Project Topographic Prominence
Due: Wednesday, September 17
CSC615: Computational Geometry

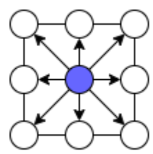
Objectives

- Input, store, and process basic geometric data (topological, in this case)
- Apply geometric algorithm techniques to solve a geometric problem
- Use advanced data structures to help process geometric data

1 Mountains and Cols

One way to classify the tallest mountains is to use *topographic prominence*[1] instead of just pure height. The *prominence* of a peak is the minimum height of a climb to the summit on any route from a higher peak, or from sea level (elevation 0) if there is no higher peak. The lowest point on that route is called the *col*.

For this problem, we will explore computing the prominence of various peaks as well as identifying the cols on a landmass. Your input will be a digital elevation model (DEM), specifically a digital terrain model (DTM), where each point is on a grid and stores a specific elevation (height) at that grid location. A point is a potential high peak if it is taller than the eight points around it.



The blue grid point and its eight neighbording points.

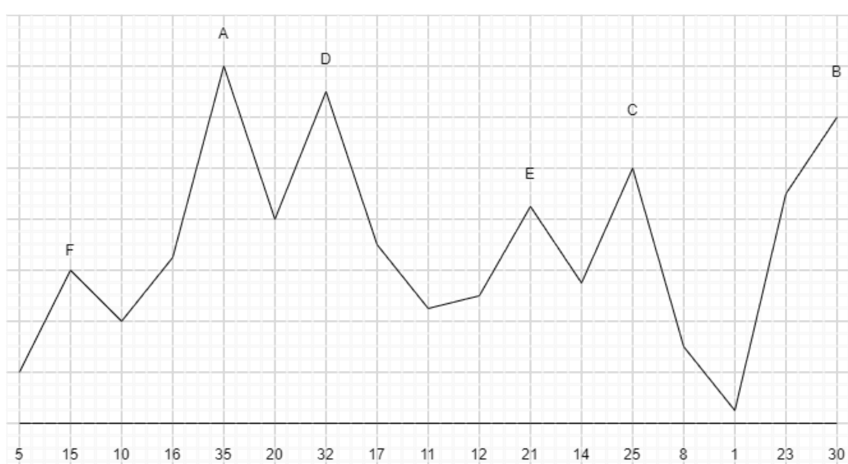
Your task is to output the 100 highest prominent peaks on the grid sorted by prominence by reporting the prominence of the peak, the (x, y) location of the peak, the peak's official height (elevation), the (x, y) location of the col, and the col's official height.

The point with the highest value is by definition the highest prominent peak. Its prominence is just its height and its col location and height would be printed as `NA NA NA`. The prominence of any other peak is computed by finding the col for that peak and taking the difference in height.

Determining the col for point p is the challenging part. By definition, you could look at every point q that is higher than p, calculate all paths connecting p to q, and among all those paths take the one that dips the least (has the highest low point). That is of course, impractical. So you will need to consider a far more efficient solution. The wikipedia article explaining topographic prominence hints at an efficient solution.

You can assume that sea level is at 0 and all points are at or above sea level (non-negative values). We will look at a landmass rather than an entire globe so you do not need to wrap the grid around to the other side. Essentially, the entire landmass is bordered by values at sea level (height 0).

Here is an example in two dimensions. Look at the following mountain range:



The following are the peaks ordered by *prominence*:

1. The highest peak is point A (position 4) with prominence 35.

[1] See https://en.wikipedia.org/wiki/Topographic_prominence

2. The second highest peak is point B with prominence 29.
   The route from B to summit D (position 6), which is higher, must go down to 1 first. The other direction goes to the ocean (0). So, the prominence is $30 - 1 = 29$.

3. The third highest peak is point C (position 12) with prominence 14.
   The route from C to summit B must go down to 1 first. The route to summit D would go down to 11. So, the col at position 8 with elevation 11 is chosen. So the prominence is $25 - 11 = 14$.

4. The fourth highest peak is point D (position 6) with prominence 12.
   The route from D to summit A must go down to 20 first. The route in the other direction never gets to a higher point so it goes to the ocean (0). So the prominence is $32 - 20 = 12$.

5. The fifth highest peak is point E (position 10) with prominence 7.
   The route from E to summit C must go down to 14 first. The route to summit D would go down to 11. So, the col at position 11 with elevation 14 is chosen. So the prominence is $21 - 14 = 7$.

6. The sixth highest (and final) peak is point F (position 1) with prominence 5.
   The route from F to summit A must go down to 10 first. The route in the other direction just goes to the ocean (0). So the prominence is $15 - 10 = 5$.

Presentation and Demo

On the due date, during class, each group shall present their algorithmic solution, analyze their algorithm's efficiency, and demonstrate their code on both the sample input data set and some new data sets presented that class. The first 15 minutes of class will be available to test running on the new data sets but then presentations will begin.

Group Work and Submissions

- You are welcome to work in groups of up to 5 people.
- You should include the list of all members in the comments.
- Only one member of the team needs to submit the code.
- Every member should participate in the presentation and demo of the code.

Tips

Here are a few tips to get you started:

- Work with smaller test cases first. Efficiency is important but it should be correct first.
- For efficiency, one suggestion is to use a line (plane) sweeping approach.