Principles of AI Planning

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Exercise Sheet 8

Due: Friday, December 20th, 2019

Send your solution to `mario.kantz@gmail.com` (PDF only) or submit a hardcopy before the lecture. The exercise sheets may and should be worked on and handed in in groups of two or three students. Please indicate all names on your solution.

Exercise 8.1 (Relaxed planning graph and heuristics, 2+2 points)
Consider the relaxed planning task Π^+ with variables $A = \{a, b, c, d, e\}$, operators $O = \{o_1, o_2, o_3\}$, $o_1 = \langle d, c \land (c \rhd e)\rangle$, $o_2 = \langle c, a\rangle$, $o_3 = \langle a, b\rangle$, goal $\gamma = b \land e$ 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 8.2 (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

$$\begin{aligned} A = \{&\textit{A-clear}, \textit{B-clear}, \textit{C-clear}, \textit{A-on-B}, \textit{A-on-C}, \textit{A-on-T}, \\ &\textit{B-on-A}, \textit{B-on-C}, \textit{B-on-T}, \textit{C-on-A}, \textit{C-on-B}, \textit{C-on-T}\} \end{aligned}$$

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

- O contains the actions

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

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

- $\gamma = \textit{B-on-C} \land \textit{C-on-A}$.

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

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

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?