

Planning Search Heuristics Analysis

This project had as objective to implement an agent, and Air Cargo transport system, that using different search algorithms and different heuristics, it would permit us to provide comparisons between them.

Optimal problem solution

One of the objectives of the agents is also to achieve the best optimal solution defined below.

Problem 1	Problem 2	Problem 3
Load(C1, P1, SF0) Load(C2, P2, JFK) Fly(P1, SF0, JFK) Fly(P2, JFK, SF0) Unload(C1, P1, JFK) Unload(C2, P2, SF0)	Load(C1, P1, SF0) Load(C2, P2, JFK) Load(C3, P3, ATL) Fly(P1, SF0, JFK) Fly(P2, JFK, SF0) Fly(P3, ATL, SF0) Unload(C3, P3, SF0) Unload(C2, P2, SF0) Unload(C1, P1, JFK)	Load(C1, P1, SF0) Load(C2, P2, JFK) Fly(P1, SF0, ATL) Load(C3, P1, ATL) Fly(P2, JFK, ORD) Load(C4, P2, ORD) Fly(P1, ATL, JFK) Fly(P2, ORD, SF0) Unload(C4, P2, SF0) Unload(C3, P1, JFK) Unload(C2, P2, SF0) Unload(C1, P1, JFK)

Uninformed planning searches analysis

Search	Path length	Time (s)	Node expansion
Breath First Search	6	0.049	43
Breath First Tree Search	6	1.470	1458
Depth First Graph Search	20	0.019	21
Depth Limited Search	50	0.138	101
Uniform Cost Search	6	0.062	55
Recursive Best First Search	6	4.122	4229
Greedy Best First Graph Search	6	0.007	7

Table 1 - Uninformed planning search results for Problem 1

Analysing the *Table 1* we can verify that for a simple problem like the Problem 1 is any of the search algorithms is able to find a solution, with 5 of them finding an optimal solution with a minimum path length of 6. In the other side is the Depth Limited Search that only expanding 101 nodes, discovers a solution with path length of 50 as for this type of problem and will be applied to the real world makes it very bad.

Taking into account all the details the best solution would be to use the *Greedy Best First Graph Search*, showing an optimal path length an optimal and the minimal node expansion.

Search	Path length	Time (s)	Node expansion
Breath First Search	9	19.209	3343
Breath First Tree Search	-	> 600	-
Depth First Graph Search	619	4.597	619
Depth Limited Search	-	> 600	-
Uniform Cost Search	9	16.839	4761
Recursive Best First Search	-	> 600	-
Greedy Best First Graph Search	9	1.903	550

Table 2 - Uninformed planning search results for Problem 2

When the problem starts to get more complex as the Problem 2, using the *Table 2* is possible to verify that three of the search algorithms weren't able to find a solution with a time inferior to 10 minutes. Three of the algorithms were able to find an optimal solution with path length of 9.

Search	Path length	Time (s)	Node expansion
Breath First Search	12	146.246	14491
Breath First Tree Search	-	> 600	-
Depth First Graph Search	2014	30.947	2099
Depth Limited Search	-	> 600	-
Uniform Cost Search	12	72.152	17783
Recursive Best First Search	-	> 600	-
Greedy Best First Graph Search	22	17.149	4031

Table 3 - Uninformed planning search results for Problem 3

As expected for the Problem 3, only four of the search algorithms found a solution in a time inferior to 10 minutes and two of them got an optimal solution.

Using all the Problem results, if *Path length* is a priority then we should go for the for the *Breath First Search* or *Uniform Cost Search*. Between the both it will depend in what is more important if time or the memory consumption, being *Uniform Cost Search* is the faster and the *Breath First Search* the one with lower memory consumption.

Informed search strategies analysis

Search	Path length	Time (s)	Node expansion
A* Search with h1 heuristic	6	0.052	55
A* Search with Ignore Preconditions heuristic	6	0.058	41
A* Search with Level Sum heuristic	6	1.740	55

Table 4 – Informed search strategies for Problem 1

Search	Path length	Time (s)	Node expansion
A* Search with h1 heuristic	9	17.924	4761
A* Search with Ignore Preconditions heuristic	9	6.535	1450
A* Search with Level Sum heuristic	-	> 600	-

Table 5 - Informed search strategies for Problem 2

Search	Path length	Time (s)	Node expansion
A* Search with h1 heuristic	12	76.453	17783
A* Search with Ignore Preconditions heuristic	12	25.656	5003
A* Search with Level Sum heuristic	-	> 600	-

Table 6 - Informed search strategies for Problem 3

The A* Search with Level Sum heuristic is able to solve the Problem 1 in a reasonable time, but once the problem gets more complex it isn't able to find a solution in under 10 minutes, when the other two found a solution in a few seconds.

Conclusion

In conclusion we can verify that *A* Search with Ignore Preconditions heuristic* is the best algorithm, it is optimal finding the shortest path, it has the lowest path expansion, meaning that will have the lower memory consumption and it is also the fastest.