********** Cover Page **********

Class:	CV
Name:	Frank Yournet
Project:	Project 7
Project Name:	Object Skeleton via thinning
Language:	Java
Due Date:	11/15/2024 before 12:00AM
Submit Date:	11/15/2024 before 12:00AM

Top Level algorithm steps

****
IV. main (...)
****

Step 0: inFile, outFile1, logFile ← open via args []
numRows, numCols, minVal, maxVal ← read from inFile
outFile1 ← "input image header"

outFile1 ← write numRows, numCols, minVal, maxVal

dynamically allocate all arrays and initialize via constructor.

changeCount ← 0

cycleCount ← 0

Step 1: loadImage (inFile,aryOne)

Step 2: outFile1 ← "In main(), before thinning, changeCount = ; cycleCount =" // print values.

prettyDotPrint (aryOne, outFile1) // using dots.

Step 3: thinning (aryOne, aryTwo, logFile)

Step 4: cycleCount ++

Step 5: ouFile1 ← "In main (), inside iteration; changeCount = ; cycleCount =" // print values.

prettyDotPrint (aryOne, outFile1) // using dots.

Step 6: repeat step 3 to step 5 until changeCount <= 0

Step 7: outFile1 ← "in main (), the final skeleton, changeCount = ; cycleCount =" // print values.

prettyPrint (aryOne, outFile1) // Use blank, no dots.

Step 8: close all files

SOURCE CODE

```
import java.io.*;
import java.util.Arrays;
import java.util.StringTokenizer;

class Thinning{
   int numRows;
   int numCols;
   int minVal;
   int maxVal;
   int changeCount;
   int cycleCount;
   int[][] aryOne;
   int[][] aryTwo;

   public Thinning(int numRows, int numCols, int minVal, int maxVal){
      this.numRows = numRows;
      this.numCols = numCols;
      this.minVal = minVal;
      this.maxVal = maxVal;
      this.changeCount = 0;
      this.cycleCount = 0;
      this.aryOne = new int[numRows + 2][numCols + 2];
      this.aryTwo = new int[numRows + 2][numCols + 2];
   }

   public void loadImage(BufferedReader inFile, int[][] aryOne) throws IOException {
      for(int i = 1; i < aryOne.length - 1; i++){
         String currentLine = inFile.readLine();
         StringTokenizer currentLineTokenizer = new StringTokenizer(currentLine);
         for(int j = 1; j < aryOne[i].length - 1; j++){
            if(currentLineTokenizer.hasMoreTokens()){
               aryOne[i][j] = Integer.parseInt(currentLineTokenizer.nextToken());
            }
         }
      }
   }

   public void prettyDotPrint(int[][] aryOne, BufferedWriter outFile1) throws IOException {
      for(int i = 0; i < aryOne.length; i++){
         for(int j = 0; j < aryOne[i].length; j++){
            if(aryOne[i][j] == 0){
               outFile1.write(".");
            } else if (aryOne[i][j] == 1) {
               outFile1.write("1");
            }
            outFile1.write(" ");
         }
         outFile1.write("\n");
      }
   }

   public void copyArys(int[][] aryOne, int[][] aryTwo){
      for(int i = 0; i < aryOne.length; i++){
         for(int j = 0; j < aryOne[i].length; j++){
            aryOne[i][j] = aryTwo[i][j];
         }
      }
   }

   public void thinning(int[][] aryOne, int[][] aryTwo, BufferedWriter logFile) throws IOException{
      logFile.write("Entering thinning() before thinning 4 sides, aryOne is below.\n");
      prettyDotPrint(aryOne, logFile);
      changeCount = 0;

      directionalThinning("north", aryOne, aryTwo, logFile);
      logFile.write("after northThinning(); aryTwo is below: ");
      prettyDotPrint(aryTwo, logFile);
      copyArys(aryOne, aryTwo);

      directionalThinning("south", aryOne, aryTwo, logFile);
      logFile.write("after southThinning(); aryTwo is below: ");
      prettyDotPrint(aryTwo, logFile);
      copyArys(aryOne, aryTwo);

      directionalThinning("west", aryOne, aryTwo, logFile);
      logFile.write("after westThinning(); aryTwo is below: ");
```

```
    prettyDotPrint(aryTwo, logFile);
    copyArys(aryOne, aryTwo);

    directionalThinning("east", aryOne, aryTwo, logFile);
    logFile.write("after eastThinning(); aryTwo is below: ");
    prettyDotPrint(aryTwo, logFile);
    copyArys(aryOne, aryTwo);

    logFile.write("Leaving thinning(); "
                  + "cycleCount = " + cycleCount
                  + "changeCount = " + changeCount
              );
}

public void directionalThinning(String direction, int[][] aryOne, int[][] aryTwo, BufferedWriter logFile) throws IOException{
    int iOffset = 0;
    int jOffset = 0;
    switch (direction){
        case "north":
            iOffset = -1;
            jOffset = 0;
            break;
        case "south":
            iOffset = 1;
            jOffset = 0;
            break;
        case "west":
            iOffset = 0;
            jOffset = -1;
            break;
        case "east":
            iOffset = 0;
            jOffset = 1;
            break;
    }
    logFile.write("Entering " + direction + "Thinning(); cycleCount = " + cycleCount + " changeCount = " + changeCount + "\n");
    int i = 1;
    while(i < numRows + 2){
        int j = 1;
        while(j < (numCols + 2)){
            if(aryOne[i][j] > 0 && aryOne[i + iOffset][j + jOffset] == 0){
                int nonZeroCount = countNonZeroNeighbors(aryOne, i, j);
                boolean flag = checkConnector(aryOne, i, j);
                logFile.write(  "In "
                        + direction + "Thinning();"
                        + "i = " + i
                        + " j = " + j
                        + " nonZeroCount = " + nonZeroCount
                        + " Flag = " + flag
                        + "\n");
                if(nonZeroCount >= 4 && !flag){
                    aryTwo[i][j] = 0;
                    prettyDotPrint(aryTwo, logFile);
                    changeCount++;
                } else {
                    aryTwo[i][j] = aryOne[i][j];
                }
            }
            j++;
        }
        i++;
    }
    logFile.write("Leaving " + direction + "Thinning();"
                  + "cycleCount = " + cycleCount
                  + "changeCount = " + changeCount
                  + "\n");
}

public int countNonZeroNeighbors(int[][] ary, int i, int j){
    int count = 0;
    for(int r = i-1; r < i+2; r++){
        for(int c = j-1; c < j+2; c++){
            if(r==i && c==j) {
                continue;
            }
            else if (ary[r][c] != 0) {
                count++;
            }
        }
    }
    return count;
```

```
    }

    public boolean checkConnector(int[][] ary, int i , int j){
        if( (ary[i-1][j] == 0 && ary[i+1][j] == 0)
                || (ary[i][j-1] == 0 && ary[i][j+1] == 0)
                || (ary[i-1][j] == 0 && ary[i][j-1] == 0 && ary[i-1][j-1] == 1)
                || (ary[i-1][j] == 0 && ary[i][j+1] == 0 && ary[i+1][j+1] == 1)
                || (ary[i][j-1] == 0 && ary[i+1][j] == 0 && ary[i+1][j-1] == 1)
                || (ary[i+1][j] == 0 && ary[i][j+1] == 0 && ary[i+1][j+1] == 1)
        ){
            return true;
        }
        else{
            return false;
        }
    }

    @Override
    public String toString() {
        return "Thinning{" +
                "numRows=" + numRows +
                ", numCols=" + numCols +
                ", minVal=" + minVal +
                ", maxVal=" + maxVal +
                ", changeCount=" + changeCount +
                ", cycleCount=" + cycleCount +
                '}';
    }
}

public class YournetF_Project7_Main {
    public static void main(String[] args) throws IOException {

        BufferedReader inFile = null;
        try{
            inFile = new BufferedReader(new FileReader(args[0]));
        } catch (FileNotFoundException e) {
            System.out.println("Unable to read file: " + args[0]);
        }

        BufferedWriter outFile1 = null;
        try{
            outFile1 = new BufferedWriter(new FileWriter(args[1]));
        } catch (IOException e) {
            throw new RuntimeException(e);
        }

        BufferedWriter logFile = null;
        try{
            logFile = new BufferedWriter(new FileWriter(args[2]));
        } catch (IOException e) {
            throw new RuntimeException(e);
        }

        //Attempts to read the header of the inFile.
        String inFileHeader = null;
        try {
            assert inFile != null;
            inFileHeader = inFile.readLine();
        } catch (IOException e) {
            throw new RuntimeException(e);
        }

        //Checks the header and assigns the proper values to the Thinning class.
        StringTokenizer inFileTokenizer = new StringTokenizer(inFileHeader);
        int numRows = Integer.parseInt(inFileTokenizer.nextToken());
        int numCols = Integer.parseInt(inFileTokenizer.nextToken());
        int minVal = Integer.parseInt(inFileTokenizer.nextToken());
        int maxVal = Integer.parseInt(inFileTokenizer.nextToken());

        //Attempts to write image header to the outFile1.txt
        try {
            outFile1.write("input image header\n");
            outFile1.write(numRows + " " + numCols + " " + minVal + " " + maxVal + "\n");
        } catch (IOException e) {
            throw new RuntimeException(e);
        }

        //Creates an instance of thinning and uses constructor to initialize attributes.
        Thinning thinning = new Thinning(numRows, numCols, minVal, maxVal);
```

```
    //Loads image into from inFile into aryOne.
    thinning.loadImage(inFile, thinning.aryOne);
    thinning.copyArys(thinning.aryTwo, thinning.aryOne);
    try{
       outFile1.write( "In main(), before thinning, changeCount = " + thinning.changeCount
                     + "; cycleCount = " + thinning.cycleCount
                     + "\n");
    } catch (RuntimeException e) {
       throw new RuntimeException(e);
    }

    thinning.prettyDotPrint(thinning.aryOne, outFile1);

    thinning.changeCount = 1;
    while(thinning.changeCount > 0){
       thinning.thinning(thinning.aryOne, thinning.aryTwo, logFile);

       thinning.cycleCount++;

       try{
          outFile1.write("In main(), inside iteration; "
                + "changeCount = " + thinning.changeCount
                + "cycleCount = " + thinning.cycleCount
                + "\n"
          );
       } catch (RuntimeException e) {
          throw new RuntimeException(e);
       }

       thinning.prettyDotPrint(thinning.aryOne, outFile1);
    }

    outFile1.write("In main(), the final skeleton; "
                + " changeCount = " + thinning.changeCount
                + " cycleCount = " + thinning.cycleCount
                + "\n"
              );

    thinning.prettyDotPrint(thinning.aryOne, outFile1);

    //Attempts to close the files that were opened for reading/writing.
    try {
       inFile.close();
    } catch (IOException e) {
       throw new RuntimeException(e);
    }
    try {
       outFile1.close();
    } catch (IOException e) {
       throw new RuntimeException(e);
    }
    try {
       logFile.close();
    } catch (IOException e) {
       throw new RuntimeException(e);
    }
  }
}
```

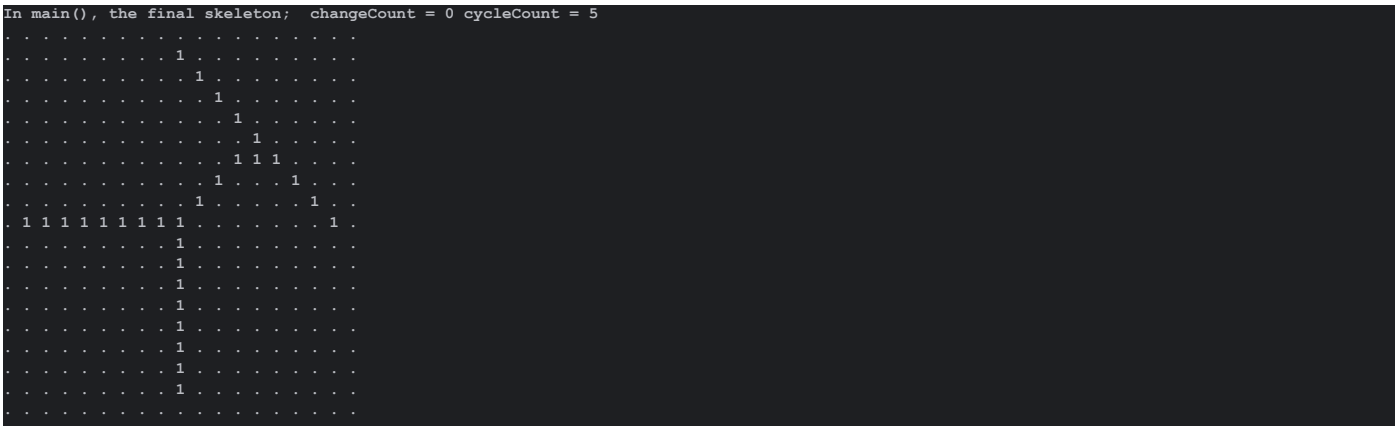
DATA 1

```
17 17 0 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 1 1 1 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 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 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 1 1 1 1 1 0 0
0 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
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 1 1 1 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 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 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 0
0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0
```

