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Algorithm Steps

```
*******************************
VI. main (…)
*******************************
step 0: open inFile and outFile1
        numRows, numCols, minVal, maxVal ← read from inFile
        dynamically allocate ZFAry with extra 2 rows and 2 cols
        dynamically allocate skeletonAry with extra 2 rows and 2 cols
Step 1: skeletonFileName ← argv[1] + "_skeleton.txt"
Step 2: skeletonFile ← open (skeletonFileName )
Step 3: deCompressedFileName ← argv[1] + "_deCompressed.txt"
Step 4: deCompressFile ← open (deCompressedFileName)
Step 5:  setZero (ZFAry)
        setZero (skeletonAry)
Step 6: loadImage (inFile, ZFAry)
Step 7: compute8Distance (ZFAry, outFile1)  // Perform distance transform
Step 8: imageCompression (ZFAry, skeletonAry, skeletonFile, outFile1) // Perform lossless compression
Step 9: close skeletonFile
Step 10: reopen skeletonFile
Step 11: setZero (ZFAry)
Step 12: loadSkeleton (skeletonFile, ZFAry)
Step 13: imageDeCompression (ZFAry, outFile1) // Perform decompression
Step 14: deCompressFile ← output numRows, numCols, newMinVal, newMaxVal
Step 15: threshold (ZFAry, deCompressFile)
Step 16: close all files
*******************************
V. Compute8Distance (ZFAry, outFile1)
*******************************
Step 1: fistPass8Distance (ZFAry)
Step 2: reformatPrettyPrint (ZFAry, outFile1) // with proper caption i.e., 1st pass distance transform
Step 3: secondPass8Distance (ZFAry)
Step 4: reformatPrettyPrint (ZFAry, outFile1) // with proper caption i.e., 2nd pass distance transform
*******************************
VI. imageCompression (ZFAry, skeletonAry, skeletonFile, outFile1)
*******************************
Step 1: computeLocalMaxima (ZFAry, skeletonAry)
Step 2: reformatPrettyPrint (skeletonAry, outFile1)// with proper caption i.e., Local maxima, skeletonAry
Step 3: extractSkeleton (skeletonAry, skeletonFile)
*******************************
VII. imageDeCompression (ZFAry, outFile1)
*******************************
Step 1:  firstPassExpension (ZFAry)
Step 2: reformatPrettyPrint (ZFAry, outFile1) // with proper caption i.e., 1st pass Expansion
Step 3: secondPassExpension (ZFAry)
Step 4: reformatPrettyPrint (ZFAry, outFile1) // with proper caption i.e., 2nd pass Expansion
```

Source Code

Main Class

```
int main( int argc, const char * argv[] ) {

    if(argc != 3){
        cout << "Invalid amount of arguments";
        exit(1);
    }

    string imgFile = argv[1] ;
    string outFile = argv[ 2 ] ;
    ifstream  imgStream, inSkeletonStream;
    ofstream outStream, outSkeletonStream, decompressedStream;
    imgStream.open( imgFile ) ;
    outStream.open( outFile ) ;
```

```
if( imgStream.is_open() ){
        // step 0:
        ImageCompression* imageObj = new ImageCompression( imgStream );
        // step 1 & 2:
        string skeletonFile = imgFile + "_skeleton.txt";
        outSkeletonStream.open( skeletonFile );
        // step 3 & 4:
        string decompressedFile = imgFile + "_decompressed.txt";
        decompressedStream.open( decompressedFile );
        // step 5:
        imageObj -> setZero(imageObj -> zfArr);
        imageObj -> setZero(imageObj -> skeletonArr);
        // step 6:
        imageObj -> loadImage(imgStream, imageObj -> zfArr);
        outStream << "Original Image \n";
        imageObj -> reformatPrettyPrint(imageObj -> zfArr, outStream);
        // step 7:
        imageObj -> compute8Distance(imageObj -> zfArr, outStream);
        // step 8:
        imageObj -> imageCompression(imageObj -> zfArr, imageObj -> skeletonArr, outSkeletonStream, outStream);
```

```
        // step 9, 10, 11:
        outSkeletonStream.close();
        inSkeletonStream.open(skeletonFile);
        imageObj -> setZero(imageObj -> zfArr);
        // step 12:
        imageObj -> loadSkeleton(inSkeletonStream, imageObj -> zfArr);
        outStream << "loaded from skeleton \n";
        imageObj -> reformatPrettyPrint(imageObj -> zfArr, outStream);
        // step 13:
        imageObj -> imageDecompression(imageObj -> zfArr, outStream);
        // step 14:
        decompressedStream << imageObj -> numRows << " " << imageObj -> numCols << " " << 0  << " " << 1 << " " << endl;
        // step 15:
        imageObj -> threshold(imageObj -> zfArr, decompressedStream);
        // step 16:
        imgStream.close() ;
        outStream.close();
        inSkeletonStream.close();
        decompressedStream.close();
        delete imageObj ;
    }
    else{
        cout << "Error: Input" << endl ;
    }

    return 0;
```

