Searching, Pathfinding and A-Star (A*)

How to look

Imagine we have a list of ***n*** numbers, and we want to find where a specific number is in the list, if it is there at all.

How do we do this?

Naive Search (Linear Search)

If we know nothing about the list, the best thing we can do is start at the front and check each element until we get to the end.

Not very efficient, O(***n***)

Educated Searching (Binary Search)

If we know that the list is in ascending order we can do something smarter

We can check the middle element, ***m***, and see if it is smaller or bigger than the element we want

If it is smaller then we can ignore all the elements less than ***m***

If it is bigger then we can ignore all the elements bigger than ***m***

Now we only have ½ of the number to deal with, so we repeat this $\log_2(\boldsymbol{n})$ times

Pathfinding

Imagine we have a grid, each cell has some elevation.

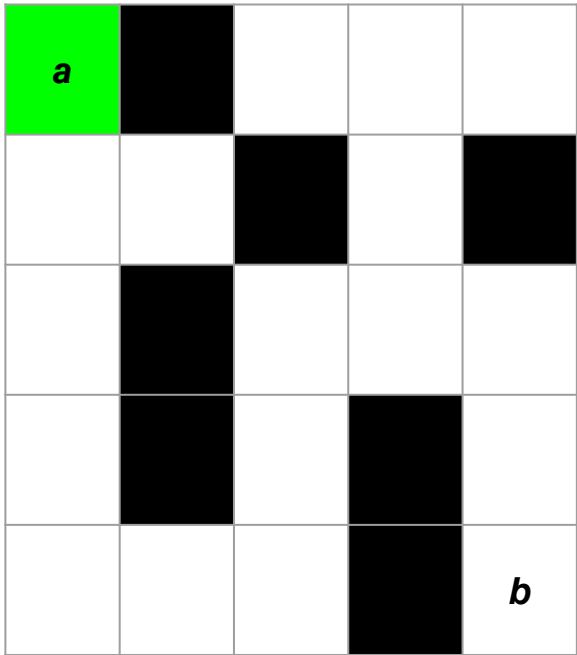
To move from one elevation to another costs some energy equal to the difference in elevation.

If we are at some location, ***a***, how do we find the most energy efficient path to another location ***b***?

Depth First Search (DFS)

One way to do this is to pretend you are on an adjacent square and do the search from there recursively until you arrive at your destination

Imagine we are at (0,0) and want to get to (4,4) following the pattern (Right, Down, Left, Up)



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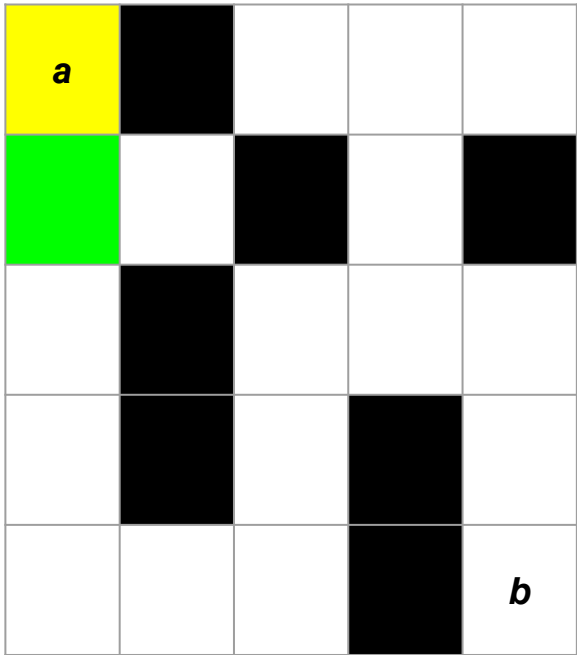

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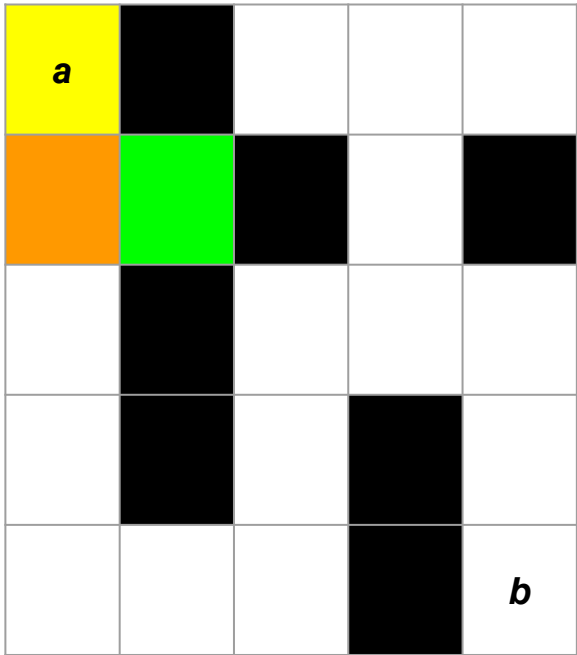

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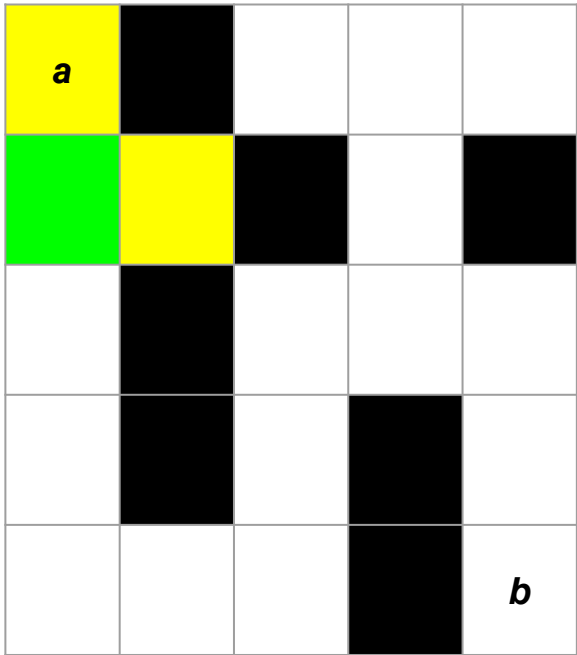

