1605. Find Valid Matrix Given Row and Column Sums

Problem Description

Greedy Array

Matrix

Medium

and column, respectively, of a 2D matrix. However, you are not given the actual values in the matrix, only these sums. Your goal is to reconstruct any 2D matrix that has non-negative integers and satisfies the given rowSum and colSum. The size of the matrix will be rowSum.length rows and colSum.length columns. You are guaranteed that there is at least one valid matrix that meets the requirements.

In this problem, you are provided with two arrays, rowSum and colSum. These arrays represent the sum of the elements in each row

Intuition

By iteratively updating the sums, we are accounting for the value we've placed in each cell. When the minimum value is chosen, it reduces the remaining row or column sum without overshooting the required sum. After an allocation, we deduct the chosen value from both sums. This strategy preserves the constraints for every step since we only allocate as much as we can 'afford' from both the row and the column at that point.

To approach this problem, we can iterate through the matrix, starting from the top-left cell, and assign each cell a value that is

the minimum value, we are ensuring that we never exceed the sum requirements for either the row or the column.

the minimum between the current row's sum and the current column's sum. The intuition behind this strategy is that by assigning

The process continues until we've filled the entire matrix. At the end of this process, we have constructed a valid matrix that fulfills both row and column sum requirements because we've continuously deduct the allocated numbers from our sum arrays, ensuring that the end state satisfies the original conditions.

Solution Approach

The algorithm for the solution takes advantage of a simple greedy approach and basic properties of matrices. The following steps

Initialize the matrix ans to be of size m \times n, where m is the number of items in rowSum, and n is the number of items in colSum.

All elements in ans are initialized to zero.

are involved in the solution:

Iterate through each element of matrix ans, index by i for the rows and j for the columns. For each element ans [i] [j], calculate the minimum value between rowSum[i] and colSum[j], which indicates the allowable value for this position that satisfies both the row's and column's sum constraints.

Assign ans [i] [j] this minimum value, which is the greedy choice of allocating as much as possible to the current cell without exceeding the sums for its row and column.

Decrease the value of rowSum[i] and colSum[j] by the amount just allocated to ans[i][j]. This step is important as it

updates the remaining sums for the row and column, reflecting the fact that we've already used part of those sums for element ans [i] [j].

Continue this process throughout the entire matrix, filling in each element with the calculated value.

A 2D array ans to store the matrix values that we are building.

build up to a globally optimal solution that meets all conditions.

to construct a matrix that satisfies these row and column sums.

Subtract the allocated value from rowSum[0] and colSum[0]:

The minimum of rowSum[0] and colSum[1] is min(0, 4) which equals 0.

We'll follow the steps outlined in the solution approach:

- Data Structures:
- The input arrays rowSum and colSum are modified in place to keep track of the remaining sums after each allocation. Patterns and Properties Used:

Matrix properties: The solution exploits the property that each row and column in the matrix has a fixed sum, and any

This approach guarantees that by the end, when all cells are filled, the remaining sums for both rows and columns will be zero,

indicating that we've met all the rowSum and colSum constraints correctly. Our solution effectively constructs a valid matrix with

To illustrate the solution approach, let's consider a small example where we have rowSum = [5, 7] and colSum = [8, 4]. We need

Greedy approach: By constantly making the locally optimal choice of picking the minimum possible value for each cell, we

allocation in an individual cell affects both the row's and column's sum.

- non-negative integers that fits the given row and column sums. **Example Walkthrough**
- Initialize ans as a 2×2 matrix with all elements set to zero (since rowSum.length is 2 and colSum.length is 2): ans = [

Compute the minimum between rowSum[i] and colSum[j]. For ans [0] [0], this minimum is min(5, 8) which equals 5.

Start iterating through the elements of the matrix. We begin with i = 0 (first row) and j = 0 (first column).

ans = [[5, 0],

• New rowSum = [0, 7]

ans [0] [1] is set to 0.

Assign ans [0] [0] the value 5:

[0, 0],

[0, 0]

[0, 0]

[0, 0]

ans =

ans = [

is:

ans = |

[5, 0],

Python

Java

class Solution:

[5, 0],

[3, 4]

[5, 0],

- New colSum = [3, 4] Repeat steps 2-5 for the next element, ans [0] [1]:
- rowSum and colSum remain the same since the allocated number is 0. ans = [[5, 0],

For ans [1] [0], we take the minimum of rowSum [1] and colSum [0], which is min (7, 3) equals 3.

