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Section: Image Processing

Project: **Project1 - Bi-Means Automatic Threshold Selection**

Due Date: Sept 13rd

Algorithm Steps

```
Step 0:
    inFile1, outFile1, deBugFile <— open via args []
Step 1:
    numRows, numCols, minVal, maxVal <— read from inFile1.
    histAry <— dynamically allocate (size of maxVal + 1) and initialized to zero.
    maxHeight <— loadHist (histAry, inFile)
Step 2:
    dispHist (histAry)
Step 3:
    BiGaussThrVal <— biGaussian (histAry, GaussAry, maxHeight, minVal, maxVal,
deBugFile)
    outFile1 <— output BiGaussThrVal with caption
Step 4: close all files
```

Video: https://www.youtube.com/watch?v=jMdDqDvGhyk

Source Code:

```
import java.io.File;

import java.io.FileReader;

import java.io.FileWriter;

import java.io.IOException;

import java.lang.reflect.Array;

import java.util.Arrays;

import java.util.Scanner;


class ThresholdSelection{

    private int numRows, numCols, minVal, maxVal;

    private int[] histogramArray;

    private int[] gaussArray;

    private int biGaussThrVal;

    private int maxHeight;


    ThresholdSelection(int numRows, int numCols, int minVal, int maxVal){

        this.numRows = numRows;

        this.numCols = numCols;

        this.minVal = minVal;

        this.maxVal = maxVal;

        this.maxHeight = 0;


        this.histogramArray = new int[maxVal + 1];

        this.gaussArray = new int[maxVal + 1];
    }


    public int getBiGaussThrVal() {
        return biGaussThrVal;
    }
    public int loadHist(Scanner inFile){
        int maxHeight = 0, grayScaleVal, grayScaleHeight;
        while(inFile.hasNext()){
            grayScaleVal = inFile.nextInt();
            grayScaleHeight = inFile.nextInt();

            this.histogramArray[grayScaleVal] = grayScaleHeight;
            maxHeight = Math.max(maxHeight, grayScaleHeight);
        }
        this.maxHeight = maxHeight;
        return maxHeight;
    }


    public void displayHistogram(FileWriter outFile) throws IOException {
        outFile.write(numRows + ' ' + numCols + ' ' + minVal + ' ' + maxVal +
'\n');
        for (int i = 0; i < this.histogramArray.length; i++) {
            outFile.write(i + " (" + this.histogramArray[i] + "):" );
            for (int j = 0; j < this.histogramArray[i]; j++) {
                outFile.write('+');
            }
            outFile.write('\n');
        }
    }
    public void setZero(int[] array){

        Arrays.fill(array, 0);

    }


    public int biGauss(FileWriter debugFile) throws IOException {

        debugFile.write("Entering biGauss method\n");

        double sum1, sum2, total, minSumDiff = 99999.0;

        int offset = (maxVal - minVal) / 10,

            bestThrVal = offset;


        for (int dividePoint = offset; dividePoint < maxVal - offset;
dividePoint++) {

            setZero(this.gaussArray);

            sum1 = fitGauss(0, dividePoint, debugFile);

            sum2 = fitGauss(dividePoint, maxVal, debugFile);

            total = sum1 + sum2;

            if (total < minSumDiff){

                minSumDiff = total;

                bestThrVal = dividePoint;

            }

            debugFile.write(dividePoint + " " + sum1 + " " + sum2 + " " +
total + " " + minSumDiff + " "

                                    + bestThrVal + "\n");


        }

        this.biGaussThrVal = bestThrVal;

        debugFile.write("Leaving biGauss method\n");

        return bestThrVal;

    }
    public double computeMean(int left, int right, FileWriter debugFile)
throws IOException {

        debugFile.write("Entering computeMean method\n");

        int numPixels = 0;

        double sum = 0.0;


        for (int i = left; i <= right; i++) {

            sum += histogramArray[i] * i;

            numPixels += histogramArray[i];

            this.maxHeight = Math.max(this.maxHeight, histogramArray[i]);

        }

        debugFile.write("Leaving computeMean method\n");

        return sum / numPixels;

    }


    public double computeVariance(int left, int right, double mean,
FileWriter debugFile) throws IOException {

        debugFile.write("Entering computeVariance method\n");

        double sum = 0.0;

        int numPixels = 0;

        for (int i = left; i <= right; i++) {

            sum += (double)histogramArray[i] * Math.pow(((double)i - mean),
2);

            numPixels += histogramArray[i];

        }

        debugFile.write("Leaving computeVariance method\n");

        return sum / (double) numPixels;

    }
    public double modifiedGauss(int x, double mean, double variance){

        return (double)this.maxHeight * Math.exp(-(Math.pow((double)x -
mean , 2) / (2.0 * variance)));

    }


    public double fitGauss(int left, int right, FileWriter debugFile) throws
IOException {

        debugFile.write("Entering fitGauss method\n");

        double mean, variance, sum = 0.0, gaussVal, maxGaussVal;

        mean = computeMean(left, right, debugFile);

        variance = computeVariance(left, right, mean, debugFile);


        for (int i = left; i <= right; i++) {

            gaussVal = modifiedGauss(i, mean, variance);

            sum += Math.abs(gaussVal - (double) histogramArray[i]);

            gaussArray[i] = (int)gaussVal;


        }

        debugFile.write("Leaving firGauss method\n");

        return sum;

    }

}



class Liu_Project1_Main{

    public static void main(String[] args) throws IOException {

        Scanner inFile = new Scanner(new FileReader(args[0]));

        FileWriter  outFile = new FileWriter(args[1]),

                    debugFile = new FileWriter(args[2]);

        int numRows = inFile.nextInt(),
            numCols = inFile.nextInt(),

            minVal = inFile.nextInt(),

            maxVal = inFile.nextInt();


        ThresholdSelection thresholdSelection = new
ThresholdSelection(numRows, numCols, minVal, maxVal);

        thresholdSelection.loadHist(inFile);

        thresholdSelection.displayHistogram(outFile);

        thresholdSelection.biGauss(debugFile);


        outFile.write("The Bi-Gaussian Value is " +
thresholdSelection.getBiGaussThrVal());


        inFile.close();

        outFile.close();

        debugFile.close();

    }

}
```

