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Algorithm Steps for Morphology

Dilation:

Step 0: Read image and structure element files

Step 1: Based on the structure element's origin, evaluate each pixel

If img[i][j] == 1, then copy the whole structure element into the pixel and its neighbors

Step 2: Update img

Erosion:

Step 0: Read image and structure element files

Step 1: Based on the structure element's origin, evaluate each pixel

If img[i][j] and its neighbors == structure element, then print 1 on the current pixel and equal all the neighbors to 0.

Step 2: Update img

Opening:

Step 0: Read image and structure element files

Step 1: Perform Erosion **Step 2:** Perform Dilation

Closing:

Step 0: Read image and structure element files

Step 1: Perform Dilation **Step 2:** Perform Erosion

Source Code:

```
#include <iostream>
#include <fstream>
using namespace std;
class Morphology{
       int numImgRows, numImgCols, imgMin, imgMax,numStructRows;
       int numStructCols, structMin, structMax, rowOrigin, colOrigin;
       int rowFrameSize, colFrameSize, extraRows, extraCols, rowSize, colSize;
       int **zeroFramedAry;
       int **morphAry;
       int **tempAry;
       int **structAry;
   Morphology(int imgRows, int imgCols, int min, int max, int structRows, int structCols, int rowO, int colO){
       numImgRows = imgRows;
       numImgCols = imgCols;
       imgMin = min;
       imgMax = max;
       numStructRows = structRows;
       numStructCols = structCols;
       rowOrigin = rowO;
       colOrigin = colO;
       rowFrameSize = numStructRows/2;
       colFrameSize = numStructCols/2;
       extraRows = rowFrameSize*2;
       extraCols = colFrameSize*2;
       rowSize = numImgRows+extraRows;
       colSize = numImgCols+extraCols;
```

```
~Morphology(){
    delete[] zeroFramedAry;
    delete[] morphAry;
    delete[] tempAry;
    delete[] structAry;
    for(int i=0; i<numImgRows; i++){</pre>
        delete[] zeroFramedAry[i];
        delete[] morphAry[i];
        delete[] tempAry[i];
        delete[] structAry[i];
    cout << "Deleted all arrays..." << endl;</pre>
}
void allocateArrs(){
    zeroFramedAry = new int*[rowSize];
    morphAry = new int*[rowSize];
    tempAry = new int*[rowSize];
    structAry = new int*[numStructRows];
    for(int i=0; i<rowSize; i++){</pre>
        zeroFramedAry[i] = new int[colSize]();
        morphAry[i] = new int[colSize]();
        tempAry[i] = new int[colSize]();
    for(int i=0; i<numStructRows; i++){</pre>
        structAry[i] = new int[numStructCols]();
}
int **zero2DAry(int **ary, int nRows, int nCols){
    for(int i=0; i<nRows; i++){</pre>
        for(int j=0; j<nCols; j++){</pre>
            ary[i][j] = 0;
        }
    }
    return ary;
```

```
void loadImg(ifstream& img){
    //load imgFile to zeroFramedAry inside of frame,
    //begins at (rowOrigin, colOrigin)
    if(img.is_open()){
        for(int i=rowOrigin; i<=numImgRows; i++){</pre>
             for(int j=colOrigin; j<=numImgCols; j++){</pre>
                 img >> zeroFramedAry[i][j];
        }
    }
}
void loadStruct(ifstream& in){
    //load structFile to structAry
    for(int i=0; i<numStructRows; i++){</pre>
        for(int j=0; j<numStructCols; j++){</pre>
             in >> structAry[i][j];
    }
}
void computeDilation(int **inAry, int **outAry){
    for(int i=rowFrameSize; i<rowSize; i++){</pre>
        for(int j=colFrameSize; j<colSize; j++){</pre>
             if(inAry[i][j] > 0){
