EECE 7205 Fundamentals of Computer Engineering

Report of Project1

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Problem Description:

You are given an input array $A[1, \dots, N]$. A grouping of the array A is described by an array $G[1, \dots, M]$, where the array A is partitioned into M groups, the 1st group consists of the first $G[1]$ elements of array A, the 2nd group consists of the next $G[2]$ elements, and so forth. Define array $B[1, \dots, M]$ such that $B[j]$ is the summation of the elements in the j-th group of array A. Use a dynamic programming algorithm to find a grouping of array A with M groups such that we maximize the minimum element of array B.

Max-min-grouping(A, N, M)

{

return $G[1, \dots, M]$

}

Part1 Pseudo Codes

First, I will show the pseudo codes as below:

Max_min_grouping (A, G, m, n) // A is input. G is an empty array and

G will be output, m is array A's size and n is the number of groups //

if $m \geq n \;\&\&\; n > 1$

c[n,m], p[n,m] to be new tables

for $i \leftarrow 0 \; to \; m-1$

$$c[0,i] \leftarrow \sum_{k=0}^{i} A[k]$$

$$p[0,i] = 0$$

for $j \leftarrow 1 \; to \; n-1$

for $i \leftarrow j \; to \; m-1$

$$c[j,i] \leftarrow \max_{j-1 \leq k < i} \min\{\, c[j-1,k], \quad \sum_{p=k+1}^{i-1} A[p] \,\}$$

$$p[j,i] \leftarrow \arg \max_{j-1 \leq k < i} \min\{\, c[j-1,k], \quad \sum_{p=k+1}^{i-1} A[p] \,\}$$

$G[n-1] \leftarrow p[n-1, m-1]$

for $j \leftarrow n-2 \; to \; 0$

$$G[j] \leftarrow m - \sum_{p=j+1}^{n-1} G[p] - p[j][m-1-\sum_{p=j+1}^{n-1} G[p]]$$

else if $n \leftarrow 1$

$G[0] \leftarrow m$

else

print "The factors input are not correct! "

Part2 Analysis of Running Time

This part I will calculate the running time of this algorithm. Note that m is the size of array A needed to be grouped, and n is the number of groups.

First, the algorithm will use "if" sentence to find the proper case. The running time of this is $\theta(1)$. The algorithm will consider three cases. I find that the latter two cases are not common cases and their running time is not large, so next step I will mainly consider the first case: if $m \geq n \,\&\&\, n > 1$.

Then, I find that the first "for" loop in the first case needs to sum up all the numbers in the array A and it will repeat m times, so in this operation the running time is $\theta(m^2)$.

Next, there are two "for" loops between which one (from 1 to m-1) is nested in another (from 1 to n-1). And the operation needs to find the maximum number from an array whose range is from j-1 to i. And the worst case we need to sum up the array's numbers whose range are from 0 to m-1(can be nearly the total array). So this part the running time is $O(m^2 n)$.

At last, the "for" loop is from n-2 to 0, so the running time is $O(n)$.

Totally the sum of four sections' running time can be $O(m^2 n)$. If n is smaller enough than m, the running time can be $\theta(m^2)$. But n is a randomized number, so ultimately the running time of the algorithm is $O(m^2 n)$.

Part3 Results

This part I will show how to use six examples below to test my codes. These examples contain almost every kind of case, which is illustrated below:

Example1:

Input: A1= {3,9,7,8,2,6,5,10,1,7,6,4}

M1=3

Output: G1= {3,4,5}

Note: The input is the same with the project request.

Example2:

Input: A2= {5,4,15,13,2,4,20,9,2,4}

M2=10

Output: G2= {1,1,1,1,1,1,1,1,1,1}

Note: The number of groups is the equal to the size of array A2.

Example3:

Input: A3= {5,19,5,71,20,13}

M3=1

Output: G3= {6}

Note: The number of groups is 1.

