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Algorithm Steps for ComputeDilation given an input 2D Array, an output 2D array of the same size, the size of the frame, and the size of the arrays:

- 0. i ← rowSizeFrame
- 1. j← colSizeFrame
- 2. if input[i][j] > 0:
- 3. onePixelDilation(i, j, input, output)
- 4. end-if
- 5. j++
- 6. repeat 2 5 while j < colSize colFrameSize
- 7. i++
- 8. repeat 2 -7 while i < rowSize rowFrameSize

Algorithm Steps for ComputeErosion given an input 2D Array, an output 2D array of the same size, the size of the frame, and the size of the arrays:

- 0. i ← rowSizeFrame
- 1. j← colSizeFrame
- 2. if input[i][j] > 0:
- 3. onePixelErosion(i, j, input, output)
- 4. end-if
- 5. j++
- 6. repeat 2 5 while j < colSize colFrameSize
- 7. i++
- 8. repeat 2 -7 while i < rowSize rowFrameSize

Algorithm Steps for OnePixelErosion given a pixel location (i,j), an input 2D Array, an output 2D array, a Structured Element 2D array, and an origin location for the Structured Element:

- 1. iOffset ←i rowOrigin
- 2. jOffest ←j colOrigin
- 3. matchFlag ← true
- 4. $r \leftarrow 0$
- 5. $c \leftarrow 0$
- 6. if (struct[r][c] > 0) and (input[iOffset + r][jOffset + c]) <= 0)
- 7. matchFlag ← false
- 8. End-if
- 9. c++
- 10. repeat 6 9 while (matchFlag == true) and (c < numStructCols)
- 11. r++
- 12. repeat 6 11 while (matchFlag == true) and (r < numStructRows)

Algorithm Steps for ComputeClosing given an input 2D array, a temp array of the same size, an output array, and all variables required for erosion and dilation:

- ComputeDilation(input, temp)
- ComputeErosion(temp, output)

Algorithm Steps for ComputeOpening given an input 2D array, a temp array of the same size, an output array, and all variables required for erosion and dilation:

- ComputeErosion(input, temp)
- 1. ComputeDilation(temp, output)

Main.java

```
import java.io.*;
import java.util.Scanner;
public class Main {
    public static void main(String[] args) {
        Scanner imgFile, structFile;
        BufferedWriter dialateOutFile, erodeOutFile, closingOutFile;
        BufferedWriter openingOutFile, prettyPrintFile;
        Morphology morphology;
        try{
            imgFile = new Scanner(new BufferedReader(new FileReader(args[0])));
            structFile = new Scanner(new BufferedReader(
                new FileReader(args[1])));
            dialateOutFile = new BufferedWriter(new FileWriter(args[2]));
            erodeOutFile = new BufferedWriter(new FileWriter(args[3]));
            closingOutFile = new BufferedWriter(new FileWriter(args[4]));
            openingOutFile = new BufferedWriter(new FileWriter(args[5]));
            prettyPrintFile = new BufferedWriter( new FileWriter(args[6]));
            //Constructor loads file info into the object
            morphology = new Morphology(imgFile, structFile);
            prettyPrintFile.write("Initial Zero Framed 2D Array: \n");
            Morphology.prettyPrint(morphology.zeroFramedAry, prettyPrintFile);
            prettyPrintFile.write("Initial Structured Element 2D Array: \n");
            Morphology.prettyPrint(morphology.structAry, prettyPrintFile);
            Morphology.zero2DAry(morphology.morphAry, morphology.rowSize,
                                    morphology.colSize);
            morphology.computeDilation(morphology.zeroFramedAry,
                                            morphology.morphAry);
            Morphology.aryToFile(morphology.morphAry, dialateOutFile);
            prettyPrintFile.write("Dilation Operation Output: \n");
            Morphology.prettyPrint(morphology.morphAry, prettyPrintFile);
            Morphology.zero2DAry(morphology.morphAry, morphology.rowSize,
                                    morphology.colSize);
            morphology.computeErosion(morphology.zeroFramedAry,
                                        morphology.morphAry);
            Morphology.aryToFile(morphology.morphAry, erodeOutFile);
            prettyPrintFile.write("Erosion Operation Output: \n");
```

```
Morphology.prettyPrint(morphology.morphAry, prettyPrintFile);
   Morphology.zero2DAry(morphology.morphAry, morphology.rowSize,
                            morphology.colSize);
   morphology.computeOpening(morphology.zeroFramedAry,
                                morphology.morphAry,
                                morphology.tempAry);
   Morphology.aryToFile(morphology.morphAry, openingOutFile);
   prettyPrintFile.write("Opening Operation Output:\n");
   Morphology.prettyPrint(morphology.morphAry, prettyPrintFile);
   Morphology.zero2DAry(morphology.morphAry, morphology.rowSize,
                            morphology.colSize);
   morphology.computeClosing(morphology.zeroFramedAry,
                                morphology.morphAry,
                                morphology.tempAry);
   Morphology.aryToFile(morphology.morphAry, closingOutFile);
   prettyPrintFile.write("Closing Operation Output: \n");
   Morphology.prettyPrint(morphology.morphAry, prettyPrintFile);
    imgFile.close();
   structFile.close();
   dialateOutFile.close();
   erodeOutFile.close();
   closingOutFile.close();
   openingOutFile.close();
   prettyPrintFile.close();
}catch(FileNotFoundException e){
   System.out.println(e.getMessage());
   System.exit(1);
catch(IOException e){
   System.out.println(e.getMessage());
   System.exit(1);
}
```

Morphology.java

```
import java.io.*;
import java.util.Scanner;
public class Morphology {
    public int numImgRows, numImgCols, imgMin, imgMax;
    public int numStructRows, numStructCols, structMin, structMax;
    public int rowOrigin, colOrigin;
    public int rowFrameSize, colFrameSize;
    public int extraRows, extraCols, rowSize, colSize;
    public int[][] zeroFramedAry, morphAry, tempAry, structAry;
    public Morphology(Scanner img, Scanner struct){
        numImgRows = img.nextInt();
        numImgCols = img.nextInt();
        imgMin = img.nextInt();
        imgMax = img.nextInt();
        numStructRows = struct.nextInt();
        numStructCols = struct.nextInt();
        structMin = struct.nextInt();
        structMax = struct.nextInt();
        rowOrigin = struct.nextInt();
        colOrigin = struct.nextInt();
        rowFrameSize = numStructRows / 2;
        colFrameSize = numStructCols / 2;
        extraRows = rowFrameSize*2;
        extraCols = colFrameSize*2;
        rowSize = numImgRows + extraRows;
        colSize = numImgCols + extraCols;
        zeroFramedAry = new int[rowSize][colSize];
        morphAry = new int[rowSize][colSize];
        tempAry = new int[rowSize][colSize];
        structAry = new int[numStructRows][numStructCols];
        Morphology.zero2DAry(zeroFramedAry, rowSize, colSize);
        loadImg(img, zeroFramedAry);
        Morphology.zero2DAry(structAry, numStructRows, numStructCols);
        loadStruct(struct, structAry);
```

```
}
public static void zero2DAry(int[][] ary, int nRows, int nCols){
    for(int i = 0; i < nRows; ++i){
        for(int j = 0; j < nCols; ++j){
            ary[i][j] = 0;
private void loadImg(Scanner imgFile, int[][] zeroFramedArray){
    int rowEnd = rowSize - rowFrameSize, colEnd = colSize - colFrameSize;
    for(int i = rowFrameSize; i < rowEnd; ++i){</pre>
        for(int j = colFrameSize; j < colEnd; ++j){</pre>
            zeroFramedArray[i][j] = imgFile.nextInt();
    }
private void loadStruct(Scanner structFile, int[][] structArray){
    for(int i = 0; i < numStructRows; ++i){</pre>
        for(int j = 0; j < numStructCols; ++j){</pre>
            structArray[i][j] = structFile.nextInt();
}
public void computeDilation(int[][] inAry, int[][] outAry){
    for(int i = rowFrameSize; i < rowSize - rowFrameSize; ++i){</pre>
        for(int j = colFrameSize; j < colSize-colFrameSize; ++j){</pre>
            if(inAry[i][j] > 0){
                //do we need the inAry? seems irrelevent
                onePixelDilation(i, j, inAry, outAry);
            }
public void computeErosion(int[][] inAry, int[][] outAry){
    for(int i = rowFrameSize; i < rowSize - rowFrameSize; ++i){</pre>
        for(int j = colFrameSize; j < colSize - colFrameSize; ++j){</pre>
            if(inAry[i][j] > 0){
                onePixelErosion(i, j, inAry, outAry);
```

```
public void computeOpening(int[][] inAry, int[][] outAry, int [][] temp){
    computeDilation(inAry, tempAry);
    computeErosion(tempAry, outAry);
public void computeClosing(int[][] inAry, int[][] outAry, int [][] temp){
    computeErosion(inAry, tempAry);
    computeDilation(tempAry, outAry);
public void onePixelDilation(int i, int j, int[][] inAry, int[][] outAry){
    int iOffset = i - rowOrigin, jOffset = j - colOrigin;
    for(int r = 0; r < numStructRows; ++r){</pre>
        for(int c = 0; c< numStructCols; ++c){</pre>
            if(structAry[r][c] > 0){
                outAry[iOffset + r][jOffset + c] = 1;
public void onePixelErosion(int i, int j, int[][] inAry, int[][] outAry){
    boolean matchFlag = true;
    int iOffset = i - rowOrigin, jOffset = j - colOrigin;
    for(int r = 0; r < numStructRows && matchFlag; ++r){</pre>
        for(int c = 0; c < numStructCols && matchFlag; ++c){</pre>
            if(structAry[r][c] > 0 && inAry[iOffset + r][jOffset + c] <= 0){</pre>
                matchFlag = false;
        }
    if(matchFlag){
        outAry[i][j] = 1;
    else{
        outAry[i][j] = 0;
```

```
public static void aryToFile(int[][] ary, BufferedWriter outfile){
    try{
        int r = ary.length, c = 0;
        for(int i = 0; i < r; ++i){
            c = ary[i].length;
            for(int j = 0; j < c; ++j){
                outfile.write(Integer.toString(ary[i][j]) + " ");
            outfile.write("\n");
        outfile.write("\n\n");
    catch(IOException e){
        System.out.println(e.getMessage());
        System.exit(1);
}
public static void prettyPrint(int[][] ary, BufferedWriter outfile){
   try{
        int r = ary.length, c = 0;
        for(int i = 0; i < r; ++i){
            c = ary[i].length;
            for(int j = 0; j < c; ++j){
                if(ary[i][j] == 0){
                    outfile.write(". ");
                else{
                    outfile.write("1 ");
            outfile.write("\n");
        outfile.write("\n\n");
    catch(IOException e){
        System.out.println(e.getMessage());
        System.exit(1);
    }
```

