CSC263: Problem Set 3

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We consulted no external resources

Question 1

part (a): BFS algorithm

The Alice maze will be represented by a 2-dimensional $n \times n$ array of nodes, with each node corresponding to a square in the maze.

Note: Terminology from here onwards

- "cell"= "node"="square" = location in Alice Maze.
- Alice Maze = Graph = Maze= Array of Nodes.

Each node has the attributes:

- **loc:** the (*row, column*) coordinates of the location of the node in the maze.
- **moves:** a list of directions *(horizontal_step, vertical_step*) the node can move in.
- **my_d:** the step size from source node to destination in each (row, column) direction.
- **d_change:** the size to adjust the current step size by.
- **d_arrivals:** a dictionary of *d _value: source_sqaure* pairs keeping track of all step sizes *d* that were used to enter the square/node.
- **is_start:** a boolean indicating whether a node represents the start square in the maze.
  - This will be used to terminate the backtracking when mapping out shortest path from goal.
- **is_goal:** a boolean indicating whether a node represents the goal in the maze.
  - This will be used to terminate the breadth first search if a path to the goal exists.

We then the traverse the maze from a given start square using Breadth First Search as in slide 22 of 27 of the week 8 lectures with some modifications.

- The major modification is that we do not keep track of whether a cell/square/node has been visited.
- Instead, in each node, we keep track of the step sizes that have been used to visit a node as well as the first source node that was moved from to that node with a given step size (see **d_arrivals** above).
- Doing this ensures we do not traverse the graph in an infinite cycle.
- Additionally, since there are a finite number of step sizes, this guarantees the search terminates after all possible steps sizes from a node are exhausted OR the shortest path is found.

Assume M is our array of nodes representing an Alice Maze and its squares.

Let S=starting node, and d=initial step size.

aliceBFS(M, S, d):

```
1.
2.      Initialize an empty Q
3.      S.my_d ← d              # set initial step size of S as d.
4.      ENQUEUE(Q, S)           # push start square into queue
5.
6.      while Q not empty:
7.
8.        cell_parent ← DEQUEUE(Q)
9.        current_d ← cell_parent.my_d      # get current step size from source square.
10.
11.       if cell_parent is goal:
12.          return cell_parent
13.
14.       if current_d > 0:
15.
16.         for each move in cell_parent.moves:
17.
18.           cell_child ← destination square by moving from cell_parent with move
19.           If cell_child is valid and current_d not in cell_child.d_arrivals:
20.
21.             cell_child.setMyD(current_d)
22.             cell_child.d_arrivals[current_d]  ← cell_parent
23.
24.           ENQUEUE(cell_child)
25.
26.     print "Destination Not Found"
27.     return None
```

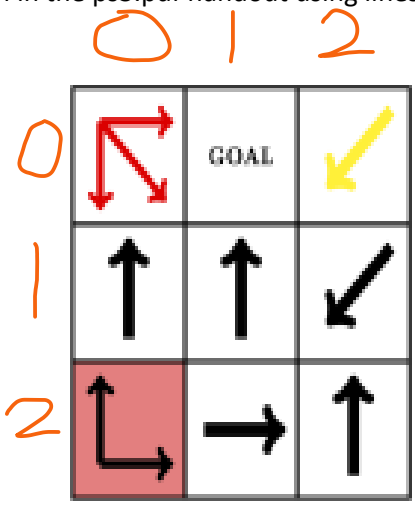
part (b): Text Representation of Alice Maze

A text representation of a maze needs to store the following information:

1. **Dimensions:** number of rows (row_num) and number of columns (col_num) of a maze.
2. **Start:** coordinates of start position in the maze as (row, col).
3. **Goal:** coordinates of goal position in the maze as (row, col).
4. **d:** the initial step size.
5. **Square data:** various attributes of each square.
   - A single line of text can represent a square and its data.
   - The format of each square presentation can be defined as:
     - square_loc|moves|step change|is_start|is_goal

- Information store in each line of text for a square in the maze includes:
  - Square Location: coordinates as (row, col).
  - Moves - a representation of all directions that can be stepped to from the square.
  - Step Change – integer representation of the size to adjust the current step size by.
  - is_start – indication of whether square is start position in maze (T or F)
  - Is_goal – indication of whether the square is goal (T or F)

