

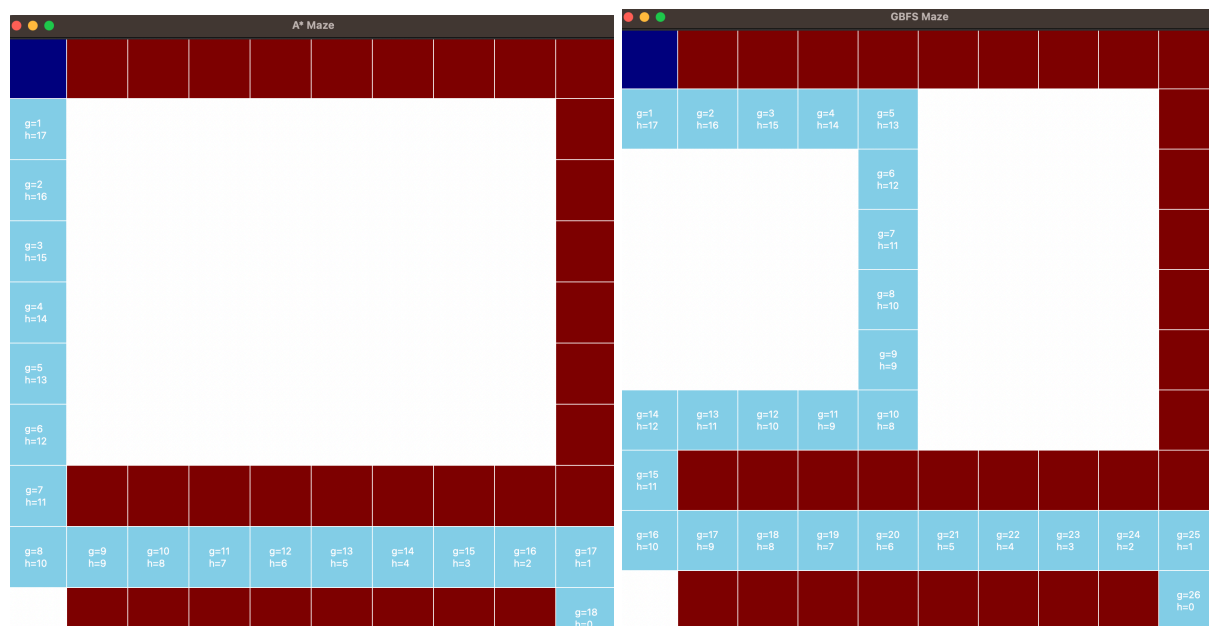
Assignment 4 A* Algorithm

Purpose: Investigate the result of the A* maze algorithm. The first two problems compare its result against the Greedy Best First Search (GBFS) algorithm and the third problem compares the effects of coefficients for the heuristic value ($h(n)$) and the moving cost ($g(n)$) on the algorithm's path.

1. Modify **AStarMaze** to compare the behaviors of the **Greedy Best-First** and **A*** search algorithms. You need to modify the maze configuration so you can visually observe differences in the optimum paths generated by the two algorithms. Your report should include a side-by-side comparison of the two approaches similar to the graph shown below along with your explanation. You only need to draw the shortest paths and not the highlighted frontiers.

Change to A* algorithm to make it GBFS

```
### Update the evaluation function for the cell n:  $f(n) = h(n)$ 
self.cells[new_pos[0]][new_pos[1]].f = self.cells[new_pos[0]][new_pos[1]].h
```



The GBFS only considers the heuristic value, so it moves to the middle of the maze where the tiles are closer to the goal, before it moves back to the left side to go around the barrier. A* remains on the left side of the algorithm as it also takes into account the $g(n)$ or step cost. As a result, the A* algorithm takes less steps to reach the goal compared to the GBFS algorithm.

