Foundations of Artificial Intelligence

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Exercise Sheet 11

Due: May 15, 2022

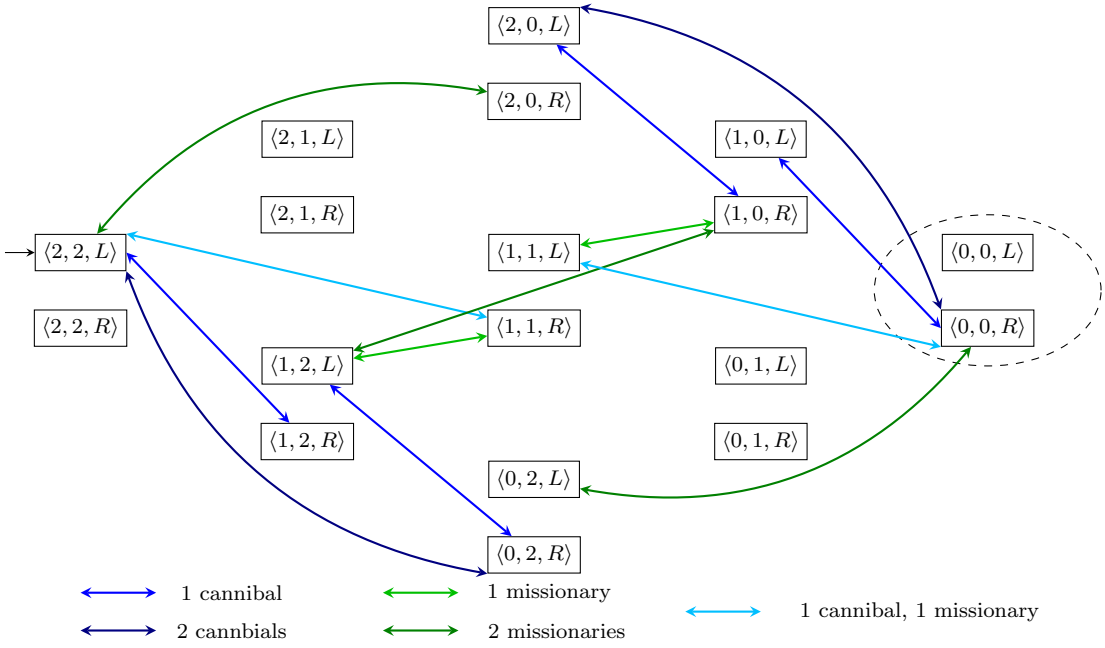
Important: for submission, consult the rules at the end of the exercise. Non-adherence to the rules will lead to your submission not being corrected.

Exercise 11.1 (1 mark)

Consider the following abstraction function: For every possible h^* value there is an abstract state representing this value, and every state s is mapped to the abstract state representing the h^* value of s. Why is the heuristic induced by this abstraction not practical?

Exercise 11.2 (1.5+1+0.5+1 marks)

The following graph depicts the search space of a cannibals and missionary problem with two cannibals and two missionaries:



A state is represented as a tuple $\langle C, M, B\rangle$, where C and M (with $\mathrm{dom}(C) = \mathrm{dom}(M) = \{0, 1, 2\}$) denote how many cannibals and missionaries respectively are on the left shore, and B (with $\mathrm{dom}(B) = \{L, R\}$) denotes on which shore the boat is. The cost of all operators is 1.

(a) Draw the abstract state space that is induced by the projection $P = \{C, M\}$ in the same way as the above depiction of the concrete state space.

(b) Use the abstraction from part (a) to derive a pattern database heuristic. Provide all database entries, i.e., the abstract distances for all states in the abstract state space.

(c) What is $h^{\{C,M\}}(I)$?

(d) For a cannibals and missionaries problem with n cannibals and n missionaries, what would $h^{\{C,M\}}(I)$ be? Justify your answer.

Exercise 11.3 (1+1 marks)
Assume we have a set of landmarks $\mathcal{L}$ as well as a single landmark $L \notin \mathcal{L}$ for some task Π^+ with initial state I. Can the following situations occur? Justify your answer.

(a) $h^{\text{MHS}}(I)$ with landmark set $\mathcal{L}$ is larger than $h^{\text{MHS}}(I)$ with landmark set $\mathcal{L} \cup \{L\}$.

(b) $h^{\text{OCP}}(I)$ with landmark set $\mathcal{L}$ is larger than $h^{\text{OCP}}(I)$ with landmark set $\mathcal{L} \cup \{L\}$.

Hint: In both parts of the exercise, consider how the optimal solutions for $\mathcal{L} \cup \{L\}$ and $\mathcal{L}$ relate to each other. Is a solution for $\mathcal{L} \cup \{L\}$ also a solution for $\mathcal{L}$, or vice versa? If so, is an optimal solution for one also an optimal solution for the other? Keep in mind that MHS is a minimization problem and the LP in OCP a maximization problem.

Exercise 11.4 (3 marks)
Consider the delete-free STRIPS planning task $\Pi^+ = \langle V, I, G, A \rangle$, with variables $V = \{i, g, k, l, m, n, o\}$, initial state $I = \{i\}$, goal description $G = \{g\}$, and actions $A = \{a_1, \ldots, a_6\}$, where

$$
\begin{array}{lll}
\mathit{pre}(a_1) = \{i\} & \mathit{add}(a_1) = \{k, n\} & \mathit{cost}(a_1) = 4 \\
\mathit{pre}(a_2) = \{i\} & \mathit{add}(a_2) = \{l, m\} & \mathit{cost}(a_2) = 3 \\
\mathit{pre}(a_3) = \{l\} & \mathit{add}(a_3) = \{n\} & \mathit{cost}(a_3) = 6 \\
\mathit{pre}(a_4) = \{l, m\} & \mathit{add}(a_4) = \{o\} & \mathit{cost}(a_4) = 4 \\
\mathit{pre}(a_5) = \{l, n\} & \mathit{add}(a_5) = \{o\} & \mathit{cost}(a_5) = 5 \\
\mathit{pre}(a_6) = \{n, o\} & \mathit{add}(a_6) = \{g\} & \mathit{cost}(a_6) = 0.
\end{array}
$$

Note that Π^+ is already in normal form.
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.

Submission rules:

- Exercise sheets must be submitted in groups of two students. Please submit a single copy of the exercises per group (only one member of the group does the submission).
- Create a single PDF file (ending .pdf) for all non-programming exercises. Use a file name that does not contain any spaces or special characters other than the underscore "_". If you want to submit handwritten solutions, include their scans in the single PDF. Make sure it is in a reasonable resolution so that it is readable, but ensure at the same time that the PDF size is not astronomically large. Put the names of all group members on top of the first page. Either use page numbers on all pages or put your names on each page. Make sure your PDF has size A4 (fits the page size if printed on A4).
- For programming exercises, only create those code textfiles required by the exercise. Put your names in a comment on top of each file. Make sure your code compiles and test it. Code that does not compile or which we cannot successfully execute will not be graded.

- For the submission: if the exercise sheet does not include programming exercises, simply upload the single PDF. If the exercise sheet includes programming exercises, upload a ZIP file (ending .zip, .tar.gz or .tgz; *not* .rar or anything else) containing the single PDF and the code textfile(s) and nothing else. Do not use directories within the ZIP, i.e., zip the files directly.
- Do not upload several versions to ADAM, i.e., if you need to resubmit, use the same file name again so that the previous submission is overwritten.