**Air Cargo Planning Problem**

Heuristic Analysis - Sebastian Mack

The objective of this project was to solve a deterministic logistics planning problem for an Air Cargo transport system using a planning search agent. A basic problem description as well as concepts and applied algorithms can be found in [1]. Furthermore, all information regarding the detailed problem (including the action schema, initial states and goals) is available in the appendix.

Tables 1-3 provide the results gained for the AirCargo problems 1-3. Each table shows properties like plan length, optimality, time elapsed, number of node expansions for several search strategies that have been used. As was suggested in the Udacity instructions, some of the searches had to be skipped because the execution time exceeded 10 minutes.

Table 1 Results AirCargo Problem 1

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Search Type** | **Plan Length** | **Optimal** | **Time [s]** | **Node Expansions** |
| Breadth First Search | 6 | True | 0.13 | 43 |
| Breadth First Tree Search | 6 | True | 5.08 | 1458 |
| Depth First Graph Search | 12 | False | 0.04 | 12 |
| Depth Limited Search | 50 | False | 0.47 | 101 |
| Uniform Cost Search | 6 | True | 0.2 | 55 |
| Recursive Best First Search | 6 | True | 15.3 | 4229 |
| Greedy Best First Graph | 6 | True | 0.03 | 7 |
| A\* Search h1 Heuristic | 6 | True | 0.15 | 55 |
| A\* Search Ignore Preconditions Heuristic | 6 | True | 0.14 | 41 |
| A\* Search Level Sum Heuristic | 6 | True | 6.12 | 11 |

Table 2 Results AirCargo Problem 2

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Search Type** | **Plan Length** | **Optimal** | **Time [s]** | **Node Expansions** |
| Breadth First Search | 9 | True | 36.63 | 3343 |
| Breadth First Tree Search |  |  |  |  |
| Depth First Graph Search | 575 | False | 6.99 | 582 |
| Depth Limited Search |  |  |  |  |
| Uniform Cost Search | 9 | True | 30.77 | 4852 |
| Recursive Best First Search |  |  |  |  |
| Greedy Best First Graph | 17 | False | 7.11 | 990 |
| A\* Search h1 Heuristic | 9 | True | 37.98 | 4852 |
| A\* Search Ignore Preconditions Heuristic | 9 | True | 17.45 | 1450 |
| A\* Search Level Sum Heuristic | 9 | True | 581.86 | 86 |

Table 3 Results AirCargo Problem 3

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Search Type** | **Plan Length** | **Optimal** | **Time [s]** | **Node Expansions** |
| Breadth First Search | 12 | True | 296.14 | 14663 |
| Breadth First Tree Search |  |  |  |  |
| Depth First Graph Search | 596 | False | 7.13 | 627 |
| Depth Limited Search |  |  |  |  |
| Uniform Cost Search | 12 | True | 124.11 | 18235 |
| Recursive Best First Search |  |  |  |  |
| Greedy Best First Graph | 22 | False | 50.03 | 5614 |
| A\* Search h1 Heuristic | 12 | True | 128.33 | 18235 |
| A\* Search Ignore Preconditions Heuristic | 12 | True | 74.96 | 5040 |
| A\* Search Level Sum Heuristic |  |  |  |  |

**Optimal Plan for Problem 3**

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)

**Optimal Plan for Problem 1**

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

**Optimal Plan for Problem 2**

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(C1, P1, JFK)  
Unload(C2, P2, SFO)

**Non-heuristic Search Result Metrics**

In this section, a comparison is given for the first seven rows of the tables 1-3 which represent the search strategies: Breadth First Search, Breadth First Tree Search, Depth First Graph Search, Depth Limited Search, Uniform Cost Search, Recursive Best First Search, Greedy Best First Graph. As mentioned before, not all of them could produce results in a reasonable time period for all three problems.

**Heuristic Search Result Metrics**

In this section

References

1. Russell, S. and Norvig, P. Artificial Intelligence: A Modern Approach **11,** 407-412 (2012).

Appendix

