EE 146: Computer Vision

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Lab 3: Morphological Operators, Connected Component Labeling & region properties

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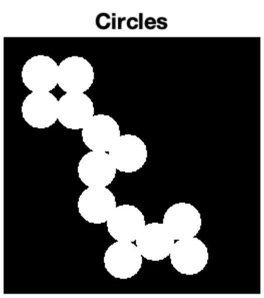
Problem 1

1) Use Matlab built in image 'circles.png.'

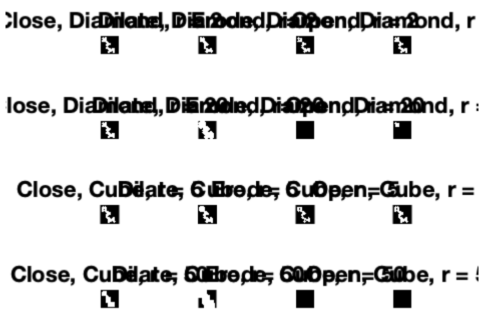
```
circles_binary = imread('circles.png');
imshow(circles_binary), title('Circles')
```



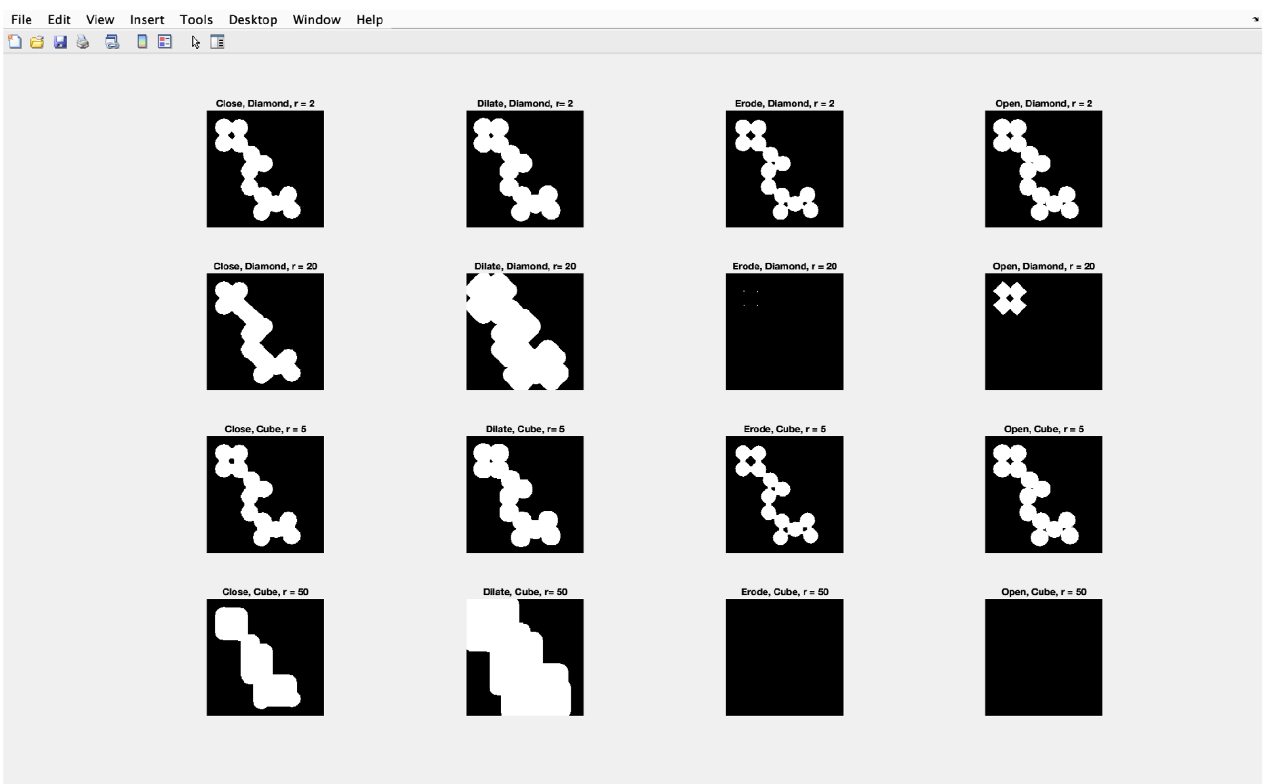
2) Using various structuring elements (of various shapes and sizes) perform morphological operations

```
% shape and size is our choice. At least use two shapes and two sizes for
% each operation
% use the Matlab functions and plot in a subplot(4,4,1)
% Create structuring elements
SE_1 =  strel('diamond', 2);
SE_2 = strel('diamond', 20);
SE_3 = strel('cube', 5);
SE_4 = strel('cube', 50);
subplot(4,4,1), imshow(imclose(circles_binary, SE_1)), title('Close, Diamond, r = 2');
subplot(4,4,2), imshow(imdilate(circles_binary, SE_1)), title('Dilate, Diamond, r= 2')
subplot(4,4,3), imshow(imerode(circles_binary, SE_1)), title('Erode, Diamond, r = 2');
subplot(4,4,4), imshow(imopen(circles_binary, SE_1)), title('Open, Diamond, r = 2');
subplot(4,4,5), imshow(imclose(circles_binary, SE_2)), title('Close, Diamond, r = 20')
subplot(4,4,6), imshow(imdilate(circles_binary, SE_2)), title('Dilate, Diamond, r= 20'
subplot(4,4,7), imshow(imerode(circles_binary, SE_2)), title('Erode, Diamond, r = 20')
subplot(4,4,8), imshow(imopen(circles_binary, SE_2)), title('Open, Diamond, r = 20');
```

```
subplot(4,4,9), imshow(imclose(circles_binary, SE_3)), title('Close, Cube, r = 5');
subplot(4,4,10), imshow(imdilate(circles_binary, SE_3)), title('Dilate, Cube, r= 5');
subplot(4,4,11), imshow(imerode(circles_binary, SE_3)), title('Erode, Cube, r = 5');
subplot(4,4,12), imshow(imopen(circles_binary, SE_3)), title('Open, Cube, r = 5');
subplot(4,4,13), imshow(imclose(circles_binary, SE_4)), title('Close, Cube, r = 50');
subplot(4,4,14), imshow(imdilate(circles_binary, SE_4)), title('Dilate, Cube, r= 50');
subplot(4,4,15), imshow(imerode(circles_binary, SE_4)), title('Erode, Cube, r = 50');
subplot(4,4,16), imshow(imopen(circles_binary, SE_4)), title('Open, Cube, r = 50');
```



```
figure
imshow('Problem_1_Results.png')
```




```
Warning: Image is too big to fit on screen; displaying at 67%
```