                 onePixelDilation(i, j, inAry, outAry);
        }
    }
```

```
void computeErosion(int **inAry, int **outAry){
    for(int i=rowFrameSize; i<rowSize; i++){</pre>
        for(int j=colFrameSize; j<colSize; j++){</pre>
            if(inAry[i][j] > 0){
                 onePixelErosion(i, j, inAry,outAry);
             }
        }
    }
}
void onePixelErosion(int i, int j, int **inAry, int **outAry){
    int iOffset = i-rowOrigin;
    int jOffset = j-colOrigin;
    bool matchFlag = true;
    for(int i=0; i<numStructRows; i++){</pre>
        for(int j=0; j<numStructCols; j++){</pre>
             if(!matchFlag){
                 break;
             }
            if((structAry[i][j]>0) && (inAry[iOffset+i][jOffset+j])<=0){</pre>
                 matchFlag=false;
             }
        }
    }
    if(matchFlag==true){
        outAry[i][j] = 1;
    }else{
        outAry[i][j] = 0;
    }
}
```

```
void onePixelDilation(int i, int j, int **inAry, int **outAry){
    int iOffset = i-rowOrigin;
    int jOffset = j-colOrigin;
    for(int i=0; i<numStructRows; i++){</pre>
        for(int j=0; j<numStructCols; j++){</pre>
            if(structAry[i][j] > 0){
                 outAry[iOffset + i][jOffset + j] = 1;
            }
        }
    }
}
void computeClosing(int **zfa, int **ma, int **ta){
    computeDilation(zfa, ta);
    computeErosion(ta, ma);
}
void computeOpening(int **zfa, int **ma, int **ta){
    computeErosion(zfa, ta);
    computeDilation(ta, ma);
}
void prettyPrint(int **ary, ofstream& out){
    for(int i=rowOrigin; i<=numImgRows; i++){</pre>
        for(int j=colOrigin; j<=numImgCols; j++){</pre>
            if(ary[i][j] == 0){
                 out << ". ";
            }else{
                 out << "1 ";
             }
        }
        out << endl;
}
```

```
void prettyPrintDilation(int **ary, ofstream& out){
    for(int i=0; i<rowSize; i++){</pre>
         for(int j=0; j<colSize; j++){</pre>
             if(ary[i][j] == 0){
                  out << ". ";
             }else{
                  out << "1 ";
             }
         }
         out << endl;
    }
}
void prettyPrintStruct(int **ary, ofstream& out){
    for(int i=0; i<numStructRows; i++){</pre>
         for(int j=0; j<numStructCols; j++){</pre>
             if(ary[i][j]==0){
                 out << ". ";
             }else{
                  out << "1 ";
             }
         }
         out << endl;
    }
}
void aryToFile(int **ary, ofstream& outFile){
    outFile << numImgRows << " ";</pre>
    outFile << numImgCols << " ";</pre>
    outFile << imgMin << " ";</pre>
    outFile << imgMax << " ";</pre>
    outFile << endl;</pre>
    for(int i=rowOrigin; i<=numImgRows; i++){</pre>
         for(int j=colOrigin; j<=numImgCols; j++){</pre>
             outFile << ary[i][j] << " ";
         outFile << endl;</pre>
    }
```

```
void dilationToFile(int **ary, ofstream& outFile){
         outFile << rowSize << " ";
         outFile << colSize << " ";</pre>
         outFile << imgMin << " ";</pre>
        outFile << imgMax << " ";</pre>
        outFile << endl;</pre>
        for(int i=0; i<rowSize; i++){</pre>
             for(int j=0; j<colSize; j++){</pre>
                  outFile << ary[i][j] << " ";
             }
             outFile << endl;</pre>
         }
    }
    void addBorder(ofstream& out){
         out << endl;
         for(int i=0; i<colSize; i++){</pre>
             out << "--";
         }