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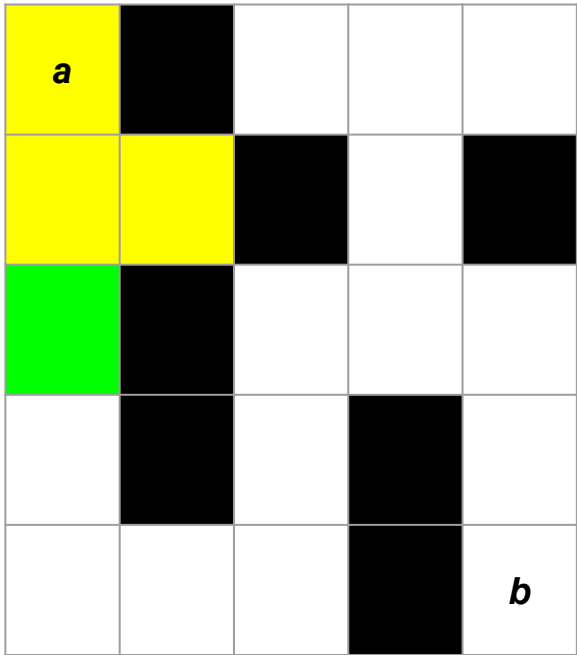

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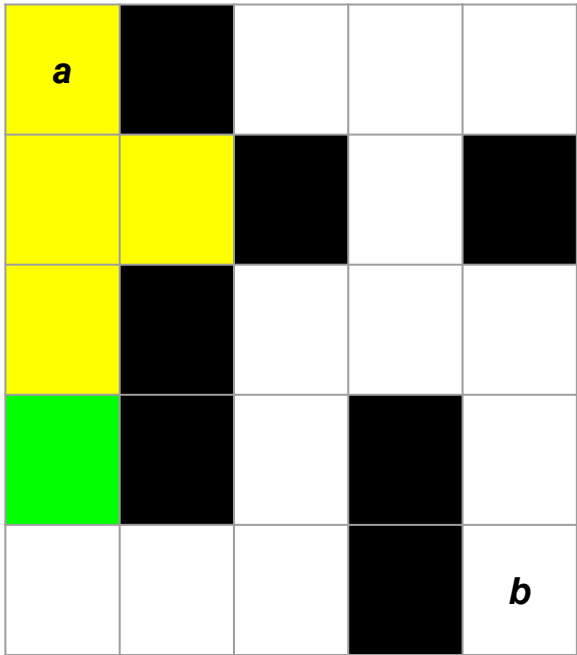

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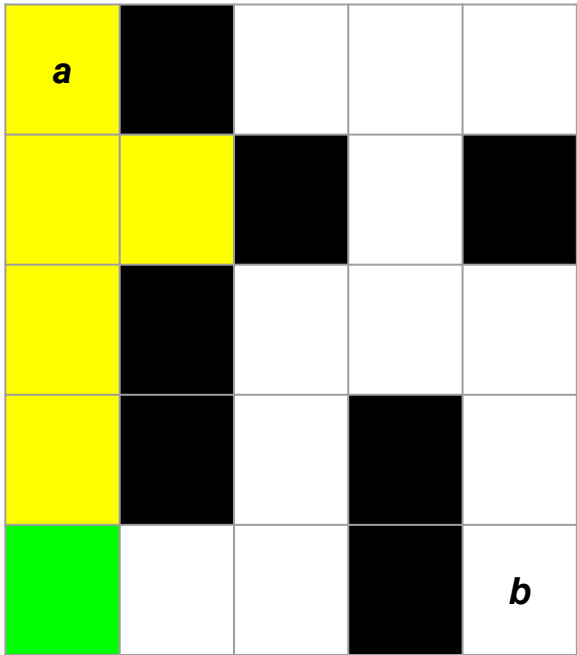

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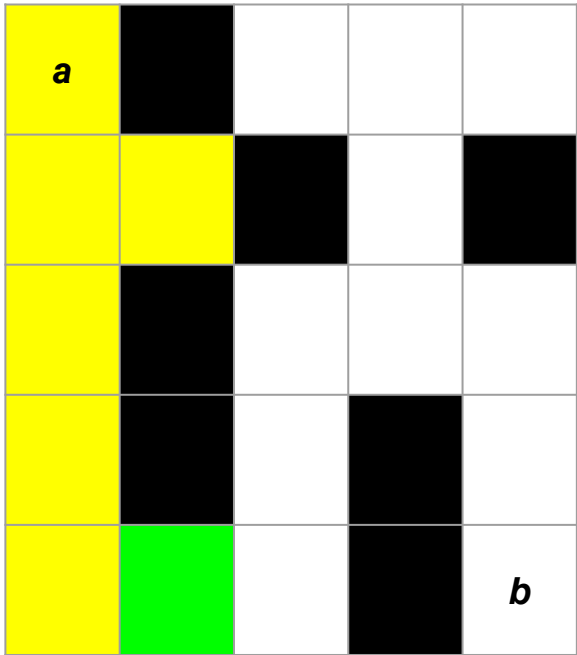

