

Project Report

Udacity AI nanodegree: Build a Forward-Planning Agent

(You should run ****all**** of the search algorithms on the first two problems)

Air Cargo Problem 1	Actions	Expansions	Goal Tests	New Node	Plan Length	Time
Uninformed search						
breadth_first_search	20	43	56	178	6	0.0061151579 99374787
depth_first_graph_search	20	21	22	84	20	0.0031514900 001639035
uniform_cost_search	20	60	62	240	6	0.0090935979 98798941
Greedy best first search						
greedy_best_first_graph_search h_unmet_goals	20	7	9	29	6	0.0020273150 003049523
greedy_best_first_graph_search h_pg_levelsum	20	6	8	28	6	0.3088236719 9956207
greedy_best_first_graph_search h_pg_maxlevel	20	6	8	24	6	0.2318806140 0105653
greedy_best_first_graph_search h_pg_setlevel	20	6	8	28	6	0.9328333610 010304
A* search						
astar_search h_unmet_goals	20	50	52	206	6	0.0092293470 00655252
astar_search h_pg_levelsum	20	28	30	122	6	0.7840214949 992514
astar_search h_pg_maxlevel	20	43	45	180	6	0.8277421179 991507
astar_search h_pg_setlevel	20	33	35	138	6	2.4127192350 006226

Air Cargo Problem 2	Actions	Expansions	Goal Tests	New Node	Plan Length	Time
Uninformed search						
breadth_first_search	72	3343	4609	30503	9	1.8469709320015681
depth_first_graph_search	72	624	625	5602	619	2.649270444000649
uniform_cost_search	72	5154	5156	46618	9	3.0495129490009276
Greedy best first search						
greedy_best_first_graph_search h_unmet_goals	72	17	19	170	9	0.017754173000867013
greedy_best_first_graph_search h_pg_levelsum	72	9	11	86	9	6.850716357999772
greedy_best_first_graph_search h_pg_maxlevel	72	27	29	249	9	13.864381858000343
greedy_best_first_graph_search h_pg_setlevel	72	9	11	84	9	19.73964697700103
A* search						
astar_search h_unmet_goals	72	2467	2469	22522	9	2.040961738999613
astar_search h_pg_levelsum	72	357	359	3426	9	173.72767657199984
astar_search h_pg_maxlevel	72	2887	2889	26594	9	1016.4963159529998
astar_search h_pg_setlevel	72	1037	1039	9605	9	1511.211917695

(You must run **at least** one uninformed search, two heuristics with greedy best first search, and two heuristics with A* on problems 3 and 4.)

Air Cargo Problem 3	Actions	Expansions	Goal Tests	New Node	Plan Length	Time
Uninformed search						
breadth_first_search	88	14663	18098	129625	12	9.3312842529 99467
depth_first_graph_search	88	408	409	3364	382	1.0453634830 009833
uniform_cost_search	88	18510	18512	161936	12	13.116758914 999082
Greedy best first search						
greedy_best_first_graph_search h_unmet_goals	88	25	27	230	15	0.0335175429 9910681
greedy_best_first_graph_search h_pg_levelsum	88	14	16	126	14	15.757352300 001003
greedy_best_first_graph_search h_pg_maxlevel	88	21	23	195	13	18.863008134 000097
greedy_best_first_graph_search h_pg_setlevel	88	35	37	345	17	95.524433360 99998
A* search						
astar_search h_unmet_goals	88	7388	7390	65711	12	7.9453503500 00808
astar_search h_pg_levelsum	88	369	371	3403	12	280.28894736 800066
astar_search h_pg_maxlevel	-	-	-	-	-	(Taking too much time)
astar_search h_pg_setlevel	-	-	-	-	-	(Taking too much time)

Air Cargo Problem 4	Actions	Expansions	Goal Tests	New Node	Plan Length	Time
Uninformed search						
breadth_first_search	104	99736	114953	944130	14	84.89080292000108
depth_first_graph_search	-	-	-	-	-	(Taking too much time)
uniform_cost_search	104	113339	113341	1066413	14	105.36923340000067
Greedy best first search						
greedy_best_first_graph_search h_unmet_goals	104	29	31	280	18	0.054025141000238364
greedy_best_first_graph_search h_pg_levelsum	104	17	19	165	17	28.59387765500105
greedy_best_first_graph_search h_pg_maxlevel	104	56	58	580	17	66.2653318130001
greedy_best_first_graph_search h_pg_setlevel	-	-	-	-	-	(Taking too much time)
A* search						
astar_search h_unmet_goals	104	34330	34332	328509	14	50.66884399300034
astar_search h_pg_levelsum	104	1208	1210	12210	15	1480.032264055
astar_search h_pg_maxlevel	-	-	-	-	-	(Taking too much time)
astar_search h_pg_setlevel	-	-	-	-	-	(Taking too much time)

Task: Analyze the number of nodes expanded against number of actions in the domain