         out << endl;</pre>
    }
};
```

```
int main(int argc, char *argv[]){
    if(argc != 8){
        cout << "Invalid arguments, ending program..." << endl;</pre>
        return 1;
    }
    //Step 0
    ifstream imgFile;
    imgFile.open(argv[1]);
    ifstream structFile;
    structFile.open(argv[2]);
    ofstream dilateOutFile;
    dilateOutFile.open(argv[3]);
    ofstream erodeOutFile;
    erodeOutFile.open(argv[4]);
    ofstream closingOutFile;
    closingOutFile.open(argv[5]);
    ofstream openingOutFile;
    openingOutFile.open(argv[6]);
    ofstream prettyPrintFile;
    prettyPrintFile.open(argv[7]);
```

```
//Step 1
int imgRows, imgCols, imgMin, imgMax;
if(imgFile.is_open()){
    imgFile >> imgRows;
    imgFile >> imgCols;
    imgFile >> imgMin;
    imgFile >> imgMax;
}else{
    cout << "Image text file couldn't be opened, closing program..." << endl;</pre>
    return 2;
}
int strctRows, strctCols, strctMin, strctMax, rowOrigin, colOrigin;
if(structFile.is_open()){
    structFile >> strctRows;
    structFile >> strctCols;
    structFile >> strctMin;
    structFile >> strctMax;
    structFile >> rowOrigin;
    structFile >> colOrigin;
}else{
    cout << "Struct File couldn't be opened, closing program..." << endl;</pre>
    return 3;
}
```

```
//Step 2
Morphology morph = Morphology(imgRows, imgCols, imgMin, imgMax, strctRows, strctCols, rowOrigin, colOrigin);
morph.allocateArrs();
morph.zeroFramedAry=morph.zero2DAry(morph.zeroFramedAry, morph.rowSize, morph.colSize);
//Step 4
morph.loadImg(imgFile);
prettyPrintFile << "Image File:" << endl;</pre>
morph.prettyPrint(morph.zeroFramedAry, prettyPrintFile);
morph.addBorder(prettyPrintFile);
morph.structAry=morph.zero2DAry(morph.structAry, morph.numStructRows, morph.numStructCols);
morph.loadStruct(structFile);
prettyPrintFile << "Structure Element:" << endl;</pre>
morph.prettyPrintStruct(morph.structAry, prettyPrintFile);
morph.addBorder(prettyPrintFile);
//step 6
morph.morphAry=morph.zero2DAry(morph.morphAry, morph.rowSize, morph.colSize);
morph.computeDilation(morph.zeroFramedAry, morph.morphAry);
morph.dilationToFile(morph.morphAry, dilateOutFile);
prettyPrintFile << "Array after Dilation:" << endl;</pre>
morph.prettyPrintDilation(morph.morphAry, prettyPrintFile);
morph.addBorder(prettyPrintFile);
morph.morphAry=morph.zero2DAry(morph.morphAry, morph.rowSize, morph.colSize);
morph.computeErosion(morph.zeroFramedAry, morph.morphAry);
morph.aryToFile(morph.morphAry, erodeOutFile);
prettyPrintFile << "Array after Erosion:" << endl;</pre>
morph.prettyPrint(morph.morphAry, prettyPrintFile);
morph.addBorder(prettyPrintFile);
```

```
//step 8
morph.morphAry=morph.zero2DAry(morph.morphAry, morph.rowSize, morph.colSize);
morph.computeOpening(morph.zeroFramedAry, morph.morphAry, morph.tempAry);
morph.aryToFile(morph.morphAry, openingOutFile);
prettyPrintFile << "Opening:" << endl;</pre>
morph.prettyPrint(morph.morphAry, prettyPrintFile);
morph.addBorder(prettyPrintFile);
//step 9
morph.morphAry=morph.zero2DAry(morph.morphAry, morph.rowSize, morph.colSize);
morph.computeClosing(morph.zeroFramedAry, morph.morphAry, morph.tempAry);
morph.aryToFile(morph.morphAry, closingOutFile);
prettyPrintFile << "Closing:" << endl;</pre>
morph.prettyPrint(morph.morphAry, prettyPrintFile);
//step 10
imgFile.close();
structFile.close();
dilateOutFile.close();
erodeOutFile.close();
openingOutFile.close();
closingOutFile.close();
prettyPrintFile.close();
return 0;
```