Problem 2: (Extra Credit if you can implement the first pass, the functions bwlabel and bwconncomp returns only the second pass)

Understand and implement connected componenet labeling algorithm 10.2;

Test my program on two simple data sets

$$I_{m1} = \begin{bmatrix} 0 & 0 & 1 & 0 & 0 & 1 & 1 & 1 \\ 0 & 1 & 1 & 1 & 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 & 0 & 0 & 1 & 1 \\ 1 & 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ 1 & 1 & 1 & 0 & 0 & 1 & 1 & 1 \\ 1 & 1 & 1 & 0 & 0 & 1 & 1 & 1 \end{bmatrix} I_{m2} = \begin{bmatrix} 1 & 1 & 0 & 1 & 1 & 1 & 0 & 1 \\ 1 & 1 & 0 & 1 & 0 & 1 & 0 & 1 \\ 1 & 1 & 1 & 1 & 0 & 0 & 0 & 1 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 \\ 1 & 1 & 1 & 1 & 0 & 1 & 0 & 1 \\ 0 & 0 & 0 & 1 & 0 & 1 & 0 & 1 \\ 1 & 1 & 0 & 1 & 0 & 0 & 0 & 1 \\ 1 & 1 & 0 & 1 & 0 & 1 & 1 & 1 \end{bmatrix}$$

for the above start label numbering at 2

```
% Compare the results from my algorithm with the one from the original
% image to test accuracy
newCircles_binary = SequentialLabeling(circles_binary);
CC_original = bwconncomp(circles_binary)
```

```
CC_original = struct with fields:
    Connectivity: 8
       ImageSize: [256 256]
      NumObjects: 1
    PixelIdxList: {[14134×1 double]}
```

```
CC_exp_Og = bwconncomp(newCircles_binary)
```

```
CC_exp_Og = struct with fields:
    Connectivity: 8
       ImageSize: [256 256]
      NumObjects: 1
    PixelIdxList: {[14134×1 double]}
```

