```
*******************************************************************************
CSCI 381-26      Project 5: Robert, Sobel and Gradient Edge Detectors      Language: JAVA

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          Hard copy: 2/12/2020

Submission date: Soft copy: 2/10/2020
                 Hard copy: 2/12/2020

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```

Part 1: Algorithm

```
*******************************
IV. main (...)
*******************************

step 0: open the image and read the image header
         dynamically allocate mirrorFramedAry and all the edge arrays

step 1: loadImage (mirrorFramedAry)
       // load input file to mirrorFramedAry begin at (1,1)

step 2: mirrowFramed (mirrorFramedAry)

step 3: process the mirrorFramedAry, from left to right and top to bottom
        begin at (1, 1) // process all pixels!!!

            RobertRightDiag(i,j)← abs(convoluteRobert (i,j, maskRobertRightDiag))
            RobertLeftDiag(i,j) ← abs (convoluteRobert (i,j, maskRobertLeftDiag))
            SobelRightDiag(i,j) ← abs(convoluteSobel (i,j, maskSobelRightDiag))
            SobelLeftDiag(i,j)← abs (convoluteSobel (i,j, maskSobelLeftDiag))
            GradiantEdge(i,j) ← computeGradient(i,j)

step 4: repeat step 3 until all pixels inside of the frame are processed.

step 5: addTwoArys (RobertRightDiag, RobertLeftDiag, edgeSum)
         output RobertRightDiag to deBugOut file // with caption
         output RobertLeftDiag to deBugOut file // with caption
         output input image header to RobertEdgeOut file
         output edgeSum to RobertEdgeOut file // begin at edgeSum[1][1]

step 6: addTwoArys (SobelRightDiag, SobelLeftDiag, edgeSum)
         output SobelRightDiag to deBugOut file // with caption
         output SobelLeftDiag to deBugOut file // with caption
         output input image header to SobelEdgeOut file
         output edgeSum to SobelEdgeOut file // begin at edgeSum[1][1]

Step 7: output input image header to GradiantEdgeOut file
        output GradiantEdge to GradiantEdgeOut file //begin at GradiantEdge[1][1]

step 8: close all files
```

Part 2: Source code

```
import java.io.*;
import java.util.*;
class Main {
    public static int numRows, numCols, minVal, maxVal;
    public static int max = 0;
    public static int min = 999999;
    public static int[][] mirrorFramedAry;
    public static int[][] maskRobertRightDiag = {{0,1},{-1,0}};
    public static int[][] maskRobertLeftDiag = {{1,0},{0,-1}};
    public static int[][] maskSobelRightDiag = {{2,1,0},{1,0,-1},{0,-1,-2}};
    public static int[][] maskSobelLeftDiag = {{0,1,2},{-1,0,1},{-2,-1,0}};
    public static int[][] RobertRightDiag, RobertLeftDiag, SobelRightDiag, SobelLeftDiag, GradiantEdge,
                          edgeSum;
    static void set2DZero(int[][] Ary){
        for(int i=0; i<numRows+2 ; i++){
            for(int j=0; j<numCols+2 ; j++){
                Ary[i][j]=0;
            }
        }
    }
    static void loadImage (int[][] Ary, Scanner file){
        for(int i=1; i<numRows+1 ; i++){
            for(int j=1 ; j<numCols+1 ; j++){
                Ary[i][j] = file.nextInt();
            }
        }
    }
    static void mirrowFramed(int[][] Ary){
        for(int i=0; i<numRows+2; i++){
            Ary[i][0]=Ary[i][1];
            Ary[i][numCols+1]=Ary[i][numCols];
        }
        for(int j=0; j<numCols+2; j++){
            Ary[0][j]=Ary[1][j];
            Ary[numRows+1][j]=Ary[numRows][j];
        }
    }
    static int convoluteRobert(int i, int j, int[][] Ary){
        int sum = 0, temp = j;
        for(int r = 0 ; r < 2 ; r++){
            for(int c = 0 ; c < 2 ; c++){
                sum += (Ary[r][c] * mirrorFramedAry[i][j]);
                j++;
            }
            i++;
            j = temp;
        }
        return sum;
    }
    static int convoluteSobel(int i, int j, int[][] Ary){
        int sum=0,temp = j;
        for(int r = 0 ; r < 3 ; r++){
            for(int c = 0 ; c < 3 ; c++){
                sum += (Ary[r][c] * mirrorFramedAry[i-1][j-1]);
                j++;
            }
            j = temp;
            i++;
        }
        return sum;
    }
    static int computeGradient(int i, int j){
        int sum=0;
        int x = mirrorFramedAry[i][j], r = mirrorFramedAry[i+1][j], c = mirrorFramedAry[i][j+1];
        sum = (int) Math.sqrt(((x-r)*(x-r))+((x-c)*(x-c)));
        return sum;
    }
```

