Heuristics for Planning agent

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Introduction

This report summarizes the application of Classical Planning to solving the logistic planning problem for cargo transportation. We consider three problems of moving cargo between 2-4 airports with 2-3 planes. The problems are defined

Evaluation

As per the assignment we validated three different uninformed search algorithms for each of the three problems. We considered breadth-first search (BFS), depth-first search (DFS) and uniform cost search (UCS). The results are summarized below. Each cell contains the three numbers - first representing the length of the plan, second is the number of expanded nodes and third is the run time in seconds. Additionally all raw results are presented in the Appendix.

Problem	BFS	DFS	UCS
Problem 1	6 / 43 / 0.04s	20 / 21 / 0.02s	6 / 55 / 0.05s
Problem 2	9 / 3343 / 9.82s	619 / 624 / 4.06s	9 / 4852 / 13.16s
Problem 3	12 / 14663 / 48.3s	392 / 408 / 1.95s	12 / 18236 / 60.37s

In all cases both BFS and UCS managed to find the optimal solution, although BFS did it with slightly less node expansions in all cases. DFS didn't manage to converge on the optimal solution in neither of problems, it was however the fastest among all three.

Recommendation

Appendix A - Raw results

Case P1-S1

```
python run_search.py -p 1 -s 1`

Solving Air Cargo Problem 1 using breadth_first_search...

Expansions   Goal Tests   New Nodes
    43          56         180

Plan length: 6  Time elapsed in seconds: 0.039851423003710806
Load(C1, P1, SFO)
Load(C2, P2, JFK)
Fly(P2, JFK, SFO)
Unload(C2, P2, SFO)
Fly(P1, SFO, JFK)
Unload(C1, P1, JFK)
```

Case P1-S3

```
python run_search.py -p 1 -s 3`

Solving Air Cargo Problem 1 using depth_first_graph_search...

Expansions   Goal Tests   New Nodes
    21          22          84

Plan length: 20  Time elapsed in seconds: 0.0190653299796395
Fly(P1, SFO, JFK)
Fly(P2, JFK, SFO)
Load(C2, P1, JFK)
Fly(P1, JFK, SFO)
Fly(P2, SFO, JFK)
Unload(C2, P1, SFO)
Fly(P1, SFO, JFK)
Fly(P2, JFK, SFO)
Load(C2, P2, SFO)
Fly(P1, JFK, SFO)
Load(C1, P2, SFO)
Fly(P2, SFO, JFK)
Fly(P1, SFO, JFK)
Unload(C2, P2, JFK)
```

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

Case P1-S5

```
python run_search.py -p 1 -s 5

Solving Air Cargo Problem 1 using uniform_cost_search...

Expansions   Goal Tests   New Nodes
    55          57         224

Plan length: 6  Time elapsed in seconds: 0.04902327200397849
Omitted as it is the same as P1-S1
```

Case P2-S1

```
python run_search.py -p 2 -s 1

Solving Air Cargo Problem 2 using breadth_first_search...

Expansions   Goal Tests   New Nodes
   3343        4609       30509

Plan length: 9  Time elapsed in seconds: 9.823018399998546
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)
```

Case P2-S3

```
python run_search.py -p 2 -s 3
```

```
Solving Air Cargo Problem 2 using depth_first_graph_search...

Expansions   Goal Tests   New Nodes
   624         625         5602

Plan length: 619  Time elapsed in seconds: 4.058151098026428
Omitted as too long
```

Case P2-S5

```
python run_search.py -p 2 -s 5

Solving Air Cargo Problem 2 using uniform_cost_search...

Expansions   Goal Tests   New Nodes
   4852        4854       44030

Plan length: 9  Time elapsed in seconds: 13.163193234999198
Omitted as it is the same as P2-S1
```

Case P3-S1

```
python run_search.py -p 3 -s 1

Solving Air Cargo Problem 3 using breadth_first_search...

Expansions   Goal Tests   New Nodes
  14663       18098       129631

Plan length: 12  Time elapsed in seconds: 48.30484216596233
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)
```

Case P3-S3

```
python run_search.py -p 3 -s 3

Solving Air Cargo Problem 3 using depth_first_graph_search...

Expansions   Goal Tests   New Nodes
   408         409         3364

Plan length: 392  Time elapsed in seconds: 1.9534217299660668
Omitted as too long
```

Case P3-S5

```
python run_search.py -p 3 -s 5

Solving Air Cargo Problem 3 using uniform_cost_search...

Expansions   Goal Tests   New Nodes
  18236       18238       159726

Plan length: 12  Time elapsed in seconds: 60.371445766999386
Omitted as it is similar to P3-S1
```