ARTIFICIAL INTELLIGENCE NANODEGREE

PROJECT-3

PLANNING

heuristic_analysis

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STATS UPON RUNNING THE FILE:-

1.AIR-CARGO PROBLEM 1:-

Problem: Air Cargo Problem 1					
Search	**Expansions**	**Goal_Tests**	**New Nodes**	**Plan length**	**Time**
breadth_first_search	43	56	180	6	0.0511
depth_first_graph_search	21	22	84	20	0.0175
uniform_cost_search	55	57	224	6	0.06
recursive_best_first_search h_1	4229	4230	17023	6	4.163
greedy_best_first_graph_search with h_1	7	9	28	6	0.006895
astar_search with h_1	55	57	224	6	0.133
astar_search h_ignore_preconditions.	41	43	170	6	0.06203
astar_search with h_pg_levelsum	11	13	50	6	11.8528

PLAN LENGTH:-6

PLAN PLAY:-

Load(C1, P1, SFO)

Fly(P1, SFO, JFK)

Load(C2, P2, JFK)

Fly(P2, JFK, SFO)

Unload(C1, P1, JFK)

Unload(C2, P2, SFO)

2.AIR-CARGO PROBLEM 2:-

Problem: Air Cargo Problem 2					
Search	**Expansions**	**Goal_Tests**	**New Nodes**	**Plan length**	**Time**
breadth_first_search	3343	4609	30509	9	45.1548
depth_first_graph_search	624	625	5602	619	11.66935
uniform_cost_search	4852	4854	44030	9	132.0314
recursive_best_first_search h_1	inf	inf	inf	inf	inf
greedy_best_first_graph_search with h_1	990	992	8910	17	27.7241
astar_search with h_1	4852	4854	44030	9	146.3674
astar_search h_ignore_preconditions.	1506	1508	13820	9	49.48725
astar_search with h_pg_levelsum	86	88	841	9	475.7886

PLAN LENGTH:-9

PLAN PLAY:-

Load(C1, P1, SFO)

Fly(P1, SFO, JFK)

Load(C2, P2, JFK)

Fly(P2, JFK, SFO)

Load(C3, P3, ATL)

Fly(P3, ATL, SFO)

Unload(C3, P3, SFO)

Unload(C1, P1, JFK)

Unload(C2, P2, SFO)

3.AIR-CARGO PROBLEM 3:-

Problem: Air Cargo Problem 3					
Search	**Expansions**	**Goal_Tests**	**New Nodes**	**Plan length**	**Time**
breadth_first_search	14663	18098	129631	12	240.1591
depth_first_graph_search	408	409	3364	392	3.8626
uniform_cost_search	18235	18237	159716	12	1091.995
recursive_best_first_search h_1	inf	inf	inf	inf	inf
greedy_best_first_graph_search h_1	5614	5616	49429	22	253.84279
astar_search with h_1	18235	18237	159716	12	1115.49438
astar_search h_ignore_preconditions.	5118	5120	45650	12	260.283
astar_search with h_pg_levelsum	408	410	3758	12	2374.5656

PLAN LENGTH:-12

PLAN PLAY:-

Load(C2, P2, JFK)

Fly(P2, JFK, ORD)

Load(C4, P2, ORD)

Fly(P2, ORD, SFO)

Load(C1, P1, SFO)

Fly(P1, SFO, ATL)

Load(C3, P1, ATL)

Fly(P1, ATL, JFK)

Unload(C4, P2, SFO)

Unload(C3, P1, JFK)

Unload(C1, P1, JFK)

Unload(C2, P2, SFO)

Analysis:

1. **Breadth first search:** BFS provides optimal plan. But it takes more time and more expansion compatibility with other function. As the complexity of the problem increases it become unusable to use.

2. **Depth first Search graph:** As we see from the values above, it produces higher plan length that optimal, in less amount of time. It's not optimal and does not guarantee to produce shortest path.

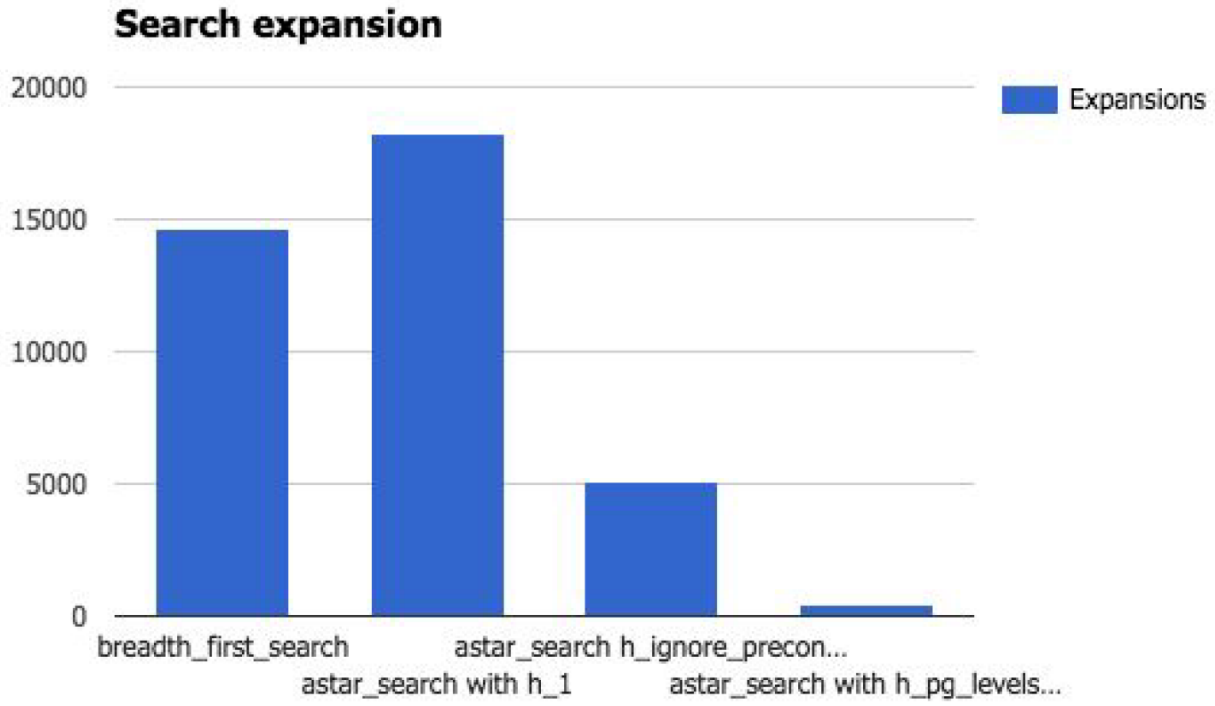
3. **Recursive BFS h1**: It is slow, to produce result. Even though it produces ideal plan its very time consuming, it because of recursion of expanding same node over again.

