Principles of AI Planning

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Exercise Sheet 7

Due: Friday, December 7th, 2018

Send your solution to `drexlerd@tf.uni-freiburg.de` or submit a hardcopy before the lecture.

Exercise 7.1 (Relaxed planning graph and heuristics, 2+2 points)
Consider the relaxed planning task Π^+ with variables $A = \{a, b, c, d, e\}$, operators $O = \{o_1, o_2, o_3\}$, $o_1 = \langle d, c \wedge (c \rhd e)\rangle$, $o_2 = \langle c, a\rangle$, $o_3 = \langle a, b\rangle$, goal $\gamma = b \wedge e$ and initial state $s = \{a \mapsto 0, b \mapsto 0, c \mapsto 0, d \mapsto 1, e \mapsto 0\}$. Solve the following exercises by drawing the relaxed planning graph for the lowest depth k that is necessary to extract a solution.

(a) Calculate $h_{\mathrm{sa}}(s)$ for Π^+.

(b) Calculate $h_{\mathrm{FF}}(s)$ for Π^+.

Exercise 7.2 (Finite-domain representation, 2+2+2 points)
Consider the propositional Blocksworld planning task $\Pi = \langle A, I, O, \gamma\rangle$, with

- the set of variables

$$A = \{A\text{-}clear, B\text{-}clear, C\text{-}clear, A\text{-}on\text{-}B, A\text{-}on\text{-}C, A\text{-}on\text{-}T, B\text{-}on\text{-}A, B\text{-}on\text{-}C, B\text{-}on\text{-}T, C\text{-}on\text{-}A, C\text{-}on\text{-}B, C\text{-}on\text{-}T\}$$

- $I(a) = 1$ for $a \in \{B\text{-}on\text{-}T, A\text{-}on\text{-}B, A\text{-}clear, C\text{-}on\text{-}T, C\text{-}clear\}$,
  $I(a) = 0$, else.

- O contains the actions

$$\begin{aligned}
\text{move-}X\text{-}Y\text{-}Z &= \langle X\text{-}on\text{-}Y \wedge X\text{-}clear \wedge Z\text{-}clear,\\
&\qquad \neg X\text{-}on\text{-}Y \wedge Y\text{-}clear \wedge X\text{-}on\text{-}Z \wedge \neg Z\text{-}clear\rangle\\
\text{move-}X\text{-Table-}Z &= \langle X\text{-}on\text{-}T \wedge X\text{-}clear \wedge Z\text{-}clear,\\
&\qquad \neg X\text{-}on\text{-}T \wedge X\text{-}on\text{-}Z \wedge \neg Z\text{-}clear\rangle\\
\text{move-}X\text{-}Y\text{-Table} &= \langle X\text{-}on\text{-}Y \wedge X\text{-}clear,\\
&\qquad \neg X\text{-}on\text{-}Y \wedge Y\text{-}clear \wedge X\text{-}on\text{-}T\rangle
\end{aligned}$$

  for pair-wise distinct $X, Y, Z \in \{A, B, C\}$

- $\gamma = B\text{-}on\text{-}C \wedge C\text{-}on\text{-}A$.

(a) The following mutex groups can be found for Π:

$$\begin{aligned}
L_1 &= \{B\text{-}on\text{-}A, C\text{-}on\text{-}A, A\text{-}clear\}\\
L_2 &= \{A\text{-}on\text{-}B, C\text{-}on\text{-}B, B\text{-}clear\}\\
L_3 &= \{A\text{-}on\text{-}C, B\text{-}on\text{-}C, C\text{-}clear\}\\
L_4 &= \{A\text{-}on\text{-}B, A\text{-}on\text{-}C, A\text{-}on\text{-}T\}\\
L_5 &= \{B\text{-}on\text{-}A, B\text{-}on\text{-}C, B\text{-}on\text{-}T\}\\
L_6 &= \{C\text{-}on\text{-}A, C\text{-}on\text{-}B, C\text{-}on\text{-}T\}
\end{aligned}$$

Specify a planning task Π' that is equivalent to Π and in finite-domain representation by using these mutex groups. Please name the variables in a reasonable way (e.g., analogously to the examples given in the lecture).

(b) Specify the propositional planning task Π'' that is induced by Π'.

(c) How are both planning tasks Π and Π'' related? Is a plan for Π always a plan for Π'' and vice versa?

You may and should solve the exercise sheets in groups of two. Please state both names on your solution.