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Section: Image Processing

Project: Project 3 - Morphological Operations

Due Date: Sept 30th

Algorithm Steps

step 0: imgFile, structFile, img1, img2, outFile1, outFile2 <-- open

step 1: numImgRows, numImgCols, imgMin, imgMax <- read from imgFile numStructRows, numStructCols, structMin, structMax <- read from structFile rowOrigin, colOrigin <— read from structFile

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, outFile1) // write a meaningful caption before prettyPrint

step 5: zero2DAry(structAry, numStructRows, numStructCols) loadstruct (structFile, structAry) // see description in the above

```
prettyPrint (structAry, outFile1) // see description in the above
step 6: zero2DAry(morphAry, rowSize, colSize)
ComputeDilation (zeroFramedAry, morphAry)
prettyPrint (morphAry, outFile1) // write a meaningful caption before prettyPrint
step 7: zero2DAry(morphAry, rowSize, colSize)
ComputeErosion (zeroFramedAry, morphAry) // see algorithm below
prettyPrint (morphAry, outFile1) // write a meaningful caption before prettyPrint
step 8: zero2DAry(morphAry, rowSize, colSize)
ComputeOpening (zeroFramedAry, morphAry, tempAry)
prettyPrint (morphAry, outFile1) // write a meaningful caption before prettyPrint
step 9: zero2DAry(morphAry, rowSize, colSize)
ComputeClosing (zeroFramedAry, morphAry, tempAry)
prettyPrint (morphAry, putFile1) // write a meaningful caption before prettyPrint
step 10: PerformTask1(...) // objectExtraction(), fillHoles()
```

