Heuristic Analysis - Planning AIND

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Introduction:

The following report is consisting of comparing various searching techniques for logistics planning in Air cargo planning, using uniformed cost planning and Heuristic planning. The measurements for the decision is Optimal solution “Finding the best solution”,number of node expansions “ Memory Used”,and Time “computational power needed”

Problem 1 -

Problem:

Init(At(C1, SFO) ∧ At(C2, JFK)
∧ At(P1, SFO) ∧ At(P2, JFK)
∧ Cargo(C1) ∧ Cargo(C2)
∧ Plane(P1) ∧ Plane(P2)
∧ Airport(JFK) ∧ Airport(SFO))
Goal(At(C1, JFK) ∧ At(C2, SFO))

Optimal Solution : 6 paths

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

Results Metrics :

Algorithm	Expansion	Length	Time	Hurestic	Optimal
BFS	43	**6**	0.0406		**Yes**
BFTS	1458	**6**	1.3237		**Yes**
DFGS	21	20	0.0186		No
DLS	101	50	0.1207		No
UCS	55	**6**	0.07011		**Yes**
RBFS	4229	**6**	3.85819	H1	**Yes**
GBFGS	**7**	**6**	**0.00862**	H1	**Yes**
A*	55	**6**	0.05215	H1	**Yes**
A*	41	**6**	0.05248	H-Ignore	**Yes**
A*	11	**6**	2.17252	H-Sum	**Yes**

Problem 2

Some search algorithms exceeded 10 Minutes so it's automatically terminated and shon in results that it exceeded 600 seconds.

Problem:

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Init(At(C1, SFO) ∧ At(C2, JFK) ∧ At(C3, ATL)
        ∧ At(P1, SFO) ∧ At(P2, JFK) ∧ At(P3, ATL)
        ∧ Cargo(C1) ∧ Cargo(C2) ∧ Cargo(C3)
        ∧ Plane(P1) ∧ Plane(P2) ∧ Plane(P3)
        ∧ Airport(JFK) ∧ Airport(SFO) ∧ Airport(ATL))
Goal(At(C1, JFK) ∧ At(C2, SFO) ∧ At(C3, SFO))
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Optimal Solution : 9 paths

Load(C1, P1, SFO)

Fly(P1, SFO, JFK)

Load(C2, P2, JFK)

Fly(P2, JFK, SFO)

Load(C3, P3, ATL)

Fly(P3, ATL, SFO)

Unload(C3, P3, SFO)

Unload(C2, P2, SFO)

Unload(C1, P1, JFK)

Results Metrics :

Algorithm	Expansion	Length	Time (s)	Hurestic	Optimal
BFS	3343	**9**	10.5601		**Yes**
BFTS	-	-	>600		No
DFGS	624	619	**4.1365**		No
DLS	-	-	>600		No
UCS	4853	**9**	14.3965		**Yes**
RBFS	-	-	>600	H1	No

GBFGS	998	20	2.98515	H1	No
A*	4853	**9**	14.427827	H1	**Yes**
A*	1450	**9**	**5.347706**	H-Ignore	**Yes**
A*	**86**	**9**	206.7499	H-Sum	**Yes**

Problem 3

Problem:

Init(At(C1, SFO) ∧ At(C2, JFK) ∧ At(C3, ATL) ∧ At(C4, ORD)
∧ At(P1, SFO) ∧ At(P2, JFK)
∧ Cargo(C1) ∧ Cargo(C2) ∧ Cargo(C3) ∧ Cargo(C4)
∧ Plane(P1) ∧ Plane(P2)
∧ Airport(JFK) ∧ Airport(SFO) ∧ Airport(ATL) ∧ Airport(ORD))
Goal(At(C1, JFK) ∧ At(C3, JFK) ∧ At(C2, SFO) ∧ At(C4, SFO))

Optimal Solution : 12 paths

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)

Results Metrics :

Algorithm	Expansion	Length	Time	Hurestic	Optimal
BFS	14663	**12**	55.84272		**Yes**
BFTS	-	-	>600		No
DFGS	**408**	392	**2.049930**		No
DLS	-	-	>600		No
UCS	18223	**12**	63.36741		**Yes**
RBFS	-	-	>600	H1	No

GBFGS	5579	22	19.927977	H1	No
A*	18223	**12**	65.878284	H1	**Yes**
A*	**5040**	**12**	**20.998089**	H-Ignore	**Yes**
A*	-	-	>600	H-Sum	No

Analysis :

All three non-heuristic search strategies, that is; breadth first search, uniform cost search, and depth first graph search, find a solution to all air cargo problems. Breadth first search always considers the shortest path first [1] and a result of it it finds a solution to the problem in a reasonable amount of time and in an optimal way.

Criterion	Breadth-First	Uniform-Cost	Depth-First	Depth-Limited	Iterative Deepening	Bidirectional (if applicable)
Complete?	Yes^a	Yes^{a,b}	No	No	Yes^a	Yes^{a,d}
Time	$O(b^d)$	$O(b^{1+\lfloor C^*/\epsilon \rfloor})$	$O(b^m)$	$O(b^\ell)$	$O(b^d)$	$O(b^{d/2})$
Space	$O(b^d)$	$O(b^{1+\lfloor C^*/\epsilon \rfloor})$	$O(bm)$	$O(b\ell)$	$O(bd)$	$O(b^{d/2})$
Optimal?	Yes^c	Yes	No	No	Yes^c	Yes^{c,d}

Figure 3.21 Evaluation of tree-search strategies. b is the branching factor; d is the depth of the shallowest solution; m is the maximum depth of the search tree; l is the depth limit. Superscript caveats are as follows: ^{a} complete if b is finite; ^{b} complete if step costs $\geq \epsilon$ for positive ϵ; ^{c} optimal if step costs are all identical; ^{d} if both directions use breadth-first search.

For the **non-heuristic** the only algorithms that marked as optimal is **BFS** and **UCS**, but regarding the node expansion **DFGS** is always the best regarding this point but it never reaches the optimal solution, Regarding the time also **DFGS** is the optimal in time basis.

For the previous points if the constraint of the system is time or memory I recommend using the **DFGS** but It may leads to a non completed search, and if the constraint is to find the optimal solution **BFS** is getting a slightly better results for the testing problems.

For the **heuristic based search** A* with H-Ignore and A* with H1 the only algorithms that marked as optimal for all the problems.also regarding the node expansion - memory - A* with H-Ignore is the best and also regarding the time and optimality.

Finally A* with the "ignore preconditions" heuristic is the the optimal algorithm regarding the all parameters.

Resources

[1] AIMA 3rd Edition.