OUTFILE 1

```
input image header
17 17 0 1
In main(), before thinning, changeCount = 0; cycleCount = 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 1 1 1 1 1 1 1 . . . . . .
. . . . . 1 1 1 1 1 1 1 1 . . . . . .
. . . . . 1 1 1 1 1 1 1 . . . . . .
. . . . . 1 1 1 1 1 . . . . . .
. . . . . 1 . . . . . .
. . . . . .
In main(), inside iteration; changeCount = 40cycleCount = 1
. . . . . .
. . . . . 1 . . . . . .
. . . . . 1 . . . . . .
. . . . . 1 1 1 . . . . . .
. . . . . 1 1 1 1 1 . . . . . .
. . . . . 1 1 1 1 1 1 1 . . . . . .
. . . . . 1 1 1 1 1 1 1 1 1 . . . . .
. . . . . 1 1 1 1 1 1 1 1 1 1 1 . . .
. . . . 1 1 1 1 1 1 1 1 1 1 1 1 1 . .
. 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 .
. . . . 1 1 1 1 1 1 1 1 1 1 1 1 . . . .
. . . . . 1 1 1 1 1 1 1 1 1 1 . . . . .
. . . . . 1 1 1 1 1 1 1 1 1 . . . . . .
. . . . . 1 1 1 1 1 1 1 . . . . . .
. . . . . 1 1 1 . . . . . .
. . . . . 1 . . . . . .
. . . . . 1 . . . . . .
. . . . . 1 . . . . . .
. . . . . .
```

```
In main(), inside iteration; changeCount = 33cycleCount = 2
. . . . . . . . . . . . . . . . . . . .
. . . . . . . . . 1 . . . . . . . . . .
. . . . . . . . . . 1 . . . . . . . . .
. . . . . . . . . . . 1 . . . . . . . .
. . . . . . . . . . 1 1 1 . . . . . . .
. . . . . . . . . 1 1 1 1 1 . . . . . .
. . . . . . . . 1 1 1 1 1 1 1 . . . . .
. . . . . . . 1 1 1 1 1 1 1 1 1 . . . .
. . . . . 1 1 1 1 1 1 1 1 1 1 1 1 . . .
. 1 1 1 1 1 1 1 1 1 1 1 1 1 1 . . . 1 .
. . . . . 1 1 1 1 1 1 1 1 . . . . . . .
. . . . . . . 1 1 1 1 1 . . . . . . . .
. . . . . . . . 1 1 1 . . . . . . . . .
. . . . . . . . . 1 . . . . . . . . . .
. . . . . . . . . 1 . . . . . . . . . .
. . . . . . . . . 1 . . . . . . . . . .
. . . . . . . . . 1 . . . . . . . . . .
. . . . . . . . . 1 . . . . . . . . . .
. . . . . . . . . . . . . . . . . . . .
In main(), inside iteration; changeCount = 25cycleCount = 3
. . . . . . . . . . . . . . . . . . . .
. . . . . . . . . 1 . . . . . . . . . .
. . . . . . . . . . 1 . . . . . . . . .
. . . . . . . . . . . 1 . . . . . . . .
. . . . . . . . . . . . 1 . . . . . . .
. . . . . . . . . . . 1 1 1 . . . . . .
. . . . . . . . . . 1 1 1 1 1 . . . . .
. . . . . . . . . 1 1 1 1 1 1 1 . . . .
. . . . . . . . 1 1 1 1 1 . . . 1 . . .
. 1 1 1 1 1 1 1 1 1 1 1 . . . . . 1 .
. . . . . . . . 1 1 1 . . . . . . . . .
. . . . . . . . . 1 . . . . . . . . . .
. . . . . . . . . 1 . . . . . . . . . .
. . . . . . . . . 1 . . . . . . . . . .
. . . . . . . . . 1 . . . . . . . . . .
. . . . . . . . . 1 . . . . . . . . . .
. . . . . . . . . 1 . . . . . . . . . .
. . . . . . . . . 1 . . . . . . . . . .
. . . . . . . . . . . . . . . . . . . .
In main(), inside iteration; changeCount = 17cycleCount = 4
. . . . . . . . . . . . . . . . . . . .
. . . . . . . . . 1 . . . . . . . . . .
. . . . . . . . . . 1 . . . . . . . . .
. . . . . . . . . . . 1 . . . . . . . .
. . . . . . . . . . . . 1 . . . . . . .
. . . . . . . . . . . . . 1 . . . . . .
. . . . . . . . . . . . 1 1 1 . . . . .
. . . . . . . . . . . 1 . . . 1 . . . .
. . . . . . . . . . 1 . . . . . 1 . . .
. 1 1 1 1 1 1 1 1 1 . . . . . . . . 1 .
. . . . . . . . . . 1 . . . . . . . . .
. . . . . . . . . 1 . . . . . . . . . .
. . . . . . . . . 1 . . . . . . . . . .
. . . . . . . . . 1 . . . . . . . . . .
. . . . . . . . . 1 . . . . . . . . . .
. . . . . . . . . 1 . . . . . . . . . .
. . . . . . . . . 1 . . . . . . . . . .
. . . . . . . . . 1 . . . . . . . . . .
. . . . . . . . . . . . . . . . . . . .
In main(), inside iteration; changeCount = 0cycleCount = 5
. . . . . . . . . . . . . . . . . . . .
. . . . . . . . . 1 . . . . . . . . . .
. . . . . . . . . . 1 . . . . . . . . .
. . . . . . . . . . . 1 . . . . . . . .
. . . . . . . . . . . . 1 . . . . . . .
. . . . . . . . . . . . . 1 . . . . . .
. . . . . . . . . . . . 1 1 1 . . . . .
. . . . . . . . . . . 1 . . . 1 . . . .
. . . . . . . . . . 1 . . . . . 1 . . .
. 1 1 1 1 1 1 1 1 1 . . . . . . . . 1 .
. . . . . . . . . . 1 . . . . . . . . .
. . . . . . . . . 1 . . . . . . . . . .
. . . . . . . . . 1 . . . . . . . . . .
. . . . . . . . . 1 . . . . . . . . . .
. . . . . . . . . 1 . . . . . . . . . .
. . . . . . . . . 1 . . . . . . . . . .
. . . . . . . . . 1 . . . . . . . . . .
. . . . . . . . . 1 . . . . . . . . . .
. . . . . . . . . . . . . . . . . . . .
```



LOGFILE 1

```
Entering thinning() before thinning 4 sides, aryOne is below.
. . . . . . . . . . . . . . . . . . . . .
. . . . . . . . . 1 . . . . . . . . . . .
. . . . . . . . . 1 1 1 . . . . . . . . .
. . . . . . . 1 1 1 1 1 . . . . . . . . .
. . . . . . 1 1 1 1 1 1 1 . . . . . . . .
. . . . . 1 1 1 1 1 1 1 1 1 . . . . . . .
. . . . 1 1 1 1 1 1 1 1 1 1 1 . . . . . .
. . . 1 1 1 1 1 1 1 1 1 1 1 1 1 . . . . .
. . 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 . . . .
. 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 . . .
. . 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 . . . .
. . . 1 1 1 1 1 1 1 1 1 1 1 1 1 . . . . .
. . . . 1 1 1 1 1 1 1 1 1 1 1 . . . . . .
. . . . . 1 1 1 1 1 1 1 1 1 . . . . . . .
. . . . . . 1 1 1 1 1 1 1 . . . . . . . .
. . . . . . . 1 1 1 1 1 . . . . . . . . .
. . . . . . . . 1 1 1 . . . . . . . . . .
. . . . . . . . . 1 . . . . . . . . . . .
. . . . . . . . . . . . . . . . . . . . .
Entering northThinning(); cycleCount = 0 changeCount = 0
In northThinning();i = 1 j = 9 nonZeroCount = 3 Flag = true
In northThinning();i = 2 j = 8 nonZeroCount = 5 Flag = false
. . . . . . . . . . . . . . . . . . . . .
. . . . . . . . . 1 . . . . . . . . . . .
. . . . . . . . . 1 1 . . . . . . . . . .
. . . . . . . 1 1 1 1 1 . . . . . . . . .
. . . . . . 1 1 1 1 1 1 1 . . . . . . . .
. . . . . 1 1 1 1 1 1 1 1 1 . . . . . . .
. . . . 1 1 1 1 1 1 1 1 1 1 1 . . . . . .
. . . 1 1 1 1 1 1 1 1 1 1 1 1 1 . . . . .
. . 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 . . . .
. 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 . . .
. . 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 . . . .
. . . 1 1 1 1 1 1 1 1 1 1 1 1 1 . . . . .
```

```
. . . . 1 1 1 1 1 1 1 1 1 1 1 . . . .
. . . . . 1 1 1 1 1 1 1 1 1 . . . . .
. . . . . 1 1 1 1 1 1 1 1 . . . . . .
. . . . . 1 1 1 1 1 . . . . . .
. . . . . 1 1 1 . . . . . .
. . . . . 1 . . . . . .
. . . . . .
In northThinning();i = 2 j = 10 nonZeroCount = 5 Flag = true
In northThinning();i = 3 j = 7 nonZeroCount = 5 Flag = false
. . . . . .
. . . . . 1 . . . . . .
. . . . . 1 1 . . . . . .
. . . . . 1 1 1 1 . . . . . .
. . . . . 1 1 1 1 1 1 1 . . . . . .
. . . . . 1 1 1 1 1 1 1 1 1 1 1 . . . . .
. . . . 1 1 1 1 1 1 1 1 1 1 1 1 1 . . . .
. . . 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 . . .
. . 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 . .
. 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 .
. . 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 . .
. . . 1 1 1 1 1 1 1 1 1 1 1 1 1 . . .
. . . . 1 1 1 1 1 1 1 1 1 1 1 . . . .
. . . . . 1 1 1 1 1 1 1 1 1 . . . . .
. . . . . 1 1 1 1 1 1 1 . . . . . .
. . . . . 1 1 1 1 1 . . . . . .
. . . . . 1 1 1 . . . . . .
. . . . . 1 . . . . . .
. . . . . .
In northThinning();i = 3 j = 11 nonZeroCount = 5 Flag = true
In northThinning();i = 4 j = 6 nonZeroCount = 5 Flag = false
. . . . . .
. . . . . 1 . . . . . .
. . . . . 1 1 . . . . . .
. . . . . 1 1 1 1 . . . . . .
. . . . . 1 1 1 1 1 1 1 . . . . . .
. . . . 1 1 1 1 1 1 1 1 1 1 1 . . . . .
. . . . 1 1 1 1 1 1 1 1 1 1 1 1 1 . . . .
. . . 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 . . .
. . 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 . .
. 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 .
. . 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 . .
. . . 1 1 1 1 1 1 1 1 1 1 1 1 1 . . .
. . . . 1 1 1 1 1 1 1 1 1 1 1 . . . .
. . . . . 1 1 1 1 1 1 1 1 1 . . . . .
. . . . . 1 1 1 1 1 1 1 . . . . . .
. . . . . 1 1 1 1 1 . . . . . .
. . . . . 1 1 1 . . . . . .
. . . . . 1 . . . . . .
. . . . . .
```

```
In northThinning();i = 4 j = 12 nonZeroCount = 5 Flag = true
In northThinning();i = 5 j = 5 nonZeroCount = 5 Flag = false
. . . . . .
. . . . . 1 . . . . . .
. . . . . 1 1 . . . . . .
. . . . . 1 1 1 1 . . . . . .
. . . . . 1 1 1 1 1 1 . . . . . .
. . . . . 1 1 1 1 1 1 1 1 . . . . . .
. . . . 1 1 1 1 1 1 1 1 1 1 1 . . . . .
. . . 1 1 1 1 1 1 1 1 1 1 1 1 1 . . .
. . 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 . .
. 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 .
. . 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 . .
. . . 1 1 1 1 1 1 1 1 1 1 1 1 1 . . .
. . . . 1 1 1 1 1 1 1 1 1 1 1 . . . .
. . . . . 1 1 1 1 1 1 1 1 1 1 . . . . .
. . . . . 1 1 1 1 1 1 1 1 . . . . . .
. . . . . 1 1 1 1 1 . . . . . .
. . . . . 1 1 1 . . . . . .
. . . . . 1 . . . . . .
. . . . . .
In northThinning();i = 5 j = 13 nonZeroCount = 5 Flag = true
In northThinning();i = 6 j = 4 nonZeroCount = 5 Flag = false
. . . . . .
. . . . . 1 . . . . . .
. . . . . 1 1 . . . . . .
. . . . . 1 1 1 1 . . . . . .
. . . . . 1 1 1 1 1 1 . . . . . .
. . . . . 1 1 1 1 1 1 1 1 . . . . . .
. . . . 1 1 1 1 1 1 1 1 1 1 1 . . . .
. . . 1 1 1 1 1 1 1 1 1 1 1 1 1 . . .
. . 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 . .
. 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 .
. . 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 . .
. . . 1 1 1 1 1 1 1 1 1 1 1 1 1 . . .
. . . . 1 1 1 1 1 1 1 1 1 1 1 . . . .
. . . . . 1 1 1 1 1 1 1 1 1 . . . . .
. . . . . 1 1 1 1 1 1 1 1 . . . . . .
. . . . . 1 1 1 1 1 . . . . . .
. . . . . 1 1 1 . . . . . .
. . . . . 1 . . . . . .
. . . . . .
```

