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Algorithm Steps for firstPass8Dist given an array:

0. newMin ←999; newMax←0
1. Scan array from L to R & T to B starting at (1,1), where i and j are the indices respectively
2. If array[i,j] > 0:
3. Array[i,j] ←1 + min(upper 3 neighbors, and left neighbor)
4. End-if
5. If newMin > Array[i,j]:
6. newMin ← Array[i,j]
7. End-if
8. If newMax < Array[i,j]:
9. newMax ← Array[i,j]
10. repeat 1 to 9 until all pixels are processed

Algorithm steps for secondPass8Dist given an array:

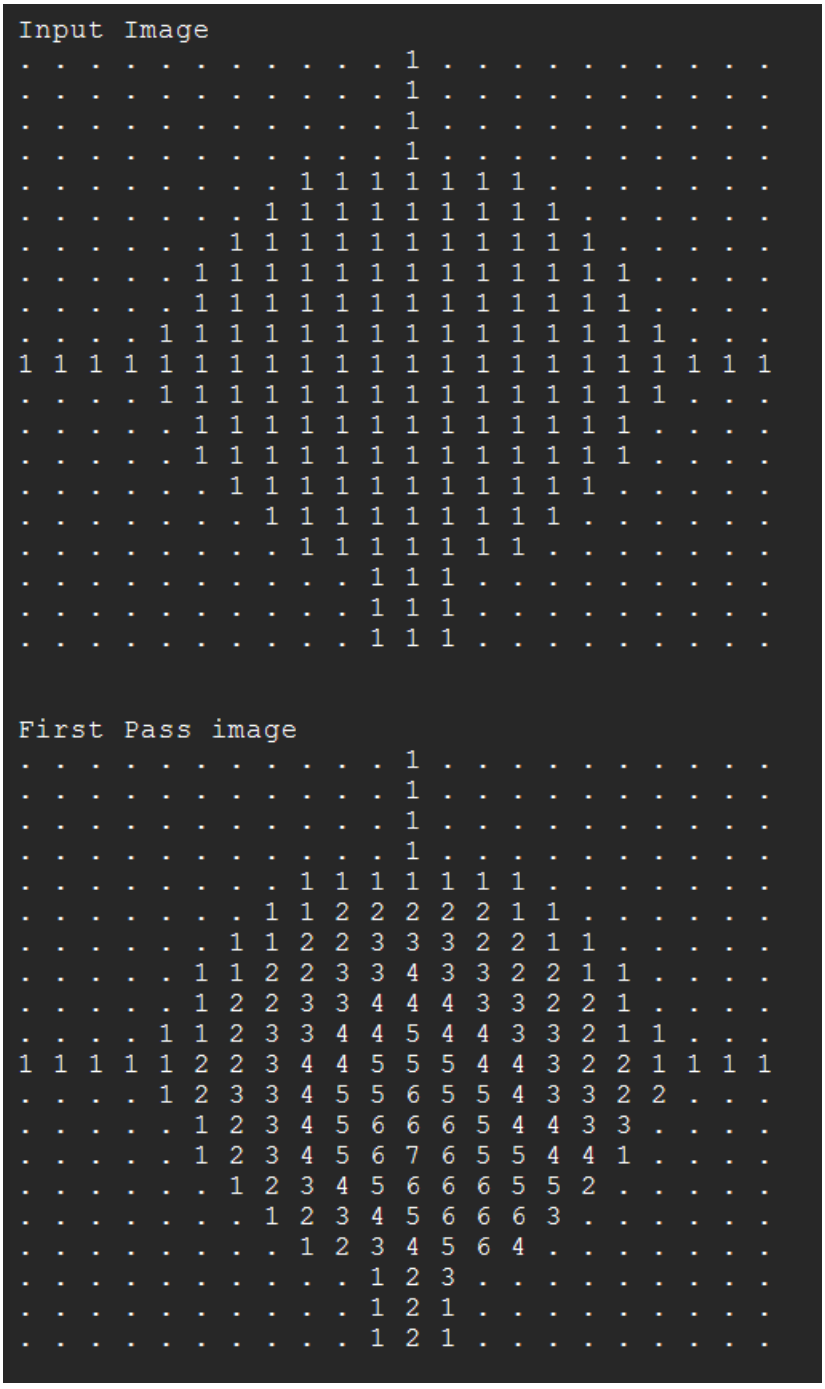
0. newMin ←999; newMax←0
1. Scan array from R to L & B to T starting at (numRows,numCols), where i and j are the indices respectively
2. If array[i,j] > 0:
3. Array[i,j] ←min (upper 3 neighbors + 1 to each, left neighbor + 1, array[i,j])
4. End-if
5. If newMin > Array[i,j]:
6. newMin ← Array[i,j]
7. End-if
8. If newMax < Array[i,j]:
9. newMax ← Array[i,j]
10. repeat 1 to 9 until all pixels are processed

```cpp
#include <iostream>
#include <fstream>
#include <string>
#include <cmath>

using namespace std;

class imageProcessing{
    public:
        int numRows, numCols, minVal, maxVal;
        int newMin, newMax;
        int** ZFArray;

        imageProcessing(int *h);
        ~imageProcessing();
        void setZero(int** zfarray);
        void loadImage(ifstream& in, int** ary);
        void firstPass8Distance(int** ary);
        void secondPass8Dustance(int** ary);
        void reformatPrettyPrint(int** array, int min, int max, ofstream& out);


};


int main(int argc, char** argv){
    string inputFileName = argv[1], outputFileName = argv[2];
    ifstream input(inputFileName);
    ofstream output(outputFileName);

    int header[4];
    for(int i = 0; i < 4; ++i){
        input >> header[i];
    }
    imageProcessing imageprocessing(header);
    imageprocessing.setZero(imageprocessing.ZFArray);
    output << "Input Image \n";
    imageprocessing.loadImage(input, imageprocessing.ZFArray);
    imageprocessing.reformatPrettyPrint(imageprocessing.ZFArray,
imageprocessing.minVal, imageprocessing.maxVal, output);
    imageprocessing.firstPass8Distance(imageprocessing.ZFArray);
    output << "First Pass image \n";
    imageprocessing.reformatPrettyPrint(imageprocessing.ZFArray,
imageprocessing.minVal, imageprocessing.maxVal, output);
    imageprocessing.secondPass8Dustance(imageprocessing.ZFArray);
```

```
    output << "Second Pass Image \n";
    imageprocessing.reformatPrettyPrint(imageprocessing.ZFArray,
imageprocessing.minVal, imageprocessing.maxVal, output);

    input.close();
    output.close();

}


imageProcessing::imageProcessing(int *h){
    numRows = h[0];
    numCols = h[1];
    minVal = h[2];
    maxVal = h[3];

    ZFArray = new int*[numRows + 2];
