CSCI 381 – Computer Vision (C++)
Program: Project 2.2: Bi-Means Gaussian Histogram
Name: Isaac Gordon
Due Date:
Soft copy: 2/20/2019 Wednesday before midnight
Hard copy: 2/21/2019 Thursday in class

```
step -1: check for valid args

step 0: inFile <-- argv[1]
        outFile1 <-- argv[2]
        outFile2 <-- argv[3]
        outFile3 <-- argv[4]
        outFile4 <-- argv[5]

step 1: numRows, numCols, minVal, maxVal <-- read from inFile

step 2: dynamically allocate 1D histAry of size maxVal+1
        set1DZero(histAry)
        dynamically allocate 1D GaussAry of size maxVal+1
        set1DZero(GaussAry)

        offSet <-- (int) (maxVal / 10)
        thrVal <-- offSet

step 3: maxCount <-- loadHist ( ) // maxCount is the largest
hist[i]

step 4: histImg <-- dynamically allocate 2D histImg array of
size
                        // (maxVal+1) by (maxCount+1)
       set2DZero(histImg)

       GaussImg <-- dynamically allocate 2D GaussImg array of
     size
                        // (maxVal+1) by (maxCount+1)
       set2DZero(GaussImg)

       GapImg <-- dynamically allocate GapImg array of size
                        // (maxVal+1) by (maxCount+1)
       set2DZero(GapImg)

step 5: plotHist ( )
       prettyPrint (histImg, outFile1)  // pretty print histImg to
outFile1
               // write caption to indicate it is the original
histogram
```

```
step 6: median1D  ( ) // to smooth the original histogram

step 7: copyArys ( ) // copy the smoothedHistAry to histAry

step 8: set2DZero(histImg) // reset histImg to zero

step 9: plotHist (histAry)
        prettyPrint (histImg, outFile1)  // pretty print histImg to
outFile1
          // write caption to indicate it is after median filtered

step 10: bestThrVal <-- biMeanGauss (thrVal)
                // bestThrVal is the principle method that
                // determines the best threshold selection

step 11: output bestThrVal to outFile4 // include caption

step 12:  bestThrPlot (bestThrVal) // plotting the result

Step 13: prettyPrint(GaussImg, outFile4)
          // output to outFile4 to see the best fitting 2 Gaussian
     curves

step 14: prettyPrint(GapImg, outFile4)
          // output to outFile4 to see the gaps between the 3 best
          fitting //Gaussian curves and the histogram

step 15: close all files

step 16: delete dynamically allocated resources
```

CODE:

```
#include<iostream>
#include<fstream>
#include<string>
#include<cmath>
using namespace std;

//data structs
ifstream inFile1;
ofstream outFile1, outFile2, outFile3, outFile4;
int numRows, numCols, minVal, maxVal;
int maxCount;           // The largest histAry[i] in the input histogram
int grayCount;
double minDiff;         // the minimum sum of absolute "distances" between
                            // the bi-Gaussians curves and the histogram
curve.
int offSet;             // offSet is set to one-tenth of the maxVal.
                                // the assumption: in a bimodal histogram,
the first
                                // modal occupies at least one-tenth from the
beginning of the histogram
int thrVal;             // Initially, ThrValue is set to offSet,
                                // the final value of thrVal is the selected
threshold value.
int* histAry;           //a 1D integer array (histogram), size of maxVal + 1
                                  // need to be dynamically allocated at run
time.
int* smoothedHistAry;   //a 1D integer array (smoothed histogram),
                            //size of maxVal + 1 need to be dynamically
allocated at run time.
int* GaussAry;          //a 1D integer array size of maxVal + 1
                            // for displaying digital Gaussian curve, need to
be dynamically allocated at run time.
int** histImg;          // a 2-D integer array of size
                            //(maxVal+1) by (maxCount+1), initialize to 0, a
2D plot of histogram, for visualization only.
int** GaussImg;         // a 2-D integer array of size
                            // (maxVal+1) by (maxCount+1), initialize to 0
                            // a 2D plot of Gaussian curve, for visualization
only.
int** GapImg;           // a 2-D integer array of size
                            // (maxVal+1) by (maxCount+1), initialize to 0 a
2D plot shows the gaps between Gaussian
                            //curves and histogram, for visualization only.