OUTPUT

Image 1, Structured Element 1 Initial Zero Framed 2D Array: . . . 1 1 1 1 1 1 1 . 1 1 . 1 1 . 1 1 1 1 1 11....11111......111111111.......1...1...1...1...1... 1 1 1 1 1 1 1 . . . 1 1 1 . 1 1 1 1 1 1 1 1 1 1 1 1 1 . . 1 . 1 1 1 1 1

Initial Structured Element 2D Array:

1 1 1

Dilation Operation Output:
1 1 1
1111111111111111.11111111.1111
111111111111111111111111111111
. 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
.11111111111111111111111111111
111111111111111111111111111
111111111111111111111111111111111111
11111111111111111
111.11111111111111111111
111111111111.11111111
11111111111111111111
1111111111111111111111
111111.11111111111111111111
1111111111111111111111111111111111
1 1 1 1 1 . 1 1 1 1 1 1 1 1 1 1 1 1
1 1 1 . 1 1 1 1 1 1 1 1 1 1 1 1 1
111.111111111111111111111111
11111111.111.1111111111111111111
111111111111111111111111111111
1111111111111111111111111111
111111111.111111111111111111
111111111111111
11111.1111

Erosion Operation Output:
1 1
111
1 1
1111111111
111
1 1 1
1
11111
1
111
1 1 1 1 1 1
1111
1 1
1 1 1

pening Operation Output:
1
11111111
1 1 1 1 1 1 1
1111111111111111111111111
.1111111111111111111111111111
.11111111
1111111111111111111111111111
11111111111111111111111111
11111111.111111
1111111
11111111111111111111111111111
1111111111111111111
.1111111.1.111111111111111111
1111111111111111111111
.11111111.1111111111111111111
1111111111111111111111
11111111111111111111111
11111111111111111111111
1 1 1 1 1 1 1
111111111111
11111

1
1 1 1
11.
11.
11.
1
1

Dilation:
$0\ 0\ 0\ 0\ 0\ 0\ 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 0 0 0 0 0 0 0 0 0
$\begin{smallmatrix} 0 & 0 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 &$
0 0 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 0 1
01111111111111111111
0 0 0 1 1 1 1 1 1 1 1 1 0 0 0 0 1 1 1 1
01111111111000001111
0 0 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 0 0 0 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 0 0 0 0
0 0 1 1 1 1 1 1 1 1 1 1 0 0 0 1 1 1 1 1
0 0 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
0 0 1 1 1 1 1 1 1 0 0 1 1 1 1 1 1 1 1 1
0 0 0 0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1
0 0 0 0 0 0 0 0 0 1 1 1 1 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 0 0 0 0 1 1 1 1 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 0 0 0 0 1 1 1 0 0 0 0 0 0 0
0 0 0 0 0 0 0 1 1 1 0 1 1 1 0 0 0 0 0 0
0 0 0 0 0 0 1 1 1 0 0 0 1 1 1 1 1 1 0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 0 0 0 0 0 1 1 1 1 1 0 0 0 0 0 0 0 1 1 1 1 1 0 0 0 0 0 0 0 1
0 0 0 0 0 1 1 1 1 0 0 0 1 1 1 1 1 1 1 1
0 0 0 0 1 1 1 1 0 0 0 1 1 1 1 1 1 1 1 1
0 0 0 1 1 1 1 1 1 0 1 1 1 1 1 1 1 1 1 1
111111111111111111111000011111111111111
001111101111111111111111000111111100001111
0 0 0 1 1 1 0 1 1 1 1 1 1 1 1 1 1 1 1 1
011111110011100001111011111111111111111
0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 0 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 0 1
$0\ 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\$
001110111000000011111111111111111111111
0 0 1 1 1 1 1 1 1 1 1 1 0 0 0 0 0 1
0 0 0 0 1 1 1 1 1 1 1 1 0 1 1 1 1 0 1
0 0 1 1 1 1 1 1 1 1 1 1 1 1 1 0 0 1
0001111111111111111100011111100000011111
000111111111111111111111111111100000001111
000011111111111100011100000000000000001111
0 0 0 0 0 1 1 1 1 1 0 1 1 1 1 1 0 0 0 0

Erosion:

Opening:
$0 \ 0 \ 0 \ 0 \ 0 \ 0 \ 0 \ 0 \ 0 \ 0 \$
$\begin{smallmatrix} 0 & 1 & 1 & 1 & 1 & 1 & 1 & 0 & 0 & 0 &$
$\begin{smallmatrix} & & & & & & & & & & & & & & & & & & &$
$0 \ 0 \ 0 \ 1 \ 1 \ 1 \ 1 \ 1 \ 1 \ 1 \ $
0 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 0 0 1 1 1 1 1 1 1 0 0 0 1 0 0 0 0 0 1 1 1 1 1 1 1 1 1 0
0000111111111111000011111100010000011111
001111111100000011111111000000011111110000
000111111100000001111111111100000011111111111111111111
* * * * * * * * *
$\begin{smallmatrix} 0 & 0 & 0 & 1 & 1 & 1 & 1 & 1 & 1 & 1 &$
000000000111111111111110000000111111110000
00000000010000001111110000000100000001111
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 1 0 0 0 1 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 1 0 0 0 0 0 1 1 1 1 0 0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 0 0 0 0 0 0 1 1 1 0 0 0 0 0 0 0 0 0 0 0 1 1 0 0 0 0 0 0 1 1 0
$f 0 \ 0 \ 0 \ 0 \ 0 \ 0 \ 1 \ 0 \ 0 \ 0 \$
$f 0 \ 0 \ 0 \ 0 \ 0 \ 1 \ 0 \ 0 \ 0 \ 0 \$
0 0 0 0 1 1 1 1 1 0 0 0 1 1 1 1 1 1 1 1
$\begin{smallmatrix} 0&1&1&1&1&1&1&1&1&1&1&1&1&1&1&1&1&1&1&1$
$0\ 0\ 0\ 1\ 1\ 1\ 0\ 0\ 0\ 1\ 1\ 1\ 1\ 1\ 1\ 1\ 1\ 1\ 1\ 0\ 0\ 0\ 0\ 1\ 1\ 1\ 0\ 0\ 0\ 0\ 0\ 1\ 1\ 1\ 0\ 0\ 0\ 0\ 0\ 0$
$\begin{smallmatrix} 0 & 0 & 0 & 0 & 1 & 0 & 0 & 1 & 1 & 1 &$
$\begin{smallmatrix} 0 & 0 & 1 & 1 & 1 & 1 & 1 & 0 & 0 & 0 &$
$0\ 0\ 0\ 0\ 0\ 0\ 1\ 1\ 1\ 1\ 1\ 1\ 0\ 0\ 0\ 1\ 1\ 1\ 1\ 1\ 1\ 1\ 1\ 1\ 1\ 1\ 1\ 1\$
$0\ 0\ 1\ 1\ 1\ 1\ 1\ 1\ 0\ 0\ 0\ 0\ 0\ 1\ 0\ 1\ 1\ 1\ 1\ 1\ 1\ 1\ 1\ 1\ 1\ 1\ 1\ 1\$
$0\ 0\ 0\ 1\ 0\ 0\ 0\ 1\ 0\ 0\ 0\ 0\ 0\ 1\ 1\ 1\ 1\ 1\ 1\ 1\ 1\ 1\ 1\ 1\ 1\ 1\$
$0\ 0\ 0\ 1\ 1\ 1\ 1\ 1\ 1\ 1\ 0\ 0\ 0\ 0\ 0\ 1\ 1\ 1\ 1\ 1\ 1\ 1\ 1\ 0\ 0\ 0\ 0\ 0\ 1\ 1\ 1\ 1\ 1\ 1\ 1\ 1\ 1\ 1\ 1\ 0\ 0\ 0\ 0\ 0$
$\begin{smallmatrix} 0 & 0 & 0 & 0 & 0 & 1 & 1 & 1 & 1 & 1 &$
$\begin{smallmatrix} 0 & 0 & 0 & 1 & 1 & 1 & 1 & 1 & 1 & 1 &$
0 0 0 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 0 0 0 0 1 1 1 0 0 0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 0
0 0 0 0 1 1 1 1 1 1 1 1 0 0 0 1 0 0 0 0
0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 1 0 0 0 0
0000011111111111100000000000000000000

