South African Computer Olympiad
Online Camp 2008
Day 1

Blow-torching Walls

Author

Carl Hultquist

Introduction

After Farmer John's cows tried to escape the farm recently, Farmer John decided that he has had enough: these cows must be sent to the abbatoir! The cows, who have been spying on Farmer John, have discovered this... and are very worried. They **really** need to escape now, otherwise they'll end up as roast beef on Farmer John's dinner table!

There is only one chance of escaping: and that is through the underground maze that runs beneath the farm. The cows raided Farmer John's office during the night and found a map of the maze. The only problem is that Farmer John has blocked up many parts of the maze with concrete wall... But luckily for the cows, they have also raided his toolshed and have stolen a blow-torch!

Blow-torching an entire piece of wall takes a **long** time: so the cows need to work out the smallest number of walls that they'll have to blow-torch away in order to escape the maze, and also find the shortest route that needs this number of walls blow-torched away.

Task

Your task is to help the cows plan their escape route. The maze consists of a number of square areas which are either open or which are a wall. The cows can move from any one of these square areas to any of the adjacent square areas (first blow-torching any wall that might be in the way). Moving from one square to another counts as moving a distance of 1 unit. You must:

1. Determine the smallest number of walls that need to be blow-torched for the cows to travel from the given starting point in the maze to the given ending point.
2. Determine the shortest route from the starting point to the ending point that requires Z walls to be blow-torched, where Z is the number determined in part 1. There may be more than one such route: you only need to determine one of them.

Example

Suppose the maze looks like the diagram below, where a '.' indicates an open part of the maze, and a 'W' indicates a wall, and that the cows need to get from the top-left hand corner to the bottom-right hand corner.

```
.W...
...WW
.W.W.
.WWW.
.WW..
```

The smallest number of walls that the cows need to blow-torch is 1, and they can get through the maze most quickly by moving: down, right, right, down, right (blow-torching this wall), right, down and down, which is a total of 8 units of movement.

Input (walls.in)

The first line of input will contain two integers, W and H, which indicate the width and height of the maze respectively. The second line of input will contain two integers, SX and SY, indicating the X and Y co-ordinates respectively of where the cows enter the maze. The third line of input will contain two integers, EX and EY, indicating the X and Y co-ordinates respectively of where the cows must exit the maze. The next H lines will each contain W integers, separated by spaces, that describe the maze. Each of these integers will either be 0 or 1: 0 indicates that there is no wall at that point in the maze, 1 indicates that there **is** a wall.

The upper-left co-ordinate of the maze is $(1, 1)$ and the lower-right co-ordinate is (W, H). This is illustrated below:

```
(1,1).........
..............
.........(W,H)
```

Sample input

```
5 5
1 1
5 5
0 1 0 0 0
0 0 0 1 1
0 1 0 1 0
0 1 1 1 0
0 1 1 0 0
```

Output (walls.out)

The first line of output must contain two integers, Z and L. Z is the smallest number of walls that need to be blow-torched (determined in part 1 above), and L is the

length of the shortest path that requires Z walls to be blow-torched. The next $L + 1$ lines should each contain two integers, X and Y, which indicate the co-ordinates of the route that the cows must take.

Sample output

```
1 8
1 1
1 2
2 2
3 2
3 3
4 3
5 3
5 4
5 5
```

Constraints

- $1 \leq W, H \leq 1000$
- The starting location, (SX, SY), will never have a wall on it.

50% constraints

- $1 \leq W, H \leq 250$

Time limit

5 seconds.

Scoring

If your output for a test-case differs in any way from the format prescribed above, then your program will score 0% for that test-case. If your path fails to lead the cows from the starting point to the ending point, then you will score 0%. If the number of walls you need to blow-torch in the path is different from Z, then you will score 0%.

Otherwise, let Q be the optimal number of walls that needed to be blow-torched. Let M be the optimal route length for a route requiring Q walls to be blow-torched. Put $K = \max(M, L)$. Your score is then given by $S = [100 - 30 \times (Z - Q)] \times (\frac{M}{K})^{Z-Q+1}\%$.

Thus if you find the optimal number of walls, and the optimal route for that number of walls, your solution scores 100% :-)