CS 430: ARTIFICIAL INTELLIGENCE
PROJECT 1 – PACMAN

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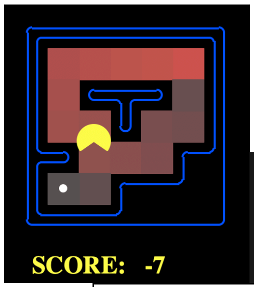
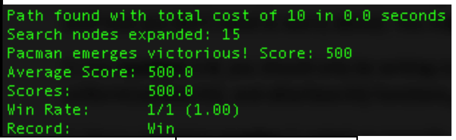
1. Depth First Search
    a. tinyMaze

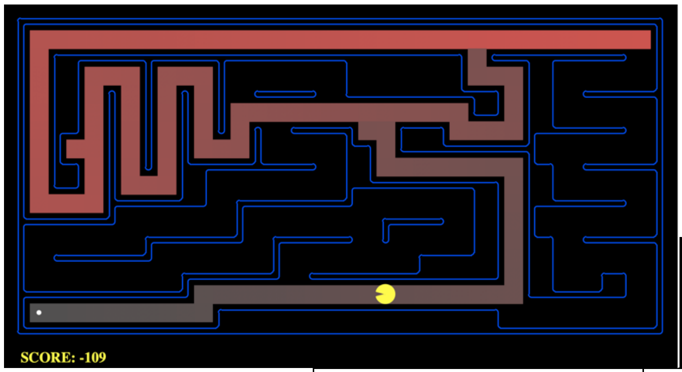


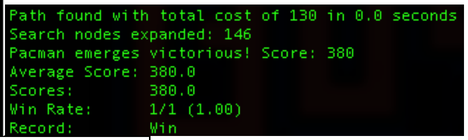


```
Path found with total cost of 10 in 0.0 seconds
Search nodes expanded: 15
Pacman emerges victorious! Score: 500
Average Score: 500.0
Scores:        500.0
Win Rate:      1/1 (1.00)
Record:        Win
```

Cost	10
Execution Time	0.0
Nodes Expanded	15
Score	500

    b. mediumMaze

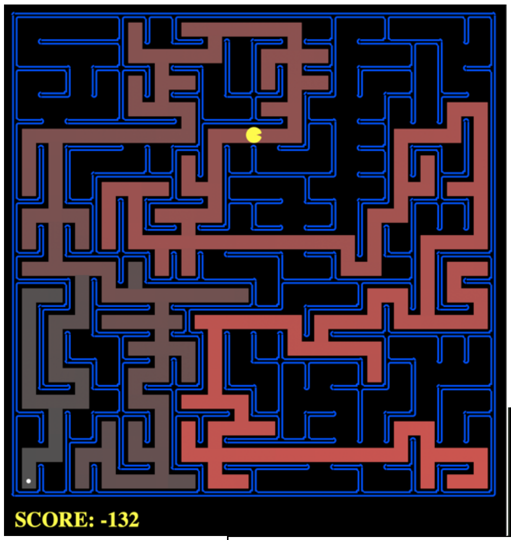


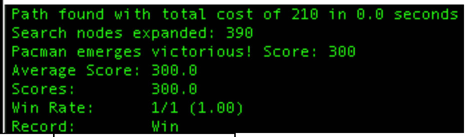


```
Path found with total cost of 130 in 0.0 seconds
Search nodes expanded: 146
Pacman emerges victorious! Score: 380
Average Score: 380.0
Scores:        380.0
Win Rate:      1/1 (1.00)
Record:        Win
```

Cost	130
Execution Time	0.0
Nodes Expanded	146
Score	380

c. bigMaze



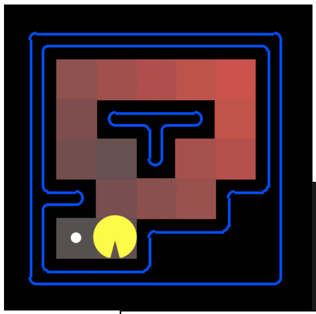


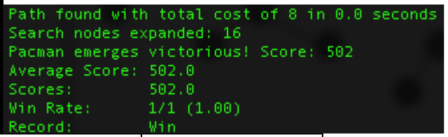
```
Path found with total cost of 210 in 0.0 seconds
Search nodes expanded: 390
Pacman emerges victorious! Score: 300
Average Score: 300.0
Scores:        300.0
Win Rate:      1/1 (1.00)
Record:        Win
```