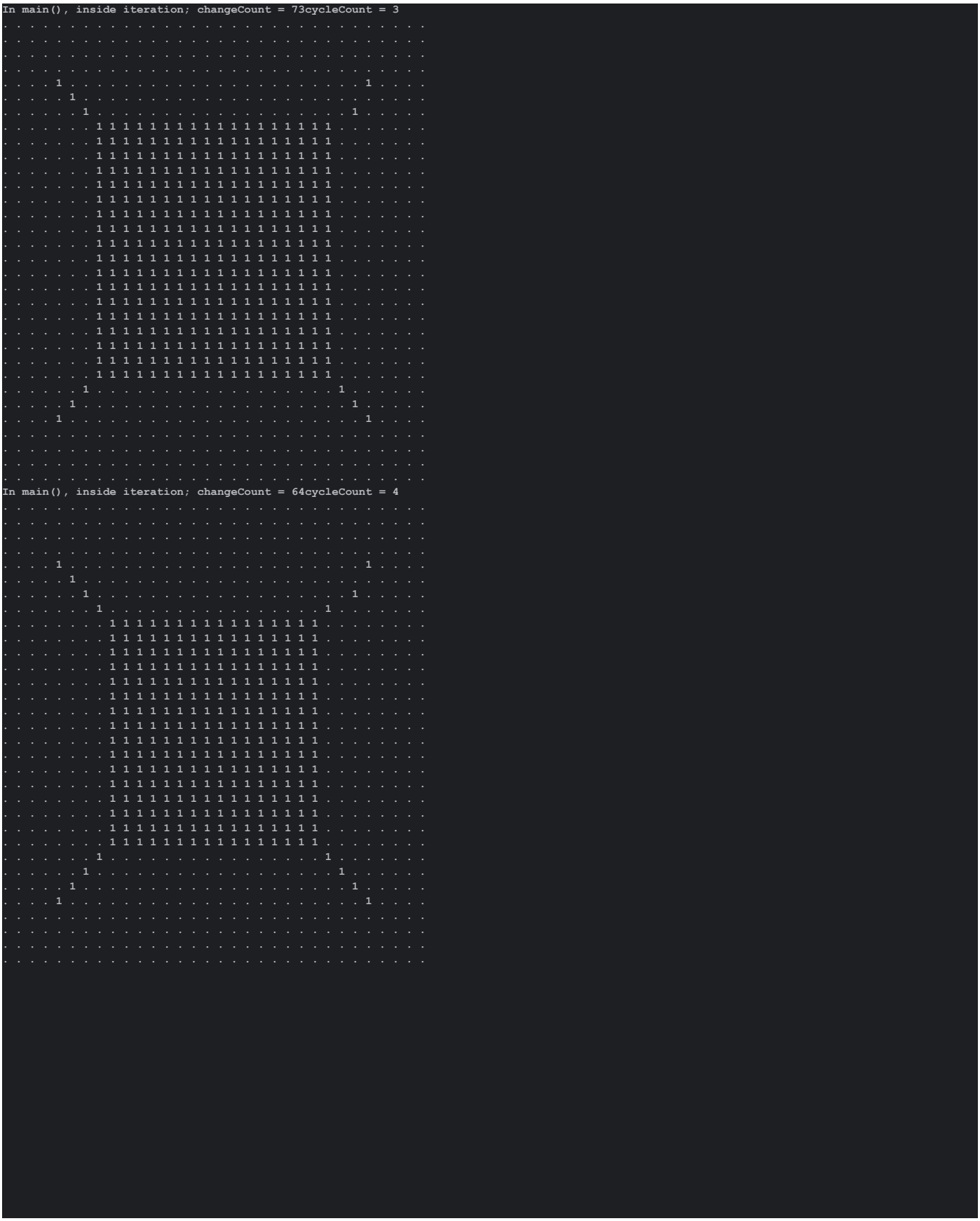
DATA 2

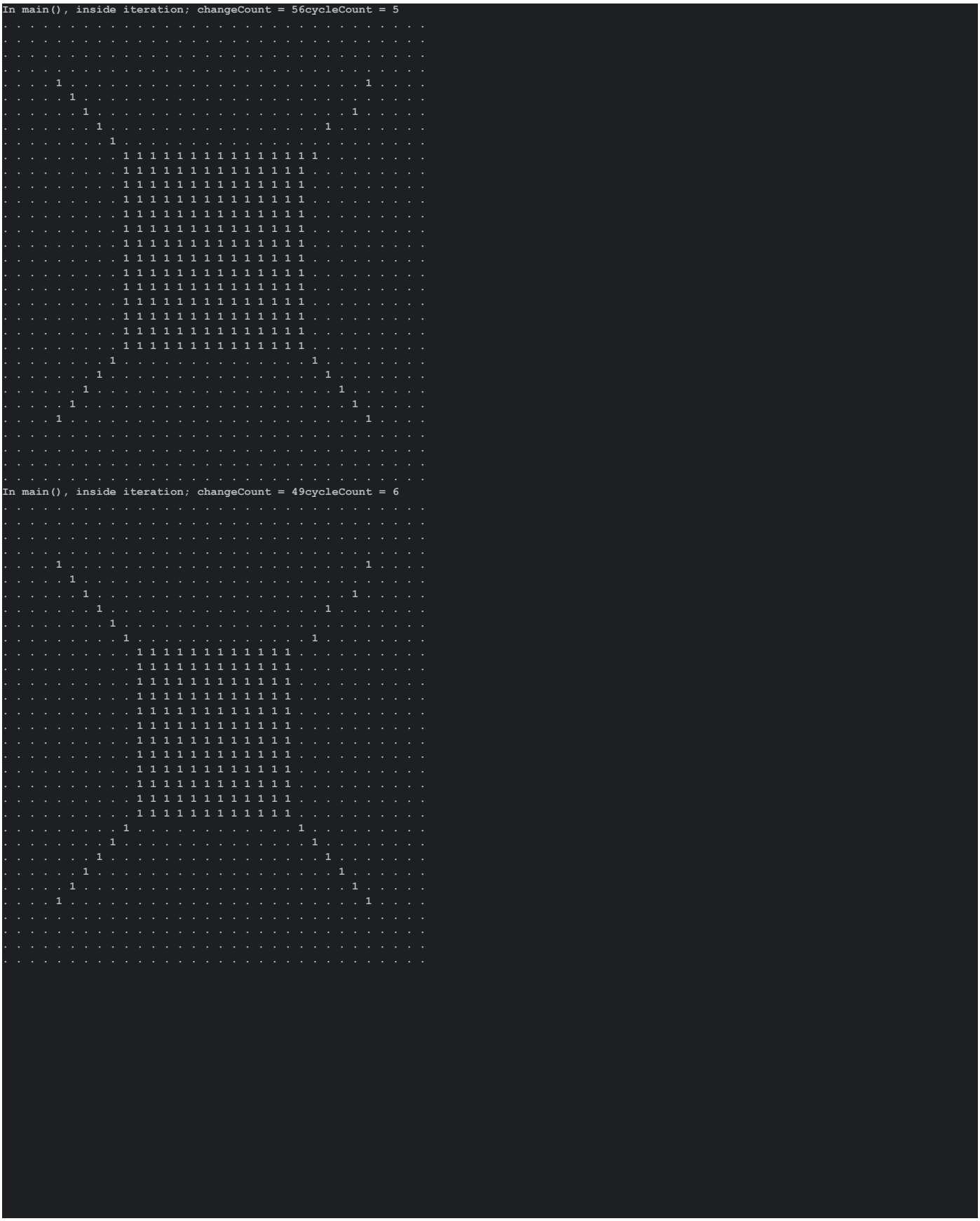
```
30 30 0 1
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 0 0
0 0 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 0 0
0 0 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
```

