PacManAI

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Week 4 & 5 & 6 Deliverables

Progress and learnings:

Through the PACMAN project, we learned how to concretely implement search algorithms, including DFS, BFS, Uniform Cost Search, A*. We also learned how to develop heuristics. The magic of the A* algorithm depends on the strength of the heuristic. To make sure the algorithm converges on the goal state, we must ensure the heuristic is admissible and consistent. The tricky part is figuring out a reasonable heuristic, which can be non-intuitive based on the problem. The functions which are already shown in the file did give us a lot of beneficial hints. What's more, we learned how to design the search states of a specific problem such as CornersProblem. We have understood that sometimes it can be difficult to characterize a search problem with concrete code and it needs manual effort. From this perspective, AI still has its limitations. Finally, when it is hard to find an optimal solution, using suboptimal search can find us an acceptable solution.

File listing:

Question8_demo.mov: Our question 8 video demo.
Final Report: Our final report.
README.docx: This summary file.
Week 4/search.py: Implementing DFS, BFS, Uniform cost search, and A*.
Week 4/searchAgents.py: Contains implementation of search states and cost functions.
Week 5/searchAgents.py: Implementing the functions of finding all corners with BFS and A*.
Week 6/searchAgents.py: Implementing the functions of eating all the dots and suboptimal search.

Question 1:

- Command :
    - python pacman.py -l tinyMaze -p SearchAgent -a fn=tinyMazeSearch
- Result :

```
Path found with total cost of 8 in 0.0 seconds
Search nodes expanded: 0
Pacman emerges victorious! Score: 502
Average Score: 502.0
Scores:        502.0
Win Rate:      1/1 (1.00)
Record:        Win
kevinferrer@Kevins-MBP search %
```

- Command:
    - python pacman.py -l tinyMaze -p SearchAgent
- Result :

```
Path found with total cost of 10 in 0.0 seconds
Search nodes expanded: 15
Pacman emerges victorious! Score: 500
Average Score: 500.0
Scores:        500.0
Win Rate:      1/1 (1.00)
Record:        Win
```

- Command :
    - python pacman.py -l mediumMaze -p SearchAgent
- Result :

```
Path found with total cost of 130 in 0.0 seconds
Search nodes expanded: 146
Pacman emerges victorious! Score: 380
Average Score: 380.0
Scores:        380.0
Win Rate:      1/1 (1.00)
Record:        Win
```

- Command :
    - python pacman.py -l bigMaze -z .5 -p SearchAgent

- Result :

```
Path found with total cost of 210 in 0.0 seconds
Search nodes expanded: 390
Pacman emerges victorious! Score: 300
Average Score: 300.0
Scores:        300.0
Win Rate:      1/1 (1.00)
Record:        Win
```

- **Q** : The Pacman board will show an overlay of the states explored, and the order in which they were explored (brighter red means earlier exploration). Is the exploration order what you would have expected? Does Pacman actually go to all the explored squares on his way to the goal?

- **A** : Yes, the order in which the board is explored was expected because we always dequeue nodes off the fringe in LIFO order using a Stack and we always enqueue nodes onto the fringe in the same order provided by the getSuccessors() method. Pacman doesn't actually go to all the explored squares because some explored squares are unnecessary for reaching the goal state.

- Command :
    - python autograder.py --q q1
- Result :

```
kevinferrer@Kevins-MBP search % python autograder.py --q q1
Starting on 10-22 at 12:30:25

Question q1
===========

*** PASS: test_cases/q1/graph_backtrack.test
***     solution:               ['1:A->C', '0:C->G']
***     expanded_states:        ['A', 'D', 'C']
*** PASS: test_cases/q1/graph_bfs_vs_dfs.test
***     solution:               ['2:A->D', '0:D->G']
***     expanded_states:        ['A', 'D']
*** PASS: test_cases/q1/graph_infinite.test
***     solution:               ['0:A->B', '1:B->C', '1:C->G']
***     expanded_states:        ['A', 'B', 'C']
*** PASS: test_cases/q1/graph_manypaths.test
***     solution:               ['2:A->B2', '0:B2->C', '0:C->D', '2:D->E2', '0:E2->F', '0:F->G']
***     expanded_states:        ['A', 'B2', 'C', 'D', 'E2', 'F']
*** PASS: test_cases/q1/pacman_1.test
***     pacman layout:          mediumMaze
***     solution length: 130
***     nodes expanded:         146

### Question q1: 3/3 ###


Finished at 12:30:25

Provisional grades
==================
Question q1: 3/3
------------------
Total: 3/3
```

