CSE166 Assignment #:
Due Date:

Please list all contributors to the assignment below.
Staple this sheet to the front of your submission.

1 Student Name(s):

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CSE166 - Image Processing - Homework 5

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November 14, 2006

Written exercises

1. GW, Problem 8.1.

   (a) Can variable-length coding procedures be used to compress a histogram equalized image with 2^n gray levels? Explain.

   No, since each 2^n gray level occurs with equal probability, all the symbols will have the same bit length n, and therefore no actual compression will be done.

   (b) Can such an image contain interpixel redundancies that could be exploited for data compression?

   Yes, there could be clusters of pixels with the same graylevels.

2. GW, Problem 8.12.

   (a) How many unique Huffman codes are there for a three-symbol source?

   1

   (b) Construct them.

   - 0, 10, 11

3. GW, Problem 8.14.
   The arithmetic decoding process is the reverse of the encoding procedure. Decode the message 0.23355 given the coding model.

Symbol	Probability	Range
a	0.2	[0.0,0.2)
e	0.3	[0.2,0.5)
i	0.1	[0.5,0.6)
o	0.2	[0.6,0.8)
u	0.1	[0.8,0.9)
!	0.1	[0.9,1.0)

   0.23355 $\rightarrow$ eaii!

4. Consider the symmetric 2×2 matrix

$$A = \begin{bmatrix} a & b \\ b & c \end{bmatrix}.$$

   By finding the roots of the characteristic equation,

$$\det(\lambda I - A) = 0,$$

   show that the eigenvalues of A are given by

$$\lambda = \frac{\operatorname{tr}(A) \pm \sqrt{\operatorname{tr}(A)^2 - 4\det(A)}}{2}$$

$$det(\lambda I - A) = \begin{vmatrix} \lambda - a & b \\ c & \lambda - d \end{vmatrix} = (\lambda - a)(\lambda - d) - bc = \lambda^2 - \lambda(a+d) + ad - bc$$

$$\lambda = \frac{a + d \pm \sqrt{(a+d)^2 - 4(1)(ad - bc)}}{2}$$

$$tr(A) = trace(A) = a + d$$

$$det(A) = \begin{vmatrix} a & b \\ c & d \end{vmatrix} = ad - bc$$

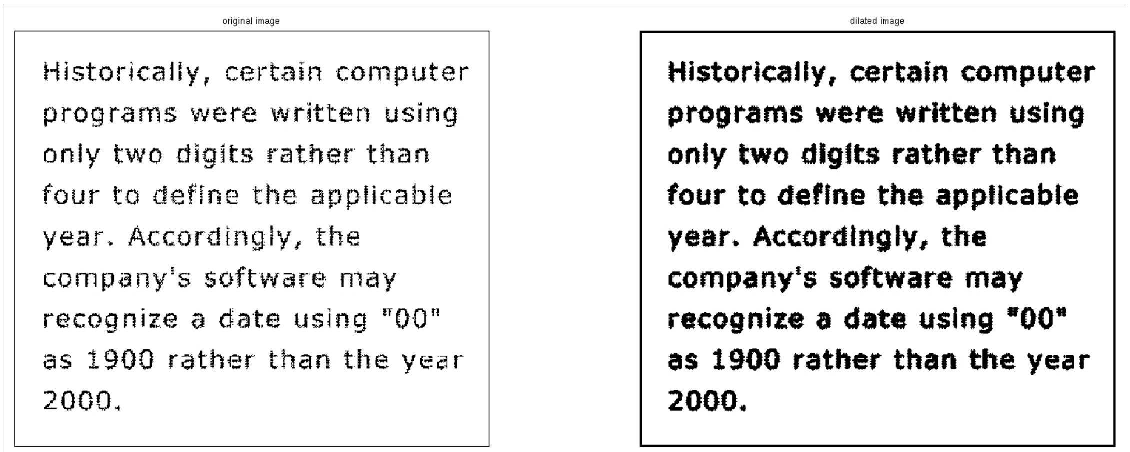
$$\lambda = \frac{a + d \pm \sqrt{(a+d)^2 - 4(1)(ad - bc)}}{2} = \frac{tr(A) \pm \sqrt{tr(A)^2 - 4det(A)}}{2}$$

