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Computer Vision

Section:CSCI381-224

Project 3

Morphological operations

Due date: 3/11/24

IV. Main(...)
****
step 0: imgFile, structFile, dilateOutFile, erodeOutFile, openingOutFile, closingOutFile, prettyPrintFile open
step 1: numImgRows, numImgCols, imgMin, imgMax read from imgFile
numStructRows, numStructCols, structMin, structMax read from structFile
rowOrigin, colOrigin read from strucFile

step 2: zeroFramedAry, structAry, morphAry, tempAry dynamically allocate // see description in the above

step 3: zero2DAry(zeroFramedAry, rowSize, colSize) // see description in the above

step 4: loadImg (imgFile, zeroFramedAry) // see description in the above prettyPrint (zeroFramedAry, prettyPrintFile) // with captions, say what your are printing.

step 5: zero2DAry(structAry, numStructRows, numStructCols) loadstruct (structFile, structAry) // see description in the above prettyPrint (structAry, prettyPrintFile) // with captions.

step 6: zero2DAry(morphAry, rowSize, colSize) ComputeDilation (zeroFramedAry, morphAry) // see algorithm below AryToFile (morphAry, dilateOutFile) // see description in the above prettyPrint (morphAry, prettyPrintFile) // with captions.

step 7: zero2DAry(morphAry, rowSize, colSize) ComputeErosion (zeroFramedAry, morphAry) // see algorithm below AryToFile (morphAry, erodeOutFile) prettyPrint (morphAry, prettyPrintFile) //with captions.

step 8: zero2DAry(morphAry, rowSize, colSize) ComputeOpening (zeroFramedAry, morphAry, tempAry) // see algorithm below AryToFile (morphAry, openingOutFile) prettyPrint (morphAry, prettyPrintFile) //with captions.

step 9: zero2DAry(morphAry, rowSize, colSize) ComputeClosing (zeroFramedAry, morphAry, tempAry) // see algorithm below AryToFile (morphAry, closingOutFile) prettyPrint (morphAry, prettyPrintFile) //with captions.