//function headers
bool endsWith(string str, string ex);
int loadHist();
void median1D();
void copyArys();
double computeMean(int leftIndex, int rightIndex, int maxCount);
double computeVar(int leftIndex, int rightIndex, double mean);
int gaussianFunc(int index, double mu, double sigma2);
void set1DZero(int *&ary);
void set2DZero(int **&imgAry);
int biMeanGauss (int thr);
void bestThrPlot(int bestThrVal);
```

```
void plotHist();
double fitGauss(int leftIndex, int rightIndex);
void plotGaps(int leftIndex, int rightIndex);
void prettyPrint(int** plot, ofstream &outputStream);

int main(int argc, char *argv[]){
    int c = 0;


     //set arg error message
    string BAD_ARGS = "Correct arguement format is \"<inputFile>
<outputFileHist> <outputFileGauss> <outputFileGaps>\".\nBoth should end in
\'.txt\'.";

    //check for correct number of args
    if(argc != 6){
        cout << "Wrong number of arguements.\n" << BAD_ARGS << endl;
        return 1;//        exit(1);
    }//if

    //make sure they are all text files
    for(int i = 1; i < argc; i++){
        if(!endsWith(argv[i], ".txt")){
            cout << argv[i] << " is not a .txt file. Try again." << endl;
            return 1;//            exit(1);
        }//if
    }//for

    //STEP 0
    inFile1.open(argv[1]);
    outFile1.open(argv[2]);
    outFile2.open(argv[3]);
    outFile3.open(argv[4]);
    outFile4.open(argv[5]);

    //STEP 1
    inFile1 >> numRows;
    inFile1 >> numCols;
    inFile1 >> minVal;
    inFile1 >> maxVal;
    int header[] = {numRows, numCols, minVal, maxVal};

    //STEP 2
    set1DZero(histAry);
    set1DZero(GaussAry);
    offSet = (int) maxVal/10;
    thrVal = offSet;

    //STEP 3
    maxCount = loadHist();

    //STEP 4
    set2DZero(histImg);
    set2DZero(GaussImg);
