ECS 170 Project 1: Part 1

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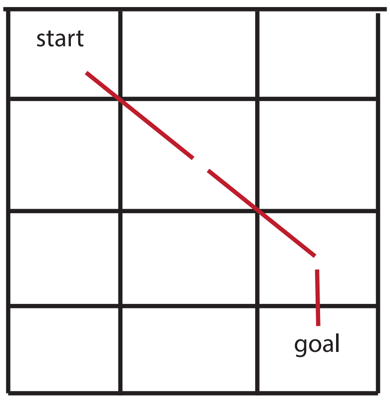
1 Heuristics

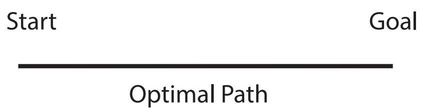
1.1 Exponential Heuristic

Our exponential world heuristic uses the number of moves away the goal point is from the current point, including diagonal movement, as the basis. This perfectly estimates the minimum number of moves required to get to the goal.



The heuristic then splits into multiple cases:

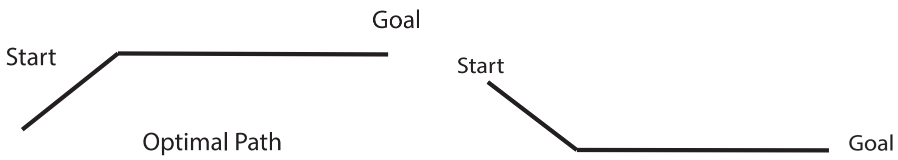
The first case is if the goal node is at the same height as the current node. The optimal path is a flat path to the goal node, whose path cost is the same as the number of points away, so we just use the number of points away.



The average cost of each move is at least one because a flat move costs one, while moving up and down is less efficient. $(1 + 1 \text{ vs } 2 + .5)$. It is consistent because for a move toward the goal, $c(n, n') \geq 1$ and $h(n') = h(n) - 1$ which obeys the triangular inequality.

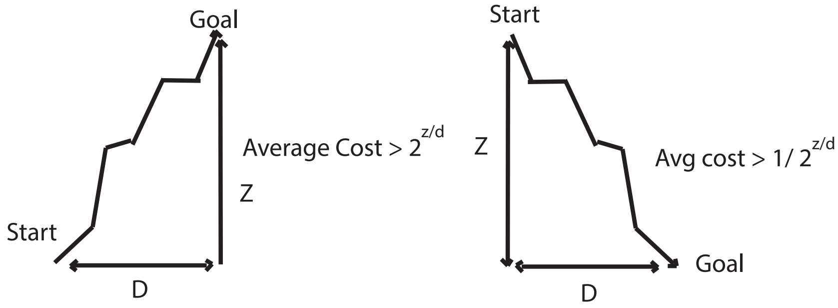
The second and third cases are if the goal node is higher or lower than the current node. These each have two subcases: if the height difference is greater than the minimum number of moves, and if the height difference is less than the minimum number of moves.

If the height difference is less than the minimum number of moves, then the optimal path is a path that moves up or down one space every move until it is level with the goal space, and then moves flat.



The cost of this path is $\Delta height * 2$ or $\Delta height/2$ multiplied by the number of spaces that move up or down, plus the number remaining moves that along the flat portion. This is consistent because $c(n, n') \geq 2$ if the height changes, while $h(n') = h(n) - 2$, which obeys the triangular inequality. If the move is flat, then $c(n, n') = 1$ and $h(n') = h(n) - 1$ which is also valid. If the move moves down, then $h(n') \geq h(n)$ which obeys the triangular inequality.

If the height difference is greater than the minimum path, then we use the minimum number of moves divided or multiplied by $2^{moves/\Delta height}$. This formula produces an underestimation of the average cost of moves to get to the goal state because the optimal path can be a combination of moves that move up different amounts.



For example, if the goal is 6 moves away and higher by 8, then the optimal path involves four moves of cost .5 and two moves of cost .25, for an average cost of .416. Our formula $2^{moves/\Delta height}$ produces a value of .3968 as an estimate for the average cost of each move, which is a good underestimation. We tested this with many different values and found that it consistently underestimated.

1.2 Bizarro World Heuristic

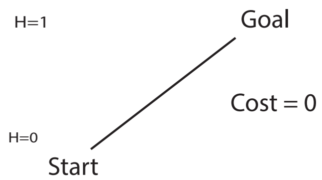
Our Bizarro world heuristic uses the number of moves away as the basis.

The heuristic splits into multiple cases:

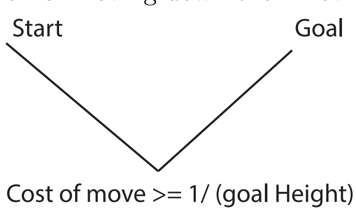
If the goal point is the same height as the current point, the best possible case is if the current point and the goal point are at height 0, and we can move there with an average path cost of .5, so our heuristic uses the number of moves away multiplied by .5.

$c(n, n')$ is either 0 or 1 on the optimal path. If $c(n, n')$ is 0, then $h(n) = h(n')$ because $h(n)$ is the number of moves - 1 and $h(n')$ is the number of moves, but it is one move closer. If $c(n, n')$ is 1, then $h(n) = h(n') - 1$, which is consistent.

If the goal point is higher than the current point, the best possible case is a special case where the current point is at height 0 and the goal point is at height 1 and is one tile away, and the cost of moving will be 0. The heuristic value must then be 0 to be admissible, and will be consistent because $c(n, n') = h(n) = h(n')$.

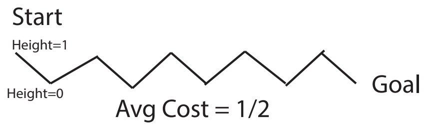


For all other cases with a higher goal point, we use a heuristic value that is a lower bound on the possible cost of a move to the goal point, $1/goalHeight+1$. The cheapest possible move on the optimal path is $1/goalHeight+1$ aside from 0, as optimal path should never rise above the goal height. The optimal path, is in fact, a combination of moving down then moving up.



$c(n, n') \geq 1/goalHeight + 1$ and $h(n') = h(n) - 1/goalHeight + 1$ so it it consistent.

If the goal point is lower than the current point, the optimal path is if the goal height is 0, and we are at height 1. In the best case, moves will cost an average of .5, so we use the number of moves away multiplied by .5.



The cost $c(n, n') \geq .5$ and $h(n') = h(n) - .5$ so it is consistent.