Planning and Optimization

M. Helmert, G. Röger | University of Basel
T. Keller, M. Wehrle | Fall Semester 2016

Exercise Sheet 10

Due: December 7, 2016

Exercise 10.1 (1+2+1+1 marks)

Consider the STRIPS task $\Pi = \langle V, I, O, G \rangle$ with variable set $V = \{a, b, c, d, e, f, g\}$, initial state $I = \{a\}$, operator set $O = \{o_1, o_2, o_3, o_4, o_5, o_6\}$ and goal $G = \{e\}$. All operators in O have cost 1. The preconditions, add and delete lists are defined as follows:

- $pre(o_1) = \{a\}$, $add(o_1) = \{b\}$, $del(o_1) = \{a\}$
- $pre(o_2) = \{a\}$, $add(o_2) = \{c\}$, $del(o_2) = \emptyset$
- $pre(o_3) = \{b\}$, $add(o_3) = \{d\}$, $del(o_3) = \emptyset$
- $pre(o_4) = \{c\}$, $add(o_4) = \{d\}$, $del(o_4) = \emptyset$
- $pre(o_5) = \{d, g\}$, $add(o_5) = \{e, f\}$, $del(o_5) = \emptyset$
- $pre(o_6) = \emptyset$, $add(o_6) = \{g\}$, $del(o_6) = \emptyset$

(a) Provide the simplified relaxed task graph $sRTG(\Pi^+)$ in graphical form.

(b) Compute the set of causal fact landmarks with the fixed-point algorithm introduced in chapter 21 (slides 15 and 16 in the handout version). Provide the intermediate steps of the algorithm.

(c) Provide a formula landmark φ for Π^+ with the property that φ is *not* a landmark of Π. Justify your answer.

(d) Is there a fact landmark in Π that is *not* a causal landmark in Π? If yes, provide such a landmark and justify your answer. Otherwise, justify why such a landmark does not exist.

Exercise 10.2 (1.5+1.5 marks)

Consider the STRIPS task $\Pi = \langle V, I, O, G \rangle$ with variable set $V = \{a, b, c, d\}$, initial state $I = \{a\}$, operator set $O = \{o_1, o_2, o_3, o_4\}$ and goal $G = \{b, d\}$. All operators in O have cost 1. The preconditions, add and delete lists are defined as follows:

- $pre(o_1) = \{a\}$, $add(o_1) = \{b\}$, $del(o_1) = \{a\}$
- $pre(o_2) = \{b\}$, $add(o_2) = \{c\}$, $del(o_2) = \{b\}$
- $pre(o_3) = \{c\}$, $add(o_3) = \{d\}$, $del(o_3) = \emptyset$
- $pre(o_4) = \{d\}$, $add(o_4) = \{a, b\}$, $del(o_4) = \emptyset$

The set of fact landmarks for I is given by $\mathcal{L} = \{a, b, c, d\}$.

Please turn the page.

(a) Is there a natural ordering $a \to b$ between the fact landmarks a and b? Is there a necessary ordering $a \to_n b$? Is there a greedy necessary ordering $a \to_{gn} b$? Justify your answers.

(b) Consider the path $\pi = \langle o_1 o_2 \rangle$. Compute $h^{\text{LM-count}}_{\mathcal{L}}(\pi)$. For the computation, also provide the sets $\mathit{reached}(\pi, \mathcal{L})$ and $\mathit{ReqAgain}(\pi, \mathcal{L}, \mathit{Ord})$.

Exercise 10.3 (3+1 marks)

Consider the planning task $\Pi = \langle V, I, O, \gamma \rangle$ where a truck can move between locations A and B, and pickup and drop a package in B and A, respectively. Π is given as follows:

$$V = \{T, P\} \text{ with } \mathrm{dom}(T) = \{A, B\} \text{ and } \mathrm{dom}(P) = \{A, B, T\}$$
$$I = \{T \mapsto A, P \mapsto B\}$$
$$O = \{\mathrm{move}_{AB}, \mathrm{move}_{BA}, \mathrm{pickup}, \mathrm{drop}\}, \text{ where}$$
$$\mathrm{move}_{AB} = \langle T = A, T := B, 1 \rangle$$
$$\mathrm{move}_{BA} = \langle T = B, T := A, 1 \rangle$$
$$\mathrm{pickup} = \langle T = B \wedge P = B, P := T, 1 \rangle$$
$$\mathrm{drop} = \langle T = A \wedge P = T, P := A, 1 \rangle$$
$$\gamma = (T = B \wedge P = A)$$

(a) Transform Π to transition normal form. Provide the linear program with objective value $h^{\text{flow}}(I)$ and report $h^{\text{flow}}(I)$.

(b) Does the introduction of the additional operator

$$\mathrm{beam} = \langle P = B; P := A, 5 \rangle$$

alter the heuristic estimate? Justify your answer.

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