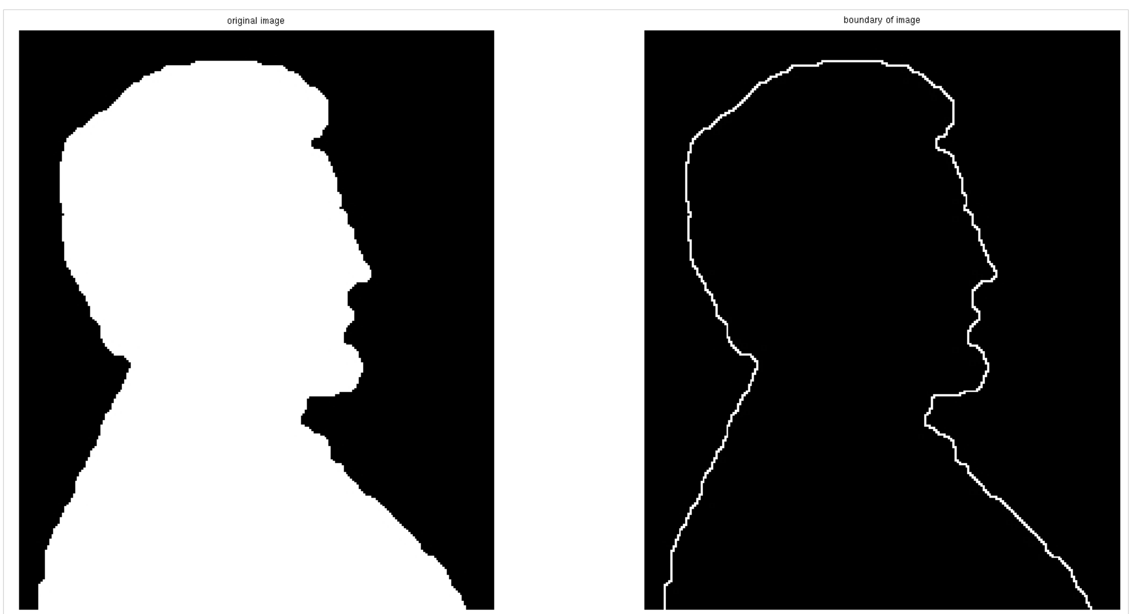
```
C (scatter matrix) =

   1.0e+04 *

    1.6146   -0.8484
   -0.8484    0.4788


eigenvalue_1_shortcut =

   2.0676e+04


eigenvalue_2_shortcut =

  257.6346


eigenvector_1_shortcut_angle =

   -0.4904


eigenvector_2_shortcut_angle =

    1.0804


eigenvector_1 (shortcut) =

   -0.8821
    0.4710


eigenvector_2 (shortcut) =

   -0.4710
   -0.8821


eigenvectors =

   -0.4710   -0.8821
   -0.8821    0.4710


eigenvalues =

   1.0e+04 *

    0.0258         0
         0    2.0676


aspect_ratio =

    8.9583
```

