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Section: Image Processing

Project: **Project 6 - Sobel and Robert Edge Detector**

Due Date: Nov 12th

Algorithm Steps

Step 0: inFile, outFile1, deBugFile ← via argv []
choice ← argv [2]
numRows, numCols, minVal, maxVal ← read from inFile
mirrorFramedAry, RobertEdgeAry, SobelEdgeAry ← all dynamically allocate with extra 2 rows and 2 cols.
histRobertAry ← dynamically allocate with maxVal+1 and **initialize to zero** (Must do in C++)
histSobelAry ← dynamically allocate with maxVal+1 and **initialize to zero** (Must do in C++)

Step 1: loadImage (inFile, mirrorFramedAry)

Step 2: mirrorFraming (mirrorFramedAry)

Step 3: imgReformat (mirrorFramedAry, outFile1)

Step 4: if choice == 1
RobertEdgeDetector (mirrorFramedAry, RobertEdgeAry, deBugFile)
computeHist (RobertEdgeAry, histRobertAry, deBugFile)
nameRobertEdge ← argv [1] + "_Robert_edge.txt" // nameRobertEdge is a string type
RobertEdgeFile ← open nameRobertEdge for write // RobertEdgeFile is a file stream type
imgReformat (RobertEdgeAry, outFile1)
RobertEdgeFile ← output numRows, numCols, minVal, maxVal
RobertEdgeFile ← output RobertEdgeAry
RobertHist ← argv [1] + "_Robert_hist.txt" // RobertHist is a string type
histRobertFile ← open RobertHist for write // histRobertFile is a file stream type
printHist (histRobertAry, histRobertFile, deBugFile)
Step 5: if choice == 2
SobelEdgeDetector (mirrorFramedAry, SobelEdgeAry, deBugFile)
computeHist (SobelEdgeAry, histSobelAry, deBugFile)
nameSobelEdge ← argv [1] + "_Sobel.txt" // nameSobelEdge is a string type
SobelEdgeFile ← open nameSobelEdge for write // SobelEdgeFile is a file stream type
imgReformat (SobelEdgeAry, outFile1)
SobelEdgeFile ← output numRows, numCols, minVal, maxVal
SobelEdgeFile ← output SobelEdgeAry
SobelHist ← argv[1] + "_Sobel_hist.txt" // SobelHist is a string type
histSobelFile ← open SobelHist for write // is a file stream type
printHist (histSobelAry, histSobelFile, deBugFile)
Step 6: close all files