step 11: close all files

Video: https://www.youtube.com/watch?v=iirFy02-jmI

Source Code:

```
// Created by Jingshi Liu on 9/24/23.
#include <iostream>
#include <fstream>
using namespace std;
namespace Util{
    static int** getArray(int rows, int cols){
        int** array = new int*[rows];
        for(int i = 0; i < rows; i++){
            array[i] = new int[cols];
            for(int j = 0; j < cols; j++){
                array[i][j] = 0;
            }
        }
        return array;
    }
    static int** copyArray(int** array, int rows, int cols){
        int** output = getArray(rows, cols);
        for(int i = 0; i < rows; i++){
            for(int j = 0; j < cols; j++){
                output[i][j] = array[i][j];
            }
```

```
}
        return output;
    }
}
class Morphology{
public:
    int numImageRows,
        numImageCols,
        imageMin,
        imageMax,
        numStructRows,
        numStructCols,
        structMin,
        structMax,
        rowOrigin,
        colOrigin,
        rowFrameSize, // numStructRows / 2
        colFrameSize, // numStructCols / 2
        extractRows, // rowFrameSize * 2
        extractCols, // colFrameSize * 2
        rowSize, // numImageRows + extraRows
        colSize; // numImageCols + extraCols
    int** zeroFramedArray;
    int** morphArray;
    int** tempArray;
    int** structArray;
    Morphology(ifstream& imageFile, ifstream& structFile){
        imageFile >> numImageRows >> numImageCols >> imageMin >> imageMax;
        structFile >> numStructRows >> numStructCols >> structMin >> structMax >> rowOrigin >>
colOrigin;
        rowFrameSize = numStructRows / 2;
        colFrameSize = numStructCols / 2;
```

```
extractRows = rowFrameSize * 2;
    extractCols = colFrameSize * 2;
    rowSize = numImageRows + extractRows;
    colSize = numImageCols + extractCols;
    zeroFramedArray = Util::getArray(rowSize, colSize);
    structArray = Util::getArray(numStructRows, numStructCols);
    morphArray = Util::getArray(rowSize, colSize);
    tempArray = Util::getArray(rowSize, colSize);
    loadImage(imageFile);
    loadStruct(structFile);
}
void zero2DArray(int** array, int rows, int cols){
    for(int i = 0; i < rows; i++){
        for(int j = 0; j < cols; j++){
            array[i][j] = 0;
        }
    }
}
// load image file to zeroFramedArray
void loadImage(ifstream& imageFile){
    int pixelVal;
    for(int i = rowOrigin; i < rowSize - rowFrameSize; i++){</pre>
        for(int j = colOrigin; j < colSize - colFrameSize; j++){</pre>
            imageFile >> pixelVal;
            zeroFramedArray[i][j] = pixelVal;
        }
    }
}
void loadStruct(ifstream& structFile){
```

```
int pixelVal;
    for(int i = 0; i < numStructRows; i++){</pre>
        for(int j = 0; j < numStructCols; j++){</pre>
            structFile >> pixelVal;
            structArray[i][j] = pixelVal;
        }
    }
}
void computeDilation(int** inputImage, int** outputImage){
    for(int i = rowOrigin; i < rowSize - rowFrameSize; i++){</pre>
        for(int j = colOrigin; j < colSize - colFrameSize; j++){</pre>
            if(inputImage[i][j] > 0){
                onePixelDilation(i, j, inputImage, outputImage);
            }
        }
    }
}
void computeErosion(int** inputImage, int** outputImage){
    for(int i = rowOrigin; i < rowSize - rowFrameSize; i++){</pre>
        for(int j = colOrigin; j < colSize - colFrameSize; j++){</pre>
            if(inputImage[i][j] > 0){
                onePixelErosion(i, j, inputImage, outputImage);
            }
        }
    }
}
void computeOpening(int** inputImage, int** outputImage, int** tempImage){
    computeErosion(inputImage, tempImage);
    computeDilation(tempImage, morphArray);
}
```

```
int** computeClosing(int** inputImage, int** outputImage, int** tempImage){
        computeDilation(inputImage, tempImage);
        computeErosion(tempImage, morphArray);
    }
    void onePixelDilation(int i, int j, int** inputImage, int** outputImage){
        int iOffset = i - rowOrigin,
            jOffset = j - colOrigin;
        for(int rIndex = 0; rIndex < numStructRows; rIndex++){</pre>
            for(int cIndex = 0; cIndex < numStructCols; cIndex++){</pre>
                if(structArray[rIndex][cIndex] > 0){
                    outputImage[i0ffset + rIndex][j0ffset + cIndex] = 1;
                }
            }
        }
    }
    void onePixelErosion(int i , int j, int** inputImage, int** outputImage){
        int iOffset = i - rowOrigin,
            jOffset = j - colOrigin;
        bool fitStructElement = true;
        for(int rIndex = 0; rIndex < numStructRows; rIndex++){</pre>
            for(int cIndex = 0; cIndex < numStructCols; cIndex++){</pre>
                if(structArray[rIndex][cIndex] > 0 && inputImage[i0ffset + rIndex][j0ffset +
cIndex] \leftarrow 0){
