Algorithm Analysis for Path Planning

Introduction

This is a report comparing results of different algorithms trying to solve path planning problems. The problems were in the air cargo domain. The variables include 'planes' and 'cargos' at 'airports'. There are only 3 possible actions: loading cargo in a plane, unloading cargo from a plane and flying a plane from one airport to the other. The algorithms tested to find the solution were Breadth First Search (BFS), Depth First Search (DFS), Uniform Cost Search (UCS), Recursive BFS, Greedy BFS and A* with various heuristics.

Results

The following table represents the data collected by running the above-mentioned algorithms on the 3 air cargo problems. 6 different algorithms are compared based on the number of nodes expanded, number of times the goal node was tested, number of new nodes created, total path length of the final solution, time elapsed for the computation and finally, its optimality. A* algorithm with different heuristics are mentioned as A*1 (A* with h_1), A*2 (A* with ignore predictions) and A*3 (A* with level_sum).

		Node Expansions	Goal Test	New Nodes	Path Length	Time Elapsed(s)	Optimality
	P1	43	56	180	6	0.075	Yes
BFS	P2	3343	4609	30509	9	16.79	Yes
	P3	14663	18098	129631	12	124.2	No
	P1	21	22	84	20	0.026	Yes
DFS	P2	624	625	5602	619	4.229	No
	P3	408	409	3364	392	2.163	No
	P1	55	57	224	6	0.054	Yes
UCS	P2	4852	4854	44030	9	14.74	Yes
	P3	18223	18225	159618	12	64.28	No
	P1	55	57	224	6	0.089	Yes
A* 1	P2	4852	4854	44030	9	14.62	Yes
	P3	18223	18225	159618	12	63.82	No
	P1	41	43	170	6	0.065	Yes
A* 2	P2	1450	1452	13303	9	5.472	Yes
	P3	5040	5042	44944	12	21.24	Yes
	P1	11	13	50	6	1.201	Yes
A* 3	P2	86	88	841	9	241.4	No
	P3	315	317	2902	12	963.3	No

Looking at the table above, we can see that:

a) For problem 1, All 6 algorithms are optimal. All of them are fast enough but the number of node expansions, goal tests and new nodes created vary significantly. DFS seemed to be the fastest, however, the path length was the longest. On the other hand, A* with level_sum was the slowest but with least number of nodes expanded.
b) For problem 2, DFS was the fastest to find a solution but with the longest path. Though A* with level_sum found the path without expanding many nodes, it took too long and hence it is not an optimal solution.
c) For problem 3, DFS was again the fastest to find a solution but with the longest path and hence, not optimal. The only optimal solution, with an acceptable computation time and path length, was A* with ignored predictions.

An interesting thing to note here that the results for Uniform Cost Search and A* with h_1 are very similar.

Following table shows the most optimal path for each of the three problems:

Problem	Optimal Algorithm	Optimal Path
P1	UCS	Load(C1, P1, SFO) Load(C2, P2, JFK) Fly(P1, SFO, JFK) Fly(P2, JFK, SFO) Unload(C1, P1, JFK) Unload(C2, P2, SFO)
P2	A* ignored predictions	Load(C3, P3, ATL) Fly(P3, ATL, SFO) Unload(C3, P3, SFO) Load(C2, P2, JFK) Fly(P2, JFK, SFO) Unload(C2, P2, SFO) Load(C1, P1, SFO) Fly(P1, SFO, JFK) Unload(C1, P1, JFK)
P3	A* ignored predictions	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(C2, P2, SFO) Unload(C1, P1, JFK)

Conclusion

After running a number of algorithms over the three problems, we found that A* with the ignored preconditions heuristic almost always outperforms all other algorithms. As we learnt in the lecture videos, reducing the number of constraints on a constraint search problem relaxes the overall computations and thus makes it faster and easier for the AI agent to come up with heuristics automatically. Since we ignore all the preconditions when applying actions, almost every action is possible at each state and thus, we reach the goal state faster.

We also note that though Depth-first-search was surprisingly very fast, it expanded a lot more nodes and the resulting path was far too long for it to be the optimal solution. Having said that, I feel that even though the total path length for solving P1 using DFS was 20 (as compared to 6 for other algorithms), the time elapsed was too low to be ignored when we talk about it being an optimal solution.