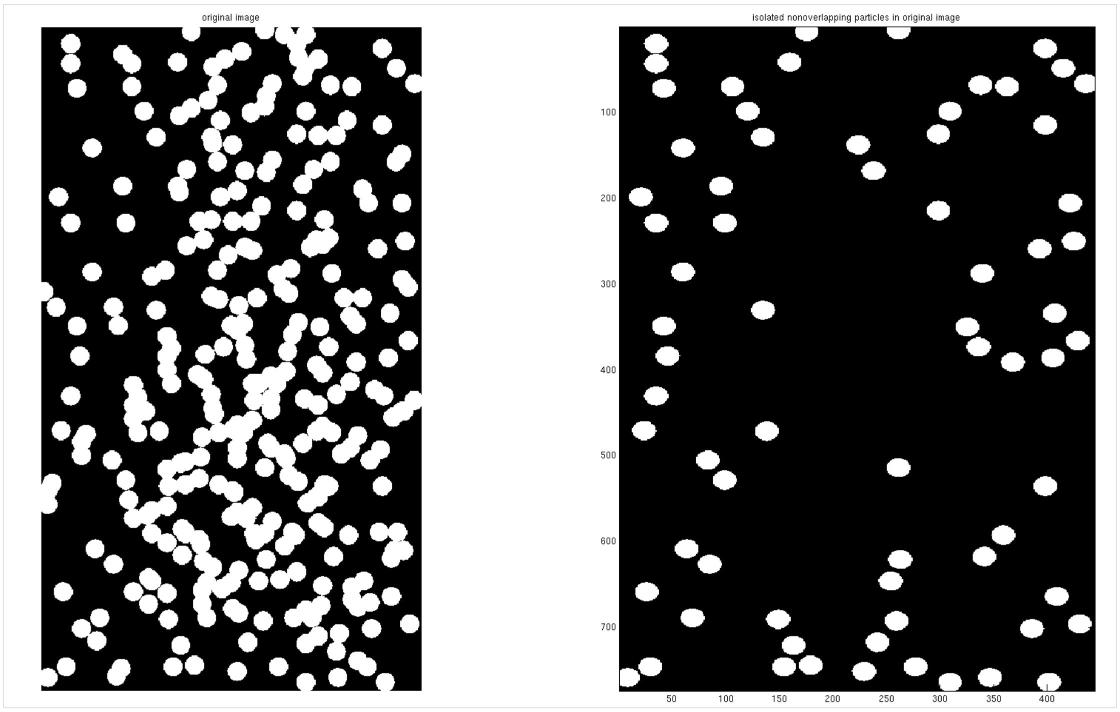
```
% Author: <njoffe@ucsd.edu> Nitay Joffe
% Date: 11/14/2006
% Class: CSE 166 - Image Processing
% Homework: 5
% Problem: 1 - Binary image processing

% (a) Reproduce GW Figure 9.5(a,c).
story_image = imread('Fig9.05(a).jpg');
structuring_element = [0 1 0;
                       1 1 1;
                       0 1 0];
% I couldn't get imdilate to work right, not sure why... it seems like I'd need the
% opposite structuring element or something. Instead I actually use
% erode to do the dilation. The results seem the same to me.
story_image_eroded = imerode(story_image, structuring_element);

figure;
subplot(1,2,1);
imshow(story_image);
title('original image');
subplot(1,2,2);
imshow(story_image_eroded);
title('dilated image');

% (b) Reproduce GW Figure 9.14(a,b).
face_image = imread('Fig9.14(a).jpg');
structuring_element = [1 1 1;
                       1 1 1;
                       1 1 1];
face_image_eroded = imerode(face_image, structuring_element);
face_image_boundary = face_image - face_image_eroded;

figure;
subplot(1,2,1);
imshow(face_image);
title('original image');
subplot(1,2,2);
imshow(face_image_boundary);
title('boundary of image');

% (c) Perform connected components labelling on the particles image for GW
%     Problem 9.27. Based on the area of each connected component, produce a
%     new image containing only the isolated (nonoverlapping) particles. Assume
%     all particles are approximately the same size.
particles_image = imread('FigProb9.27.jpg');
particles_labels = bwlabel(particles_image, 8);
stats = imfeature(particles_labels, 'Area');
particle_area_min = 250;
particle_area_max = 550;
for i = 1:numel(stats)
  areas(i) = stats(i).Area;
end

% Threshold according to area
areas(areas<particle_area_min) = 0;
areas(areas>particle_area_max) = 0;

isolated_image = particles_image;
for removed_label = find(areas==0)
  isolated_image(find(particles_labels==removed_label)) = 0;
end

figure;
subplot(1,2,1);
imshow(particles_image);
title('original image');
subplot(1,2,2);
imagesc(isolated_image);
title('isolated nonoverlapping particles in original image');
```

