COMPUTER VISION   PROJECT 1: HISTOGRAM THRESHOLD   C++

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Project Due date: 2/14/2021

Algorithm Steps for Computing the Histogram

Step 0: **Input file** (Gray-Scale image). Open **Output files** for histogram.

Step 1: Read the image header. Obtain the **numRows, numCols, minVal,** and **maxVal** from the given input file. Dynamically allocate the **histAry [...]** initializing all indices values to 0.

Step 2: Read the file left → right from Top → Bottom. Read one pixel at a time and augment the pixels value by one.

Step 3: Repeat step 2 until the input file is empty.

Step 4: Write histogram array to **Output file**.

Step 5: Close input file and output file streams

Algorithm Steps for Binary Threshold Operation

Step 0: **Input file** (Gray-Scale image). Open **Output files** for histogram. **Threshold** is given.

Step 1: Read the file left → right from Top → Bottom. Read one pixel at a time and augment the pixels value by one.

```
Step 2: If (the pixel value) ( P( x, y ).value >= threshold)
                    P' (x, y).value = 1;
    Else
                    P' (x, y).value = 0;
```

Step 3: Repeat **Step 1** and **2** until all pixels are processed.

Source Code

```
/* Andrew Alleyne
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 */

#include <iostream>
#include <fstream>
#include <string>
#include <vector>
#include <bits/stdc++.h>

using namespace std;

class Image
{
private:
  int numRows;
  int numCols;
  int minVal;
  int maxVal;
  int *histAry;
  int thresholdValue;

public:
  string inputFile;
  ifstream input;

  string line;
  string histogramHeader;

  vector<string> tokens;

  ofstream myOutputFile;
  string outputData;

  ofstream myOutputFile2;
  string outputData2;

  ofstream myOutputFile3;
  string outputData3;

public:
  Image(string inputFile, int thresholdValue, string outputData, string outputData2)
  {

    //Open input file to get headers
    input.open(inputFile);

    getline(input, line, '\n');

    histogramHeader = line;

    //Open output file for later use
    myOutputFile.open(outputData);

    //Open output file for later use
    myOutputFile2.open(outputData2);

    //Tokenize string
    stringstream check1(line);
    while (getline(check1, line, ' '))
    {
      tokens.push_back(line);
    }

    numRows = stoi(tokens[0]);
    numCols = stoi(tokens[1]);
    minVal = stoi(tokens[2]);
    maxVal = stoi(tokens[3]);

    //Dynamically allocate and initialize 1-D array
    histAry = new int[maxVal + 1];

    for (int i = 0; i < maxVal; i++)
    {
      histAry[i] = 0;
    }
  }

  void computeHistogram()
  {
    int pixel;
    while (input >> pixel)
    {
      histAry[pixel]++;
    }
    input.close();
  }

  void printHistogram()
  {
    myOutputFile << histogramHeader << endl;
    for (int i = 0; i <= maxVal; i++)
    {

      myOutputFile << i << " " << histAry[i] << "";

      myOutputFile << endl;
    }
           myOutputFile.close();
         }

        void displayHist()
         {

           myOutputFile2 << histogramHeader << endl;
           for (int i = 0; i <= maxVal; i++)
           {
             int pixValRep = 0;

             myOutputFile2 << i << " " << histAry[i] << " ";
             /* Use the maximum of 70 +’s for all counts greater than 70. Use small font
             size so that 70 +'s can be printed on one text line. */
             while (pixValRep != histAry[i] && pixValRep <= 70)
             {
               myOutputFile2 << "+";
               pixValRep++;
             }
      myOutputFile2 << endl;
    }
    myOutputFile2.close();
  }

  void threshold(ifstream &inputFile, ofstream &outputFile3, ofstream &outputFile4, int thresholdValue)
  {
    string line2;
    int line3;
    getline(inputFile, line2, '\n');

    //Header for Binary Threshold Operation - !FIXME BEFORE NEXT ASSIGNEMNT
    outputFile3 << numRows << " " << numCols << " " << 0 << " " << 1 << endl;
    outputFile4 << numRows << " " << numCols << " " << 0 << " " << 1 << endl;

    if (inputFile.is_open() && outputFile3.is_open() && outputFile4.is_open())
    {
      while (!inputFile.eof())
      {
        for (int y = 0; y < numRows; y++)
        {
          for (int x = 0; x < numCols; x++)
          {
            inputFile >> line3;

            if (line3 >= thresholdValue)
            {
              outputFile3 << 1 << " ";
              outputFile4 << 1 << " ";
            }
            else
            {
              outputFile3 << 0 << " ";
              outputFile4 << "."
                          << " ";
            }
          }
          outputFile3 << endl;
          outputFile4 << endl;
        }
      }
    }
  }
};

int main(int argc, char *argv[])
{
  /*
  check argument count.
  ./a.out,
  data.txt,
  Threshold values */

  if (argc < 7)
  {
    cout << "Missing arguments. It should look like "
         << "\"  inputFile ThresholdValue(int) outputFile1.txt ...... outputFile4.txt \"" << endl;
  }

