Non-heuristic search strategies do not have any addition al information about states beyond that provided in the problem. They generate successors and distinguish goal states from non-goal states. In this section performance of these non-heuristic search strategies are compared in terms of metrics node expansions required, number of goal tests, time elapsed, and optimality of solution.

**Table 1 : Problem 1 non-heuristic search strategies metrics**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | Expansion | Goal Tests | New Nodes | Length | Time | Optimality |
| breadth\_first\_search | 43 | 56 | 180 | 6 | 0.01994841 | Yes |
| breadth\_first\_tree\_search | 1458 | 1459 | 5960 | 6 | 0.61806022 | Yes |
| depth\_first\_graph\_search | 21 | 21 | 84 | 20 | 0.00870802 | No |
| depth\_limited\_search | 101 | 271 | 414 | 50 | 0.05988025 | No |
| uniform\_cost\_search | 55 | 57 | 224 | 6 | 0.02276062 | Yes |

**Table 2 : Problem 2 non-heuristic search strategies metrics**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | Expansions | Goal Tests | New Nodes | Length | Time | Optimality |
| breadth\_first\_search | 3343 | 4609 | 30509 | 9 | 11.1150175 | Yes |
| breadth\_first\_tree\_search | NA | NA | NA | NA | NA | NA |
| depth\_first\_graph\_search | 624 | 625 | 5602 | 619 | 2.71455507 | No |
| depth\_limited\_search | NA | NA | NA | NA | NA | NA |
| uniform\_cost\_search | 4852 | 4854 | 44030 | 9 | 8.75425266 | Yes |

**Table 3 : Problem 3 non-heuristic search strategies metrics**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | Expansion | Goal Test | New Nodes | Lengt | Time | Optimality |
| breadth\_first\_search | 14663 | 18098 | 129631 | 12 | 85.7846844 | Yes |
| breadth\_first\_tree\_search | NA | NA | NA | NA | NA | NA |
| depth\_first\_graph\_search | 408 | 409 | 3364 | 392 | 1.74755026 | No |
| depth\_limited\_search | NA | NA | NA | NA | NA | NA |
| uniform\_cost\_search | 18235 | 18237 | 159716 | 12 | 53.2305078 | Yes |

Tables 1, 2, 3 show the results obtained by running 5 non-heuristic search strategies on the given 3 problems. Results for breadth first tree search and depth limited search are not included for problems 2 and 3 as the execution time for these exceed the given 10 min time limit.

Breadth first and uniform cost search are the only two non-heuristic search strategies that are able to achieve the optimal path to the solution for all 3 given problems. Breadth first search expands fewer nodes than uniform cost search for all 3 cases. Breadth fist search has a shorter execution time than uniform cost search for problem #1, but as the problems get more complicated (problems 2 and 3) uniform cost search outperform breadth fist search in execution time.

Out of all non-heuristic search strategies observed depth first search strategy has the shortest execution time. However, it fails to obtain the optimal path to the solution.

The optimal paths for problems 1, 2, and 3 have 6, 9, and 12 actions respectively as shown in table 4.

**Table 4 : Optimal list of actions**

|  |  |  |
| --- | --- | --- |
| Problem | Search strategy | Optimal list of Actions |
| Air Cargo Problem 1 | breadth\_first\_search | Load(C1, P1, SFO) Load(C2, P2, JFK) Fly(P2, JFK, SFO) Unload(C2, P2, SFO) Fly(P1, SFO, JFK) Unload(C1, P1, JFK) |
| Air Cargo Problem 2 | breadth\_first\_search | Load(C1, P1, SFO) Load(C2, P2, JFK) Load(C3, P3, ATL) Fly(P2, JFK, SFO) Unload(C2, P2, SFO) Fly(P1, SFO, JFK) Unload(C1, P1, JFK) Fly(P3, ATL, SFO) Unload(C3, P3, SFO) |
| Air Cargo Problem 3 | breadth\_first\_search | 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) Unload(C1, P1, JFK) Unload(C3, P1, JFK) Fly(P2, ORD, SFO) Unload(C2, P2, SFO) Unload(C4, P2, SFO) |

Heuristic search strategies use problem specific knowledge beyond the definition of the problem to find solutions more efficiently than non-heuristic search strategies. In this section performance of 3 different heuristic search strategies are compared in terms of metrics node expansions required, number of goal tests, time elapsed, and optimality of solution.

Table 5 : Problem 1 heuristic search strategies metrics

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | Expansions | Goal Tests | New Nodes | Length | Time | Optimality |
| astar\_search with h\_1 | 55 | 57 | 224 | 6 | 0.038490756 | Yes |
| h\_ignore\_preconditions | 41 | 43 | 170 | 6 | 0.028834768 | Yes |
| astar\_search with h\_pg\_levelsum | 11 | 13 | 50 | 6 | 0.70320505 | Yes |

Table 6 : Problem 2 heuristic search strategies metrics

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | Expansions | Goal Tests | New Nodes | Length | Time | Optimality |
| astar\_search with h\_1 | 4852 | 4854 | 44030 | 9 | 9.611471554 | Yes |
| h\_ignore\_preconditions | 1450 | 1452 | 13303 | 9 | 3.548625226 | Yes |
| astar\_search with h\_pg\_levelsum | 86 | 88 | 841 | 9 | 148.1646866 | Yes |

Table 7 : Problem 3 heuristic search strategies metrics

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | Expansions | Goal Tests | New Nodes | Length | Time | Optimality |
| astar\_search with h\_1 | 18235 | 18237 | 159716 | 12 | 50.48441678 | Yes |
| h\_ignore\_preconditions | 5040 | 5042 | 44944 | 12 | 16.28220661 | Yes |
| astar\_search with h\_pg\_levelsum | NA | NA | NA | NA | NA | NA |

A\* search with h\_pg\_levelsum results are not included for problem 3 as it takes longer that the given execution time limit of 10 min to get a solution. All heuristics search strategies provide optimal paths to the solution. A\* search with h\_ignore\_preconditions performed the best with the least execution time of all 3 heuristic search strategies. The A\* search with h\_pg\_levelsum performed poorly in all 3 cases. This may be due to the complexity of the given heuristic algorithm of h\_pg\_levelsum.