UCS vs A* Report

by David Allen ([redacted])

Uniform Cost Search
The UCS search was easy to implement into the existing codebase by modifying the Breadth First Search algorithm already provided. Since moving a step in any direction is always the same cost, the UCS algorithm is almost identical to BFS. The "cost" of a node in the maze is equal to its "level". One can imagine the contours of cost to be completely flat. Therefore all that is needed to implement the algorithm is to check each neighbor and add it to the stack.

Strengths: The strength of the UCS algorithm is that it is guaranteed to find the exit in the maze because it will eventually explore every single path. It can sometimes beat DFS, especially in cases where the optimal path contains a lot of backtracking.

Weaknesses: Since UCS only explores nodes that have the least traversal cost, when cost is uniform across nodes it becomes identical to BFS. A shortcoming is that while the algorithm will explore every path, it has no information of what might make one path better than another, which can cause it to take many unnecessary steps. For example, there may be an open path to the goal, but the algorithm will explore nearer paths first.

A Star Search
The A* Algorithm is similar to UCS, except information from a heuristic function is also preserved to influence pathfinding. I initialized the cost of every cell in the grid to positive infinity, set the cost of the starting cell to 0 and inserted it into the queue. The algorithm pops the minimum cost node from the queue, iterates over all the neighbors and inserts them into the queue along with their cost. A cell's cost is the sum of the path cost to that cell and its Euclidean distance to the exit. This continues until the exit is found.

Strengths: The A* algorithm is able to make better predictions about the best possible move because it has more information regarding the goal. The algorithm incentivizes choosing paths that are shorter in length and bring it closer to the exit. This algorithm performed well whenever there was a straight path to the goal.

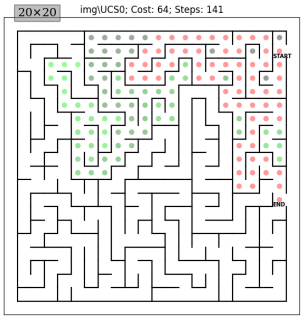
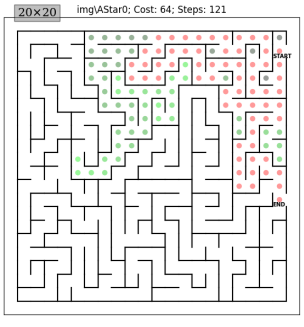
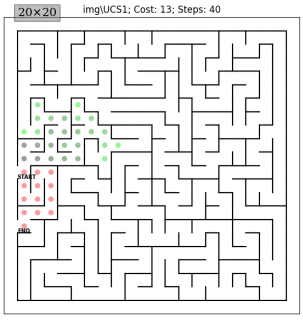
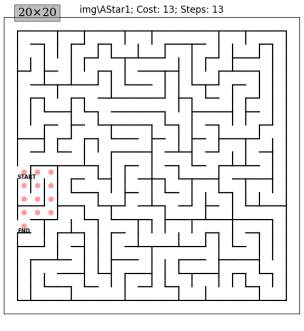
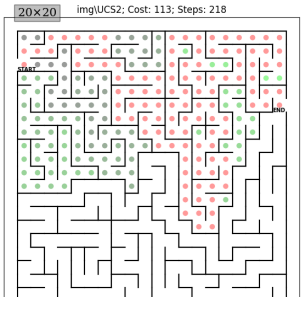
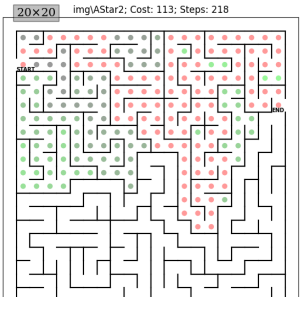
Weaknesses: Since all the nodes in the maze have uniform traversal cost, the algorithm loses effectiveness and sometimes resembles UCS, since path cost is one of the driving factors in its decision making.

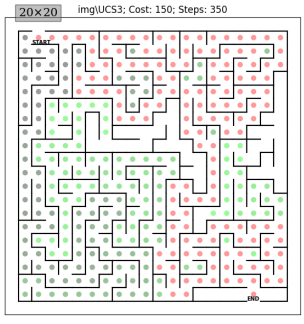
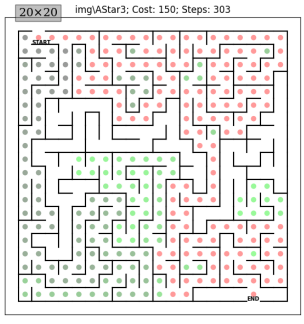
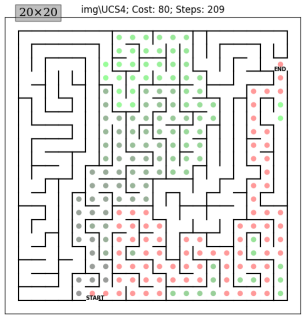
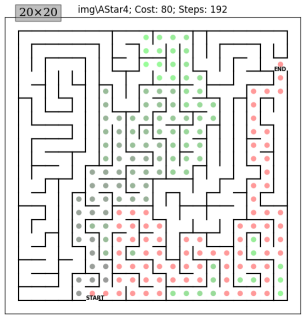
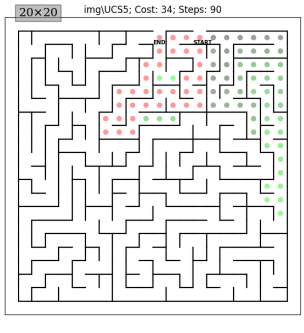
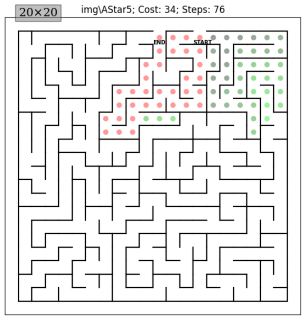
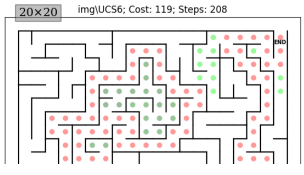
Analysis
The A* algorithm either matched or outperformed the UCS algorithm in every single