```
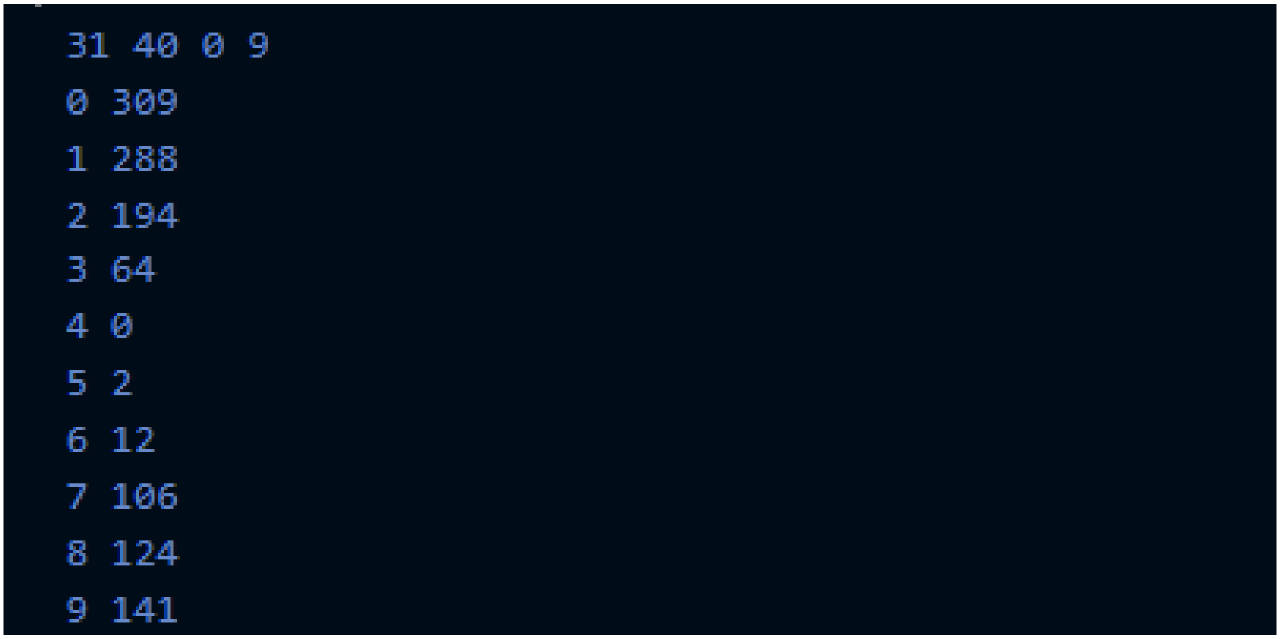
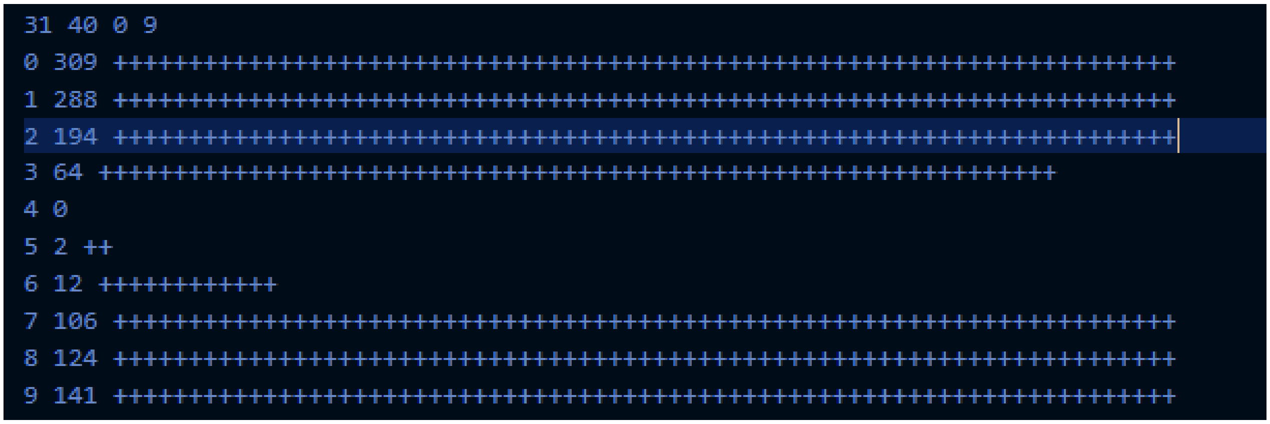

```
    //Get input filename
    string inputFile = argv[1];

    //Get threshold
    int thresholdValue = atoi(argv[2]);

    string outputFile1 = argv[3];
    string outputFile2 = argv[4];

    //Iamge class
    Image
        image(inputFile, thresholdValue, outputFile1, outputFile2);
    image.computeHistogram();
    image.displayHist();
    image.printHistogram();

    //Reopen inputfile stream
    ifstream inputFileStream;
    inputFileStream.open(inputFile);

    string outputFile3 = argv[5];
    string outputFile4 = argv[6];

    ofstream outputFile3_Stream;
    outputFile3_Stream.open(outputFile3);

    ofstream outputFile4_Stream;
    outputFile4_Stream.open(outputFile4);

    image.threshold(inputFileStream, outputFile3_Stream, outputFile4_Stream, thresholdValue);

    return 0;
  }
```

Program output for data1 with a threshold value of 5.



