Planning Search Project Heuristic Analysis

AirCargo P1 Results

Search	Expansions	Goal Tests	New Nodes	Plan Length	Time	Optimal
Bread First Search	43	56	180	6	0.029s	True
Depth First Graph Search	21	22	84	20	0.013s	False
Uniform Cost Search	55	57	224	6	0.034s	True
A* Search h_1	55	57	224	6	0.033s	True
A* Search h_ignore_preconditions	41	43	170	6	0.034s	True
A* Search h_pg_levelsum	11	13	50	6	0.44s	True
A* Search h_pg_maxlevel	53	55	220	6	0.86s	True

Optimal Sequence of Actions:

Breadth First Search:

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

AirCargo P2 Results

Search	Expansions	Goal Tests	New Nodes	Plan Length	Time	Optimal
Bread First Search	3343	4609	30509	9	12.95s	True
Depth First Graph Search	624	625	5602	619	3.31s	False
Uniform Cost Search	4853	4855	44041	9	11.31s	True
A* Search h_1	4853	4855	44041	9	10.74s	True
A* Search h_ignore_preconditions	1450	1452	13303	9	4.03s	True
A* Search h_pg_levelsum	86	88	841	9	68.88s	True
A* Search h_pg_maxlevel	----	----	----	----	>10min	----

Optimal Sequence of Actions:

A* Search h_1

- Load(C3, P3, ATL)
- Fly(P3, ATL, SFO)
- Unload(C3, P3, SFO)
- Load(C2, P2, JFK)
- Fly(P2, JFK, SFO)
- Unload(C2, P2, SFO)
- Load(C1, P1, SFO)
- Fly(P1, SFO, JFK)
- Unload(C1, P1, JFK)

AirCargo P3 Results

Search	Expansions	Goal Tests	New Nodes	Plan Length	Time	Optimal
Bread First Search	14663	18098	129631	12	101.15s	True
Depth First Graph Search	408	409	3364	392	1.69s	False
Uniform Cost Search	18223	18225	159618	12	48.27s	True
A* Search h_1	18223	18225	159618	12	46.60s	True
A* Search h_ignore_preconditions	5040	5042	44944	12	15.32s	True
A* Search h_pg_levelsum	----	----	----	----	>10min	----
A* Search h_pg_maxlevel	----	----	----	----	>10min	----

Optimal Sequence of Actions:

A* Search h1_ignore_predictions

- Load(C2, P2, JFK)
- Fly(P2, JFK, ORD)
- Load(C4, P2, ORD)
- Fly(P2, ORD, SFO)
- Unload(C4, P2, SFO)
- Load(C1, P1, SFO)
- Fly(P1, SFO, ATL)
- Load(C3, P1, ATL)
- Fly(P1, ATL, JFK)
- Unload(C3, P1, JFK)
- Unload(C2, P2, SFO)
- Unload(C1, P1, JFK)

Analysis:

The Non-Heuristic search methods used were Bread-First Search, Depth-First Search and Uniform Cost Search. All the three methods successfully reached the goals in all the three problems. DFS produced the fastest result but it was not optimal. BFS produced the shortest path solutions and hence it was optimal as explained in the lessons. Uniform cost search also is also optimal as it considers the cheapest first way as explained in the lessons.

As explained in the lessons, DFS traverses in the depth first and then backs up, hence this is not optimal and causes the search enter many unnecessary nodes before reaching the goal.

Non-Heuristic search with BFS performed well in the case of problem 1, this indicated that when the problem complexity is less, a simpler approach can be used rather than using heuristic based searching.

A* Search with Null Heuristic also performed very well in case of problem 2, this again proves the above point.

The Heuristic search methods used were A* with h_ignore_predictions, h_pg_levelsum and h_pg_maxlevel. A* with h_ignore_predictions was the fastest and optimal out of all the three. A* with h_pg_levelsum failed to find the solution in less than 10 minutes in case of problem 3 and A* with h_pg_maxlevel failed to reach the solution in less than 10 minutes in case of problem 2 and 3. This could be because of the complex heuristics.

As mentioned in the Artificial Intelligence – A Modern Approach textbook, the maxlevel heuristic is admissible but does not necessarily be accurate, but this could not be verified in the case of problem 2 and 3 as it took a long time to run. Also, the levelsum heuristic is not admissible but produces accurate results for complex problems.

As the results indicate, BFS can be used for planning search problems when the problem is simple, as the complexity of the problem increases the search can be switched with an A* search but with a simpler heuristic like h_ignore_predictions.