Cost	210
Execution Time	0.0
Nodes Expanded	390
Score	300

2. Breadth First Search

a. tinyMaze

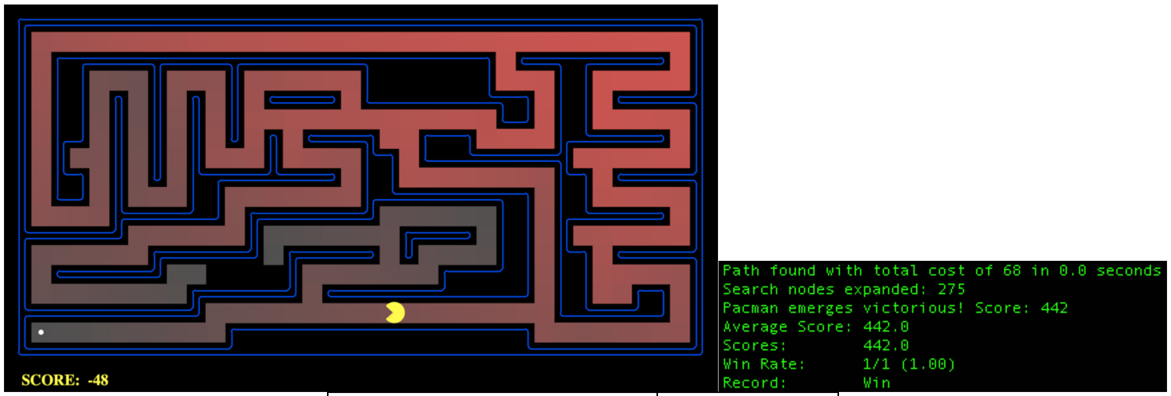




```
Path found with total cost of 8 in 0.0 seconds
Search nodes expanded: 16
Pacman emerges victorious! Score: 502
Average Score: 502.0
Scores:        502.0
Win Rate:      1/1 (1.00)
Record:        Win
```

Cost	8
Execution Time	0.0
Nodes Expanded	16
Score	502

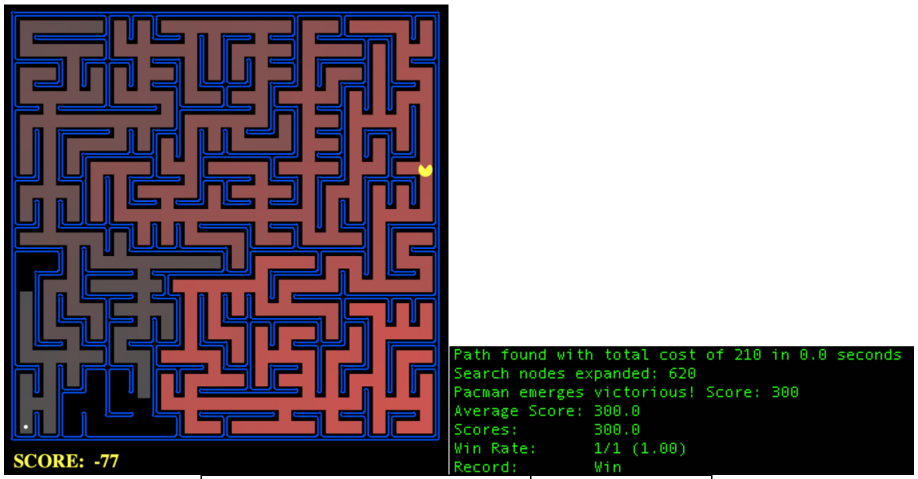
b. mediumMaze



```
Path found with total cost of 68 in 0.0 seconds
Search nodes expanded: 275
Pacman emerges victorious! Score: 442
Average Score: 442.0
Scores:        442.0
Win Rate:      1/1 (1.00)
Record:        Win
```

Cost	68
Execution Time	0.0
Nodes Expanded	275
Score	442

c. bigMaze

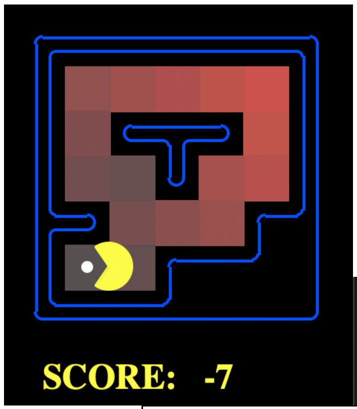


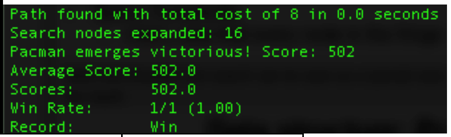
```
Path found with total cost of 210 in 0.0 seconds
Search nodes expanded: 620
Pacman emerges victorious! Score: 300
Average Score: 300.0
Scores:        300.0
Win Rate:      1/1 (1.00)
Record:        Win
```