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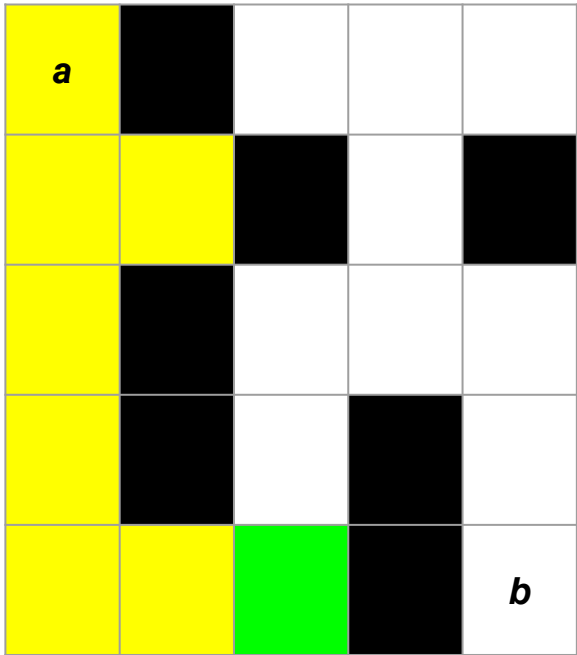

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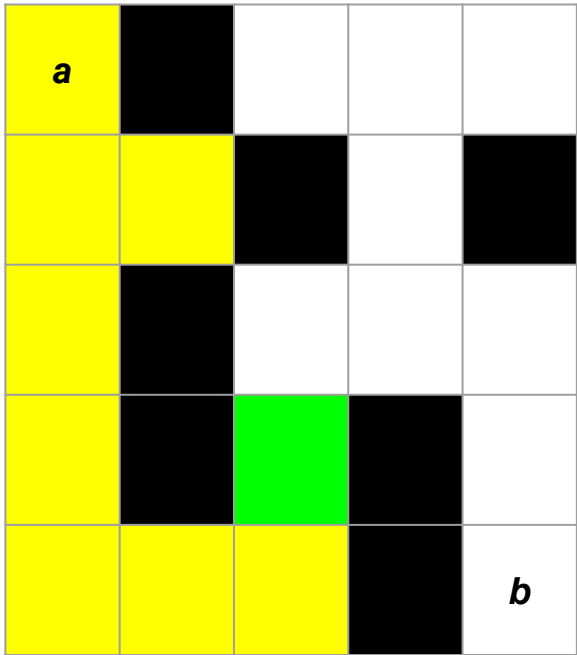

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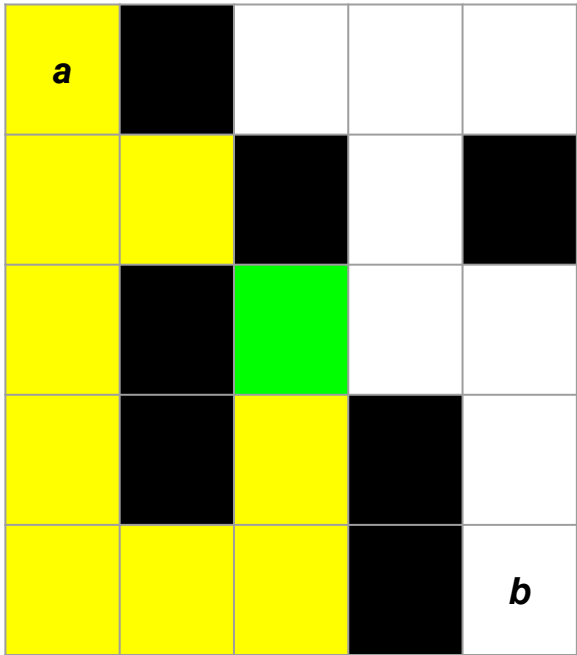

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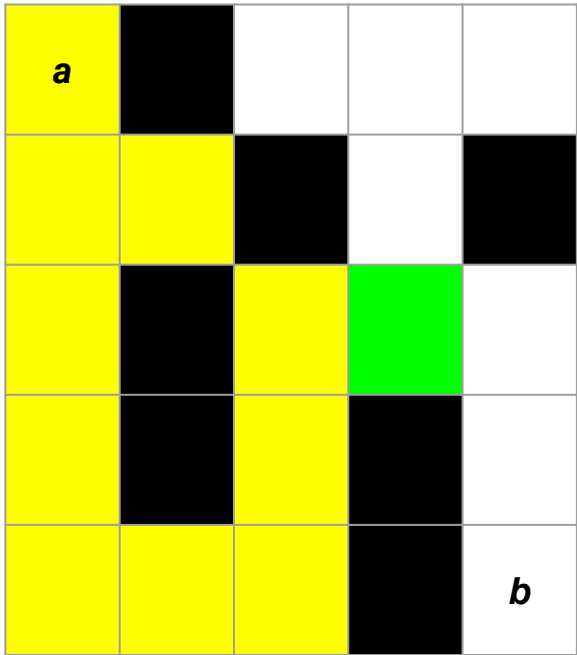

