Optimum Plans

Air Cargo Problem 1

Problem 1 is optimized with 6 actions:

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

Air Cargo Problem 2

Problem 2 is optimized with 9 actions:

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

Air Cargo Problem 3

Problem 3 is optimized with 12 actions:

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

Search Methods

The following search methods are used in this report:

1. **Breadth First Search:**
    a. Is guaranteed to find the shortest path in terms of number of steps.
    b. It requires storage of 2^n.
    c. The search is complete even if the tree is infinite.
2. **Depth First Search:**
    a. Choose the longest path with the most links in it.
    b. It has a huge advantage of storage saved of n.
    c. The search is not complete as the depth first search will keep going down and down and never gets to the path that the goal consists of.
3. **Uniform Cost Search/ Cheapest first:**
    a. Is guaranteed to find the path with the cheapest total cost.
    b. Finding the path is more complicated but it is going to have the similar of number of nodes for Breadth first search.
    c. The search is complete even if the tree is infinite.
4. **Best estimated total path cost (A*):**
    a. Combines both: Explores the number of nodes in many cases and Uniform Cost Search which is guaranteed to find the shortest path.
    b. Search strategy that is the best possible. Finds the shortest length path while expanding the minimum.
    c. It uses heuristic: In this report, **two heuristic methods** are used.
    d. **Ignore preconditions heuristic:** dropping negative effects from every action resulted in a relaxed problem. Negative effects put restrictions on the action schema. When these restrictions are put into place, then the number of actions that can be taken to get to the next time step decreases because with each addition of a restriction, the actions that do not meet the restriction are filtered out. When these negative effects are dropped, then the number of actions increase and dropping all of the negative effects from the action schema results in a relaxed problem.
    e. **Level Sum heuristic:** It is following the subgoal independence assumption, returns the sum of the level costs of the goals; this is inadmissible but works very well in practice for problems that are largely decomposable.

Air Cargo Problem 1

	Expansions	Goal Tests	New Nodes	Time Elapsed (in seconds)
Breadth First Search	43	56	180	0.059
Depth First Search	12	13	48	0.014
Uniform Cost Search	55	57	224	0.121
A* search with ignore preconditions heuristics	41	43	170	0.041
A* search with level sum heuristics	11	13	50	0.971

