Heuristic Analysis

Plan Search Run Data:

Air Cargo Problem 1

Search	Expansions	Goal Test	New Nodes	Plan Length	Time
breadth_first_search	43	56	180	6	0.043 sec
breadth_first_tree_search	1458	1459	5960	6	1.397 sec
depth_first_graph_search	12	13	48	12	0.012 sec
depth_limited_search	101	271	414	50	0.127 sec
uniform_cost_search	55	57	224	6	0.050 sec
greedy_best_first_graph_search with h_1	7	9	28	6	0.007 sec
astar_search with h_1	55	57	224	6	0.133 sec
astar_search h_ignore_preconditions	41	43	170	6	0.062 sec
astar_search with h_pg_levelsum	11	13	50	6	11.86 sec

Optimal Plan

Load(C1, P1, SFO)
Fly(P1, SFO, JFK)
Load(C2, P2, JFK)
Fly(P2, JFK, SFO)
Unload(C1, P1, JFK)
Unload(C2, P2, SFO)

Air cargo Problem 2

Search	Expansions	Goal Test	New Nodes	Plan Length	Time
breadth_first_search	3343	4609	30509	9	21.013 sec
depth_first_graph_search	624	625	5602	619	10.718 sec
uniform_cost_search	4852	4854	44030	9	140.04 sec
greedy_best_first_graph_search with h_1	990	992	8910	17	25.814 sec
astar_search with h_1	4852	4854	44030	9	144.71 sec
astar_search h_ignore_preconditions	1506	1508	13820	9	38.717 sec
astar_search with h_pg_levelsum	86	88	841	9	453.88 sec

Optimal Plan

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)

Air Cargo Problem 3

Search	Expansions	Goal Test	New Nodes	Plan Length	Time
breadth_first_search	14663	18098	129631	12	235.08 sec
depth_first_graph_search	408	409	3364	392	4.717 sec
uniform_cost_search	18235	18237	159716	12	980.71 sec
greedy_best_first_graph_search with h_1	5614	5616	49429	22	241.80 sec
astar_search with h_1	18235	18237	159716	12	1108.8 sec
astar_search h_ignore_preconditions	5118	5120	45650	12	244.40 sec
astar_search with h_pg_levelsum	408	410	3758	12	2380.7 sec

Optimal Plan

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 and Conclusion:

Uninformed Non-Heuristic Search

The uninformed non-heuristic planning was experimented with for Breadth First Search (BFS), Depth First Search (DFS) and Uniform Cost Search (UCS). It can be seen from the tables above that the number of nodes expanded and the number of Goal Tests bears resemblance. This is expected since the goal test is performed for every node search. Also, it can be seen from the analysis table is that time taken to reach goal state by DFS in comparison to BFS and UCS is the lowest, therefore, DFS is the fastest planning search among DFS, BFS, and UCS. The memory required by the search can be analyzed by number of nodes expanded by the algorithm. From the analysis tables, DFS expands least number of nodes as compared to BFS and UCS. This is also the reason why the time taken by DFS is the least. Also, from the analysis table, BFS and UCS provide optimal solution for each problem with path length of 6, 9, and 12 for P1, P2, and P3 respectively. The path length of DFS is high compared to BFS or UCS. This result is expected based on Lesson 7 video lectures.

Heuristic Search

The heuristic planning was tested with the following:

- h-1: Similar to UCS as the heuristic always returns 1
- h_ignore_preconditions: Heuristic obtained by relaxed problem as defined in “Artificial Intelligence: A Modern Approach” Third Edition
- h_pg_level_sum: Heuristic obtained by planning graph

It can be seen from the tables above that the metrics for h_1 is same as that of UCS as expected. Similar to the non-heuristic search, the table shows that the number of nodes expanded and number of goal tests are almost similar. Also, from the table, it shows that time taken to reach goal state by h_ignore_preconditions heuritics compared to h_1 and h_pg_level_sum is the lowest. The advantage of h_ignore_preconditions over h_1 can be attributed to better heuristics. The h_pg_level_sum heuristics suffer due to high computation thus it takes longer time. This means that h_ignore_preconditions heuristics provides lowest execution time. Also, as per test results, it shows that h_pg_level_sum heuristics has the lowest number of expanded nodes. All three heuristics provide optimal solution for each of the problems with path length of 6, 9, and 12 for P1, P2, and P3 respectively.

References:

http://aima.cs.berkeley.edu/