Question 2:

- Command :
  - python pacman.py -l mediumMaze -p SearchAgent -a fn=bfs
- Result :

```
Path found with total cost of 68 in 0.0 seconds
Search nodes expanded: 269
Pacman emerges victorious! Score: 442
Average Score: 442.0
Scores:        442.0
Win Rate:      1/1 (1.00)
Record:        Win
```

- Command :
  - python pacman.py -l bigMaze -p SearchAgent -a fn=bfs -z .5
- Result:

```
Path found with total cost of 210 in 0.0 seconds
Search nodes expanded: 620
Pacman emerges victorious! Score: 300
Average Score: 300.0
Scores:        300.0
Win Rate:      1/1 (1.00)
Record:        Win
```

- **Q** : Does BFS find a least cost solution?
- **A** : Yes. All actions have the same cost so BFS returns an optimal solution.

- Command :
    - python autograder.py --q q2
- Result :

```
kevinferrer@Kevins-MBP search % python autograder.py --q q2
Starting on 10-22 at 12:35:10

Question q2
===========

*** PASS: test_cases/q2/graph_backtrack.test
***     solution:               ['1:A->C', '0:C->G']
***     expanded_states:        ['A', 'B', 'C', 'D']
*** PASS: test_cases/q2/graph_bfs_vs_dfs.test
***     solution:               ['1:A->G']
***     expanded_states:        ['A', 'B']
*** PASS: test_cases/q2/graph_infinite.test
***     solution:               ['0:A->B', '1:B->C', '1:C->G']
***     expanded_states:        ['A', 'B', 'C']
*** PASS: test_cases/q2/graph_manypaths.test
***     solution:               ['1:A->C', '0:C->D', '1:D->F', '0:F->G']
***     expanded_states:        ['A', 'B1', 'C', 'B2', 'D', 'E1', 'F', 'E2']
*** PASS: test_cases/q2/pacman_1.test
***     pacman layout:          mediumMaze
***     solution length: 68
***     nodes expanded:         269

### Question q2: 3/3 ###


Finished at 12:35:10

Provisional grades
==================
Question q2: 3/3
------------------
Total: 3/3
```

Question 3:

- Command :
    - python pacman.py -l mediumMaze -p SearchAgent -a fn=ucs

- Result :

```
[→  search git:(xinan_UCS) ✗ python pacman.py -l mediumMaze -p SearchAgent -a fn=]
ucs
[SearchAgent] using function ucs
[SearchAgent] using problem type PositionSearchProblem
DEPRECATION WARNING: The system version of Tk is deprecated and may be removed i
n a future release. Please don't rely on it. Set TK_SILENCE_DEPRECATION=1 to sup
press this warning.
Path found with total cost of 68 in 0.0 seconds
Search nodes expanded: 269
Pacman emerges victorious! Score: 442
Average Score: 442.0
Scores:        442.0
Win Rate:      1/1 (1.00)
Record:        Win
```

- Command :
  - python pacman.py -l mediumDottedMaze -p StayEastSearchAgent
- Result :

```
[→  search git:(xinan_UCS) ✗ python pacman.py -l mediumDottedMaze -p StayEastSear]
chAgent
DEPRECATION WARNING: The system version of Tk is deprecated and may be removed i
n a future release. Please don't rely on it. Set TK_SILENCE_DEPRECATION=1 to sup
press this warning.
Path found with total cost of 1 in 0.0 seconds
Search nodes expanded: 186
Pacman emerges victorious! Score: 646
Average Score: 646.0
Scores:        646.0
Win Rate:      1/1 (1.00)
Record:        Win
```

- Command :
  - python pacman.py -l mediumScaryMaze -p StayWestSearchAgent
- Result :

```
[→  search git:(main) python pacman.py -l mediumScaryMaze -p StayWestSearchAgent                                    ]
DEPRECATION WARNING: The system version of Tk is deprecated and may be removed in a future release. Please don't rely on
it. Set TK_SILENCE_DEPRECATION=1 to suppress this warning.
Path found with total cost of 68719479864 in 0.0 seconds
Search nodes expanded: 108
Pacman emerges victorious! Score: 418
Average Score: 418.0
Scores:        418.0
Win Rate:      1/1 (1.00)
Record:        Win
```

