$$\neg\text{mythical} \lor \text{sailing} \quad (4)$$
$$\text{mythical} \lor \text{mortal} \quad (5)$$
$$\text{mythical} \lor \text{mammal} \quad (6)$$
$$\text{mortal} \lor \text{horned} \quad (7)$$
$$\neg\text{mammal} \lor \text{horned} \quad (8)$$
$$\neg\text{horned} \lor \text{magical} \quad (9)$$
$$\neg\text{plant} \quad (10)$$

(1) + (9):

$$\neg\text{horned} \lor \text{plant} \quad (11)$$

Proof: The unicorn can place rainbow seeds

$$\neg \text{magical} \vee \text{plant} \tag{1}$$
$$\neg \text{sailing} \vee \text{plant} \tag{2}$$
$$\neg \text{mythical} \vee \neg \text{mortal} \tag{3}$$
$$\neg \text{mythical} \vee \text{sailing} \tag{4}$$
$$\text{mythical} \vee \text{mortal} \tag{5}$$
$$\text{mythical} \vee \text{mammal} \tag{6}$$
$$\text{mortal} \vee \text{horned} \tag{7}$$
$$\neg \text{mammal} \vee \text{horned} \tag{8}$$
$$\neg \text{horned} \vee \text{magical} \tag{9}$$
$$\neg \text{plant} \tag{10}$$
$$\neg \text{horned} \vee \text{plant} \tag{11}$$

(2) + (4):

$$\neg \text{mythical} \vee \text{plant} \tag{12}$$

Proof: The unicorn can place rainbow seeds

$$\neg\text{magical} \lor \text{plant} \quad (1)$$

$$\neg\text{sailing} \lor \text{plant} \quad (2)$$

$$\neg\text{mythical} \lor \neg\text{mortal} \quad (3)$$

$$\neg\text{mythical} \lor \text{sailing} \quad (4)$$

$$\text{mythical} \lor \text{mortal} \quad (5)$$

$$\text{mythical} \lor \text{mammal} \quad (6)$$

$$\text{mortal} \lor \text{horned} \quad (7)$$

$$\neg\text{mammal} \lor \text{horned} \quad (8)$$

$$\neg\text{horned} \lor \text{magical} \quad (9)$$

$$\neg\text{plant} \quad (10)$$

$$\neg\text{horned} \lor \text{plant} \quad (11)$$

$$\neg\text{mythical} \lor \text{plant} \quad (12)$$

(6) + (8):

$$\text{mythical} \lor \text{horned} \quad (13)$$

Proof: The unicorn can place rainbow seeds

$$\neg \text{magical} \lor \text{plant} \quad (1)$$

$$\neg \text{sailing} \lor \text{plant} \quad (2)$$

$$\neg \text{mythical} \lor \neg \text{mortal} \quad (3)$$

$$\neg \text{mythical} \lor \text{sailing} \quad (4)$$

$$\text{mythical} \lor \text{mortal} \quad (5)$$

$$\text{mythical} \lor \text{mammal} \quad (6)$$

$$\text{mortal} \lor \text{horned} \quad (7)$$

$$\neg \text{mammal} \lor \text{horned} \quad (8)$$

$$\neg \text{horned} \lor \text{magical} \quad (9)$$

$$\neg \text{plant} \quad (10)$$

$$\neg \text{horned} \lor \text{plant} \quad (11)$$

$$\neg \text{mythical} \lor \text{plant} \quad (12)$$

$$\text{mythical} \lor \text{horned} \quad (13)$$

(12) + (13):

$$\text{horned} \lor \text{plant} \quad (14)$$

Proof: The unicorn can place rainbow seeds

$$\neg \text{magical} \vee \text{plant} \quad (1)$$
$$\neg \text{sailing} \vee \text{plant} \quad (2)$$
$$\neg \text{mythical} \vee \neg \text{mortal} \quad (3)$$
$$\neg \text{mythical} \vee \text{sailing} \quad (4)$$
$$\text{mythical} \vee \text{mortal} \quad (5)$$
$$\text{mythical} \vee \text{mammal} \quad (6)$$
$$\text{mortal} \vee \text{horned} \quad (7)$$
$$\neg \text{mammal} \vee \text{horned} \quad (8)$$
$$\neg \text{horned} \vee \text{magical} \quad (9)$$
$$\neg \text{plant} \quad (10)$$

$$\neg \text{horned} \vee \text{plant} \quad (11)$$
$$\neg \text{mythical} \vee \text{plant} \quad (12)$$
$$\text{mythical} \vee \text{horned} \quad (13)$$
$$\text{horned} \vee \text{plant} \quad (14)$$