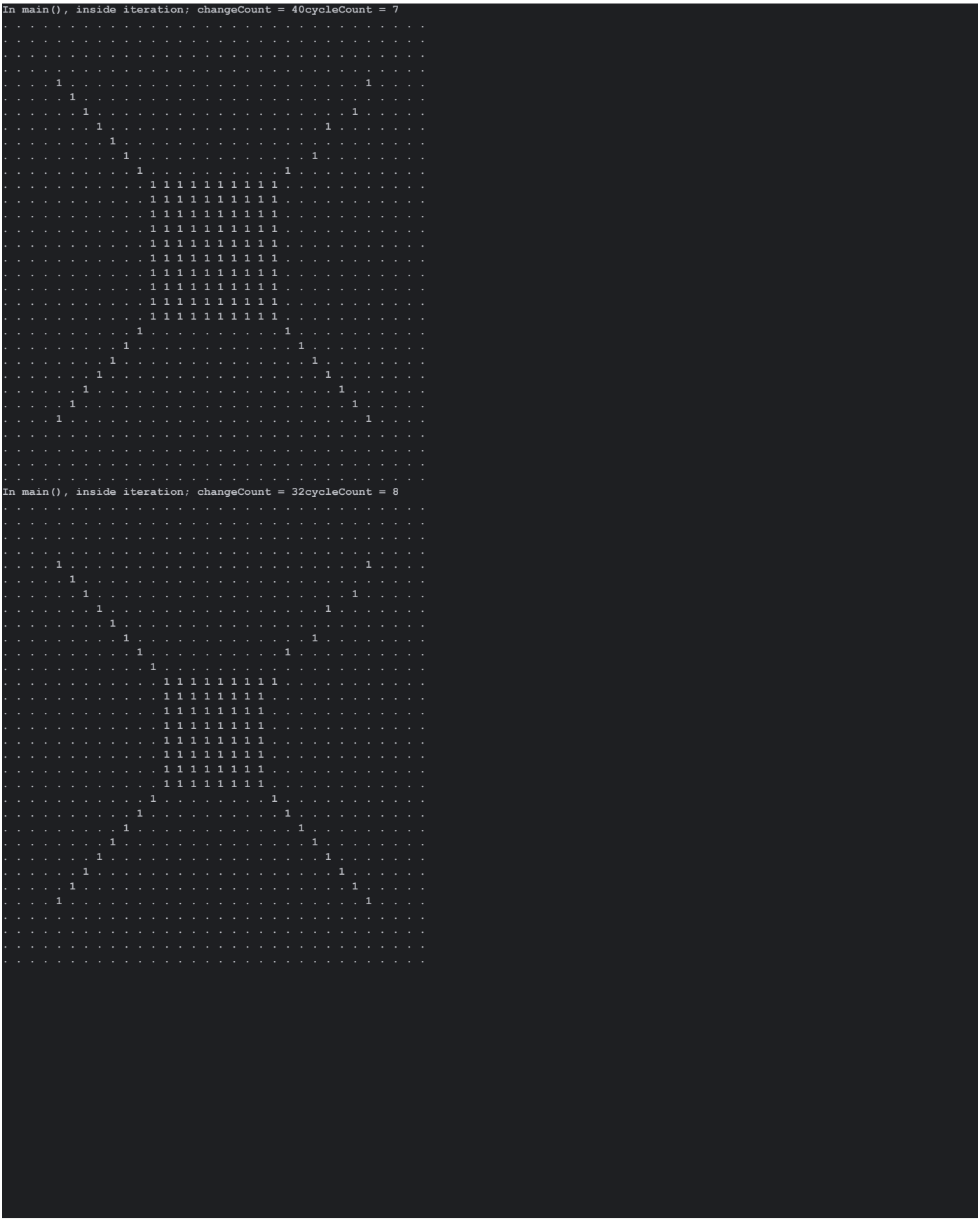
OUTFILE 2

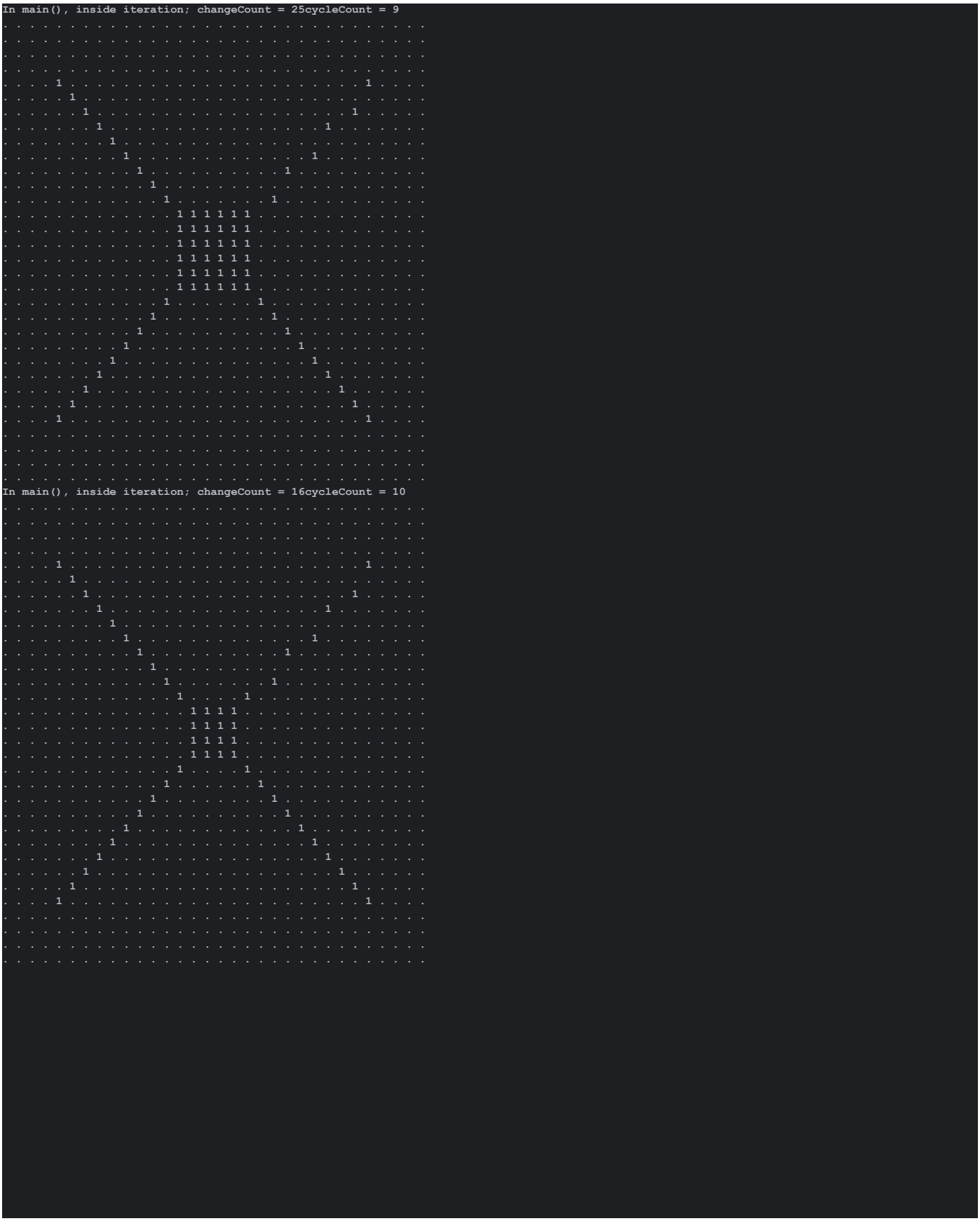
```
input image header
30 30 0 1
In main(), before thinning, changeCount = 0; cycleCount = 0
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
. . . . 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 . . . .
. . . . 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 . . . .
. . . . 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 . . . .
. . . . 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 . . . .
. . . . 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 . . . .
. . . . 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 . . . .
. . . . 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 . . . .
. . . . 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 . . . .
. . . . 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 . . . .
. . . . 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 . . . .
. . . . 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 . . . .
. . . . 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 . . . .
. . . . 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 . . . .
. . . . 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 . . . .
. . . . 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 . . . .
. . . . 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 . . . .
. . . . 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 . . . .
. . . . 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 . . . .
. . . . 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 . . . .
. . . . 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 . . . .
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
```

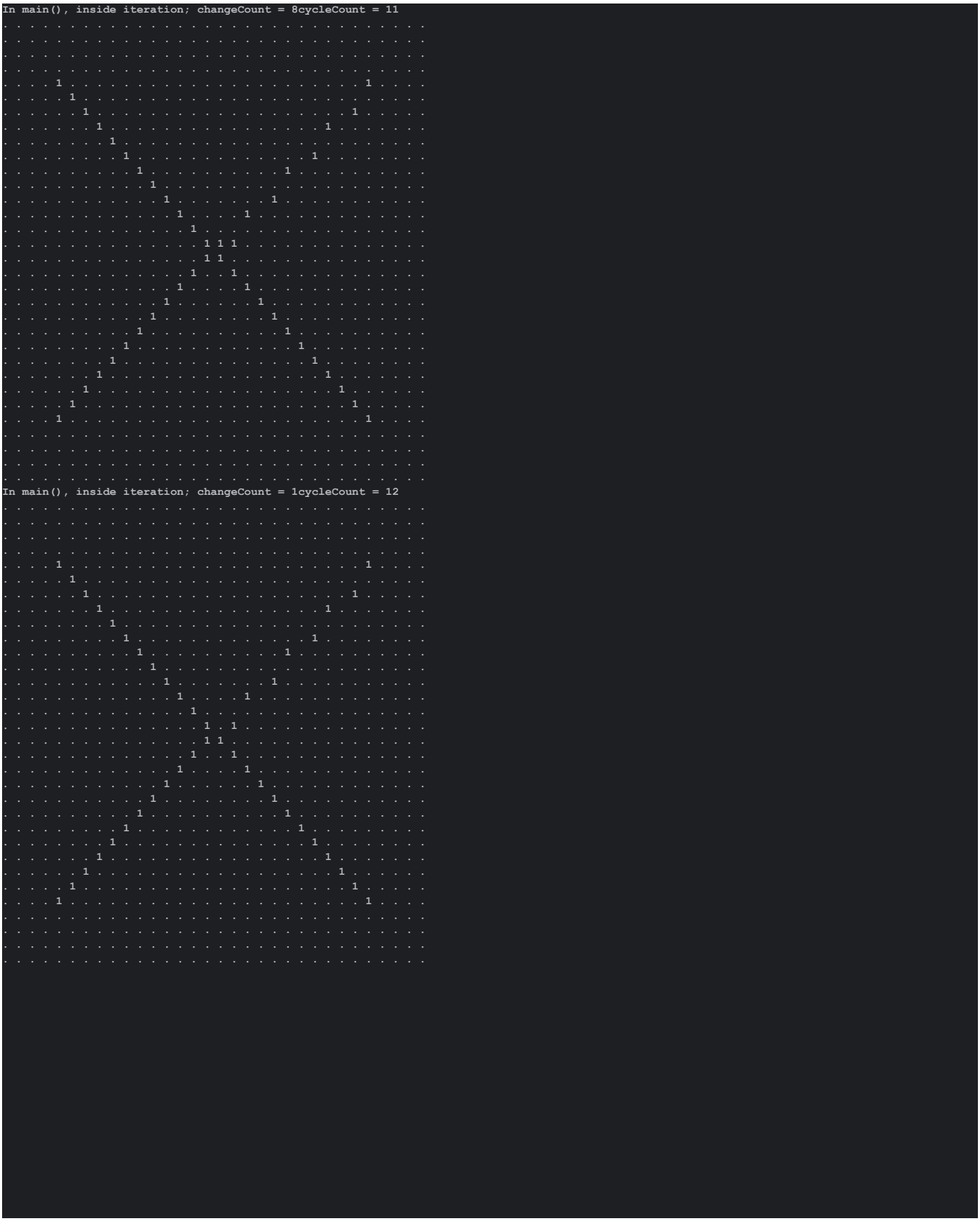
```
In main(), inside iteration; changeCount = 88cycleCount = 1
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
. . . . 1 . . . . . . . . . . . . . . . . . . . . . . 1 . . . .
. . . . . 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 . . . . .
. . . . . 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 . . . . .
. . . . . 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 . . . . .
. . . . . 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 . . . . .
. . . . . 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 . . . . .
. . . . . 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 . . . . .
. . . . . 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 . . . . .
. . . . . 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 . . . . .
. . . . . 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 . . . . .
. . . . . 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 . . . . .
. . . . . 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 . . . . .
. . . . . 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 . . . . .
. . . . . 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 . . . . .
. . . . . 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 . . . . .
. . . . . 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 . . . . .
. . . . . 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 . . . . .
. . . . . 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 . . . . .
. . . . . 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 . . . . .
. . . . . 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 . . . . .
. . . . . 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 . . . . .
. . . . . 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 . . . . .
. . . . . 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 . . . . .
. . . . 1 . . . . . . . . . . . . . . . . . . . . . . 1 . . . .
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
In main(), inside iteration; changeCount = 80cycleCount = 2
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
. . . . 1 . . . . . . . . . . . . . . . . . . . . . . 1 . . . .
. . . . . 1 . . . . . . . . . . . . . . . . . . . . . . . . . .
. . . . . . 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 . . . . .
. . . . . . 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 . . . . . .
. . . . . . 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 . . . . . .
. . . . . . 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 . . . . . .
. . . . . . 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 . . . . . .
. . . . . . 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 . . . . . .
. . . . . . 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 . . . . . .
. . . . . . 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 . . . . . .
. . . . . . 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 . . . . . .
. . . . . . 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 . . . . . .
. . . . . . 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 . . . . . .
. . . . . . 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 . . . . . .
. . . . . . 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 . . . . . .
. . . . . . 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 . . . . . .
. . . . . . 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 . . . . . .
. . . . . . 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 . . . . . .
. . . . . . 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 . . . . . .
. . . . . . 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 . . . . . .
. . . . . . 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 . . . . . .
. . . . . . 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 . . . . . .
. . . . . 1 . . . . . . . . . . . . . . . . . . . . 1 . . . . .
. . . . 1 . . . . . . . . . . . . . . . . . . . . . . 1 . . . .
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
```