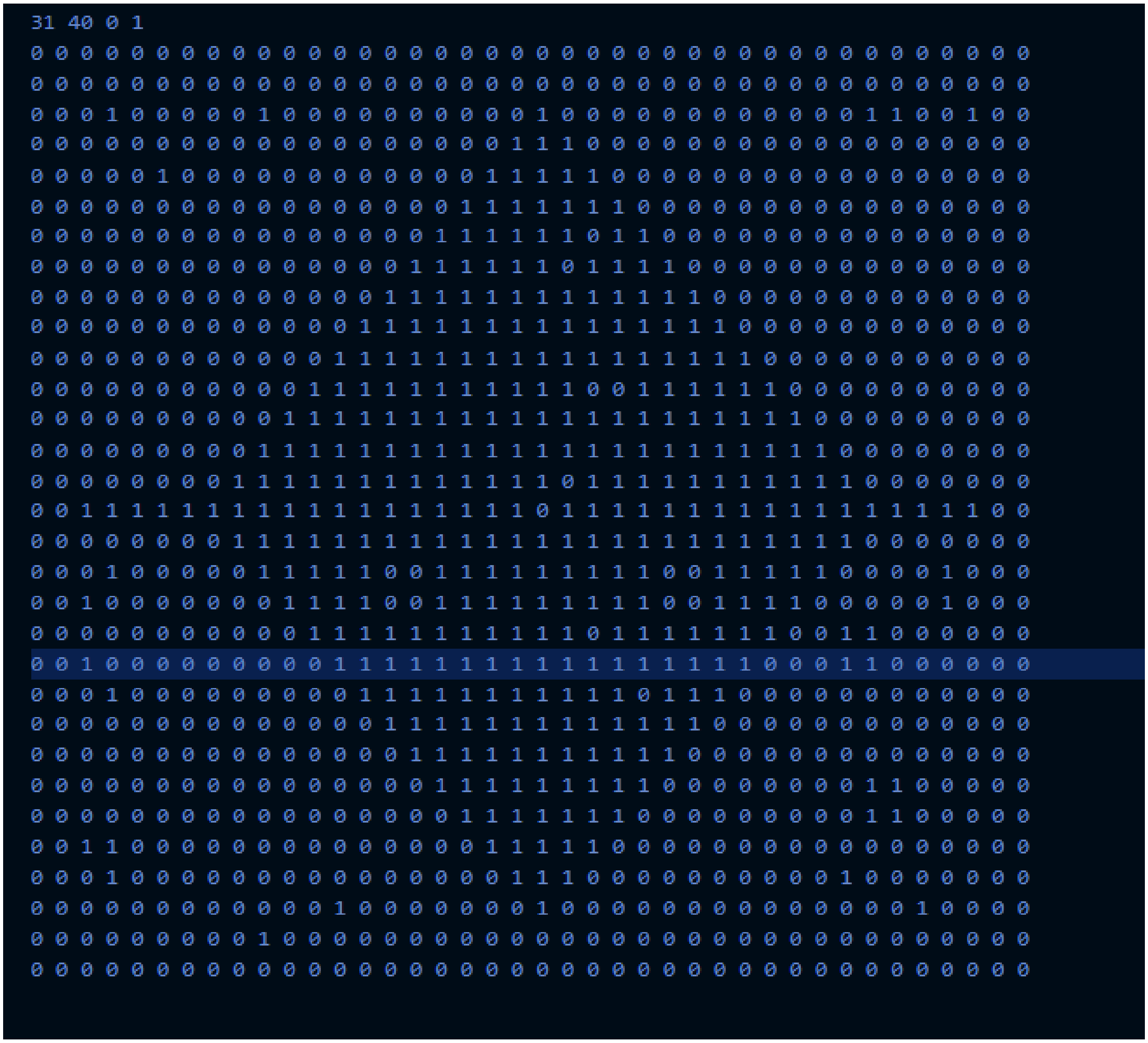
```
31 40 0 9
0 309
1 288
2 194
3 64
4 0
5 2
6 12
7 106
8 124
9 141
```

Figure 1: Output outFile1 for data 1.



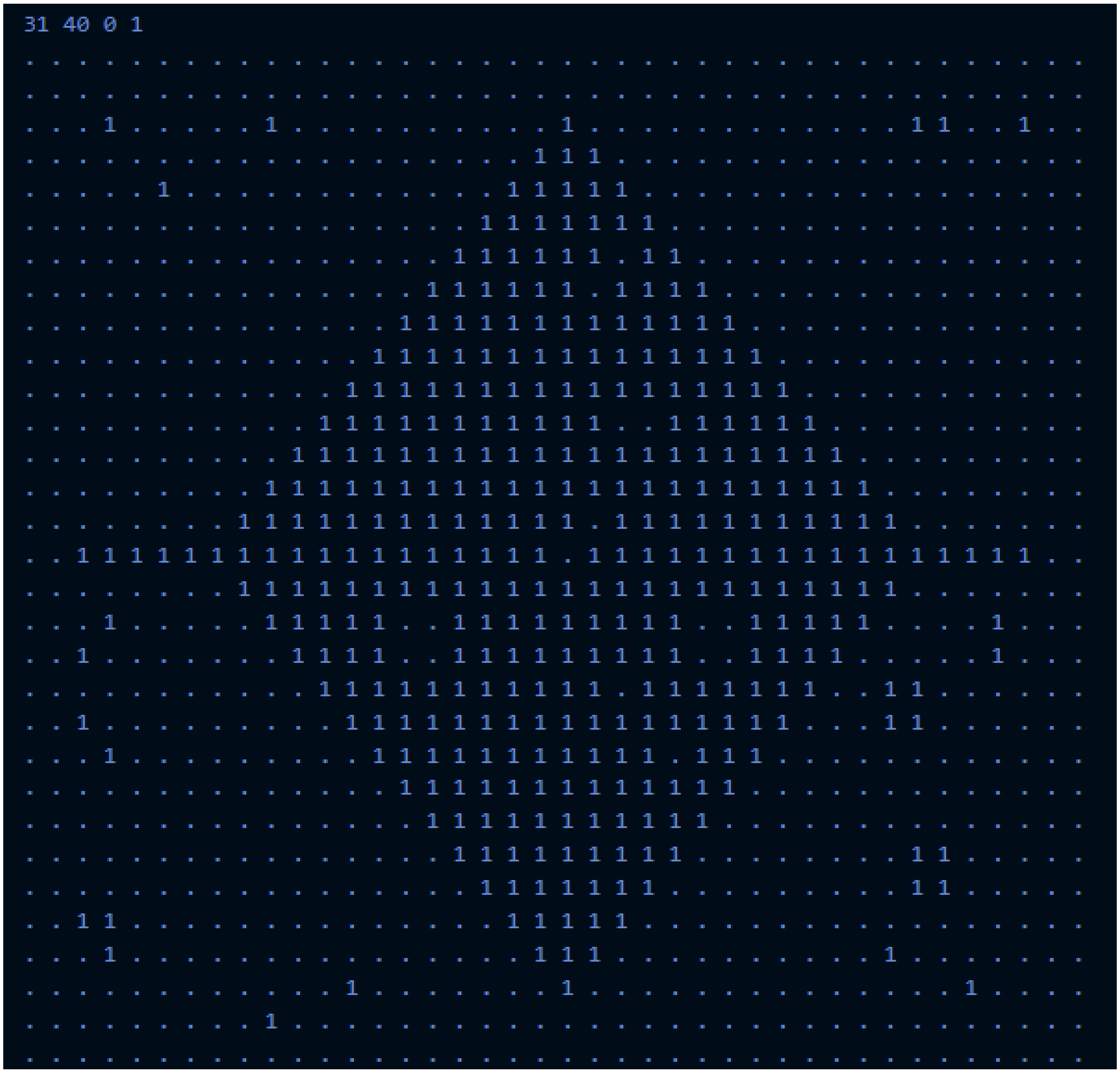
```
31 40 0 9
0 309 +++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
1 288 +++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
2 194 +++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
3 64 ++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
4 0
5 2 ++
6 12 ++++++++++++
7 106 +++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
8 124 +++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
9 141 +++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
```