```
static void addTwoArys(int[][] Ary1,int[][] Ary2,int[][] Ary3){
    for(int i=1; i<numRows+1; i++){
        for(int j=1; j<numCols+1; j++){
            Ary3[i][j] = Ary2[i][j] +  Ary1[i][j];
            if(Ary3[i][j] > max){
                max = Ary3[i][j];
            }
            if (Ary3[i][j] < min) {
                min = Ary3[i][j];
            }
        }
    }
}
static void imgOut(int[][] Ary, PrintWriter file){
    int newmin = min;
    int newmax = max;
    file.println(numRows+" "+numCols+" "+newmin+" "+newmax);
    for(int i=1; i<numRows+1; i++){
        for(int j=1 ; j<numCols+1 ; j++){
            file.print(Ary[i][j]+" ");
        }
        file.println();
    }
}
static void prettyprint(int[][] Ary, PrintWriter file){
    for(int i=1; i<numRows+1; i++){
        for(int j=1 ; j<numCols+1 ; j++){
            file.print(Ary[i][j]+" ");
        }
        file.println();
    }
}
public static void main(String[] args) throws IOException {
    Scanner inFile = new Scanner(new FileInputStream(args[0]));
    PrintWriter outFile1 = new PrintWriter(new FileOutputStream(args[1]));
    PrintWriter outFile2 = new PrintWriter(new FileOutputStream(args[2]));
    PrintWriter outFile3 = new PrintWriter(new FileOutputStream(args[3]));
    PrintWriter outFile4 = new PrintWriter(new FileOutputStream(args[4]));
    numRows = inFile.nextInt();
    numCols = inFile.nextInt();
    minVal = inFile.nextInt();
    maxVal = inFile.nextInt();
    mirrorFramedAry = new int[numRows + 2][numCols + 2];
    RobertRightDiag = new int[numRows + 2][numCols + 2];
    RobertLeftDiag = new int[numRows + 2][numCols + 2];
    SobelRightDiag = new int[numRows + 2][numCols + 2];
    SobelLeftDiag = new int[numRows + 2][numCols + 2];
    GradiantEdge = new int[numRows + 2][numCols + 2];
    edgeSum = new int[numRows + 2][numCols + 2];
    loadImage(mirrorFramedAry, inFile);
    mirrowFramed(mirrorFramedAry);
    for(int i=1; i<numRows+1; i++){
        for(int j=1 ; j<numCols+1 ; j++){
            RobertRightDiag[i][j] = Math.abs(convoluteRobert(i, j, maskRobertRightDiag));
               RobertLeftDiag[i][j] = Math.abs(convoluteRobert(i, j, maskRobertLeftDiag));
                  SobelRightDiag[i][j] = Math.abs(convoluteSobel(i, j, maskSobelRightDiag));
                  SobelLeftDiag[i][j] = Math.abs(convoluteSobel(i, j, maskSobelLeftDiag));
            GradiantEdge[i][j] = computeGradient(i,j);
            if(GradiantEdge[i][j] > max){
                max = GradiantEdge[i][j];
            }
            if (GradiantEdge[i][j] < min) {
                min = GradiantEdge[i][j];
            }
        }
    }
    imgOut(GradiantEdge, outFile3);
    addTwoArys(RobertRightDiag, RobertLeftDiag, edgeSum);
    outFile4.println("--------RobertLeftDiag to pretty print file ------"+"\n");
```

