Efficiency of
Heuristics in HTN Planning

Automated Planning Class

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Introduction

Planning (automation of world-relevant problems)

Approaches to solve planning tasks:

- Classical planning;
- Hierarchical planning → HTNs.

Heuristics:

- basis for the existing solvers;
- techniques in classical planning are more sophisticated.

We measure the efficiency of classical heuristics applied to hierarchical planning using PANDA.

Overview

- **Heuristic search;**
- **Delete-relaxation, critical path, landmark, operator-counting;**
- **HTN (Hierarchical Task Network);**
  - **primitive and abstract tasks**

Strategies to solve HTN problems:

- decomposition-based search (plan-space);
- progression-search (state-space);

Solvers:

- SHOP2 (progression-search without heu);
- PANDA (progression-search with heu).

PANDA

- **Planner** (progression search as a search-based algorithm);
- **Heuristics:**
  - delete- and ordering-relaxation
  - landmark counting
  - additive
  - maximization
  - fast-forward

In order to measure the performance of HTN solvers that use progression search and rely on heuristics, we consider using the heuristic function information of the progression-search-based PANDA solver.

Approach

Measure the efficiency of heuristics in HTNs on PANDA planner.

- Use PANDA solver;
- HDDL language;
- Add, FF, LM heuristics;
- DFS (Depth-First Search).
  - SHOP2.

In order to improve the selection of methods process, we implemented a DFS algorithm that uses a stack fringe with move-ordering by following the heuristic function information to select the task method.

Implementation

WA*

Weighted A-Star

A*

A-Star

GBFS

Greedy Best-First Search

DFS*

Depth-First Search with move-ordering

X

h^{add}

Additive heuristic

h^{FF}

Fast-forward heuristic

$h^{LM\text{-}cut}$

Landmark heuristic

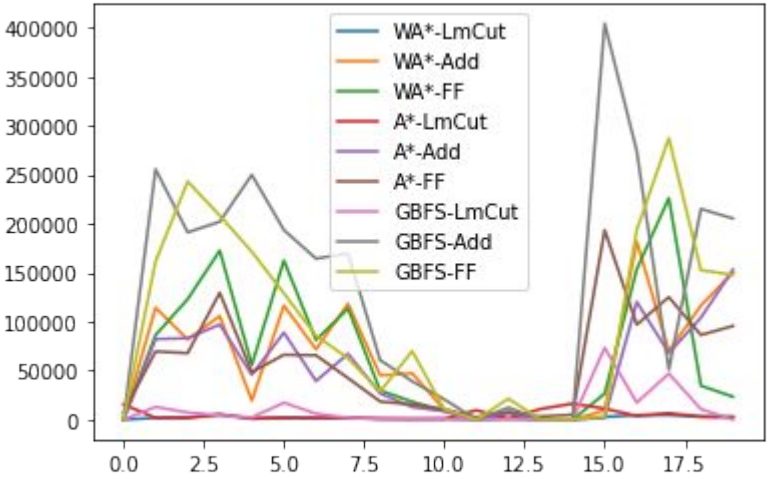
Experiments

Domains	instances	WA*			A*			GBFS			DFS*			DFS
		$h^{LM^{cut}}$	h^{Add}	h^{FF}	$h^{LM^{cut}}$	h^{Add}	h^{FF}	$h^{LM^{cut}}$	h^{Add}	h^{FF}	$h^{LM^{cut}}$	h^{Add}	h^{FF}	
entertainment	12	11	**12**	**12**	9	**12**	11	**12**	**12**	**12**	10	10	11	5
pcp	17	**14**	**14**	**14**	**14**	**14**	**14**	**14**	**14**	**14**	2	2	1	0
rover	20	6	**7**	**7**	4	6	4	6	6	5	5	5	4	4
satellite	25	23	23	**25**	21	21	**25**	**25**	24	24	24	24	23	17
smartphone	7	**6**	5	5	5	5	5	5	5	5	5	5	5	4
transport	30	**12**	5	**12**	4	9	11	8	4	7	0	2	3	0
umtranslog	21	**21**	**21**	**21**	**21**	**21**	**21**	**21**	**21**	**21**	**21**	**21**	**21**	**21**
woodworking	11	**10**	**10**	**10**	8	**10**	**10**	**10**	**10**	9	9	**10**	8	6
Total	143	93	97	**106**	95	98	101	101	98	97	76	79	76	57

Table 1: Solved instances from our results with timeout of 20 seconds.