step 10: close all files

Source Code:

```
#include <iostream>
#include <fstream>
#include <string>
#include <vector>

using namespace std;

class Morphology {
public:
   int numImgRows, numImgCols, imgMin, imgMax;
   int numStructRows, numStructCols, structMin, structMax, rowOrigin, colOrigin;
   vector<vector<int>> zeroFramedAry, morphAry, tempAry, structAry;

   Morphology(string imgFilePath, string structFilePath) {
      // Load image and structuring element from file
      loadImg(imgFilePath);
      loadStruct(structFilePath);
   }

   //initialize to 0.
   void initArrays(int rows, int cols) {
      zeroFramedAry.resize(rows, vector<int>(cols, 0));
      morphAry.resize(rows, vector<int>(cols, 0));
      tempAry.resize(rows, vector<int>(cols, 0));
   }

   void zero2DAry(vector<vector<int>>& Ary, int nRows, int nCols) {
      for (int i = 0; i < nRows; ++i) {
         for (int j = 0; j < nCols; ++j) {
            Ary[i][j] = 0;
         }
      }
   }



   /// load imgFile to zeroFramedAry inside of frame, begins at (rowOrigin, colOrigin)
   void loadImg(string filePath) {
      ifstream inFile(filePath);

      inFile >> numImgRows >> numImgCols >> imgMin >> imgMax;
      initArrays(numImgRows + 2, numImgCols + 2);
      for (int i = 1; i <= numImgRows; i++) {
         for (int j = 1; j <= numImgCols; j++) {
            inFile >> zeroFramedAry[i][j];
         }
```

```
        }
        inFile.close();
    }

    //load structFile to structAry
    void loadStruct(string filePath) {
        ifstream inFile(filePath);

        inFile >> numStructRows >> numStructCols >> structMin >> structMax >> rowOrigin >>
colOrigin;
        structAry.resize(numStructRows, vector<int>(numStructCols, 0));
        for (int i = 0; i < numStructRows; i++) {
            for (int j = 0; j < numStructCols; j++) {
                inFile >> structAry[i][j];
            }
        }
        inFile.close();
    }




    void ComputeDilation(vector<vector<int>>& inAry, vector<vector<int>>& outAry) {
        for (int i = 1; i <= numImgRows; i++) {
            for (int j = 1; j <= numImgCols; j++) {
                if (inAry[i][j] == 1) onePixelDilation(i, j, inAry, outAry);
            }
        }
    }

    void ComputeErosion(vector<vector<int>>& inAry, vector<vector<int>>& outAry) {
        for (int i = 1; i <= numImgRows; i++) {
            for (int j = 1; j <= numImgCols; j++) {
                onePixelErosion(i, j, inAry, outAry);
            }
        }
    }


    void ComputeOpening(vector<vector<int>>& inAry, vector<vector<int>>& outAry,
vector<vector<int>>& tmp) {
        ComputeErosion(inAry, tmp);
        ComputeDilation(tmp, outAry);
    }

    void ComputeClosing(vector<vector<int>>& inAry, vector<vector<int>>& outAry,
vector<vector<int>>& tmp) {
        ComputeDilation(inAry, tmp);
        ComputeErosion(tmp, outAry);
    }

    void onePixelDilation(int i, int j, vector<vector<int>>& inAry, vector<vector<int>>& outAry)
{
        for (int row = 0; row < numStructRows; row++) {
            for (int col = 0; col < numStructCols; col++) {
                if (structAry[row][col] == 1) {
                    outAry[i + row - rowOrigin][j + col - colOrigin] = 1;
                }
            }
        }
    }

    void onePixelErosion(int i, int j, vector<vector<int>>& inAry, vector<vector<int>>& outAry)
{
        bool match = true;
        for (int row = 0; row < numStructRows && match; row++) {
            for (int col = 0; col < numStructCols; col++) {
                if (structAry[row][col] == 1 && inAry[i + row - rowOrigin][j + col - colOrigin] == 0) {
                    match = false;
                    break;
                }
            }
        }
        if (match) outAry[i][j] = 1;
    }


    void AryToFile(string filePath, vector<vector<int>>& ary) {
        ofstream outFile(filePath);
        // Output the image header (numImgRows, numImgCols, imgMin, imgMax) to outFile
        outFile << numImgRows << " " << numImgCols << " " << imgMin << " " << imgMax <<
endl;

        // Output the ary to outFile excluding the framed borders
        for (int i = 1; i <= numImgRows; i++) {
            for (int j = 1; j <= numImgCols; j++) {
                outFile << ary[i][j] << " ";
            }
            outFile << endl;
        }
        outFile.close();
    }


    void prettyPrint(vector<vector<int>>& ary, ofstream& outFile) {
        outFile << "Original Image:" << endl;
        outFile << numImgRows << " " << numImgCols << " " << imgMin << " " << imgMax <<
endl;

        // if Ary [i, j] == 0 output “. ” // a period follows by a blank
        // else output “1 “ // 1 follows by a blank

        for (int i = 1; i <= numImgRows; i++) {
            for (int j = 1; j <= numImgCols; j++) {
                if (ary[i][j] == 0) {
                    outFile << ". ";
                }
                else {
                    outFile << "1 ";
                }
            }
            outFile << endl;
        }
        outFile << endl;
    }



};


int main(int argc, char* argv[]) {
    if (argc != 8) {
        cout << "Usage: " << argv[0] << " <imgFile> <structFile> <dilateOutFile> <erodeOutFile>
<openingOutFile> <closingOutFile> <prettyPrintFile>" << endl;
        return 1;
    }
    ofstream prettyPrintFile(argv[7]);
    Morphology morphology(argv[1], argv[2]);

    // Preparing arrays for operations
    vector<vector<int>> tempArray(morphology.numImgRows + 2,
vector<int>(morphology.numImgCols + 2, 0));
    vector<vector<int>> dilateArray(morphology.numImgRows + 2,
vector<int>(morphology.numImgCols + 2, 0));
    vector<vector<int>> erodeArray(morphology.numImgRows + 2,
vector<int>(morphology.numImgCols + 2, 0));
    vector<vector<int>> openingArray(morphology.numImgRows + 2,
vector<int>(morphology.numImgCols + 2, 0));
    vector<vector<int>> closingArray(morphology.numImgRows + 2,
vector<int>(morphology.numImgCols + 2, 0));

    morphology.zero2DAry(morphology.zeroFramedAry, morphology.numImgRows,
morphology.numImgCols);
```

```
    morphology.loadImg(argv[1]);
    morphology.prettyPrint(morphology.zeroFramedAry, prettyPrintFile);

    // Dilation
    morphology.zero2DAry(dilateArray, morphology.numImgRows, morphology.numImgCols);
// Reset dilateArray
    morphology.ComputeDilation(morphology.zeroFramedAry, dilateArray);
    morphology.AryToFile(argv[3], dilateArray);

    // Erosion
    morphology.zero2DAry(erodeArray, morphology.numImgRows, morphology.numImgCols);
// Reset erodeArray
    morphology.ComputeErosion(morphology.zeroFramedAry, erodeArray);
    morphology.AryToFile(argv[4], erodeArray);

    // Opening
    morphology.zero2DAry(openingArray, morphology.numImgRows,
morphology.numImgCols); // Reset openingArray
    morphology.ComputeOpening(morphology.zeroFramedAry, openingArray, tempArray);
    morphology.AryToFile(argv[5], openingArray);

    // Closing
    morphology.zero2DAry(closingArray, morphology.numImgRows, morphology.numImgCols);
// Reset closingArray
    morphology.ComputeClosing(morphology.zeroFramedAry, closingArray, tempArray);
    morphology.AryToFile(argv[6], closingArray);


    return 0;
}
```