An example of this representation is of the Alice Maze given in the ps3.pdf handout using lines 1–15 in example_maze.txt:




```
1.  row_num-3
2.  col_num-3
3.  start-0,0
4.  goal-0,1
5.  d-1
6.  square_loc| moves |step change|is_start|is_goal
7.  0,0| 1,0#0,1#1,1 |1|F|F
8.  0,1||0|F|T
9.  0,2| 1,-1 |-1|F|F
10. 1,0| -1,0 |0|F|F
11. 1,1| -1,0 |0|F|F
12. 1,2| 1,-1 |0|F|F
13. 2,0| -1,0#0,1 |0|T|F
14. 2,1| 1,0 |0|F|F
15. 2,2| -1,0 |0|F|F
```

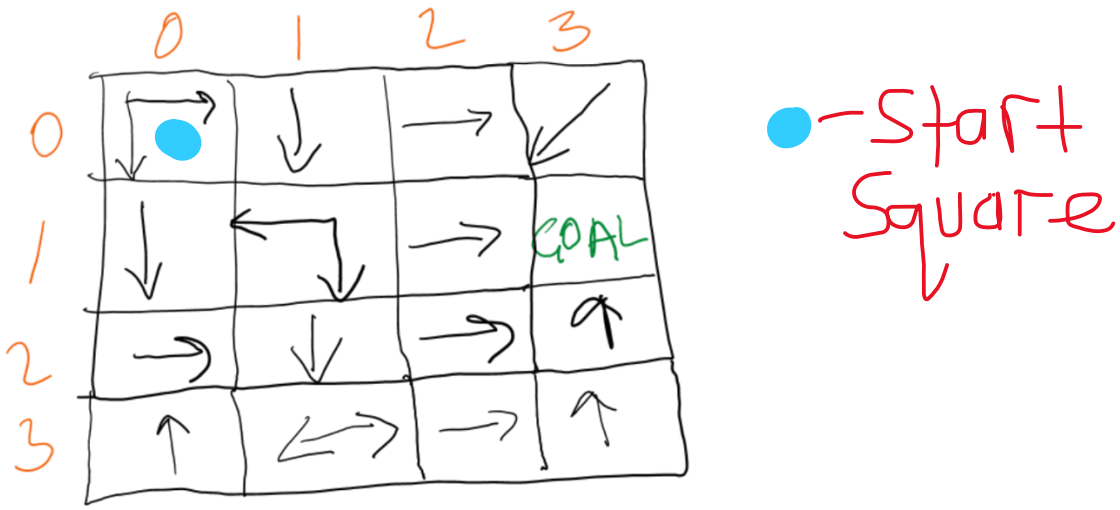
part (c): Python Implementation

See Alice.py

part (d): Tests

test1_in.txt: Algorithmic Correctness

- This test has been designed to check if the algorithm works as per specifications with a basic maze.
- The 4 x 4 maze has at least one path from start to goal with constant step size of d=1, that is none of the squares is configured to adjust the step size d.
- The **input** of this test is in test1_in.txt, with the maze represented depicted below.