Outputs

Data1 Elem1:

closing

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000	0	0	0	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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0 1 1	0	0	1	1	0	0	1	1	1	1	1	1	1	1	1	0	0	0	0	0	1	1	1	0	0	1	0
0 0 1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	1	1	1	1	1	1	0	0
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Dilation

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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	1	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	1	1	1	1	1	0	0	0	0
0 1 1	1	1 1	1	1	1	1	1	0 1	. 1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0
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0 0 0	1	1 1	. 1	1	0	0		0 0		1	1	1	1	1	1	0	0	0	1	1	1	1	1	0	0	0	0	0	0
0 0 0	0	0 1	. 1	0	0	0	0	0 0	0	0	1	1	1	1	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 6			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
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Erosion

4	a 3	30	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	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
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0	0	0	0	1	1	1	0	0	0	0	0	0	0	1	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	1	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
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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
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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
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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	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Ор	en	ing	<u>,</u>																										
46) 3	30	0	1																									
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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	1	1	0	0	0	0	0	1	<u>-</u> 1	ī	ī	1	1	0	0	0	0	0	0	0	0	0	0	0	ø
0	0	0	0	1	ī	ī	1	0	0	0	0	ī	ī	ī	ī	ī	ī	0	0	0	0	0	0	0	ø	0	0	0	0
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ø	0	0	ī	ī	ī	ī	ī	ī	Ö	0	ø	ō	ī	ī	ī	ī	ø	1	ī	ī	1	0	ø	0	ø	0	Ö	0	ø
ø	Ø	ø	ō	ī	ī	ī	ī	ō	0	0	Ø	ø	ō	ī	ī	ō	1	ī	ī	ī	ī	1	ø	ø	ø	Ø	0	Ø	0
0	0	0	0	ō	ī	ī	ō	0	Ö	0	0	0	0	ō	ō	0	ī	ī	ī	ī	ī	ī	0	0	0	0	Ö	0	0
ø	0	0	0	0	ō	ō	0	0	0	0	ø	ø	ø	0	0	0	ō	ī	ī	ī	ī	ō	ø	ø	ø	0	0	0	ø
ø	Ø	ø	0	0	Ø	0	0	0	1	1	Ø	ø	ø	0	0	0	ø	ō	ī	ī	ō	0	ø	ø	ø	0	0	Ø	0
ø	Ø	ø	0	0	Ø	0	0	1	ī	ī	1	0	0	Ö	0	0	ø	0	ō	ō	0	0	ø	Ø	ø	0	0	0	0
ø	ø	1	1	0	Ø	0	1	ī	ī	ī	ī	1	ø	ø	ø	0	ø	ø	Ø	ø	ø	0	ø	ø	ø	0	ø	0	0
ø	1	ī	ī	1	Ø	0	ī	ī	ī	ī	ī	ī	ø	0	0	0	ø	ø	Ø	0	0	0	ø	ø	ø	0	0	Ø	0
1	ī	ī	ī	ī	1	0	ō	ī	ī	ī	ī	ō	ø	Ö	0	0	0	ø	0	Ö	1	1	0	ø	ø	0	0	0	0
ī	ī	ī	ī	ī	ī	0	0	ō	ī	ī	ō	0	ø	0	0	0	ø	0	0	1	ī	ī	1	0	ø	0	0	0	ø
ō	ī	ī	ī	ī	ō	0	0	0	ī	ī	ø	0	0	Ö	0	0	0	0	1	ī	ī	ī	ī	1	0	0	0	Ø	0
0	ō	ō	ō	ō	0	0	0	1	ī	ī	1	0	0	Ö	0	0	0	0	ī	ī	ī	ī	ī	ī	0	Ö	Ö	0	0
0	0	0	0	0	0	0	1	ī	ī	ī	ī	1	0	0	0	0	0	0	0	ī	ī	ī	ī	0	0	0	0	0	0
0	0	0	0	0	0	0	ī	ī	ī	1	ī	ī	0	0	0	0	0	0	0	0	ī	1	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	ø
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	ø
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	0	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	0	0
0	0	1	1	1	1	1	1	0	0	0	0	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0
0	0	1	1	1	1	1	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	1	1	1	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	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	1	1	1	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	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	1	1	1	1	1	1	0	0	0	0	0	0
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0	0	0	0	0	0	0	0	0	0			1				1		0	0	1		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		1			1		1			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

Data1 Elem2:

Closing

40 30 0 1	
000000000001001100000000000	000
110000000011111110000000100	001
010001100101111111000001000	010
001011111000111111100000100	100
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000110110111000011111000000	000
000100011111000111111100011	000
00111011111100011000111111	100
011111111111100110000011111	1 1 0
111111101111000000000111110	1 1 0
111111000111000110101111100	000
0 1 1 1 1 0 0 0 0 1 1 1 1 0 0 0 1 1 1 1	000
0 1 1 1 0 0 0 0 1 1 1 1 1 1 0 1 1 1 1 1	000
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0 0 0 0 1 1 1 0 1 1 1 1 1 0 1 1 0 0 0 1 1 1 1 1 0 0 0 1	000
0 0 0 1 1 1 0 0 0 1 1 0 0 0 0 1 0 0 0 1 1 1 1 1 1 0 1 0	000
0 0 1 1 1 1 1 0 1 1 0 0 0 0 0 1 0 0 0 0	000
	1 1 0
	010
	100
	000
	000
	000
	100
	000
	100
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001101100000011100011110001	100
001111100001111110001111000	100
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	0 0 0
	0 0 0
	0 0 0
00001000000001010000001100	000

Dilation

01000000000011000000000000000000000000
011100001000011111100000011100000110010000
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1 1 1
1 1 1 1
000111111111111111111111111111111111111
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1 1 0 0
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111111111111111111111111111111111111111
1 0 0 1
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011111100001111111110011111111111111111
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1 1 0 0
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Erosion