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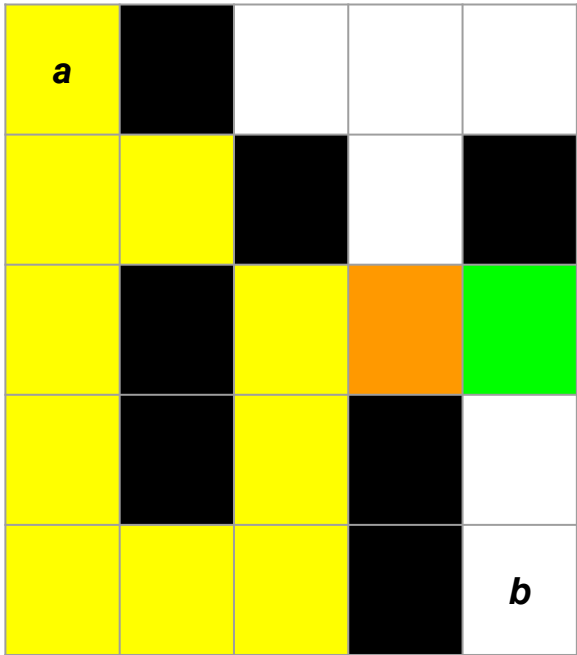

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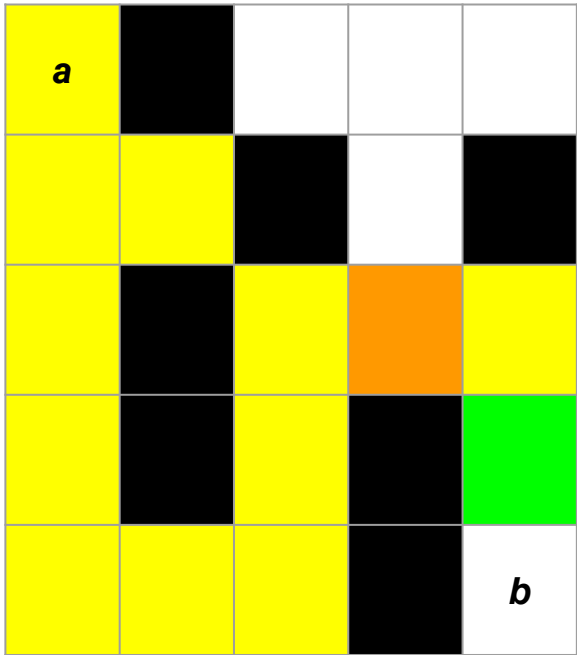

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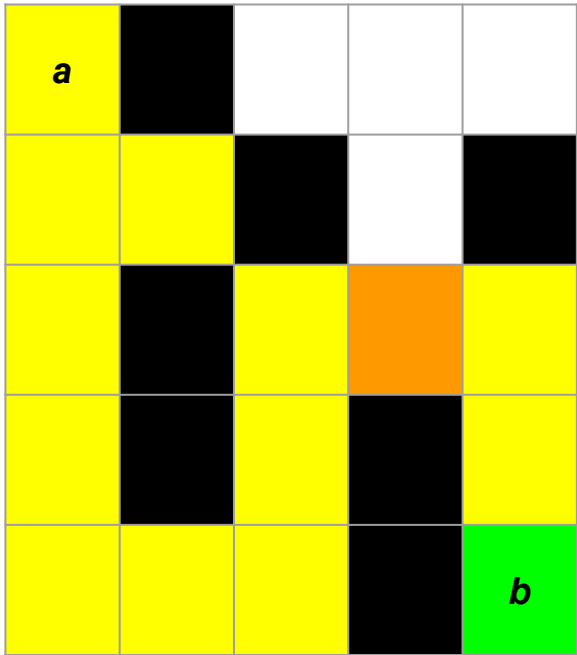

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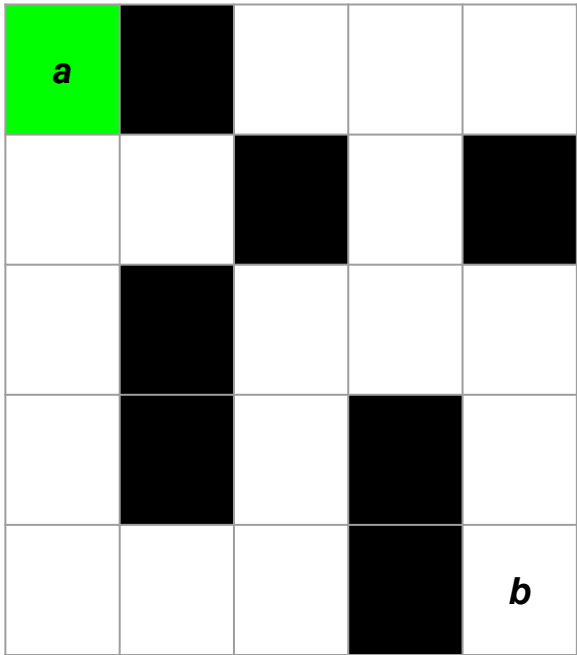

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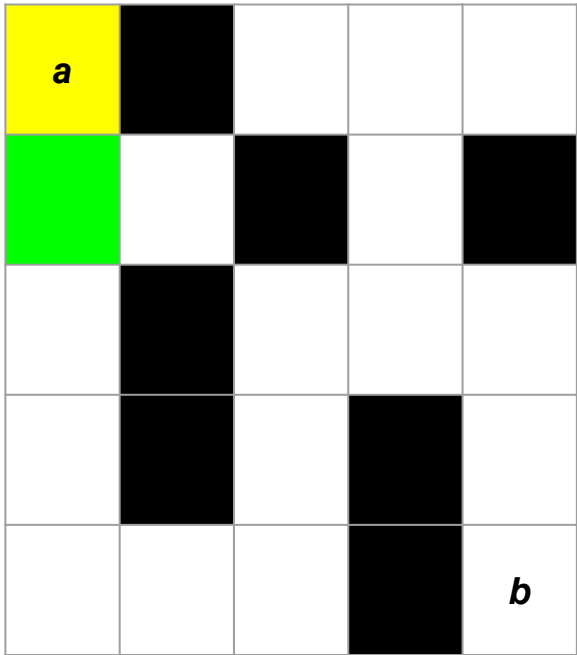

