Solving Air Cargo problems using uninformed search methods.

I explored 3 uninformed search methods: Breadth First, Depth First and Uniform Cost Search.

Following are the results of test runs for 3 problems:

Air Cargo Problem 1

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Search method | Time | Expansions | Goal Tests | New Nodes | Plan length |
| breadth\_first\_search | 0.0277855 | 43 | 56 | 180 | 6 |
| depth\_first\_graph\_search | 0.01220614 | 21 | 22 | 84 | 6 |
| uniform\_cost\_search | 0.030791 | 55 | 57 | 224 | 6 |

Air Cargo Problem 2

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Search method | Time | Expansions | Goal Tests | New Nodes | Plan length |
| breadth\_first\_search | 10.061483 | 3343 | 4609 | 30509 | 9 |
| depth\_first\_graph\_search | 4.2584862 | 624 | 625 | 5602 | 9 |
| uniform\_cost\_search | 14.244175 | 4853 | 4855 | 44041 | 9 |

Air Cargo Problem 3

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Search method | Time | Expansions | Goal Tests | New Nodes | Plan length |
| breadth\_first\_search | 53.21847586 | 14663 | 18098 | 129631 | 12 |
| depth\_first\_graph\_search | 2.22066 | 408 | 409 | 3364 | 12 |
| uniform\_cost\_search | 62.149463 | 18223 | 18225 | 159618 | 12 |

Considering the above tables, it turns out that Depth First Search works best for the current instances of the problem, but it doesn’t guarantee optimality as it stops whenever it finds the goal. Depth First Search always expands the deepest node in the current frontier of the search tree (AIMA, 3.4). For the current problem description where there seems to be a goal in the left subtree, the depth first search explores the minimum number of nodes and is able to find the goal faster. It event seems to be optimal. Breadth first search and uniform cost search are building the large frontiers with many nodes, and if the solution lies deep enough, it’ll make it harder to reach there. The memory requirements are a bigger problem for both BFS and Uniform Cost Search than the execution time (AIMA, 3.4). However, it’s guaranteed to get the optimal solution there. We can see the proof from our experiments.

In general, exponential-complexity search problems cannot be solved by uninformed methods for any but the smallest instances (AIMA, 3.4).

Solving Air Cargo problems using A\* with h\_ignore\_preconditions and h\_level\_sum heuristics.

The best heuristic for all 3 problems was the ignore precoditions heuristics (see the tables below for proof). It appears to be that the computational cost for ignore precoditions is O(n), but for levelsum the performance seems to be much slower due to the following: each time the method is called, it’s required to build the PlanningGraph data structure which has the complexity of at least O(n^2). It’s guaranteed to receive the optimal solution using A\* search if we have the consistent heuristics (AIMA, 3.5).

Air Cargo Problem 1

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Heuristics | Time | Expansions | Goal Tests | New Nodes | Plan length |
| h\_ignore\_preconditions | 0.0394931 | 41 | 43 | 170 | 6 |
| h\_pg\_levelsum | 0.7867919 | 44 | 46 | 178 | 6 |

Air Cargo Problem 2

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Heuristics | Time | Expansions | Goal Tests | New Nodes | Plan length |
| h\_ignore\_preconditions | 4.81047 | 1450 | 1452 | 13303 | 9 |
| h\_pg\_levelsum | 569.7005 | 4853 | 4855 | 44041 | 9 |

Air Cargo Problem 3

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Heuristics | Time | Expansions | Goal Tests | New Nodes | Plan length |
| h\_ignore\_preconditions | 18.225881 | 5040 | 5042 | 44944 | 12 |
| h\_pg\_levelsum | 3450.699 | 18266 | 18268 | 160136 | 12 |

Considering the above result, the most optimal heuristics so far is h\_ignore\_preconditions.

Both algorithms returned the optimal plans of the same contents.

Optimal plans for Air Cargo Problems.

Air Cargo Problem 1:

Plan length: 6

Load(C1, P1, SFO)

Load(C2, P2, JFK)

Fly(P1, SFO, JFK)

Unload(C1, P1, JFK)

Fly(P2, JFK, SFO)

Unload(C2, P2, SFO)

Air Cargo Problem 2:

Plan length: 9

Load(C3, P3, ATL)

Fly(P3, ATL, SFO)

Unload(C3, P3, SFO)

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 3:

Plan length: 12

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(C1, P1, JFK)

Unload(C2, P2, SFO)