Foundations of Artificial Intelligence

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Exercise Sheet 12

Due: May 27, 2016

Exercise 12.1 (2+3 marks)

Consider again the planning task of Exercise 11.2 where an agent aims to raise a treasure by collecting a key and using it to open the chest that contains the treasure. Recall the problem formalization $\Pi = \langle V, \mathrm{dom}, I, G, A \rangle$ in the SAS^+ formalism, where

- $V = \{loc, key, trs\}$ is the set of variables with $\mathrm{dom}(loc) = \{A, B, C\}$, $\mathrm{dom}(key) = \{\top, \bot\}$, and $\mathrm{dom}(trs) = \{\top, \bot\}$;
- $I = \{loc \mapsto B, key \mapsto \bot, trs \mapsto \bot\}$ is the initial state;
- $G = \{key \mapsto \top, trs \mapsto \top\}$ is the goal description; and
- $A = \{move_{A,B}, move_{B,A}, move_{B,C}, move_{C,B}, take, open\}$ is the set of actions with

$pre(move_{A,B}) = \{loc \mapsto A\}$	$\mathit{eff}(move_{A,B}) = \{loc \mapsto B\}$	$cost(move_{A,B}) = 3$
$pre(move_{B,A}) = \{loc \mapsto B\}$	$\mathit{eff}(move_{B,A}) = \{loc \mapsto A\}$	$cost(move_{B,A}) = 3$
$pre(move_{B,C}) = \{loc \mapsto B\}$	$\mathit{eff}(move_{B,C}) = \{loc \mapsto C\}$	$cost(move_{B,C}) = 3$
$pre(move_{C,B}) = \{loc \mapsto C\}$	$\mathit{eff}(move_{C,B}) = \{loc \mapsto B\}$	$cost(move_{C,B}) = 3$
$pre(take) = \{key \mapsto \bot, loc \mapsto A\}$	$\mathit{eff}(take) = \{key \mapsto \top\}$	$cost(take) = 1$
$pre(open) = \{key \mapsto \top, loc \mapsto C\}$	$\mathit{eff}(open) = \{trs \mapsto \top\}$	$cost(open) = 1$

(a) Provide a graph that represents the atomic projections for the variables *loc*, *key* and *trs*.

(b) Compute the merge-and-shrink abstraction for the given planning task. Assume that abstractions with up to $K = 8$ states can be kept in memory and shrink the *larger* one of two abstractions S_1 and S_2 that are selected for the next merge step. Use the following strategies:

- merge strategy: start with *loc* and *key*, then merge the result with *trs*
- shrink strategy: combine nodes with equal goal distance, ordered by their goal distance (from small to large)

What is the value of the merge-and-shrink heuristic in the initial state?

Exercise 12.2 (7 marks)

Consider the delete-free STRIPS planning task $\Pi^+ = \langle V, I, G, A \rangle$, with

- set of variables $V = \{a, b, c, d, e, f, g\}$
- initial state $I = \{a\}$,
- goal description $G = \{g\}$, and

- set of actions $A = \{a_1, \ldots, a_6\}$ with

$$
\begin{array}{lll}
pre(a_1) = \{a\} & add(a_1) = \{b, d\} & cost(a_1) = 1 \\
pre(a_2) = \{b\} & add(a_2) = \{d, e, f\} & cost(a_2) = 6 \\
pre(a_3) = \{a\} & add(a_3) = \{c, d\} & cost(a_3) = 2 \\
pre(a_4) = \{c, d\} & add(a_4) = \{e\} & cost(a_4) = 1 \\
pre(a_5) = \{e\} & add(a_5) = \{f\} & cost(a_5) = 2 \\
pre(a_6) = \{d, e, f\} & add(a_6) = \{g\} & cost(a_6) = 0.
\end{array}
$$

Compute $h^{\text{LM-cut}}(I)$ and provide all intermediate results in the same way they were given in the example of the lecture (including the justification graph with h^{max} annotations).

The exercise sheets can be submitted in groups of two students. Please provide both student names on the submission.