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AIND: Planning Search

Air Cargo Planning Heuristic Analysis

After implementing the logic for the graph search and all the problem described, the following results of six different algorithms for each of the problems are obtained. The goal of this analysis is to document the results of each search type and find an optimal solution for each air cargo problem.
The results are separated for each air cargo problem and the best results in terms of optimality and speed and been flagged with **yellow** highlight.

Table 1: Air Cargo Problem 1

SEARCH TYPE	EXPANSIONS	GOAL TESTS	NEW NODES	LENGTH	TIME (S)	OPTIMAL
BREADTH FIRST SEARCH	43	56	180	6	0.044	TRUE
DEPTH FIRST GRAPH SEARCH	12	13	48	12	0.011	FALSE
UNIFORM COST SEARCH	55	57	224	6	0.053	TRUE
A* SEARCH H_1	55	57	224	6	0.054	TRUE
A* SEARCH H_IGNORE_PRECONDITIONS	41	43	170	6	0.056	TRUE
A* SEARCH H_PG_LEVELSUM	11	13	50	6	2.110	TRUE

Table 2: Air Cargo Problem 2

SEARCH TYPE	EXPANSIONS	GOAL TESTS	NEW NODES	LENGTH	TIME (S)	OPTIMAL
BREADTH FIRST SEARCH	3343	4609	30509	9	16.661	TRUE
DEPTH FIRST GRAPH SEARCH	1669	1670	14863	1444	15.264	FALSE
UNIFORM COST SEARCH	4852	4854	44030	9	55.562	TRUE
A* SEARCH H_1	4852	4854	44030	9	55.123	TRUE
A* SEARCH H_IGNORE_PRECONDITIONS	**1506**	**1508**	**13820**	**9**	**16.459**	**TRUE**
A* SEARCH H_PG_LEVELSUM	86	88	841	9	284.285	TRUE

Table 3: Air Cargo Problem 3

SEARCH TYPE	EXPANSIONS	GOAL TESTS	NEW NODES	LENGTH	TIME (S)	OPTIMAL
BREADTH FIRST SEARCH	13601	16987	106167	12	96.330	TRUE
DEPTH FIRST GRAPH SEARCH	1292	1293	5744	875	3.730	FALSE
UNIFORM COST SEARCH	17013	17015	132138	12	383.684	TRUE
A* SEARCH H_1	17013	17015	132138	12	377.873	TRUE
A* SEARCH H_IGNORE_PRECONDITIONS	**3890**	**3892**	**31331**	**12**	**58.501**	**TRUE**
A* SEARCH H_PG_LEVELSUM	451	453	3090	12	1247.112	TRUE

Search Strategies Discussion

All non-heuristic search strategies, which are breadth first search, depth first graph search, and uniform cost search find a solution to all air cargo problems. Breadth first search always considers the shortest path first (Russell and Norvig, 2009) and the result is found in a reasonable amount of time. The result is optimal if the shortest path is considered which is for this puzzle.

Depth first graph search finds a solution fast with a low amount of memory consumption. However, the result is not optimal since its only consider the first goal in the deepest depth on the left (Russell and Norvig, 2009).

As the results shows, the non-heuristic search strategy did perform better on Air Cargo Problem 1 which suggest using them in small problem.

In another hand, the heuristic search did perform well as the problem size increased. The result for Air Cargo Problem 2 and 3 shows that the A* search with **h_ignore_precondition** has higher performance in compare with other strategies. This search strategy is the fastest strategy which provide the optimal solution between the other methods. Besides that the **h_pg_levelsum** performed not acceptable in all the problems. The reason behind it is the heuristic method for **h_pg_levelsum** is complex and the **h_1** heuristic method is simple.

Based on the results, breadth first search strategy provide both fast and optimal solution at the same time for the simple and small problem. It makes it considerable option for start when the simple problems are analyzed.

As the size or the complexity of the problem is increased, or the criteria is rather than the number of steps such as distance, and capacity are important, A* search strategies play a significant role in solving such that problems.

Optimal Sequence of Actions

The optimal sequence of actions are listed in the following table. Those are match with the result that obtained from the highlighted strategy for each Air Cargo Problem.

Table 4: Optimal Action Sequence for each problem

Problem	*Action Sequence*
Air Cargo Problem 1	Load(C2, P2, JFK) Load(C1, P1, SFO) Fly(P2, JFK, SFO) Unload(C2, P2, SFO) Fly(P1, SFO, JFK) Unload(C1, P1, JFK)

Air Cargo Problem 2	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)
Air Cargo Problem 3	Load(C1, P1, SFO) Fly(P1, SFO, ATL) Load(C3, P1, ATL) Fly(P1, ATL, JFK) Unload(C3, P1, JFK) Unload(C1, P1, JFK) Load(C2, P1, JFK) Fly(P1, JFK, ORD) Load(C4, P1, ORD) Fly(P1, ORD, SFO) Unload(C4, P1, SFO) Unload(C2, P1, SFO)

References

Russell, S. J. and Norvig, P. (2009) *Artificial Intelligence: A Modern Approach*. 3rd edn. Prentice Hall.