National University of Singapore
Mechanical Engineering Department

ME 5405 Computer Vision

2015/2016 Exercise Set 3

Image Segmentation

1. Figures 1(a) to 1(f) show the steps in the segmentation of light microscope image of red blood cells. Figure 1(a) is the original image and Figure 1(f) is the final segmented image. Describe the steps used in this segmentation process.

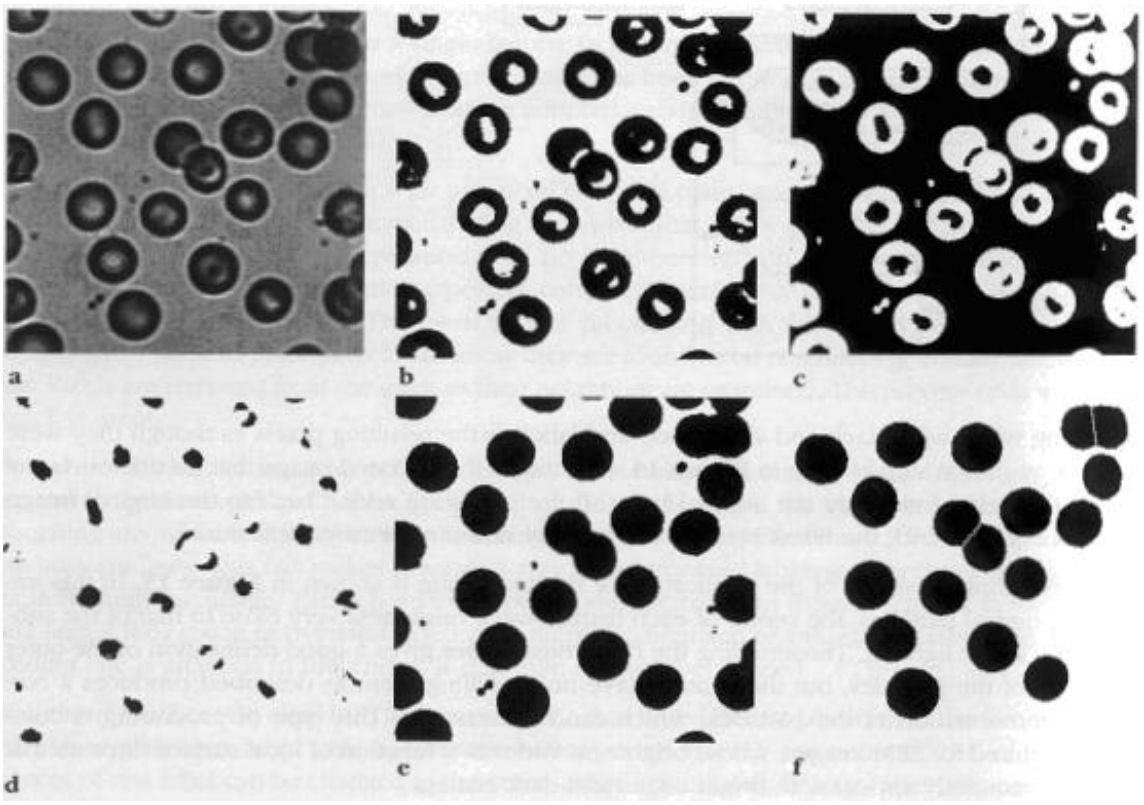


Fig. 1

[ME5405 Nov 02 – Q 1(a)]

2 Fig 2 shows an image of round particles. We wish to isolate individual round particles from similar particles that overlap in groups of two or more. Assuming that all particles are of the same size, propose a method that produces an image containing only overlapping particles. You may wish to start the process by first eliminating the particles that have merged with the boundary of the image.