Closing:
$0\ 0\ 0\ 0\ 0\ 1\ 1\ 1\ 1\ 1\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\$
01111111111000000000
0111111111111000000000011111100000111111
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
0 0 1 1 1 1 1 1 1 1 1 1 1 1 0 0 1 1 1 1
1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 0 0 1
$f 0 \ 1 \ 1 \ 1 \ 1 \ 1 \ 1 \ 1 \ 1 \ 1 \$
$f 0 \ 1 \ 1 \ 1 \ 1 \ 1 \ 1 \ 1 \ 1 \ 1 \$
0 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
$f 0 \ 1 \ 1 \ 1 \ 1 \ 1 \ 1 \ 1 \ 1 \ 1 \$
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 1 1 1 1 1 1 0 0 0 0 1 1 1 1 1 1 1 1 1 1 1 1 0 0 1 1 1 1 1 1 1 0 0 0 0 0 0 0 1
000000001111100000000001111111000000000
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 1 1 1 1 1 1 0 1 1 1 1 1 1 1 1
0 0 0 0 1 1 1 1 1 0 1 1 1 1 1 1 1 1 1 1
0 0 0 1 1 1 1 1 1 0 1 1 1 1 1 1 1 1 1 1
0011111111111111111111111111111111110000
011111111111111111111111111111111111111
011111111111111111111111111111111111111
0 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
111111111111111111111111111111111111111
0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
011111111100001111111111111111111111111
0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 0 0 1
0 0 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
011111111111111111111111111111111111111
$\begin{smallmatrix} 0 & 0 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 &$
$\begin{smallmatrix} 0 & 0 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 &$
$\begin{smallmatrix} 0 & 0 & 0 & 1 & 1 & 1 & 1 & 1 & 1 & 1 &$
$\begin{smallmatrix} 0 & 0 & 0 & 0 & 1 & 1 & 1 & 1 & 1 & 1 &$
000000000000000000000000000000000000000

CV

######################################
Initial Zero Framed 2D Array:
.111111
1 . 1 1 1 1 1
1 . 1 1 1 1 1 1 1 1 1 1 1 1 1
1111111111111111
1 1 1 1 1 1 1 1 . 1 1 1 1 1 1 1 1
1111
11111.111.11.11.111.11111
1.11.1.11.1.111.111111.1111
1
11111111111
11111111111111111
111111111111111111111
111.111.11.11.1111111
1 . 1
11.11111
1 1
1 . 1 1 . 1 1
111.111111111111111111
1 1 1 1 1
11111111.111.111111111
11111111.11.1.11111111.11111
1.111111.11
11111.11
1 1 1 1 1

Initial Structured Element 2D Array:

. 1 . 1 1 . 1 . 1 .

Dilation Operation Output:	
.111111	
111111111111	1111111111
.1111111111111111111.111111	1111111111
1 1	1111111111
.11111111111111111111111111111111111111	111.11111111111
	111111111111111111
.1111111111111111111111111111111	11111111111111111
1111111111111111111111111111	
1111111111111111111111111111111	
11111111111111111111111111111111111	
11111111.11111111111111111111111111	
1.1.1.111111111111111111111111111111	
1111111111	
1111111111111111111111	
.111111111111111111111111111111	
111111111111111111111111111111111111	
.111111.11111111111111111111.	
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	
.1111111111111111.1111.1111111111111111	
1 . 1	
.1111111111111111111111111111111	
11111111.11111111111111111111111	
1111111111.11111111111111111111	
111111111.111.1111111111111111111111	
111111111111111111111111111111	
1111111111111111.1.111111111111	
111111111111111111111111111111111	
11111111111111111111	.11111111111111
111111.11111	1111.111111
1 1 1 1 1	
	1

Erosion Operation Output:
1
1 1
1
1
1 . 1 1 1
1 1 1
1
1

pening Operation Output:
1
111111
.1111111111
.1111111111.1111111111111111111
111111111111111111111111
.111111111111111111111111111
1111111
111111111111111111111111111
111111111111111111111111111
1 . 1 . 1 1 . 1 1 1 1 1 1 1
111111111111111
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1
111111.11111111111111111111
1111111111.111111111111
.1.11111
1111111111111111111111111
11111111.1
11111111111
111111.1.111
11111

crossing operaction output.
.111111
111111111111111111111111111111
111111111111111111111111111111111111
. 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
111111111111111111111111111111111111111
. 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1111111111111.1111111111111111111111111
. 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
.11111111111111111111111111111111111111
1.1.11111111111111111111111111111111
1111111111111111111111111111111111
11111111111111111111111111111
11111111111111111111111
11111.111111111111111111111
.111111111111111111111111111111111111.1111
111111111111111111111111111111111111111
.11111111111111111111111111111111111111
.11111111111111111111111111111111111111
111111111111111111111111111111111111111
. 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
. 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
.1111111111111111111111111111111
11111111111111111111111111111111
111111111111111111111111111111111
11111111111111111111111111111
11111.11111
11111