Finally for ans [1] [1], the minimum of rowSum[1] and colSum[1] is min(4, 4) equals 4.

def restoreMatrix(self, rowSums: List[int], colSums: List[int]) -> List[List[int]]:

Initialize a matrix filled with zeros with dimensions (num_rows x num_cols)

Determine the value at matrix[i][j] by taking the minimum between

Subtract the chosen value from the respective row sum and column sum

// Determine the minimum value to satisfy both rowSum and colSum constraints

// After setting the value for restoredMatrix[row][col], subtract it from

// the corresponding rowSum and colSum to maintain the sum constraints

the current row sum and column sum, to satisfy both constraints

Return the restored matrix that satisfies the row and column sums

// Get the number of rows and columns from the size of the passed arrays

// Return the restored matrix that matches the given row and column sums

Get the number of rows and columns from the given sums

num_rows, num_cols = len(rowSums), len(colSums)

Iterate through each cell in the matrix

for i in range(num_rows):

return matrix

for j in range(num_cols):

matrix[i][j] = value

rowSums[i] -= value

colSums[j] -= value

int rowCount = rowSum.length;

int colCount = colSum.length;

// Initialize the matrix to return

for (int row = 0; row < rowCount; ++row) {</pre>

rowSum[row] -= value;

colSum[col] -= value;

#include <algorithm> // to use the std::min function

for (let j = 0; j < numCols; j++) {</pre>

matrix[i][j] = minSum;

rowSums[i] -= minSum;

colSums[j] -= minSum;

// Return the constructed matrix

for i in range(num_rows):

for j in range(num_cols):

matrix[i][j] = value

rowSums[i] -= value

colSums[j] -= value

return matrix;

class Solution:

const minSum = Math.min(rowSums[i], colSums[j]);

Get the number of rows and columns from the given sums

num_rows, num_cols = len(rowSums), len(colSums)

Iterate through each cell in the matrix

matrix = [[0] * num_cols for _ in range(num_rows)]

value = min(rowSums[i], colSums[j])

// Assign that minimum value to the current matrix cell

// Update the remaining sum for the current row and column

def restoreMatrix(self, rowSums: List[int], colSums: List[int]) -> List[List[int]]:

Initialize a matrix filled with zeros with dimensions (num_rows x num_cols)

Determine the value at matrix[i][j] by taking the minimum between

Subtract the chosen value from the respective row sum and column sum

the current row sum and column sum, to satisfy both constraints

Return the restored matrix that satisfies the row and column sums

// Restores a matrix based on given row and column sums.

// - row_sum represents the sum of the elements for each row.

return restoredMatrix;

matrix = [[0] * num_cols for _ in range(num_rows)]

value = min(rowSums[i], colSums[j])

public int[][] restoreMatrix(int[] rowSum, int[] colSum) {

int[][] restoredMatrix = new int[rowCount][colCount];

for (int col = 0; col < colCount; ++col) {</pre>

restoredMatrix[row][col] = value;

// Iterate over each cell in the matrix to calculate its value

int value = Math.min(rowSum[row], colSum[col]);

Update rowSum and colSum: New rowSum = [0, 4]

ans [1] [0] is set to 3.

New colSum = [0, 4]

ans [1] [1] is set to 4.

Update rowSum and colSum:

New rowSum = [0, 0]

New colSum = [0, 0]

- At this point, we have filled the matrix while satisfying the row and column sums described by rowSum and colSum. The final matrix
- And thus we have reconstructed any 2D matrix using the solution approach, successfully meeting the given rowSum and colSum requirements.

Solution Implementation

class Solution { // Restores the matrix given the sum of every row and every column.

C++

public:

#include <vector>

class Solution {

```
// - col_sum represents the sum of the elements for each column.
    std::vector<std::vector<int>> restoreMatrix(std::vector<int>& row_sum, std::vector<int>& col_sum) {
        int rows = row_sum.size(); // Number of rows in the matrix.
       int cols = col_sum.size(); // Number of columns in the matrix.
        std::vector<std::vector<int>> matrix(rows, std::vector<int>(cols));
       // Iterate through each cell of the matrix
        for (int i = 0; i < rows; ++i) {
            for (int j = 0; j < cols; ++j) {
                // Find the minimum value between the current row sum and column sum.
                int value = std::min(row_sum[i], col_sum[j]);
                matrix[i][j] = value; // Assign the calculated value to the current cell.
                // Subtract the assigned value from both row and column sums.
                row_sum[i] -= value;
                col_sum[j] -= value;
       // The matrix is now restored such that it meets the row and column sums criteria.
       return matrix;
};
TypeScript
function restoreMatrix(rowSums: number[], colSums: number[]): number[][] {
    const numRows = rowSums.length; // Number of rows based on rowSums length
    const numCols = colSums.length; // Number of columns based on colSums length
   // Initialize a 2D array 'matrix' with dimensions numRows x numCols filled with zeros
    const matrix: number[][] = Array.from({ length: numRows }, () => new Array(numCols).fill(0));
    // Iterate over each cell in the matrix
   for (let i = 0; i < numRows; i++) {</pre>
```

// Determine the minimum value between the current row sum and column sum

```
Time and Space Complexity
Time Complexity
```

return matrix

The time complexity of the given code is 0(m * n), where m is the number of rows and n is the number of columns. This is

because the code contains two nested loops: the outer loop iterating over each row, and the inner loop iterating over each column. On each iteration, it performs a constant amount of work (calculating the minimum and updating rowSum and colSum). **Space Complexity**

The space complexity of the code is 0(m * n), this space is used to store the answer matrix ans. Other than that, the only extra space used is a constant amount for variables like x, i, j, and the space to copy and update the rowSum and colSum arrays, which does not depend on the size of the input and thus does not increase the order of space complexity.