Air Cargo Problem 1	Actions	Expansions
Uninformed search		
breadth_first_search	20	43
depth_first_graph_search	20	21
uniform_cost_search	20	60
Greedy best first search		
greedy_best_first_graph_search h_unmet_goals	20	7
greedy_best_first_graph_search h_pg_levelsum	20	6
greedy_best_first_graph_search h_pg_maxlevel	20	6
greedy_best_first_graph_search h_pg_setlevel	20	6
A* search		
astar_search h_unmet_goals	20	50
astar_search h_pg_levelsum	20	28
astar_search h_pg_maxlevel	20	43
astar_search h_pg_setlevel	20	33

Air Cargo Problem 2	Actions	Expansions
Uninformed search		
breadth_first_search	72	3343
depth_first_graph_search	72	624
uniform_cost_search	72	5154
Greedy best first search		
greedy_best_first_graph_search h_unmet_goals	72	17
greedy_best_first_graph_search h_pg_levelsum	72	9
greedy_best_first_graph_search h_pg_maxlevel	72	27
greedy_best_first_graph_search h_pg_setlevel	72	9
A* search		
astar_search h_unmet_goals	72	2467
astar_search h_pg_levelsum	72	357
astar_search h_pg_maxlevel	72	2887
astar_search h_pg_setlevel	72	1037

Air Cargo Problem 3	Actions	Expansions
Uninformed search		
breadth_first_search	88	14663
depth_first_graph_search	88	408
uniform_cost_search	88	18510
Greedy best first search		
greedy_best_first_graph_search h_unmet_goals	88	25
greedy_best_first_graph_search h_pg_levelsum	88	14
greedy_best_first_graph_search h_pg_maxlevel	88	21
greedy_best_first_graph_search h_pg_setlevel	88	35
A* search		
astar_search h_unmet_goals	88	7388
astar_search h_pg_levelsum	88	369
astar_search h_pg_maxlevel	-	-
astar_search h_pg_setlevel	-	-

Air Cargo Problem 4	Actions	Expansions
Uninformed search		
breadth_first_search	104	99736
depth_first_graph_search	-	-
uniform_cost_search	104	113339
Greedy best first search		
greedy_best_first_graph_search h_unmet_goals	104	29
greedy_best_first_graph_search h_pg_levelsum	104	17
greedy_best_first_graph_search h_pg_maxlevel	104	56
greedy_best_first_graph_search h_pg_setlevel	-	-
A* search		
astar_search h_unmet_goals	104	34330
astar_search h_pg_levelsum	104	1208
astar_search h_pg_maxlevel	-	-
astar_search h_pg_setlevel	-	-

Task: Analyze the search time against the number of actions in the domain

Air Cargo Problem 1	Actions	Time
Uninformed search		
breadth_first_search	20	0.0061151579 99374787
depth_first_graph_search	20	0.0031514900 001639035
uniform_cost_search	20	0.0090935979 98798941
Greedy best first search		
greedy_best_first_graph_search h_unmet_goals	20	0.0020273150 003049523
greedy_best_first_graph_search h_pg_levelsum	20	0.3088236719 9956207
greedy_best_first_graph_search h_pg_maxlevel	20	0.2318806140 0105653
greedy_best_first_graph_search h_pg_setlevel	20	0.9328333610 010304
A* search		
astar_search h_unmet_goals	20	0.0092293470 00655252
astar_search h_pg_levelsum	20	0.7840214949 992514
astar_search h_pg_maxlevel	20	0.8277421179 991507
astar_search h_pg_setlevel	20	2.4127192350 006226

Air Cargo Problem 2	Actions	Time
Uninformed search		
breadth_first_search	72	1.8469709320 015681
depth_first_graph_search	72	2.6492704440 00649
uniform_cost_search	72	3.0495129490 009276
Greedy best first search		
greedy_best_first_graph_search h_unmet_goals	72	0.0177541730 00867013
greedy_best_first_graph_search h_pg_levelsum	72	6.8507163579 99772
greedy_best_first_graph_search h_pg_maxlevel	72	13.864381858 000343
greedy_best_first_graph_search h_pg_setlevel	72	19.739646977 00103
A* search		
astar_search h_unmet_goals	72	2.0409617389 99613
astar_search h_pg_levelsum	72	173.72767657 199984
astar_search h_pg_maxlevel	72	1016.4963159 529998
astar_search h_pg_setlevel	72	1511.2119176 95

Air Cargo Problem 3	Actions	Time
Uninformed search		
breadth_first_search	88	9.3312842529 99467
depth_first_graph_search	88	1.0453634830 009833
uniform_cost_search	88	13.116758914 999082
Greedy best first search		
greedy_best_first_graph_search h_unmet_goals	88	0.0335175429 9910681
greedy_best_first_graph_search h_pg_levelsum	88	15.757352300 001003
greedy_best_first_graph_search h_pg_maxlevel	88	18.863008134 000097
greedy_best_first_graph_search h_pg_setlevel	88	95.524433360 99998
A* search		
astar_search h_unmet_goals	88	7.9453503500 00808
astar_search h_pg_levelsum	88	280.28894736 800066
astar_search h_pg_maxlevel	-	(Taking too much time)
astar_search h_pg_setlevel	-	(Taking too much time)