40 30	0	1																								
000	0	0 0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
000	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
000	0	00	0	0	0	0	0	0	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
000	0	0 1	. 1	0	0	0	0	0	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
000	0	1 1	. 1	1	0	0	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
000	0	1 1	. 1	1	0	0	0	0	0	0	1	1	0	0	0	1	1	0	0	0	0	0	0	0	0	0
000	0	0 1	. 1	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	0	0	0	0	0	0	0	0
000	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
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0 0 1	1	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
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0 0 0	0	00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
000	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	0 1	. 1	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 1	0	1 1	. 1	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
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000	1	1 1	. 0	0	0	0	0	0	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0
000	0	1 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
000	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
000	0	0 0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
000	_	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
000		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
000	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
000	0	00	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	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	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	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	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	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
000		0 0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
000	0	0 0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Opening	
40 30 0 1	
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 1 1 1 1 0 0 0 0 0 0 0 0 0 0 0	
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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 1 1 1 1 1 0 0 0 0 0 0 0	
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0 0 0 1 1 1 1 0 0 0 0 0 0 0 0 1 0 0 0 0	
0 0 1 0 1 1 1 1 0 0 0 0 0 0 1 1 1 0 0 0 0 0 0 0 0 0 0 0	
0111111100000111110000000000000	0
0111111100001110111000000000000	0
0 0 1 1 1 1 1 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 1 1 1 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 1 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 1 1 1 0 0 0 1 1 0 0 0 0 0 0 0	
00000000000000000001111000000	
000000000000000000111111000000	
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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 1 1 1 1 1 1 0 0 0 1 1 0 0 0 0 0 0	
0 0 0 0 0 0 0 0 0 0 0 1 1 1 1 1 1 0 0 0 0 0 0 0 0 0 0 0 0	
$egin{array}{cccccccccccccccccccccccccccccccccccc$	
$egin{array}{cccccccccccccccccccccccccccccccccccc$	
	0
	V

Data2 Elem2:

Closing

30 30 0 1	
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	000000
010000000000000000000000000000000000000	0100000
11100110100100001000000	1000010
0111111110001000110000	000000
01111111100000000111100	1000000
0 1 1 1 1 1 1 1 1 1 0 0 0 0 0 0 0 1 1 1 1 1 1	1110000
0 0 1 1 1 1 1 1 1 0 0 0 1 0 0 0 1 1 1 1	1100000
0 1 1 1 1 1 1 1 0 0 0 0 0 0 0 0 1 1 1 1	1110000
0 0 1 1 1 1 1 1 1 0 0 0 0 0 0 0 1 1 1 1	1111000
0 0 1 1 1 1 1 1 1 1 0 0 0 0 0 0 0 1 1 1 1 1 1	1110000
0 0 0 1 1 1 1 1 1 0 0 0 1 0 0 0 1 1 1 1	1100000
0 0 1 0 1 1 0 0 1 1 0 0 0 0 0 1 1 1 1 1	1100000
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 1 1	1110000
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 1 1 1	1100000
0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 1 1 1 0 0	1000011
0 0 0 0 1 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0	000000
0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0	000000
0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 1 0 0 0 0	1000100
0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	000000
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0 0 1 1 1 1 1 0 0 0 0 0 0 0 0 0 0 1 1 1 1 1 1	000000
0 1 1 1 1 1 1 1 0 0 0 0 0 0 0 1 1 1 1 1	1010000
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0 1 1 0 1 1 1 1 0 0 0 0 1 0 0 0 1 1 1 1	1111000
1 1 1 1 1 1 1 1 0 0 0 0 0 0 0 1 1 1 1 1	1111000
0 1 1 1 1 1 1 1 1 0 0 0 0 0 0 0 1 1 1 1	1111100
0 0 1 1 1 1 1 1 0 0 0 0 0 0 0 0 1 0 1 1 1 1 1	1111110
0 0 0 0 1 0 1 0 0 0 0 0 0 0 0 0 0 0 1 1 1 1	1101100
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 1	000000