Example4:

Input: A4= {3,8,50,1,3,44,12,5,9,32,9,7}

M4=6

Output: G4= {3,3,1,2,1,2}

Example5:

Input: A5= {5,7,3,4,8,1,20,4,5,13,8,10,6,9,12,3,6,14,11,5}

M5=5

Output: G5= {6,3,3,4,4}

Example6:

Input: A6= {2,5,4,8}

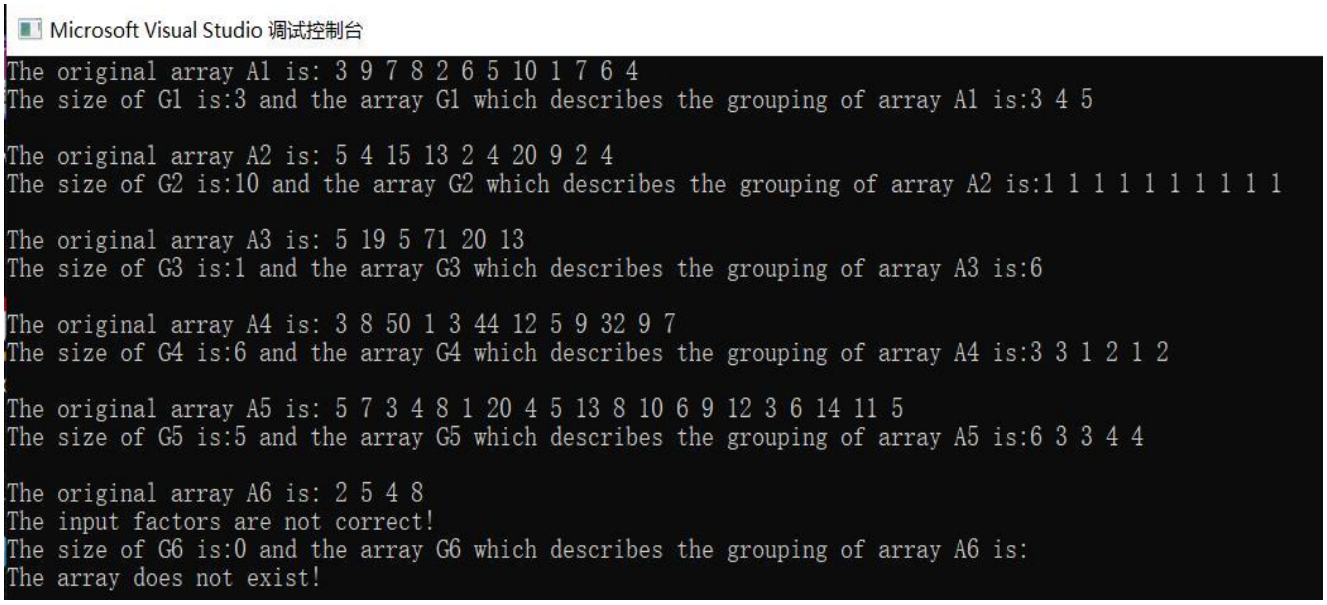
M6=0

Output: The input factors are not correct!

The array does not exist!

Note: The number of groups is 0 (It is not a correct factor).

And my result of codes is as following:



Part4 Source codes

This part, I will list the source codes as below:

```
#include "Matrix.h"
#include<iostream>
using namespace Numeric_lib;
using namespace std;

// the fuction of summing up an array which begins with A[p] and ends with A[q]
int sumup(Matrix<int,1>&A, int p, int q)
{
	if (q >= p)
	{
		int i;
		int sum;
		sum = 0;
		for (i = p; i <= q; i++)
			sum = sum + A(i);
		return sum;
	}
}

// find the minimum in two numbers
int min_in2(int p, int q)
{
	if (p <= q)
		return p;
	else
		return q;
}

// find the serial number of the maximum number in an array
int max_inarray(Matrix<int,1>&A, int p, int q)
{
	if (q > p)
	{
		int i;
		int max;
		max = p;
		for (i = p; i <= q; i++)
			if (A(i) > A(max))
				max = i;
```

```
            return max;
        }
        else if (p == q)
            return p;
}

void max_min_grouping(Matrix<int,1>&A, Matrix<int,1>&G, int m, int n)
{
        if ((m >= n) && (n > 1))
        {
            Matrix<int, 2>c(n, m);
            Matrix<int, 2>p(n, m);
            Matrix<int, 1>b(m);
            int i, j, k;
            for (i = 0; i < m; i++)
            {
                c(0, i) = sumup(A, 0, i);
                p(0, i) = 0;
            }
            for (j = 1; j < n; j++)
            {
                for (i = j; i < m; i++)
                {
                    for (k = 0; k < i; k++)
                        b(k) = min_in2(c(j - 1, k), sumup(A, k + 1, i));
                    c(j, i) = b(max_inarray(b, 0, i - 1));
                    p(j, i) = 1 + max_inarray(b, 0, i - 1);
                }
            }
            G(n - 1) = m - p(n - 1, m - 1);
            for (j = n - 2; j >= 0; j--)
                G(j) = m - sumup(G, j + 1, n - 1) - p(j, m - 1 - sumup(G, j + 1, n - 1));
        }
        else if (n == 1)
            G[0] = m;
        else
        {
            cerr << "The input factors are not correct!";
            cout << endl;
        }
}

// print all numbers of an array
void print_all_array1(Matrix<int, 1>&A)
```

```
{
	if (A.size() > 0)
	{
		int i;
		for (i = 0; i < A.size(); i++)
			cout << A(i) << " ";
		cout << endl;
	}
	else
	{
		cout << endl;
		cerr << "The array does not exist!";
		cout << endl;
	}
}

int main()
{
	int C1[12] = { 3,9,7,8,2,6,5,10,1,7,6,4 };
	int C2[10] = { 5,4,15,13,2,4,20,9,2,4 };
	int C3[6] = { 5,19,5,71,20,13 };
	int C4[12] = { 3,8,50,1,3,44,12,5,9,32,9,7 };
	int C5[20] = { 5,7,3,4,8,1,20,4,5,13,8,10,6,9,12,3,6,14,11,5 };
	int C6[4] = { 2,5,4,8 };
	int M1 = 3, M2 = 10, M3 = 1, M4 = 6, M5 = 5, M6 = 0;
	Matrix<int, 1>A1=C1;
	Matrix<int, 1>G1(M1);
	cout << "The original array A1 is: ";
	print_all_array1(A1);
	max_min_grouping(A1, G1, A1.size(), G1.size());
	cout << "The size of G1 is:"<<M1<<" and the array G1 which describes the grouping of
array A1 is:";
	print_all_array1(G1);
	cout << endl;
	Matrix<int, 1>A2 = C2;
	Matrix<int, 1>G2(M2);
	cout << "The original array A2 is: ";
	print_all_array1(A2);
	max_min_grouping(A2, G2, A2.size(), G2.size());
	cout << "The size of G2 is:" << M2 << " and the array G2 which describes the grouping of
array A2 is:";
	print_all_array1(G2);
	cout << endl;
	Matrix<int, 1>A3 = C3;
```

```
    Matrix<int, 1>G3(M3);
    cout << "The original array A3 is: ";
    print_all_array1(A3);
    max_min_grouping(A3, G3, A3.size(), G3.size());
    cout << "The size of G3 is:" << M3 << " and the array G3 which describes the grouping of array A3 is:";
    print_all_array1(G3);
    cout << endl;
    Matrix<int, 1>A4 = C4;
    Matrix<int, 1>G4(M4);
    cout << "The original array A4 is: ";
    print_all_array1(A4);
    max_min_grouping(A4, G4, A4.size(), G4.size());
    cout << "The size of G4 is:" << M4 << " and the array G4 which describes the grouping of array A4 is:";
    print_all_array1(G4);
    cout << endl;
    Matrix<int, 1>A5 = C5;
    Matrix<int, 1>G5(M5);
    cout << "The original array A5 is: ";
    print_all_array1(A5);
    max_min_grouping(A5, G5, A5.size(), G5.size());
    cout << "The size of G5 is:" << M5 << " and the array G5 which describes the grouping of array A5 is:";
    print_all_array1(G5);
    cout << endl;
    Matrix<int, 1>A6 = C6;
    Matrix<int, 1>G6(M6);
    cout << "The original array A6 is: ";
    print_all_array1(A6);
    max_min_grouping(A6, G6, A6.size(), G6.size());
    cout << "The size of G6 is:" << M6 << " and the array G6 which describes the grouping of array A6 is:";
    print_all_array1(G6);
}
```

The head file “Matrix.h” is in the file “First Submission.zip”, and I will not list the codes here for that the codes are too long.

Part5 Summary

At last, I successfully design an algorithm and codes to group one array as

requests. As the results show, the codes can work very well and fit the bill. The problem is that I do not design a beautiful interface for users, like GUI. This is because my C++'s skill is not so good. I believe in several days' study, I can address this problem.