Dilation:
$0\ 0\ 0\ 0\ 0\ 0\ 1\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\$
$0\ 1\ 1\ 1\ 0\ 0\ 1\ 1\ 1\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 1\ 1\ 1\ 0\ 0\ 1\ 1\ 1\ 1\ 1\ 1\ 1\ 1\ 1\ 0\ 0\ 0\ 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 0 0 0 0 0 0 0 0 0 0
$\begin{smallmatrix} 0&1&1&1&1&1&1&1&1&1&1&1&1&1&1&1&1&1&1&1$
$\begin{smallmatrix} 0 & 0 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 &$
$\begin{smallmatrix} 0 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 &$
$\begin{smallmatrix} 0 & 0 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 &$
$\begin{smallmatrix} 0 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 &$
0 0 1 1 1 1 1 1 1 1 1 0 0 0 0 0 1 1 1 1
$\begin{smallmatrix} 0 & 0 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 &$
$\begin{smallmatrix} 0 & 0 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 &$
$\begin{smallmatrix} 0 & 0 & 1 & 0 & 1 & 0 & 1 & 1 & 1 & 1 &$
0 0 0 0 0 0 0 0 1 1 1 0 0 1 0 1 1 1 1 1
0 0 0 0 0 0 0 1 0 1 1 1 0 0 0 0 0 0 1 1 1 0 0 1 0 1 1 1 1 1 1 1 1 1 0 0 0 0 0 0 1 1 1 0 0 0 1 1 1 1 0 1 1 1 1 0
$\begin{smallmatrix} 0 & 0 & 0 & 0 & 0 & 0 & 1 & 1 & 1 & 1 &$
$\begin{smallmatrix} 0 & 0 & 0 & 0 & 0 & 1 & 1 & 1 & 1 & 0 & 0$
$0\ 0\ 0\ 0\ 0\ 1\ 1\ 1\ 0\ 0\ 0\ 1\ 1\ 1\ 1\ 1\ 1\ 1\ 1\ 1\ 1\ 1\ 1\ 1\$
$0\ 0\ 0\ 0\ 1\ 1\ 1\ 1\ 0\ 0\ 1\ 1\ 1\ 1\ 1\ 1\ 1\ 1\ 1\ 1\ 1\ 1\ 1\$
$\begin{smallmatrix} 0&1&1&1&1&1&1&1&1&1&1&1&1&1&1&1&1&1&1&1$
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
$\begin{smallmatrix} 0&1&1&1&1&1&1&1&1&1&1&1&1&1&1&1&1&1&1&1$
$\begin{smallmatrix} 0 & 0 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 &$
011111111111111111111111111111111111111
$\begin{smallmatrix} 0 & 0 & 1 & 0 & 1 & 1 & 1 & 1 & 1 & 1 &$
$0\ 1\ 1\ 1\ 1\ 1\ 1\ 1\ 1\ 0\ 0\ 1\ 0\ 1\ 1\ 1\ 1\ 1\ 1\ 1\ 1\ 1\ 1\ 1\ 1\ 1\$
$0\ 0\ 1\ 1\ 1\ 1\ 1\ 1\ 1\ 0\ 0\ 0\ 0\ 1\ 1\ 1\ 1\ 1\ 1\ 1\ 1\ 1\ 1\ 1\ 1\ 1\$
$\begin{smallmatrix} 0 & 0 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 &$
$0\ 0\ 0\ 1\ 1\ 1\ 1\ 1\ 1\ 1\ 1\ 1\ 1\ 1\ 1\ 1\$
$0\ 0\ 1\ 1\ 1\ 1\ 1\ 1\ 1\ 1\ 1\ 1\ 1\ 1\ 1\$
$0\ 0\ 0\ 1\ 1\ 1\ 1\ 1\ 1\ 1\ 1\ 1\ 1\ 1\ 1\ 1\$
0 0 0 1 1 1 1 1 1 1 1 1 1 0 1 1 1 1 1 1
$\begin{smallmatrix} 0 & 0 & 0 & 0 & 1 & 1 & 1 & 1 & 1 & 1 &$
$0\ 0\ 0\ 0\ 0\ 1\ 1\ 1\ 1\ 1\ 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\ 1\ 0\ 0\ 0\ 1\ 1\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\$

Erosion:

Opening:
$0\ 0\ 0\ 0\ 0\ 0\ 1\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\$
$\begin{smallmatrix} 0&1&1&1&0&0&1&1&1&0&0&0&0&0&0&0&0&0&0&0$
$\begin{smallmatrix} 0 & 0 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 0 & 0$
$\begin{smallmatrix} 0 & 0 & 0 & 1 & 1 & 1 & 1 & 1 & 1 & 1 &$
$\begin{smallmatrix} 0 & 0 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 &$
$\begin{smallmatrix} 0 & 0 & 0 & 1 & 1 & 1 & 1 & 1 & 1 & 0 & 0$
0 0 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 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 1 1 0
0 0 0 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 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 0 0 0 0 0
0 0 0 1 1 1 1 1 1 1 1 0 0 0 0 0 1 1 1 1
0 0 0 0 1 1 1 1 1 1 1 0 1 0 0 0 0 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 0 0 0 0 0 0
0 0 0 1 0 1 0 1 0 0 0 0 1 1 1 1 1 1 1 1
0 0 0 0 0 0 0 0 0 0 1 0 0 1 0 1 0 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 0
0 0 0 0 0 0 0 0 0 1 0 1 0 0 0 0 0 0 1 1 1 0 0 1 0 0 0 0 1 1 1 1 1 0 0 0 0 0 0 0 0 0 0 1 1 1 1 1 1 0 0 1 0
$0 \ 0 \ 0 \ 0 \ 0 \ 0 \ 0 \ 0 \ 1 \ 0 \ 0$
$\begin{smallmatrix} 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 $
0 0 0 0 0 0 1 0 0 0 0 0 1 1 1 0 0 0 0 0
0 0 0 0 0 0 1 0 0 0 0 0 1 1 1 1 1 1 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 1 0 0 0 0 0 0 0 1 1 1 0
0 0 0 0 0 1 1 0 0 0 0 0 1 1 1 1 1 1 1 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 0 1 1 1 1 1 1 0
0 0 0 0 1 1 1 1 0 0 1 1 1 1 1 1 1 1 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 1 1 0
011111101111111110000011111111100000000
0 0 1 1 1 1 0 0 0 1 1 1 1 1 1 1 1 1 1 0 0 0 0 0 1 1 1 1 1 0 0 0 0 1 1 1 1 0 0 0 0 0 1 0
0 0 0 1 1 1 1 0 1 1 1 1 1 1 1 1 0 0 1 1 0 0 0 0 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 0
0 0 1 0 1 1 1 1 1 1 1 1 1 1 1 0 0 0 0 1 1 1 0 0 0 1
0 0 0 0 0 1 1 1 1 1 1 0 1 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 1 0 0 0 0 0 1
0 0 1 0 1 1 1 1 1 1 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 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 0 0 0 0 0 0 0 0 1
0 0 0 1 1 1 1 1 1 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 1 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 0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 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 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 0
0 0 0 1 1 1 1 1 1 0 1 0 0 0 0 0 0 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 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 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 0 0 0 1 0 0 0 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 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 1 1 1 1 1 1 1 1 1 1 1 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 1 1 1 1 1 1 1 1 0 1 0 0 0 0 1 0 1
$\begin{smallmatrix} 0 & 0 & 0 & 1 & 1 & 1 & 1 & 1 & 1 & 1 &$
00001111111100001000001110000000111110000
$\begin{smallmatrix} 0 & 0 & 0 & 0 & 1 & 1 & 1 & 1 & 1 & 1 &$
$\begin{smallmatrix} 0&0&0&0&1&1&1&1&1&1&1&1&1&1&1&1&1&1&1&1$
00000111000110000000
0000000000000000000

Closing:
$\begin{smallmatrix} 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 &$
$0\ 1\ 1\ 1\ 0\ 0\ 1\ 1\ 1\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 1\ 1\ 1\ 0\ 0\ 1\ 1\ 1\ 1\ 1\ 1\ 1\ 1\ 1\ 0\ 0\ 0\ 1\ 1\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\$
111111111100000000000111111111111111111
$\begin{smallmatrix} & & & & & & & & & & & & & & & & & & &$
111111111111110011000011111111111111111
01111111111111111111
* * * * - * - *
000000011111111111111111111111111111111
000000111111111110011100111111111111111
000001111101111111111111111111111111111
000011111011111111111111111111111111111
011111111111111111111111111111111111111
111111111111111111111111111111111111111
01111111111111111111
111111111111111111111111111111111111111
figc 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
01111111111111111111
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\$
$0\ 1\ 1\ 1\ 1\ 1\ 1\ 1\ 1\ 1\ 1\ 1\ 1\ 1\$
$0\ 0\ 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\$
$\begin{smallmatrix} 0 & 0 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 &$
$\begin{smallmatrix} 0 & 0 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 &$
$\begin{smallmatrix} 0 & 0 & 0 & 1 & 1 & 1 & 1 & 1 & 1 & 1 &$
0 0 0 0 1 1 1 1 1 1 1 1 1 1 1 1 1 0 0 1 1 1 1 0 0 1 0 1 0 0 0 0 0 0 0 0 1
$\begin{smallmatrix} 0 & 0 & 0 & 0 & 1 & 1 & 1 & 1 & 1 & 1 &$
$\begin{smallmatrix} 0&0&0&0&0&1&1&1&1&1&1&1&1&1&1&1&1&1&1&1$

Image 1, Structured Element 3 ********* Initial Zero Framed 2D Array: 1 1 1 1 1 1 1 1 1 1 . 1 . 1 1 1 1 1 1 1 1 . 1 1 1 1 . 1

Initial Structured Element 2D Array:

- .11.
- 1111
- . 11.

briación operación ouque.	
1 1 1 1 . 1 1 1 1	
.11111111111	
. 1	1
111111111111111111111111111111111111	
111111111111111111111111111111111111	
11111111111111111111111111111111111	
11111.1111111111111111111111	
11111.1111111111111111111111	
. 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	
. 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	
	1
111111111111111111111111111111111111	L 1
	111
	1111
111111111111111111111111111111111111	1111
111111111111111111111111111111111111	111
111111111111111111111111111111111111	111
111111111111111111111111111111111111	111
11111111111111111111111111111111111	
1111111111111	
1111111	

Erosion Operation Output:	
1	
1 1	

Opening Operation Output:
1
1 1 1 1 1 1
111111111
1111111111 11 111111
1 1
1 1
1 1
11 1111111 111111
1111 111111111
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
11111111111111111111 111111
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1
1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
11111111111111111111111 111111
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 1 1 1 1 1 1 1 1
111 11