    for(int i = 0; i < numRows + 2; ++i){
        ZFArray[i] = new int[numCols + 2];
    }
}

imageProcessing::~imageProcessing(){
    for(int i = 0; i < numRows + 2; ++i){
        delete[] ZFArray[i];
    }
    delete[] ZFArray;
}

void imageProcessing::loadImage(ifstream& in, int** ary){
    int rows = numRows+1, cols = numCols + 1;
    for(int i = 1; i < rows; ++i){
        for(int j = 1; j < cols; ++j){
            in >> ary[i][j];
        }
    }
}


void imageProcessing::setZero(int** zfarray){
    for(int i = 0; i < numRows + 2; ++i){
        for(int j = 0; j < numCols + 2; ++j){
            zfarray[i][j] = 0;
        }
    }
```

```
}


void imageProcessing::reformatPrettyPrint(int** array, int min, int max,
ofstream& out){
    for(int i = 1; i < numRows + 1;++i){
        for(int j = 1; j < numCols + 1; ++j){
            if(array[i][j] > 0){
                out << to_string(array[i][j]) + " ";
            }
            else{
                out << ". ";
            }
        }
        out << "\n";
    }
    out << "\n\n";
}


void imageProcessing::firstPass8Distance(int** ary){
    int newMin = 99999, newMax = 0;
    for(int i = 1; i < numRows + 1; ++i){
        for(int j = 1; j < numCols + 1; ++j){
            if(ary[i][j] > 0){
                int* inp = new int[4];
                inp[0] = ary[i][j-1];
                int minimum = inp[0];
                inp[1] = ary[i-1][j+1];
                inp[2] = ary[i-1][j];
                inp[3] = ary[i-1][j-1];
                for(int i = 1; i < 4; ++i){
                    if(inp[i] < minimum){
                        minimum = inp[i];
                    }
                }
                ary[i][j] = minimum + 1;
            }
            newMin = newMin > ary[i][j] ? ary[i][j] : newMin;
            newMax = newMax < ary[i][j] ? ary[i][j] : newMax;
        }
    }
}
```

```cpp
void imageProcessing::secondPass8Dustance(int** ary){
    int newMin = 99999, newMax = 0;
    for(int i = numRows; i > 0; --i){
        for(int j = numCols; j > 0; --j){
            if(ary[i][j] > 0){
                int* inp = new int[5];
                inp[0] = ary[i][j+1]+1;
                int minimum = inp[0];
                inp[1] = ary[i+1][j+1] + 1;
                inp[2] = ary[i+1][j] + 1;
                inp[3] = ary[i+1][j-1] + 1;
                inp[4] = ary[i][j];
                for(int i = 1; i < 5; ++i){
                    if(inp[i] < minimum){
                        minimum = inp[i];
                    }
                }
                ary[i][j] = minimum;
            }
            newMin = newMin > ary[i][j] ? ary[i][j] : newMin;
            newMax = newMax < ary[i][j] ? ary[i][j] : newMax;
        }
    }
}
```


Input Image
. . . . . 1 . . . . . .