                        fitStructElement = false;
                }
            }
        }
        if(fitStructElement){
            outputImage[i][j] = 1;
        }else{
            outputImage[i][j] = 0;
        }
    }
```

```
void outputImageToFile(int** imageArray, ofstream& outFile){
    outFile<<numImageRows<<" "<<numImageCols<<" "<<iimageMin<<" "<<iimageMax<<"\n";</pre>
    for(int i = rowOrigin; i < rowOrigin + numImageRows; i++){</pre>
        for(int j = colOrigin; j < colOrigin + numImageCols; j++){</pre>
            outFile<< imageArray[i][j]<< " ";</pre>
        }
        outFile<< "\n";</pre>
    }
}
    void prettyPrint(int** imageArray, int rows, int cols, ofstream& outFile){
        for(int i = 0; i < rows; i++){
            for(int j = 0; j < cols; j++){
                 if(imageArray[i][j] == 0){
                     outFile << ". ";</pre>
                 }else{
                     outFile <<"1 ";
            }
            outFile << "\n";</pre>
        }
    }
    void objectExtraction(int** inputImage, int** outputImage){
        zero2DArray(tempArray, rowSize, colSize);
        zero2DArray(outputImage, rowSize, colSize);
        computeOpening(inputImage, outputImage, tempArray);
    }
    void fillHoles(int** inputImage, int** outputImage){
        zero2DArray(tempArray, rowSize, colSize);
        zero2DArray(outputImage, rowSize, colSize);
```

```
computeClosing(inputImage, outputImage, tempArray);
    }
};
int main(int argc, const char* argv[]){
    ifstream imageFile(argv[1]),
             structFile(argv[2]),
             taskImageFile(argv[3]),
             structImageFile(argv[4]);
    ofstream outFile1(argv[5]),
             outFile2(argv[6]);
    Morphology* morphology = new Morphology(imageFile, structFile);
    outFile1<< "Data 1 Image \n";</pre>
    morphology->prettyPrint(morphology->zeroFramedArray, morphology->rowSize, morphology-
>colSize, outFile1);
    outFile1<< "\n\nStructure Element\n";</pre>
    morphology->prettyPrint(morphology->structArray, morphology->numStructRows, morphology-
>numStructCols, outFile1);
    // Step 6
    morphology->computeDilation(morphology->zeroFramedArray, morphology->morphArray);
    outFile1<< "\n\nData1 Image after Dilation\n";</pre>
    morphology->prettyPrint(morphology->morphArray, morphology->rowSize, morphology-
>colSize,outFile1);
    // Step 7
    morphology->zero2DArray(morphology->morphArray, morphology->rowSize, morphology->colSize);
    morphology->computeErosion(morphology->zeroFramedArray, morphology->morphArray);
    outFile1<< "\n\nData1 Image Erosion\n";</pre>
    morphology->prettyPrint(morphology->morphArray, morphology->rowSize, morphology-
>colSize,outFile1);
    // Step 8
    morphology->zero2DArray(morphology->morphArray, morphology->rowSize, morphology->colSize);
```

```
morphology->computeOpening(morphology->zeroFramedArray, morphology->morphArray, morphology-
>tempArray);
   outFile1<< "\n\nData1 Image Opening\n";</pre>
   morphology->prettyPrint(morphology->morphArray, morphology->rowSize, morphology-
>colSize.outFile1);
   // Step 9
   morphology->zero2DArray(morphology->morphArray, morphology->rowSize, morphology->colSize);
   morphology->zero2DArray(morphology->tempArray, morphology->rowSize, morphology->colSize);
   morphology->computeClosing(morphology->zeroFramedArray, morphology->morphArray, morphology-
>tempArray);
    outFile1<< "\n\nData1 Image Closing\n";</pre>
    morphology->prettyPrint(morphology->morphArray, morphology->rowSize, morphology-
>colSize,outFile1);
   // Step 10 - Task 1: extract large blobs and fill holes in the blobs
   Morphology* taskMorphology = new Morphology(taskImageFile, structImageFile);
   outFile2<< "Image 1\n";</pre>
    taskMorphology->prettyPrint(taskMorphology->zeroFramedArray, taskMorphology->rowSize,
taskMorphology->colSize, outFile2);
   // Structuring Element
   outFile2<< "\n\n\nStructure Element for objectExtraction()\n";</pre>
    taskMorphology->prettyPrint(taskMorphology->structArray, taskMorphology->numStructRows,
taskMorphology->numStructCols, outFile2);
   // objectExtraction
    taskMorphology->objectExtraction(taskMorphology->zeroFramedArray, taskMorphology-
>morphArray);
   outFile2<< "\n\nObject Extraction\nOperation: Opening\nImage 1 after objectExtraction().\n";
    taskMorphology->prettyPrint(taskMorphology->morphArray, taskMorphology->rowSize,
taskMorphology->colSize ,outFile2);
   // fillHoles
   taskMorphology->fillHoles(Util::copyArray(taskMorphology->morphArray, taskMorphology-
>rowSize, taskMorphology->colSize),
                              taskMorphology->morphArray);
    outFile2<< "\n\nFill Holes\nOperation: Closing\nImage after objectExtraction() and
fillHoles()\n";
```

```
taskMorphology->prettyPrint(taskMorphology->morphArray, taskMorphology->rowSize,
taskMorphology->colSize ,outFile2);
}
```