Cost	210
Execution Time	0.0
Nodes Expanded	620
Score	300

3. Uniform Cost Search

a. tinyMaze

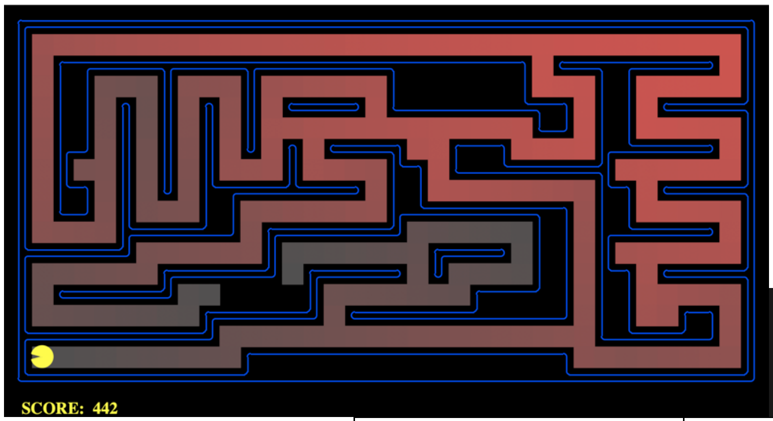


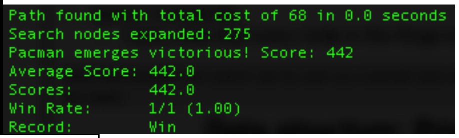


```
Path found with total cost of 8 in 0.0 seconds
Search nodes expanded: 16
Pacman emerges victorious! Score: 502
Average Score: 502.0
Scores:        502.0
Win Rate:      1/1 (1.00)
Record:        Win
```

Cost	8
Execution Time	0.0
Nodes Expanded	16
Score	502

b. mediumMaze

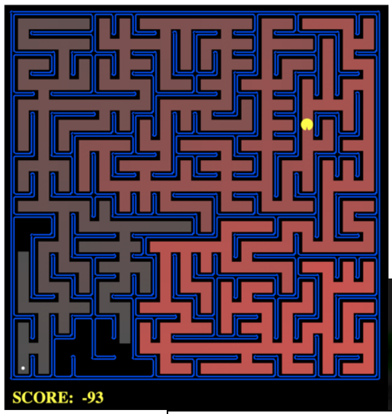


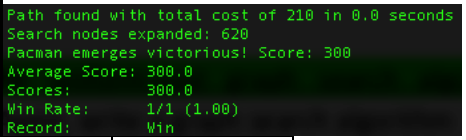


```
Path found with total cost of 68 in 0.0 seconds
Search nodes expanded: 275
Pacman emerges victorious! Score: 442
Average Score: 442.0
Scores:        442.0
Win Rate:      1/1 (1.00)
Record:        Win
```

Cost	68
Execution Time	0.0
Nodes Expanded	275
Score	442

c. bigMaze

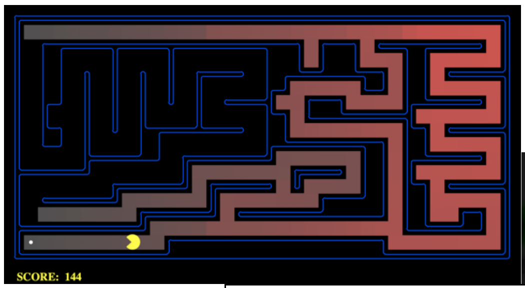


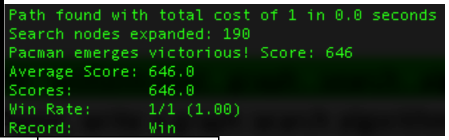


```
Path found with total cost of 210 in 0.0 seconds
Search nodes expanded: 620
Pacman emerges victorious! Score: 300
Average Score: 300.0
Scores:        300.0
Win Rate:      1/1 (1.00)
Record:        Win
```