1st run

dilate:

```
42 31 0 1
1 1 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 1 1
1 1 1 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 1 1 1
1 1 0 0 1 1 0 0 0 0 0 0 0 1 1 1 1 1 0 0 0 0 0 0 0 0 0 0 0 1 0
0 0 0 1 1 1 1 0 0 0 0 0 1 1 1 1 1 1 1 0 0 0 0 0 0 1 1 0 0 0 0
0 0 1 1 1 1 1 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 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 0 0 0 0
0 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 0 0 0
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 0 0
0 1 1 1 1 0 1 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 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 1 1 1 1 1 1 0 0 0 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 1 1 0 0 0
0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 0
0 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 0 0
0 0 0 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 0 0
0 0 1 1 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 0 0
0 0 0 1 0 0 0 0 1 1 1 1 1 1 1 1 1 1 1 1 1 0 1 1 1 0 0 0 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 1 0 0 0 0 0
0 0 0 0 0 0 1 1 1 0 0 0 0 1 1 1 1 1 1 1 1 0 0 0 1 1 1 0 0 0 0
0 0 0 0 0 1 1 1 0 0 0 0 0 0 1 1 1 0 0 1 1 1 0 0 0 1 0 0 0 0 0
0 0 0 1 0 0 1 0 0 0 0 0 0 0 1 1 1 0 0 0 1 0 0 0 0 0 0 0 0 0 0
0 0 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 0 0
0 1 1 1 1 1 0 0 0 0 0 0 0 0 1 1 1 0 0 0 0 0 0 0 0 1 0 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 1 1 1 0 0 0 0
0 0 1 1 1 0 0 0 0 0 0 0 0 1 1 1 1 1 0 0 0 0 0 1 1 1 0 0 0 0 0
0 0 0 1 0 0 1 0 0 0 0 0 1 1 1 1 1 1 1 0 0 0 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 1 1 1 1 0 1 1 1 1 1 1 0 0 0 0
0 0 0 0 1 1 1 1 1 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 0 0
0 0 1 1 1 1 0 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 1 1 1 1 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 0
0 0 1 1 0 0 0 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 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 1 1 1 0 0 0 1 1 0 0 0
0 0 1 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 0 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 0 0 0 0 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 1 1 1 1 0 0 0 0 0 0
0 0 1 1 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 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 0 0
0 0 0 0 0 0 1 1 1 0 1 1 1 1 1 1 1 1 1 1 1 0 0 0 0 1 1 1 0 0 0
0 0 1 1 0 1 1 1 0 0 0 0 1 1 1 1 1 1 1 0 0 0 1 1 0 1 1 1 0 0 0
0 1 1 1 1 1 1 0 0 0 0 0 0 1 1 1 1 1 0 0 0 1 1 1 1 0 1 0 0 0 0
1 1 1 1 1 1 0 0 0 0 0 0 0 1 1 1 1 1 0 0 0 0 1 1 1 1 0 0 0 0 0
1 1 1 0 1 0 0 0 0 0 0 0 0 0 1 1 1 0 0 0 0 0 0 1 1 0 0 0 0 0 0
1 1 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
```