Dilation

32 32	0	1																											
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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	0	0	0	0	0	0
0 1 1	1	0	0	1	1	0	1	0	0	1	0	0	0	0	1	0	0	0	0	0	0	1	1	1	0	0	1	0	0
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0 1 1	1	1	1	1	1	1	1	1	0	1	1	1	0	1	1	1	1	1	1	0	0	1	0	0	0	0	1	0	0
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000	1	1	1	1	1	1	1	1	0	1	1	1	0	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	0	1	0	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0
0 0 0	1	0	1	1	0	0	1	1	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0
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0 1 1	1	1	1	1	1	1	1	1	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0
0 0 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	1	1	1	1	1	1	0	0	0	0	0	0	0	0	1	0	1	1	1	1	1	1	1	1	1	1	1	0	0
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000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	Ø	0	0	0	0

Erosion

30) :	30	0	1																									
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Opening

Data3 Elem3

Closing

В0 30 0 1	
000000000000000	0000000000000000
010000000000000	0000000000100000
1111111111111111	111111111111111
000000000000000	00000000000000000
000000000000000	00000000000000000
1111111111111111	111111111111111
1111111111111111	1111111111000000
000000000000000	00000000000000000
000000000000000	00000000000000000
1111111111111111	11111111111111111
000000000000000	00000000000000000
010000000000000	0000000000100000
1111111111111111	11111111111111111
000000000000000	00000000000000000
000000000000000	00000000000000000
1111111111111111	1111111111111111
0 1 1 1 1 1 1 1 1 1 1 1 1 1	1111111111000000
00000000000000	00000000000000000
00000000000000	00000000000000000
111111111111111	11111111111111111
000000000000000	00000000000000000
010000000000000	0000000000100000
111111111111111	1111111111111110
000000000000000	00000000000000000
000000000000000	00000000000000000
111111111111111	1111111111111110
11111111111111	111111111111100
0 0 0 0 0 0 0 0 0 0 0 0 0 0	0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
000000000000000	0000000000000000
11111111111111	1111111111111111
000000000000000	00000000000000000

Dilation

В	ð :	32	0	1																											
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0	1	1	1	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
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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
1	1	1	1	1	1	1	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
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Erosion

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Img2: vertElm closing

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00001011000000110001011000000100010001000100010001000100010001
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Erode

Opening (Best)

horiElm Closing

Erosion

Opening (Best)