ImageCompression

```
class ImageCompression{
    public:
        int numRows,
            numCols,
            minVal,
            maxVal,
            newMinVal,
            newMaxVal,
            rowSize,
            colSize;

        int **skeletonArr, **zfArr;


    public:
        ImageCompression( ifstream &imgFile ){
            read_header(imgFile);
            this -> newMaxVal = 0;
            this -> newMinVal = 99999;
            this -> rowSize = this -> numRows + 2;
            this -> colSize = this -> numCols + 2;
            this -> zfArr = new int* [this -> rowSize];
            this -> skeletonArr = new int* [this -> rowSize];

            // create 2D array
            for(int i = 0; i < this -> rowSize; i++){
                this -> zfArr[i] = new int [this -> colSize];
                this -> skeletonArr[i] = new int [this -> colSize];
            }
        }
```

```
void read_header( ifstream &inFile ){
    inFile >> this -> numRows >> this -> numCols >> this -> minVal >> this -> maxVal ;
}

void setZero(int** arr){
    for(int i = 0; i < this -> rowSize; i++){
        for(int j = 0; j < this -> colSize; j++){
            arr[i][j] = 0;
        }
    }
}

void loadImage(ifstream &inFile, int** arr){
    for(int i = 1; i < this -> numRows + 1; i++){
        for(int j = 1; j < this -> numCols + 1; j++){{
            inFile >> arr[i][j];
        }}
    }
}

void compute8Distance(int** arr, ofstream &output){
    firstPass8Distance(arr);
    output << "Distance Transform: 1st Pass \n";
    reformatPrettyPrint(arr, output);
    secondPass8Distance(arr);
    output << "Distance Transform: 2nd Pass \n";
    reformatPrettyPrint(arr, output);
}

void firstPass8Distance(int** arr){
    // step 1 & 3:
    for(int i = 1; i < this -> numRows + 1; i++){
        for(int j = 1; j < this -> numCols + 1; j++){
            int p = arr[i][j];

            // step 2:
            if(p > 0){
                int a = arr[i-1][j-1];
                int b = arr[i-1][j];
                int c = arr[i-1][j+1];
                int d = arr[i][j-1];

                arr[i][j] = min( min(a,b), min(c,d) ) + 1;
            }
        }
    }
}
```

```cpp
void computeLocalMaxima(int** zfArr, int** skeletonArr){
    // Step 1 & 3:
    for(int i = 1; i < this -> numRows + 1; i++){
        for(int j = 1; j < this -> numCols + 1; j++){

            // Step 2:
            int p = zfArr[i][j];
            int a = zfArr[i-1][j-1];
            int b = zfArr[i-1][j];
            int c = zfArr[i-1][j+1];
            int d = zfArr[i][j-1];
            int e = zfArr[i][j+1];
            int f = zfArr[i+1][j-1];
            int g = zfArr[i+1][j];
            int h = zfArr[i+1][j+1];
            int neighbors[8] = {a,b,c,d,e,f,g,h};

            // isLocalMaxima
            bool flag = true;
            for(int k = 0; k < 9; k++){
                if(p >= neighbors[k]) continue;
                else flag = false;
            }

            if( flag ){
                skeletonArr[i][j] = p;
                if(p > this -> newMaxVal) this -> newMaxVal = p;
                else if( p < this -> newMinVal ) this -> newMinVal = p;
            }
            else {
                skeletonArr[i][j] = 0;
                this -> newMinVal = 0;
            }

        }
    }
}
```

```cpp
void loadSkeleton(ifstream &inFile, int** arr){
    read_header(inFile);