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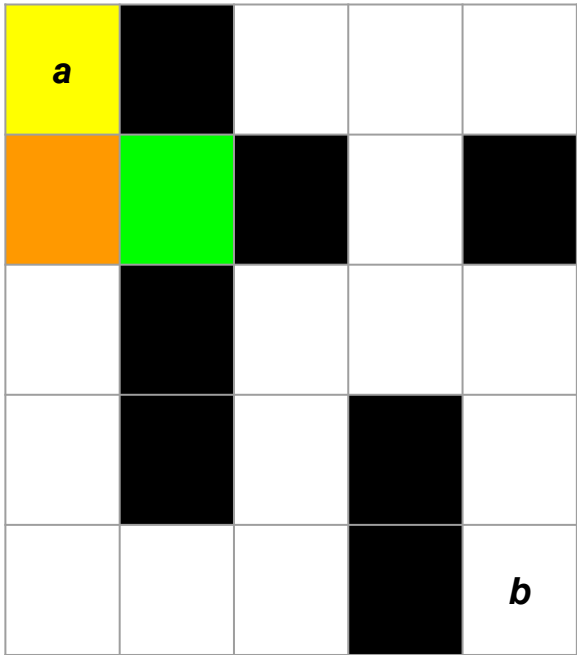

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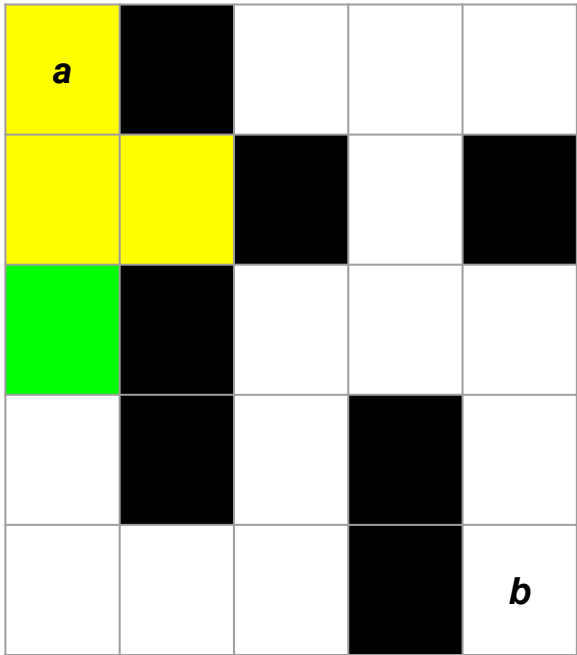

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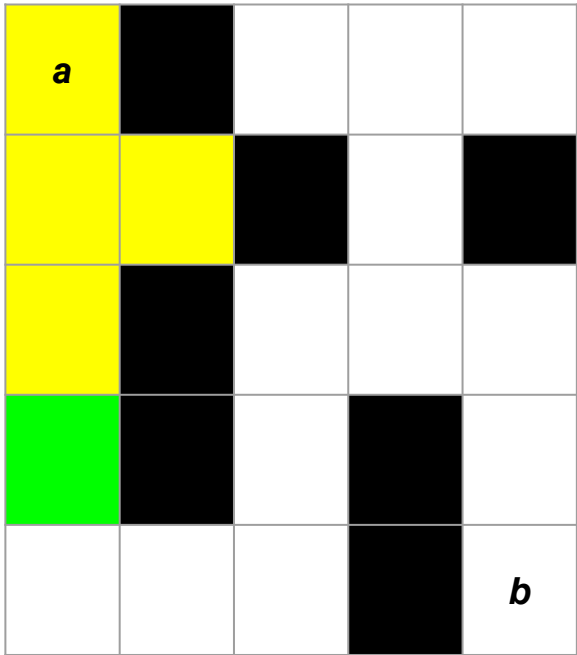

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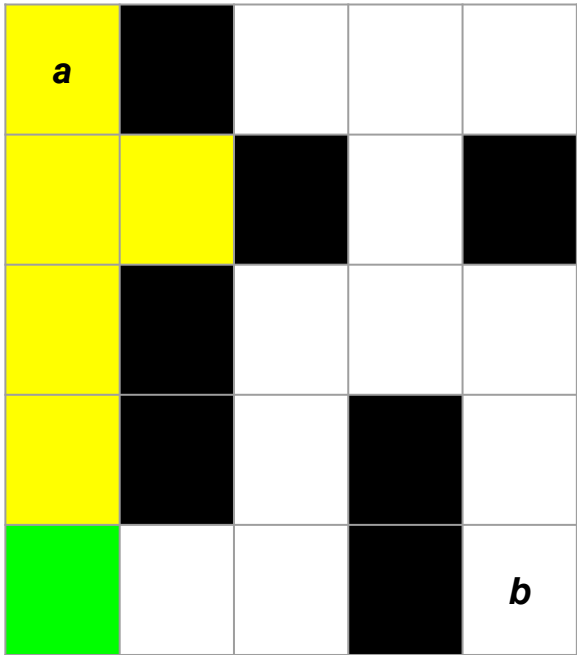