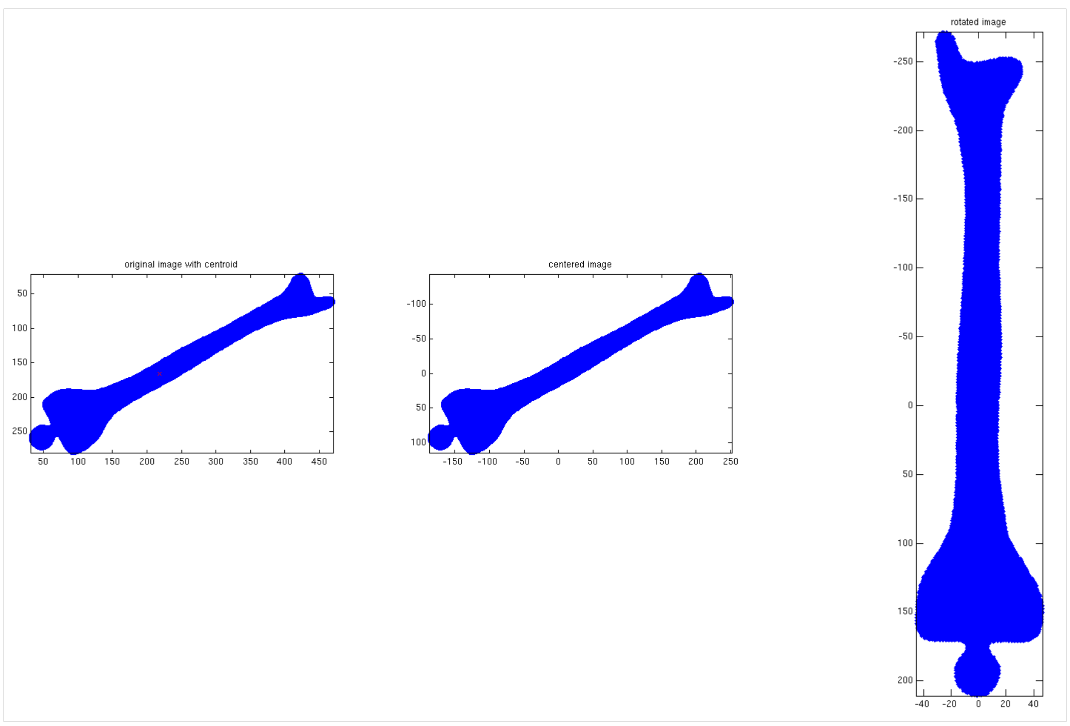
```
% Author: <njoffe@ucsd.edu> Nitay Joffe
% Date: 11/14/2006
% Class: CSE 166 - Image Processing
% Homework: 5
% Problem: 2 - Shape and the scatter matrix

% (a) Load in GW Figure 11.10, call it I, and binarize using the command
%     BW=I>128. Use find to obtain the (x, y) coordinates of the nonzero pixels.
%     Plot the resulting pointset using the axis('image') and axis('ij') options
%     and the 'b.' pointmarker.
I = imread('Fig11.10.jpg');
BW = I>128;
[x,y] = find(BW);
number_of_elements = numel(x);

% (b) Compute the centroid m and plot it in the preceding figure (turn hold on)
%     using the 'rx' pointmarker.
m_x = mean(x);
m_y = mean(y);

% (c) Compute and display the scatter matrix C. Find its eigenvalues and
%     eigenvectors, first using the above shortcuts, then using the Matlab
%     function eig, and demonstrate that both methods give you the same result.
x_centered = x - m_x;
y_centered = y - m_y;
C = [sum(x_centered.*x_centered), sum(x_centered.*y_centered);
     sum(y_centered.*x_centered), sum(y_centered.*y_centered)];
C = C./number_of_elements

eigenvalue_1_shortcut = (trace(C)+sqrt(trace(C)^2-4*det(C)))/2
eigenvalue_2_shortcut = (trace(C)-sqrt(trace(C)^2-4*det(C)))/2
eigenvector_1_shortcut_angle = 0.5*atan2(2*C(1,2),(C(1,1)-C(2,2)))
eigenvector_2_shortcut_angle = eigenvector_1_shortcut_angle+pi/2
eigenvector_1 = [-cos(eigenvector_1_shortcut_angle);
                 -sin(eigenvector_1_shortcut_angle)]
eigenvector_2 = [-cos(eigenvector_2_shortcut_angle);
                 -sin(eigenvector_2_shortcut_angle)]

[eigenvectors,eigenvalues] = eig(C)

% (d) Compute the aspect ratio of this shape using the formula
%     (\lambda_max / \lambda_min)^{1/2}.
lambda_max = eigenvalue_1_shortcut;
lambda_min = eigenvalue_2_shortcut;
aspect_ratio = sqrt(lambda_max/lambda_min)

% (e) Center the pointset so that its centroid lies on the origin. By visual
%     inspection, estimate the rotation (in degrees) of the shape with respect
%     to horizontal. Compare this to the estimate of the rotation provided by
%     \phi. Now derotate the coordinates so that the shape is oriented along the
%     x-axis, and make a plot of the result.
points = eigenvectors * [x_centered';y_centered'];
x_rotated = points(1,:);
y_rotated = points(2,:);

figure;
subplot(1,3,1);
plot(x,y,'b.');
hold on;
plot(m_x,m_y,'rx');
axis image;
axis ij;
title('original image with centroid');
subplot(1,3,2);
plot(x_centered,y_centered,'b.');
axis image;
axis ij;
title('centered image');
subplot(1,3,3);
```

```
plot(x_rotated, y_rotated, 'b.');
axis image;
axis ij;
title('rotated image');
```


original image
Historically, certain computer programs were written using only two digits rather than four to define the applicable year. Accordingly, the company's software may recognize a date using "00" as 1900 rather than the year 2000.
dilated image
Historically, certain computer programs were written using only two digits rather than four to define the applicable year. Accordingly, the company's software may recognize a date using "00" as 1900 rather than the year 2000.


original image
boundary of image


original image
isolated nonoverlapping particles in original image
100
200
300
400
500
600
700
50
100
150
200
250
300
350
400


original image with centroid
50
100
150
200
250
50
100
150
200
250
300
350
400
450
centered image
-100
-50
0
50
100
-150
-100
-50
0
50
100
150
200
250
rotated image
-250
-200
-150
-100
-50
0
50
100
150
200
-40
-20
0
20
40