```
        prettyprint(RobertLeftDiag, outFile4);
        outFile4.println("\n"+"-------- RobertRightDiag to pretty print file -------"+"\n");
        prettyprint(RobertRightDiag, outFile4);
        imgOut(edgeSum, outFile1);
        set2DZero(edgeSum);
        min = 9999999;
        max = 0;
        addTwoArys(SobelRightDiag, SobelLeftDiag, edgeSum);
        outFile4.println("\n"+"-------- SobelLeftDiag to pretty print file ------"+"\n");
        prettyprint(SobelLeftDiag, outFile4);
        outFile4.println("\n"+"-------- SobelRightDiag to pretty print file -------"+"\n");
        prettyprint(SobelRightDiag, outFile4);
        imgOut(edgeSum, outFile2);
        outFile4.println("\n"+"--------- GradiantEdge to pretty print file -------"+"\n");
        prettyprint(GradiantEdge, outFile4);
        inFile.close();
        outFile1.close();
        outFile2.close();
        outFile3.close();
        outFile4.close();
    }
}
```

Part 3: Output

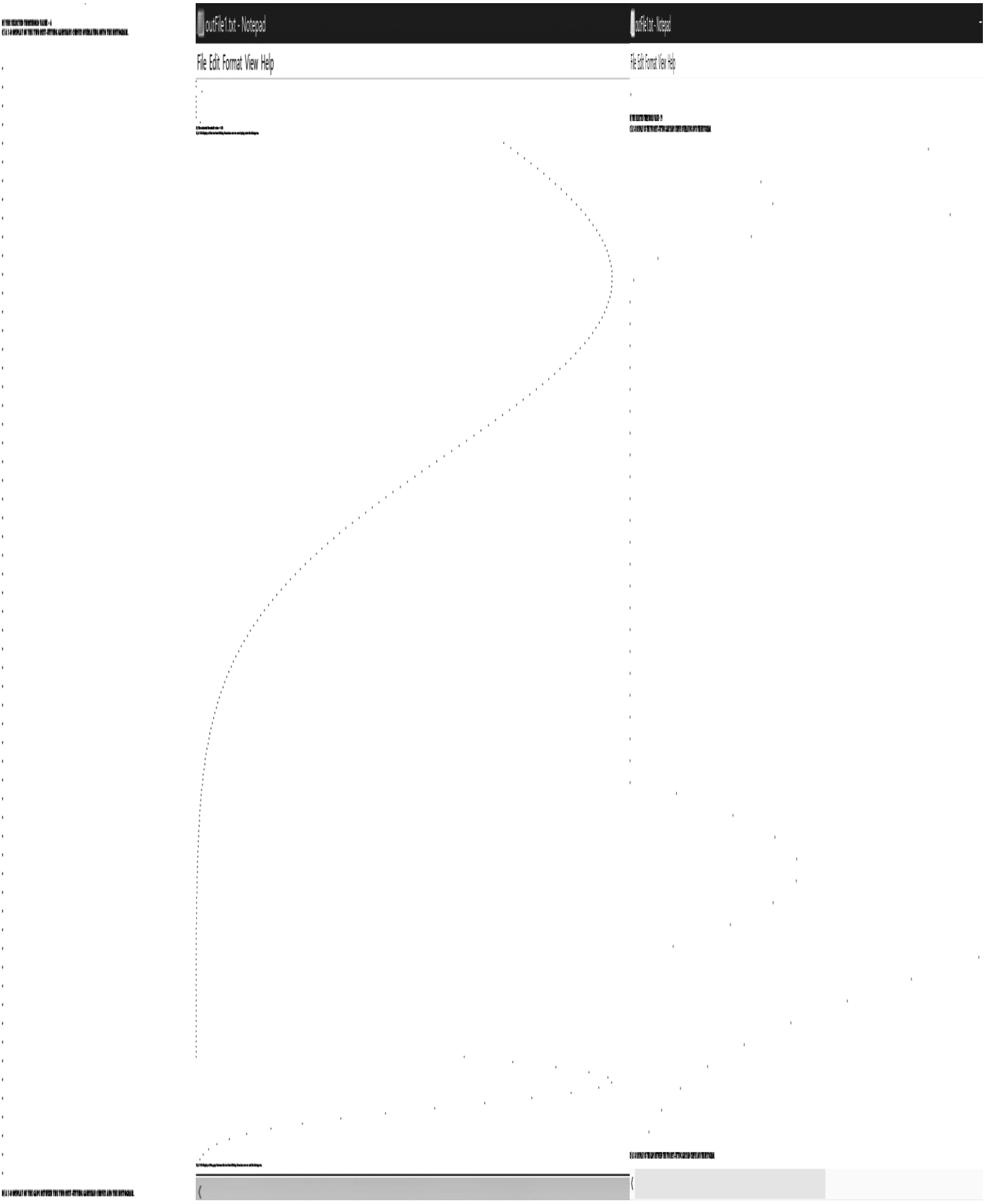
histogram of RobertEdgeOut	**histogram of SobelEdgeOut**	**histogram of GradientEdgeOut**
45 45 0 60	45 45 0 198	45 45 0 45
0 1897	0 0	0 44
1 0	1 0	1 1493
2 1	2 0	2 3
3 0	3 0	3 1