    int r, c, val;
    inFile >> r >> c >> val;

    for(int i = 0; i < this -> rowSize; i++){
        for(int j = 0; j < this -> colSize; j++){
            if(i == r && j == c){
                arr[i][j] = val;
                inFile >> r >> c >> val;
            }
            else arr[i][j] = 0;
        }
    }
}

void extractSkeleton(int** arr, ofstream &output){
    output << this -> numRows << " " << this -> numCols << " " << this -> newMinVal << " " << this -> newMaxVal << endl;
    for(int i = 1; i < this -> numRows + 1; i++){
        for(int j = 1; j < this -> numCols + 1; j++){
            if( arr[i][j] > 0 ) output << i << " " << j << " " << arr[i][j] << endl;
        }
    }
}

void reformatPrettyPrint(int** arr, ofstream &output){
    for(int i = 0; i < this -> rowSize; i++){
        for(int j = 0; j < this -> colSize; j++){
            output << arr[i][j] << " ";
        }
        output << endl;
    }
    output << endl;
}
```

```
void imageDecompression(int** arr, ofstream &output){
    firstPassExpansion(arr);
    output << "Image Decompression: Expansion Pass 1 \n";
    reformatPrettyPrint(arr, output);
    secondPassExpansion(arr);
    output << "Image Decompression: Expansion Pass 2 \n";
    reformatPrettyPrint(zfArr, output);
}

void firstPassExpansion(int** arr){
    for(int i = 1; i < this -> numRows; i++){
        for(int j = 1; j < this -> numCols; j++){
            int p = arr[i][j];
            if(p == 0){
                int a = zfArr[i-1][j-1];
                int b = zfArr[i-1][j];
                int c = zfArr[i-1][j+1];
                int d = zfArr[i][j-1];
                int e = zfArr[i][j+1];
                int f = zfArr[i+1][j-1];
                int g = zfArr[i+1][j];
                int h = zfArr[i+1][j+1];
                int maximum;
                maximum = max(
                                    max( max(a,b), max(c,d) ),
                                    max( max(e,f), max(g,h) )
                                ) - 1;
                if(maximum < 0) arr[i][j] = 0;
                else arr[i][j] = maximum;
            }
        }
    }
}
```

```
void secondPassExpansion(int** arr){
    this -> newMaxVal = 0;
    this -> newMinVal = 999;
    for(int i = this -> numRows; i > 0; i--){
        for(int j = this -> numCols; j > 0; j--){
            int p = arr[i][j];
            int a = arr[i-1][j-1];
            int b = arr[i-1][j];
            int c = arr[i-1][j+1];
            int d = arr[i][j-1];
            int e = arr[i][j+1];
            int f = arr[i+1][j-1];
            int g = arr[i+1][j];
            int h = arr[i+1][j+1];

            int maximum;
            maximum = max(
                        max(
                            max( max(a,b), max(c,d) ),
                            max( max(e,f), max(g,h) )
                        ) - 1,
                        p
                    );

            if (p > this -> newMaxVal) this -> newMaxVal = p;
            if (p < this -> newMinVal) this -> newMinVal = p;
            if(p < maximum) arr[i][j] = maximum;
        }
    }
}

void threshold(int** arr, ofstream &output){
    for(int i = 1; i < this -> numRows + 1; i++){
        for(int j = 1; j < this -> numCols + 1; j++){
            int p = arr[i][j];
            if(p > 0) output << 1 << " ";
            else output << 0 << " ";
        }
        output << endl;
    }
}
```