Figure 2: Output outFile2 for data 1. Histogram pretty visualizer with numpixels representing greyscale ranging from 0-9.



```
31 40 0 1
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 1 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 1 1 0 0 1 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 1 1 1 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 1 1 1 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 1 1 1 1 0 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 1 1 1 1 0 1 1 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 1 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 1 0 0 1 1 1 1 1 1 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 1 1 1 0 1 1 1 1 1 1 1 1 1 1 1 0 0 0 0 0 0 0
0 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 0
0 0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 0 0 0 0 0 0
0 0 0 1 0 0 0 0 0 1 1 1 1 1 0 0 1 1 1 1 1 1 1 1 1 0 0 1 1 1 1 1 0 0 0 0 1 0 0 0
0 0 1 0 0 0 0 0 0 0 1 1 1 1 0 0 1 1 1 1 1 1 1 1 1 0 0 1 1 1 1 0 0 0 0 0 1 0 0 0
0 0 0 0 0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 1 0 1 1 1 1 1 1 1 0 0 1 1 0 0 0 0 0 0
0 0 1 0 0 0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 0 0 1 1 0 0 0 0 0 0
0 0 0 1 0 0 0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 1 0 1 1 1 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 1 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 0 0 0 0 0 0 0 0 1 1 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 1 1 1 1 1 0 0 0 0 0 0 0 0 0 1 1 0 0 0 0 0
0 0 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 1 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 1 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0
0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
```

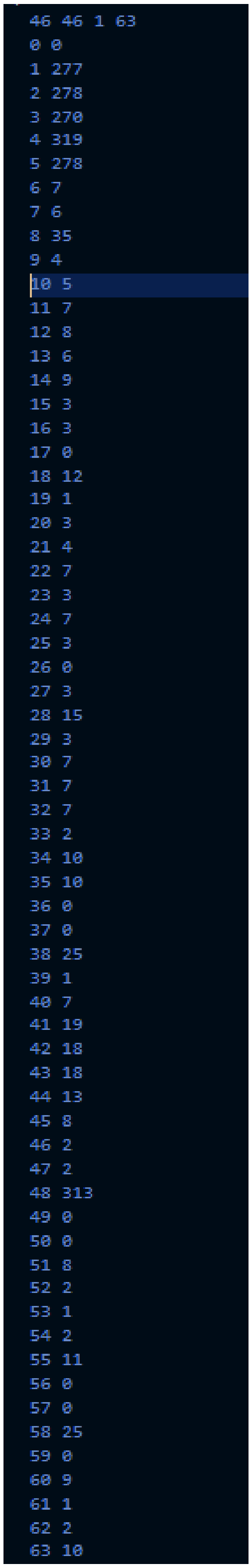
Figure 3: Output outFile3 for data 1. Binary Threshold Operation.



```
31 40 0 1
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
. . . 1 . . . . . 1 . . . . . . . . . . 1 . . . . . . . . . . . . 1 1 . . 1 . .
. . . . . . . . . . . . . . . . . . . 1 1 1 . . . . . . . . . . . . . . . . . .
. . . . . 1 . . . . . . . . . . . . 1 1 1 1 1 . . . . . . . . . . . . . . . . .
. . . . . . . . . . . . . . . . . 1 1 1 1 1 1 1 . . . . . . . . . . . . . . . .
. . . . . . . . . . . . . . . . 1 1 1 1 1 1 . 1 1 . . . . . . . . . . . . . . .
. . . . . . . . . . . . . . . 1 1 1 1 1 1 . 1 1 1 1 . . . . . . . . . . . . . .
. . . . . . . . . . . . . . 1 1 1 1 1 1 1 1 1 1 1 1 1 . . . . . . . . . . . . .
. . . . . . . . . . . . . 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 . . . . . . . . . . . .
. . . . . . . . . . . . 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 . . . . . . . . . . .
. . . . . . . . . . . 1 1 1 1 1 1 1 1 1 1 1 . . 1 1 1 1 1 1 . . . . . . . . . .
. . . . . . . . . . 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 . . . . . . . . .
. . . . . . . . . 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 . . . . . . . .
. . . . . . . . 1 1 1 1 1 1 1 1 1 1 1 1 1 . 1 1 1 1 1 1 1 1 1 1 1 . . . . . . .
. . 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 . 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 . .
. . . . . . . . 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 . . . . . . .
. . . 1 . . . . . 1 1 1 1 1 . . 1 1 1 1 1 1 1 1 1 . . 1 1 1 1 1 . . . . 1 . . .
. . 1 . . . . . . . 1 1 1 1 . . 1 1 1 1 1 1 1 1 1 . . 1 1 1 1 . . . . . 1 . . .
. . . . . . . . . . . 1 1 1 1 1 1 1 1 1 1 1 . 1 1 1 1 1 1 1 . . 1 1 . . . . . .
. . 1 . . . . . . . . . 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 . . . 1 1 . . . . . .
. . . 1 . . . . . . . . . 1 1 1 1 1 1 1 1 1 1 1 . 1 1 1 . . . . . . . . . . . .
. . . . . . . . . . . . . . 1 1 1 1 1 1 1 1 1 1 1 1 1 . . . . . . . . . . . . .
. . . . . . . . . . . . . . . 1 1 1 1 1 1 1 1 1 1 1 . . . . . . . . . . . . . .
. . . . . . . . . . . . . . . . 1 1 1 1 1 1 1 1 1 . . . . . . . . 1 1 . . . . .
. . . . . . . . . . . . . . . . . 1 1 1 1 1 1 1 . . . . . . . . . 1 1 . . . . .
. . 1 1 . . . . . . . . . . . . . . 1 1 1 1 1 . . . . . . . . . . . . . . . . .
. . . 1 . . . . . . . . . . . . . . . 1 1 1 . . . . . . . . . . 1 . . . . . . .
. . . . . . . . . . . . 1 . . . . . . . 1 . . . . . . . . . . . . . . 1 . . . .
. . . . . . . . . 1 . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
```

