Heuristic Analysis

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1. Comparison between search algorithms

a) Algorithms tested

Algorithm Abbreviation	Algorithm Name
BFS	Breadth First Search
DFGS	Depth First Graph Search
DLS	Depth Limited Search (limit = 50)
UCS	Uniform Cost Search
A*IP	A* Search Ignore Preconditions
A*LS	A* Search Level Sum

b) Results

Problem	Search Algorithm	Time Elapsed	Plan Length	Expansions	Goal Tests	Optimal Solution
1	**BFS**	**0.023s**	**6**	**43**	**56**	**Yes**
	DFGS	0.007s	12	12	13	No
	DLS	0.063s	50	101	271	No
	UCS	0.027s	6	55	57	Yes
	A*IP	**0.027s**	**6**	**41**	**43**	**Yes**
	A*LS	0.487s	6	39	41	Yes
2	**BFS**	**5.729s**	**9**	**3343**	**4609**	**Yes**
	DFGS	1.573s	466	476	477	No
	DLS	10min	50	222719	2053741	No
	UCS	8.224s	9	4853	4855	Yes
	A*IP	**3.041s**	**9**	**1450**	**1452**	**Yes**
	A*LS	174.827s	9	1129	1131	Yes
3	**BFS**	**30.210s**	**12**	**14663**	**18098**	**Yes**
	DFGS	9.219s	1442	1511	1512	No
	DLS	> 15min	-	-	-	-
	UCS	36.406s	12	17882	17884	Yes
	A*IP	**12.053s**	**12**	**5034**	**5036**	**Yes**
	A*LS	10min	12	2025	2027	Yes

Best solutions in bold.

Initialy it was thought that DLS would have a better perfomance and solution than DFGS, but runing problem 2, it became clear that this assumption was wrong. On the problem 3, DLS runned for more than 15minutes without finding a solution. That is why UCS was also executed.

The algorithms BFS and UCS always found the optimal solution on the three problems. That is because they always find the optimal solution, i.e the shortest path, if the path cost is a nondecreasing function of the depth of the node. In the other hand, DFGS and DLS were not able to find the optimal solution because they always expand the deepest node in the current frontier of the search tree. The A*IP and A*LS also always found the optimal solution.

BFS and A*IP achieved the best results regarding elapsed time. Meaning that Ignore Preconditions heuristics had better performance compared to H Level Sum heuristics.

These experiments were executed using a notebook with Intel core i7-7500U CPU 2.70GHz and 16 GB (2 x 8GB) 2400MHz DDR4 RAM.

The optimal sequence of actions for each problem are shown below:

Problem	**1**	**2**	**3**
Actions	Load(C1, P1, SFO) Load(C2, P2, JFK) Fly(P1, SFO, JFK) Fly(P2, JFK, SFO) Unload(C1, P1, JFK) Unload(C2, P2, SFO)	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(C1, P1, JFK) Unload(C2, P2, SFO) Unload(C3, P3, SFO)	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(C1, P1, JFK) Unload(C2, P2, SFO) Unload(C3, P1, JFK) Unload(C4, P2, SFO)