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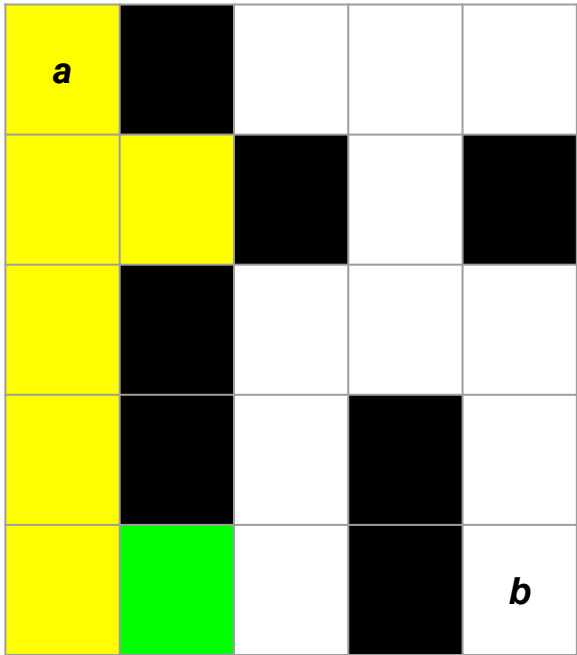

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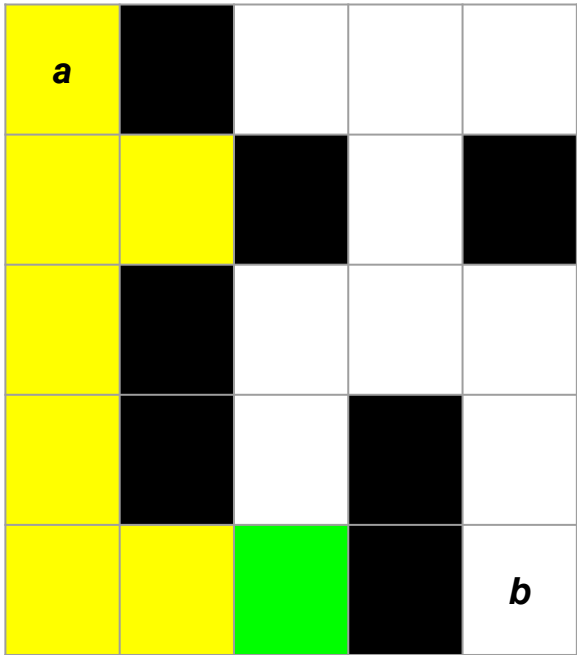

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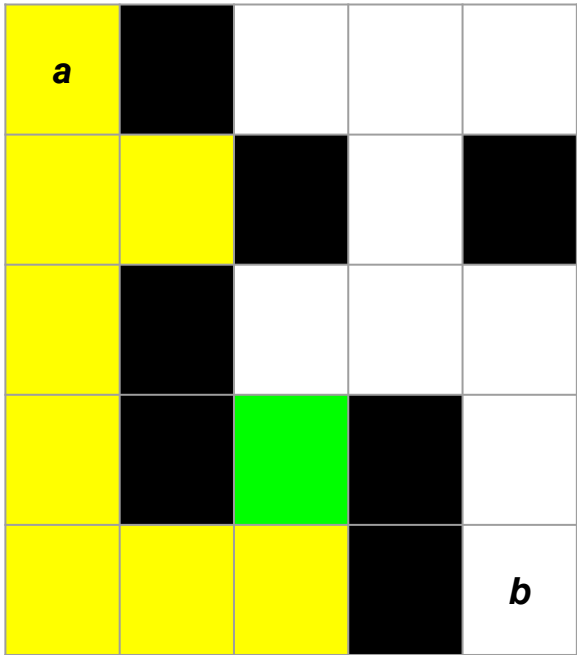

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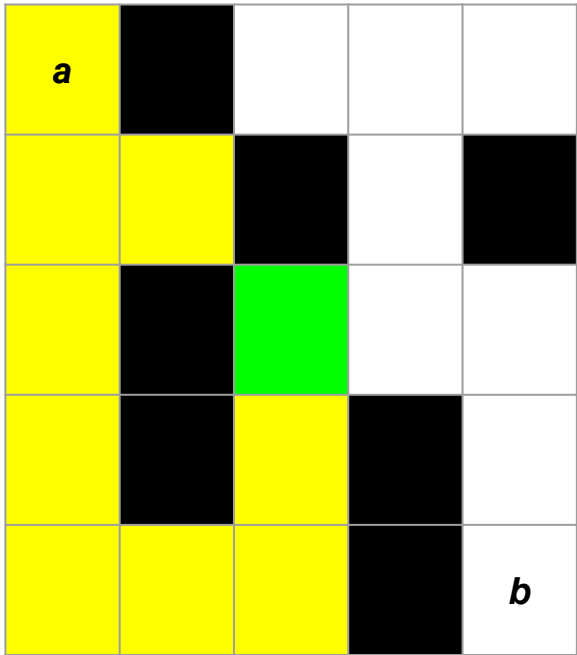

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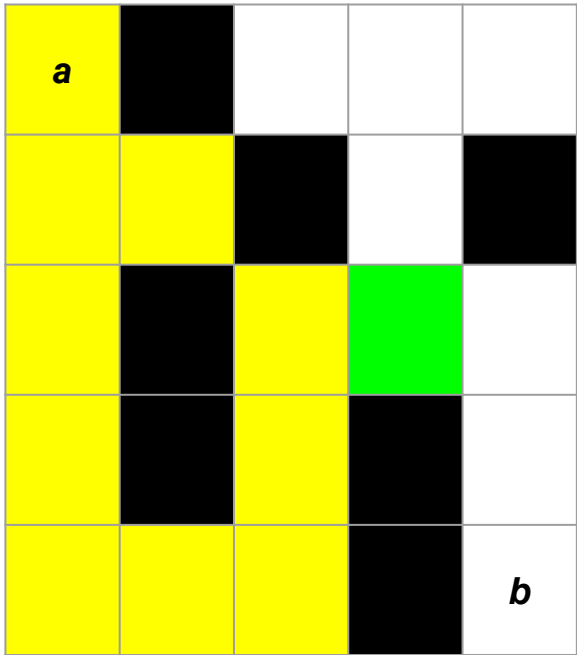