Program Output

OutFile1

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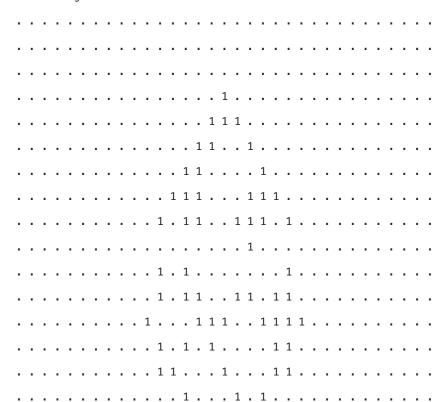
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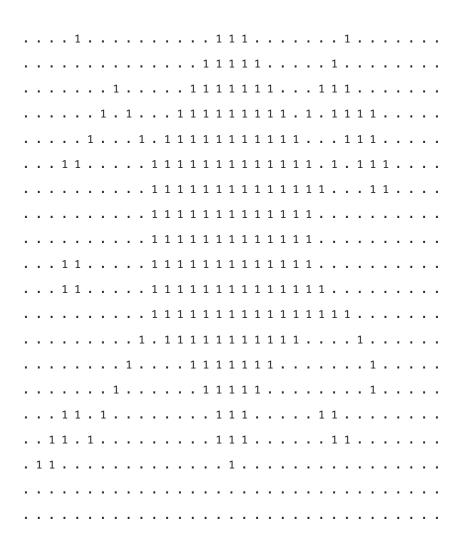
Data1 Image Erosion



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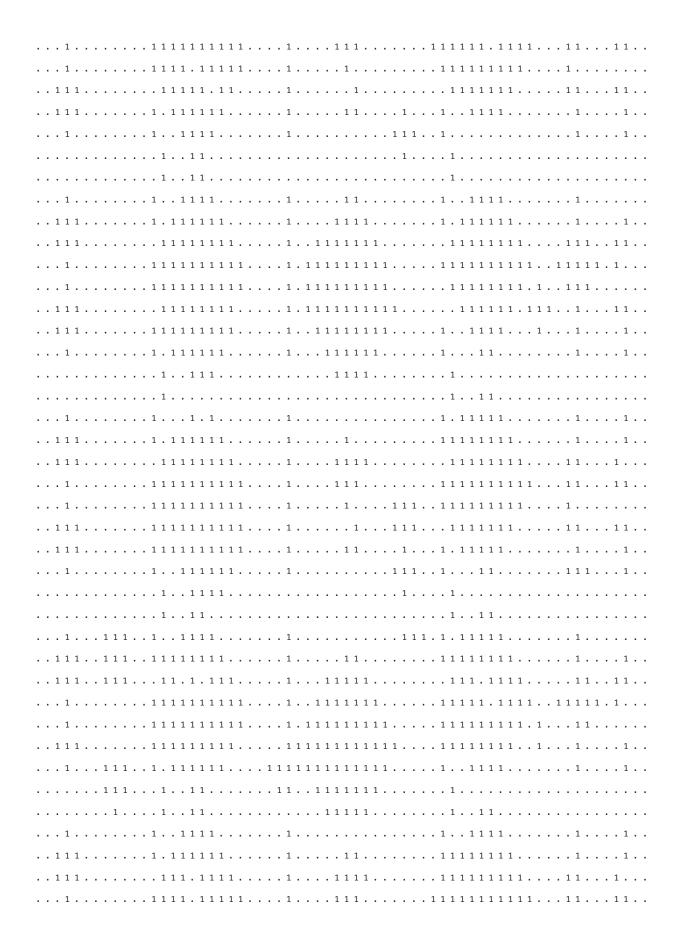
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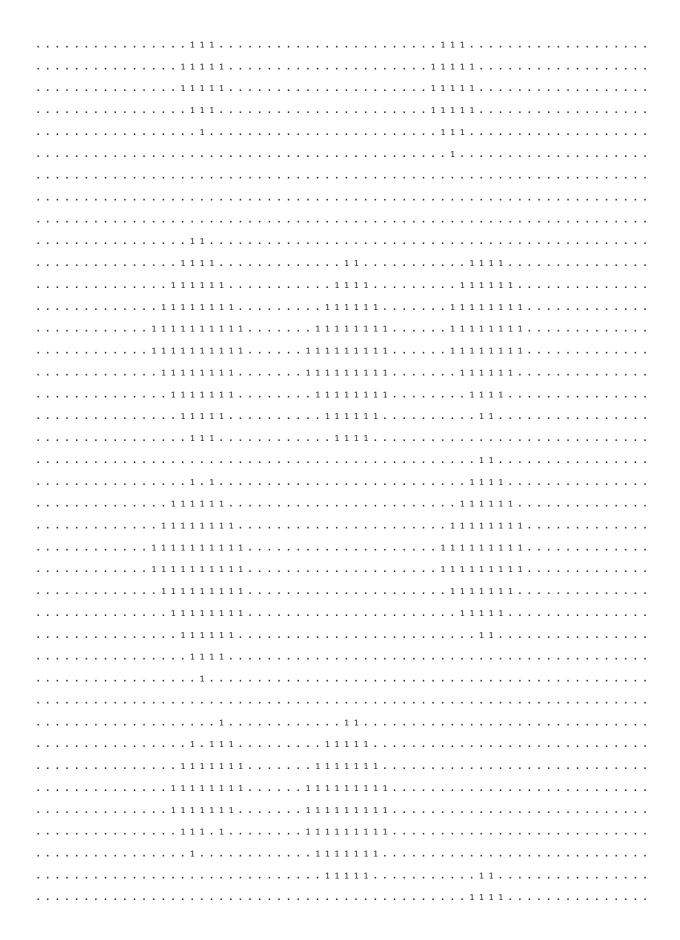


