Air Cargo Planning problem

Non-heuristic search strategies

The following tables show the results of applying non-heuristic search strategies to Air cargo problems. We evaluate these strategies based on speed, memory, and optimality.

Air Cargo problem 1 result:

Search Strategy	optimal	Path length	Execution Times	Node Expansions
Breadth First Search	Yes	6	0.073	43
Breadth First Tree Search	Yes	6	1.338	1458
Depth First Graph Search	No	12	0.0096	12
Depth Limited Search	No	50	0.1117	101
Uniform Cost Search	Yes	6	0.048	55
Recursive Best First Search	Yes	6	4.79	4229

Air Cargo problem 2 result: Problem 2: We does not include the results of Breadth First Tree Search, Depth First Graph Search, and Recursive Best First Search, since the execution time exceed 10 mins (per udacity instruction)

Search Strategy	optimal	Path length	Execution Times	Node Expansions
Breadth First Search	Yes	9	21.90	3401
Breadth First Tree Search				
Depth First Graph Search	No	346	2.0971	350
Depth Limited Search				
Uniform Cost Search	Yes	9	17.479	4761

Recursive Best First Search				

Air Cargo problem 3 result: We does not include the results of Breadth First Tree Search, Depth First Graph Search, and Recursive Best First Search as same reason as problem 2.

Search Strategy	optimal	Path length	Execution Times	Node Expansions
Breadth First Search	Yes	12	144.24	14491
Breadth First Tree Search				
Depth First Graph Search	No	1878	29.427	1948
Depth Limited Search				
Uniform Cost Search	Yes	12	74.46	17783
Recursive Best First Search				

Analysis: Based on the three problems, we conclude that Breadth First Search, Uniform Cost Search solve those problems optimally in certain amounts of time and memory, whereas Depth First Graph Search, Depth Limited Search, Recursive Best First Search could find a quick solution and need a small amount of memory, but it is not optimal, since it does not consider if a node is better than another. It explores the nodes that take it as deep as possible in the graph.

If we look deeper, we can differentiate between choosing Breadth First Tree Search and Uniform Cost Search. In term of Execution Times time, Uniform Cost Search is better than Breadth First Tree Search to achieve optimal goal, while Breadth First Tree Search is outperformed if considering memory usages. Therefore, if we have limitation of memory, we should decide to use Breadth First Search.

Optimal Sequence of Actions: Breadth First Search

Problem 1 (6 paths)	Problem 2 (9 paths)	Problem 3 (12 paths)
Load(C2, P2, JFK) Load(C1, P1, SFO) Fly(P2, JFK, SFO) Unload(C2, P2, SFO) Fly(P1, SFO, JFK) Unload(C1, P1, JFK)	Load(C3, P3, ATL) Load(C2, P2, JFK) Load(C1, P1, SFO) Fly(P3, ATL, SFO) Unload(C3, P3, SFO) Fly(P2, JFK, SFO) Unload(C2, P2, SFO) Fly(P1, SFO, JFK) Unload(C1, P1, JFK)	Load(C2, P2, JFK) Load(C1, P1, SFO) Fly(P2, JFK, ORD) Load(C4, P2, ORD) Fly(P2, ORD, SFO) Unload(C2, P2, SFO) Unload(C4, P2, SFO) Fly(P1, SFO, ATL) Load(C3, P1, ATL) Fly(P1, ATL, JFK) Unload(C1, P1, JFK) Unload(C3, P1, JFK)

Heuristic search strategies

The following tables show the results of applying heuristic search strategies to Air cargo problems. We evaluate these strategies based on speed, memory, and optimality.

Air Cargo problem 1 result:

Search Strategy	optimal	Path length	Execution Times	Node Expansions
A* Search with h1 heuristic	Yes	6	0.04	55
A* Search with ignore Preconditions heuristic	Yes	6	0.045	41
A* Search with Level Sum heuristic	No	6	0.047	55

Air Cargo problem 2 result:

Search Strategy	optimal	Path length	Execution Times	Node Expansions
A* Search with h1 heuristic	Yes	9	15.150	4761

A* Search with ignore Preconditions heuristic	Yes	9	6.19	1450
A* Search with Level Sum heuristic	No	9	239.530	86

Air Cargo problem 3 result: We does not include the results of BA* Search with Level Sum heuristic, since the execution time exceed 10 mins (per udacity instruction)

Search Strategy	optimal	Path length	Execution Times	Node Expansions
A* Search with h1 heuristic	Yes	12	74.222	17783
A* Search with ignore Preconditions heuristic	Yes	12	23.596	5003
A* Search with Level Sum heuristic				

Analysis: we evaluate these strategies regarding to memory, execution time, and optimality. We can view that A* Search with ignore Preconditions heuristic is outperformed in all problems.

Heuristic vs Non-Heuristic Search Strategies:

Air Cargo problem 1 result:

Search Strategy	optimal	Path length	Execution Times	Node Expansions
Breadth First Search	Yes	6	0.073	43
A* Search with ignore Preconditions heuristic	Yes	6	0.41	41

Air Cargo problem 2 result:

Search Strategy	optimal	Path length	Execution Times	Node Expansions
Breadth First Search	Yes	9	21.90	3401
A* Search with ignore Preconditions heuristic	Yes	9	6.19	1450

Air Cargo problem 3 result:

Search Strategy	optimal	Path length	Execution Times	Node Expansions
Breadth First Search	Yes	12	144.24	14491
A* Search with ignore Preconditions heuristic	Yes	12	23.596	5003

Analysis: When we compare best choice of heuristic to non-Heuristic. We conclude that A* Search with ignore Preconditions heuristic is best regarding to optimality, execution time, and node expansion factors.

Conclusion

All the results above demonstrate the advantages of heuristic search strategies over non-Heuristic one when take optimal plan, memory usage, and execution time into account. However, we should experiment more on different set of problems, so that we can conclude with confidence what a problem is suitable with a strategies.