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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
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 :	1 1	1	1 :	1 1	1	1 1	1	1 1	1 1	1	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	1 €	9 0	1 1	1 1	1 1	0	1 0	1	1	1 1	1	9 6	1	1	1 :	1 1	0	0 (9 9	1	0 1	1	1 1	1 1	0	0 0	0 1	1	1 :	1 1	1	1 1	0	0 1	1 6	1	1	1 1	1	9 1	0
0 0																																									
1 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 :	1 1	1	1 1	1	1 1	1 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
1 1	1 1	1	1 :	1 1	1 1	1	1 1	1	1	1 1	1	1 1	1	1	1 :	1	1	1 :	1 1	1	1 1	1	1 1	1 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
1 1	1 1	1	1 :	1 1	1 1	1	1 1	1	1	1 1	1	1 1	1	1	1 :	1	1	1 :	1 1	1	1 1	1	1 1	1 1	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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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 :	1 1	1	1 1	1	1 1	1 1	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	1 6	1	1 :	1 1	1 1	0	1 1	1	1	1 1	1	0 6	1	1	1 :	1	0	1 (9 1	0	0 0	1	1 1	1 1	0	0 0	0 1	1	1 :	1 1	1	1 1	0	1 (9 1	. 0	1	1 1	1	9 1	0
0 1	0 1	L Ø	1 :	1 1	1 1	1	0 1	1	1	1 1	1	0 6	1	1	1 :	l 1	1	0 :	1 0	0	0 0	1	1 1	1 1	0	0 0	0 1	1	1 :	1 1	1	1 1	1	0 (9 6	1	1	1 1	1	1 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 :	1	1	1 :	1 1	1	1 1	1	1 1	1 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
1 1	1 1	1	1 :	1 1	1 1	1	1 1	1	1	1 1	1	1 1	1	1	1 :	1	1	1 :	1 1	1	1 1	1	1 1	1 1	1	1 1	1 1	1	1 :	1 1	1	1 1	1	1 :	1 1	. 1	1	1 1	1	1 1	1
1 1	1 1	1	1 :	1 1	1 1	1	1 1	1	1	1 1	1	1 1	1	1	1 :	1	1	1 :	1 1	1	1 1	1	1 1	1 1	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 1	1 1	1	1 :	1 1	1 1	1	1 1	1	1	1 1	1	1 1	1	1	1 :	1 1	1	1 :	1 1	1	1 1	1	1 1	1 1	1	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	1 (9 0	1 :	1 1	1 1	1	1 6	1	1	1 1	1	0 6	1	1	1 :	l 1	1	1 (9 0	1	0 1	1	1 1	1 1	0	0 0	0 1	1	1 :	1 1	1	1 1	1	0 :	1 6	1	1	1 1	1	1 1	0
0 0	0 1	1 0	1 :	1 1	1 1	. 0	1 1	1	1	1 1	1	1 6	1	1	1 :	l 1	0	1 :	1 1	0	1 0	1	1 :	1 1	1	0 0	0 1	1	1 :	1 1	1	1 1	0	1 (9 1	0	1	1 1	1	9 1	1
1 0	1 1	1	1 :	1 1	1 1	1	1 1	1	1	1 1	1	1 1	1	1	1 :	l 1	1	1 :	1 1	1	1 1	1	1 1	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	1
1 1																																									
1 1																																									
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64 64 0 1	
8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8	0000000000
010000011000001100000110000010000000000	9199991999
001000011100000111000011100000000001110000	1110010100
00010001111000011110001111000000101110000	9111191919
000010011111000111110011111000010111110000	
0000010111110001111110111110001010111111	
011011111111111111111111111111111111111	
011111111111111111111111111111111111111	
001111111111111111111111111111111111111	1111111100
000111111111111111111111111111111111111	1111111110
000011111111111111111111111111111111111	1111111111
$\tt 0 0 0 0 0 0 0 1 1 1 1 1 1 0 0 0 1 1 1 1 1 1 1 0 0 0 1 1 1 1 1 1 0 0 0 1 1 1 1 1 1 0 1 0 0 0 1$	1111110000
00000001111110011111001111110000111110000	9111111000
011111111111111111111111111111111111111	1111111100
011111111111111111111111111111111111111	
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011011111111111111111111111111111111111	1111111000
011111111111111111111111111111111111111	1111111000
011111111111111111111111111111111111111	1111111100
001111111111111111111111111111111111111	111111111
000111111111111111111111111111111111111	
00001001111100011111001111100001011111010	
0000010111110001111110111110001010111111	
011011111111111111111111111111111111111	
011111111111111111111111111111111111111	1111111100
001111111111111111111111111111111111111	1111111110
000111111111111111111111111111111111111	1111111111
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000000011111000111110011111010111110101111	9111199999
000000011111100111110011111101011111111	1111100000
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801111111111111111111111111111111111111	
000111111111111111111111111111111111111	1111111111
00001001111111101111110111110101111111010	1111111000
000001011110111111111111111010110111111	1111101100
$\begin{smallmatrix} 6&1&1&6&1&1&1&1&1&1&1&1&1&1&1&1&1&1&1&1$	1111110110
011111111111111111111111111111111111111	1111111000
011111111111111111111111111111111111111	1111111100
001111111111111111111111111111111111111	
000111111111111111111111111111111111111	
8 9 8 9 1 9 9 1 1 1 1 1 9 1 9 1 1 1 1 1	
000001011111101111111111100010101111110001111	
011011111111111111111111111111111111111	
011111111111111111111111111111111111111	1111111000
001111111111111111111111111111111111111	1111111100
$\tt 0.001111111111111111111111111111111111$	1111111110
$\tt 0.000111111111111111111111111111111111$	1111111111
0000101111110111111100111111010100011110000	0111101010
00010101111110111111001111110000111110000	1111110101
011111111111111111111111111111111111111	
811111111111111111111111111111111111111	
601111111111111111111111111111111111111	
000111111111111111111111111111111111111	
000010011111110111110011111110010111111	1111111000
000001011111011111111111111111111111111	0111101100
$\begin{smallmatrix} 6&1&1&6&1&1&1&1&1&1&1&1&1&1&1&1&1&1&1&1$	1111110110
011111111111111111111111111111111111111	1111111000
001111111111111111111111111111111111111	
000111111111111111111111111111111111111	
000011110111111111111111111111111111111	

Erosion

```
0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 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
```

Opening (Best)