OutFile 2 - output of Task 1, objeceExtraction() and fillHoles()

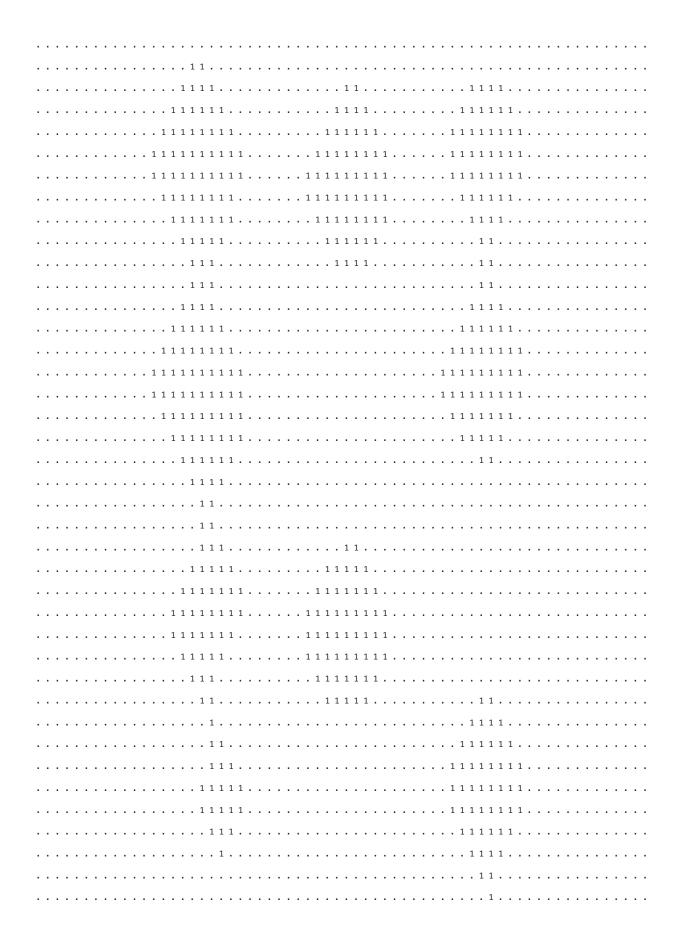
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Operation: Closing	
<pre>Image after objectExtraction() and fillHoles()</pre>	
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