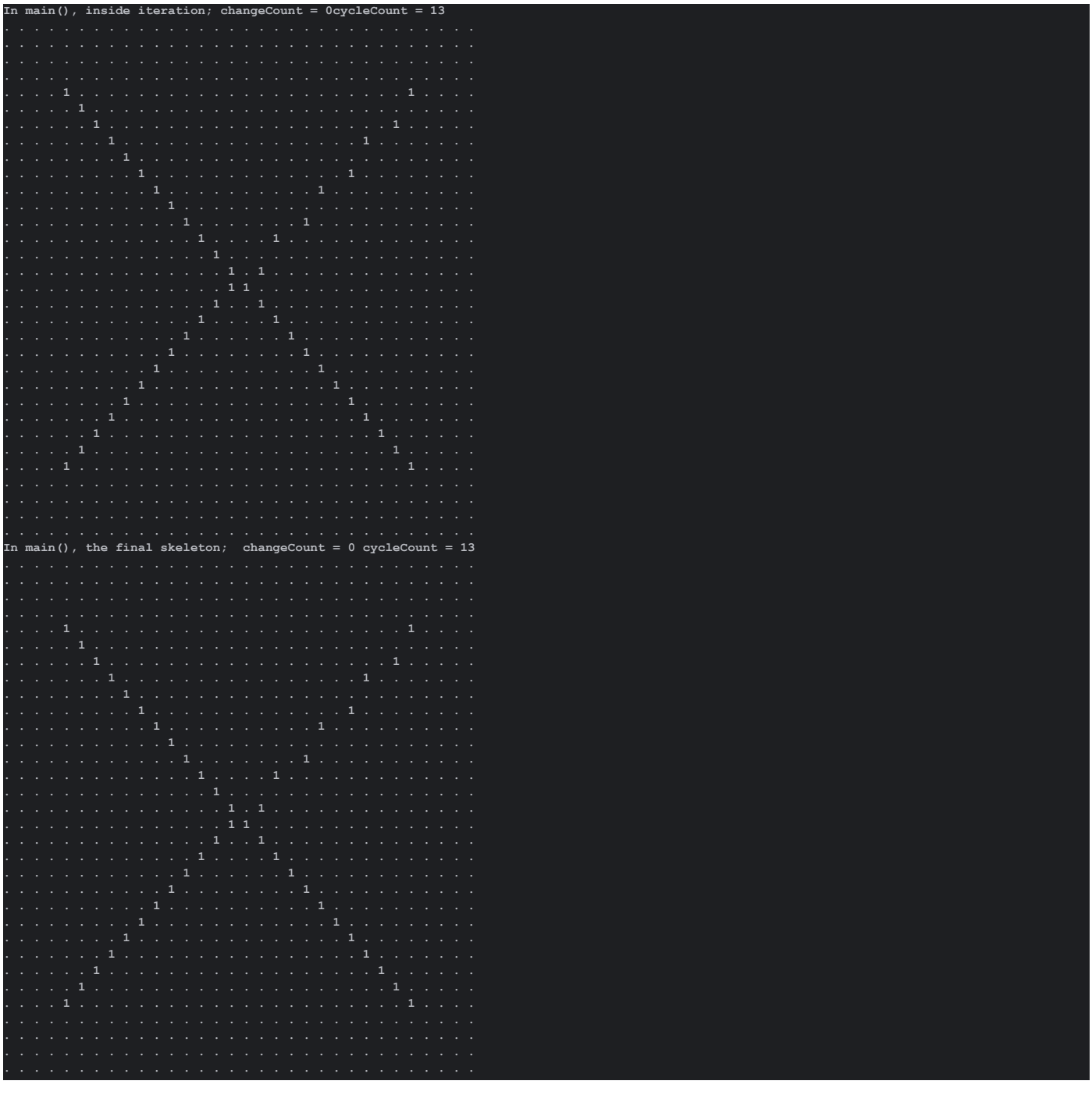

In main(), inside iteration; changeCount = 73cycleCount = 3
In main(), inside iteration; changeCount = 64cycleCount = 4


In main(), inside iteration; changeCount = 56cycleCount = 5
In main(), inside iteration; changeCount = 49cycleCount = 6


In main(), inside iteration; changeCount = 40cycleCount = 7
In main(), inside iteration; changeCount = 32cycleCount = 8


In main(), inside iteration; changeCount = 25cycleCount = 9
In main(), inside iteration; changeCount = 16cycleCount = 10


In main(), inside iteration; changeCount = 8cycleCount = 11
In main(), inside iteration; changeCount = 1cycleCount = 12


In main(), inside iteration; changeCount = 0cycleCount = 13
In main(), the final skeleton; changeCount = 0 cycleCount = 13

LOGFILE 2

```
Entering thinning() before thinning 4 sides, aryOne is below.
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
. . . . 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 . . . .
. . . . 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 . . . .
. . . . 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 . . . .
. . . . 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 . . . .
. . . . 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 . . . .
. . . . 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 . . . .
. . . . 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 . . . .
. . . . 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 . . . .
. . . . 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 . . . .
. . . . 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 . . . .
. . . . 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 . . . .
. . . . 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 . . . .
. . . . 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 . . . .
. . . . 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 . . . .
. . . . 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 . . . .
. . . . 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 . . . .
. . . . 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 . . . .
. . . . 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 . . . .
. . . . 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 . . . .
. . . . 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 . . . .
. . . . 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 . . . .
. . . . 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 . . . .
. . . . 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 . . . .
. . . . 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 . . . .
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
Entering northThinning(); cycleCount = 0 changeCount = 0
In northThinning();i = 4 j = 4 nonZeroCount = 3 Flag = false
In northThinning();i = 4 j = 5 nonZeroCount = 5 Flag = false
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
. . . . 1 . 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 . . . .
. . . . 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 . . . .
. . . . 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 . . . .
. . . . 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 . . . .
. . . . 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 . . . .
. . . . 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 . . . .
. . . . 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 . . . .
. . . . 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 . . . .
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. . . . 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 . . . .
. . . . 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 . . . .
. . . . 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 . . . .
. . . . 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 . . . .
. . . . 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 . . . .
. . . . 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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In northThinning();i = 4 j = 6 nonZeroCount = 5 Flag = false
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In northThinning();i = 4 j = 7 nonZeroCount = 5 Flag = false
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DATA 3

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31 31 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
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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
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OUTFILE 3

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input image header
31 31 0 1
In main(), before thinning, changeCount = 0; cycleCount = 0
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
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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 . . . . . .
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. . . . . . . . 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 . . . . . . . .
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. . . . . . . . . . . . . . . 1 1 1 . . . . . . . . . . . . . . .
. . . . . . . . . . . . . . 1 1 1 1 1 . . . . . . . . . . . . . .
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. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
```
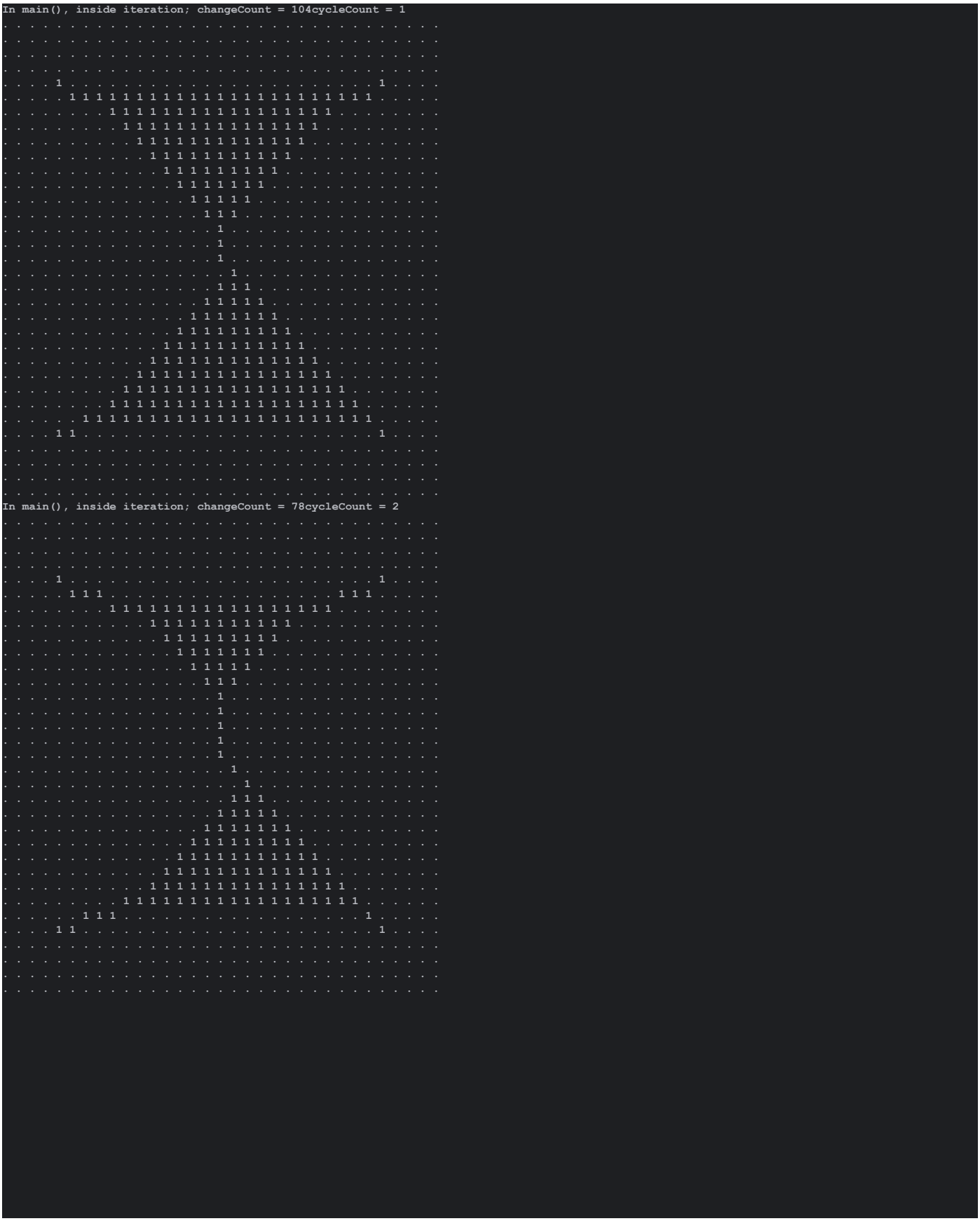
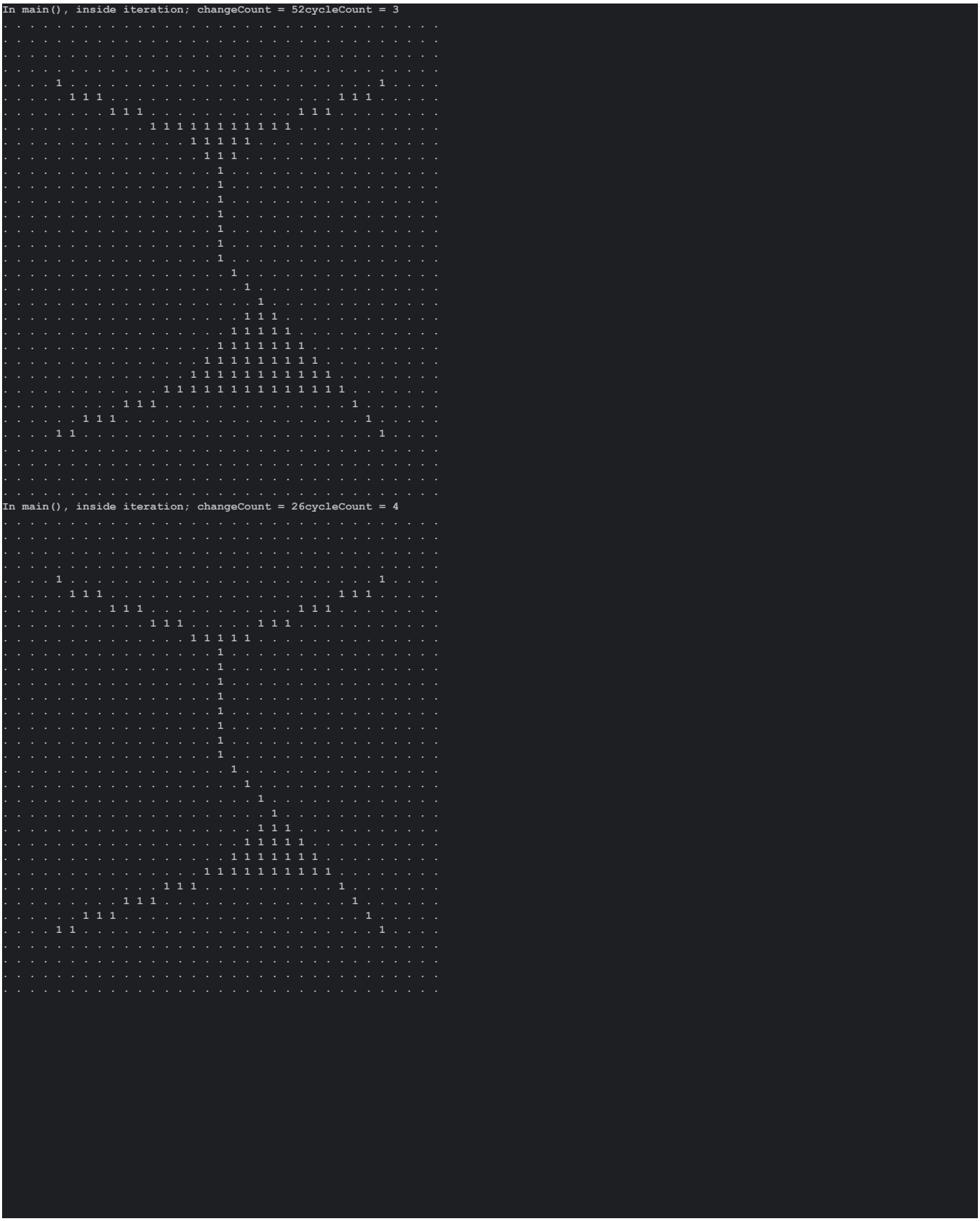
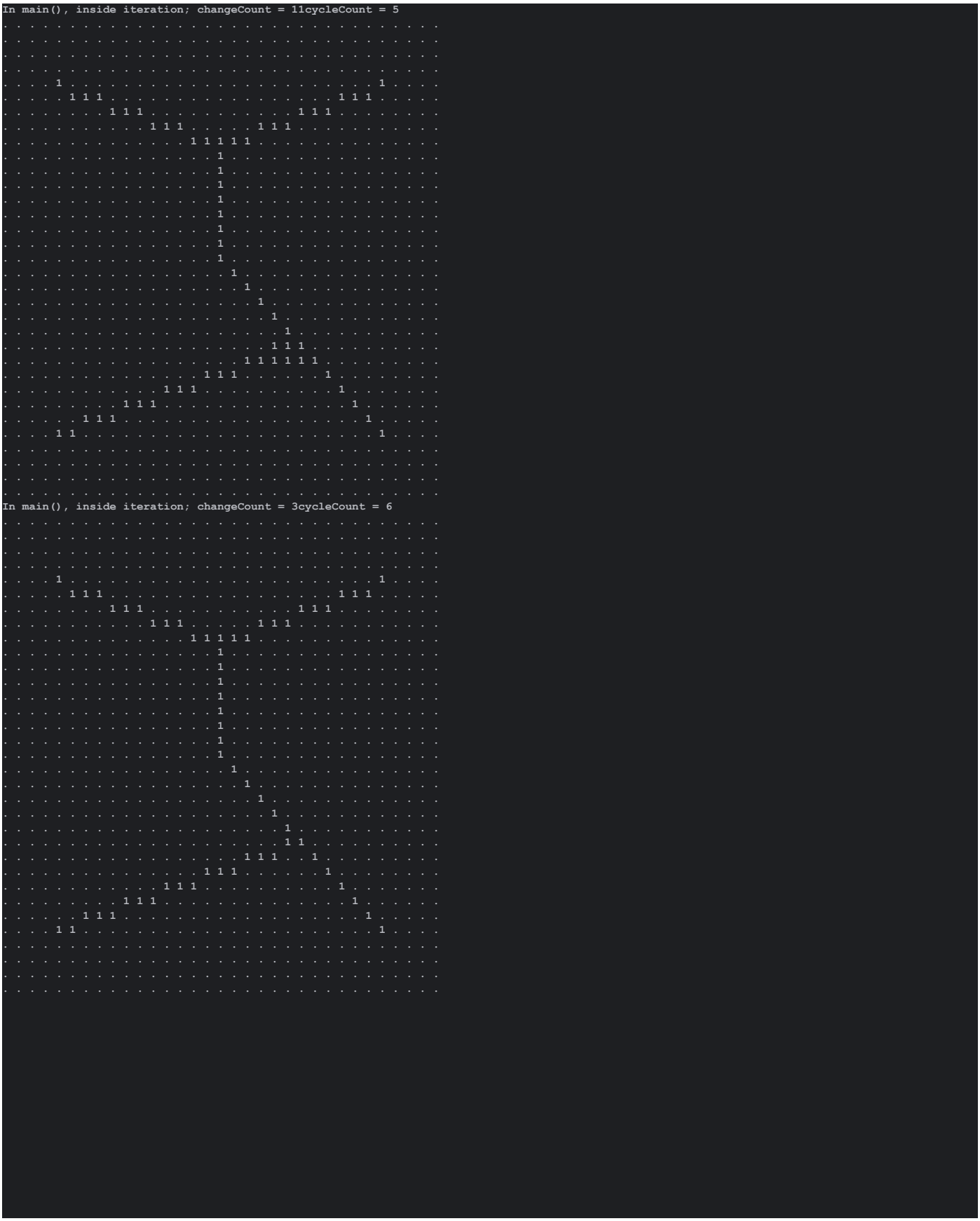