Program Output

Output 1

```
10 (6):++++++
1 (8):++++++++
2 (12):++++++++++++
3 (10):++++++++++
4 (10):++++++++++
5 (18):++++++++++++++++++
6 (21):+++++++++++++++++++++
7 (25):+++++++++++++++++++++++++
8 (30):++++++++++++++++++++++++++++++
9 (56):++++++++++++++++++++++++++++++++++++++++++++++++++++++++
10 (73):+++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
11 (110):++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
12 (140):++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
13 (175):+++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
14 (200):++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
15 (250):++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
16 (192):++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
17 (172):++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
18 (150):++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
19 (120):++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
20 (88):++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
21 (78):++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
22 (61):+++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
23 (40):++++++++++++++++++++++++++++++++++++++++
24 (22):++++++++++++++++++++++
25 (16):++++++++++++++++
26 (12):++++++++++++
27 (8):++++++++
28 (7):+++++++
29 (5):+++++
30 (4):++++
31 (4):++++
32 (3):+++
33 (5):+++++
34 (6):++++++
35 (8):++++++++
36 (10):++++++++++
37 (12):++++++++++++
38 (21):+++++++++++++++++++++
39 (26):++++++++++++++++++++++++++
40 (33):+++++++++++++++++++++++++++++++++
41 (45):+++++++++++++++++++++++++++++++++++++++++++++
42 (58):++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
43 (72):++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
44 (90):++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++

45 (100):++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++

46 (120):++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++

47 (150):++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++

48 (175):+++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++

49 (200):++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++

50 (170):++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++

51 (152):++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++

52 (120):++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++

53 (100):++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++

54 (90):++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++

55 (70):++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++

56 (46):++++++++++++++++++++++++++++++++++++++++++++++

57 (33):+++++++++++++++++++++++++++++++++

58 (20):++++++++++++++++++++

59 (10):++++++++++

60 (8):++++++++

61 (6):++++++

62 (8):++++++++

63 (6):++++++
```

The Bi-Gaussian Value is 32

Debug 1

According to Hardcopy requirement, debugFile should not be included when it’s more than 10 pages. My debugFile is longer than 20 pages even if I had change to font size of 10. So I’m not including it in the HardCopy.

Output 2

```
10 (0):

1 (0):

2 (0):

3 (0):

4 (4):++++

5 (5):+++++

6 (7):+++++++

7 (9):+++++++++

8 (11):+++++++++++
9 (10):++++++++++

10 (12):++++++++++++

11 (15):+++++++++++++++

12 (16):++++++++++++++++

13 (14):++++++++++++++

14 (15):+++++++++++++++

15 (22):++++++++++++++++++++++

16 (20):++++++++++++++++++++

17 (18):++++++++++++++++++

18 (28):++++++++++++++++++++++++++++

19 (38):++++++++++++++++++++++++++++++++++++++

20 (44):++++++++++++++++++++++++++++++++++++++++++++

21 (56):++++++++++++++++++++++++++++++++++++++++++++++++++++++++

22 (70):++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++

23 (90):++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++

24 (110):++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++

25 (120):++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++

26 (140):++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++

27 (155):+++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++

28 (170):++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++

29 (210):++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++

30 (220):++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++

31 (189):+++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++

32 (150):++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++

33 (120):++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++

34 (110):++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++

35 (90):++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
```

```
36 (77):+++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++

37 (50):++++++++++++++++++++++++++++++++++++++++++++++++++

38 (28):++++++++++++++++++++++++++++

39 (12):++++++++++++

40 (10):++++++++++

41 (9):+++++++++

42 (9):+++++++++

43 (5):+++++

44 (3):+++

45 (6):++++++

46 (10):++++++++++

47 (30):++++++++++++++++++++++++++++++

48 (70):++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++

49 (100):++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++

50 (120):++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++

51 (145):+++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++

52 (188):++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++

53 (214):++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++

54 (196):++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++

55 (160):++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++

56 (138):++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++

57 (97):+++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++

58 (76):++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++

59 (33):+++++++++++++++++++++++++++++++++

60 (20):++++++++++++++++++++

61 (2):++
```

The Bi-Gaussian Value is 43

Debug 2

According to Hardcopy requirement, debugFile should not be included when it’s more than 10 pages. My debugFile is longer than 20 pages even if I had change to font size of 10. So I’m not including it in the HardCopy.