

Project 3 Heuristic Analysis

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None Heuristic Search:

Optimal plan for Problems

Problem 1:

	Breadth first search	Breadth first tree search	Depth first graph search	Depth limited search	Uniform cost search
Expansions	43	1458	12	101	55
Goal Tests	56	1459	13	271	57
New Nodes	180	5960	48	414	224
Plan length	6	6	12	50	6
Time elapsed (s)	0.029581904993392527	0.8272135610168334	0.006662177998805419	0.07681783000589348	0.0321922590082977

Breadth first search gives the best plan for problem 1 for faster time and less node expansions than Uniform cost 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)

Problem 2:

	Breadth first search	Breadth first tree search	Depth first graph search	Depth limited search	Uniform cost search
Expansions	3346	-	859	-	4853
Goal Tests	4612	-	860	-	4855
New Nodes	30534	-	7745	-	44041

Plan length	9	-	846	-	9
Time elapsed (s)	12.049078251002356	-	4.570675719005521	-	10.287407764990348

Uniform cost search gives the best plan for problem 2 for faster run time, the optimal length is 9:

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

Problem 3:

	Breadth first search	Breadth first tree search	Depth first graph search	Depth limited search	Uniform cost search
Expansions	14120	-	1401	-	18235
Goal Tests	17673	-	1402	-	18237
New Nodes	124926	-	11649	-	159716
Plan length	12	-	1345	-	12
Time elapsed (s)	85.98846060101641	-	11.068943439022405	-	51.29503973398823

Uniform cost search gives the best plan for problem 3 for faster run time the optimal length is 12:

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

Unload(C3, P1, JFK)
Unload(C2, P2, SFO)
Unload(C1, P1, JFK)

Heuristic Search:

Optimal plan for Problems

Problem 1:

	A* search h1	A* search ignore preconditions	A* search pg level sum
Expansions	55	41	11
Goal Tests	57	43	13
New Nodes	224	170	50
Plan length	6	6	6
Time elapsed (s)	0.035351316997548565	0.03439703499316238	0.404157020006096

A* search pg level sum gives the best result for less expansions, new nodes and goal tests. The plan is:
Load(C1, P1, SFO)
Fly(P1, SFO, JFK)
Load(C2, P2, JFK)
Fly(P2, JFK, SFO)
Unload(C1, P1, JFK)
Unload(C2, P2, SFO)

Problem 2:

	A* search h1	A* search ignore preconditions	A* search pg level sum
Expansions	4853	1450	86
Goal Tests	4855	1452	88

New Nodes	44041	13303	841
Plan length	9	9	9
Time elapsed (s)	10.248599935002858	3.6054688559961505	33.79871973200352

A* search ignore preconditions pg level sum gives the best result for faster time usage. The plan is:

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

Problem 3:

	A* search h1	A* search ignore preconditions	A* search pg level sum
Expansions	18235	5040	315
Goal Tests	18237	5042	317
New Nodes	159716	44944	2902
Plan length	12	12	12
Time elapsed (s)	46.72065876200213	14.516251816996373	171.09589302598033

A* search ignore preconditions pg level sum gives the best result for faster time usage. The plan is:

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)

Summary:

According to Norvig and Russell's textbook, optimal planning is usually hard, but sub-optimal planning is sometimes easy. Thus In most case, we need a good search heuristic to do well on easier than worst case problems.

In problem 1, Breadth first search, a non heuristic search strategy outperformed all the heuristic searches. Because the search space is small, so that explore all the space is cheap in this problem.

In problem 2 and 3, A* search ignore preconditions is the best because it reduced the computational cost greatly and running faster than A* search pg level sum. heuristic search are more convenient in large search space.