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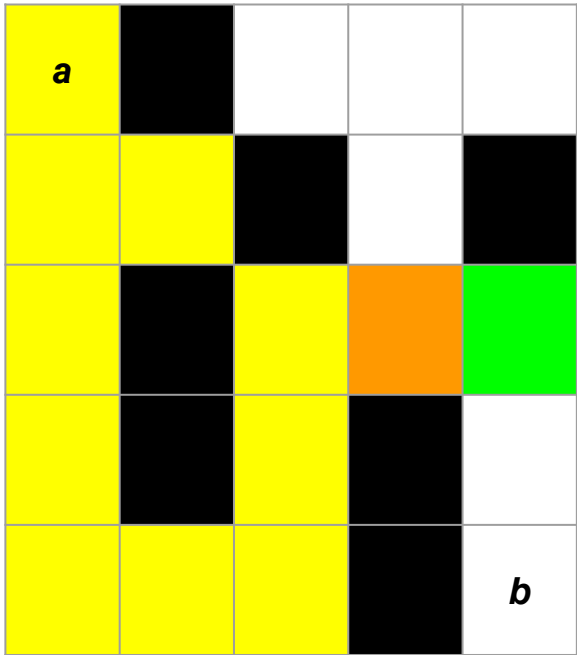

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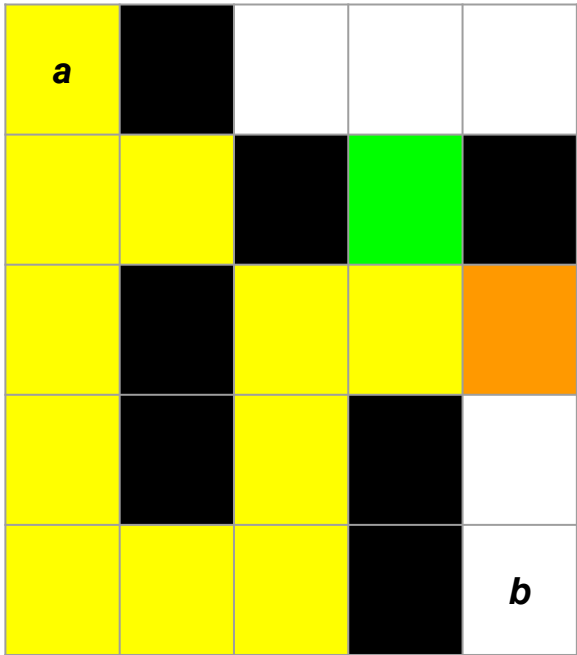

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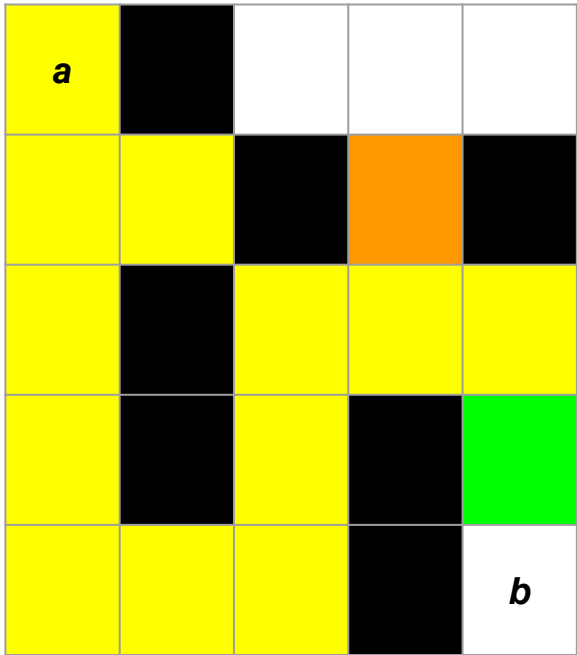

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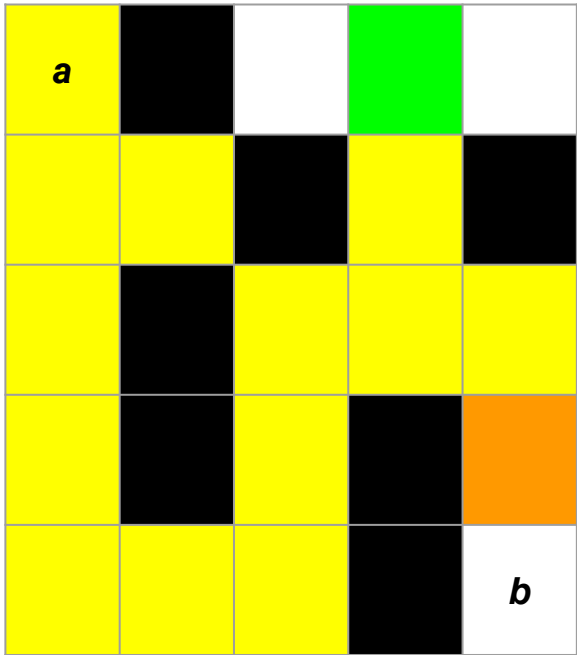