(11) + (14):

$$\text{plant} \quad (15)$$

Proof: The unicorn can place rainbow seeds

$$\neg\text{magical} \lor \text{plant} \quad (1)$$
$$\neg\text{sailing} \lor \text{plant} \quad (2)$$
$$\neg\text{mythical} \lor \neg\text{mortal} \quad (3)$$
$$\neg\text{mythical} \lor \text{sailing} \quad (4)$$
$$\text{mythical} \lor \text{mortal} \quad (5)$$
$$\text{mythical} \lor \text{mammal} \quad (6)$$
$$\text{mortal} \lor \text{horned} \quad (7)$$
$$\neg\text{mammal} \lor \text{horned} \quad (8)$$
$$\neg\text{horned} \lor \text{magical} \quad (9)$$
$$\neg\text{plant} \quad (10)$$
$$\neg\text{horned} \lor \text{plant} \quad (11)$$
$$\neg\text{mythical} \lor \text{plant} \quad (12)$$
$$\text{mythical} \lor \text{horned} \quad (13)$$
$$\text{horned} \lor \text{plant} \quad (14)$$
$$\text{plant} \quad (15)$$

(10) + (15):

$$\textbf{False} \quad (16)$$

Proof: The unicorn can place rainbow seeds

$$\neg\text{magical} \lor \text{plant} \tag{1}$$
$$\neg\text{sailing} \lor \text{plant} \tag{2}$$
$$\neg\text{mythical} \lor \neg\text{mortal} \tag{3}$$
$$\neg\text{mythical} \lor \text{sailing} \tag{4}$$
$$\text{mythical} \lor \text{mortal} \tag{5}$$
$$\text{mythical} \lor \text{mammal} \tag{6}$$
$$\text{mortal} \lor \text{horned} \tag{7}$$
$$\neg\text{mammal} \lor \text{horned} \tag{8}$$
$$\neg\text{horned} \lor \text{magical} \tag{9}$$
$$\neg\text{plant} \tag{10}$$
$$\neg\text{horned} \lor \text{plant} \tag{11}$$
$$\neg\text{mythical} \lor \text{plant} \tag{12}$$
$$\text{mythical} \lor \text{horned} \tag{13}$$
$$\text{horned} \lor \text{plant} \tag{14}$$
$$\text{plant} \tag{15}$$
$$\textbf{False} \tag{16}$$

- Contradiction found, therefore “plant” is proven.

A2.3 aka “The Trainwreck”

- anything that follows after this slide is an effort to fix A2.3 in such a way that it makes sense
- in any case, you don’t need to know any of this for the exam, so feel free to switch off your ears

Horn Clauses and Integrity Constraints

- Horn clauses have **at most one** positive literal
- $\neg A \vee \neg B \vee C \equiv A \wedge B \rightarrow C$
- rules of the form $A \wedge B \rightarrow C$ are called **definite clauses**
- rules of the form $A \wedge B \rightarrow \mathit{false}$ are called **integrity constraints**
- integrity constraints allow us to express that some combination of propositions cannot **all** be true
- the rule $A \wedge B \rightarrow \mathit{false}$ means that A and B cannot **both** be true

Horn Clauses and Integrity Constraints

- $KB_1 = \{A \wedge B \rightarrow \mathit{false}, C \rightarrow A, C \rightarrow B\}$
- C must be *false* in all models of KB_1
- $KB_1 \models \neg C$ or alternatively: $KB_1 \models C \rightarrow \mathit{false}$
- $KB_2 = \{A \wedge B \rightarrow \mathit{false}, C \rightarrow A, D \rightarrow B\}$
- either C is *false* or D is *false* in all models of KB_2
- $KB_2 \models \neg C \vee \neg D$ or alternatively: $KB_2 \models C \wedge D \rightarrow \mathit{false}$

Conflicts and Assumables

- reasoning from contradictions can be useful for planning
- it is useful for an agent to know that certain combinations of actions are impossible
- an **assumable** is a proposition that can be assumed in a proof by contradiction
- a **conflict** $C = \{c_0, ...c_i\}$ is a set of assumables that implies *false* for a given knowledgebase *KB*
- formally: $KB \cup \{c_0, ..., c_i\} \vDash false$
- informally: if we assume all propositions in *KB* and all propositions in the conflict set are *true*, we can derive *false*

Incomplete definitions and infinity ...

