Planning Search Heuristic Analysis

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Air Cargo Planning Heuristic Analysis

The following tables show the results gathered after solving the air cargo problems for this project with both uninformed and heuristic based search. The goal of this analysis is to document the results obtained from each search type and find an optimal solution (a search algorithm that finds the lowest path) for each air cargo problem.

The optimal solution for each set of problems has been highlighted with bold face.

Air Cargo Problem 1:

Search Type	Expansions	Goal Test	New Nodes	Length	Time Lapsed(s)	Category
BFS	43	56	180	6	0.032	PP
UCS	55	57	224	6	0.041	PP
DFGS	21	22	84	20	0.0164	PP
A*S H1	55	57	224	6	0.044	DIH
A*S HIP	41	43	170	6	0.049	DIH
A*S HPGLS	11	13	50	6	10.41	DIH

Air Cargo Problem 2:

Search Type	Expansions	Goal Test	New Nodes	Length	Time Lapsed(s)	Category
BFS	3343	4609	30509	9	14.136	PP
UCS	4853	4855	44041	9	47.01	PP
DFGS	624	625	5602	619	3.732	PP
A*S H1	4853	4855	44041	9	49.378	DIH
A*S HIP	1506	1508	13820	9	16.711	DIH
A*S HPGLS	86	88	841	9	1110.27	DIH

Air Cargo Problem 3:

Search Type	Expansions	Goal Test	New Nodes	Length	Time Lapsed(s)	Category
BFS	14663	18098	129631	12	147.081	PP
UCS	18223	18225	159618	12	616.25	PP
DFGS	408	409	3364	392	2.23	PP
A*S H1	18223	18225	159618	12	654.581	DIH

A*S HIP	5118	5120	45650	12	107.513	DIH
A*S HPGLS	-	-	-	-	-	DIH

Search Strategies Discussion

All three non-heuristic search strategies, breadth first search, uniform cost search, and depth first graph search, find a solution to all air cargo problems. Breadth first search always considers the shortest path first. And it finds a solution to the problem in a reasonable amount of time and in an optimal way.

Depth first graph search does find a quick solution and requires a small amount of memory, but it lacks optimality. It is not optimal because it does not consider if a node is better than another, it simply explores the nodes that take it as deep as possible in the graph even if the goal is to its right.

Non-heuristic based search did perform better in problem 1 and 2, which suggest that when working with simple problems using a more elaborated approach, such a A* search with heuristics, is not worth the increase in the solution complexity.

Heuristic based search did perform better as the problem complexity increased. This is more evident in the air cargo problem 3, where the "A* Search with 'h_ignore_preconditions'" performance was optimal and the fastest amongst those that were optimal. It's also worth noting that the 'h_pg_levelsum' heuristic did in overall perform poorly, most likely due to the heuristic being too complex.

According to the results obtained in this analysis, the breadth first search strategy can solve planning problems both fast and optimality, which makes it a good candidate to start off an analysis when dealing with search planning problems. As the complexity of the problems increase, it might be worth to consider if a heuristic based approach such as A* HIP can outperform breadth first search and thus be used instead.

Optimal Sequence of Actions

The following table describes an optimal sequence of actions to solve each of the air cargo problems provided using the highlighted approaches from the tables above:

Problem	**Search Type**	**Optimal Sequence of Actions**
Air Cargo Problem 1	BFS	Load(C1, P1, SFO) Load(C2, P2, JFK) Fly(P2, JFK, SFO) Unload(C2, P2, SFO) Fly(P1, SFO, JFK) Unload(C1, P1, JFK)
Air Cargo Problem 2	BFS	Load(C1, P1, SFO) Load(C2, P2, JFK) Load(C3, P3, ATL) Fly(P2, JFK, SFO) Unload(C2, P2, SFO) Fly(P1, SFO, JFK) Unload(C1, P1, JFK) Fly(P3, ATL, SFO) Unload(C3, P3, SFO)

Air Cargo Problem 3	A* S HIP	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)

Optimal Plans

For problem 1 and 2, breadth first search performs optimally, as it always considers the shortest path first. And A*S HIP is clearly optimal to the problem 3. It uses the shortest possible plan length of 12 within a comparatively short time of 107.513 seconds as compared to other optimal sequences. The major reason for the results is that while non-heuristic based search may perform better in simpler problems, a more elaborated heuristic approach is needed for more complex problems.

References

1. Stuart J. Russell, Peter Norvig (2010), Artificial Intelligence: A Modern Approach (3rd Edition).