- Command :
  - python autograder.py --q q3
- Result :

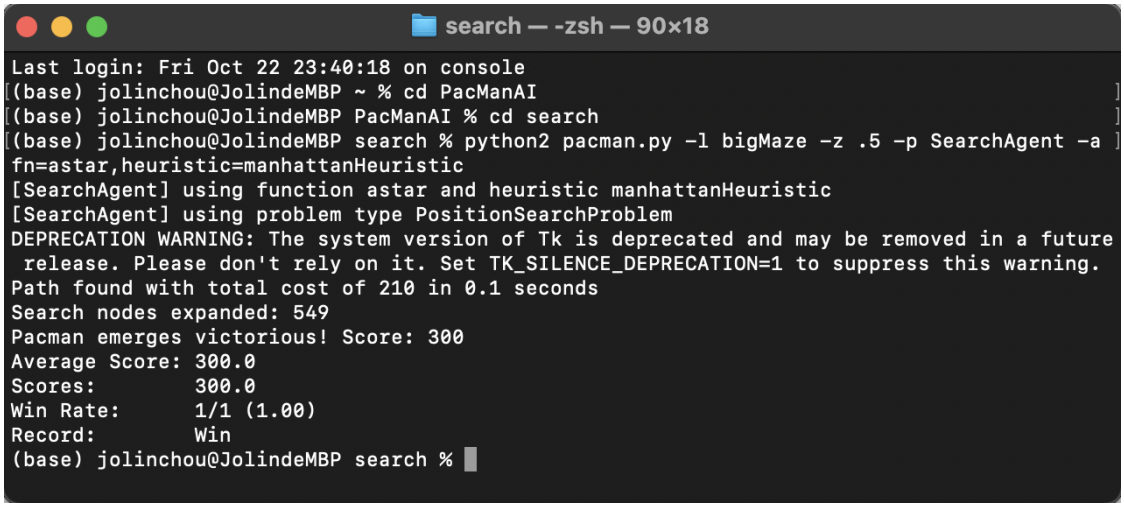
```
➜  search git:(main) ✗ python autograder.py --q q3
Starting on 10-24 at 23:50:00

Question q3
===========

*** PASS: test_cases/q3/graph_backtrack.test
***     solution:               ['1:A->C', '0:C->G']
***     expanded_states:        ['A', 'B', 'C', 'D']
*** PASS: test_cases/q3/graph_bfs_vs_dfs.test
***     solution:               ['1:A->G']
***     expanded_states:        ['A', 'B']
*** PASS: test_cases/q3/graph_infinite.test
***     solution:               ['0:A->B', '1:B->C', '1:C->G']
***     expanded_states:        ['A', 'B', 'C']
*** PASS: test_cases/q3/graph_manypaths.test
***     solution:               ['1:A->C', '0:C->D', '1:D->F', '0:F->G']
***     expanded_states:        ['A', 'B1', 'C', 'B2', 'D', 'E1', 'F', 'E2']
*** PASS: test_cases/q3/ucs_0_graph.test
***     solution:               ['Right', 'Down', 'Down']
***     expanded_states:        ['A', 'B', 'D', 'C', 'G']
*** PASS: test_cases/q3/ucs_1_problemC.test
***     pacman layout:          mediumMaze
***     solution length: 68
***     nodes expanded:         269
*** PASS: test_cases/q3/ucs_2_problemE.test
***     pacman layout:          mediumMaze
***     solution length: 74
***     nodes expanded:         260
*** PASS: test_cases/q3/ucs_3_problemW.test
***     pacman layout:          mediumMaze
***     solution length: 152
***     nodes expanded:         173
*** PASS: test_cases/q3/ucs_4_testSearch.test
***     pacman layout:          testSearch
***     solution length: 7
***     nodes expanded:         14
*** PASS: test_cases/q3/ucs_5_goalAtDequeue.test
***     solution:               ['1:A->B', '0:B->C', '0:C->G']
***     expanded_states:        ['A', 'B', 'C']

### Question q3: 3/3 ###


Finished at 23:50:00

Provisional grades
==================
Question q3: 3/3
------------------
Total: 3/3
```