Closing Operation Output:
111
11111111111111111111111111111
.111111111111
. 1
. 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
.11111111111111111111111111111111111111
.11111111111111111111111111111111111111
.11111111111111111111111111111111111111
1111111111111111111111111111111111111
1111111111111111111111111111111111111
1111111111111111111111111111111111111
1111111111111111111111111111111111111
111111111111111111111111111111111111
11111111111111111111111111111111111
1111111111111111111111111111111111
1111111111111111111111111111111111
. 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
. 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
. 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
.11111111111111111111111111111111111111
.11111111111111111111111111111111111111
.11111111111111111111111111111111111111
.11111111111111111111111111111111111111
.11111111111111111111111111111111111111
.11111111111111111111111111111111111111
11111111111111111111111111111111111
1111111111111111111111111111111
111111111111111111111111111
1111111111111111

Dilation:
$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 1 1 1 1 0 1 1 1 1 1 0 0 0 0 0 0 0 0
011111111111000000000001111111111111111
011111111111100000000000000000000000000
0 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
0 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
0 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
0 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
0 0 1 1 1 1 1 1 1 1 1 1 1 0 0 0 0 1
0 0 0 1 1 1 1 1 1 1 1 1 1 1 0 0 1 1 1 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 1 1 1 1 1 1 1 1 1 1 1
0 0 0 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
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 1 1 1 1 1 1 1 1 1 1 1 0 0 1 1 1 1 1 1 1 1 1 0 0 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 0 1 1 1 1 0 0
$\begin{smallmatrix} 0 & 0 & 0 & 0 & 0 & 0 & 1 & 1 & 1 & 1 &$
$\begin{smallmatrix} 0 & 0 & 0 & 0 & 0 & 1 & 1 & 1 & 1 & 1 &$
$\begin{smallmatrix} 0 & 0 & 0 & 0 & 0 & 1 & 1 & 1 & 1 & 1 &$
$\begin{smallmatrix} 0&1&1&1&1&1&1&1&1&1&1&1&1&1&1&1&1&1&1&1$
0 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
0 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
$\begin{smallmatrix} 0 & 0 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 &$
$\begin{smallmatrix} 0 & 0 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 &$
$\begin{smallmatrix} 0 & 0 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 &$
$\begin{smallmatrix} 0 & 0 & 0 & 1 & 1 & 1 & 1 & 1 & 1 & 1 &$
$\begin{smallmatrix} 0 & 0 & 0 & 1 & 1 & 1 & 1 & 1 & 1 & 1 &$
$\begin{smallmatrix} 0 & 0 & 0 & 1 & 1 & 1 & 1 & 1 & 1 & 1 &$
0 0 0 1 1 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 1 1 1 1 1 1 1 1 1 1
$\begin{smallmatrix} 0 & 0 & 0 & 0 & 1 & 1 & 1 & 1 & 1 & 1 &$
$\begin{smallmatrix} 0 & 0 & 0 & 0 & 0 & 1 & 1 & 1 & 1 & 1 &$
$\begin{smallmatrix} 0 & 0 & 0 & 0 & 0 & 1 & 1 & 1 & 1 & 1 &$
$0\;0\;0\;0\;0\;0\;0\;1\;1\;1\;1\;0\;0\;1\;1\;1\;0\;0\;0\;0$
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0

Erosion:

Opening:

0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	Closing:
0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	$\begin{smallmatrix} 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 $
0 1 1 1 1 1 1 1 1 1	$\begin{smallmatrix} 0 & 0 & 0 & 0 & 0 & 0 & 1 & 1 & 1 & 0 & 0$
0 1 1 1 1 1 1 1 1 1	$\begin{smallmatrix} 0 & 0 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 &$
0 1 1 1 1 1 1 1 1 1	011111111111110000000000111111111111111
0 1 1 1 1 1 1 1 1 1	
0 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	
0 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	
0 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	
$ \begin{array}{c} 0 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 &$	
$ \begin{array}{c} 0 & 0 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 &$	
$ \begin{array}{c} 0 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 &$	
$ \begin{array}{c} 0 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 &$	
$ \begin{array}{c} 0 & 0 & 0 & 1 & 1 & 1 & 1 & 1 & 1 & 1 &$	
$ \begin{array}{c} 0 & 0 & 0 & 0 & 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	
$ \begin{array}{c} 0 & 0 & 0 & 0 & 0 & 1 & 1 & 1 & 1 & 1 &$	*****
$ \begin{array}{c} 0 & 0 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 &$	
$ \begin{array}{c} 0 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 &$	
$ \begin{array}{c} 0 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 &$	
$ \begin{array}{c} 0 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 &$	
$ \begin{array}{c} 0 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 &$	
$ \begin{array}{c} 0 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 &$	
$ \begin{array}{c} 0 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 &$	
$ \begin{array}{c} 0 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 &$	
$ \begin{array}{c} 0 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 &$	01111111111111111111
$ \begin{array}{c} 0 \; 1 \; 1 \; 1 \; 1 \; 1 \; 1 \; 1 \; 1 \; 1 \;$	
$\begin{smallmatrix} 0 & 0 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 &$	
$\begin{smallmatrix} 0 & 0 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 &$	01111111111111111111
$\begin{smallmatrix} 0 & 0 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 &$	$\begin{smallmatrix} 0 & 0 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 &$
$\begin{smallmatrix} 0 & 0 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 &$	$\begin{smallmatrix} 0 & 0 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 &$
$\begin{smallmatrix} 0 & 0 & 0 & 1 & 1 & 1 & 1 & 1 & 1 & 1 &$	$\begin{smallmatrix} 0 & 0 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 &$
$\begin{smallmatrix} 0 & 0 & 0 & 1 & 1 & 1 & 1 & 1 & 1 & 1 &$	$\begin{smallmatrix} 0 & 0 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 &$
$\begin{smallmatrix} 0 & 0 & 0 & 0 & 1 & 1 & 1 & 1 & 1 & 1 &$	$\begin{smallmatrix} 0 & 0 & 0 & 1 & 1 & 1 & 1 & 1 & 1 & 1 &$
0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	$\begin{smallmatrix} 0 & 0 & 0 & 1 & 1 & 1 & 1 & 1 & 1 & 1 &$
	$\begin{smallmatrix} 0 & 0 & 0 & 0 & 1 & 1 & 1 & 1 & 1 & 1 &$
$\begin{smallmatrix} 0 & 0 & 0 & 0 & 0 & 1 & 1 & 1 & 1 & 1 &$	$\begin{smallmatrix} 0 & 0 & 0 & 0 & 0 & 1 & 1 & 1 & 1 & 1 &$
	$\begin{smallmatrix} 0 & 0 & 0 & 0 & 0 & 1 & 1 & 1 & 1 & 1 &$

Image 2, Structured Element 1
Initial Zero Framed 2D Array:
· · · · · · · · · · · · · · · · · · ·
1
.111111
1.111111
1111.11111111.11.11.1
1.11.111111111111111.1.
1.11111
1111
11111.11
1.11.1.1.1.1.1.1.1.1.1.1.1.1.1.1.1.1
1.1.11.1.1.1.1.1.1.1.1.1.111111
1111111.11111111
1111111111111111
111111111111111111
1 1 1 . 1 1 1 . 1
.1111.11.1111111111111.1111
1 . 1 1 111111 1 1
1 1 . 1 1 1 1 1 1
1 1 1
1.1.1.1.1.1.1.1.1.1.1.1.1.1.1.1.1.1
1 . 1 1
111.11111111111111111111111111
11.111.11.111111111111111.1.
11111111111.1111111111
111111111.11.1.11111111.11
1.1111111.111111111111
1111.1111.11.1111
111111.111
11111

Initial Structured Element 2D Array: 1 1 1

Dilation Operation Output:	
111	
1111111111111111111111111.1111	
1 1 1 1 1 1 1 1 1	
. 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	
. 1	
1 1	
1 1 1 1 1 1 1 1 1 1 1 1 1 1	
1111111111.1111111111111111111111	
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	
111 . 111	
1 1 1 1	
1 1	
11111111111111111111111111111111111	
1 1 1 1 1 . 1 1 1 1 1 1 1 1 1 1 1 1	
111 . 11111111111 . 1111 . 11111 111111	
. 1	
111111111 1111111111	
. 1 1 1 1 1 1 1 1 1 1 1 1 1 . 1	
1 1	
1 1	
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	
1 1	