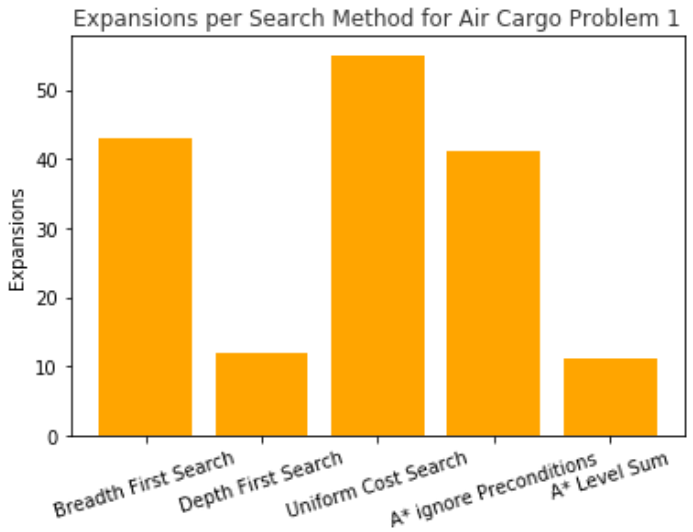

Figure 1 Expansions per Search Method for Air Cargo Problem 1

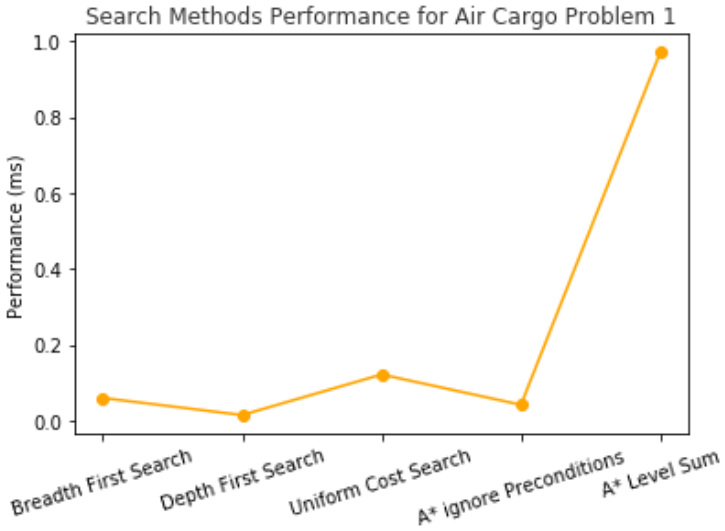

Figure 2 Search Methods Performance for Air Cargo Problem 1

Air Cargo Problem 2

	Expansions	Goal Tests	New Nodes	Time Elapsed (in seconds)
Breadth First Search	3343	4609	30509	11.494
Depth First Search	582	583	5211	4.954
Uniform Cost Search	4852	4854	44030	16.708
A* search with ignore preconditions heuristics	1450	1452	13303	5.108
A* search with level sum heuristics	86	88	841	86.292

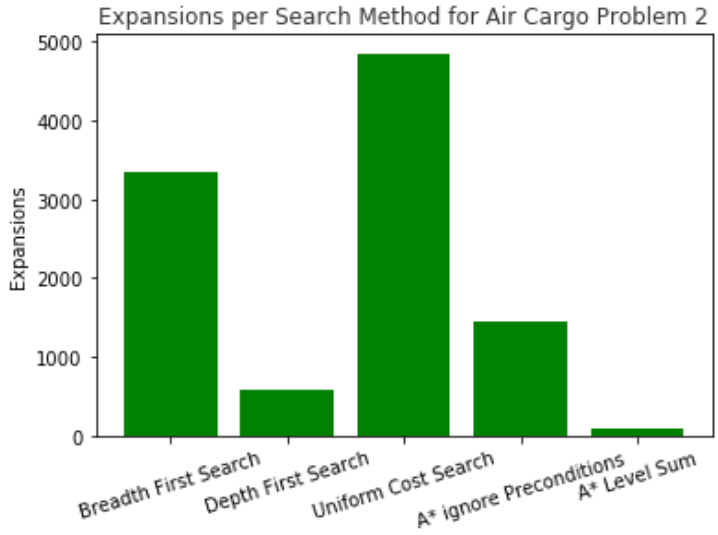

Figure 3 Expansions per Search Method for Air Cargo Problem 2

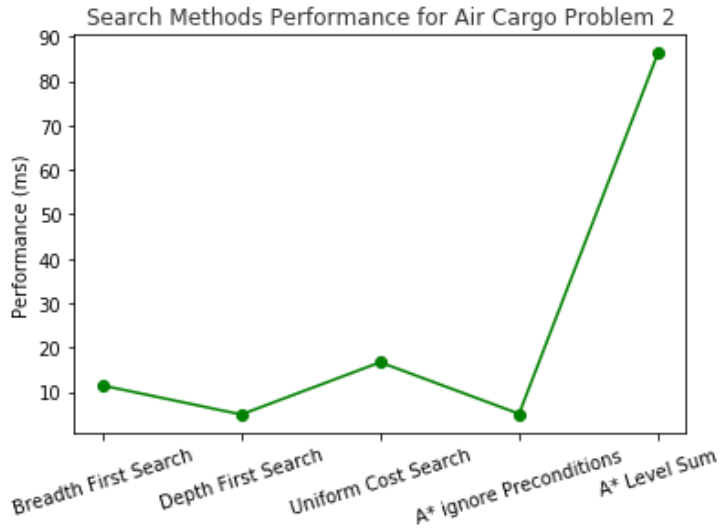

Figure 4 Search Methods Performance for Air Cargo Problem 2

Air Cargo Problem 3

	Expansions	Goal Tests	New Nodes	Time Elapsed (in seconds)
Breadth First Search	14663	18098	128554	57.775
Depth First Search	627	628	5176	5.116
Uniform Cost Search	18235	18237	158284	70.773
A* search with ignore preconditions heuristics	5040	5042	44720	20.627
A* search with level sum heuristics	424	426	3834	637.939