Cost	210
Execution Time	0.0
Nodes Expanded	620
Score	300

d. mediumDottedMaze

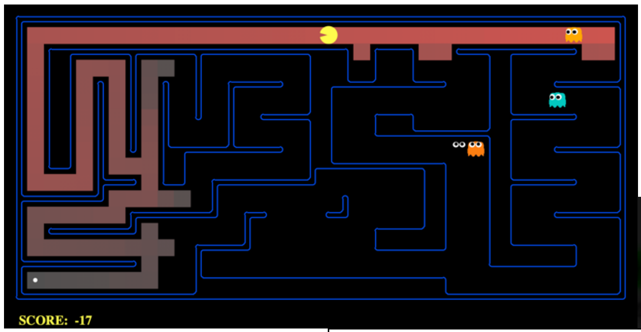


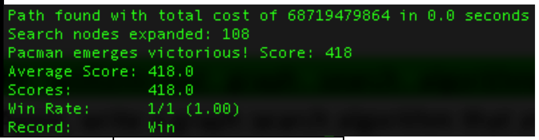


```
Path found with total cost of 1 in 0.0 seconds
Search nodes expanded: 190
Pacman emerges victorious! Score: 646
Average Score: 646.0
Scores:        646.0
Win Rate:      1/1 (1.00)
Record:        Win
```

Cost	1
Execution Time	0.0
Nodes Expanded	190
Score	646

e. mediumScaryMaze



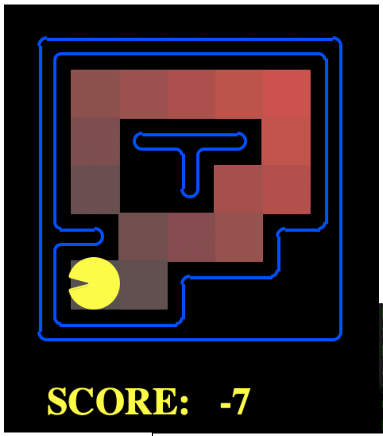


```
Path found with total cost of 68719479864 in 0.0 seconds
Search nodes expanded: 108
Pacman emerges victorious! Score: 418
Average Score: 418.0
Scores:        418.0
Win Rate:      1/1 (1.00)
Record:        Win
```

Cost	68719479864
Execution Time	0.0
Nodes Expanded	108
Score	418

4. A* Search

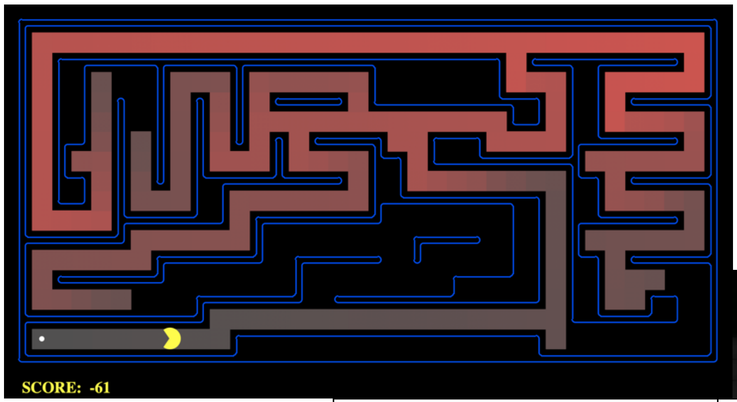
a. tinyMaze



```
Path found with total cost of 8 in 0.0 seconds
Search nodes expanded: 14
Pacman emerges victorious! Score: 502
Average Score: 502.0
Scores:        502.0
Win Rate:      1/1 (1.00)
Record:        Win
```