    set2DZero(GapImg);

    //STEP 5
```

```
    plotHist();
    outFile1 << "ORIGINAL HISTOGRAM:" << endl << endl;
    prettyPrint(histImg, outFile1);     //pretty print histImg to outFile1

    //STEP 6
    median1D();                         //to smooth the original histogram

    //STEP 7
    copyArys();                         //copy the smoothedHistAry to histAry

    //STEP 8
    set2DZero(histImg);                 //reset histImg to zero

    //STEP 9
    plotHist();
    outFile1 << endl << "POST-MEDIAN FILTER HISTOGRAM:" << endl <<endl;
      prettyPrint(histImg, outFile1);    //pretty print histImg to outFile1

    //STEP 10
    int bestThrVal = biMeanGauss(thrVal);

    //STEP 11
    outFile4 << "BEST THRESHOLD VALUE: " << bestThrVal << endl << endl;
    //STEP 12
    bestThrPlot(bestThrVal);

    //STEP 13
    prettyPrint(GaussImg, outFile4);    //output to outFile4 to see the best
fitting 2 Gaussian curves
    outFile4 << endl << endl;
    outFile4 <<
"================================================================================
================================================================================
===="<<endl;
    outFile4 <<
"x+x+x+x+x+x+x+x+x+x+x+x+x+x+x+x+x+x+x+x+x+x+x+x+x+x+x+x+x+x+x+x+x+x+x+x+x+x+x+
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+x+"<<endl;
    outFile4 <<
"================================================================================
================================================================================
===="<<endl;

    //STEP 14
    prettyPrint(GapImg, outFile4);      //output to outFile4 to see the gaps
between the 3 best fitting
                                            //Gaussian curves and the
histogram

    //STEP 15
    inFile1.close();
    outFile1.close();
    outFile2.close();