Source Code:

```
#include <iostream>
#include <fstream>

using namespace std;

namespace Util{
    static int** getArray(int rows, int cols){
        int** array = new int*[rows];
        for(int i = 0; i < rows; i++){
            array[i] = new int[cols];
            for(int j = 0; j < cols; j++){
                array[i][j] = 0;
            }
        }
        return array;
    }

    static int* getArray(int length){
        int* array = new int[length];
        for(int i = 0; i < length; i++){
            array[i] = 0;
        }
        return array;
    }

    static int min(int a, int b){
        return a < b ? a : b;
    }

    static int max(int a, int b){
        return a > b ? a : b;
    }
}
```

```
class EdgeDetector{
public:
    int numRows,
        numCols,
        minVal,
        maxVal;
    int** mirrorFramedAry;
    int robertVerticalMask[2][2] = {{1, -1}, {1, -1}};
    int robertHorizontalMask[2][2] = {{1, 1}, {-1, -1}};
    int robertLeftDiagonalMask[2][2] = {{1, -1}, {-1, 1}};
    int robertRightDiagonalMask[2][2] = {{-1, 1}, {1, -1}};
    int** robertEdgeAry;

    int sobelVerticalMask[3][3] = {{-1, 0, 1}, {-2, 0, 2}, {-1, 0, 1}};
    int sobelHorizontalMask[3][3] = {{1, 2, 1}, {0, 0, 0}, {-1, -2, -1}};
    int sobelLeftDiagonalMask[3][3] = {{2, 1, 0}, {1, 0, -1}, {0, -1, -2}};
    int sobelRightDiagonalMask[3][3] = {{0, 1, 2}, {-1, 0, 1}, {-2, -1, 0}};
    int** sobelEdgeAry;

    int* histRobertAry;
    int* histSobelAry;

    EdgeDetector(ifstream& inFile){
        inFile >> numRows >> numCols >> minVal >> maxVal;
        mirrorFramedAry = Util::getArray(numRows + 2, numCols + 2);
        robertEdgeAry = Util::getArray(numRows + 2, numCols + 2);
        sobelEdgeAry = Util::getArray(numRows + 2, numCols + 2);
        histRobertAry = Util::getArray(maxVal + 1);
        histSobelAry = Util::getArray(maxVal + 1);
        loadImage(inFile);
        mirrorFraming();
    }

    void loadImage(ifstream& inFile){
        for(int i = 1; i < numRows + 1; i++){
            for(int j = 1; j < numCols + 1; j++){
                inFile >> mirrorFramedAry[i][j];
```

```
        }
    }
}

void mirrorFraming(){
    for(int i = 0; i < numRows + 2; i++){
        mirrorFramedAry[i][0] = mirrorFramedAry[i][1];
        mirrorFramedAry[i][numCols + 1] = mirrorFramedAry[i][numCols];
    }
    for(int j = 0; j < numCols + 2; j++){
        mirrorFramedAry[0][j] = mirrorFramedAry[1][j];
        mirrorFramedAry[numRows + 1][j] = mirrorFramedAry[numRows][j];
    }
}

void imageReformat(int** image, ofstream& outFile){
    outFile << numRows << " " << numCols << " " << minVal << " " << maxVal << '\n';
    string str;
    int curWidth,
        pixelWidth = to_string(maxVal).length();

    for(int r = 1; r < numRows + 1; r++){
        for(int c = 1; c < numCols + 1; c++){
            outFile << image[r][c];
            str = to_string(image[r][c]);
            curWidth = str.length();
            while(curWidth < pixelWidth){
                outFile<<' ';
                curWidth++;
            }
            outFile<<' ';
        }
        outFile << '\n';
    }
}

void robertEdgeDetector(ofstream& debugFile){
```

```
    debugFile << "Enter robertEdgeDetector\n";
    int newMax = 0, newMin = 99999;
    int tempV, tempH, tempLD, tempRD;
    for(int i = 1; i < numRows + 1; i++){
        for(int j = 1; j < numCols + 1; j++){
            tempH = abs(computeRobertConvolution(i, j, robertHorizontalMask));
            tempV = abs(computeRobertConvolution(i, j, robertVerticalMask));
            tempLD = abs(computeRobertConvolution(i, j, robertLeftDiagonalMask));
            tempRD = abs(computeRobertConvolution(i, j, robertRightDiagonalMask));
            robertEdgeAry[i][j] = tempH + tempV + tempLD + tempRD;
            newMax = Util::max(newMax, robertEdgeAry[i][j]);
            newMin = Util::min(newMin, robertEdgeAry[i][j]);
        }
    }
    maxVal = newMax;
    minVal = newMin;

    debugFile << "Exit robertEdgeDetector\n";
}

int computeRobertConvolution(int row, int col, int mask[2][2]){
    int sum = 0;
    sum += mirrorFramedAry[row][col] * mask[0][0];