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. . . . . 1 1 1 1 1 1 1 1 1 1 1 . . . . . .
. . . . . 1 1 1 1 1 1 1 1 1 1 1 1 1 . . . . .
. . . . . 1 1 1 1 1 1 1 1 1 1 1 1 1 . . . . .
. . . . 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 . . . .
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. . . . 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 . . . .
. . . . . 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 . . . .
. . . . . 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 . . . .
. . . . . 1 1 1 1 1 1 1 1 1 1 1 1 1 . . . . . .
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. . . . . 1 1 1 . . . . . .
. . . . . 1 1 1 . . . . . .
First Pass image
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. . . . . 1 . . . . . .
. . . . . 1 . . . . . .
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. . . . . 1 1 2 2 2 2 2 1 1 . . . . . .
. . . . . 1 1 2 2 3 3 3 2 2 1 1 . . . . . .
. . . . . 1 1 2 2 3 3 4 3 3 2 2 1 1 . . . . .
. . . . . 1 2 2 3 3 4 4 4 3 3 2 2 1 . . . . .
. . . . 1 1 2 3 3 4 4 5 4 4 3 3 2 1 1 . . . .
1 1 1 1 1 2 2 3 4 4 5 5 5 4 4 3 2 2 1 1 1 1 1
. . . . 1 2 3 3 4 5 5 6 5 5 4 3 3 2 2 . . . .
. . . . . 1 2 3 4 5 6 6 6 5 4 4 3 3 . . . . .
. . . . . 1 2 3 4 5 6 7 6 5 5 4 4 1 . . . . .
. . . . . 1 2 3 4 5 6 6 6 5 5 2 . . . . . .
. . . . . 1 2 3 4 5 6 6 6 3 . . . . . .
. . . . . 1 2 3 4 5 6 4 . . . . . .
. . . . . 1 2 3 . . . . . .
. . . . . 1 2 1 . . . . . .
. . . . . 1 2 1 . . . . . .

```
Second Pass Image
. . . . . . . . . . . 1 . . . . . . . . . .
. . . . . . . . . . . 1 . . . . . . . . . .
. . . . . . . . . . . 1 . . . . . . . . . .
. . . . . . . . . . . 1 . . . . . . . . . .
. . . . . . . . 1 1 1 1 1 1 1 . . . . . . .
. . . . . . . 1 1 2 2 2 2 2 1 1 . . . . . .
. . . . . . 1 1 2 2 3 3 3 2 2 1 1 . . . . .
. . . . . 1 1 2 2 3 3 4 3 3 2 2 1 1 . . . .
. . . . . 1 2 2 3 3 4 4 4 3 3 2 2 1 . . . .
. . . . 1 1 2 3 3 4 4 5 4 4 3 3 2 1 1 . . .
1 1 1 1 1 2 2 3 4 4 5 5 5 4 4 3 2 2 1 1 1 1
. . . . 1 1 2 3 3 4 4 5 4 4 3 3 2 1 1 . . .
. . . . . 1 2 2 3 3 4 4 4 3 3 2 2 1 . . . .
. . . . . 1 1 2 2 3 3 4 3 3 2 2 1 1 . . . .
. . . . . . 1 1 2 2 3 3 3 2 2 1 1 . . . . .
. . . . . . . 1 1 2 2 2 2 2 1 1 . . . . . .
. . . . . . . . 1 1 1 2 1 1 1 . . . . . . .
. . . . . . . . . . 1 2 1 . . . . . . . . .
