Heuristic Analysis

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Example Optimal Paths

Problem 1: Length 6	Problem 2: Length 9	Problem 3: Length 12
Load(C1, P1, SFO) Load(C2, P2, JFK) Fly(P2, JFK, SFO) Unload(C2, P2, SFO) Fly(P1, SFO, JFK) Unload(C1, P1, JFK)	Load(C3, P3, ATL) Fly(P3, ATL, JFK) Load(C2, P3, JFK) Fly(P3, JFK, SFO) Load(C1, P3, SFO) Unload(C2, P3, SFO) Unload(C3, P3, SFO) Fly(P3, SFO, JFK) Unload(C1, P3, JFK)	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)

Uninformed Heuristic Choice: Out of the three metrics that were tested, Uniform Cost performed significantly better than breadth or depth first searches, expanding fewer nodes and taking less time to find an optimal path. The uniform cost metric is performing better since it examines a metric that leads to progress towards the goal, rather than looking down each branch like depth first, or expanding every level below a parent like breadth first.

Informed Heuristic Choice: Between A* ignore-preconditions and Level-Sum, level sum expanded fewer nodes, but always took significantly longer to find the optimal path, with a time out in problem 3. So even though it is more effective in exploring nodes, A* ignore-preconditions is the more useful heuristic to use since it will return an optimal plan faster.

The ignore preconditions heuristic probably performs faster since it has less conditions to meet and analyze when examining actions. It allows the algorithm to look at what actions can be used to reach the goal, essentially removing a step for each node. Compared to the level sum metric, it is cheaper to calculate, but could be less accurate [1] From the text book, this is sometimes a worthwhile trade off, as in the more complex problem sets, level sum ran over the allowed time.

Of the two classes of metrics, informed search always performed better when finding an optimal path. For planning problems, an informed metric should be used over uninformed metrics.

Problem 1	Optimal Path Length?	Expansions	Goal Tests	New Nodes	Time Elapsed	Steps	Solution
Breadth First	Y	1458	1459	5960	.906	6	Load(C1, P1, SFO) Load(C2, P2, JFK) Fly(P2, JFK, SFO) Unload(C2, P2, SFO) Fly(P1, SFO, JFK) Unload(C1, P1, JFK)

Depth First	N	21	22	84	.0232	20	
Uniform Cost	Y	55	57	224	.0591	6	Load(C1, P1, SFO) Load(C2, P2, JFK) Fly(P1, SFO, JFK) Fly(P2, JFK, SFO) Unload(C1, P1, JFK) Unload(C2, P2, SFO)
A* ignore-preconditions	Y	41	43	170	.037	6	Load(C1, P1, SFO) Fly(P1, SFO, JFK) Unload(C1, P1, JFK) Load(C2, P2, JFK) Fly(P2, JFK, SFO) Unload(C2, P2, SFO)
A*-level_sum	Y	11	13	50	.88	6	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							
Breadth First	Y	27996	27997	104586	37.3	9	Load(C3, P3, ATL) Fly(P3, ATL, JFK) Load(C2, P3, JFK) Fly(P3, JFK, SFO) Load(C1, P3, SFO) Unload(C2, P3, SFO) Unload(C3, P3, SFO) Fly(P3, SFO, JFK) Unload(C1, P3, JFK)
Depth First	N	624	625	6502	3.78	619	
Uniform Cost	Y	4852	4854	44030	11.22	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)
A* ignore-preconditions	Y	1450	1452	13303	4.34	9	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)
A*-level_sum	Y	86	88	841	175	9	Load(C1, P1, SFO) Fly(P1, SFO, JFK) Load(C2, P2, JFK) Fly(P2, JFK, SFO) Load(C3, P3, ATL)

								Fly(P3, ATL, SFO) Unload(C3, P3, SFO) Unload(C2, P2, SFO) Unload(C1, P1, JFK)
Problem 3		python run_search.py -p 3 -s 3 5 9 10						
Breadth First								
Depth First	N	408	409	3364	2.06	392		
Uniform Cost	Y	18223	18225	159618	47	12		
A* ignore-preconditions	Y	5040	5042	44944	15	12		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)
A*-level_sum		**Ran over ten minutes**						

1: Artificial Intelligence A modern approach, Peter Norvig, Stuart Russell