Air Cargo Problem 4	Actions	Time
Uninformed search		
breadth_first_search	104	84.89080292000108
depth_first_graph_search	-	(Taking too much time)
uniform_cost_search	104	105.36923340000067
Greedy best first search		
greedy_best_first_graph_search h_unmet_goals	104	0.054025141000238364
greedy_best_first_graph_search h_pg_levelsum	104	28.59387765500105
greedy_best_first_graph_search h_pg_maxlevel	104	66.2653318130001
greedy_best_first_graph_search h_pg_setlevel	-	(Taking too much time)
A* search		
astar_search h_unmet_goals	104	50.66884399300034
astar_search h_pg_levelsum	104	1480.032264055
astar_search h_pg_maxlevel	-	(Taking too much time)
astar_search h_pg_setlevel	-	(Taking too much time)

Task: Analyze the length of the plans returned by each algorithm

Air Cargo Problem 1	Plan Length
Uninformed search	
breadth_first_search	6
depth_first_graph_search	20
uniform_cost_search	6
Greedy best first search	
greedy_best_first_graph_search h_unmet_goals	6
greedy_best_first_graph_search h_pg_levelsum	6
greedy_best_first_graph_search h_pg_maxlevel	6
greedy_best_first_graph_search h_pg_setlevel	6
A* search	
astar_search h_unmet_goals	6
astar_search h_pg_levelsum	6
astar_search h_pg_maxlevel	6
astar_search h_pg_setlevel	6

Air Cargo Problem 2	Plan Length
Uninformed search	
breadth_first_search	9
depth_first_graph_search	619
uniform_cost_search	9
Greedy best first search	
greedy_best_first_graph_search h_unmet_goals	9
greedy_best_first_graph_search h_pg_levelsum	9
greedy_best_first_graph_search h_pg_maxlevel	9
greedy_best_first_graph_search h_pg_setlevel	9
A* search	
astar_search h_unmet_goals	9
astar_search h_pg_levelsum	9
astar_search h_pg_maxlevel	9
astar_search h_pg_setlevel	9

Air Cargo Problem 3	Plan Length
Uninformed search	
breadth_first_search	12
depth_first_graph_search	382
uniform_cost_search	12
Greedy best first search	
greedy_best_first_graph_search h_unmet_goals	15
greedy_best_first_graph_search h_pg_levelsum	14
greedy_best_first_graph_search h_pg_maxlevel	13
greedy_best_first_graph_search h_pg_setlevel	17
A* search	
astar_search h_unmet_goals	12
astar_search h_pg_levelsum	12
astar_search h_pg_maxlevel	-
astar_search h_pg_setlevel	-

Air Cargo Problem 4	Plan Length
Uninformed search	
breadth_first_search	14
depth_first_graph_search	-
uniform_cost_search	14
Greedy best first search	
greedy_best_first_graph_search h_unmet_goals	18
greedy_best_first_graph_search h_pg_levelsum	17
greedy_best_first_graph_search h_pg_maxlevel	17
greedy_best_first_graph_search h_pg_setlevel	-
A* search	
astar_search h_unmet_goals	14
astar_search h_pg_levelsum	15
astar_search h_pg_maxlevel	-
astar_search h_pg_setlevel	-

Use your results to answer the following questions:

Q1. Which algorithm or algorithms would be most appropriate for planning in a very restricted domain (i.e., one that has only a few actions) and needs to operate in real time?

Answer:

If the domain is restricted then the best algorithms are:

- Uninformed search - Breadth first search
- Greedy best first search - unmet goals
- A* search - unmet goals

Q1. Which algorithm or algorithms would be most appropriate for planning in very large domains (e.g., planning delivery routes for all UPS drivers in the U.S. on a given day)

Answer:

If we are looking for an algorithm that has least response time then Greedy best first search - unmet goals is the best one.

- In Air Cargo Problem 4, expansion is 29, in 0.05540 second.

But if we take in the factor of number of expansions then Uniform cost search is better than all. Looking at the data:

- In Air Cargo Problem 1, expansion is 60, in 0.0090 second
- In Air Cargo Problem 2, expansion is 5154, in 3.0495 second
- In Air Cargo Problem 3, expansion is 181510, in 13.1167 second
- In Air Cargo Problem 4, expansion is 113339 in 105.3692 second

Q1. Which algorithm or algorithms would be most appropriate for planning problems where it is important to find only optimal plans?

Answer:

Assuming we are looking for the algorithms with least plan length the algorithms we are looking for are:

- Breadth first search
- Uniform cost search
- A* (except 'level_sum' the rest 3 are good)