Domains	instances	WA*			A*			GBFS			DFS
		$h^{LM^{cut}}$	h^{Add}	h^{FF}	$h^{LM^{cut}}$	h^{Add}	h^{FF}	$h^{LM^{cut}}$	h^{Add}	h^{FF}	
entertainment	12	11	11	11	8	11	8	**12**	**12**	**12**	6
pcp	17	13	**14**	13	13	13	13	2	2	2	1
rover	20	4	**7**	5	0	4	2	4	4	4	3
satellite	25	23	24	**25**	23	24	24	23	24	24	24
smartphone	7	**5**	**5**	**5**	**5**	**5**	4	**5**	4	**5**	4
transport	30	**13**	4	11	3	7	1	1	1	2	0
umtranslog	21	**22**	**22**	**22**	**22**	**22**	**22**	**22**	**22**	**22**	**22**
woodworking	11	**10**	**10**	**10**	8	**10**	**10**	9	9	9	8
Total	144	101	97	**102**	82	96	84	78	78	80	68

Table 2: Solved instances with timeout of 10 minutes from Holler's et al. paper (Holler et al. 2019).



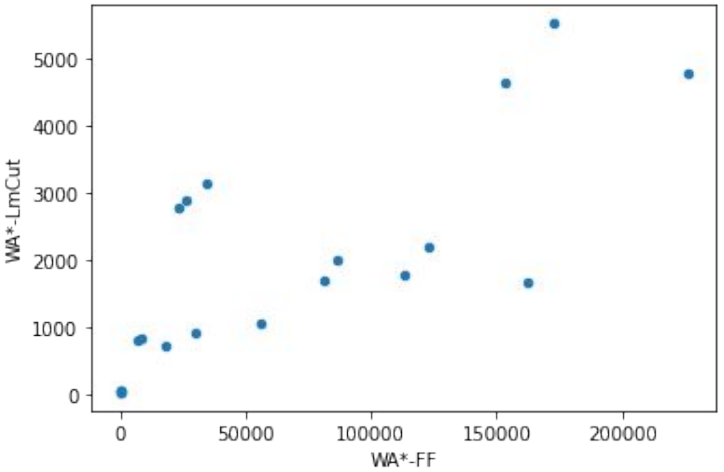
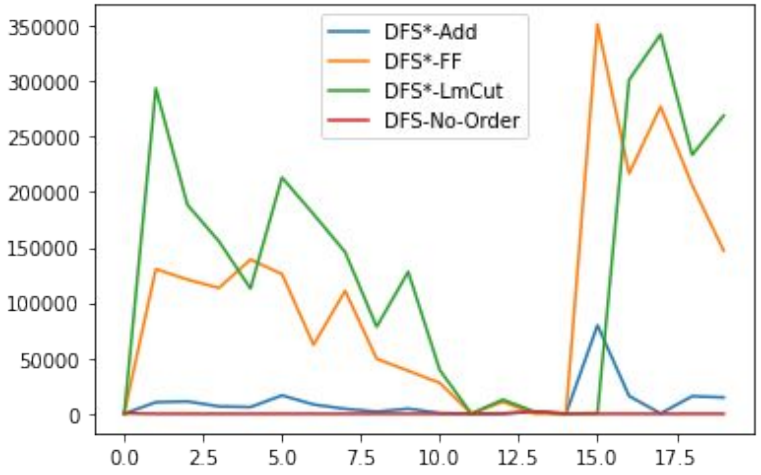


Figure 1 e 2: Expanded nodes.



