Subset-Saturated Transition Cost Partitioning

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In a Nutshell

- Optimal classical planning
- A* search with admissible heuristic
- Cost partitioning [Katz and Domshlak, 2008]
- Saturated cost partitioning [Seipp et al., 2020]
- Main contribution: unify two orthogonal generalizations [Keller et al., 2016, Seipp and Helmert, 2019]

generalization (2) →

generalization (1) ↓

	all states	subset of states
operators	saturated operator CP	subset-saturated operator CP
transitions	saturated transition CP	**subset-saturated transition CP**

Cost Partitioning

- How to **admissibly** combine the information of collection of admissible heuristics $h_1, \dots, h_n$?
- Consider operator cost function $ocf : L \to \mathbb{R}^+$ of planning task
- Heuristic admissible if $h(ocf, s) \leq h^*(ocf, s)$ for all states s
- $\max(h_1(ocf, s), \dots, h_n(ocf, s))$ ✓
- $h_1(ocf, s) + \ldots + h_n(ocf, s)$ ✗
- **Cost partitioning**: $h_1(ocf_1, s) + \ldots + h_n(ocf_n, s)$ ✓
  if $\sum_{i=1}^{n} ocf_i(l) \leq ocf(l)$ for all $l \in L$

How to find cost partitioning that yields strong heuristic?

Saturated Cost Partitioning

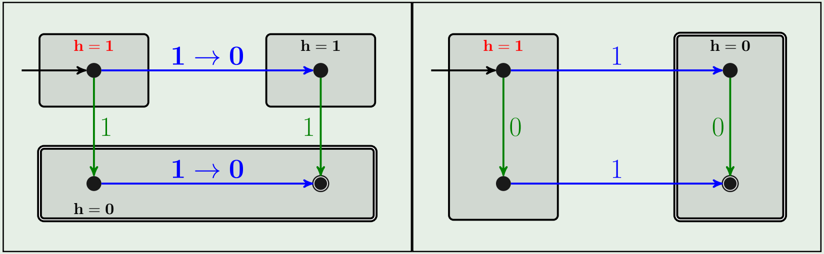
for heuristic h in sequence $h_1, \ldots, h_n$ **do**

$ocf_i \leftarrow saturate(h, ocf)$

$ocf \leftarrow ocf - ocf_i$

end for

Example



- $h_1(ocf_1, s_0) + h_2(ocf_2, s_0) = 1 + 1 = 2$ ✓

Generalizations of Saturated Cost Partitioning

generalization (2)

generalization (1)

	all states	subset of states
operators	saturated operator CP	subset-saturated operator CP
transitions	saturated transition CP	**subset-saturated transition CP**

(1) Costs partitioned among transitions [Keller et al., 2016]

- Function *saturate* returns $tcf_i : T \to \mathbb{R}$ instead of ocf_i
- Intractable in the worst-case, often manageable

(2) Saturate for subset of states $S' \subseteq S$ [Seipp and Helmert, 2019]

- E.g., reachable, single state

Further Contributions

1. Faster computation of $h(tcf, s)$
   - Reduce computations of abstract transition costs
2. Restrictions on tcf_i
   - Tractability depends on tcf_i
   - Focus computational effort on the subset of states S'
3. Future work: when to restrict to ocf_i?

Experiments

	(1)	(2)	(3)	(4)
(1) saturated operator CP	–	47	164	59
(2) subset-saturated operator CP	**488**	–	**390**	55
(3) saturated transition CP	**345**	236	–	34
(4) subset-saturated transition CP	**683**	**400**	**482**	–
Coverage (1827 total tasks)	1056	1061	1024	**1083**

Conclusions and Future Work

- Generalized saturated cost partitioning further
- Our planner is competitive with state of the art
- Future work: switching between the cost function type (using reasoning or learning techniques)

Katz, M. and Domshlak, C. (2008).
Optimal additive composition of abstraction-based admissible heuristics.
In *Proc. ICAPS 2008*, pages 174–181.

Keller, T., Pommerening, F., Seipp, J., Geißer, F., and Mattmüller, R. (2016).
State-dependent cost partitionings for Cartesian abstractions in classical planning.
In *Proc. IJCAI 2016*, pages 3161–3169.

Seipp, J. and Helmert, M. (2019).
Subset-saturated cost partitioning for optimal classical planning.
In *Proc. ICAPS 2019*, pages 391–400.

Seipp, J., Keller, T., and Helmert, M. (2020).
Saturated cost partitioning for optimal classical planning.
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