    sum += mirrorFramedAry[row][col + 1] * mask[0][1];
    sum += mirrorFramedAry[row + 1][col] * mask[1][0];
    sum += mirrorFramedAry[row + 1][col + 1] * mask[1][1];
    return sum;
}

void sobelEdgeDetector(ofstream& debugFile){
    debugFile << "Enter sobelEdgeDetector\n";
    int newMax = 0, newMin = 99999;
    int tempV, tempH, tempLD, tempRD;
    for(int i = 1; i < numRows + 1; i++){
        for(int j = 1; j < numCols + 1; j++){
            tempH = abs(computeSobelConvolution(i, j, sobelHorizontalMask));
            tempV = abs(computeSobelConvolution(i, j, sobelVerticalMask));
```

```
            tempLD = abs(computeSobelConvolution(i, j, sobelLeftDiagonalMask));
            tempRD = abs(computeSobelConvolution(i, j, sobelRightDiagonalMask));
            sobelEdgeAry[i][j] = tempH + tempV + tempLD + tempRD;
            newMax = Util::max(newMax, sobelEdgeAry[i][j]);
            newMin = Util::min(newMin, sobelEdgeAry[i][j]);
        }
    }
    maxVal = newMax;
    minVal = newMin;
    debugFile << "Exit sobelEdgeDetector\n";
}

int computeSobelConvolution(int row, int col, int mask[3][3]){
    int sum = 0;
    int startX = row - 1, startY = col - 1;
    for(int i = 0; i < 3; i++){
        for(int j = 0; j < 3; j++){
            sum += mirrorFramedAry[startX + i][startY + j] * mask[i][j];
        }
    }
    return sum;
}

void computeHistogram(int** image, int* hist, ofstream& debugFile){
    debugFile << "Enter computeHistogram\n";
    for(int i = 1; i < numRows + 1; i++){
        for(int j = 1; j < numCols + 1; j++){
            hist[image[i][j]]++;
        }
    }
    debugFile << "Exit computeHistogram\n";
}

void outputHistogram(int* hist, ofstream& outFile, ofstream& debugFile){
    debugFile << "Enter outputHistogram\n";
    outFile << numRows << " " << numCols << " " << minVal << " " << maxVal << '\n';
    for(int i = 0; i <= maxVal; i++){
```

```
            outFile << i << " " << hist[i] << '\n';
        }
        debugFile << "Exit outputHistogram\n";
    }

    void outputImage(int** image, ofstream& outFile){
        outFile << numRows << " " << numCols << " " << minVal << " " << maxVal << '\n';
        for(int i = 1; i < numRows + 1; i++){
            for(int j = 1; j < numCols + 1; j++){
                outFile << image[i][j] << " ";
            }
            outFile << '\n';
        }
    }
};


void useRobert(const char* argv[], EdgeDetector* edgeDetector, ofstream& outFile, ofstream& debugFile){
    edgeDetector->robertEdgeDetector(debugFile);
    edgeDetector->computeHistogram(edgeDetector->robertEdgeAry, edgeDetector->histRobertAry, debugFile);
    edgeDetector->imageReformat(edgeDetector->robertEdgeAry, outFile);

    ofstream robertEdgeFile((string)argv[1] + "_Robert_Edge.txt"),
             robertHistFile((string)argv[1] + "_Robert_Histogram.txt");
    edgeDetector->outputImage(edgeDetector->robertEdgeAry, robertEdgeFile);
    edgeDetector->outputHistogram(edgeDetector->histRobertAry, robertHistFile, debugFile);
}

void useSobel(const char* argv[], EdgeDetector* edgeDetector, ofstream& outFile, ofstream& debugFile){
    edgeDetector->sobelEdgeDetector(debugFile);
    edgeDetector->computeHistogram(edgeDetector->sobelEdgeAry, edgeDetector->histSobelAry, debugFile);
    edgeDetector->imageReformat(edgeDetector->sobelEdgeAry, outFile);

    ofstream sobelEdgeFile((string)argv[1] + "_Sobel_Edge.txt"),
             sobelHistFile((string)argv[1] + "_Sobel_Histogram.txt");
    edgeDetector->outputImage(edgeDetector->sobelEdgeAry, sobelEdgeFile);
    edgeDetector->outputHistogram(edgeDetector->histSobelAry, sobelHistFile, debugFile);
```

```
}



int main(int argc, const char* argv[]) {
    ifstream inFile(argv[1]);
    int choice = atoi(argv[2]);
    ofstream outFile(argv[3]), debugFile(argv[4]);

    EdgeDetector edgeDetector(inFile);
    edgeDetector.imageReformat(edgeDetector.mirrorFramedAry, outFile);

    if (choice == 1) {
        useRobert(argv, &edgeDetector, outFile, debugFile);
    } else if (choice == 2) {
        useSobel(argv, &edgeDetector, outFile, debugFile);
    }

    return 0;
}
```