As can be seen from the results, the sequential labeling function works

1. Find the connected components in the image and report four properties of components: area, centroid, perimeter, and circularity for each component

```
% Circles original
regionprops(CC_exp_Og, "Area"), regionprops(CC_exp_Og, "Perimeter"), regionprops(CC_exp
```

```
ans = struct with fields:
    Area: 14134
ans = struct with fields:
    Perimeter: 952.8480
ans = struct with fields:
```

```
    Centroid: [106.6583 135.0756]
```

```
%     regionprops(CC_exp_Og, "Circularity")
% Circles Closed
CC_Closed = bwconncomp(imclose(circles_binary, SE_1));
regionprops(CC_Closed, "Area"), regionprops(CC_Closed, "Perimeter"), regionprops(CC_Clo
```

```
ans = struct with fields:
    Area: 14262
ans = struct with fields:
    Perimeter: 902.2540
ans = struct with fields:
    Centroid: [106.7082 135.1915]
```

```
%     regionprops(CC_Closed, "Circularity")
% Circles Dilated
CC_Dilated = bwconncomp(imdilate(circles_binary, SE_1));
regionprops(CC_Dilated, "Area"), regionprops(CC_Dilated, "Perimeter"), regionprops(CC_D
```

```
ans = struct with fields:
    Area: 15906
ans = struct with fields:
    Perimeter: 912.9560
ans = struct with fields:
    Centroid: [106.6818 135.1242]
```

```
%     regionprops(CC_Dilated, "Circularity")
% Circles Erosion
CC_Erosion = bwconncomp(imerode(circles_binary, SE_1));
regionprops(CC_Erosion, "Area"), regionprops(CC_Erosion, "Perimeter"), regionprops(CC_E
```

```
ans = struct with fields:
    Area: 12261
ans = struct with fields:
    Perimeter: 939.3520
ans = struct with fields:
    Centroid: [106.5234 134.8411]
```

```
%     regionprops(CC_Erosion, "Circularity")
% Circles Open
CC_Open = bwconncomp(imopen(circles_binary, SE_2));
regionprops(CC_Open, "Area"), regionprops(CC_Open, "Perimeter"), regionprops(CC_Open, "
```

```
ans = struct with fields:
    Area: 3413
ans = struct with fields:
    Perimeter: 282.7040
ans = struct with fields:
    Centroid: [54.5965 55.5904]
```

```
%     regionprops(CC_Open, "Circularity")
```

```
function newMatrix = SequentialLabeling(binary_image)

% Input should be an integer-valued image with inital values 0 =
% background, and 1 = foreground. Returns nothing but modifies the image

    % Step 1
    % Assign inital labels
    M = size(binary_image, 1);
    N = size(binary_image, 2);
    % Value of next label to be assigned
    Label = 2;
    % Create an empty list of labels and label collisions
    label_list = {};
    collisions = {};
    % counters for indexing labels
    key1 = 1;
    key2 = 1;
    % Create an array to hold neighbors
    Neighbors = zeros(1,4);
    newMatrix = zeros(size(binary_image,1), size(binary_image,2));

    for u = 2:1:M
        for v = 1:1:N
            % This means that the pixel at this location is a foreground
            % pixel because it has the value 1
            if binary_image(u, v) == 1
                % Check boundary conditions.
                % Check the left boundary condition
                if v == 1
                    Neighbors(1,1) = newMatrix(u-1, v+1);
                    Neighbors(1,2) = newMatrix(u-1,v);
                    Neighbors(1,3) = 0;
                    Neighbors(1,4) = 0;
                % Check right boundary condition
                elseif v+1 > N
                    Neighbors(1,1) = 0;
                    Neighbors(1,2) = newMatrix(u-1, v);
                    Neighbors(1,3) = newMatrix(u-1, v-1);
                    Neighbors(1,4) = newMatrix(u, v-1);
                % First pass
                else
                    % Using the eight neighbor method
                    Neighbors(1,1) = newMatrix(u-1,v+1);
                    Neighbors(1,2) = newMatrix(u-1, v);
                    Neighbors(1,3) = newMatrix(u-1, v-1);
                    Neighbors(1,4) = newMatrix(u, v-1);
                end
                % Check if all neighbors are 0. If so, change the value of
                % that foreground pixel to the value of the current label,
                % then increment the label by one
```

```
                if all(Neighbors(:)==0)
                    newMatrix(u,v) = Label;
                    % Store the label in the label list
                    label_list{key1} = Label;
                    Label = Label + 1;
                    key1 = key1 + 1;
                else
                    neighborCheck = 0;
                    for i = 1:1
                        for j = 1:size(Neighbors,2)
                            if Neighbors(i,j) > 1
                                neighborCheck = neighborCheck + 1;
                            end
                        end
                    end
                    % exactly one neighbor has a value greater than 1
                    if neighborCheck == 1
                        newMatrix(u,v) = max(Neighbors);
                    % if more than one neighbor has a value greater than 1
                    else
                        newMatrix(u,v) = max(Neighbors);
                        %Register collisions
                        for i = 1:1
                            for j = 1:size(Neighbors,2)
                                if Neighbors(i,j) ~= newMatrix(u,v) && Neighbors(i,j) >
                                    N_l = Neighbors(i,j);
                                end
                            end
                        end
                        collisions{key2} = [newMatrix(u,v), N_l];
                        key2 = key2+1;
                    end
                end
            end
        end
    end
    % The binary image now contains labels 0,2...,label-1
    newMatrix;
    % Resolve collisions
    % Step 2 Resolve Label Collisions
    for i = 1:key2-1
        A = collisions{i}(1,1);
        B = collisions{i}(1,2);
        for j = 1:key1-1
            % Find the sets R(a), R(b) holding labels A, B. a is the index
            % of the set R(a) that contains label A
            if label_list{j} == A
                a = j;
            end
            if label_list{j} == B
                b = j;
            end
        end
```

```
        if a ~= b
            label_list{a} = [label_list{a} label_list{b}];
            label_list{b} = [];
        end
    end
    % All equivalent labels (i.e., all labels of pixels in the same
    % connected component) are now contained the same subset of R

    % Step 3: Relabel the image
%     for u = 1:M
        for v = 1:N
            if binary_image(u,v) > 1
                for i = 1:size(label_list, 2)
                    if binary_image(u,v) == label_list{i}(1,1) ||...
                            binary_image(u,v) == label_list{i}(1,2)
                        j = i;
                    end
                end
                k = min(label_list{j});
                binary_image(u,v) = k;
            end
        end
    %newMatrix
end
```