Image 1 Output

```
Original Image
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 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 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 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 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 1 1 1 1 1 1 1 1 1 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 1 0 0 0 0 0 0 0 0
0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 1 1 1 0 0 0 0 0 0 0
0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 1 1 1 0 0 0 0 0 0 0
0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 0 0 0 0 0
0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0
0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 0 0 0 0 0
0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 0 0 0 0 0
0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 0 0 0 0 0
0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 1 1 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 1 1 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 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 0 0 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 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 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

Distance Transform: 1st Pass
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 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 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 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 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 1 1 2 2 2 2 2 1 1 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 1 1 2 2 3 3 3 2 2 1 1 0 0 0 0 0 0 0 0
0 0 0 0 0 0 1 1 2 2 3 3 4 3 3 2 2 1 1 0 0 0 0 0 0 0
0 0 0 0 0 0 1 2 2 3 3 4 4 4 3 3 2 2 1 0 0 0 0 0 0 0
0 0 0 0 0 1 1 2 3 3 4 4 5 4 4 3 3 2 1 1 0 0 0 0 0 0
0 1 1 1 1 1 2 2 3 4 4 5 5 5 4 4 3 2 2 1 1 1 1 0 0 0
0 0 0 0 0 1 2 3 3 4 5 5 6 5 5 4 3 3 2 2 0 0 0 0 0 0
0 0 0 0 0 0 1 2 3 4 5 6 6 6 5 4 4 3 3 0 0 0 0 0 0 0
0 0 0 0 0 0 1 2 3 4 5 6 7 6 5 5 4 4 1 0 0 0 0 0 0 0
0 0 0 0 0 0 0 1 2 3 4 5 6 6 6 5 5 2 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 1 2 3 4 5 6 6 6 3 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 1 2 3 4 5 6 4 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 1 2 3 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 1 2 1 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 1 2 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
```

```
Distance Transform: 2nd Pass
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 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 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 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 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 1 1 2 2 2 2 2 1 1 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 1 1 2 2 3 3 3 2 2 1 1 0 0 0 0 0 0 0 0
0 0 0 0 0 0 1 1 2 2 3 3 4 3 3 2 2 1 1 0 0 0 0 0 0 0
0 0 0 0 0 0 1 2 2 3 3 4 4 4 3 3 2 2 1 0 0 0 0 0 0 0
0 0 0 0 0 1 1 2 3 3 4 4 5 4 4 3 3 2 1 1 0 0 0 0 0 0
0 1 1 1 1 1 2 2 3 4 4 5 5 5 4 4 3 2 2 1 1 1 1 0 0 0
0 0 0 0 0 1 1 2 3 3 4 4 5 4 4 3 3 2 1 1 0 0 0 0 0 0
0 0 0 0 0 0 1 2 2 3 3 4 4 4 3 3 2 2 1 0 0 0 0 0 0 0
0 0 0 0 0 0 1 1 2 2 3 3 4 3 3 2 2 1 1 0 0 0 0 0 0 0
0 0 0 0 0 0 0 1 1 2 2 3 3 3 2 2 1 1 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 1 1 2 2 2 2 2 1 1 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 1 1 1 2 1 1 1 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 1 2 1 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 1 2 1 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 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

After computing local maxima, skeleton array
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 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 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 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 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 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 0
0 0 0 0 0 0 0 0 0 0 0 0 4 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 0 0 0 0 0 0 5 0 0 0 0 0 0 0 0 0 0 0 0 0
0 1 1 1 1 0 2 0 0 4 0 5 5 5 0 4 0 0 2 0 1 1 1 0