Question 4:

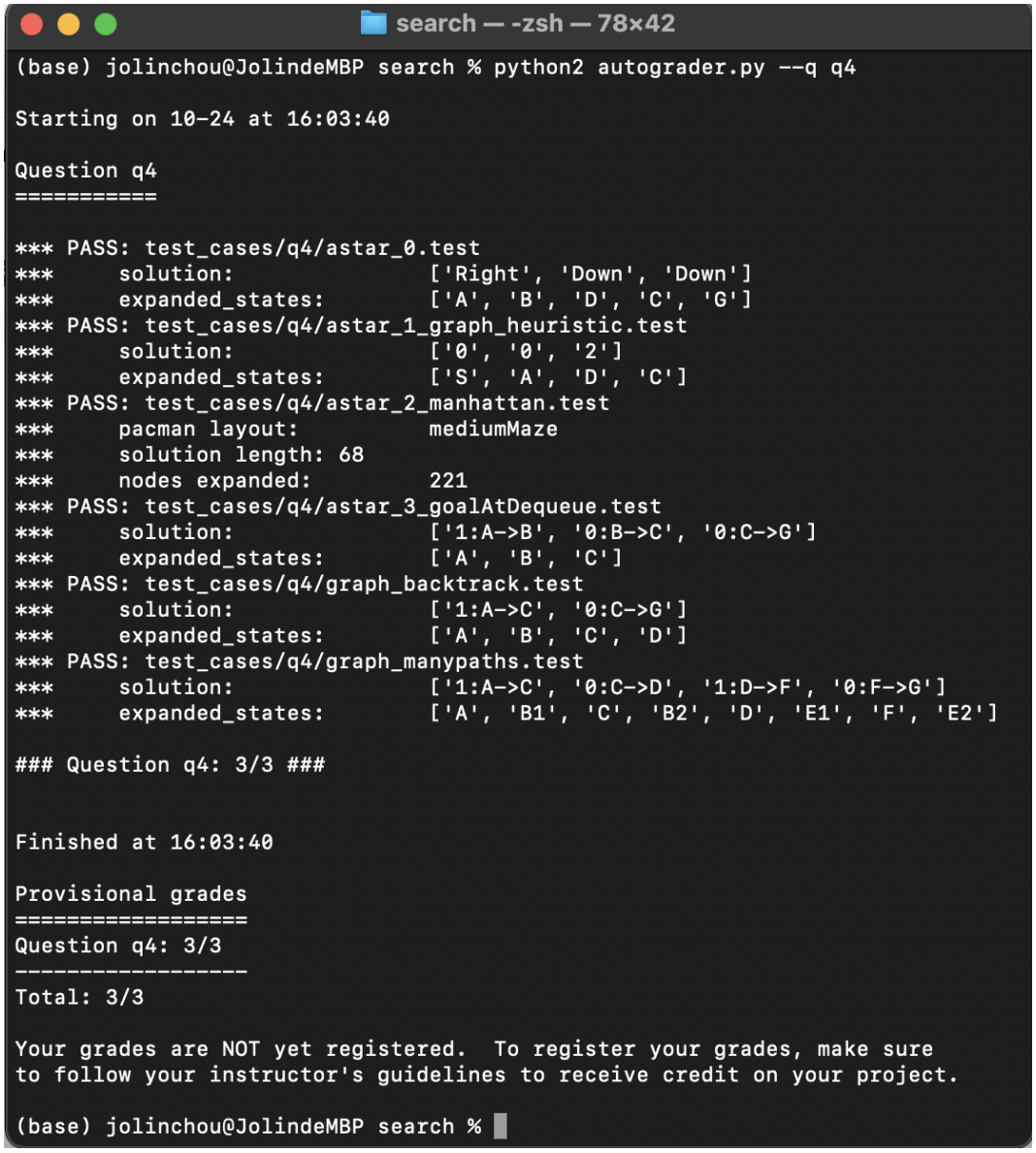
- Command :

    - python2 pacman.py -l bigMaze -z .5 -p SearchAgent -a fn=astar,heuristic=manhattanHeuristic

- Result :



- Command :
    - python2 autograder.py --q q4
- Result :



Question 5:

