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Problem Definition

Initial State: The initial state is the die lying on S space in the maze with the one on the die facing up, the two on the die facing north, and the three on the die facing east.

State Transition: A state transition consists of moving from one square to another while also rolling the die in that direction. Transitions that would require the six on the die to face up are not allowed. Additionally, a transition onto a astriek(*) that acts as a barrier is not allowed.

Transition Costs: Transitions are measured in moves (e.g. it took four moves to reach the solution). Therefore each transition costs the same.

Goal State: The goal state is the die lying on G space in the maze with the one on the die facing up with any configuration of the other sides.

Heuristic Functions

Euclidean Distance:

The first heuristic function I used was the Euclidean distance from the current state to the goal state. This heuristic is admissible because it calculates the shortest distance from a state to the goal state. It is not possible for this to overestimate because there is no distance that is shorter. This heuristic assumes:

1.Die can move in a straight line to goal

2.Die can slide. (Doesn't need to roll)

3.There are no obstacles between the die and the goal (Including no bounds on the size of the maze)

Manhattan Distance:

The second heuristic function I used was the Manhattan distance from the current state to the goal state. This heuristic is admissible because it calculates the shortest amount of spaces from a state to the goal state. It is not possible for this to overestimate because there is no path through spaces that is shorter. This heuristic assumes:

1.Die must move horizontally and vertically

2.Die can slide (Doesn't need to roll)

3.There are no obstacles between the die and the goal (Including no bounds on the size of the maze)

Breadth First Search Distance:

The third heuristic function I used is a Breadth First Search distance to find distances from the goal for each loc.This heuristic is admissible because it uses Breadth For Search Algorithm to find the depth to goal from start sate.It is not possible for this to overestimate because the distance between every child node and parent node is 1 unit. The step is constant. Apart from that it prunes out the places where there are obstacles between die and goal which were not taken into account in the other two heuristics.

The assumptions for these rules are:

1. Die must move horizontally and vertically.

2. Die can slide. (Doesn't need to roll)

3. There are obstacles between die and the goal.

Performance Metrics

Euclidean Distance, Manhattan Distance and Breadth First Search Distance Generated Visited Generated Visited Generated Visited

Puzzle 1

Euclidean Distance

13 nodes visited out of 19 generated.

Total Moves : 6

Manhattan Distance

16 nodes visited out of 22 generated.

Total Moves : 6

Breadth First Search Distance

16 nodes visited out of 22 generated.

Total Moves : 6

Puzzle 2

Euclidean Distance

62 nodes visited out of 82 generated.

Total Moves : 16

Manhattan Distance

61 nodes visited out of 80 generated.

Total Moves : 16

Breadth First Search Distance

61 nodes visited out of 83 generated.

Total Moves : 16

Puzzle 4

Euclidean Distance

19 nodes visited out of 20 generated.

Total Moves : 14

Manhattan Distance

19 visited out of 20 generated.

Total Moves : 14

Breadth First Search Distance

19 visited out of 20 generated.

Total Moves : 14

Puzzle 5

Euclidean Distance

116 nodes visited out of 140 generated.

Total Moves : 21

Manhattan Distance

105 nodes visited out of 129 generated.

Total Moves : 21

Breadth First Search Distance

114 nodes visited out of 139 generated.

Total Moves : 21

Puzzle 6

Euclidean Distance

2832 nodes visited out of 3069 generated.

Total Moves : 30

Manhattan Distance

2018 nodes visited out of 2316 generated.

Total Moves : 28

Breadth First Search Distance

2018 nodes visited out of 2316 generated.

Total Moves : 28

Discussion

The Euclidean distance was always the absolute shortest path and was always less than the actual cost of the path.

The Manhattan distance can only occasionally calculate something near to the actual cost. Since the die never slides and its face is always on one the Manhattan distance can underestimate as well.

Breadth First Search Distance is the only method which takes obstacles into account. It is optimal too as the step cost in this case is constant which is one unit. Due to this it generally makes an exact distance measurement or is very close.

In the end the cenario appeared where Euclidean search had to concede to Manhattan and Breadth For Search heuristics if the puzzle had more number of obstacles. In case of simple puzzle without obstacles all the three performed competently.

A* is optimally efficient provided , heuristic never overestimates. If a heuristic could calculate the exact distance from any point to the goal then A* would only ever follow one path because it would be the optimal path. So the heuristics have to be accurate and closer to getting exact distance from a point to goal.As the size of the puzzle increases, the searches that do a poor job of estimating near the actual cost generate and explore more states than those that are more accurate in estimating.

There was no solution for puzzle 3 as the search was exhaustive and no solution was by either heuristics.