

Artificial Intelligence Nanodegree Programm

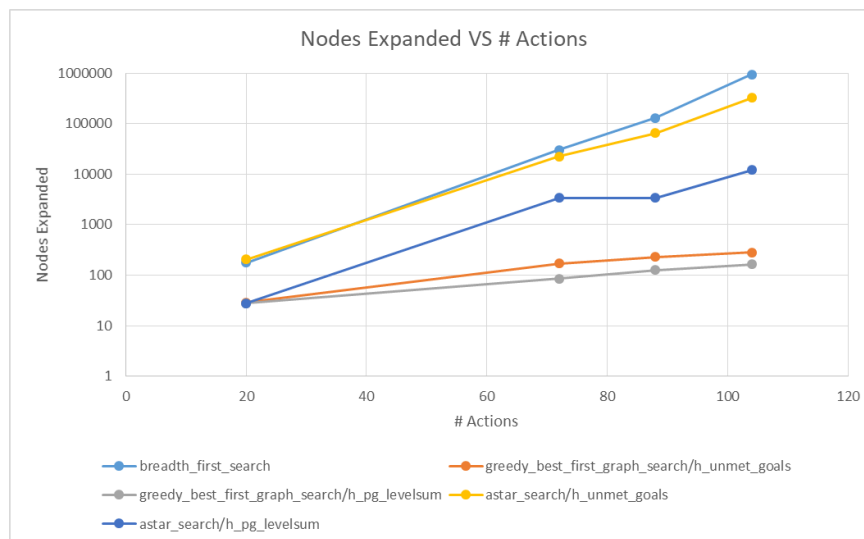
Project 3: Building a Forward-Planning Agent

For all the 4 given Air Cargo Problems the *greedy_best_first_graph_search* with *h_unmet_goals* appears to be the fastest.

For problems 3 and 4 only one uninformed search, two heuristics with greedy best first search, and two heuristics with A* are investigated. Because of long computation times I decided to only use the fastest of each category. *depth_first_graph_search* is excluded because it fails to deliver the shortest route.

Again *greedy_best_first_graph_search* with *h_unmet_goals* is fastest, but this time fails to deliver the shortest routes. Using a more complex heuristic seems to increase the computation time but does not improve the results.

To better understand the differences of computational time we have a look at the number of nodes expanded in relation to the number of actions of the various problems. The graphs clearly show an exponential growth in expanded nodes and therefore computational time, except for *greedy_best_first_graph_search* which grows linear.



According to this findings I recommend the following:

- *greedy_best_first_graph_search* with *h_unmet_goals* for planning in very restricted domains that need to operate in real time
- *greedy_best_first_graph_search* with *h_unmet_goals* for planning in very large domains where it's not important to find the optimum.
- *astar_search* with *h_unmet_goals* when it's important to find the optimal plans. In general BFS, UCS, A* with any admissible heuristic (including a null heuristic, max-level, and set-level) can find the optimum while DFS, all greedy searches, and A* with inadmissible heuristics are NOT appropriate (level-sum and ignore-preconditions are not admissible) for this task.

Air Cargo Problem 1

Solution Name	Actions	Expansions	New Nodes	Plan length	Time
greedy_best_first_graph_search/h_unmet_goals	20	7	29	6	0.002
depth_first_graph_search	20	21	84	20	0.003
breadth_first_search	20	43	178	6	0.006
uniform_cost_search	20	60	240	6	0.010
astar_search with h_unmet_goals	20	50	206	6	0.010
greedy_best_first_graph_search/h_pg_maxlevel	20	6	24	6	0.215
greedy_best_first_graph_search/h_pg_levelsum	20	6	28	6	0.279
astar_search/h_pg_levelsum	20	28	122	6	0.743
astar_search/h_pg_maxlevel	20	43	180	6	0.788
greedy_best_first_graph_search/h_pg_setlevel	20	6	28	6	0.846
astar_search/h_pg_setlevel	20	33	138	6	2.233

Air Cargo Problem 2

Solution Name	Actions	Expansions	New Nodes	Plan length	Time
greedy_best_first_graph_search/h_unmet_goals	72	17	170	9	0.020
breadth_first_search	72	3343	30503	9	1.941
astar_search/h_unmet_goals	72	2467	22522	9	2.381
depth_first_graph_search	72	624	5602	619	2.975
uniform_cost_search	72	5154	46618	9	3.426
greedy_best_first_graph_search/h_pg_levelsum	72	9	86	9	6.474
greedy_best_first_graph_search/h_pg_maxlevel	72	27	249	9	12.851
greedy_best_first_graph_search/h_pg_setlevel	72	9	84	9	18.563
astar_search/h_pg_levelsum	72	357	3426	9	161.471
astar_search/h_pg_maxlevel	72	2887	26594	9	955.507
astar_search/h_pg_setlevel	72	1037	9605	9	1399.004

Air Cargo Problem 3

Solution Name	Actions	Expansions	New Nodes	Plan length	Time
greedy_best_first_graph_search/h_unmet_goals	88	25	230	15	0.039
astar_search/h_unmet_goals	88	7388	65711	12	8.915
breadth_first_search	88	14663	129625	12	11.011
greedy_best_first_graph_search/h_pg_levelsum	88	14	126	14	14.654
astar_search/h_pg_levelsum	88	369	3403	12	263.836

Air Cargo Problem 4

Solution Name	Actions	Expansions	New Nodes	Plan length	Time
greedy_best_first_graph_search/h_unmet_goals	104	29	280	18	0.060
greedy_best_first_graph_search/h_pg_levelsum	104	17	165	17	25.554
astar_search/h_unmet_goals	104	34330	328509	14	55.503
breadth_first_search	104	99736	944130	14	94.557
astar_search/h_pg_levelsum	104	1208	12210	15	1449.827