    outFile3.close();
    outFile4.close();

    //STEP 16
```

```
    delete[] GaussAry;
    delete[] histAry;
    delete[] smoothedHistAry;
    delete[] GapImg;
    delete[] GaussImg;
    delete[] histImg;

return 0;

}//main

bool endsWith(string str, string ex){
    int pos = str.find(ex);
    if(pos != str.size() - 4) return false;
    return true;
}//endsWith

int loadHist(){
    int maxGrayCount = 0;
    int sum = 0;
    while(!inFile1.eof()){
        int index = 0;
        int val = 0;
        inFile1 >> index;
        inFile1 >> val;
        sum += val;
        histAry[index] = val;
        if(val > maxGrayCount) maxGrayCount = val;
    }//while
    grayCount = sum;
    return maxGrayCount;
}//loadHist

void median1D(){
    smoothedHistAry = new int[maxVal + 1];
    for(int i = 2; i <= maxVal - 2; i++){
        int x[5];
        int index = 0;
        for(int j = i - 2; j <= i + 2; j++){
            x[index++] = histAry[j];
        }//for

        //bubble sort array x
        bool swapped;

        for(int k = 0; k < 4; k++){
            for(int r = 0; r < 4 - k - 1; r++){
                if(x[r] > x[r+1]){
                    int temp = x[r];
                    x[r] = x[r+1];
                    x[r+1] = temp;
                    swapped = true;
                }//if-then-swap
            }//inner-for
            if(!swapped) break;
        }//outer-for
```

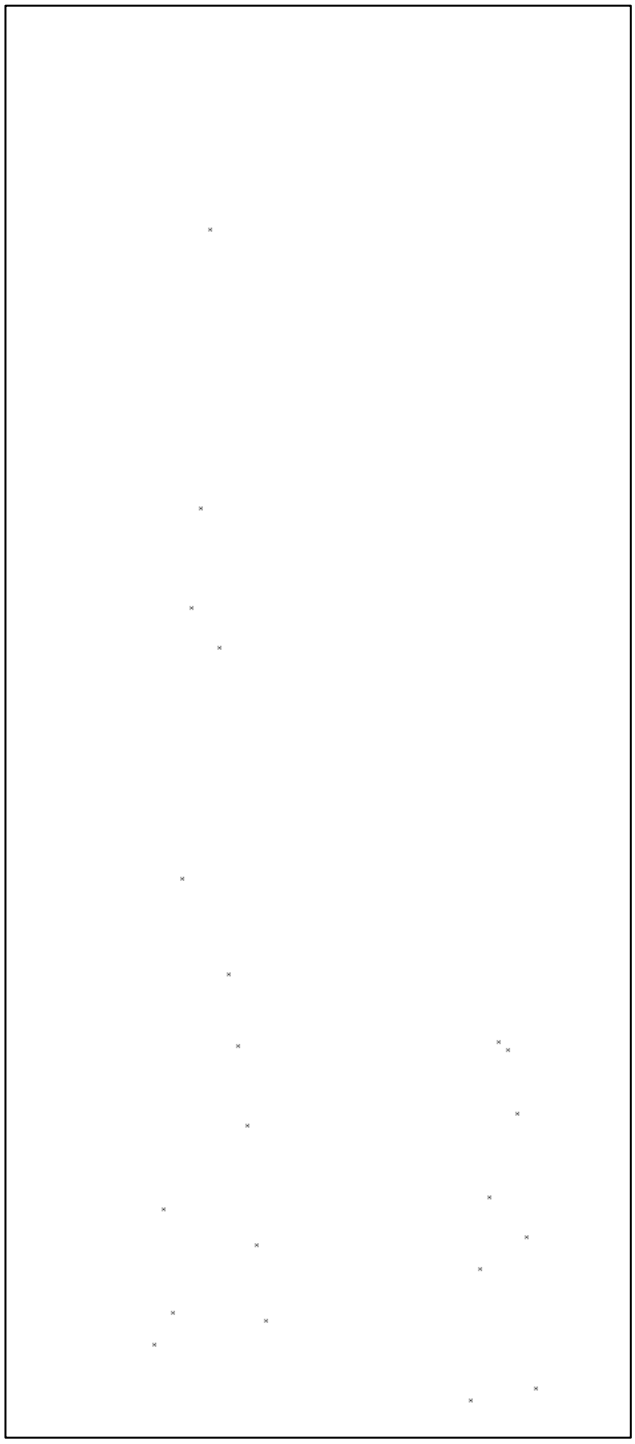
```
        //set median value into smoothed histogram
        smoothedHistAry[i] = x[2];
    }//for
}//median1D

void copyArys(){
    for(int i = 0; i <= maxVal - 2; i++){
        histAry[i] = smoothedHistAry[i];
    }//for
} //copyArys

double computeMean(int leftIndex, int rightIndex, int maxCount){
    double m = 0;
    int count = 0;
