

## Spring 2024 COP 4533 Programming Project

**Language** - C, C++, or Python (your choice)

If you do not know any of these languages, please contact a TA

### Problem

You are in charge of directing water through an aqueduct from a source to several bath houses. The aqueduct consists of stations connected by ramps that carry water. The stations are laid out in an  $m \times n$  grid, in which the source station  $S$  is located at position  $(0,0)$ . From any station located at position  $(x,y)$ , where  $0 \leq x \leq m$  and  $0 \leq y \leq n$ , there is a ramp leading to the station at position  $(x-1,y)$ ,  $(x+1,y)$ ,  $(x,y-1)$ , and  $(x,y+1)$ , so long as the target station lies inside the grid. Each station is at some height above the ground, and the time it takes for water to move along a ramp from station  $(x,y)$  to station  $(x',y')$  is

$$\text{time}((x,y),(x',y')) = \max(-1, 1 + (\text{height}(x',y') - \text{height}(x,y))).$$

Given a set  $B = \{b_1 = (x_1, y_1), \dots, b_n = (x_n, y_n)\}$  of positions of stations that supply water to baths, a *supply path* is a (not necessarily simple) path in the aqueduct that starts from the source station  $S$  and visits every station in  $B$ . The cost of a supply path is the total time it takes water to move along this path. Note that if such a path visits station  $(x,y)$ , followed by station  $(x+1,y)$ , followed by station  $(x,y)$ , then the time it takes for water to move between these stations is

$$\text{time}((x,y),(x+1,y)) + \text{time}((x+1,y),(x,y))$$

Goal: given the set  $B$ , compute the minimum cost of any supply path.

### Submission/Grade Details

- Submit to Canvas a zip file named UFID\_4533PA1\_Lang, replacing UFID with your UFID and Lang with the programming language you used (Py, C, or Cpp). The zip file should contain your write-up and all files necessary to run your code. Further details below.

- (30 points) Write-up: write 1-2 paragraphs explaining your solution. You should include the definitions of dynamic programming problems you designed, and their recursive equations. Also, briefly discuss the time-complexity of your algorithm.
- (70 points) Program: submit the correct option below for your language
  - C/C++ - makefile and source code. To test this, we will run the commands (with map.txt in the folder).
 

```
make
./aqueduct
```
  - Python - aqueduct.py. We will test this using (with map.txt in the folder):
 

```
py ./aqueduct.py
```

### Program Input Details

Your program should read a file called “grid.txt” in the root directory (where the program is running). This file contains the following information:

1. Number of rows and columns in the grid - e.g. 5, 5
2. Station height, x-coordinate, and y-coordinate - e.g., 5, 1, 2. Each station is written on its own line. The stations are listed row by row, starting with the station at position (0,0). For example:
 

```
2, 0, 0
4, 1, 0
...
1, m, 0
7, 0, 1
...
```
3. x-coordinate and y-coordinate of the stations in B, each written on their own line. For example:
 

```
3, 2
4, 5
...
```

### **Expected output**

“pathLength.txt” file with the path length as an integer

You do **NOT** have to find the path itself

### **Constraints**

Number of stations in B will be between 1 and 100

The height of a station will be an integer between 1 and 25

The dimensions of the grid will be between 1 and 100

### **Examples**

Here is a simple example if map.txt looks like this:

3, 3

5, 0, 0

5, 1, 0

1, 2, 0

1, 0, 1

3, 1, 1

4, 2, 1

6, 0, 2

5, 1, 2

5, 2, 2

0, 0

0, 2

The output solution is 3.

Please find a more complex example map and corresponding answer in a folder on the assignment page