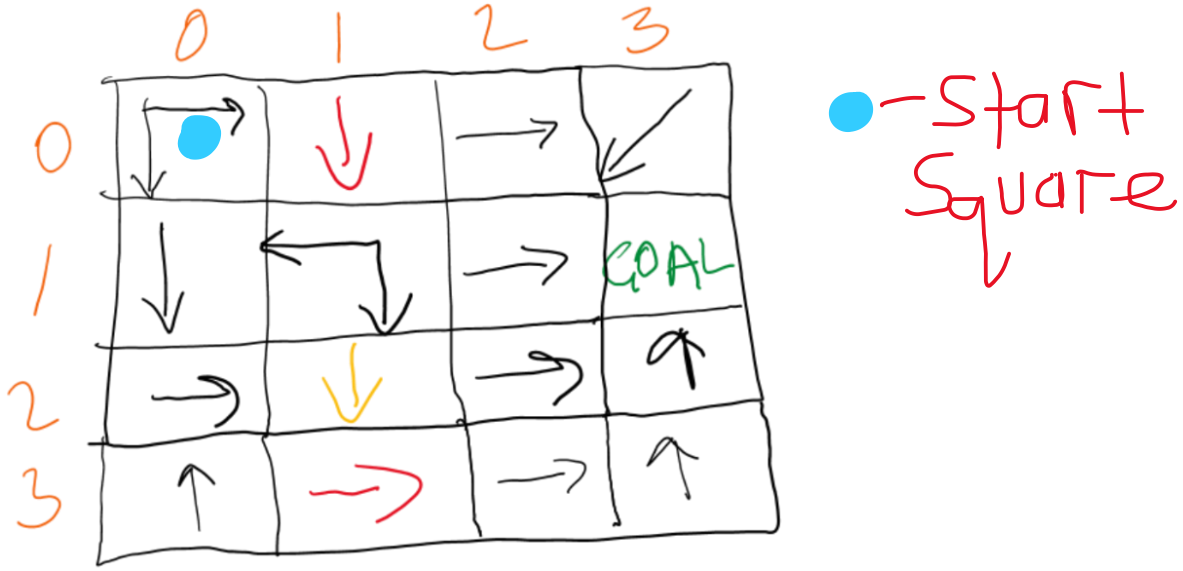


- The **expected output:**
  **********Hello World, I Solve Alice Mazes**********

  Start: (0, 0)
  Goal Found: (1, 3)
  The shortest path is (0, 0)->(1, 0)->(2, 0)->(2, 1)->(3, 1)->(3, 2)->(3, 3)->(2, 3)->(1, 3)
  The shortest path length is 8

test2_in.txt: Step Size Change

- The point of this test is to check if the implantation still finds the shortest goal when some squares are configured to increase and/or decrease the value of the step size d.
- In this case, it turns out the shortest path includes squares in which the size of d is altered.
- The **input** is in test2_in.txt that has representation of the maze below.



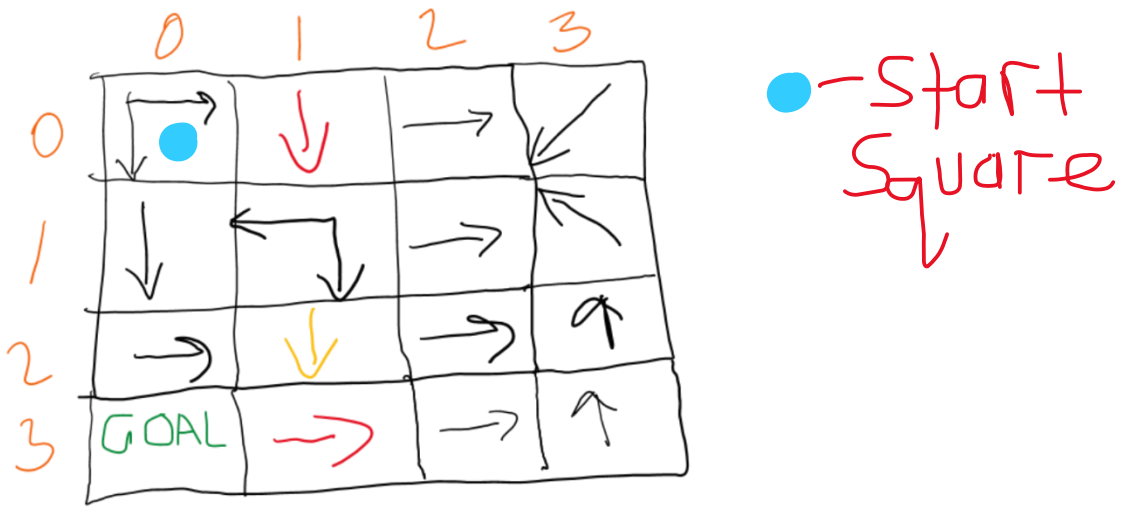
- The **expected output:**

**********Hello World, I Solve Alice Mazes**********

Start: (0, 0)
Goal Found: (1, 3)
The shortest path is (0, 0)->(0, 1)->(2, 1)->(3, 1)->(3, 3)->(1, 3)
The shortest path length is 5

test3_in.txt: No Path To Goal

- In this test, we are ensuring the python Alice maze solver reports when there is no path from start to goal when none exists.
- Since test1 and test2 above already confirm the implementation finds the shortest path given changes in step size, we know that 'no path found' is reported because there is none.
- The input is in **test3_in.txt** with pictorial representation of the maze below.