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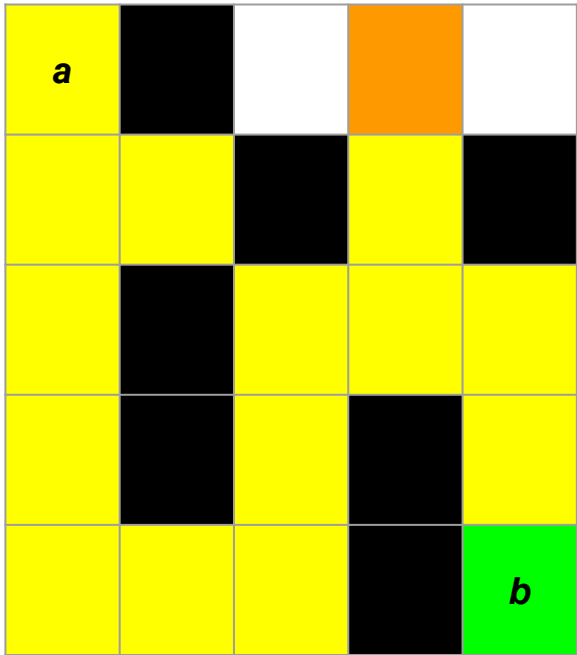

More Pathfinding

Imagine we have a grid, each represents the elevation of the landscape

It costs energy to change elevation equal to the difference in elevation

If we are at some location, ***a***, how do we find the most energy efficent path to another location ***b***?

Greedy Search

Always go to the “closest” square

Imagine we are at (0,0) and want to get to (4,4) following the pattern (Right, Down, Left, Up)

1	2	3	4	5
2	3	4	5	6
1	2	3	4	5
1	2	2	2	3
1	1	1	1	1

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Always go to the “closest” square

Imagine we are at (0,0) and want to get to (4,4) following the pattern (Right, Down, Left, Up)

Not always the best path

Cost: 12

1	2	3	4	5
2	3	4	5	6
1	2	3	4	5
1	2	2	2	3
1	1	1	1	1

A-Star Search

Look at all the edge squares and go to the one with the lowest “cost so far” + heuristic

A heuristic is a guess at what the remaining cost will be

In this case our heuristic will be city distance to goal

Imagine we are at (0,0) and want to get to (4,4) following the pattern (Right, Down, Left, Up)

1 (0+8)	2	3	4	5
2	3	4	5	6
1	2	3	4	5
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1 (0+8)	2 (1+7)	3	4	5
2 (1+7)	3	4	5	6
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Imagine we are at (0,0) and want to get to (4,4) following the pattern (Right, Down, Left, Up)

1 (0+8)	2 (1+7)	3 (2+6)	4 (3+5)	5 (4+4)
2 (1+7)	3 (2+6)	4 (3+5)	5 (4+4)	6
1	2	3	4	5
1	2	2	2	3
1	1	1	1	1

A-Star Search

Look at all the edge squares and go to the one with the lowest “cost so far” + heuristic

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2 (1+7)	3 (2+6)	4 (3+5)	5 (4+4)	6 (5+3)
1 (2+6)	2	3	4	5
1	2	2	2	3
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1 (2+6)	2 (3+5)	3	4	5
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1 (2+6)	2 (3+5)	3 (4+4)	4	5
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1 (2+6)	2 (3+5)	3 (4+4)	4 (5+3)	5
1	2	2	2	3
1	1	1	1	1

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1 (2+6)	2 (3+5)	3 (4+4)	4 (5+3)	5 (6+2)
1 (2+5)	2	2	2	3
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1 (2+6)	2 (3+5)	3 (4+4)	4 (5+3)	5 (6+2)
1 (2+5)	2 (3+4)	2	2	3
1 (2+4)	1	1	1	1

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1 (2+5)	2 (3+4)	2	2	3
1 (2+4)	1 (2+3)	1	1	1

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2 (1+7)	3 (2+6)	4 (3+5)	5 (4+4)	6 (5+3)
1 (2+6)	2 (3+5)	3 (4+4)	4 (5+3)	5 (6+2)
1 (2+5)	2 (3+4)	2	2	3
1 (2+4)	1 (2+3)	1 (2+2)	1	1

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2 (1+7)	3 (2+6)	4 (3+5)	5 (4+4)	6 (5+3)
1 (2+6)	2 (3+5)	3 (4+4)	4 (5+3)	5 (6+2)
1 (2+5)	2 (3+4)	2 (3+3)	2	3
1 (2+4)	1 (2+3)	1 (2+2)	1 (2+1)	1

A-Star Search

Look at all the edge squares and go to the one with the lowest “cost so far” + heuristic

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1 (2+6)	2 (3+5)	3 (4+4)	4 (5+3)	5 (6+2)
1 (2+5)	2 (3+4)	2 (3+3)	2 (3+2)	3
1 (2+4)	1 (2+3)	1 (2+2)	1 (2+1)	1 (2+0)

A-Star Search

Look at all the edge squares and go to the one with the lowest “cost so far” + heuristic

A heuristic is a guess at what the remaining cost will be

In this case our heuristic will be city distance to goal

Imagine we are at (0,0) and want to get to (4,4) following the pattern (Right, Down, Left, Up)

Cost: 2

1 (0+8)	2 (1+7)	3 (2+6)	4 (3+5)	5 (4+4)
2 (1+7)	3 (2+6)	4 (3+5)	5 (4+4)	6 (5+3)
1 (2+6)	2 (3+5)	3 (4+4)	4 (5+3)	5 (6+2)
1 (2+5)	2 (3+4)	2 (3+3)	2 (3+2)	3
1 (2+4)	1 (2+3)	1 (2+2)	1 (2+1)	1 (2+0)