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Trapping Rain Water in a Matrix

Difficulty Level : Hard • Last Updated : 01 Sep, 2021



Given a <u>matrix</u> arr[][] of dimension M*N consisting of positive integers, where arr[i][j] represents the height of each unit cell, the task is to find the total volume of water trapped in the matrix after rain.

Examples:

Input: arr[][] = {{4, 2, 7}, {2, 1, 10}, {5, 10, 2}}

Output: 1

Explanation:

The rain water can be trapped in the following way:

- The cells, {(0, 0), (0, 1), (0, 2), (1, 0), (1, 2), (2, 0), (2, 1), (2, 2)} traps 0 unit volume of rain water as all water goes out of the matrix as cells are on the boundary.
- 2. The cell (2, 2) traps 1 unit volume of rain water in between the cells $\{(0, 1), (1, 0), (1, 2), \text{ and } (2, 1)\}$.

Therefore, a total of 1 unit volume of rain water has been trapped inside the matrix.

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Got It!

7/12/2022, 6:04 AM

Recommended: Please try your approach on *[IDE]* first, before moving on to the solution.

Approach: The given problem can be solved by using the <u>Greedy</u>

<u>Technique</u> and <u>Min-Heap</u>. Follow the steps below to solve the problem:

- Initialize a Min-Heap using the priority queue, say **PQ**, to store the pairs of positions of a cell and its height.
- Push all the boundary cells in the PQ and mark all the pushed cells as visited.
- Initialize two variables, say ans as 0 and maxHeight as 0 to store the total volume and the maximum height of all the cells in PQ respectively.
- Iterate <u>until **PQ** is not empty</u> and perform the following steps:
 - Store the top node of PQ in a variable, say front, and erase the top element of PQ.
 - Update the value of maxHeight as the maximum of maxHeight and front.height.
 - Now, <u>traverse to all the adjacent nodes</u> of the current cell
 (front.X, front.Y) and do the following:
 - If the adjacent cell is valid i.e, the cell is not out of bound and not yet visited, then, push the value of the adjacent cell into PQ.
 - If the height of the adjacent cell is less than maxHeight then increment the ans by the difference of maxHeight and the height of the adjacent cell.
- Finally, after completing the above steps, print the value of **ans** as the resultant water trapped after rain.

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```
// C++ program for the above approach
#include <bits/stdc++.h>
using namespace std;
// Stores the direction of all the
// adjacent cells
vector<vector<int> > dir
    = \{ \{ -1, 0 \}, \{ 0, 1 \}, \{ 1, 0 \}, \{ 0, -1 \} \};
// Node structure
struct node {
    int height;
    int x, y;
};
// Comparator function to implement
// the min heap using priority queue
struct Compare {
    // Comparator function
    bool operator()(node const& a, node const& b)
    {
        return a.height > b.height;
    }
};
// Function to find the amount of water
// the matrix is capable to hold
int trapRainWater(vector<vector<int> >& heightMap)
{
    int M = heightMap.size();
    int N = heightMap[0].size();
    // Stores if a cell of the matrix
    // is visited or not
    vector<vector<bool> > visited(M,
                                   vector<bool>(N, false));
    // Initialize a priority queue
    nnionity augustanda vactorinadas Companas nas
```

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```
// If element is not on
        // the boundary
        if (!(i == 0 || j == 0 || i == M - 1
              || j == N - 1)
            continue;
        // Mark the current cell
        // as visited
        visited[i][j] = true;
        // Node for priority queue
        node t;
        t.x = i;
        t.y = j;
        t.height = heightMap[i][j];
        // Pushe all the adjacent
        // node in the pq
        pq.push(t);
    }
}
// Stores the total volume
int ans = 0;
// Stores the maximum height
int max_height = INT_MIN;
// Iterate while pq is not empty
while (!pq.empty()) {
    // Store the top node of pq
    node front = pq.top();
    // Delete the top element of pq
    pq.pop();
    // Update the max_height
    max_height = max(max_height, front.height);
```

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```
for (int i = 0; i < 4; i++) {
        int new_x = curr_x + dir[i][0];
        int new_y = curr_y + dir[i][1];
        // If adjacent cells are out
        // of bound or already visited
        if (new_x < 0 || new_y < 0 || new_x >= M
            | | new_y >= N | | visited[new_x][new_y]) {
            continue;
        }
        // Stores the height of the
        // adjacent cell
        int height = heightMap[new_x][new_y];
        // If height of current cell
        // is smaller than max_height
        if (height < max_height) {</pre>
            // Increment the ans by
            // (max_height-height)
            ans = ans + (max_height - height);
        }
        // Define a new node
        node temp;
        temp.x = new_x;
        temp.y = new_y;
        temp.height = height;
        // Push the current node
        // in the pq
        pq.push(temp);
        // Mark the current cell
        // as visited
        visited[new_x][new_y] = true;
    }
}
```

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Output

4

Time Complexity: (N * M * log(N * M))

Auxiliary Space: O(N * M)

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Shortest Path Properties

Convert A into B by incrementing or decrementing 1, 2, or 5 any number of times

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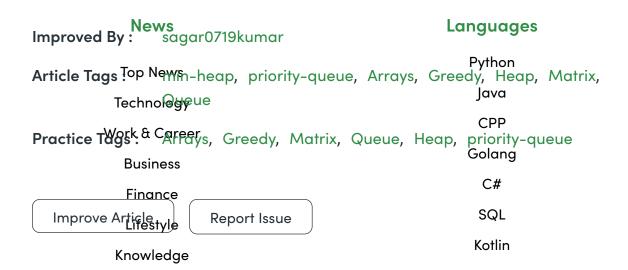
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