- The **expected output:**

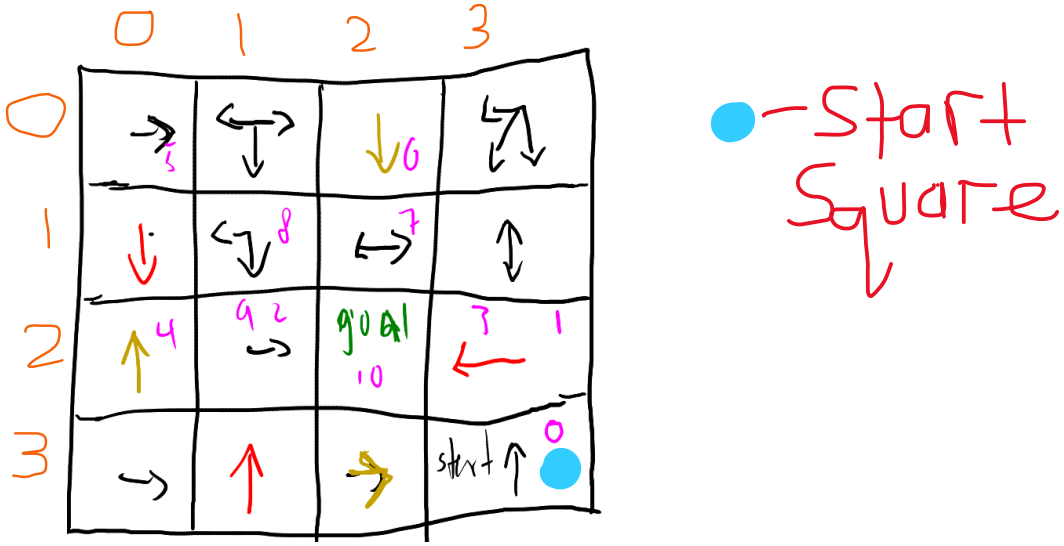
**********Hello World, I Solve Alice Mazes**********

Start: (0, 0)
Destination is not found

test4_in.txt: Multiple Visits To Square

- Here we check if the program still finds the shortest path where it has to step into at least one square multiple times.
- In those multiple visits to a square, the step size may be adjusted as well.

- The input is in **test4_in.txt** with pictorial representation of the maze below.



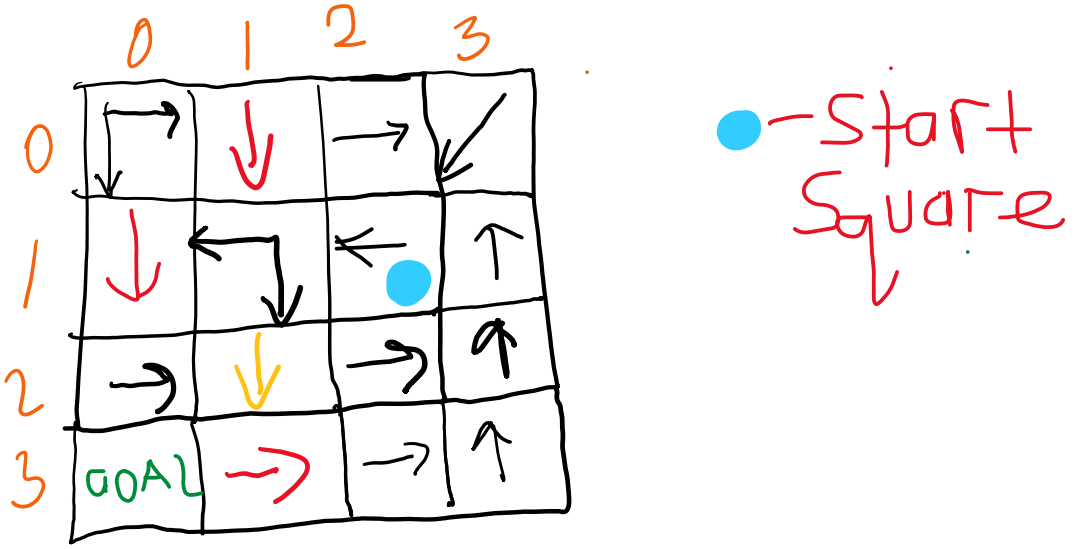
- The **expected output:**

  **********Hello World, I Solve Alice Mazes**********

  Start: (3, 3)
  Goal Found: (2, 2)
  The shortest path is (3, 3)->(2, 3)->(2, 1)->(2, 3)->(2, 0)->(0, 0)->(0, 2)->(1, 2)->(1, 1)->(2, 1)->(2, 2)
  The shortest path length is 10

test5_in.txt: Random Start And Goal

- This test demonstrates the start and goal squares can be chosen arbitrarily, but our Alice maze solver still finds the shortest path.
- In previous tests the start was (0,0) and goal was mostly (1,3).
- For this maze start is (1,2) and goal (3,0).
- The test i**nput** for this test is in test5_in.txt represented below.



