

Landmarks

Michal Štolba

stolba@agents.fel.cvut.cz



PAH (Planning and Games)

Planners and Heuristics

Planner	Heuristic(s)	Description	Admissible
FF	FF	Sub-optimal relaxed plan	NO
fd-ms	Merge&Shrink	Abstraction heuristic	YES
fd-lmcut	LM-Cut	Relaxation heuristic based on landmarks	YES
LAMA	FF + Landmarks	FF and Landmark heuristic	NO
mercury	Red-Black relaxation	Sub-optimal plan in partial relaxation	NO
symba	Abstraction	Regressively built abstraction	YES

Action Landmark

Definition

Action that must be used in all plans.

Disjunctive Action Landmark

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Set L of actions such that in each plan at least one $a \in L$ must be used.

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LM-Cut Heuristic

- ▶ Admissible landmark-based heuristic
- ▶ Lower estimate of **optimal relaxed plan**
- ▶ Using disjunctive action landmarks, for a set \mathcal{L} of landmarks:

$$h_{\text{LM-Cut}} = \sum_{L \in \mathcal{L}} \text{cost}(L)$$

LM-Cut Heuristic

How to find the landmarks

1. Find preconditions which justify the cost of actions

- ▶ Using h_{\max} :

$$h_{\max}(p) = \min_{p \in \text{add}(a)} h_{\max}(a) + \text{cost}(a)$$

$$h_{\max}(a) = \max_{p \in \text{pre}(a)} h_{\max}(p)$$

2. Construct a **justification graph** using only those preconditions
3. Find a **cut** in the justification graph
4. The cut forms a **disjunctive action landmark**
5. **Discount the cost** of the landmark from the costs of all actions in the landmark
 - ▶ Results in a cost-partitioning
6. Start all over again (with the modified costs)
 - ▶ Until $h_{\max}(g) = 0$

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LM-Cut Heuristic

How to find the cut

- ▶ In the justification graph J :
 1. Find all facts p from which g is reachable by a 0-cost path $\rightarrow V_g$
 2. Find all facts p' reachable from i without visiting a fact in V^*
 3. Edges between facts in V^* and V_g form the cut