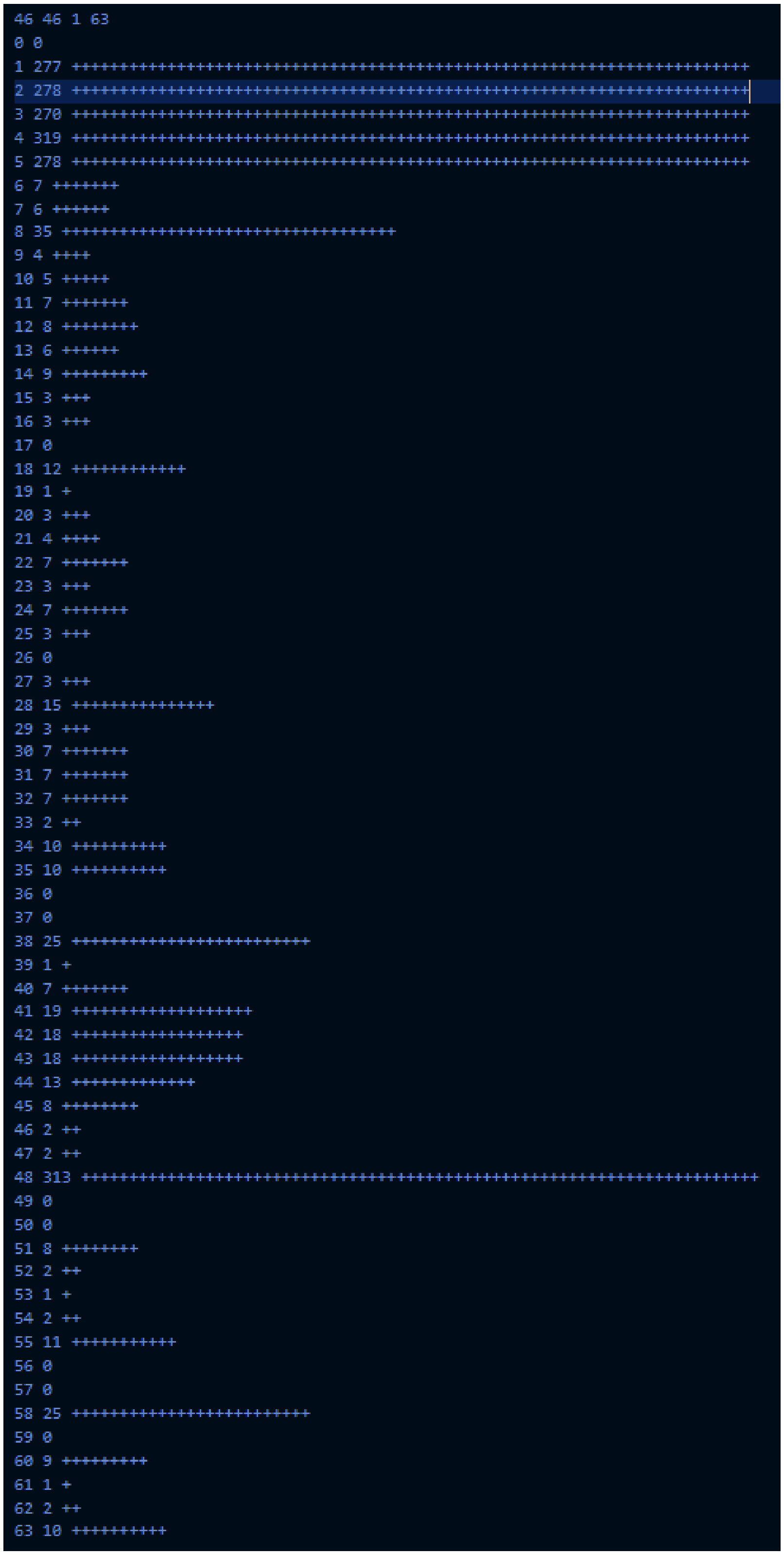
Figure 4: Output outFile4 for data 1. Pretty printing (replaced 0 with ***"."****)*

Program output for data2 with a threshold value of 38.



