Foundations of Artificial Intelligence

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Exercise Sheet 11

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Exercise 11.1 (1+1 marks)

Are the following statements about landmarks correct? Justify your answer.

(a) If L is a landmark and a is an action not occuring in L, then $L' = L \cup \{a\}$ is a landmark.

(b) Given a set of landmarks $\mathcal{L}$ which are pairwise disjoint (meaning we have $L_i \cap L_j = \emptyset$ for all $L_i \in \mathcal{L}$ and $L_j \in \mathcal{L}$ with $i \neq j$), the sum of the costs of all landmarks is an admissible heuristic.

Exercise 11.2 (3 marks)

Consider the delete-free STRIPS planning task $\Pi^+ = \langle V, I, G, A \rangle$, with variables $V = \{i, a, b, c, d, e, f, g\}$, initial state $I = \{i\}$, goal description $G = \{g\}$, and actions $A = \{a_1, \ldots, a_7\}$, where

$$
\begin{array}{lll}
pre(a_1) = \{i\} & add(a_1) = \{a, b\} & cost(a_1) = 2 \\
pre(a_2) = \{i\} & add(a_2) = \{b, c\} & cost(a_2) = 3 \\
pre(a_3) = \{a\} & add(a_3) = \{d, e\} & cost(a_3) = 5 \\
pre(a_4) = \{b, c\} & add(a_4) = \{e, f\} & cost(a_4) = 3 \\
pre(a_5) = \{e, f\} & add(a_5) = \{d\} & cost(a_5) = 2 \\
pre(a_6) = \{e\} & add(a_6) = \{f\} & cost(a_6) = 4 \\
pre(a_7) = \{d, f\} & add(a_6) = \{g\} & cost(a_6) = 0.
\end{array}
$$

Compute $h^{\text{LM-cut}}(I)$ and provide all intermediate results in the same way they were given in the example of the lecture. Specifically, provide the following for each iteration except the last one (where $h^{\max}(g) = 0$):

- the justification graph with $h^{\max}$ annotations and marked goal zone
- the cut
- the cost of the cut
- the updated action costs

In cases where the precondition choice function is not deterministic, choose the precondition in alphabetical order.

Exercise 11.3 (2+2+1 Punkte)

A state in the *Nim* game consist of $n > 0$ stacks of coins where $c_i \geq 0$ is the number of coins on stack i. Players MAX and MIN alternate (with MAX starting) choosing a nonempty stack i and removing between 1 and c_i coins from it. Whichever player removes the last coin from the last stack wins the game.

(a) Draw the game tree for a game starting with two stacks, one with three coins and one with one coin. Denote leaves with 1 if they represent a winning state for MAX and with -1 if they represent a winning state for MIN.

(b) Apply Minimax in order to determine the value of the root. Which player has a winning strategy?

(c) Who would have the winning strategy if the initial state would be $(4, 1)$? Justify your answer by describing the winning strategy.

Submission rules:
Upload a single PDF file (ending .pdf). If you want to submit handwritten parts, include their scans in the single PDF. Put the names of all group members on top of the first page. Use page numbers or put your names on each page. Make sure your PDF has size A4 (fits the page size if printed on A4).