erodeOutFile

```
42 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
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 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 1 1 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 1 1 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 1 1 1 0 0 0 1 1 1 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 1 0 1 1 0 0 1 1 1 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 1 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 1 0 1 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 1 0 1 1 0 0 1 1 0 1 1 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 1 0 0 0 1 1 1 0 0 1 1 1 1 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 1 0 1 0 1 0 0 0 0 1 1 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 1 1 0 0 0 1 0 0 0 1 1 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 1 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 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 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 1 1 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 1 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 1 0 0 0 1 1 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 0 0 0 0 1 1 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 1 0 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 0 0 0 0 1 1 1 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 1 1 0 0 0 0 1 0 0 0 1 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 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 0 0 1 1 1 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 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 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
```

openingOutFile

```
42 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 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 1 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 1 1 1 1 1 1 1 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 1 1 1 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 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 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 0 0 1 0 1 1 0 0 1 1 1 0 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 0 0 1 1 0 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 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 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 1 1 1 1 0 0 1 1 1 1 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 1 1 1 1 0 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 0 1 1 1 1 0 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 1 0 0 1 1 1 1 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 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 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 1 1 1 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 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 0 0
0 0 0 1 0 0 0 0 0 0 0 0 0 0 1 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 1 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 1 1 1 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 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 1 1 1 1 1 1 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 1 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 1 1 1 0 0 1 1 1 1 0 0 1 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 1 1 1 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 1 0 1 1 1 1 0 0 1 1 1 1 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 1 1 1 1 1 1 1 0 0 0 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 0 0 0 1 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 1 1 1 1 0 0 1 1 1 0 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 1 1 1 0 1 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 1 1 1 1 1 1 1 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 1 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 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 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
```

closingOutFIle

```
42 31 0 1
1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1
1 1 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 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 0
0 0 0 0 1 1 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 1 1 1 0 0 0 0 0 0 1 1 1 1 1 1 1 0 0 0 0 0 0 1 1 0 0 0 0
0 0 1 1 1 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 0 0 0 0 0 1 0 0 0 0 0
0 0 1 1 1 1 0 0 0 0 1 1 1 1 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 0 1 1 1 1 1 1 1 1 1 1 1 1 1 0 0 0 0 1 1 0 0 0
0 0 1 1 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 1 1 1 0 0 0 0 1 0 0 0 0
0 0 0 1 1 0 1 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 0 0 0 0 0 0 0 0
0 0 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 0 0 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 1 1 0 0 0
0 0 0 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 0 0
0 0 0 0 1 0 0 0 0 1 1 1 1 1 1 1 1 1 1 1 1 1 0 0 0 0 0 0 0 0 0
0 0 0 1 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 1 0 1 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 1 0 0 1 1 1 1 1 1 1 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 1 1 1 1 1 1 0 0 0 0 0 1 0 0 0 0 0 0
0 0 0 0 0 0 0 1 0 0 0 0 0 0 1 1 1 0 0 1 0 0 0 0 0 1 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 1 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 1 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 1 1 1 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 1 1 1 0 0 0 0 0 0 0 0 0 1 1 1 0 0 0 0 0 0 0 0 1 0 0 0 0 0
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prettyPrintFile

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2nd run

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3rd run