Heuristic Analysis

A – Apply different search algorithms and evaluate optimality

B - Optimal plan for Problems 1, 2, and 3

C - Compare and contrast heuristic search result metrics using A* with the "ignore preconditions" and "level-sum" heuristics for Problems 1, 2, and 3.

D - What was the best heuristic used in these problems? Was it better than non-heuristic search planning methods for all problems? Why or why not?

A – Apply different search algorithms and evaluate optimality

Problem 1: -

Algorithm	Expansion	Goal Tests	Time Elapsed	Plan Length	New nodes
BFS	43	56	0.8805	6	180
DFGS	21	22	0.41	20	84
GBFGS	7	9	0.142	6	28
UCS	55	57	1.14789	6	224
A* by ignore Preconditions	41	43	0.1562	6	170

➔ All of them are optimal except A* by ignore preconditions

Problem 2: -

Algorithm	Expansion	Goal Tests	Time Elapsed	Plan Length	New nodes
BFS	3343	4609	41.18	9	30509
DFGS	624	625	9.64	619	5602
GBFGS	990	992	10.511	21	8910
UCS	4852	4854	57.9157	9	44030
A* by ignore_ Preconditions	1450	1452	14.8815	9	13303

➔ All of them are optimal except depth first graph search and greedy best first graph search

Problem 3: -

Algorithm	Expansion	Goal Tests	Time Elapsed	Plan Length	New nodes
BFS	14663	18098	205.608	12	129631
DFGS	408	409	6.17	392	3364
GBFGS	5614	5616	87.4365	22	49429
UCS	18235	18237	280.508	12	159716
A* by ignore_ Preconditions	5040	5042	85.3657	12	44944

➔ All of them are optimal except depth first graph search and greedy best first graph search

Screenshot for more details about readings → Click here

B - Optimal plan for Problems 1, 2, and 3

Problem1

➔ Optimal plan contains 6 steps to reach the goal

Algorithm	Plan length	Plan
BFS	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)
GBFGS	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)
UCS	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* by ignore_ Preconditions	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)

Problem2

➔ Optimal plan contains 9 steps to reach the goal

Algorithm	Plan length	Plan
BFS	9	Load(C1, P1, SFO) Load(C2, P2, JFK) Load(C3, P3, ATL) Fly(P2, JFK, SFO) Unload(C2, P2, SFO) Fly(P1, SFO, JFK) Unload(C1, P1, JFK) Fly(P3, ATL, SFO) Unload(C3, P3, SFO)
UCS	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(C1, P1, JFK) Unload(C2, P2, SFO)
A* by ignore_ Preconditions	9	Load(C3, P3, ATL) Fly(P3, ATL, SFO) Unload(C3, P3, SFO) Load(C1, P1, SFO) Fly(P1, SFO, JFK) Unload(C1, P1, JFK) Load(C2, P2, JFK) Fly(P2, JFK, SFO) Unload(C2, P2, SFO)

Problem3

➔ Optimal plan contains 9 steps to reach the goal

Algorithm	Plan length	Plan

BFS	12		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)	
UCS	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(C1, P1, JFK) Unload(C2, P2, SFO)	
A* by ignore_ Preconditions	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(C1, P1, JFK) Unload(C2, P2, SFO)	

C - Compare and contrast heuristic search result metrics using A* with the "ignore preconditions" and "level-sum" heuristics for Problems 1, 2, and 3.

Problem 1

Algorithm	Expansion	Goal Tests	Time Elapsed	Plan Length	New nodes
ignore preconditions	41	43	0.1562	6	170
level-sum	11	13	2.408	6	50

Problem 2

Algorithm	Expansion	Goal Tests	Time Elapsed	Plan Length	New nodes
ignore preconditions	1450	1452	14.8815	9	13303
level-sum	86	88	406.45	9	841

Problem 3

Algorithm	Expansion	Goal Tests	Time Elapsed	Plan Length	New nodes
ignore preconditions	5040	5042	85.3657	12	44944
level-sum	--	--	--	--	--

Note:

➔ Problem 3 with level-sum take more 10 minutes

D - What was the best heuristic used in these problems? Was it better than non-heuristic search planning methods for all problems? Why or why not?

1 - Their exist a tradeoff between heuristic as observed from previous table that

→ **Ignore preconditions heuristic**: generate huge amount of nodes but takes little time

→ **Level-sum heuristic**: generate small amount of nodes but takes more time

2 – All of them reach the goal with the equal number of steps