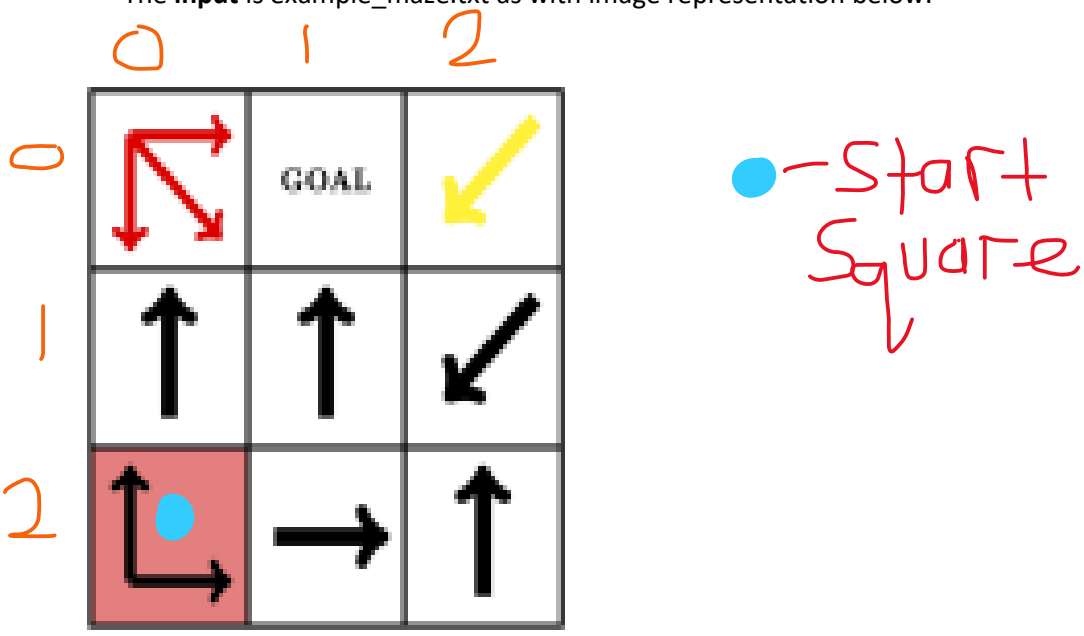
- The **expected output:**

  **********Hello World, I Solve Alice Mazes**********

  Start: (1, 2)
  Goal Found: (3, 0)
  The shortest path is (1, 2)->(1, 1)->(1, 0)->(3, 0)
  The shortest path length is 3

example_maze.txt: Difference Maze Size

- This test illustrates that our solver can works on any specified size.
- In this example, the maze is of 3 x 3 but in previous tests we had 4 x 4 mazes.
- This maze also has a looping path: (2, 0)->(2, 1)->(2, 2)->(1, 2)->(2, 1)->(2, 2) ->(1, 2)->(2, 1)->(2, 2)….
- The **input** is example_maze.txt as with image representation below.