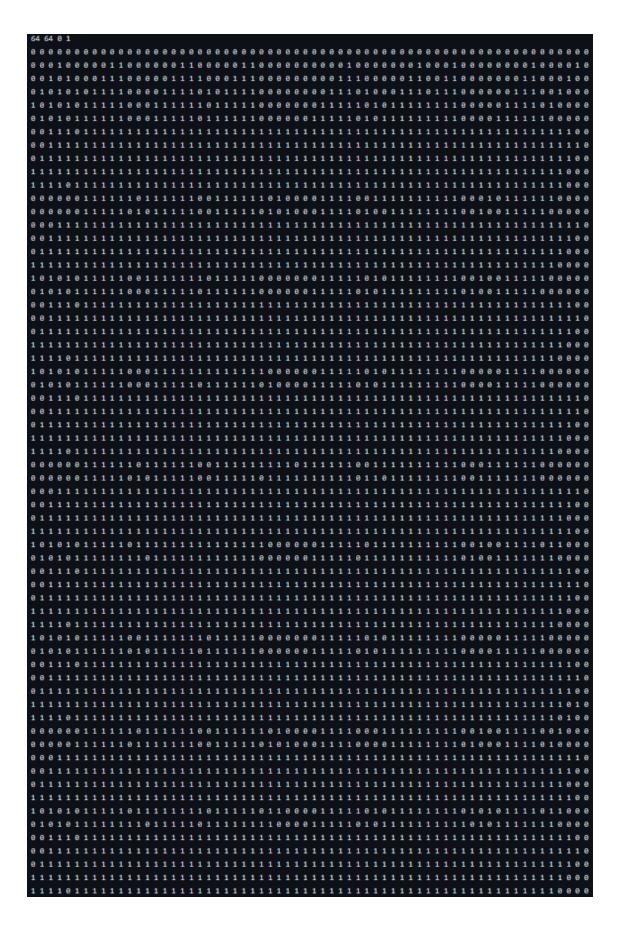
```
60 60 0 1
```

rightElm

closing

60 60 0 1	
1010001110000011110001110000000011100000	0110001
01010111100001111010111100000000111010000	1110010
1010111110001111110111110000000111110101	1110100
0101111110001111110111111000000111110101	1111000
111011111111111111111111111111111111111	1111111
111111111111111111111111111111111111111	1111111
111111111111111111111111111111111111111	1111111
111111111111111111111111111111111111111	1111110
110111111111111111111111111111111111111	1111110
0000111111011111001111110100001111001111	1111100
00001111101011111001111101010001111101001111	1111000
011111111111111111111111111111111111111	
111111111111111111111111111111111111111	
111111111111111111111111111111111111111	
111111111111111111111111111111111111111	
1010111110011111110111110000000111110101	
0101111110001111101111110000001111110101	
111011111111111111111111111111111111111	
111111111111111111111111111111111111111	
111111111111111111111111111111111111111	
111111111111111111111111111111111111111	
110111111111111111111111111111111111111	
0101111110001111101111110100001111110101	
111011111111111111111111111111111111111	
111111111111111111111111111111111111111	
111111111111111111111111111111111111111	
111111111111111111111111111111111111111	
110111111111111111111111111111111111111	
0000111111011111100111111111111111111001111	
000011111010111110011111101111111111111	
011111111111111111111111111111111111111	
111111111111111111111111111111111111111	
111111111111111111111111111111111111111	1111110
101011111011111111111111100000011111101111	1110110
0101111111110111111111111100000011111101111	1111100
111011111111111111111111111111111111111	1111111
111111111111111111111111111111111111111	1111111
111111111111111111111111111111111111111	
111111111111111111111111111111111111111	1111110
110111111111111111111111111111111111111	1111100
1010111110011111110111110000000111110101	1111000
0101111110101111110111111000000111110101	1110000
111011111111111111111111111111111111111	1111111
111111111111111111111111111111111111111	1111111
111111111111111111111111111111111111111	111111
111111111111111111111111111111111111111	1111110
110111111111111111111111111111111111111	1111101
000011111101111100111111000001111100001111	1110010
000111111011111111001111110101010111110000	1110100
011111111111111111111111111111111111111	1111111
111111111111111111111111111111111111111	1111111
111111111111111111111111111111111111111	1111110
111111111111111111111111111111111111111	1111111
101011111011111111111111101110000111111	1110110
0101111111101111101111111110000111111010	1111100
111011111111111111111111111111111111111	
111111111111111111111111111111111111111	
111111111111111111111111111111111111111	

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Erosion

```
69 69 9 1
0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 0 1 0 0 0 1 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 1 0 0 0 0 0 0 0
0 0 0 0 0 0 0 1 1 0 0 0 0 0 0 0 1 0 0 0 0 0 0 1 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 1 0 0 0 0 0
```

Opening (Best)

```
60 60 0 1
```