- A2.3 was supposed to be about planning, so the set of assumables will be propositions which model movement
- unfortunately the definitions for

$$Stay_{ij}, Left_{ij}, Right_{ij}, Up_{ij}, Down_{ij}$$

  are missing the "t", so to speak, and interpretability suffers
- the more usable definitions are

$$Stay_{ij}^{(t)}, Left_{ij}^{(t)}, Right_{ij}^{(t)}, Up_{ij}^{(t)}, Down_{ij}^{(t)}$$

- furthermore, t is not bounded above, so there are infinitely many clauses
- we'll fix that, and simply restrict the set of assumables

The (fixed) Knowledge Base from A2.3

$$U_{0,0}^{(0)}, S_{2,1}^{(0,2)}, F_{3,0}$$

$$Right_{i,j}^{(t)}, Left_{i,j}^{(t)}$$

$$Up_{i,j}^{(t)}, Down_{i,j}^{(t)}$$

$$Stay_{i,j}^{(t)}$$

$$U_{i,j}^{(t)} \wedge Right_{i,j} \Rightarrow U_{i,j+1}^{(t+1)}$$

$$U_{i,j}^{(t)} \wedge Left_{i,j} \Rightarrow U_{i,j-1}^{(t+1)}$$

$$U_{i,j}^{(t)} \wedge Up_{i,j} \Rightarrow U_{i-1,j}^{(t+1)}$$

$$U_{i,j}^{(t)} \wedge Down_{i,j} \Rightarrow U_{i+1,j}^{(t+1)}$$

$$U_{i,j}^{(t)} \wedge Stay_{i,j} \Rightarrow U_{i,j}^{(t+1)}$$

$$S_{i,j}^{(t,f)} \Rightarrow S_{i,j}^{(t+1,f-1)}$$

$$S_{i,j}^{(t,0)} \Rightarrow R_{i,j}^{(t)}$$

$$S_{i,j}^{(t,0)} \Rightarrow R_{i,j+1}^{(t)}$$

$$S_{i,j}^{(t,0)} \Rightarrow R_{i,j-1}^{(t)}$$

$$S_{i,j}^{(t,0)} \Rightarrow R_{i-1,j}^{(t)}$$

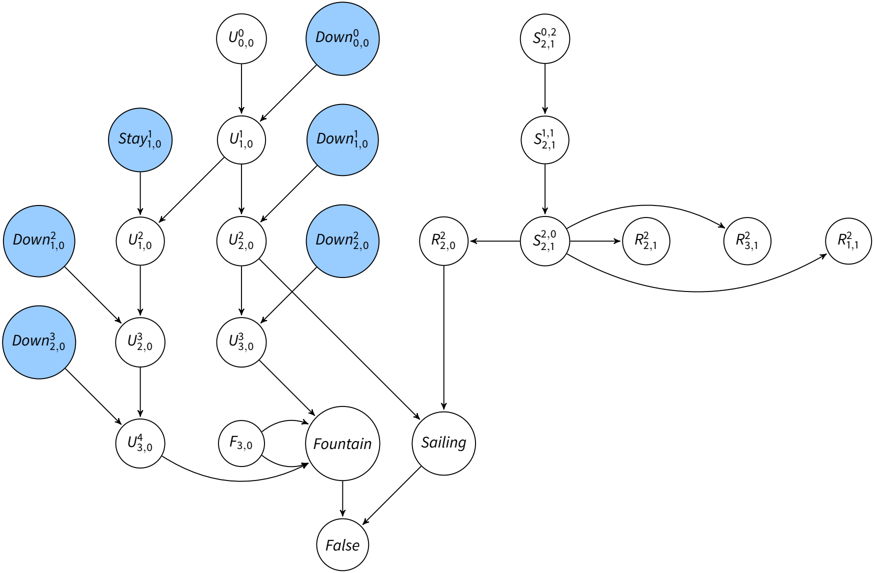
$$S_{i,j}^{(t,0)} \Rightarrow R_{i+1,j}^{(t)}$$

$$U_{i,j}^{(t)} \wedge R_{i,j}^{(t)} \Rightarrow Sailing$$

$$U_{i,j}^{(t)} \wedge F_{i,j} \Rightarrow Fountain$$

$$Sailing \wedge Fountain \Rightarrow False$$

An AND-OR subgraph for A2.3



Forward Chaining for Definite Clauses

(Definite Clauses only)

function *DeductFC*(KB) $\triangleright$ KB is the set of known propositions

  $C \leftarrow \{\}$ $\triangleright$ C is the set of Consequences

  repeat

    select $b_1 \wedge \ldots \wedge b_i \rightarrow h$, such that

      $\forall i : b_i \in C \cup KB$ and

      $h \notin C$

    $C \leftarrow C \cup \{h\}$

  until no more clauses can be selected

  return C

end function

Forward Chaining for Horn Clauses
(Definite Clauses and Integrity Constraints)

function $DeductFCWIC(KB, A)$ $\triangleright$ A is a set of assumables

$C \leftarrow \{\langle a, \{a\}\rangle | a \in A\}$ $\triangleright$ C is a set of pairs $\langle atom, assumables\rangle$

