Heuristic Analysis

Uninformed Planning Algorithms

Air Cargo Problem 1					
Algorithm	**Expansions**	**Goal Tests**	**New Nodes**	**Time Elapsed**	**Plan length**
breadth_first_search	43	56	180	0.0218	
depth_first_graph_search	12	13	48	0.006	1
uniform_cost_search	55	57	224	0.0272	

Optimal Plan (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)
```

Air Cargo Problem 2					
Algorithm	**Expansions**	**Goal Tests**	**New Nodes**	**Time Elapsed**	**Plan length**
breadth_first_search	3343	4609	30509	10.0867	
depth_first_graph_search	476	477	4253	1.68	46
uniform_cost_search	4853	4855	44041	8.6407	

Optimal Plan (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)
```

Air Cargo Problem 3					
Algorithm	**Expansions**	**Goal Tests**	**New Nodes**	**Time Elapsed**	**Plan length**
breadth_first_search	14663	18098	129631	74.0203	1
depth_first_graph_search	1511	1512	12611	9.4421	144
uniform_cost_search	18234	18236	159707	38.8443	1

Optimal Plan (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(C2, P2, SFO)
Unload(C1, P1, JFK)
```

The 3 algorithms: Breadth First Search, Depth First Search and Uniform Cost Search were compared in each of the 3 Air Cargo Problems. From the data, we can see that on each of the problems the depth first search was always the quickest but gave a far from optimal result. This is because it is looking down the longest path until it finds the result, and therefore would guarantee an optimal path. Both Breadth First and Uniform Cost search find the optimal plan in each of the problems with Uniform Cost performing better in 2 out of 3 problems.

Automated Heuristics

Air Cargo Problem 1

Algorithm	Expansions	Goal Tests	New Nodes	Time Elapsed	Plan length
A* h_ignore_preconditions	41	43	170	0.0265	6
A* h_pg_levelsum	11	13	50	0.753	6

Air Cargo Problem 2

Algorithm	Expansions	Goal Tests	New Nodes	Time Elapsed	Plan length
A* h_ignore_preconditions	1450	1452	13303	3.028	9
A* h_pg_levelsum	86	88	841	124.175	9

Air Cargo Problem 3

Algorithm	Expansions	Goal Tests	New Nodes	Time Elapsed	Plan length
A* h_ignore_preconditions	5040	5042	44944	12.005	12
A* h_pg_levelsum	325	327	3002	878.256	12

Two heuristics were tested with the A* Algorithm: Ignore Preconditions and Level Sum. The A* algorithm is guaranteed to find the optimal path, whilst also visiting a smaller number of nodes. Only the Ignore Preconditions algorithm performed faster than the uninformed planning algorithms, as although the Level Sum version visited less nodes the cost of calculating the heuristic had a negative impact on performance.

A* Ignore Preconditions would be the chosen algorithm based on the problems presented in this review. But ‘because it keeps all generated nodes in memory (as do all GRAPH-SEARCH algorithms), A* usually runs out of space long before it runs out of time. For this reason, A* is not practical for many large-scale problems.’ (Russel and Norvig, 2009)

References

Russell, S. and Norvig, P. (2009). *Artificial intelligence: A Modern Approach*. 3rd ed. p.99.