Cost	8
Execution Time	0.0
Nodes Expanded	14
Score	502

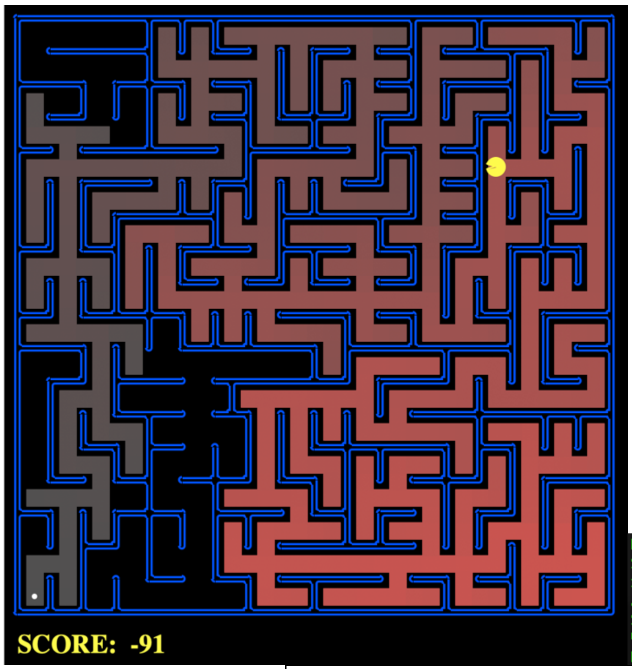
b. mediumMaze

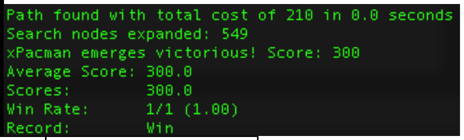


```
Path found with total cost of 68 in 0.0 seconds
Search nodes expanded: 224
Pacman emerges victorious! Score: 442
Average Score: 442.0
Scores:        442.0
Win Rate:      1/1 (1.00)
Record:        Win
```

Cost	68
Execution Time	0.0
Nodes Expanded	224
Score	442

c. bigMaze





```
Path found with total cost of 210 in 0.0 seconds
Search nodes expanded: 549
xPacman emerges victorious! Score: 300
Average Score: 300.0
Scores:        300.0
Win Rate:      1/1 (1.00)
Record:        Win
```

Cost	210
Execution Time	0.0
Nodes Expanded	549
Score	380

SUMMARY CHART

		Cost	Execution	Time Complexity
DFS	tinyMaze	10	0	15
	mediumMaze	130	0	146
	bigMaze	210	0	390
BFS	tinyMaze	8	0	16
	mediumMaze	68	0	275
	bigMaze	210	0	620
UCS	tinyMaze	8	0	16
	mediumMaze	68	0	275
	bigMaze	210	0	620
A*	tinyMaze	8	0	14
	mediumMaze	68	0	224
	bigMaze	210	0	549

There is a large problem with the algorithms as all the time executions were 0.0 seconds. The analysis of all these algorithms will consist of only cost and time complexity.

UCS is similar to BFS because the costs of the actions are "1". The only time that they would be different is when they are being compared to mediumDottedMaze or mediumScaryMaze which changes the cost of each action.

The very first easy thing to compare is the cost of each DFS and BFS in tinyMaze because of the ability to actually count the path. DFS has a cost of 10 while BFS has a cost of 8. This is easily verifiable as the DFS path would take the first node and expand it until it reaches the solution. Due to the algorithm, pacman will expand his left node which causes him 2 extra steps in the cost. For BFS, it is 8 because that is the "depth" of the solution. A* also has the same cost because BFS and A* are optimal, but DFS is not. Comparing the time complexity, A* has the lowest time complexity because of its heuristics. This may be due to the fact that at left side, the heuristics increases due to moving away from the solution. It doesn't expand those nodes anymore because the other path is more optimal. DFS has the second lowest time complexity because it searches one path and luckily there is a solution. This allows DFS to only have expanded 15 nodes. BFS has the most expanded nodes because it expands both paths at the same time, causing it to have a time complexity of 16 nodes.

For mediumMaze the cost for DFS is 130, for BFS, UCS, A* the cost is 68. The cost for DFS is twice of the algorithms because it expands the path to the left. There is a solution at the end of this path, which is 130 steps. The time complexity for all algorithm varies. DFS has a time complexity of 146 since it is only expanding on a "straight" path. The second longest is A* with a time complexity of 224. Analyzing the map, it is easy to understand why. It first expands to the left which decreases the distance to the solution. As it approaches the solution, it has to turn around which increases the heuristic every step. After a while the

heuristic is finally greater than going down from the spawn point. From this point on, the algorithm expands going down the spawn point and reaching an optimal solution. BFS has the largest number of nodes expanded just because it has to expand all the nodes on the left side even if there is no solution. There is a gap in between the red to show that where it did not expand the nodes due to finding the solution.

All the algorithms have the same cost because there is only one path to the solution. The time complexity varies with DFS being the lowest, followed by A*, and finally BFS and UCS tied for 3rd place. DFS has the lowest time complexity due to how the nodes were expanded. If the nodes were expanded in reverse, it might have expanded more nodes on the right side of the maze. A* has the second largest number of nodes expanded. It starts to expand to the left, which is represented by the red on the maze. The algorithm realizes that there is no way to reach the solution from expanding to the left, so it backtracks until it is able to find the same path that the DFS algorithm found and expand until it finds the solution. BFS and UCS expands every node on the right side and almost every node on the entire maze until the end, resulting in the largest number of nodes expanded.