Planning and Optimization

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Exercise Sheet 10

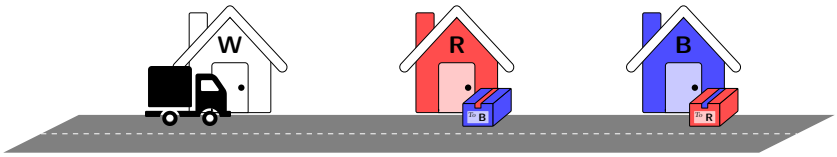
Due: December 11, 2023

Important: For submission, consult the rules at the end of the exercise. Non-adherence to these rules might lead to a penalty in the form of a deduction of marks or, in the worst case, that your submission will not be marked at all.

Exercise 10.1 (0.5+0.5+0.5+0.5 marks)

Recall the logistics problem from exercise 8.1 with the additional restriction that the truck must return to the depot W to reach the goal: Let $\Pi = \langle V, I, O, \gamma \rangle$ be a SAS$^+$ planning task with

- $V = \{t, p_B, p_R\}$ where $dom(t) = \{W, R, B\}$ and $dom(p_B) = dom(p_R) = \{W, R, B, T\}$;
- $I = \{t \mapsto W, p_B \mapsto R, p_R \mapsto B\}$;
- $O = \{move_{o,d} \mid o, d \in \{W, R, B\}, o \neq d\} \cup \{load_{p,l} \mid p \in \{p_B, p_R\}, l \in \{W, R, B\}\} \cup \{unload_{p,l} \mid p \in \{p_B, p_R\}, l \in \{W, R, B\}\}$ where
  - $move_{o,d} = \langle t = o, t := d, 1 \rangle$,
  - $load_{p,l} = \langle t = l \wedge p = l, p := T, 1 \rangle$, and
  - $unload_{p,l} = \langle t = l \wedge p = T, p := l, 1 \rangle$; and
- $\gamma = (t = W \wedge p_B = B \wedge p_R = R)$.



(a) Provide a fact landmark for I that neither holds in the initial state nor any goal state and justify why it holds.

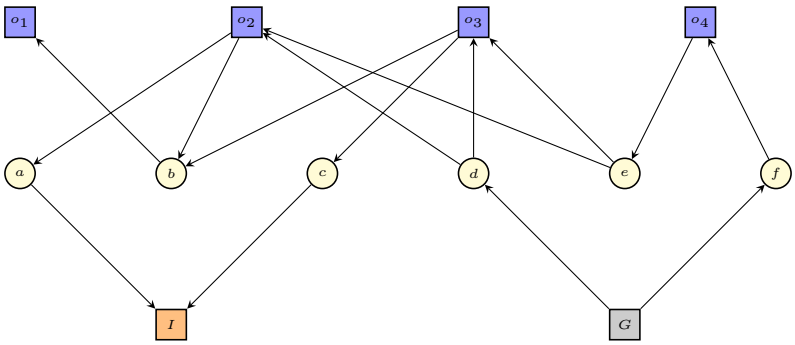
(b) Provide a formula landmark for I that is not an atomic proposition and neither holds in the initial state nor any goal state and justify why it holds.

(c) Provide a disjunctive action landmark for I that is a proper subset of O and justify why it holds.

(d) Provide a landmark ordering (of any type) for I and justify, why it holds.

Exercise 10.2 (2+0.5+0.5 marks)

Consider the simplified relaxed task graph depicted below.



(a) Compute the set of causal fact landmarks and disjunctive action landmarks of size 1 with the fixed-point algorithm introduced in Chapter G2. You can annotate the nodes of the above graph as in the lecture, but denote in which order you update the values of the nodes. If you change the same node several times provide all intermediate values.

(b) Provide a natural ordering between two landmarks of the above problem.

(c) Provide a greedy-necessary ordering between two landmarks of the above problem.

Exercise 10.3 (0.5+1.5 mark)

(a) Considering arbitrary planning problems: Why is the set of all operators not necessarily a disjunctive action landmark?

(b) We have seen in the lecture that all landmarks of the delete relaxation are also landmarks for the original problem. However, the opposite is not true. Formally provide a STRIPS planning task Π and a disjunctive action landmark L for Π such that L is not a landmark for Π^+. Justify why L is a landmark for Π but not for Π^+.

Exercise 10.4 (1+1+1 marks)
Let $X = \{u, v, w, x, y, z\}$ and $\mathcal{F} = \{\{u, v, x\}, \{w, x\}, \{z\}, \{u, v, y\}, \{u, v, w\}, \{u, v, x, z\}\}$.

(a) Compute a minimum hitting set H under the cost function $c = \{i \mapsto 1 \mid i \in X\}$.

(b) Compute a minimum hitting set H' under the cost function $c' = \{u \mapsto 3, v \mapsto 2, w \mapsto 1, x \mapsto 1, y \mapsto 0, z \mapsto 2\}$. What is the cost of H'?

(c) Assume an oracle can tell us all disjunctive action landmarks for all states of a given planning task. Is the minimum hitting set heuristic equivalent to the perfect heuristic in this case? Justify your answer.

Submission rules:

- Exercise sheets must be submitted in groups of 2–3 students. Create a team on ADAM including all members of your group and submit a single copy of the exercises per group.
- 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 text file(s) 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 text file(s) and nothing else. Do not use directories within the ZIP, i.e., zip the files directly. After creating your zip file and before submitting it, open the file and verify that it complies with these requirements.
- 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.