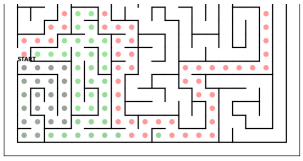
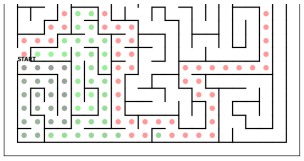
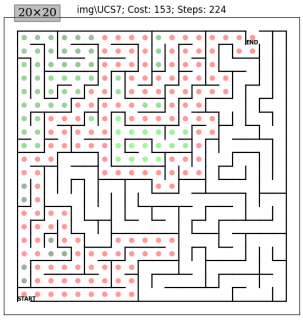
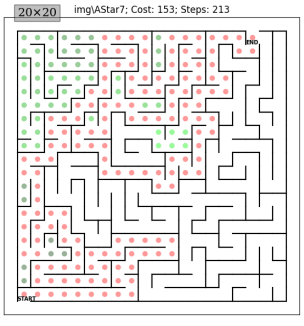
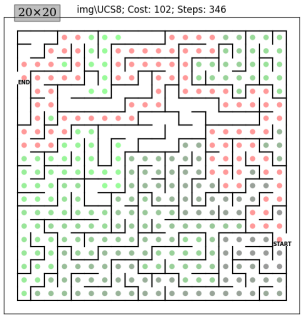
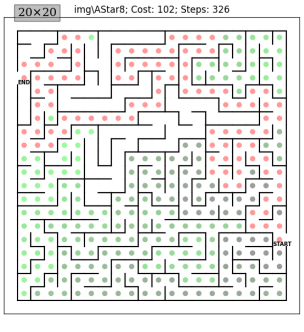
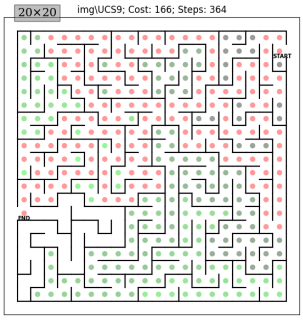
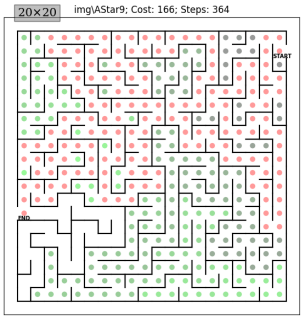
maze that was randomly generated. However, A* never completely outshone UCS, as their final step count was usually very close. Due to the nature of the problem, every cell having a uniform weight and the entry/exit always being on the edges (rather than in the middle, limiting directions of travel), the A* ends up being more like an enhanced version of UCS, while UCS is nearly identical to BFS. An algorithm like Greedy Search may be better suited for this type of problem.

Visuals

Here are the 10 generated mazes and the resulting path taken by each algorithm. The red line represents the optimal path, while the grey/green dots represent other squares that the algorithm explored. At the top of each diagram the type of algorithm, the cost of the optimal path, and the number of steps taken are all shown.

1		
2		
3		

4	 20×20 img\UCS3; Cost: 150; Steps: 350 START END	 20×20 img\AStar3; Cost: 150; Steps: 303 START END
5	 20×20 img\UCS4; Cost: 80; Steps: 209 END START	 20×20 img\AStar4; Cost: 80; Steps: 192 END START
6	 20×20 img\UCS5; Cost: 34; Steps: 90 END START	 20×20 img\AStar5; Cost: 34; Steps: 76 END START
	 20×20 img\UCS6; Cost: 119; Steps: 208 END	 20×20 img\AStar6; Cost: 119; Steps: 200 END

7		
8	 20×20 img\UCS7; Cost: 153; Steps: 224	 20×20 img\AStar7; Cost: 153; Steps: 213
9	 20×20 img\UCS8; Cost: 102; Steps: 346	 20×20 img\AStar8; Cost: 102; Steps: 326
10	 20×20 img\UCS9; Cost: 166; Steps: 364	 20×20 img\AStar9; Cost: 166; Steps: 364