2. Repeat the above experiment but this time:

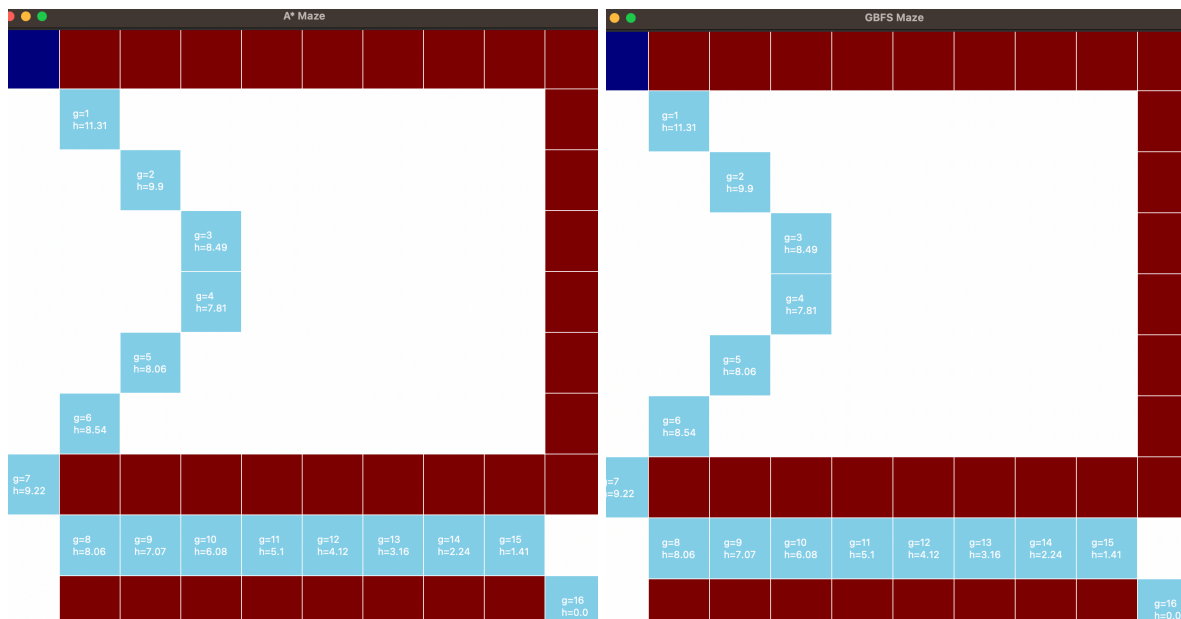
- Use the Euclidean Distance heuristic.
- The agent is allowed to make diagonal moves (i.e., NE, NW, SE, SW) in addition to the usual N, S, E, and W moves.
- The moves are made randomly and not in any specific order.

```
moves = np.array([(0, 1), (0, -1), (1, 0), (-1, 0), (1, 1), (-1, -1), (1, -1), (-1, 1)])
np.random.shuffle(moves)
#### Agent goes E, W, N, and S, whenever possible
for dx, dy in moves:
```

Change to A* and GBFS algorithm that allows diagonal movement (Uses numpy array to randomize directions)

```
#####
#### Euclidean distance
#####
def heuristic(self, pos):
    return math.sqrt((pos[0] - self.goal_pos[0])**2 + (pos[1] - self.goal_pos[1])**2)
```

Change to A* and GBFS to make the heuristic calculated with euclidean distance.



There is no difference between the A* and GBFS algorithm when they are using euclidean distance because there is no additional g(n) cost for moving towards the middle where the heuristic h(n) value is lower. Thus, the A* algorithm does the same path as the GBFS algorithm.

3.

a.

The evaluation function in **AstarMaze** is defined as $f(n) = g(n) + h(n)$. A weighted version of the function can be defined as:

$$f(n) = \alpha \cdot g(n) + \beta \cdot h(n) \text{ where } \alpha, \beta \geq 0$$

Explain how different values of α and β affect the A* algorithm's behavior. Tabulate your results:

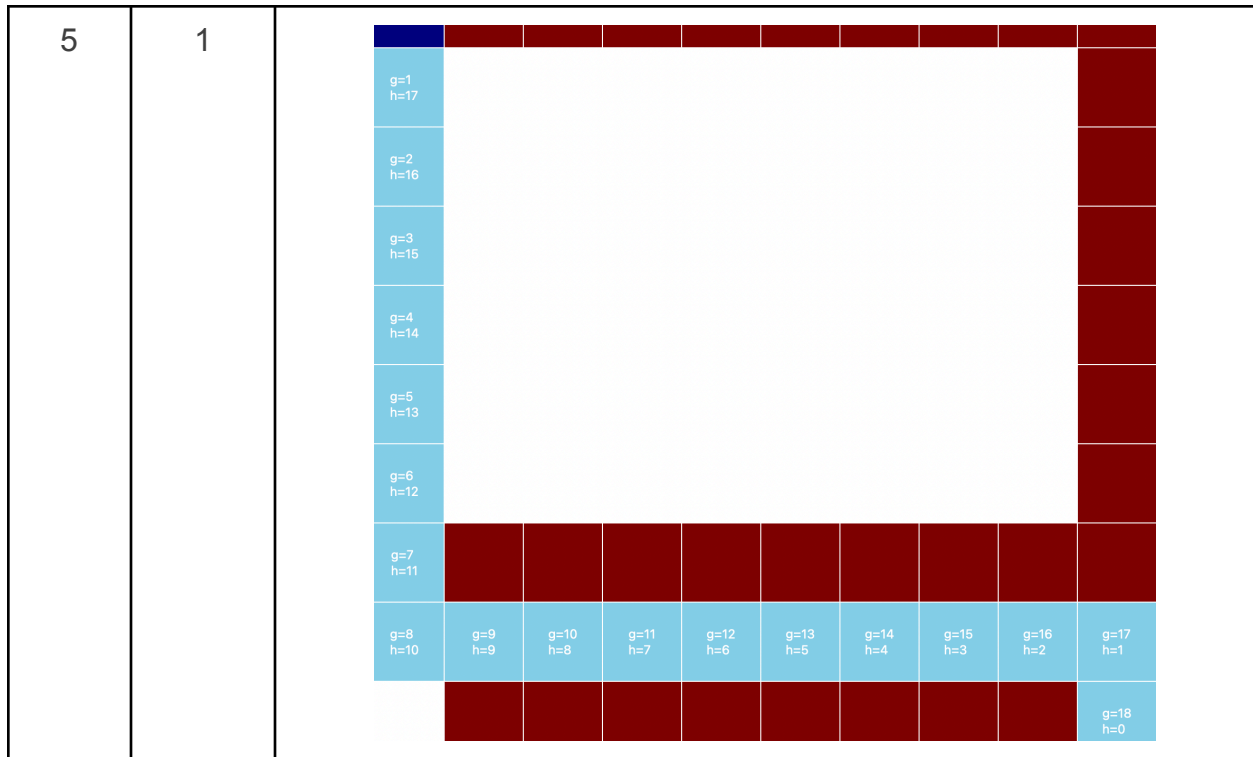
```
### Update the evaluation function for the cell n: f(n) =  $\alpha \cdot g(n) + \beta \cdot h(n)$   
self.cells[new_pos[0]][new_pos[1]].f = (1*new_g) + (2*self.cells[new_pos[0]][new_pos[1]].h)
```

Change to A* code to factor coefficients into the algorithm

α	β	Result
1	2	

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- b. While increased α values had no effect on the algorithm's path as this affected each tile equally, the β value had an impact on the performance. As seen in the screenshots above, the higher the value of β was the more the algorithm prioritized tiles with lower Heuristic $H(n)$ cost. As a result, the algorithm moves more towards the middle of the maze since those tiles are closer to the goal state. This caused the algorithm to perform worse than it normally would because it would have to move around the barrier that prevented the goal from being reached from the center of the maze. The final g cost when $\beta = 5$ was 24 compared to 18 normally. This is because our heuristic calculation did not take into account any obstacles leading to it being an inaccurate guide.

Conclusion: The A* algorithms can be implemented in a variety of ways to match the situation. It differs from GBFS algorithm because it considers the heuristic cost (in our case the distance from the maze exit). Euclidean or Manhattan distance can be used to calculate the heuristic cost depending on the mobility of the agent. Also, increasing the weight of the heuristic $h(n)$ value at least in our case can lead to worse performance.