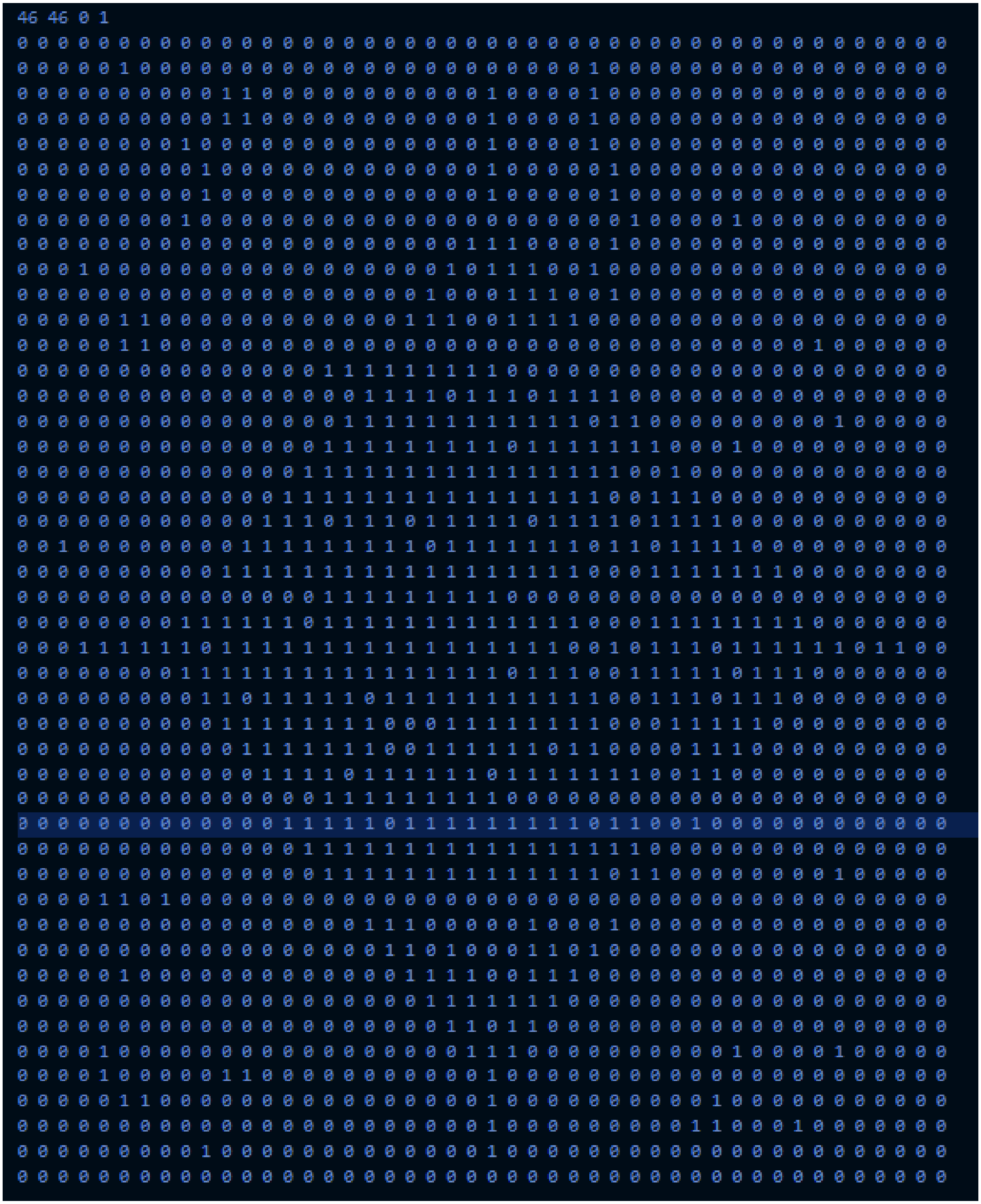
```
46 46 1 63
0 0
1 277
2 278
3 270
4 319
5 278
6 7
7 6
8 35
9 4
10 5
11 7
12 8
13 6
14 9
15 3
16 3
17 0
18 12
19 1
20 3
21 4
22 7
23 3
24 7
25 3
26 0
27 3
28 15
29 3
30 7
31 7
32 7
33 2
34 10
35 10
36 0
37 0
38 25
39 1
40 7
41 19
42 18
43 18
44 13
45 8
46 2
47 2
48 313
49 0
50 0
51 8
52 2
53 1
54 2
55 11
56 0
57 0
58 25
59 0
60 9
61 1
62 2
63 10
```

Figure 4: Output outFile1 for data 2. Histogram



```
46 46 1 63
0 0
1 277 +++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
2 278 +++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
3 270 +++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
4 319 +++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
5 278 +++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
6 7 +++++++
7 6 ++++++
8 35 +++++++++++++++++++++++++++++++++++
9 4 ++++
10 5 +++++
11 7 +++++++
12 8 ++++++++
13 6 ++++++
14 9 +++++++++
15 3 +++
16 3 +++
17 0
18 12 ++++++++++++
19 1 +
20 3 +++
21 4 ++++
22 7 +++++++
23 3 +++
24 7 +++++++
25 3 +++
26 0
27 3 +++
28 15 +++++++++++++++
29 3 +++
30 7 +++++++
31 7 +++++++
32 7 +++++++
33 2 ++
34 10 ++++++++++
35 10 ++++++++++
36 0
37 0
38 25 +++++++++++++++++++++++++
39 1 +
40 7 +++++++
41 19 +++++++++++++++++++
42 18 ++++++++++++++++++
43 18 ++++++++++++++++++
44 13 +++++++++++++
45 8 ++++++++
46 2 ++
47 2 ++
48 313 +++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
49 0
50 0
51 8 ++++++++
52 2 ++
53 1 +
54 2 ++
55 11 +++++++++++
56 0
57 0
58 25 +++++++++++++++++++++++++
59 0
60 9 +++++++++
61 1 +
62 2 ++
63 10 ++++++++++
```