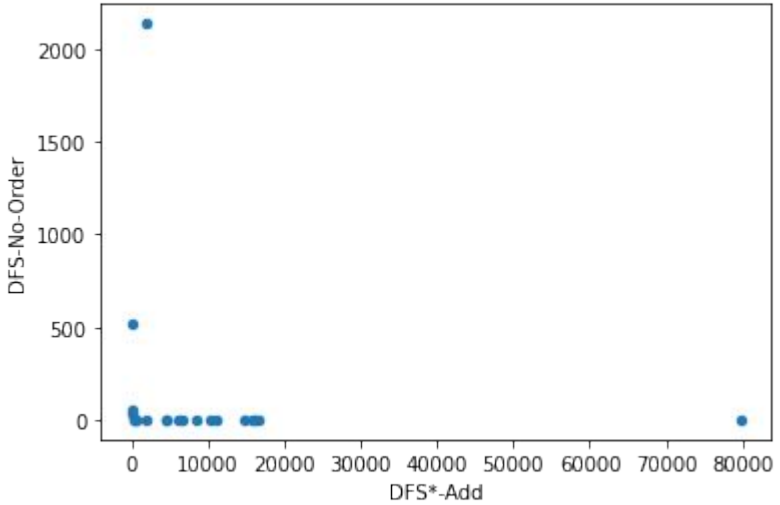


Figure 3 e 4: Expanded nodes.

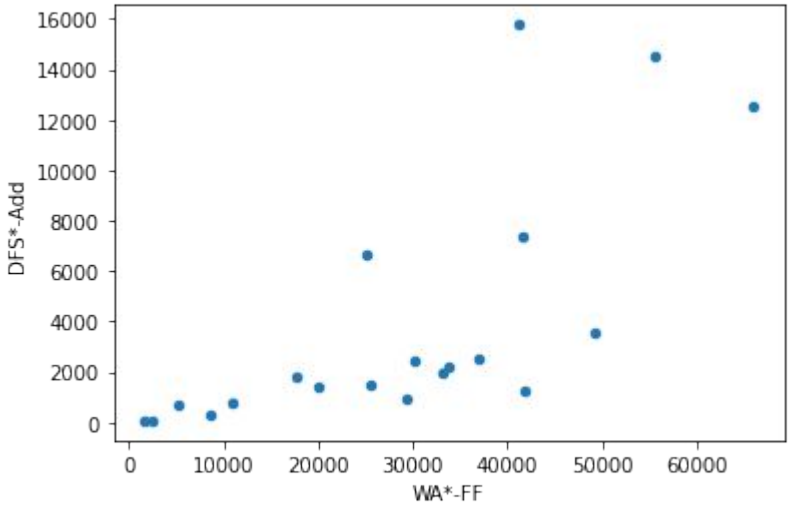


Figure 5: Generated nodes per second between WA* h^FF and DFS* h^Add.

Related Work

Related work

Holler, D.; Bercher, P.; Behnke, G.; and Biundo, S. 2019.

On Guiding Search in HTN Planning with Classical Planning Heuristics. In Proceedings of the 28th International Joint Conference on Artificial Intelligence.

Nau, D.; Munoz Avila, H.; Cao, Y.; Lotem, A.; and Mitchell, S. 2001

Total-Order Planning with Partially Ordered Subtasks. In Proceedings of the 17th International Joint Conference on Artificial Intelligence.

Conclusion

Efficiency of heuristics in HTN planning.

- How PANDA planner works;
- How heuristics in PANDA works;
- How SHOP2 works;
- Implement a novel DFS+heu;
- Results comparison.

Future work:

- Study how good the heu function is;
- How it influences each approach's fringe.

Thank you!

Heuristics in HTN planning

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