Heuristic Analysis

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1 Air Cargo Problem 1

Problem:

Init(At(C1, SFO) ∧ At(C2, JFK) ∧ At(P1, SFO) ∧ At(P2, JFK) ∧ Cargo(C1) ∧ Cargo(C2) ∧Plane(P1) ∧ Plane(P2) ∧ Airport(JFK) ∧ Airport(SFO))
Goal(At(C1, JFK) ∧ At(C2, SFO))

Optimal Solution:

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

Comparison of different search methods

2 Air Cargo Problem 2

Problem:

Init(At(C1, SFO) ∧ At(C2, JFK) ∧ At(C3, ATL) ∧ At(P1, SFO) ∧ At(P2, JFK) ∧ At(P3, ATL) ∧ Cargo(C1) ∧ Cargo(C2) ∧ Cargo(C3) ∧ Plane(P1) ∧ Plane(P2) ∧ Plane(P3) ∧ Airport(JFK) ∧ Airport(SFO) ∧ Airport(ATL))
Goal(At(C1, JFK) ∧ At(C2, SFO) ∧ At(C3, SFO))

Search Strategy	Plan Length	Optimal	Expansians	Goal Tests	New Nodes	Running Time(s)
Breadth First Search	6	Yes	43	56	180	0.022
Depth First Tree Search	20	No	21	22	84	0.011
Uniform Cost Search	6	Yes	55	57	224	0.028
A* h_1	6	Yes	55	57	224	0.028
A* h_ignore_precondition	6	Yes	41	43	170	0.027
A* h_pg_levelsum	6	Yes	11	13	50	0.561

Search Strategy	Plan Length	Optimal	Expansians	Goal Tests	New Nodes	Running Time(s)
Breadth First Search	9	Yes	3346	4612	30534	10.038
Depth First Tree Search	105	No	107	108	959	0.241
Uniform Cost Search	9	Yes	4853	4855	44041	8.900
A* h_1	9	Yes	4853	4855	44041	8.862
A* h_ignore_precondition	9	Yes	1450	1452	13303	3.148
A* h_pg_levelsum	9	Yes	86	88	842	96.064

Optimal Solution:

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

Comparison of different search methods

3 Air Cargo Problem 3

Problem:

Init(At(C1, SFO) ∧ At(C2, JFK) ∧ At(C3, ATL) ∧ At(C4, ORD) ∧ At(P1, SFO) ∧ At(P2, JFK) ∧ Cargo(C1) ∧ Cargo(C2) ∧ Cargo(C3) ∧ Cargo(C4) ∧ Plane(P1) ∧ Plane(P2) ∧ Airport(JFK) ∧ Airport(SFO) ∧ Airport(ATL) ∧ Airport(ORD))
Goal(At(C1, JFK) ∧ At(C3, JFK) ∧ At(C2, SFO) ∧ At(C4, SFO))

Optimal Solution:

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

Search Strategy	Plan Length	Optimal	Expansians	Goal Tests	New Nodes	Running Time(s)
Breadth First Search	12	Yes	14663	18098	129631	69.503
Depth First Tree Search	392	No	408	409	3364	1.177
Uniform Cost Search	12	Yes	18235	18237	159716	39.438
A* h_1	12	Yes	18235	18237	159716	33.875
A* h_ignore_precondition	12	Yes	5040	5042	44944	12.492
A* h_pg_levelsum	12	Yes	316	318	2912	574.142

Comparison of different search methods

4 Analysis

For **uninformed search**, breadth first search and uniform cost search can return optimal solution. Depth First Tree search cannot return optimal solution, but using less time to finish. This is consistent with lectures as depth first search doesn't need expand at every level.

For **Heuristic Search**, all three methods were able to return optimal solutions. And for A* using h_1 heuristics and A* using ignored precondition for h heuristic, it achieve better time efficient than uninformed search. The A* with pg level sum heuristic, is much slower than other methods. This may because we need to go through all levels to find if a goal is achieved.

In general, on problem 2 and 3, heuristics method is faster than uninformed methods. On problem 1, the performance is similar. This is because problem 1 is much simple than problem 2 and 3.