Program Output

Robert OutFile

```
45 45 1 35

1 2 3 5 5 1 2 3 4 5 1 2 3 4 5 1 2 3 4 5 1 2 33 4 5 1 2 3 4 5 1 2 3 4 5 1 2 3 4 5 1 2 3 4 5

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Pretty Print Robert Edge File

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Robert Edge Histogram

45 45 0 128

0 43

1 0

2 1463

3 0

4 1

5 0

6 4

7 0

8 336

9 0

10 2

11 0

12 0

13 0

14 0

15 0

16 0

17 0

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106 0

107 0

108 1

109 0

110 1

111 0

112 6

113 0

114 0

115 0

116 0

117 0

118 54

119 0

120 1

121 0

122 53

123 0

124 0

125 0

126 0

127 0

128 8

Robert Histogram and Threshold Value – Project 1

ń0 (43):+++

1 (0):

2 (1463):+++
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3 (0):

4 (1):+

5 (0):

6 (4):++++

7 (0):

8 (336):++
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9 (0):

10 (2):++

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):

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50 (0):

51 (0):

52 (0):

53 (0):

54 (0):

55 (0):

56 (0):

57 (0):

58 (13):++++++++++++

59 (0):

60 (2):++

61 (0):

62 (29):+++++++++++++++++++++++++++++

63 (0):

64 (0):

65 (0):

66 (0):

67 (0):

68 (8):++++++++

69 (0):

70 (0):

71 (0):

72 (0):

73 (0):

74 (0):

75 (0):

76 (0):

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100 (0):

101 (0):

102 (0):

103 (0):

104 (0):

105 (0):

106 (0):

107 (0):

108 (1):+

109 (0):

110 (1):+

111 (0):

112 (6):++++++

113 (0):

114 (0):

115 (0):

116 (0):

117 (0):

118 (54):++

119 (0):

120 (1):+

121 (0):

122 (53):+++

123 (0):

124 (0):

125 (0):

126 (0):

127 (0):

128 (8):++++++++

The Bi-Gaussian Value is 107

Robert Edge Threshold Binary Image – Project 0A

Threshold Value 107

45 45 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 0 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 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0

Robert Edge Threshold Binary Image – Project 0A

Threshold Value 25

45 45 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 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0

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Robert Edge Debug

Enter robertEdgeDetector

Exit robertEdgeDetector

Enter computeHistogram

Exit computeHistogram

Enter outputHistogram

Exit outputHistogram