- Command :
    - python pacman.py -l tinyCorners -p SearchAgent -a fn=bfs,prob=CornersProblem
- Result :

```
→  search git:(main) python pacman.py -l tinyCorners -p SearchAgent -a fn=bfs,pr
ob=CornersProblem
[SearchAgent] using function bfs
[SearchAgent] using problem type CornersProblem
DEPRECATION WARNING: The system version of Tk is deprecated and may be removed i
n a future release. Please don't rely on it. Set TK_SILENCE_DEPRECATION=1 to sup
press this warning.
Path found with total cost of 28 in 0.0 seconds
Search nodes expanded: 252
Pacman emerges victorious! Score: 512
Average Score: 512.0
Scores:        512.0
Win Rate:      1/1 (1.00)
Record:        Win
```

- Command :
    - python pacman.py -l mediumCorners -p SearchAgent -a fn=bfs,prob=CornersProblem
- Result :

```
→  search git:(main) python pacman.py -l mediumCorners -p SearchAgent -a fn=bfs,
prob=CornersProblem
[SearchAgent] using function bfs
[SearchAgent] using problem type CornersProblem
DEPRECATION WARNING: The system version of Tk is deprecated and may be removed i
n a future release. Please don't rely on it. Set TK_SILENCE_DEPRECATION=1 to sup
press this warning.
Path found with total cost of 106 in 0.0 seconds
Search nodes expanded: 1966
Pacman emerges victorious! Score: 434
Average Score: 434.0
Scores:        434.0
Win Rate:      1/1 (1.00)
Record:        Win
```

- Command :
    - python autograder.py --q q5
- Result :

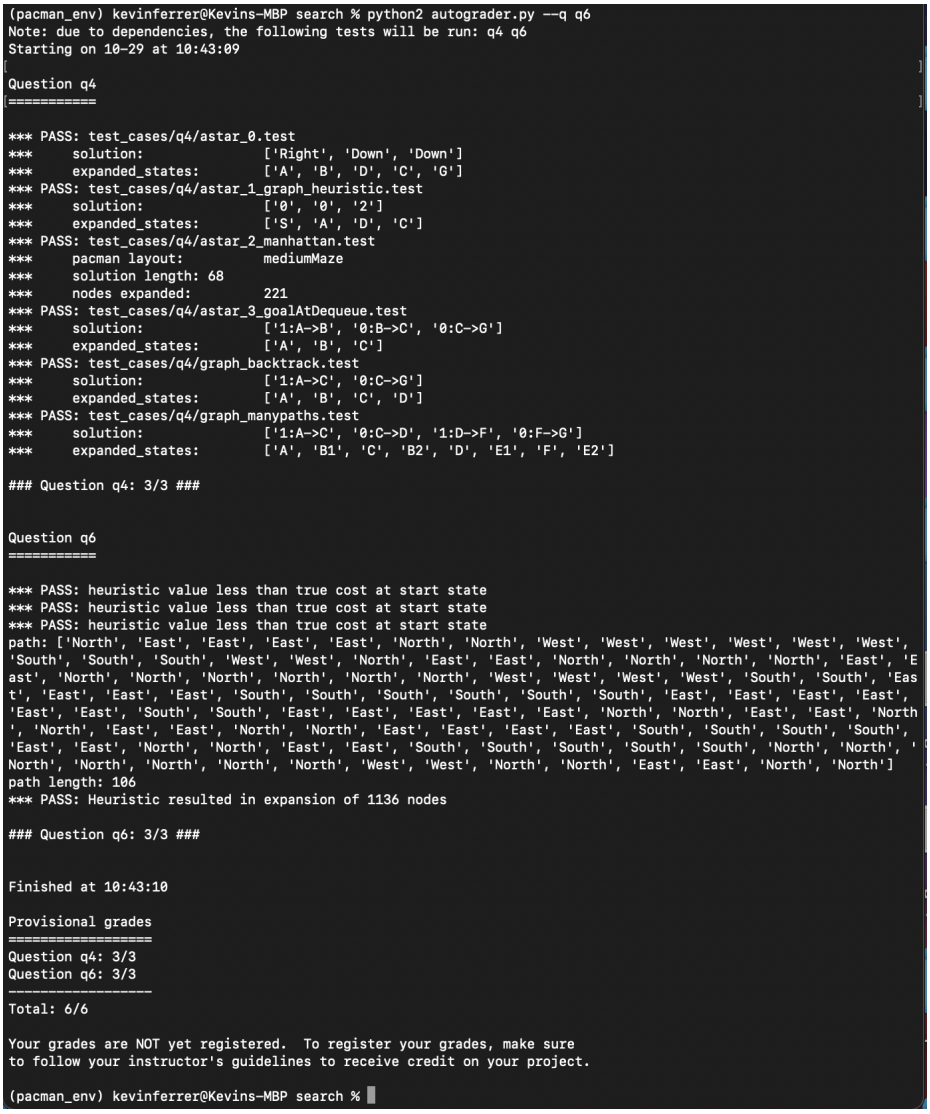