repeat

select $b_1 \wedge \ldots \wedge b_i \rightarrow h$, such that

$\forall i : \langle b_i, A_i\rangle \in C \vee b_i \in KB$ and

$\langle h, A_u\rangle \notin C, A_u = \bigcup A_i$

$C \leftarrow C \cup \{\langle h, A_u\rangle\}$

until no more clauses can be selected

return $\{A_c : \langle false, A_c\rangle \in C\}$

end function

Finding Conflicts

In the following, we write C as a union: $C = \bigcup C_i$

$$
\begin{aligned}
C_0 = \{ \quad & \langle Down^0_{0,0}, \{Down^0_{0,0}\}\rangle, \langle Down^1_{1,0}, \{Down^1_{1,0}\}\rangle, \langle Down^2_{2,0}, \{Down^2_{2,0}\}\rangle, \\
& \langle Stay^1_{1,0}, \{Stay^1_{1,0}\}\rangle, \langle Down^2_{1,0}, \{Down^2_{1,0}\}\rangle, \langle Down^3_{2,0}, \{Down^3_{2,0}\}\rangle\} \\
C_1 = \{ \quad & \langle U^1_{1,0}, \{Down^0_{0,0}\}\rangle\} \\
C_2 = \{ \quad & \langle U^2_{2,0}, \{Down^0_{0,0}, Down^1_{1,0}\}\rangle\} \\
C_3 = \{ \quad & \langle Sailing, \{Down^0_{0,0}, Down^1_{1,0}\}\rangle\} \\
C_4 = \{ \quad & \langle U^3_{3,0}, \{Down^0_{0,0}, Down^1_{1,0}, Down^2_{2,0}\}\rangle\} \\
C_5 = \{ \quad & \langle Fountain, \{Down^0_{0,0}, Down^1_{1,0}, Down^2_{2,0}\}\rangle\} \\
C_6 = \{ \quad & \langle False, \{Down^0_{0,0}, Down^1_{1,0}, Down^2_{2,0}\}\rangle\} \\
C_7 = \{ \quad & \langle U^2_{1,0}, \{Down^0_{0,0}, Stay^1_{1,0}\}\rangle\} \\
C_8 = \{ \quad & \langle U^3_{2,0}, \{Down^0_{0,0}, Stay^1_{1,0}, Down^2_{1,0}\}\rangle\} \\
C_9 = \{ \quad & \langle U^4_{3,0}, \{Down^0_{0,0}, Stay^1_{1,0}, Down^2_{1,0}, Down^3_{2,0}\}\rangle\} \\
C_{10} = \{ \quad & \langle Fountain, \{Down^0_{0,0}, Stay^1_{1,0}, Down^2_{1,0}, Down^3_{2,0}\}\rangle\} \\
C_{11} = \{ \quad & \langle False, \{Down^0_{0,0}, Stay^1_{1,0}, Down^2_{1,0}, Down^3_{2,0}, Down^1_{1,0}\}\rangle\}
\end{aligned}
$$

Two Conflicts

$$C_6 = \{ \quad \langle False, \{Down^0_{0,0}, Down^1_{1,0}, Down^2_{2,0}\}\rangle\}$$
$$C_{11} = \{ \quad \langle False, \{Down^0_{0,0}, Stay^1_{1,0}, Down^2_{1,0}, Down^3_{2,0}, Down^1_{1,0}\}\rangle\}$$

This means that our Knowledge Base entails:

$$KB \models \neg Down^0_{0,0} \vee \neg Down^1_{1,0} \vee \neg Down^2_{2,0}$$
$$KB \models \neg Down^0_{0,0} \vee \neg Stay^1_{1,0} \vee \neg Down^2_{1,0} \vee \neg Down^3_{2,0} \vee \neg Down^1_{1,0}$$

What does this mean for A2.3?

- it means in order to fix the inconsistencies in the *KB*, we have to assume that one of the original assumables is actually *False*
- for each conflict we can now set each combination of assumables to *False*, which means we simply do not assume them to be *True*, and see whether we still have conflicts
- in the case of A2.3 this can mean:
  - if we assume $Down^1_{1,0}$ to be *False*, we have no conflicts anymore, and we can prove *Fountain*
  - if we assume $Stay^1_{1,0}$ and $Down^2_{2,0}$ both to be *False*, we have no conflicts, and we can prove *Sailing*

A3

- Unification - you will be asked to unify some sentences, and give the Most General Unifier
- Answering Probabilistic Queries - given the Joint Probability
- Forward / Backward Chaining in First Order Logic

Competition

- if you want to **get points** for the competition, you **have** to participate in the **final** round on **08.01.2016** !
- all **other rounds** are/were **only warmup** !
- one group almost beat the best group from last year, so it's definitely possible ...
- remember you **don't need to beat** the best group, just **try** and come **close**

Questions

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