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Air Cargo Problem Result Analysis

The paper contains non-heuristic search(breadth_first_search, depth_first_search and uniform_cost_search) and heuristic search(astar_search *with*,h_ignore_preconditions,h_pg_levelsum) results of Air cargo problem.

AIR CARGO PROBLEM 1

Method	expansions	goal tests	New Nodes	Length	time elapsed	optimality of solution
breadth_first_search	43	56	180	6	0.03	true
depth_first_graph_search	12	13	48	12	0.02	false
uniform_cost_search	55	57	224	6	0.047	true
astar_search with h_1	55	57	224	6	0.043	true
astar_search with h_ignore_preconditions	41	43	170	6	0.038	true
astar_search with h_pg_levelsum	11	13	50	6	1.155	true

AIR CARGO PROBLEM 2

Method	expansions	goal tests	New Nodes	Length	time elapsed	optimality of solution
breadth_first_search	477	1110	4317	6	1.524	true
depth_first_graph_search	322	333	2964	328	1.312	false
uniform_cost_search	1670	1672	15294	6	3.745	true
astar_search with h_1	1670	1672	15294	6	3.725	true
astar_search with h_ignore_preconditions	17	19	162	6	52.779	true
astar_search with h_pg_levelsum	14491	17947	128184	12	99.28	false

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AIR CARGO PROBLEM 3

Method	expansions	goal tests	New Nodes	Length	time elapsed	optimality of solution
breadth_first_search	14491	17947	128184	12	99.28	true
depth_first_graph_search	1948	1949	16253	1878	19.153	false
uniform_cost_search	17783	17785	155920	12	51.9	true
astar_search with h_1	17783	17785	155920	12	53.86	true
astar_search with h_ignore_preconditions	5003	5005	44586	12	17.6	true
astar_search with h_pg_levelsum	-	-	-	-	>10 min	-

Depth_first_ graph search always gives the shortest time elapsed with fewest expansions and goal tests, but can't reach the optimal solution because it doesn't consider which nodes are better options, it just search as deep as it can(Norvig and Russell's).On the other hand, breadth_first_search and uniform_cost search can get the optimal solustion with more expansions, goal tests and longer time elapsed. The uniform_cost_search usually gets slightly more expansion nodes, goal tests time.

All heuristic search can make sure the optimality of the solution. According to their performance on expansions, goal tests and time elapsed. Astar_ searh with h_ignore_precondition seems to perform better on more complex problems than h_1 and h_pg_levelsum does. The time elaspsed for h_pg_levelsum dramatically increase with the increasing complexity of the problem and it can't find the solution within 10 minutes for the problem 3. It was slow because the high cost of the calculation of the heuristic(Norvig and Russell's).

The best heuristic used in the problem are highlighted in green and the best searching plans are highlighted in yellow. As the results show, only in problem 3 the heuristic perform better than the no_heuristic because the heuristic searching methods like astar_h1 and h_ignore are observed to be more good at solving complex problems. In other words, breadth_first_search should be always the first option to try, considering its efficiency and optimality on solving simple problems. When the problems become more complex, h1 and h_ignore should be considered.

Optimal Plans

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Air Cargo Problem 1 using breadth_first_search

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


Air Cargo Problem 2 using breadth_first_search

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 3 using astar_search with h_ignore_preconditions

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)
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Reference:

1. **Stuart. Russell,Peter Norvig(2010), Artificial intelligence: Amodern Approach**