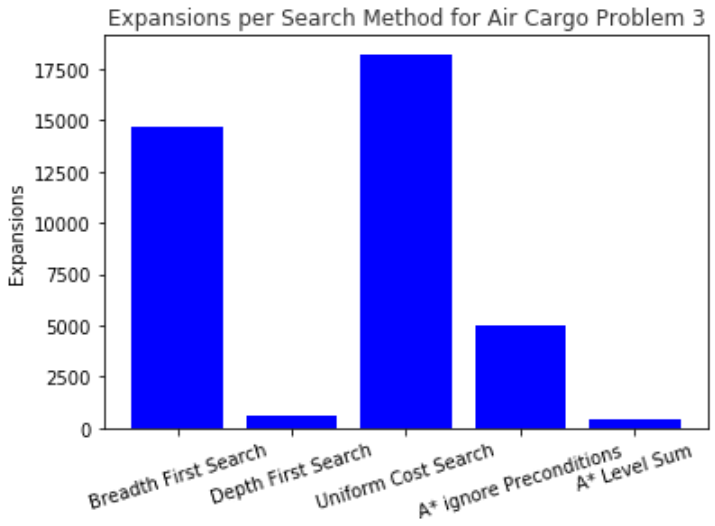

Figure 5 Expansions per Search Method for Air Cargo Problem 3

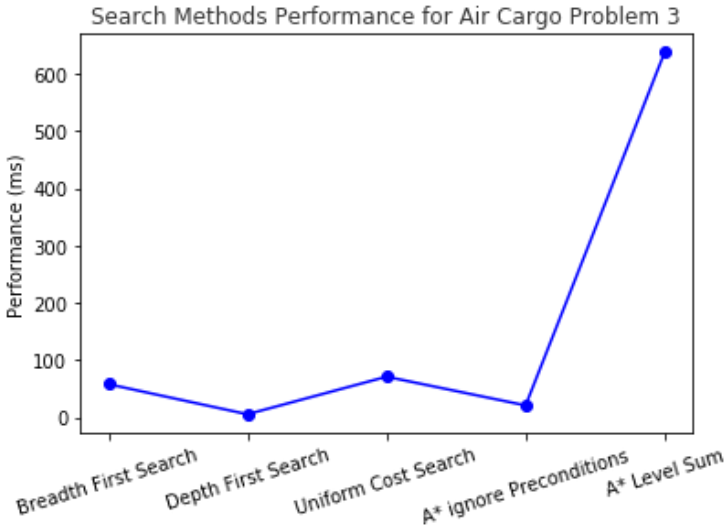

Figure 6 Search Methods Performance for Air Cargo Problem 2

Summary

1. Figures 1, 3, and 5 showed that the goal can be reached with minimum expansion with using Depth First Search and A* with Level Sum search methods.
2. The search methods demonstrated the same trend of expansion for all Air Cargo problems in which A* with Level Sum gives the best result while Uniform Cost Search gives the worst result. The Level Sum heuristic is considered inadmissible although generally efficient for independent subplans. However for Air Cargo problems, the goals are independent so that the Level Sum heuristic is admissible and optimistic.
3. Figures 2, 4, and 6 showed the same trend of performance for all Air Cargo in which Depth First Search gives the best result while the A* with Level Sum gives the worst result for time elapsed.
4. It can be concluded that Depth First Search can be considered as the optimum solution in which the goal can be reached with reasonable minimum expansion and time elapsed compared to the rest of the search methods for Air Cargo problems. According to the video lessons, the Breadth First and Uniform Cost search methods are optimum compared to Depth First Search as the search may not be completed in case of Depth First resulted in keep going down and down and never gets to the path that the goal consists of. In the case of very limited depth (limited number of moves), then the depth first search can be more preferable and faster to reach the goal than the rest of the search methods.

References

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