Udacity AI Nanodegree

Heuristic Analysis

Project 3 - Planning

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Introduction - Heuristic Analysis for Air Cargo Problems

This paper discusses the results of uninformed and A* searches applied to the Air Cargo problem presented in the Project 3 of Udacity AI Nanodegree.

The goal is to find an optimal solution to each problem using a variety of search algorithms. The complexity increases from problem 1 to problem 3.

Uninformed Search Results

The below table shows the results of the uninformed search algorithms applied to the 3 problems.

Problem	Search	Expansions	Goal Tests	New Nodes	Plan Length	Time Elapsed
P1	breadth_first_search	43	56	180	6	0.029
	depth_first_graph_search	12	13	48	12	0.007
	uniform_cost_search	55	57	224	6	0.030
	greedy_best_first_graph_search with h_1	7	9	28	6	0.005
P2	breadth_first_search	3343	4609	30509	9	7.011
	depth_first_graph_search	582	583	5211	575	2.812
	uniform_cost_search	4853	4855	44041	9	10.632
	greedy_best_first_graph_search with h_1	998	1000	8982	17	2.002
P3	breadth_first_search	14120	17673	124926	12	34.045
	depth_first_graph_search	677	678	5608	660	3.222
	uniform_cost_search	18234	18236	159707	12	43.342
	greedy_best_first_graph_search with h_1	5605	5607	49360	22	13.307

Key Points:

- None of the searches exceeded the 10 min threshold.
- As evident from the table, DFGS consistently posted the shortest time across the 3 problems. However it isn't the most optimal solution since it's plan length is directly proportional to the problem's complexity. E.g. the plan length goes from 12 in P1 to 575 and 660 in P2 and P3 respectively. This also impacts the other parameters (Expansion, goal tests etc).
- Across all 3 problems, **GBFS appears to be the optimal solution** when we consider the time and plan length together. E.g in problem 3 while the time taken by GBFS is almost 4 times more than DFS the plan length is the shortest (22).

A* Search with Heuristics Results

The below table summarizes the results of A* searches for the 3 problems

Problem	Search	Expansions	Goal Tests	New Nodes	Plan Length	Time Elapsed
P1	astar_search h_ignore_preconditions	41	43	170	6	0.021
	astar_search h_pg_levelsum	11	13	50	6	1.086
P2	astar_search h_ignore_preconditions	1450	1452	13303	9	3.212
	astar_search h_pg_levelsum	86	88	841	9	203.115
P3	astar_search h_ignore_preconditions	5040	5042	44944	12	12.953
	astar_search h_pg_levelsum	325	327	3002	12	936.443

Key points:

- Barring the *astar_search_h_pg_levelsum* for problem 3, all other algorithm executions finished within 10 minutes. While it is very efficient, the execution time is unacceptable for real world scenarios.
- From a holistic perspective, astar_search_h_ignore_preconditions consistently proves to be an optimal solution even though the nodes and other parameters are way high. From a user's perspective, this algorithm will be more responsive and hence must be preferred

Optimal Plans

Following are the optimal plans for the various problems

Problem 1

Load (C1, P1, SFO)

Load (C2, P2, JFK)

Fly (P1, SFO, JFK)

Fly (P2, JFK, SFO)

Unload (C1, P1, JFK)

Unload (C2, P2, SFO)

Problem 2

Load (C1, P1, SFO)

Load (C2, P2, JFK)

Load (C3, P3, ATL)

Fly (P1, SFO, JFK)

Fly (P2, JFK, SFO)

Fly (P3, ATL, SFO)

Unload (C1, P1, JFK)

Unload (C2, P2, SFO)

Unload (C3, P3, SFO)

Problem 3

Load (C1, P1, SFO)

Load (C2, P2, JFK)

Fly (P1, SFO, ATL)

Fly (P2, JFK, ORD)

Load (C3, P1, ATL)

Load (C4, P2, ORD)

Fly (P1, ATL, JFK)

Fly (P2, ORD, SFO)

Unload (C1, P1, JFK)

Unload (C2, P2, SFO)

Unload (C3, P1, JFK)

Unload (C4, P2, SFO)