Figure 5: Output outFile2 for data 2. Histogram pretty visualizer with numpixels representing greyscale ranging from 0-9.



```
46 46 0 1
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 1 1 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 1 1 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 1 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 1 1 1 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 1 1 1 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 1 1 0 0 0 0 0 0 0 0 0 0 0 0 1 1 1 0 0 1 1 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 1 1 0 1 1 1 0 1 1 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 1 1 0 1 1 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 0 1 1 1 1 1 1 1 0 0 0 1 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 0 1 1 1 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 1 1 1 0 1 1 1 0 1 1 1 1 1 0 1 1 1 1 0 1 1 1 1 0 0 0 0 0 0 0 0 0 0 0
0 0 1 0 0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 0 1 1 1 1 1 1 1 0 1 1 0 1 1 1 1 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 0 0 1 1 1 1 1 1 1 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 1 1 1 1 1 1 0 1 1 1 1 1 1 1 1 1 1 1 1 1 0 0 0 1 1 1 1 1 1 1 1 0 0 0 0 0 0 0
0 0 0 1 1 1 1 1 1 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 0 1 0 1 1 1 0 1 1 1 1 1 1 0 1 1 0 0
0 0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 1 1 1 0 0 1 1 1 1 1 0 1 1 1 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 1 1 0 1 1 1 1 1 0 1 1 1 1 1 1 1 1 1 1 1 0 0 1 1 1 0 1 1 1 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 0 0 0 1 1 1 1 1 1 1 1 0 0 0 1 1 1 1 1 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 1 1 1 1 1 1 1 0 0 1 1 1 1 1 1 0 1 1 0 0 0 0 1 1 1 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 1 1 1 1 0 1 1 1 1 1 1 0 1 1 1 1 1 1 1 0 0 1 1 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 1 1 1 0 1 1 1 1 1 1 1 1 0 1 1 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 1 1 0 0 0 0 0 0 0 0 1 0 0 0 0 0
0 0 0 0 1 1 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 1 0 0 0 0 0 1 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 0 1 0 0 0 1 1 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 1 1 0 0 1 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
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0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 0 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
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0 0 0 0 0 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 1 1 0 0 0 1 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
```
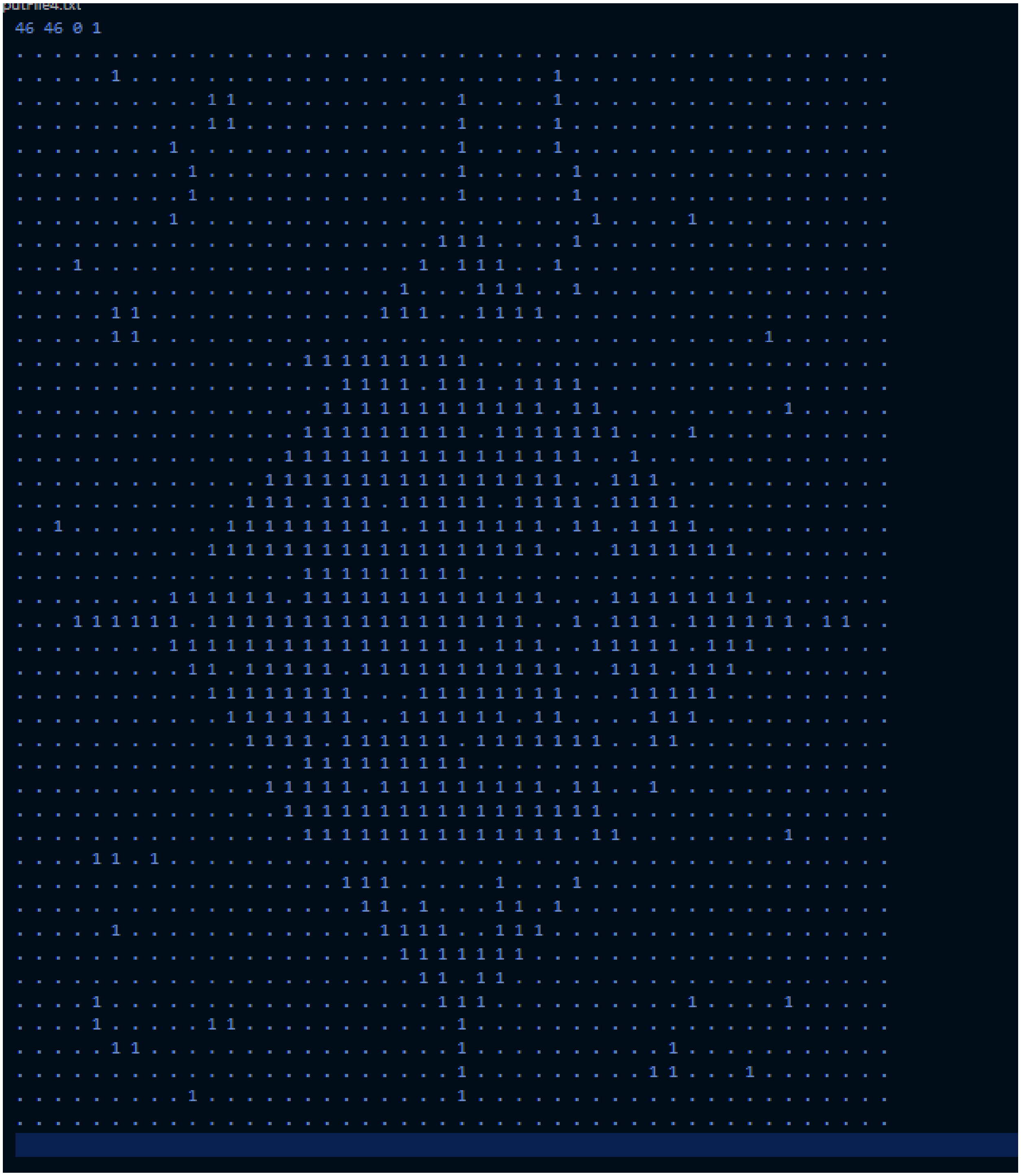

Figure 6 :Output outFile3 for data 2. Binary Threshold Operation.