0 0 0 0 0 0 0 0 0 0 0 0 5 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 0 0 0 0 0 0 4 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 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 2 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 2 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 2 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 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
```

```
loaded from skeleton
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 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 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 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 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 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 0
0 0 0 0 0 0 0 0 0 0 0 0 4 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 0 0 0 0 0 0 5 0 0 0 0 0 0 0 0 0 0 0 0 0
0 1 1 1 1 0 2 0 0 4 0 5 5 5 0 4 0 0 2 0 1 1 1 0
0 0 0 0 0 0 0 0 0 0 0 0 5 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 0 0 0 0 0 0 4 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 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 2 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 2 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 2 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 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0

Image Decompression: Expansion Pass 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 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 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 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 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 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 3 3 3 2 1 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 2 3 4 3 2 1 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 1 2 4 4 4 3 2 1 0 0 0 0 0 0 0 0
0 0 0 0 0 1 1 1 3 3 4 4 5 4 4 3 3 2 1 1 0 0 0 0 0 0
0 1 1 1 1 1 2 2 3 4 4 5 5 5 4 4 3 2 2 1 1 1 1 0 0 0
0 0 0 0 0 1 1 2 3 3 4 4 5 4 4 3 3 2 1 1 0 0 0 0 0 0
0 0 0 0 0 0 1 2 2 3 3 4 4 4 3 3 2 2 1 0 0 0 0 0 0 0
0 0 0 0 0 0 1 1 2 2 3 3 4 3 3 2 2 1 1 0 0 0 0 0 0 0
0 0 0 0 0 0 0 1 1 2 2 3 3 3 2 2 1 1 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 1 1 2 2 2 2 2 1 1 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 1 1 1 2 1 1 1 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 1 2 1 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 1 2 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 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
```

```
Image Decompression: Expansion Pass 2
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 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 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 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 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 1 1 2 2 2 2 2 1 1 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 1 1 2 2 3 3 3 2 2 1 1 0 0 0 0 0 0 0
0 0 0 0 0 0 0 1 1 2 2 3 3 4 3 3 2 2 1 1 0 0 0 0 0 0
0 0 0 0 0 0 1 2 2 3 3 4 4 4 3 3 2 2 1 0 0 0 0 0 0 0
0 0 0 0 0 1 1 2 3 3 4 4 5 4 4 3 3 2 1 1 0 0 0 0 0 0
0 1 1 1 1 1 2 2 3 4 4 5 5 5 4 4 3 2 2 1 1 1 1 1 0 0
0 0 0 0 0 1 1 2 3 3 4 4 5 4 4 3 3 2 1 1 0 0 0 0 0 0
0 0 0 0 0 0 1 2 2 3 3 4 4 4 3 3 2 2 1 0 0 0 0 0 0 0
0 0 0 0 0 0 1 1 2 2 3 3 4 3 3 2 2 1 1 0 0 0 0 0 0 0
0 0 0 0 0 0 0 1 1 2 2 3 3 3 2 2 1 1 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
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Image 1 Decompressed File

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20 22 0 1
0 0 0 0 0 0 0 0 0 0 0 0 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 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 1 0 0 0 0 0 0 0 0 0 0 0 0 0
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Image 1 Skeleton File

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20 22 0 5
1 12 1
2 12 1
3 12 1
4 12 1
8 12 4
10 12 5
11 1 1
11 2 1
11 3 1
11 4 1
11 6 2
11 9 4
11 11 5
11 12 5
11 13 5
11 15 4
11 18 2
11 20 1
11 21 1
11 22 1
12 12 5
14 12 4
17 12 2
18 12 2
19 12 2
```

Image 2 output

Original Image

Distance Transform: 1st Pass


Distance Transform: 2nd Pass

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After computing local maxima, skeleton array
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 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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Image 2 Skeleton File

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