    for(int i = leftIndex; i < rightIndex + 1; i++){
        m += i * histAry[i];
        count += histAry[i];
    }//for
    grayCount = count;
    return (double) (m/count);
}//computeMean

double computeVar(int leftIndex, int rightIndex, double mu){
    double sum = 0;
    int count = 0;
    for(int i = leftIndex; i < rightIndex + 1; i++){
        sum += (i - mu)*(i - mu)*histAry[i];
        count += histAry[i];
    }//for
    return (double) sum/count;
}//computeVar

void set1DZero(int *&ary){
    delete[] ary;
    ary = new int[maxVal + 1];
    for(int i = 0; i < maxVal +1; i++)
        ary[i] = 0;
}//set1DZero

void set2DZero(int **&imgAry){
    delete[] imgAry;
    imgAry = new int*[maxVal +1];
    for(int i = 0; i < maxVal + 1; i++){
        imgAry[i] = new int[maxCount + 1];
        for(int j = 0; j < maxCount + 1; j++) imgAry[i][j] = 0;
    }//for
}//set2DZero

int biMeanGauss(int thr){
    double sum1, sum2, total;
    int bestThr = thr;
    minDiff = 999999.0;

    //find threshold val that minimizes disparity between origional ans gauss
curves
    while(thr < (maxVal - offSet)){
        set1DZero(GaussAry);
```

```
        sum1 = fitGauss(0, thr);
        sum2 = fitGauss(thr, maxVal);
        total = sum1 + sum2;
        if(total < minDiff){
            minDiff = total;
            bestThr = thr;
        } //if
        thr++;
    }//while

    return bestThr;
}//biMeansGauss

void bestThrPlot(int bestThrVal){
    double sum1, sum2;
    set1DZero(GaussAry);
    set2DZero(GaussImg);
    set2DZero(GapImg);

    sum1 = fitGauss(0, bestThrVal);
    plotGaps(0, thrVal);
    sum2 = fitGauss(bestThrVal, maxVal);
    plotGaps(thrVal, maxVal);
}//bestThrPlot

void plotHist(){
    for(int i = 0; i < maxVal + 1; i++){
        histImg[i][histAry[i]] = 1;
    }//for