Erosion Operation Output:
1 1
1 1
11111111111
111
11111
1
111
111111111
1111
11
111

pening Operation Output:
1
11111111
1 1 1 1 1 1 1
1111111111111111111111111
.1111111111111111111111111111
1111111111111111111111
111111
11111111111111111111111111
1
1111111111111111
111111111111111
11111111111111111
11111111111111111111
111111111111111111111111111111
1 1 1 1 1 1 1 1 1 1 1 1 1 1
11111111111111111111111
.1111111
1 1
11111111111111111111111
1111111111111111111111111111
11111111111111111111111
111111111111111
11111111111
11111

crosing operation output:	
	•
111111	
.111111111111111111111111111111111	
.11111111111	
111111111111111111111111111111111111111	
11111111111111111111111111111	
.1111111111111111111111111111111111	
.11111111111111111111111111111111111111	
.11111111111111111111111111111111111111	
111111111111111111111111	
11111.111111111111111111111	
11111.11111111111111111111111	
11111.111111111111111111111111	
111111111111111111111111111111111	
.11111111111111111111111111111111111	
. 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	
111111111111111111111111111111111111	
111111111111111111111111111111111111	
1111111111111111111111111111111111	
1111111111111111111111111111111111	
.111111111111111111111111111111111	
111111111111111111111111111111111111	
1111111111111111111111111111111	
11111111111111111111111111111111111	
1111111111111	
	٠

Dilation:
$\begin{smallmatrix} 0 & 0 & 0 & 0 & 0 & 1 & 1 & 1 & 0 & 0 &$
1 1 1 1 1 1 1 1 1 1 0 0 0 0 0 0 0 0 0 0
$\begin{smallmatrix} 0 & 0 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 &$
$\begin{smallmatrix} 0 & 0 & 0 & 1 & 1 & 1 & 1 & 1 & 1 & 1 &$
$0\;1\;1\;1\;1\;1\;1\;1\;1\;1\;1\;1\;1\;1\;1\;1\;1\;1\;1\;1$
$\begin{smallmatrix} 0 & 0 & 0 & 1 & 1 & 1 & 1 & 1 & 1 & 1 &$
$\begin{smallmatrix} 0&1&1&1&1&1&1&1&1&1&1&1&1&1&1&1&1&1&1&1$
$\begin{smallmatrix} 0 & 0 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 0 & 0$
0 0 1 1 1 1 1 1 1 1 1 1 1 0 0 0 1 1 1 1
0 0 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
0 0 1 1 1 1 1 1 1 0 0 1 1 1 1 1 1 1 1 1
0 0 0 0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1
0 0 0 0 0 0 0 0 0 1 1 1 1 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 0 0 0 0 1 1 1 1 0 0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 1 1 1 0
$\begin{smallmatrix} 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 1 &$
0 0 0 0 0 0 0 1 1 1 0 1 1 1 0 0 0 0 0 0
0 0 0 0 0 0 1 1 1 0 0 0 1 1 1 1 1 1 0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 1 0 0 0 0 0 1 1 1 1 1 1 0 0 0 0 0 0 1
0 0 0 0 0 1 1 1 1 0 0 0 1 1 1 1 1 1 1 1
0 0 0 0 1 1 1 1 0 0 0 1 1 1 1 1 1 1 1 1
0 0 0 1 1 1 1 1 1 0 1 1 1 1 1 1 1 1 1 1
111111111111111111111000011111111111111
0 0 1 1 1 1 1 1 0 1 1 1 1 1 1 1 1 1 1 1
0 0 0 1 1 1 0 1 1 1 1 1 1 1 1 1 1 1 1 1
$0\ 1\ 1\ 1\ 1\ 1\ 1\ 1\ 0\ 0\ 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 0 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 0 1
$0\ 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\$
0 0 1 1 1 0 1 1 1 0 0 0 0 0 0 0 1 1 1 1
0 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 1
0 0 0 0 1 1 1 1 1 1 1 1 0 1 1 1 1 1 1 1
0 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 0 0 0 1
0001111111111111111100011111100000111111
0 0 0 1 1 1 1 1 1 1 1 1 0 1 1 1 1 0 0 1 1 1 1 1 1 1 1 1 1 1 1 0 0 0 0 0 0 0 1
00001111111111110001110000000000000001111
000001111101111000000000000000000000111001111
$f 0 \ 0 \ 0 \ 0 \ 0 \ 0 \ 0 \ 0 \ 0 \ 0 $

Erosion:

Opening:
$\begin{smallmatrix} 0&1&1&1&1&1&1&1&1&0&0&0&0&0&0&0&0&0&0&0$
0 0 0 1 1 1 1 1 1 1 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 1 1 1 1 1 1 1 1 1 0 0 0 0 0 1 1 1 1 1 1 1 1 0
0 0 1 1 1 1 1 1 1 1 1 1 1 1 1 0 0 0 1 1 1 1 1 1 0 0 0 1 0 0 0 0 0 1 1 1 1 1 1 1 0 0 0 0 0 0 0 0 0 1 1 1 0 0 0 0 1 1 1 0 0 0 0 0
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 0 0 0 0 0 0 0 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 0
0 0 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 0 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
0 0 0 1 1 1 1 1 1 1 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 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 0 0 0 0 0
0 0 0 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 0 0 0 0 0
0 0 0 0 1 1 1 1 1 1 1 1 0 0 0 1 1 1 1 1
0 0 0 1 1 1 1 1 1 0 0 0 0 1 1 1 1 1 1 1
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 1 0 0 0 0 0 0 0 0 0
000000000000000000000000000000000000000
0000000100010000000000001111100000001110001110000
000000010000011100000001111111100000011100010000
000000100000111110000000111111111000000
000001000001111111000000011111110000000
000011110001111111100000111111111000000
011111111111111111111111111111111111111
0001110001111111111110000011111000000110001110000
$\begin{smallmatrix} 0 & 0 & 0 & 0 & 1 & 0 & 1 & 1 & 1 & 1 &$
001111100001000001000011111111111111111
$\begin{smallmatrix} 0 & 0 & 0 & 0 & 0 & 0 & 1 & 1 & 1 & 1 &$
$\begin{smallmatrix} 0 & 0 & 1 & 1 & 1 & 1 & 1 & 1 & 0 & 0 &$
$\begin{smallmatrix} 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 &$
$\begin{smallmatrix} 0 & 0 & 0 & 1 & 1 & 1 & 1 & 1 & 1 & 0 & 0$
$egin{array}{c} 0\ 0\ 0\ 0\ 0\ 1\ 1\ 1\ 1\ 0\ 0\ 0\ 1\ 1\ 1\ 1\ 1\ 1\ 1\ 1\ 1\ 1\ 1\ 1\ 1\$

Closing:
$0\ 0\ 0\ 0\ 0\ 1\ 1\ 1\ 1\ 1\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\$
$\begin{smallmatrix} 0 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 0 & 0$
$\begin{smallmatrix} 0 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 &$
01111111111000011111
01111111111111111111
0 0 0 0 0 0 0 0 1 1 1 1 1 1 0 0 0 0 1
00000000111110000000011111110000000001111
000000111111111000000000111111111111111
0 0 0 0 0 1 1 1 1 1 1 0 1 1 1 1 1 1 1 1
0 0 0 0 1 1 1 1 1 0 1 1 1 1 1 1 1 1 1 1
0 0 0 1 1 1 1 1 1 0 1 1 1 1 1 1 1 1 1 1
001111111111111111111111111111111111111
011111111111111111111111111111111111111
01111111111111111111
001111111111111111111111111111111111111
111111111111111111111111111111111111111
000001111111111111111111111111111111111
111111111111111111111111111111111111111
01111111110000111111
01111111111110001111
0 0 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
01111111111111111111
$\begin{smallmatrix} 0 & 0 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 &$
$\begin{smallmatrix} 0 & 0 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 &$
0 0 0 1 1 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\ 1\ 1\ 1\ 1\ 1\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\$
$0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0$

Image 2, Structured Element 2 ********* Initial Zero Framed 2D Array:

Initial Structured Element 2D Array:

- 111
- 111

Dilation Operation Output:	
1	
.111111	1
1111111111111.	1 1 1
. 1 1 1 1 1 1 1 1 1 1 1 1	1 1 1
1 1	
.11111111111111111111111111111	
1111111111111111111111111111	
1111111111.111111111111111111.111111	
11111111.111111111111111111.1111.11111	11111111
1 . 1 1 1 1 1 1 1 1 1 1 1	1111111
	11.111
	1.111
	. 1 1 1 1 1
11111111111111111111111	
.111111111111111111111111111111111111	
111111111111111111111111111111111111	
.111111.11111111111111111111111111	
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 . 1 1 1 1 1 . 1 . 1 1 1	
. 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	
1 . 1	
. 1	1111111111
1 1 1 1 1 1 1 1 1 1 1 1	111111111
1 1 1 1 1 1 1 1 1 . 1 1 1 1 1	11111111
1 1 1 1 1 1 1 1 . 1 1 1 . 1 1 1 1	11111.111
1 1	11111111
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	
11111111111111111111111111111111111	
11111.111111	
11111	