. . . . . . . . . . 1 2 1 . . . . . . . . .
. . . . . . . . . . 1 1 1 . . . . . . . . .
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Input Image
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
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. . . . . 1 1 1 1 1 . . . . . . . . . . . . . . . . . . 1 1 1 1 1 . . . . . . .
. . . . 1 1 1 1 1 1 . . . . . . . . . . . . . . . . . 1 1 1 1 1 1 1 . . . . . .
. . . . . 1 1 1 1 1 . . . . . . 1 . . . . . . . . . 1 1 1 1 1 1 1 1 1 . . . . .
. . . . . . . 1 1 1 . . . . . . 1 . . . . . . . . 1 1 1 1 1 1 1 1 1 1 1 . . . .
. . . . 1 1 1 1 1 1 . . . . . . 1 . . . . . . . 1 1 1 1 1 1 1 1 1 1 1 1 1 . . .
. . . . 1 1 1 1 1 1 . . . . . 1 1 1 . . . . . 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 . .
. . . . 1 1 1 1 1 1 . . . . 1 1 1 1 1 . . . . . . . 1 1 1 1 1 1 1 1 1 . . . . .
. . . . 1 1 1 1 1 1 . . . 1 1 1 1 1 1 . . . . . . . . 1 1 1 1 1 1 1 . . . . . .
. . . . 1 1 1 1 1 1 1 . 1 1 1 1 1 1 1 1 . . . . . . . . . 1 1 1 . . . . . . . .
. . . . 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 . . 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 . .
. . . . 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 . . . 1 1 1 1 1 1 1 1 1 1 1 1 1 . . .
. . . . 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 . . . . 1 1 1 1 1 1 1 1 1 1 1 . . . .
. . . . . 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 . . . 1 1 1 1 1 1 1 1 1 1 . . . . . .
. . . . . . 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 . 1 1 1 1 1 . . . . . . .
. . . . . . . 1 1 1 1 1 . . . 1 1 1 1 1 1 1 1 1 1 1 1 . . 1 1 1 . . . . . . . .
. . . . . . . . . 1 1 . . . . . . 1 1 1 . . . 1 1 . . . . . 1 . . . . . . . . .
. . . . . . . . . 1 . . . . . . . . 1 . . . . . 1 . . . . . . . . . . . . . . .
```
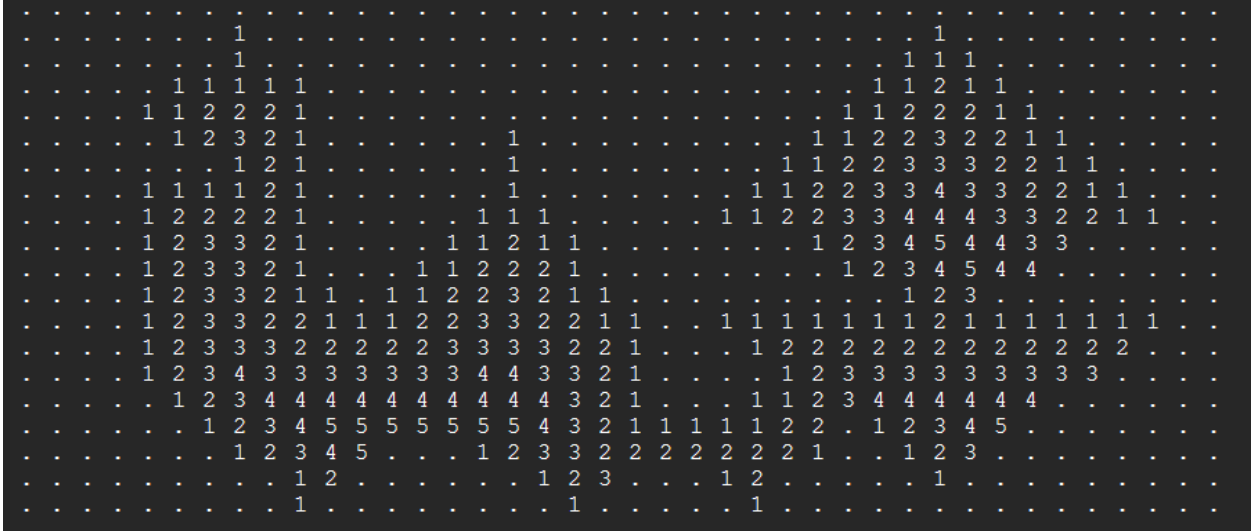

First Pass image



Second Pass Image