In main(), inside iteration; changeCount = 104cycleCount = 1
In main(), inside iteration; changeCount = 78cycleCount = 2


In main(), inside iteration; changeCount = 52cycleCount = 3
In main(), inside iteration; changeCount = 26cycleCount = 4


In main(), inside iteration; changeCount = 11cycleCount = 5
In main(), inside iteration; changeCount = 3cycleCount = 6

```
In main(), inside iteration; changeCount = 0cycleCount = 7
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. . . . . .
. . . . . .
. . . . 1 . . . . . 1 . . . .
. . . . . 1 1 1 . . . . . 1 1 1 . . . . . .
. . . . . 1 1 1 . . . . . 1 1 1 . . . . . .
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. . . . . 1 1 1 1 1 . . . . . .
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. . . . . 1 . . . . . .
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. . . . . 1 1 . . . . . .
. . . . . 1 1 1 . . 1 . . . . . .
. . . . . 1 1 1 . . . . . 1 . . . . . .
. . . . . 1 1 1 . . . . . 1 . . . . . .
. . . . . 1 1 1 . . . . . 1 . . . . . .
. . . . . 1 1 1 . . . . . 1 . . . . . .
. . . . 1 1 . . . . . 1 . . . .
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In main(), the final skeleton;  changeCount = 0 cycleCount = 7
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. . . . 1 . . . . . 1 . . . .
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. . . . . 1 . . . . . .
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. . . . . 1 1 1 . . . . . 1 . . . . . .
. . . . . 1 1 1 . . . . . 1 . . . . . .
. . . . . 1 1 1 . . . . . 1 . . . . . .
. . . . . 1 1 1 . . . . . 1 . . . . . .
. . . . 1 1 . . . . . 1 . . . .
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. . . . . .
. . . . . .
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LOGFILE 3

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Entering thinning() before thinning 4 sides, aryOne is below.
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
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. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
Entering northThinning(); cycleCount = 0 changeCount = 0
In northThinning();i = 4 j = 4 nonZeroCount = 2 Flag = true
In northThinning();i = 4 j = 5 nonZeroCount = 4 Flag = false
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
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. . . . . . . . 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 . . . . . . . .
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. . . . . . . . . . 1 1 1 1 1 1 1 1 1 1 1 1 1 . . . . . . . . . .
```
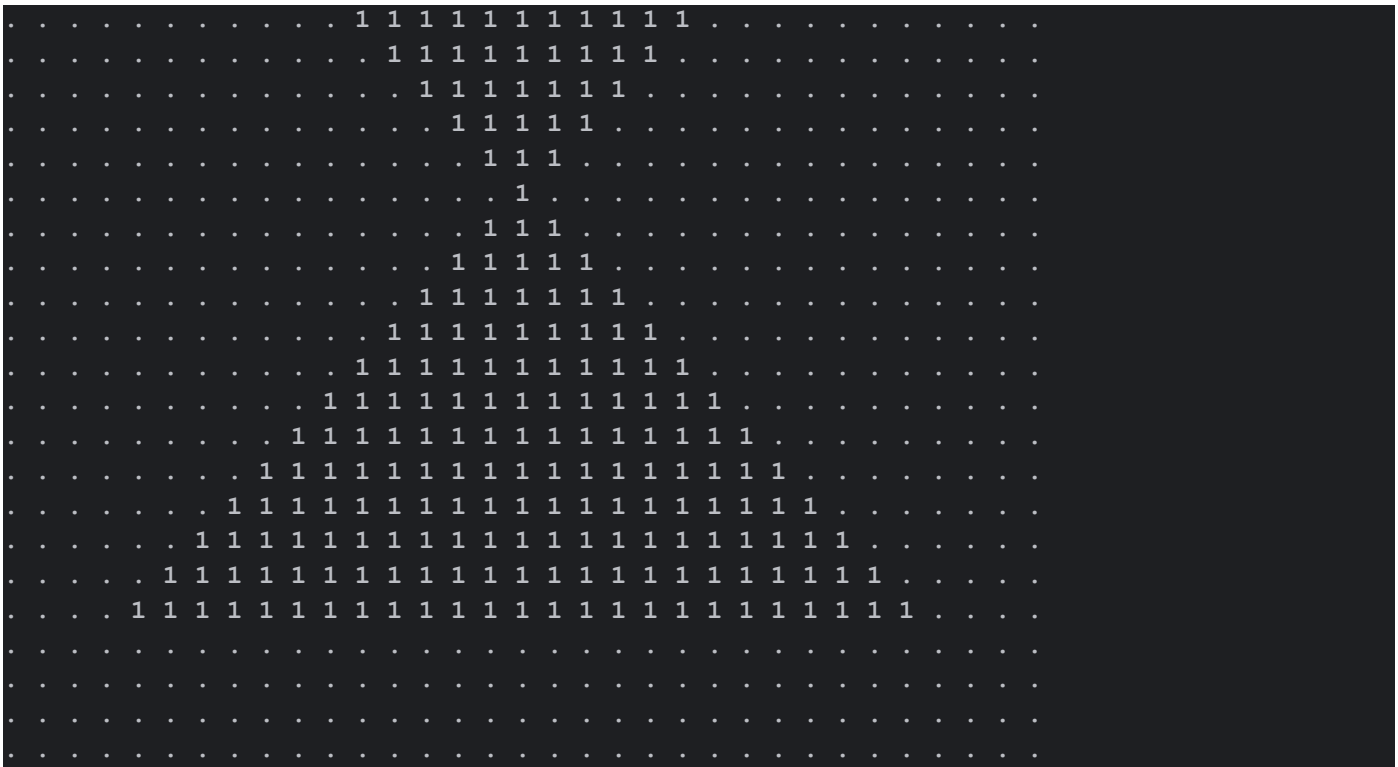
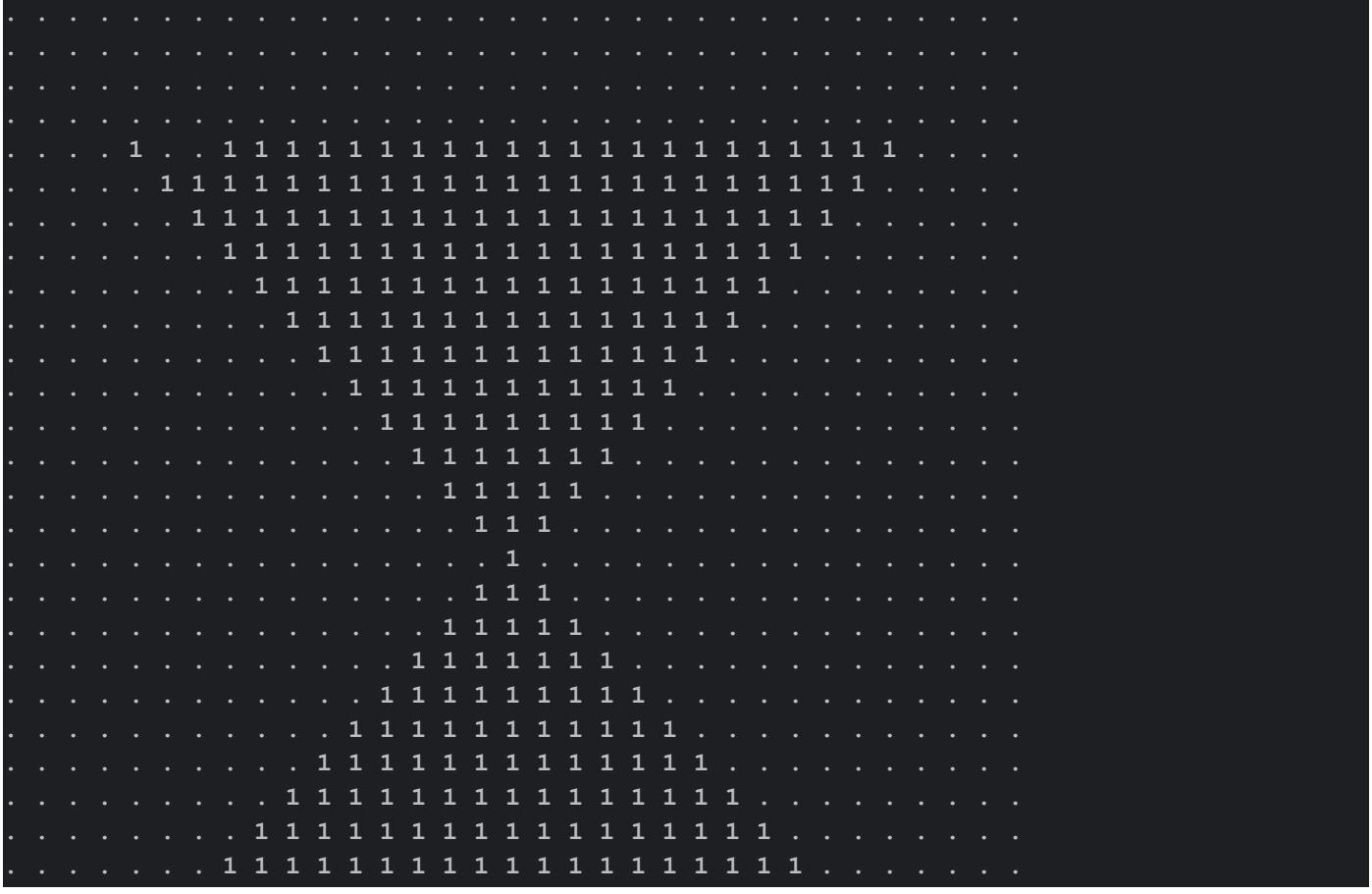
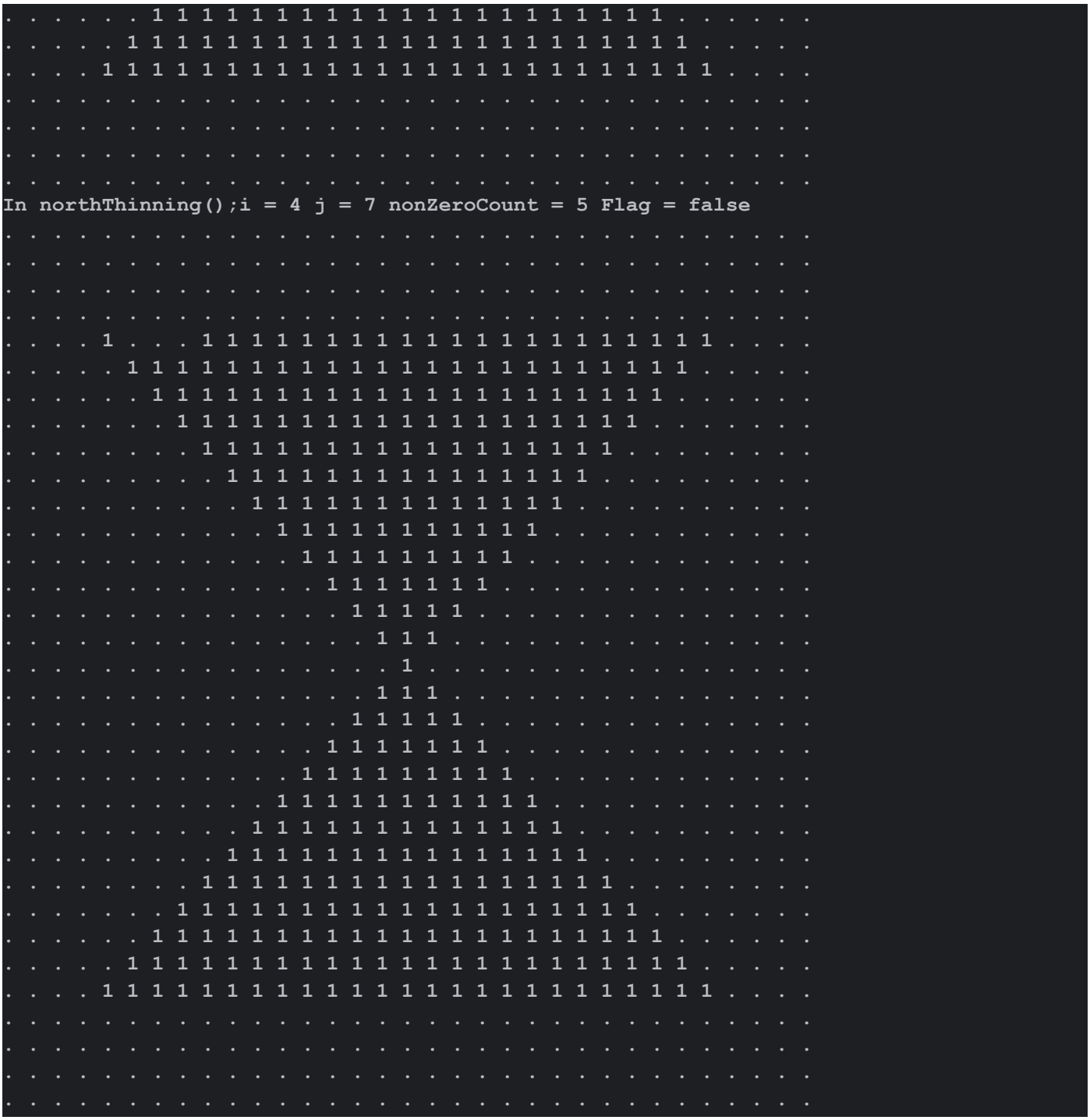



