Planning and Optimization

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Exercise Sheet 12

Due: December 21, 2016

Exercise 12.1 (1+1+3 marks)

Let $\langle V, I, O, \gamma \rangle$ be a STRIPS planning task. In the lecture, we have proven that elementary landmarks can be compiled into merge-and-shrink abstractions in polynomial time. The proof is constructive in the sense that for a given state s, for a given set of operators $L \subseteq O$, and for the induced set of variables U that cannot be reached from s in Π^+ without using an operator from L^+, a corresponding merge-and-shrink abstraction α has been defined (chapter D6, slides 18–20 in the handout version).

Consider the following delete-relaxed STRIPS planning task $\Pi = \langle V, I, O, \gamma \rangle$ with $V = \{a, b, c, d, e\}$, $I = \{a\}$, $O = \{o_1, o_2, o_3\}$, and $\gamma = (d \wedge e)$, where the operators are defined as follows:

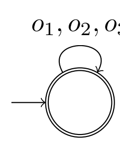
- $pre(o_1) = \{a\}$, $add(o_1) = \{b, c\}$, $del(o_1) = \emptyset$, $cost(o_1) = 1$
- $pre(o_2) = \{b\}$, $add(o_2) = \{d\}$, $del(o_2) = \emptyset$, $cost(o_2) = 2$
- $pre(o_3) = \{c\}$, $add(o_3) = \{e\}$, $del(o_3) = \emptyset$, $cost(o_3) = 3$

Consider the set of operators $L \subseteq O$ with $L = \{o_2, o_3\}$.

(a) Compute the elementary landmark heuristic $h_L(I)$.

(b) Compute the set U of variables that cannot be reached from the initial state I in Π^+ without using an operator from L^+.

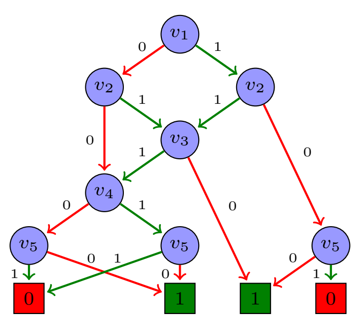
(c) Consider the variable order $a < b < c < d < e$ and the corresponding merge-and-shrink computation described in the proof in chapter D6 on slide 19 in the handout version. The abstraction obtained after merging variables a, b, and c, interleaved with the corrsponding shrinking steps described in the proof, is given by



Based on this intermediate abstraction, compute the remaining steps of merge-and-shrink according to the merging and shrinking strategies given in the proof in D6, slide 19 in the handout version. Provide the final abstraction α and the corresponding heuristic value $h^\alpha(I)$ in the initial state, and compare $h^\alpha(I)$ with $h_L(I)$.

Exercise 12.2 (2 marks)

Consider the following BDD over variables $v_1, \dots, v_5$:



Reduce the BDD until no further isomorphism reductions or Shannon reductions are possible. Provide all intermediate results.

Exercise 12.3 (2+1 marks)

Provide the reduced ordered BDD for the formula $(v_1 \wedge v_3) \vee (\neg v_2 \wedge v_4) \vee (v_1 \wedge v_5)$ for the following variable orderings:

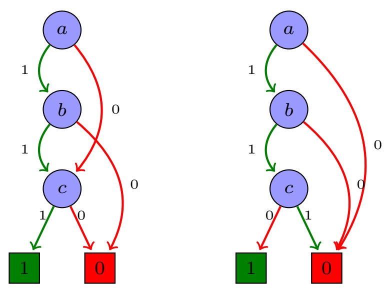
(a) $v_1 \succ v_2 \succ v_3 \succ v_4 \succ v_5$

(b) $v_1 \succ v_3 \succ v_5 \succ v_2 \succ v_4$

It suffices to provide the final results for (a) and (b).

Exercise 12.4 (2 marks)

Consider the following reduced ordered BDDs B (left) and B' (right) over variables a, b, c with order $a \succ b \succ c$:



Provide the reduced ordered BDD that is the result of `bdd-union`(B, B'). Provide appropriate intermediate steps.

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