```
→  search git:(main) python autograder.py --q q5
Note: due to dependencies, the following tests will be run: q2 q5
Starting on 10-30 at 12:23:29

Question q2
===========

*** PASS: test_cases/q2/graph_backtrack.test
***     solution:               ['1:A->C', '0:C->G']
***     expanded_states:        ['A', 'B', 'C', 'D']
*** PASS: test_cases/q2/graph_bfs_vs_dfs.test
***     solution:               ['1:A->G']
***     expanded_states:        ['A', 'B']
*** PASS: test_cases/q2/graph_infinite.test
***     solution:               ['0:A->B', '1:B->C', '1:C->G']
***     expanded_states:        ['A', 'B', 'C']
*** PASS: test_cases/q2/graph_manypaths.test
***     solution:               ['1:A->C', '0:C->D', '1:D->F', '0:F->G']
***     expanded_states:        ['A', 'B1', 'C', 'B2', 'D', 'E1', 'F', 'E2']
*** PASS: test_cases/q2/pacman_1.test
***     pacman layout:          mediumMaze
***     solution length: 68
***     nodes expanded:         269

### Question q2: 3/3 ###


Question q5
===========

*** PASS: test_cases/q5/corner_tiny_corner.test
***     pacman layout:          tinyCorner
***     solution length:                28

### Question q5: 3/3 ###


Finished at 12:23:29

Provisional grades
==================
Question q2: 3/3
Question q5: 3/3
------------------
Total: 6/6

Your grades are NOT yet registered.  To register your grades, make sure
to follow your instructor's guidelines to receive credit on your project.
```