In northThinning();i = 4 j = 6 nonZeroCount = 5 Flag = false




In northThinning();i = 4 j = 7 nonZeroCount = 5 Flag = false

DATA 4

```
20 40 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 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 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 1 1 1 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 1 1 1 1 1 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 0 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 0 0 0 0 0 0 1 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 1 1 1 0 0 0 0 0 0 1 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 0 0 1 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 1 1 1 1 1 1 0 0 0 0 0 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 0 0 0 1 1 1 1 1 1 0 0 0 0 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 1 1 1 1 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 0 0 0 0 0 0
0 0 0 0 1 1 1 1 1 1 1 0 1 1 1 1 1 1 1 1 0 0 0 0 0 0 0 0 0 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 1 1 0 0 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 1 1 0 0 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 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 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 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 0 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 1 1 1 1 1 1 1 1 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 1 1 0 0 0 0 0 0 1 1 1 0 0 0 1 1 0 0 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 0 0 0 0 0 1 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
```

OUTFILE 4

```
input image header
20 40 0 1
In main(), before thinning, changeCount = 0; cycleCount = 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 1 1 1 . . . . . .
. . . . . 1 1 1 1 1 1 . . . 1 1 1 1 1 1 . . . . . . . . 1 1 1 1 1 1 1 . . . . . . .
. . . . . 1 1 1 1 1 1 1 . 1 1 1 1 1 1 1 1 . . . . . . . . . 1 1 1 . . . . . . . . .
. . . . . 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 . . 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 . . .
. . . . . 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 . . . 1 1 1 1 1 1 1 1 1 1 1 1 1 . . . .
. . . . . 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 . . . . 1 1 1 1 1 1 1 1 1 1 1 . . . . .
. . . . . . 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 . . . 1 1 1 1 1 1 1 1 1 1 . . . . . . .
. . . . . . . 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 . 1 1 1 1 1 . . . . . . . .
. . . . . . . . 1 1 1 1 1 . . . 1 1 1 1 1 1 1 1 1 1 1 1 . . 1 1 1 . . . . . . . . .
. . . . . . . . . . 1 1 . . . . . . 1 1 1 . . . 1 1 . . . . . 1 . . . . . . . . . .
. . . . . . . . . . 1 . . . . . . . . 1 . . . . . 1 . . . . . . . . . . . . . . . .
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
In main(), inside iteration; changeCount = 128cycleCount = 1
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
. . . . . . . . 1 . . . . . . . . . . . . . . . . . . . . . . 1 . . . . . . . . . .
. . . . . . . . 1 . . . . . . . . . . . . . . . . . . . . . . . 1 . . . . . . . . .
. . . . . . . . 1 . 1 . . . . . . . . . . . . . . . . . . . . 1 1 1 . . . . . . . .
. . . . . 1 1 1 1 1 . . . . . . . . . . . . . . . . . . . . 1 1 1 1 1 . . . . . . .
. . . . . . . . . 1 . . . . . . . 1 . . . . . . . . . . . 1 1 1 1 1 1 1 . . . . . .
. . . . . . . . . 1 . . . . . . . 1 . . . . . . . . . . 1 1 1 1 1 1 1 1 1 . . . . .
. . . . . 1 . . . 1 . . . . . . . 1 . . . . . . . . 1 1 1 1 1 1 1 1 1 1 1 1 . . . .
. . . . . . 1 1 1 1 . . . . . . . . 1 . . . . . 1 1 . . 1 1 1 1 1 1 1 . . . 1 . . .
. . . . . . 1 1 1 1 . . . . . . . 1 . . . . . . . . . . . 1 1 1 1 1 . . . . . . . .
. . . . . . 1 1 1 1 . . . . . . 1 1 1 1 . . . . . . . . . . . 1 . . . . . . . . . .
. . . . . . 1 1 1 1 1 . . . . 1 1 1 1 1 . . . . . . . . . . . 1 . . . . . . . . . .
. . . . . . 1 1 1 1 1 . . . 1 1 1 1 1 1 . . . . 1 . . . . . . 1 . . . . . . 1 . . .
. . . . . . 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 . . . . 1 1 1 1 1 1 1 1 1 1 1 1 1 . . . .
. . . . . . . 1 1 1 1 1 1 1 1 1 1 1 1 1 1 . . . . . . 1 1 1 1 1 1 1 . . . . . . . .
. . . . . . . . 1 1 1 1 1 1 1 1 1 1 1 1 1 . . . . . . 1 . . 1 1 1 . . . . . . . . .
. . . . . . . . . 1 1 1 . . . . . 1 1 1 1 1 . . . . 1 1 . . . 1 . . . . . . . . . .
. . . . . . . . . . . 1 . . . . . . . 1 . . 1 1 1 1 . 1 . . . 1 . . . . . . . . . .
. . . . . . . . . . 1 . . . . . . . . 1 . . . . . 1 . . . . . 1 . . . . . . . . . .
. . . . . . . . . . 1 . . . . . . . . 1 . . . . . 1 . . . . . . . . . . . . . . . .
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
```

```
In main(), inside iteration; changeCount = 73cycleCount = 2
. . . . . .
. . . . . .
. . . . . 1 . . . . . 1 . . . . . .
. . . . . 1 . . . . . 1 . . . . . .
. . . . . 1 . 1 . . . . . 1 . . . . . .
. . . . 1 1 1 1 . . . . . 1 1 1 . . . . . .
. . . . . 1 . . . . . 1 . . . . . 1 1 1 1 1 . . . . . .
. . . . . 1 . . . . . 1 . . . . . 1 1 1 1 1 1 1 . . . . . .
. . . . 1 . . . 1 . . . . . 1 . . . . . 1 1 1 1 1 1 1 1 . . . 1 . . . .
. . . . . 1 . . 1 . . . . . 1 . . . . . 1 1 . . . . 1 1 1 . . . . . 1 . . .
. . . . . 1 1 . . . . . 1 . . . . . 1 . . . . . .
. . . . . 1 1 . . . . . 1 . 1 . . . . . 1 . . . . . .
. . . . . 1 1 . . . . . 1 1 . . . . . 1 . . . . . .
. . . . . 1 1 1 . . . . . 1 1 1 . . . . . 1 . . . . . 1 . . .
. . . . . 1 1 . . . . . 1 1 1 1 . . . . . 1 1 . . . . 1 . . 1 1 1 1 . . . .
. . . . . 1 1 1 1 1 1 1 1 1 1 1 . . . . . 1 1 1 1 1 1 1 . . . . . .
. . . . . 1 . . . . . 1 1 1 . . . . . 1 . . . 1 . . . . . .
. . . . . 1 . . . . . 1 . 1 . . . . 1 1 . . . 1 . . . . . .
. . . . . 1 . . . . . 1 . . 1 1 1 1 . 1 . . . 1 . . . . . .
. . . . . 1 . . . . . 1 . . . . . 1 . . . . . .
. . . . . 1 . . . . . 1 . . . . . .
. . . . . .
In main(), inside iteration; changeCount = 29cycleCount = 3
. . . . . .
. . . . . .
. . . . . 1 . . . . . 1 . . . . . .
. . . . . 1 . . . . . 1 . . . . . .
. . . . . 1 . 1 . . . . . 1 . . . . . .
. . . . . 1 1 1 1 . . . . . 1 . . . . . .
. . . . . 1 . . . . . 1 . . . . . 1 1 1 . . . . . .
. . . . . 1 . . . . . 1 . . . . . 1 . . . 1 . . . . . .
. . . . 1 . . . 1 . . . . . 1 . . . . . 1 1 1 1 1 1 . . . . . 1 . . . .
. . . . . 1 . . 1 . . . . . 1 . . . . . 1 1 . . . . . 1 . . . . . 1 . . .
. . . . . 1 . . . . . 1 . . . . . 1 . . . . . .
. . . . . 1 . . . . . 1 . 1 . . . . . 1 . . . . . .
. . . . . 1 . . . . . 1 . . . . . 1 . . . . . .
. . . . . 1 . . . . . 1 . . . . . 1 . . . . . 1 . . .
. . . . . 1 . . . . . 1 1 1 . . . . . 1 1 . . . . 1 . . 1 1 1 1 . . . .
. . . . . 1 . 1 1 1 1 1 . . . 1 . . . . . 1 1 1 1 1 1 1 . . . . . .
. . . . . 1 . . . . . 1 . . . . . 1 . . . 1 . . . . . .
. . . . . 1 . . . . . 1 . 1 . . . . 1 1 . . . 1 . . . . . .
. . . . . 1 . . . . . 1 . . 1 1 1 1 . 1 . . . 1 . . . . . .
. . . . . 1 . . . . . 1 . . . . . 1 . . . . . .
. . . . . 1 . . . . . 1 . . . . . .
. . . . . .
In main(), inside iteration; changeCount = 0cycleCount = 4
. . . . . .
. . . . . .
. . . . . 1 . . . . . 1 . . . . . .
. . . . . 1 . . . . . 1 . . . . . .
. . . . . 1 . 1 . . . . . 1 . . . . . .
. . . . 1 1 1 1 . . . . . 1 . . . . . .
. . . . . 1 . . . . . 1 . . . . . 1 1 1 . . . . . .
. . . . . 1 . . . . . 1 . . . . . 1 . . . 1 . . . . . .
. . . . 1 . . . 1 . . . . . 1 . . . . . 1 1 1 1 1 1 . . . . . 1 . . . .
. . . . . 1 . . 1 . . . . . 1 . . . . . 1 1 . . . . . 1 . . . . . 1 . . .
. . . . . 1 . . . . . 1 . . . . . 1 . . . . . .
. . . . . 1 . . . . . 1 . 1 . . . . . 1 . . . . . .
. . . . . 1 . . . . . 1 . . . . . 1 . . . . . .
. . . . . 1 . . . . . 1 . . . . . 1 . . . . . 1 . . .
. . . . . 1 . . . . . 1 1 1 . . . . . 1 1 . . . . 1 . . 1 1 1 1 . . . .
. . . . . 1 . 1 1 1 1 1 . . . 1 . . . . . 1 1 1 1 1 1 1 . . . . . .
. . . . . 1 . . . . . 1 . . . . . 1 . . . 1 . . . . . .
. . . . . 1 . . . . . 1 . 1 . . . . 1 1 . . . 1 . . . . . .
. . . . . 1 . . . . . 1 . . 1 1 1 1 . 1 . . . 1 . . . . . .
. . . . . 1 . . . . . 1 . . . . . 1 . . . . . .
. . . . . 1 . . . . . 1 . . . . . .
. . . . . .
```