outFile4.txt

```
 46 46 0 1
 . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
 . . . . . 1 . . . . . . . . . . . . . . . . . . . . . . 1 . . . . . . . . . . . . . . . . .
 . . . . . . . . . . 1 1 . . . . . . . . . . . 1 . . . . 1 . . . . . . . . . . . . . . . . .
 . . . . . . . . . . 1 1 . . . . . . . . . . . 1 . . . . 1 . . . . . . . . . . . . . . . . .
 . . . . . . . . 1 . . . . . . . . . . . . . . 1 . . . . 1 . . . . . . . . . . . . . . . . .
 . . . . . . . . . 1 . . . . . . . . . . . . . 1 . . . . . 1 . . . . . . . . . . . . . . . .
 . . . . . . . . . 1 . . . . . . . . . . . . . 1 . . . . . 1 . . . . . . . . . . . . . . . .
 . . . . . . . . 1 . . . . . . . . . . . . . . . . . . . . . 1 . . . . 1 . . . . . . . . . .
 . . . . . . . . . . . . . . . . . . . . . . 1 1 1 . . . . 1 . . . . . . . . . . . . . . . .
 . . . 1 . . . . . . . . . . . . . . . . . 1 . 1 1 1 . . 1 . . . . . . . . . . . . . . . . .
 . . . . . . . . . . . . . . . . . . . . 1 . . . 1 1 1 . . 1 . . . . . . . . . . . . . . . .
 . . . . . 1 1 . . . . . . . . . . . . 1 1 1 . . 1 1 1 1 . . . . . . . . . . . . . . . . . .
 . . . . . 1 1 . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 1 . . . . . .
 . . . . . . . . . . . . . . . 1 1 1 1 1 1 1 1 1 . . . . . . . . . . . . . . . . . . . . . .
 . . . . . . . . . . . . . . . . . 1 1 1 1 . 1 1 1 . 1 1 1 1 . . . . . . . . . . . . . . . .
 . . . . . . . . . . . . . . . . 1 1 1 1 1 1 1 1 1 1 1 1 . 1 1 . . . . . . . . . 1 . . . . .
 . . . . . . . . . . . . . . . 1 1 1 1 1 1 1 1 1 . 1 1 1 1 1 1 1 . . . 1 . . . . . . . . . .
 . . . . . . . . . . . . . . 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 . . 1 . . . . . . . . . . . . .
 . . . . . . . . . . . . . 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 . . 1 1 1 . . . . . . . . . . . .
 . . . . . . . . . . . . 1 1 1 . 1 1 1 . 1 1 1 1 1 . 1 1 1 1 . 1 1 1 1 . . . . . . . . . . .
 . . 1 . . . . . . . . 1 1 1 1 1 1 1 1 1 . 1 1 1 1 1 1 1 . 1 1 . 1 1 1 1 . . . . . . . . . .
 . . . . . . . . . . 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 . . . 1 1 1 1 1 1 1 . . . . . . . .
 . . . . . . . . . . . . . . . 1 1 1 1 1 1 1 1 1 . . . . . . . . . . . . . . . . . . . . . .
 . . . . . . . . 1 1 1 1 1 1 . 1 1 1 1 1 1 1 1 1 1 1 1 1 . . . 1 1 1 1 1 1 1 1 . . . . . . .
 . . . 1 1 1 1 1 1 . 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 . . 1 . 1 1 1 . 1 1 1 1 1 1 . 1 1 . .
 . . . . . . . . 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 . 1 1 1 . . 1 1 1 1 1 . 1 1 1 . . . . . . .
 . . . . . . . . . 1 1 . 1 1 1 1 1 . 1 1 1 1 1 1 1 1 1 1 1 . . 1 1 1 . 1 1 1 . . . . . . . .
 . . . . . . . . . . 1 1 1 1 1 1 1 1 . . . 1 1 1 1 1 1 1 1 . . . 1 1 1 1 1 . . . . . . . . .
 . . . . . . . . . . . 1 1 1 1 1 1 1 . . 1 1 1 1 1 1 . 1 1 . . . . 1 1 1 . . . . . . . . . .
 . . . . . . . . . . . . 1 1 1 1 . 1 1 1 1 1 1 . 1 1 1 1 1 1 1 . . 1 1 . . . . . . . . . . .
 . . . . . . . . . . . . . . . 1 1 1 1 1 1 1 1 1 . . . . . . . . . . . . . . . . . . . . . .
 . . . . . . . . . . . . . 1 1 1 1 1 . 1 1 1 1 1 1 1 1 1 . 1 1 . . 1 . . . . . . . . . . . .
 . . . . . . . . . . . . . . 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 . . . . . . . . . . . . . . .
 . . . . . . . . . . . . . . . 1 1 1 1 1 1 1 1 1 1 1 1 1 1 . 1 1 . . . . . . . . 1 . . . . .
 . . . . 1 1 . 1 . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
 . . . . . . . . . . . . . . . . . 1 1 1 . . . . . 1 . . . 1 . . . . . . . . . . . . . . . .
 . . . . . . . . . . . . . . . . . . 1 1 . 1 . . . 1 1 . 1 . . . . . . . . . . . . . . . . .
 . . . . . 1 . . . . . . . . . . . . . 1 1 1 1 . . 1 1 1 . . . . . . . . . . . . . . . . . .
 . . . . . . . . . . . . . . . . . . . . 1 1 1 1 1 1 1 . . . . . . . . . . . . . . . . . . .
 . . . . . . . . . . . . . . . . . . . . . 1 1 . 1 1 . . . . . . . . . . . . . . . . . . . .
 . . . . 1 . . . . . . . . . . . . . . . . . 1 1 1 . . . . . . . . . . 1 . . . . 1 . . . . .
 . . . . 1 . . . . . 1 1 . . . . . . . . . . . 1 . . . . . . . . . . . . . . . . . . . . . .
 . . . . . 1 1 . . . . . . . . . . . . . . . . 1 . . . . . . . . . . 1 . . . . . . . . . . .
 . . . . . . . . . . . . . . . . . . . . . . . 1 . . . . . . . . . 1 1 . . . 1 . . . . . . .
 . . . . . . . . . 1 . . . . . . . . . . . . . 1 . . . . . . . . . . . . . . . . . . . . . .
 . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
```

Figure 7: Output outFile4 for data 2. Pretty printing (replaced 0 with ".")