4 4	4 0	4 340
5 0	5 0	5 0
6 0	6 81	6 0
7 0	7 0	7 0
8 0	8 1	8 0
9 0	9 0	9 0
10 0	10 0	10 0
11 0	11 0	11 0
12 0	12 1007	12 0
13 0	13 0	13 0
14 0	14 0	14 0
15 0	15 0	15 0
16 0	16 0	16 0
17 0	17 0	17 0
18 0	18 593	18 0
19 0	19 0	19 0
20 0	:: :	20 0
21 0	57 0	21 0
22 0	58 1	22 0
23 0	59 0	23 0
24 0	60 56	24 0
25 0	61 0	25 0
26 0	62 1	26 2
27 0	63 0	27 0
28 0	64 0	28 0
29 0	65 0	29 27
30 0	66 2	30 57
31 0	67 0	31 26
32 0	68 0	32 0
33 0	69 0	33 0
34 0	70 0	34 2
35 0	71 0	35 0
36 0	72 35	36 0
37 0	73 0	37 0
38 0	74 0	38 0
39 0	75 0	39 2
	76 0	
	77 0	
	78 21	
	79 0	
	80 0	
	81 0	
	82 0	
	83 0	
	84 0	
	85 0	
	86 0	
	87 0	
	88 0	
	89 0	
	90 0	
	91 0	
	92 0	
	93 0	

40 0	94 0	40 0
41 0	95 0	41 13
42 0	96 0	42 1
43 0	97 0	43 13
44 0	98 0	44 0
45 0	99 0	45 2
46 0	100 0	
47 0	101 0	
48 0	102 2	
49 0	103 0	
50 0	104 0	
51 0	105 0	
52 0	106 0	
53 0	107 0	
54 0	108 3	
55 0	109 0	
56 0	110 0	
57 0	111 0	
58 3	112 0	
59 0	113 0	
60 121	114 1	
	115 0	
	116 0	
	117 0	
	118 1	
	119 0	
	120 62	
	121 0	
	122 1	
	123 0	
	124 2	
	125 0	
	126 1	
	127 0	
	128 0	
	129 0	
	130 0	
	131 0	
	132 38	
	133 0	
	134 0	
	135 0	
	136 0	
	137 0	
	138 21	
	139 0	
	::: :	
	161 0	
	162 10	
	163 0	
