SM2-21ST Computer Lab 8

2D Array

3 Nov 2017, Friday, 6:45pm

Assignment 1

Unzip lab8.zip sent to you by email attachment. The content in **image.c** is related to a digitized image of an English letter. The image is composed of 8x8 small rectangles, and the content of each rectangle is a digit representing the light intensity. Assume that the range of the light intensity in the image is unknown.

```
6 6 6 6 6 6 6 6
6 2 2 2 2 2 2 6
6 3 1 0 1 1 2 7
6 6 5 0 1 5 6 6
6 6 5 3 3 5 6 7
7 6 5 3 2 6 6 7
7 6 6 2 2 5 6 7
7 7 7 7 7 7 7 7
```

(In our scale of light intensity, 0 represents no light (completely dark), and the light intensity increases or the rectangle becomes brighter for a larger value.)

What you have to do is to complete the program to convert the digitized image to a binary image and display the English letter on the screen. The following steps should be followed.

(i) Write a function to compute the threshold for constructing a binary image based on the contents of digitized image. The function header is given as follows:

```
float computeThreshold (int  image[8][8])
```

This function will first find the maximum (max) and the minimum (min) values of the light intensity from the 64 rectangles and return $\frac{(max+ min)}{2}$ to its caller.

(ii) Write a function to convert the digitized image to a binary image based on a threshold value. The function header is given as follows.

```
void convertToBinaryImage (int image[8][8], float threshold)
```

This function will change the light intensity for all the rectangles to either 0 (dark) or 1 (bright).

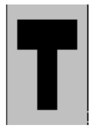
Suggested algorithm :

```
for each row
  for each rectangle in the row
  {
     if the light intensity of this rectangle > threshold
        change that intensity to 1 (bright);
     else
        change that intensity to 0 (dark);
  }
```

(iii) Write a `main` function that declares an int-array of dimension 8x8, and initializes the array by the digitized values. The `main` function will call the first function to compute the threshold for constructing the binary image, and call the second function to convert the digitized image to a binary image based on the threshold value. Finally, the `main` function will display the binary image on the screen by the following suggested algorithm:

```
for each row
{
   print a new line;
   for each rectangle in the row
   {
       if the binary value of this rectangle is 1
          print a rectangle (ASCII code = 219);
       else
          print a space to skip the rectangle;
   }
}
```

On the screen we should see a capital T.



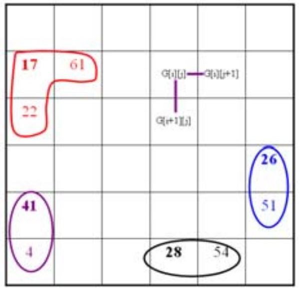
Use debugger whenever in doubt !!

Assignment 2

Given *n* x *n* unsorted data. Let **G** represent a square grid, where G[i][j] refers to the data on the grid location (i, j), $0 \le i < n$, and $0 \le j < n$. The root of grid/sub-grid refers to the left-top corner data on the grid/sub-grid region. The sons of G[i][j] refer to G[i][j+1] and G[i+1][j] if they exist. **G** is said to have heap property if for each G[i][j], G[i][j] $\le$ G[i][j+1] if G[i][j+1] exists, and G[i][j] $\le$ G[i+1][j] if G[i+1][j] exists. Assume n = 6, and **G** is loaded with random data initially.

	j=0	j=1	j=2	j=3	j=4	j=5
i=0	88	31	29	21	1	99
i=1	17	61	16	13	19	50
i=2	22	27	18	71	56	17
i=3	83	66	98	29	97	26
i=4	41	32	76	10	43	51
i=5	4	63	23	28	54	84

Initial Grid Contents with Random Data



The Father-and-Son Relationship in a Square Grid

The heap property in the square grid can be established by a pre-processing procedure where each row in **G** is sorted in ascending order, followed by each column in ascending order.

```
88 31 29 21  1 99
17 61 16 13 19 50
22 27 18 71 56 17
83 66 98 29 97 26
41 32 76 10 43 51
 4 63 23 28 54 84
```

Random Data

```
 1 21 29 31 88 99
13 16 17 19 50 61
17 18 22 27 56 71
26 29 66 83 97 98
10 32 41 43 51 76
 4 23 28 54 63 84
```

After Row Sort

```
 1 16 17 19 50 61
 4 18 22 27 51 71
10 21 28 31 56 76
13 23 29 43 63 84
17 29 41 54 88 98
26 32 66 83 97 99
```

After Column Sort
(Heap property established)

But G is said to be sorted only if G[0][0] $\le$ G[0][1] $\le$ … $\le$ G[0][n-1] $\le$ G[1][0] $\le$ G[1][1] $\le$ … $\le$ G[1][n-1] $\le$ … < G[i][0] $\le$ ….. $\le$ G[i][n-1] $\le$ G[i+1][0] $\le$ ….$\le$ G[n-1][n-1]. After the pre-processing procedure is performed, the data in the square

grid is not sorted yet. The following data interchange and heap restoration procedure is able to arrange the data on **G** in ascending order.