}//plotHist

double fitGauss(int leftIndex, int rightIndex){
    double mean, var, sum;
    mean = computeMean(leftIndex, rightIndex, maxCount);
    var = computeVar(leftIndex, rightIndex, mean);
    sum = 0.0;

    for(int i = leftIndex; i <= rightIndex; i++){
        int gval = gaussianFunc(i, mean, var);
        sum += abs(gval - histAry[i]);
        GaussAry[i] = gval;
        GaussImg[i][gval] = 1;
    }//for

    return sum;
}//fitGauss

int gaussianFunc(int index, double mu, double sigma2){
    int x = index;
    double a = 1 / (sqrt(2 * M_PI * sigma2));
    double p = -0.5 * (pow(x - mu,2)/(sigma2));
    double g = a * exp(p);
    g *= grayCount;
    return (int) g;
}//gaussianFunc

void plotGaps(int leftIndex, int rightIndex){
```

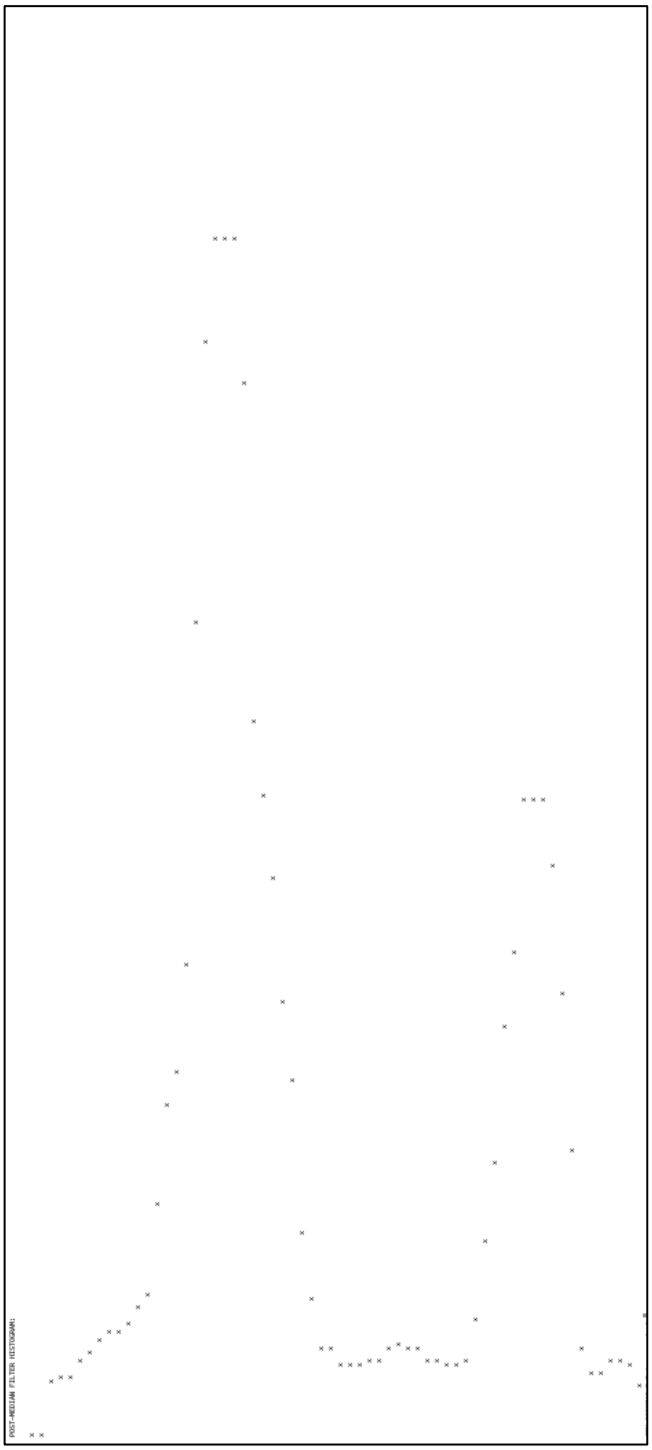
```
    int index = leftIndex;

    while(index <= rightIndex){
        int first = min(histAry[index], GaussAry[index]);
        int last = max(histAry[index], GaussAry[index]);
        while(first < last){
            GapImg[index][first] = 1;
            first++;
        }//while
        index++;
    }//while
}//plotGaps

void prettyPrint(int** plot, ofstream &outputStream){
    for(int i = 0; i < maxVal + 1; i++){
        for(int j = 0; j < maxCount + 1; j++){
            int v = plot[i][j];
            switch (v){
                case 1:
                    outputStream << "o";
                    break;
                default:
                    outputStream << " ";
                    break;
            }//switch
        }//for
        outputStream << endl;
    }//for
}//prettyPrint
```

Output: Histogram

Original

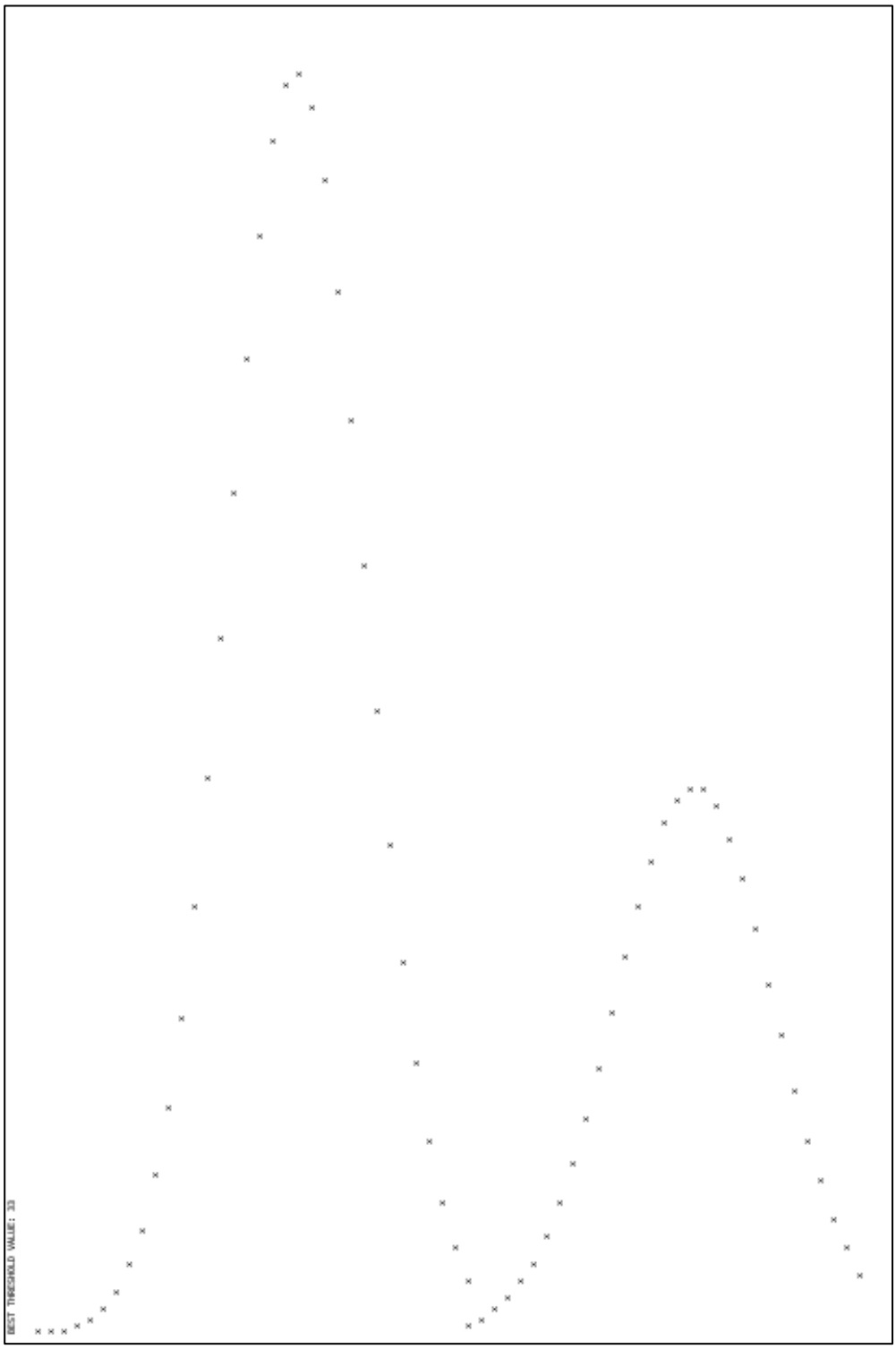


Smoothed



Output: Bi-Mean Gaussian

Best Threshold Value: 33



Output: Gaps Filled Btwn Histogram and Bi-Mean Gaussian