In main(), the final skeleton; changeCount = 0 cycleCount = 4

LOGFILE 4

```
Entering thinning() before thinning 4 sides, aryOne is below.
. . . . . .
. . . . . .
. . . . . 1 . . . . . 1 . . . . . .
. . . . . 1 . . . . . 1 1 1 . . . . . .
. . . . . 1 1 1 1 1 . . . . . 1 1 1 1 1 . . . . . .
. . . . . 1 1 1 1 1 1 . . . . . 1 1 1 1 1 1 1 . . . . . .
. . . . . 1 1 1 1 1 . . . . . 1 . . . . . 1 1 1 1 1 1 1 1 1 . . . . . .
. . . . . 1 1 1 . . . . . 1 . . . . . 1 1 1 1 1 1 1 1 1 1 1 . . . . .
. . . . . 1 1 1 1 1 1 . . . . . 1 . . . . . 1 1 1 1 1 1 1 1 1 1 1 1 . . . .
. . . . . 1 1 1 1 1 1 . . . . . 1 1 1 . . . . . 1 1 1 1 1 1 1 1 1 1 1 1 1 . . .
. . . . . 1 1 1 1 1 1 . . . . 1 1 1 1 1 . . . . . 1 1 1 1 1 1 1 1 1 . . . . . .
. . . . . 1 1 1 1 1 1 . . . 1 1 1 1 1 1 . . . . . 1 1 1 1 1 1 1 . . . . . .
. . . . . 1 1 1 1 1 1 1 . 1 1 1 1 1 1 1 1 . . . . . 1 1 1 . . . . . .
. . . . . 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 . . 1 1 1 1 1 1 1 1 1 1 1 1 1 1 . . .
. . . . . 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 . . . 1 1 1 1 1 1 1 1 1 1 1 1 1 . . . .
. . . . . 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 . . . . 1 1 1 1 1 1 1 1 1 1 1 1 . . . . .
. . . . . 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 . . . 1 1 1 1 1 1 1 1 1 1 1 1 . . . . . .
. . . . . 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 . . . . . .
. . . . . 1 1 1 1 1 1 . . . 1 1 1 1 1 1 1 1 1 1 1 1 1 1 . . 1 1 1 1 . . . . . .
. . . . . 1 1 . . . . . 1 1 1 . . . 1 1 . . . . . 1 . . . . . .
. . . . . 1 . . . . . 1 . . . . . 1 . . . . . .
. . . . . .
Entering northThinning(); cycleCount = 0 changeCount = 0
In northThinning();i = 2 j = 8 nonZeroCount = 1 Flag = true
In northThinning();i = 2 j = 31 nonZeroCount = 3 Flag = true
In northThinning();i = 3 j = 30 nonZeroCount = 5 Flag = false
. . . . . .
. . . . . .
. . . . . 1 . . . . . 1 . . . . . .
. . . . . 1 . . . . . 1 1 . . . . . .
. . . . . 1 1 1 1 1 . . . . . 1 1 1 1 1 . . . . . .
. . . . . 1 1 1 1 1 1 1 . . . . . 1 1 1 1 1 1 1 . . . . . .
. . . . . 1 1 1 1 1 1 . . . . . 1 . . . . . 1 1 1 1 1 1 1 1 1 . . . . . .
. . . . . 1 1 1 . . . . . 1 . . . . . 1 1 1 1 1 1 1 1 1 1 1 . . . . .
. . . . . 1 1 1 1 1 1 . . . . . 1 . . . . . 1 1 1 1 1 1 1 1 1 1 1 1 . . . .
. . . . . 1 1 1 1 1 1 . . . . . 1 1 1 . . . . . 1 1 1 1 1 1 1 1 1 1 1 1 1 . . .
. . . . . 1 1 1 1 1 1 . . . . 1 1 1 1 1 . . . . . 1 1 1 1 1 1 1 1 1 . . . . . .
. . . . . 1 1 1 1 1 1 . . . 1 1 1 1 1 1 . . . . . 1 1 1 1 1 1 1 . . . . . .
. . . . . 1 1 1 1 1 1 1 . 1 1 1 1 1 1 1 1 . . . . . 1 1 1 . . . . . .
. . . . . 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 . . 1 1 1 1 1 1 1 1 1 1 1 1 1 1 . . .
. . . . . 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 . . . 1 1 1 1 1 1 1 1 1 1 1 1 . . . .
. . . . . 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 . . . . 1 1 1 1 1 1 1 1 1 1 1 . . . . .
. . . . . 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 . . . 1 1 1 1 1 1 1 1 1 1 1 . . . . . .
. . . . . 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 . . . . . .
. . . . . 1 1 1 1 1 1 . . . 1 1 1 1 1 1 1 1 1 1 1 1 1 1 . . 1 1 1 1 . . . . . .
. . . . . 1 1 . . . . . 1 1 1 . . . 1 1 . . . . . 1 . . . . . .
```


In northThinning();i = 3 j = 32 nonZeroCount = 5 Flag = true
In northThinning();i = 4 j = 6 nonZeroCount = 4 Flag = false
In northThinning();i = 4 j = 7 nonZeroCount = 6 Flag = false

```
In northThinning();i = 4 j = 9 nonZeroCount = 6 Flag = false
. . . . . .
. . . . . .
. . . . . 1 . . . . . 1 . . . . . .
. . . . . 1 . . . . . 1 1 . . . . . .
. . . . . 1 . 1 . . . . . 1 1 1 1 1 . . . . . .
. . . . . 1 1 1 1 1 1 . . . . . 1 1 1 1 1 1 1 . . . . . .
. . . . . 1 1 1 1 1 1 . . . . . 1 . . . . . 1 1 1 1 1 1 1 1 1 . . . . . .
. . . . . 1 1 1 . . . . . 1 . . . . . 1 1 1 1 1 1 1 1 1 1 1 . . . . .
. . . . . 1 1 1 1 1 1 . . . . . 1 . . . . . 1 1 1 1 1 1 1 1 1 1 1 1 . . . .
. . . . . 1 1 1 1 1 1 . . . . . 1 1 1 . . . . . 1 1 1 1 1 1 1 1 1 1 1 1 1 . . .
. . . . . 1 1 1 1 1 1 . . . . 1 1 1 1 1 . . . . . 1 1 1 1 1 1 1 1 1 1 1 . . . . . .
. . . . . 1 1 1 1 1 1 . . . 1 1 1 1 1 1 . . . . . 1 1 1 1 1 1 1 1 . . . . . .
. . . . . 1 1 1 1 1 1 1 . 1 1 1 1 1 1 1 1 . . . . . 1 1 1 . . . . . .
. . . . . 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 . . 1 1 1 1 1 1 1 1 1 1 1 1 1 1 . . .
. . . . . 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 . . . 1 1 1 1 1 1 1 1 1 1 1 1 1 . . . .
. . . . . 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 . . . . 1 1 1 1 1 1 1 1 1 1 1 . . . . .
. . . . . 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 . . . 1 1 1 1 1 1 1 1 1 1 1 . . . . . .
. . . . . 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 . 1 1 1 1 1 . . . . . .
. . . . . 1 1 1 1 1 . . . 1 1 1 1 1 1 1 1 1 1 1 1 . . 1 1 1 . . . . . .
. . . . . 1 1 . . . . . 1 1 1 . . . 1 1 . . . . . 1 . . . . . .
. . . . . 1 . . . . . 1 . . . . . 1 . . . . . .
. . . . . .
In northThinning();i = 4 j = 10 nonZeroCount = 3 Flag = false
In northThinning();i = 4 j = 29 nonZeroCount = 5 Flag = false
. . . . . .
. . . . . .
. . . . . 1 . . . . . 1 . . . . . .
. . . . . 1 . . . . . 1 1 . . . . . .
. . . . . 1 . 1 . . . . . 1 1 1 1 . . . . . .
. . . . . 1 1 1 1 1 1 . . . . . 1 1 1 1 1 1 1 . . . . . .
. . . . . 1 1 1 1 1 1 . . . . . 1 . . . . . 1 1 1 1 1 1 1 1 1 . . . . . .
. . . . . 1 1 1 . . . . . 1 . . . . . 1 1 1 1 1 1 1 1 1 1 1 . . . . .
. . . . . 1 1 1 1 1 1 . . . . . 1 . . . . . 1 1 1 1 1 1 1 1 1 1 1 1 . . . .
. . . . . 1 1 1 1 1 1 . . . . . 1 1 1 . . . . . 1 1 1 1 1 1 1 1 1 1 1 1 1 . . .
. . . . . 1 1 1 1 1 1 . . . . 1 1 1 1 1 . . . . . 1 1 1 1 1 1 1 1 1 1 1 . . . . . .
. . . . . 1 1 1 1 1 1 . . . 1 1 1 1 1 1 . . . . . 1 1 1 1 1 1 1 1 . . . . . .
. . . . . 1 1 1 1 1 1 1 . 1 1 1 1 1 1 1 1 . . . . . 1 1 1 . . . . . .
. . . . . 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 . . 1 1 1 1 1 1 1 1 1 1 1 1 1 1 . . .
. . . . . 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 . . . 1 1 1 1 1 1 1 1 1 1 1 1 1 . . . .
. . . . . 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 . . . . 1 1 1 1 1 1 1 1 1 1 1 . . . . .
. . . . . 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 . . . 1 1 1 1 1 1 1 1 1 1 1 . . . . . .
. . . . . 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 . 1 1 1 1 1 . . . . . .
. . . . . 1 1 1 1 1 . . . 1 1 1 1 1 1 1 1 1 1 1 1 . . 1 1 1 . . . . . .
. . . . . 1 1 . . . . . 1 1 1 . . . 1 1 . . . . . 1 . . . . . .
. . . . . 1 . . . . . 1 . . . . . 1 . . . . . .
. . . . . .
In northThinning();i = 4 j = 33 nonZeroCount = 5 Flag = true
In northThinning();i = 5 j = 5 nonZeroCount = 3 Flag = true
17 17 0 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 1 1 1 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 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 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 1 1 1 1 1 0 0
0 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
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 1 1 1 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 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 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 0
0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0
```