Question 6:

- Command :
  - python2 pacman.py -l mediumCorners -p AStarCornersAgent -z 0.5
- Result :

```
Path found with total cost of 106 in 0.1 seconds
Search nodes expanded: 1136
Pacman emerges victorious! Score: 434
Average Score: 434.0
Scores:        434.0
Win Rate:      1/1 (1.00)
Record:        Win
(pacman_env) kevinferrer@Kevins-MBP search %
```

- Command :
    - python2 autograder.py --q q6
- Result :



```
(pacman_env) kevinferrer@Kevins-MBP search % python2 autograder.py --q q6
Note: due to dependencies, the following tests will be run: q4 q6
Starting on 10-29 at 10:43:09

Question q4
==========

*** PASS: test_cases/q4/astar_0.test
***     solution:               ['Right', 'Down', 'Down']
***     expanded_states:        ['A', 'B', 'D', 'C', 'G']
*** PASS: test_cases/q4/astar_1_graph_heuristic.test
***     solution:               ['0', '0', '2']
***     expanded_states:        ['S', 'A', 'D', 'C']
*** PASS: test_cases/q4/astar_2_manhattan.test
***     pacman layout:          mediumMaze
***     solution length: 68
***     nodes expanded:         221
*** PASS: test_cases/q4/astar_3_goalAtDequeue.test
***     solution:               ['1:A->B', '0:B->C', '0:C->G']
***     expanded_states:        ['A', 'B', 'C']
*** PASS: test_cases/q4/graph_backtrack.test
***     solution:               ['1:A->C', '0:C->G']
***     expanded_states:        ['A', 'B', 'C', 'D']
*** PASS: test_cases/q4/graph_manypaths.test
***     solution:               ['1:A->C', '0:C->D', '1:D->F', '0:F->G']
***     expanded_states:        ['A', 'B1', 'C', 'B2', 'D', 'E1', 'F', 'E2']

### Question q4: 3/3 ###


Question q6
==========

*** PASS: heuristic value less than true cost at start state
*** PASS: heuristic value less than true cost at start state
*** PASS: heuristic value less than true cost at start state
path: ['North', 'East', 'East', 'East', 'East', 'North', 'North', 'West', 'West', 'West', 'West', 'West', 'West',
'South', 'South', 'South', 'West', 'West', 'North', 'East', 'East', 'North', 'North', 'North', 'North', 'East', 'E
ast', 'North', 'North', 'North', 'North', 'North', 'North', 'West', 'West', 'West', 'West', 'South', 'South', 'Eas
t', 'East', 'East', 'East', 'South', 'South', 'South', 'South', 'South', 'South', 'East', 'East', 'East', 'East',
'East', 'East', 'South', 'South', 'East', 'East', 'East', 'East', 'East', 'North', 'North', 'East', 'East', 'North
', 'North', 'East', 'East', 'North', 'North', 'East', 'East', 'East', 'East', 'South', 'South', 'South', 'South',
'East', 'East', 'North', 'North', 'East', 'East', 'South', 'South', 'South', 'South', 'South', 'North', 'North', '
North', 'North', 'North', 'North', 'North', 'West', 'West', 'North', 'North', 'East', 'East', 'North', 'North']
path length: 106
*** PASS: Heuristic resulted in expansion of 1136 nodes

### Question q6: 3/3 ###


Finished at 10:43:10

Provisional grades
==================
Question q4: 3/3
Question q6: 3/3
------------------
Total: 6/6

Your grades are NOT yet registered.  To register your grades, make sure
to follow your instructor's guidelines to receive credit on your project.

(pacman_env) kevinferrer@Kevins-MBP search %
```

Question 7:

- Command :
    - python2 pacman.py -l testSearch -p AStarFoodSearchAgent
- Result :

```
[→  search git:(main) python pacman.py -l testSearch -p AStarFoodSearchAgent     ]
DEPRECATION WARNING: The system version of Tk is deprecated and may be removed i
n a future release. Please don't rely on it. Set TK_SILENCE_DEPRECATION=1 to sup
press this warning.
Path found with total cost of 7 in 0.0 seconds
Search nodes expanded: 10
Pacman emerges victorious! Score: 513
Average Score: 513.0
Scores:        513.0
Win Rate:      1/1 (1.00)
Record:        Win
```

- Command :
    - python2 pacman.py -l trickySearch -p AStarFoodSearchAgent
- Result :

```
[→  search git:(main) python pacman.py -l trickySearch -p AStarFoodSearchAgent   ]
DEPRECATION WARNING: The system version of Tk is deprecated and may be removed i
n a future release. Please don't rely on it. Set TK_SILENCE_DEPRECATION=1 to sup
press this warning.
Path found with total cost of 60 in 14.7 seconds
Search nodes expanded: 4137
Pacman emerges victorious! Score: 570
Average Score: 570.0
Scores:        570.0
Win Rate:      1/1 (1.00)
Record:        Win
```

- Command :
    - python2 autograder.py --q q7
- Result :

```
Finished at 20:54:42

Provisional grades
==================
Question q4: 3/3
Question q7: 5/4
------------------
Total: 8/7

Your grades are NOT yet registered.  To register your grades, make sure
to follow your instructor's guidelines to receive credit on your project.
```

Question 8:

- Command :
    - python2 pacman.py -l bigSearch -p ClosestDotSearchAgent -z .5

- Result :

```
[→  search git:(main) python pacman.py -l bigSearch -p ClosestDotSearchAgent -z .]
5
[SearchAgent] using function depthFirstSearch
[SearchAgent] using problem type PositionSearchProblem
DEPRECATION WARNING: The system version of Tk is deprecated and may be removed i
n a future release. Please don't rely on it. Set TK_SILENCE_DEPRECATION=1 to sup
press this warning.
Path found with cost 350.
Pacman emerges victorious! Score: 2360
Average Score: 2360.0
Scores:        2360.0
Win Rate:      1/1 (1.00)
Record:        Win
```

- Command :
    - python2 autograder.py --q q8
- Result :

```
### Question q8: 3/3 ###


Finished at 20:56:54

Provisional grades
==================
Question q8: 3/3
------------------
Total: 3/3

Your grades are NOT yet registered.  To register your grades, make sure
to follow your instructor's guidelines to receive credit on your project.
```