For each data on (i_1, j_1), $0 \le i_1 \le$ n-2, $1 \le j_1 \le$ n-1, we move the data on **G** to their be-sorted location, which is the grid location the value should be placed, in row-wise order from the left-top corner to the right-bottom corner. To insert a sorted data to (i_1, j_1) we have to compare G[i_1][j_1] and G[i_1+1][0]. Data interchange is required if these two data are not in order, followed by the heap restoration of the affected sub-grid. To restore the heap property, we first restore the heap property of a cell of 3 data, which consists of the new data, denoted by u, at the root of the affected sub-grid and the two sons of u (or one son for boundary condition). Such a cell restoration is performed recursively until no data interchange is required.

```
 1 16 17 19 50 61
 4 18 22 27 51 71
10 21 28 31 56 76
13 23 29 43 63 84
17 29 41 54 88 98
26 32 66 83 97 99
```

G[0][1] and G[1][0] are compared.

```
 1  4 17 19 50 61
16 18 22 27 51 71
10 21 28 31 56 76
13 23 29 43 63 84
17 29 41 54 88 98
26 32 66 83 97 99
```

G[0][1] and G[1][0] are exchanged.

```
 1  4 17 19 50 61
10 18 22 27 51 71
16 21 28 31 56 76
13 23 29 43 63 84
17 29 41 54 88 98
26 32 66 83 97 99
```

Heap restoration continues …

```
 1  4 17 19 50 61
10 18 22 27 51 71
13 21 28 31 56 76
16 23 29 43 63 84
17 29 41 54 88 98
26 32 66 83 97 99
```

Heap restoration for G[0][1] is completed as no interchange of data is needed.

Once the data interchange and heap restoration is completed for G[0][1], we have to do the same for G[0][2] and so on.

1	4	17	19	50	61
10	18	22	27	51	71
13	21	28	31	56	76
16	23	29	43	63	84
17	29	41	54	88	98
26	32	66	83	97	99

G[0][2] and G[1][0] are compared.

1	4	10	13	16	17
17	18	19	21	22	23
26	27	28	29	29	31
32	41	43	50	51	54
56	61	63	66	71	76
83	84	88	97	98	99

Sorted Data

Unzip lab8.zip to complete the program named as **gridsort.c** to sort 64 random numbers in an 8x8 integer array. Check the contents of grid after each procedure is performed. If your program runs correctly, the screen output will be as shown on the right:

```
Raw Data:
   94     3    98   164    92    34   163   174
    2   199    34    82    28   190   141    24
   17   139   151    78     6   183   128   111
   97    49   183   183    90   108    53    76
  163    55    31   165   191    71   115   173
   15    24   155   176    22    86   102    23
  109   188   163    94   163    46   158   117
   90   156    82    34    55   126    20    78
Checksum = 6420

After row sort:
    3    34    92    94    98   163   164   174
    2    24    28    34    82   141   190   199
    6    17    78   111   128   139   151   183
   49    53    76    90    97   108   183   183
   31    55    71   115   163   165   173   191
   15    22    23    24    86   102   155   176
   46    94   109   117   158   163   163   188
   20    34    55    78    82    90   126   156
Checksum = 6420

After column sort:
    2    17    23    24    82    90   126   156
    3    22    28    34    82   102   151   174
    6    24    55    78    86   108   155   176
   15    34    71    90    97   139   163   183
   20    34    76    94    98   141   164   183
   31    53    78   111   128   163   173   188
   46    55    92   115   158   163   183   191
   49    94   109   117   163   165   190   199
Checksum = 6420

After interchange and restoration:
    2     3     6    15    17    20    22    23
   24    24    28    31    34    34    34    46
   49    53    55    55    71    76    78    78
   82    82    86    90    90    92    94    94
   97    98   102   108   109   111   115   117
  126   128   139   141   151   155   156   158
  163   163   163   163   164   165   173   174
  176   183   183   183   188   190   191   199
Checksum = 6420   sorted

Press any key to continue . . . _
```

What is the time complexity of this Square Grid Sort Algorithm to sort ***n*** random data where ***n*** is a square number?

Use debugger whenever in doubt !!