Erosion Operation Output:
1
1 1
1
1.111111
111
1

pening Operation Output:
1
111111
.1111111111
.1111111111.1111111111111111111
111111111111111111
.11111111111111111111111111
1111111
111111111111111111111111111
111111111111111111111111111
1 . 1 . 1 1 . 1 1 1 1 1 1 1
.1111111111111.11111111111
.1.111111111111111111111.111111
1111111111.11111111111111
.1.1111111111111111111111111
11111
1111111111111111111111111
11111111.1111111111111111111
1111111111.1111111
11111.1.111
1 1 1 1 1

Closing Operation Output:
1
. 1 1 1 1 1 1
111111111111111111111111111111.111
.111111111111111111111111111111111
111111111111111111111111111111111111
. 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
111111111111111111111111111111111111111
. 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
111111111111111111111111111111111111111
. 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
. 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
. 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
111111111111111111111111111
1 . 1 . 1 1 1 1 1 1 1 1 1 1 1 1 1
.11111111111111111111111111111111111111
.11111111111111111111111111111111111111
.11111111111111111111111111111111111111
11111111111111111111111111
11111111111111111111111
11111.1111
11111

Dilation:
$\begin{smallmatrix} 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 &$
$\begin{smallmatrix} 0&1&1&1&1&0&0&1&1&1&0&0&0&0&0&0&0&0&0&0$
1 1 1 1 1 1 1 1 1 1 1 0 0 0 0 0 0 0 0 0
$\begin{smallmatrix} 0&1&1&1&1&1&1&1&1&1&1&1&1&1&1&1&1&1&1&1$
0 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 0 1 1 1 1 1 1 1 1 1 1 1 1 1 0 0 0 1 1 1 1 1 1 1 1 1 0 0 0 0 0 0 0 0 1 1 1 1 0 0 0 0 1 1 1 1 0 0 0 0 0
$\begin{smallmatrix} 0 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 &$
0 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
$\begin{smallmatrix} 0 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 &$
0 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 1 0 0 0 1 1 1 1 1 1 1 1 1 1 0 0 0 0 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 0 0 0 1 1 1 1
0 0 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
0 0 1 1 1 1 1 1 1 1 0 1 1 1 1 1 1 1 1 1
0 0 0 1 0 1 0 1 0 1 0 1 1 1 1 1 1 1 1 1
0 0 0 0 0 0 0 0 1 1 1 1 0 0 1 0 1 0 1
0 0 0 0 0 0 0 0 1 0 1 1 1 0 0 0 0 0 0 1 1 1 0 0 1 0 1 1 1 1 1 1 1 1 0 0 0 0 0 0 1 1 1 0 0 0 1 1 1 1 0 1 1 1 0 0 0 0 0 0
0 0 0 0 0 0 1 1 1 0 1 1 1 1 1 0 0 0 0 0
0 0 0 0 0 0 1 1 1 0 0 0 1 1 1 1 1 0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 1 1 0 0 0 0 0 1 1 1 1 1 1 1 0 0 0 0 0 1
0 0 0 0 0 1 1 1 1 0 0 0 1 1 1 1 1 1 1 1
0 0 0 0 1 1 1 1 1 0 0 1 1 1 1 1 1 1 1 1
$\begin{smallmatrix} 0 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 &$
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
$\begin{smallmatrix} 0 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 &$
001111111111111111111111111111111111111
$\begin{smallmatrix} 0 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 &$
001011111111111111111111111111111111111
$\begin{smallmatrix} 0 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 &$
$\begin{smallmatrix} 0 & 0 & 1 & 1 & 1 & 1 & 1 & 1 & 0 & 1 & 0 & 1 & 1$
$\begin{smallmatrix} 0 & 0 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 &$
$\begin{smallmatrix} 0 & 0 & 0 & 1 & 1 & 1 & 1 & 1 & 1 & 1 &$
$egin{array}{c} 0\ 0\ 1\ 1\ 1\ 1\ 1\ 1\ 1\ 1\ 1\ 1\ 1\ 1\ 1\$
$oxed{0}$
f0.000111111111111111111111111111111111
$oxed{0}$
$oxed{0}$

Erosion:

Opening: $0\ 0\ 0\ 0\ 1\ 1\ 1\ 1\ 1\ 1\ 1\ 1\ 0\ 0\ 0\ 1\ 0\ 0\ 0\ 0\ 1\ 1\ 1\ 0\ 0\ 0\ 0\ 0\ 0\ 1\ 1\ 1\ 1\ 1\ 1\ 1\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0$ $0\ 0\ 0\ 0\ 1\ 1\ 1\ 1\ 1\ 1\ 1\ 0\ 0\ 0\ 1\ 1\ 0\ 0\ 0\ 1\ 0\ 1\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 1\ 1\ 1\ 0\ 0\ 1\ 1\ 1\ 0\ 1\ 1\ 1\ 0\ 1\ 1\ 0\ 0\ 1\ 0\ 0\ 0\ 0\ 0\ 0\ 0$

Closing:
$0\ 0\ 0\ 0\ 0\ 0\ 1\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\$
$0\ 1\ 1\ 1\ 0\ 0\ 1\ 1\ 1\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 1\ 1\ 1\ 0\ 0\ 1\ 1\ 1\ 1\ 1\ 1\ 1\ 1\ 0\ 0\ 0\ 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 0 0 0 0 0 0 0 0 0 0
$\begin{smallmatrix} 0&1&1&1&1&1&1&1&1&1&1&1&1&1&1&1&1&1&1&1$
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 0 1
$\begin{smallmatrix} 0&1&1&1&1&1&1&1&1&1&1&1&1&1&1&1&1&1&1&1$
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
$\begin{smallmatrix} 0&1&1&1&1&1&1&1&1&1&1&1&1&1&1&1&1&1&1&1$
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
$\begin{smallmatrix} 0&1&1&1&1&1&1&1&1&1&1&1&1&1&1&1&1&1&1&1$
$\begin{smallmatrix} 0&1&1&1&1&1&1&1&1&1&1&1&1&1&1&1&1&1&1&1$
$\begin{smallmatrix} 0 & 0 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 &$
01111111111111111111
$\begin{smallmatrix} 0 & 0 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 &$
$\begin{smallmatrix} 0 & 0 & 0 & 1 & 0 & 1 & 0 & 1 & 1 & 1 &$
$\begin{smallmatrix} 0 & 0 & 0 & 0 & 0 & 0 & 1 & 1 & 1 & 1 &$
$\begin{smallmatrix} 0 & 0 & 0 & 0 & 0 & 0 & 1 & 1 & 1 & 1 &$
$\begin{smallmatrix} 0 & 0 & 0 & 0 & 0 & 1 & 1 & 1 & 1 & 1 &$
$\begin{smallmatrix} 0 & 0 & 0 & 0 & 1 & 1 & 1 & 1 & 1 & 1 &$
$\begin{smallmatrix} 0&1&1&1&1&1&1&1&1&1&1&1&1&1&1&1&1&1&1&1$
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
01111111111111111111
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
01111111111111111111
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
01111111111111111111
111111111111111111111111111111111111111
$0\ 1\ 1\ 1\ 1\ 1\ 1\ 1\ 1\ 1\ 1\ 1\ 1\ 1\$
figcup 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
0 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
figcup 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
0 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
0 0 1 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 1 1 1 1 1 1 1 1 1 1 1
0 0 0 0 1 1 1 1 1 1 1 1 1 1 1 1 0 0 0 1 1 1 0 0 0 1 0 1 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 0 0 1 0 0 0 0 0 0 0 0 0
0 0 0 0 0 1 1 1 1 1 1 0 1 1 1 1 1 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 1 1 1 0 1 1 1 1 1 1 1 0
0 0 0 0 0 0 1 1 1 0 0 0 1 1 0 0 0 0 0 0

Image 2, Structured Element 3 ********* Initial Zero Framed 2D Array: 1 1 1 1 1 1 1 1 1 1 . 1 . 1 1 1 1 1 1 1 1 . 1 1 1 1 . 1

Initial Structured Element 2D Array:

- .11.
- 1111
- . 11.