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1 2 3 5 5 1 2 3 4 5 1 2 3 4 5 1 2 3 4 5 1 2 33 4 5 1 2 3 4 5 1 2 3 4 5 1 2 3 4 5 1 2 3 4 5

1 2 3 4 5 1 2 3 4 5 1 2 3 4 5 1 2 3 4 5 1 32 33 34 5 1 2 3 4 5 1 2 3 4 5 1 2 3 4 5 1 2 3 4 5

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Sobel Edge Threshold Selection – Project 1

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289 (0):

290 (1):+

291 (0):

292 (35):+++++++++++++++++++++++++++++++++++

293 (0):

294 (0):

295 (0):

296 (0):

297 (0):

298 (0):

299 (0):

300 (1):+

301 (0):

302 (0):

303 (0):

304 (0):

305 (0):

306 (0):

307 (0):

308 (24):++++++++++++++++++++++++

309 (0):

310 (0):

311 (0):

312 (16):++++++++++++++++

313 (0):

314 (0):

315 (0):

316 (0):

317 (0):

318 (0):

319 (0):

320 (45):+++

321 (0):

322 (0):

323 (0):

324 (0):

325 (0):

326 (0):

327 (0):

328 (0):

329 (0):

330 (29):+++++++++++++++++++++++++++++

331 (0):

332 (0):

333 (0):

334 (0):

335 (0):

336 (0):

337 (0):

338 (0):

339 (0):

340 (4):++++

341 (0):

342 (0):

343 (0):

344 (0):

345 (0):

346 (0):

347 (0):

348 (2):++

349 (0):

350 (0):

351 (0):

352 (0):

353 (0):

354 (0):

355 (0):

356 (2):++

357 (0):

358 (0):

359 (0):

360 (0):

361 (0):

362 (0):

363 (0):

364 (2):++

365 (0):

366 (0):

367 (0):

368 (0):

369 (0):

370 (0):

371 (0):

372 (2):++

373 (0):

374 (0):

375 (0):

376 (0):

377 (0):

378 (0):

379 (0):

380 (4):++++

The Bi-Gaussian Value is 37

Sobel Edge Threshold – Project 0A

Threshold Value: 37

45 45 0 1

0 0 0 0 1 0 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 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

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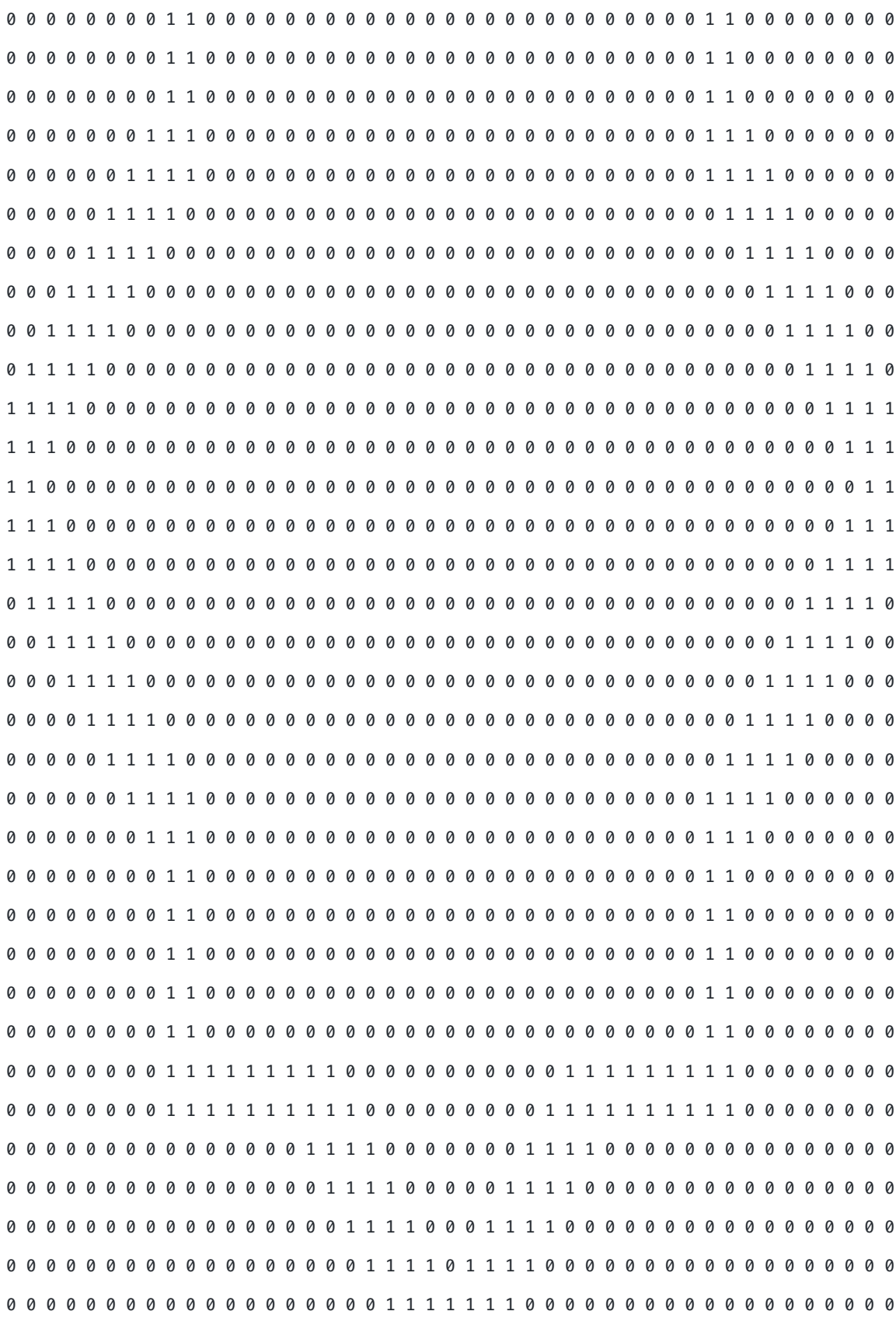
0 0 0 0 0 0 0 0 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 0 0 0 0 0 0 0



0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 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

Sobel Edge Threshold – Project 0A

Threshold Value: 120

45 45 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 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0

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Sobel Edge Debug

Enter sobelEdgeDetector

Exit sobelEdgeDetector

Enter computeHistogram

Exit computeHistogram

Enter outputHistogram

Exit outputHistogram