# Overview

This paper compares and discusses the test results for non-heuristic and heuristic based search solutions. Non-heuristic based searches include Breadth First, Depth First and Uniform Cost. Heuristic based searches include A\* w/ Ignore Preconditions and A\* w/ PG LevelSum. First, a comparison of non-heuristic based searches. Next, a comparison of heuristic based searches. Finally, a comparison of non-heuristic and heuristic based searches and discussion of the optimal search solution.

# Non-Heuristic Search

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | **Breadth First Search** | | | | |
|  | Expansions | Goal Tests | New Nodes | Plan Length | Elapsed Time (sec) |
| Air Cargo Problem |  |  |  |  |  |
| 1 | 43 | 56 | 180 | 6 | 0.06 |
| 2 | 3343 | 4609 | 30509 | 9 | 24.24 |
| 3 | 14663 | 18098 | 129631 | 12 | 173.41 |

**Figure 1**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | **Depth First Search** | | | | |
|  | Expansions | Goal Tests | New Nodes | Plan Length | Elapsed Time (sec) |
| Air Cargo Problem |  |  |  |  |  |
| 1 | 12 | 13 | 48 | 12 | 0.02 |
| 2 | 582 | 583 | 5211 | 575 | 5.36 |
| 3 | 627 | 628 | 5176 | 596 | 5.71 |

**Figure 2**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | **Uniform Cost Search** | | | | |
|  | Expansions | Goal Tests | New Nodes | Plan Length | Elapsed Time (sec) |
| Air Cargo Problem |  |  |  |  |  |
| 1 | 55 | 57 | 224 | 6 | 0.08 |
| 2 | 4853 | 4855 | 44041 | 9 | 22.44 |
| 3 | 18236 | 18238 | 159726 | 12 | 97.84 |

**Figure 3**

In Breadth First and Depth First, the data is organized in a tree whereas Uniform Cost organizes data in a graph. Based on the three figures above, Uniform Cost and Breadth First searches are similar in the number of node expanded, number of goal tests, discovery of new nodes and elapsed times. Interestingly, Depth First performs better than Breadth First and Uniform Cost because Depth First explores the levels from top to bottom thus reducing the time to reach the goal(s). Of the three non-heuristic based searches, Depth First seems to be the optimal choice for its speed and efficient process of reaching the goal(s).

# Heuristic Search

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | **A\* Search w/ Ignore Preconditions Heuristic** | | | | |
|  | Expansions | Goal Tests | New Nodes | Plan Length | Elapsed Time (sec) |
| Air Cargo Problem |  |  |  |  |  |
| 1 | 41 | 43 | 170 | 6 | 0.08 |
| 2 | 1450 | 1452 | 13303 | 9 | 8.98 |
| 3 | 5040 | 5042 | 44944 | 12 | 34.62 |

**Figure 4**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | **A\* Search w/ PG LevelSum Heuristic** | | | | |
|  | Expansions | Goal Tests | New Nodes | Plan Length | Elapsed Time (sec) |
| Air Cargo Problem |  |  |  |  |  |
| 1 | 11 | 13 | 50 | 6 | 1.01 |
| 2 | 86 | 88 | 841 | 9 | 86.67 |
| 3 | 318 | 320 | 2934 | 12 | 432.88 |

**Figure 5**

Of the two heuristic based searches, A\* Search w/ PG LevelSum performs better than A\* Search w/ Ignore Preconditions because LevelSum surveys the levels for the goal(s) first and then attempts to determine the best route to get to goal(s). A\* Search w/ PG LevelSum heuristic is the optimal solution.

# Conclusion

A\* Search w/ PG LevelSum heuristic is the optimal choice for solving planning problems when the number of conditions increase. A\* Search w/ PG LevelSum heuristic is more efficient and reduces the number of nodes expanded with smaller number of plans requires to reach the goal(s).