	164 0	
	165 0	
	166 0	
	167 0	
	168 14	
	169 0	
	170 0	
	171 0	
	172 0	
	173 0	
	174 0	
	175 0	
	176 0	
	177 0	
	178 0	
	179 0	
	180 48	
	181 0	
	182 0	
	183 0	
	184 0	
	185 0	
	186 0	
	187 0	
	188 0	
	189 0	
	190 0	
	191 0	
	192 14	
	193 0	
	194 0	
	195 0	
	196 0	
	197 0	
	198 10	

Note: In sobel's histogram, pixel value from 19 to 57 pixel count is 0 and also from 139 to 161 pixel count is 0.

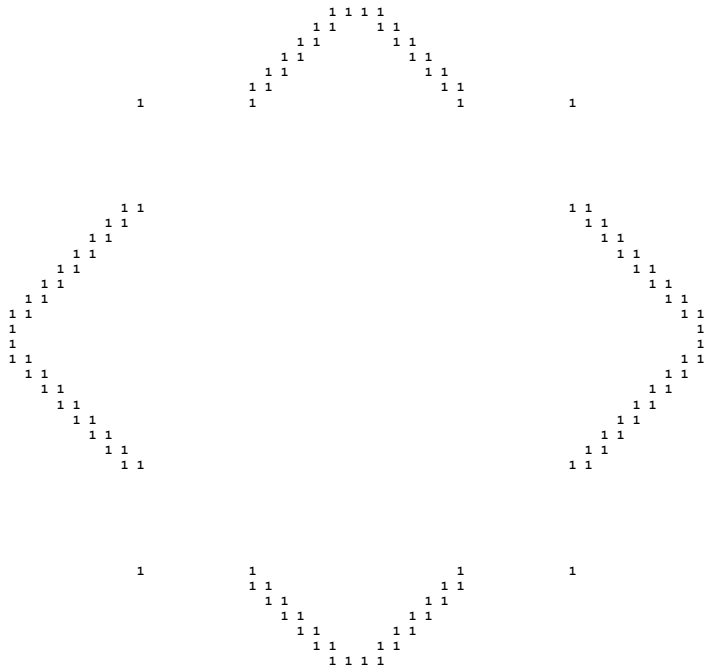
- **overlay bi-Gaussian curves on histogram of**

RobertEdgeOut	SobelEdgeOut	GradientEdgeOut

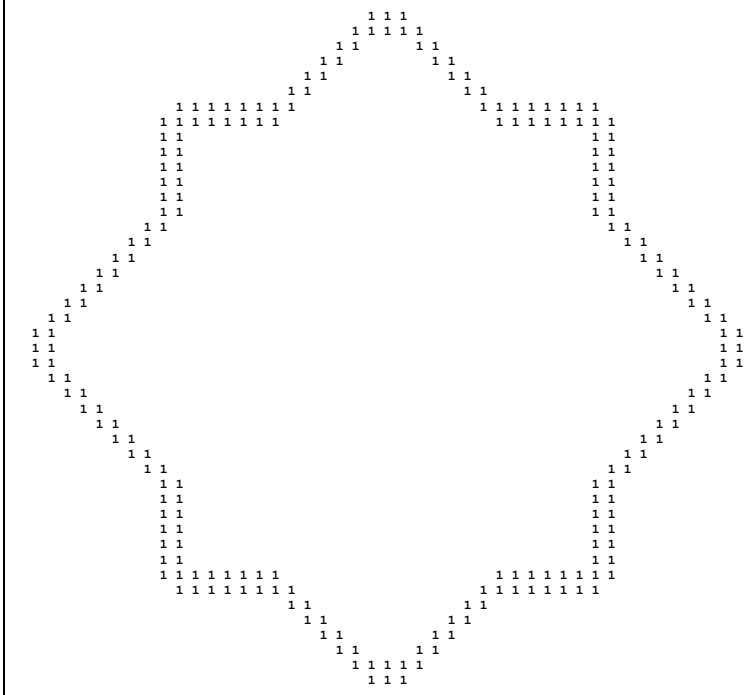


- **pretty print the best threshold result**

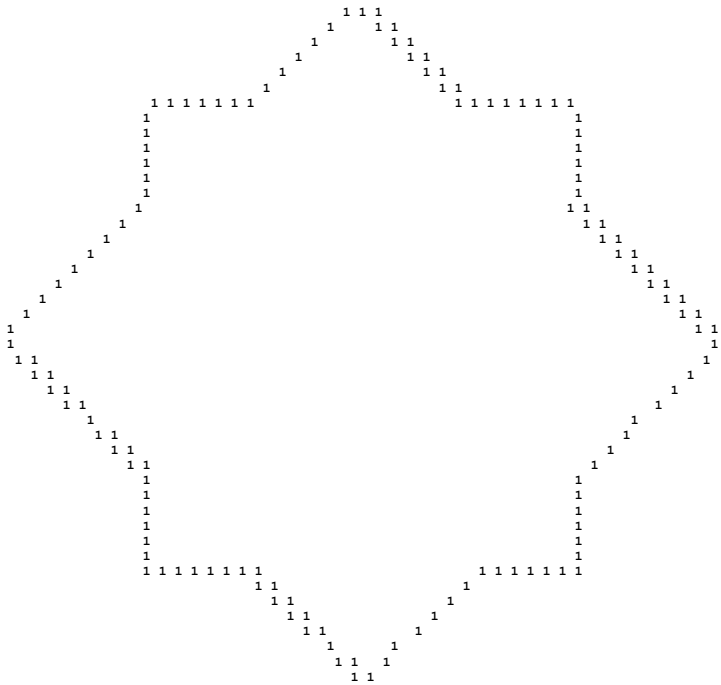
RobertEdgeOut



SobelEdgeOut



GradientEdgeOut



- **with new Robert mask**

+1	0
0	-1

0	+1
-1	0

Gx

```
45 45 0 62
0  44
1  0
2  1467
3  1
4  2
5  0
6  0
7  0
8  336
9  0
10  0
11  0
12  0
13  0
14  0
15  0
16  0
17  0
18  0
19  0
20  0
21  0
22  0
23  0
24  0
25  0
26  0
27  0
28  0
29  1
30  60
31  1
32  53
33  1
34  0
35  0
36  0
37  0
38  8
39  0
40  0
41  0
42  0
43  0
44  0
45  0
46  0
47  0
48  0
49  0
50  0
51  0
52  0
53  0
54  0
55  0
56  0
57  0
58  13
59  0
60  26
61  0
62  13
```

Gy