

heuristic_analysis

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1 Heuristic Analysis - Planning Search Algorithm

1.1 Air Cargo System

1.2 Uninformed planning searches

1.2.1 Optimal sequence of actions for each problem (Planning problems):

Problem 1

Optimal plan length 6

```
Load(C1, P1, SFO)
Load(C2, P2, JFK)
Fly(P1, SFO, JFK)
Fly(P2, JFK, SFO)
Load(C1, P1, JFK)
Load(C2, P2, SFO)
```

Problem 2

Optimal plan length 9

```
Load(C1, P1, SFO)
Load(C2, P2, JFK)
Fly(P2, JFK, ATL)
Load(C3, P2, ATL)
Fly(P1, SFO, JFK)
Load(C1, P1, JFK)
Fly(P2, ATL, SFO)
Load(C2, P2, SFO)
Load(C3, P2, SFO)
```

Problem 3

Optimal plan length 12

Load(C1, P1, SFO)
Load(C2, P2, JFK)
Fly(P2, JFK, ORD)
Load(C4, P2, ORD)
Fly(P1, SFO, ATL)
Load(C3, P1, ATL)
Fly(P1, ATL, JFK)
Load(C1, P1, JFK)
Load(C3, P1, JFK)
Fly(P2, ORD, SFO)
Load(C2, P2, SFO)
Load(C4, P2, SFO)

1.2.2 Analysis for non heuristic search

Breadth First Search BFS is optimal with better performance in terms of time and space complexity (number of node expansion)

| | Expansions | Goal Tests | Time elapsed | Plan length |
|-----------|------------|------------|--------------|-------------|
| Problem 1 | 43 | 56 | 0.041 | 6 |
| Problem 2 | 3190 | 4380 | 16.083 | 9 |
| Problem 3 | 14663 | 18098 | 139.33 | 12 |

Depth First Graph Search DFGS is not optimal with high space complexity

| | Expansions | Goal Tests | Time elapsed | Plan length |
|-----------|------------|------------|--------------|-------------|
| Problem 1 | 21 | 22 | 0.022 | 20 |
| Problem 2 | 1172 | 1173 | 4.59 | 200 |
| Problem 3 | 408 | 409 | 2.24 | 392 |

Uniform Cost Search UCS is optimal however explores nodes more than BFS

| | Expansions | Goal Tests | Time elapsed | Plan length |
|-----------|------------|------------|--------------|-------------|
| Problem 1 | 55 | 57 | 0.049 | 6 |
| Problem 2 | 4548 | 4550 | 13.74 | 9 |
| Problem 3 | 18235 | 18237 | 72.18 | 12 |

1.2.3 Analysis for A* searches

| | Expansions | Goal Tests | Time elapsed | Plan length |
|-----------|------------|------------|--------------|-------------|
| Problem 1 | 55 | 57 | 0.98 | 6 |
| Problem 2 | 4548 | 4550 | 558 | 9 |

| | Expansions | Goal Tests | Time elapsed | Plan length |
|-----------|------------|------------|--------------|-------------|
| Problem 3 | 18235 | 18237 | 3147.5 | 12 |

A* search h_pg_levelsum.

| | Expansions | Goal Tests | Time elapsed | Plan length |
|-----------|------------|------------|--------------|-------------|
| Problem 1 | 41 | 43 | 0.04 | 6 |
| Problem 2 | 1379 | 1381 | 4.9 | 9 |
| Problem 3 | 5040 | 5042 | 21.5 | 12 |

A* search h_ignore_preconditions Ignore Preconditions heuristic out perform all non-heuristic algorithms and levelsum heuristic as well in terms of the number of node expansion and in time, which indicate that evaluating the preconditions takes time.

In general A* search is optimal and it has less expansion than non-heuristic algorithms, however, it takes more time/ computation effort to reach the goal.