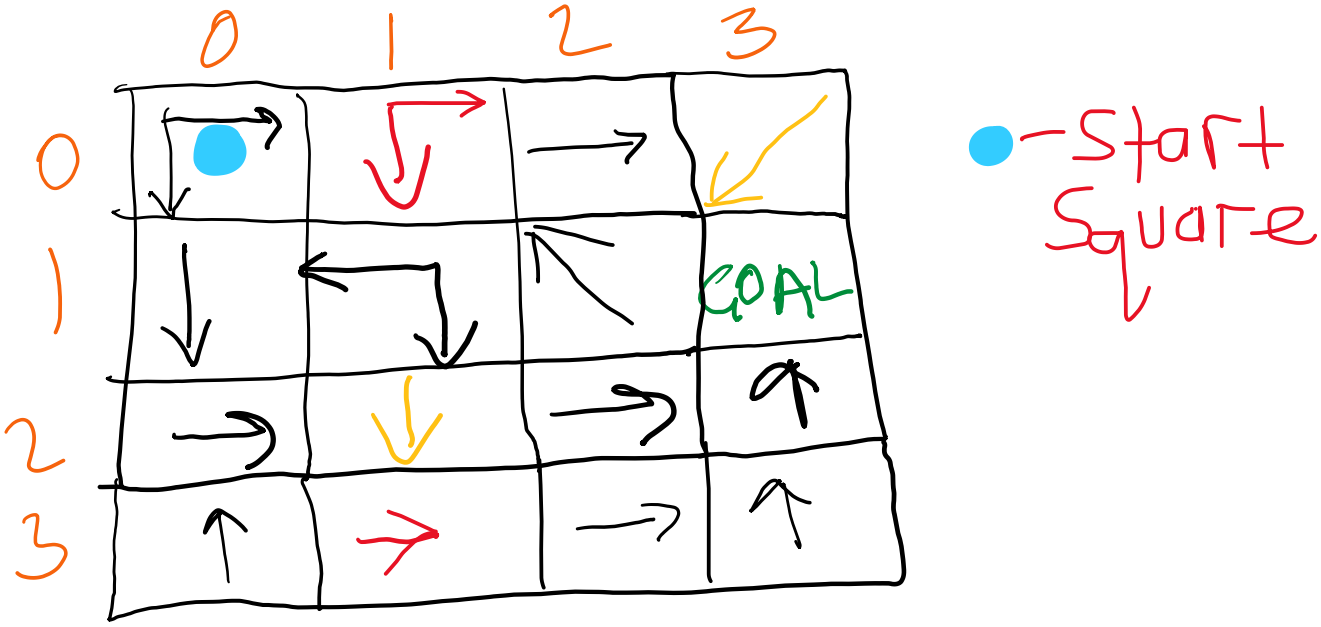
- The **expected output:**

**********Hello World, I Solve Alice Mazes**********

Start: (2, 0)
Goal Found: (0, 1)
The shortest path is (2, 0)->(1, 0)->(0, 0)->(0, 2)->(1, 1)->(0, 1)
The shortest path length is 5

test6_in.txt: Looping Path – Solution Found

- Here we demonstrate the solver still finds the shortest path to the goal even if there is a looping path: (0,0) → (0,1) → (0,3) → (1,2) → (0,1) → (0,3) → (1,2) ….
- The **input** file for this test is test6_in.txt



- The **expected output:**

**********Hello World, I Solve Alice Mazes**********

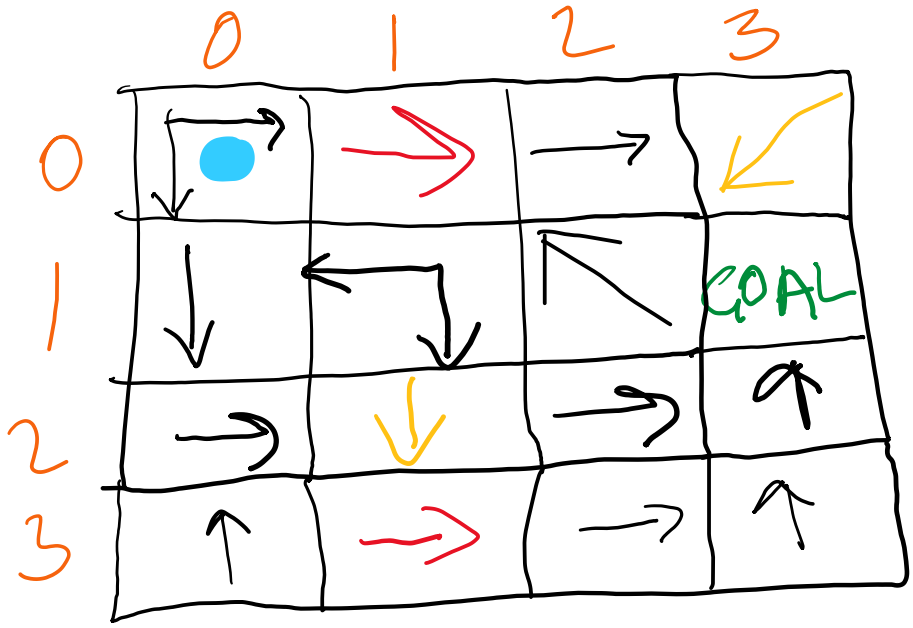
Start: (0, 0)
Goal Found: (1, 3)
The shortest path is (0, 0)->(0, 1)->(2, 1)->(3, 1)->(3, 3)->(1, 3)
The shortest path length is 5

test7_in.txt: Looping Path – No Solution

- Here we demonstrate the solver still terminates if there is no path to the goal even if there is a looping path: (0,0) → (0,1) → (0,3) → (1,2) → (0,1) → (0,3) → (1,2) ….
- The **input** file for this is test7_in.txt

**********Hello World, I Solve Alice Mazes**********

Start: (0, 0)
Destination is not found



● - Start Square