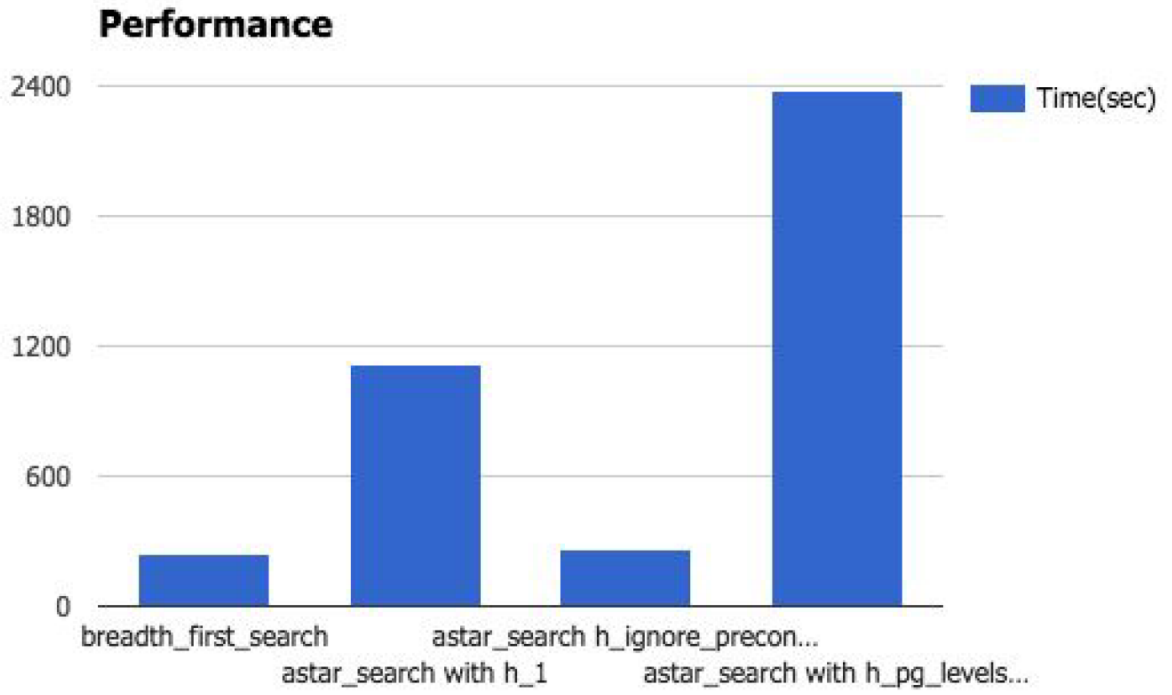
4. **Greedy BFS with h1**: It doesn't return optimal plan. Even though provides result with less expansion than any of the above searches in less time. Greedy BFS is accomplished by specifying f(n) = h(n).

5. **Uniform Cost search and A* Search with h1:** Both have same number of expanded nodes, goal test and nodes created and same amount of time to produce results. According AIMA code - Uniform cost search uses best_first_graph_search and A* search is best-first graph search. Even though, both produces optimal plan, in terms to node expansion and time consumed, it performs poorly compared to Breadth first search. This is mainly because once goal is found is breadth first search it doesn't expand unlike uniform cost search plan - which look for cheap path.

6. **A* with h_ignore precondition and h_pg_levelsum:** The h_ignore precondition, heuristic estimates the minimum number of actions that must be carried out from the current state in order to satisfy all of the goal conditions by ignoring the preconditions required for an action to be executed. h_pg_levelsum, refers to the sum of the level costs of the individual goals . Both A* with h_ignore precondition and h_pg_levelsum produces a good plan. It is better than any above searches. Comparing A* h_ignore precondition and h_pg_levelsum, former produces plan optimal plan with less time, even though h_pg_sum expansion of node is less. This is because of the heuristic calculation duration produced by h_pg_sum.

BFS vs A* Search with h1 vs A* with h_ignore precondition vs A* with h_pg_levelsum:





Conclusion:

From the above analysis and graph even though best optimal heuristic planning search for the Aircargo problem is A* with h_ignore precondition. From analysis, h_ignore precondition produce significantly quicker than A* with h_pg_levelsum, even though node expansion of h_pg_levelsum is minimal, as calculation timing of h_pg_levelsum is expensive. Best non heuristic optimal planning search is BFS.