Diffaction operaction out	-			
1 1 .		1 1 1 1 1	1	
1 1 1 1 . 1 1 1 1		1 1 1 1 . 1 1 1 1	111111111	1 1 1 1
. 1 1 1 1 1 1 1 1 1 1	1	1 1 1 1 1 1 1 1 1	11111111111	1 1 1 1 1 1 1 1
				1 1 1 1 1 1 1 1 1
				1 1 1 1 1 1 1 1 1 1
				1.111111111111
				11111111111111
				111111111111111
				111111111111111
				11111111111111
				. 1 1 1 1 1 1 1 1 1 1 1 1 1
				. 1 1 1 1 1 1 1 1 1 1 1 1 1 1
				11111111111111
				11111111111111
1 1	111111111	1 1 1 1 1 1 1 1 1 1 1 1 1 1	11111111111.11	111111111111
1 1 1	1111111.	. 1 1 1 1 . 1 1 1 1 1 1 1	1111111111	111111111111111
1 1 1 1	11111111.	1 1 1 1 1 1 1	1111111111	111111111.1111.
1 1 1 1 1	.11111111	1 1 1 1 1 1 1 1	11111111111	11111111111111.
1 1 1 1 1 .	111111111	1111111111	11111111.11	11111111111
				11.1111111111
				1.11111111111
				. 1 1 1 1 1 1 1 1 1 1 1 1
				1111111111111
				11111111111111
				111111111111111
				1111111111111111
				111111111111111
				111111111111111
				111111111111111
				111111111111111
1 1 1 1 1 1 1 1	111111111	1111111111	. 1 1 1 1 1 1 1 1 1 1 1 1 1	11111111111111
1 1 1 1 1 1 1	111111111	111111111	1 1 1 1 1 1 1 1 1 1 1 1	11111111111111
1 1 1 1 1 1 1	111111111	111111111	1 1 1 1 1 1 1 1 1 1	1111111111111
1 1 1 1 1 1	1111111.	. 1 1 1 1 . 1 1	1 1 1 1 1 1 1 1 1	11111111111
1 1 1 1 1	111111	1 1	1 1 1 1 1 1 1	111111
				111
				11
		· · · · · · · · · · · · · · · · · · ·		

Erosion Operacion Ouch				
	 			. .
	 11			
1	 			
	 	1		
	 		1 .	

Opening Operation Output:	
111111111	1 1 1
1 1	1 1 1 1
1 1	1 1 1 1 1 1 1
1 1	1 1 1 1 1 1 1 1 1 1 1 1
1 1 1 1 1 1 1 1 1	1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 1 1 1 1 1 1	1 1 1 1 1 1 1 1 1 1 1 1
1 1	111111111111
1 1	1 1 1 1 1 1 1 1 1 1 1
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	
1 1	
11111111111111111111111111111111	
111111111111111111111111111111111	
111111111111111111111111111111111	
11111111111111111111111111111	
111111111111111111111111111	
1111111111 111111111111	
11111111111 1111111111111 111111	
1111111111111111111111111111111	
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	
1111111111111111111111111111111111	
1111111111111111	
111 11	

oroning operation output.	
1 1 1 1 1 1 1 1 1 1	
.111111111111	
.11111111111111111111111111111111111	
.11111111111111111111111111111111111111	
. 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	
. 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	11111111111111.
. 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	11111111111111.
. 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
. 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	1111111111111111
	111111111111111
	11111111111111
1111111111111111111111111111111111111	
1111111111111111111111111111111111111	
111111111111111111111111111111111111	
11111111111111111111111111111111111	
1111111111111111111111111111111111	
1111111111111111111111111111111111	1111111111111111
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	1111.11111111111
. 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	1111111111111111
. 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	1111111111111111
. 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	1111111111111111
. 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	111111111111111.
. 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	1111111111111.
.11111111111111111111111111111111111111	
.11111111111111111111111111111111111111	
.11111111111111111111111111111111111111	
1111111111111111111111111111111111111	
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	11111111111111111
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	11111111111111.
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	1111111111111
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	
1111111111111111111111111111111111	
1111111111111111111111111111111111	
	11111

	Dilation:
$ \begin{array}{c} 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 $	
O	
0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	
O O O O O O O O O O	
0 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	
$ \begin{array}{c} 0 & 0 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 &$	
$ \begin{array}{c} 0 & 0 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 &$	
$ \begin{array}{c} 0 & 0 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 &$	
$ \begin{array}{c} 0 & 0 & 0 & 1 & 1 & 1 & 1 & 1 & 1 & 1 &$	
$ \begin{array}{c} 0 & 0 & 0 & 1 & 1 & 1 & 1 & 1 & 1 & 1 &$	
$ \begin{array}{c} 0 & 0 & 0 & 1 & 1 & 1 & 1 & 1 & 1 & 1 &$	
$ \begin{array}{c} 0 & 0 & 0 & 1 & 1 & 1 & 1 & 1 & 1 & 1 &$	
$ \begin{array}{c} 0 & 0 & 0 & 0 & 1 & 1 & 1 & 1 & 1 & 1 &$	
$ \begin{array}{c} 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 1 &$	* * * *
$ \begin{array}{c} 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 1 & 1 &$	
$ \begin{array}{c} 0 & 0 & 0 & 0 & 0 & 0 & 1 & 1 & 1 & 1 &$	* * * * * * * * * * * * * * * * * * * *
$ \begin{array}{c} 0 & 0 & 0 & 0 & 0 & 1 & 1 & 1 & 1 & 1 &$	
$ \begin{array}{c} 0 & 0 & 0 & 0 & 0 & 1 & 1 & 1 & 1 & 1 &$	
$ \begin{array}{c} 0 & 0 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 &$	
$ \begin{array}{c} 0 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 &$	
$ \begin{array}{c} 0 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 &$	
$ \begin{array}{c} 0 \; 0 \; 1 \; 1 \; 1 \; 1 \; 1 \; 1 \; 1 \; 1 \;$	
$ \begin{array}{c} 0 \; 0 \; 1 \; 1 \; 1 \; 1 \; 1 \; 1 \; 1 \; 1 \;$	
$ \begin{array}{c} 0 & 0 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 &$	
$ \begin{array}{c} 0 & 0 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 &$	* *
$ \begin{array}{c} 0 & 0 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 &$	
$ \begin{smallmatrix} 0 & 0 & 0 & 1 & 1 & 1 & 1 & 1 & 1 & 1 &$	
$\begin{smallmatrix} 0 & 0 & 0 & 1 & 1 & 1 & 1 & 1 & 1 & 1 &$	
$\begin{smallmatrix} 0 & 0 & 0 & 1 & 1 & 1 & 1 & 1 & 1 & 1 &$	
$\begin{smallmatrix} 0 & 0 & 0 & 1 & 1 & 1 & 1 & 1 & 1 & 1 &$	
$\begin{smallmatrix} 0 & 0 & 0 & 0 & 1 & 1 & 1 & 1 & 1 & 1 &$	
$\begin{smallmatrix} 0 & 0 & 0 & 0 & 1 & 1 & 1 & 1 & 1 & 1 &$	
$\begin{smallmatrix} 0 & 0 & 0 & 0 & 0 & 1 & 1 & 1 & 1 & 1 &$	
$\begin{smallmatrix} 0 & 0 & 0 & 0 & 0 & 1 & 1 & 1 & 1 & 1 &$	
0000001111001110000000000000000000000110001111	

Erosion:

Opening:

Closing:
$\begin{smallmatrix} 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 1 & 1 &$
$\begin{smallmatrix} 0 & 0 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 &$
$\begin{smallmatrix} 0 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 &$
01111111111111111111
0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
01111111111111111111
011111111111111111111111111111111111111
011111111111111111111111111111111111111
011111111111111111111111111111111111111
011111111111111111111111111111111111111
011111111111111111111111111111111111111
$\begin{smallmatrix} 0 & 0 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 &$
0 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
0 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
0 0 1 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 1 1 1 1 1 1 1 1 1 1 1
0 0 0 0 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
0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
0 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
011111111111111111111111111111111111111
011111111111111111111111111111111111111
01111111111111111111
$\begin{smallmatrix} 0&1&1&1&1&1&1&1&1&1&1&1&1&1&1&1&1&1&1&1$
$\begin{smallmatrix} 0&1&1&1&1&1&1&1&1&1&1&1&1&1&1&1&1&1&1&1$
01111111111111111111
01111111111111111111
01111111111111111111
01111111111111111111
$\begin{smallmatrix} 0 & 0 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 &$
$\begin{smallmatrix} 0 & 0 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 &$
$\begin{smallmatrix} 0 & 0 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 &$
$\begin{smallmatrix} 0 & 0 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 &$
$\begin{smallmatrix} 0 & 0 & 0 & 1 & 1 & 1 & 1 & 1 & 1 & 1 &$
$\begin{smallmatrix} 0 & 0 & 0 & 1 & 1 & 1 & 1 & 1 & 1 & 1 &$
$\begin{smallmatrix} 0 & 0 & 0 & 0 & 1 & 1 & 1 & 1 & 1 & 1 &$
$\begin{smallmatrix} 0 & 0 & 0 & 0 & 0 & 1 & 1 & 1 & 1 & 1 &$
0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 1 1 1 0 0 0 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 1 1 0