Planning and Optimization

M. Helmert, G. Röger
C. Büchner, R. Christen, S. Dold

University of Basel
Fall Semester 2023

Exercise Sheet 11

Due: December 18, 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 11.1 (5 marks)

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

- $V = \{i, a, b, c, d, e, g\}$;
- $I = \{i \mapsto \mathbf{T}\} \cup \{v \mapsto \mathbf{F} \mid v \in V \setminus \{i\}\}$;
- $O = \{o_1, \ldots, o_7\}$ where
  - $o_1 = \langle \{i\}, \{a\}, \{\}, 1 \rangle$,
  - $o_2 = \langle \{i\}, \{b\}, \{\}, 1 \rangle$,
  - $o_3 = \langle \{a\}, \{b, c\}, \{\}, 4 \rangle$,
  - $o_4 = \langle \{b\}, \{a, c\}, \{\}, 5 \rangle$,
  - $o_5 = \langle \{a, b\}, \{d\}, \{\}, 3 \rangle$,
  - $o_6 = \langle \{c, d\}, \{e\}, \{\}, 2 \rangle$,
  - $o_7 = \langle \{d, e\}, \{g\}, \{\}, 0 \rangle$; and
- $\gamma = g$.

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 for each iteration (except the last):

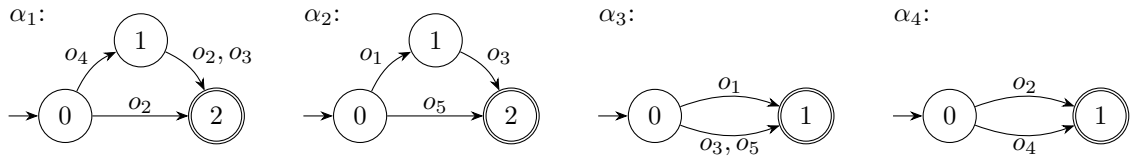
- the justification graph with $h^{\max}$ annotations and marked goal zone,
- the cut,
- the cost of the cut, and
- the updated costs.

If multiple preconditions of an operator have the same maximal $h^{\max}$ value, the precondition choice function breaks ties in alphabetical order (i.e. for an operator $o = \langle \{a, b\}, \{c\}, \{\}, 2 \rangle$ with $h^{\max}(a) = 3$ and $h^{\max}(b) = 3$, we have $pcf(o) = a$).

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

Consider a planning task with four variables and with operator set $O = \{o_1, o_2, o_3, o_4, o_5\}$. The cost function is defined as $cost(o_i) = i$ for $i \in \{1, \ldots, 5\}$. Consider the four pattern databases induced by the four projections to the variables, which are given as follows (for brevity, self loops are omitted):

Hint: We suggest to represent the cost partitioning as a table with one row for each abstraction/landmark and one column for each operator.



(a) Provide the uniform cost partitioning for this problem. What is the heuristic value for the initial state?

(b) Provide a saturated cost partitioning for the order $\alpha_3, \alpha_1, \alpha_2, \alpha_4$. What is the heuristic value for the initial state?

(c) Provide a saturated cost partitioning for the order $\alpha_4, \alpha_3, \alpha_2, \alpha_1$. What is the heuristic value for the initial state?

(d) What estimate do we get from a heuristic that uses the maximum over all abstraction heuristics using the original cost function? How do the two orderings for saturated cost partitioning compare to this heuristic and what does this tell us about the choice of ordering for saturated cost partitioning?

(e) Consider the following set of disjunctive action landmarks based on cuts in the abstract transition systems above:

$$\mathcal{L} = \{\{o_2, o_4\}, \{o_2, o_3\}, \{o_1, o_5\}, \{o_3, o_5\}, \{o_1, o_3, o_5\}\}$$

Use SoPlex to compute an optimal cost partitioning for these landmarks. Submit both the file encoding the LP with clear names for variables and constraints, as well as the resulting cost partitioning. What is the heuristic value for the initial state?

Update the course VM to find instructions on how to use SoPlex in the file `soplex-readme.txt`*. Note that SoPlex should already be installed in your course VM.*

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.