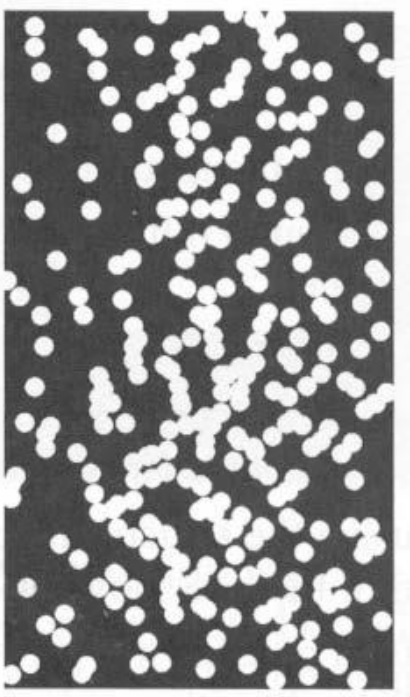
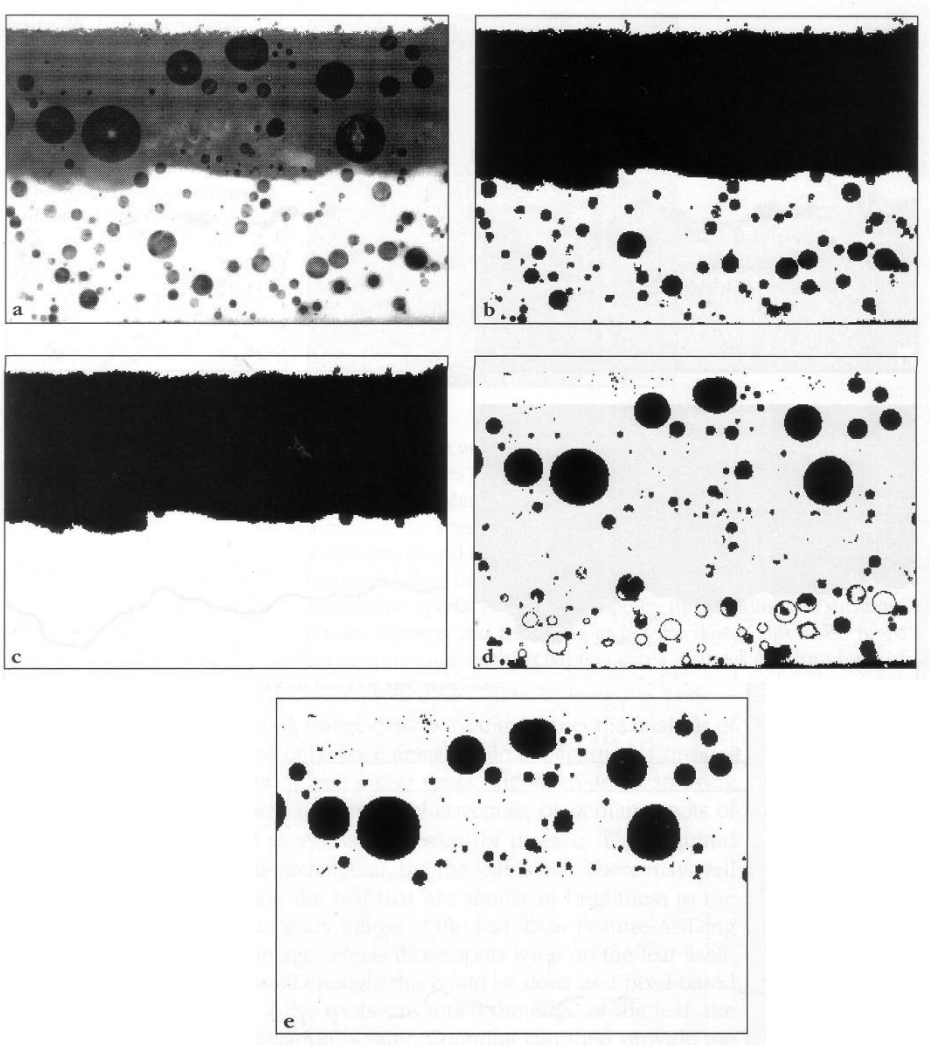


Fig. 2

[ME5405 Nov 03 – Q 1(b)]

3 Figure 3(a) is the original image of a polished cross section of an enamel coating on steel. The two distinct layers are different colour enamel containing different size distribution of pores. The purpose of an image processing operation is to isolate only the pores within the darker layer as shown in Figure 3(e). Figures 3(b) to 3(d) show the results of the intermediate steps. Describe the steps employed in this operation. [Hints: You may need to use Logical operation in this operation]



Figures 3

[ME5405 Nov 09 – Q 3(b)]

4 The bright rectangle in the binary image shown in Figure 4(a) is of size 9 by 7 pixels.

(i) Calculate the magnitude of the gradient of this image at every pixel based on the approximation given as $\nabla f(x,y) = |g_x| + |g_y|$, where $|g_x|$ and $|g_y|$ are obtained using the Sobel operators.

(ii) What would the Laplacian of this image look like by using the operator given as: $\nabla^2 f(x,y) = f(x+1,y) + f(x-1,y) + f(x,y+1) + f(x,y-1) - 4f(x,y)$, **or** in the form of a 3 by 3 mask shown in Figure 4(b)

(iii) Compare the results of using the gradient and the Laplacian as an edge detector.

Note: In this question, you need to process also the one-pixel thick boundary around the bright rectangle. Due to the symmetric nature of the image, you need only to consider one quarter of the image in your calculation.

0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	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	0	0	0
0	0	0	1	1	1	1	1	1	1	1	1	0	0	0
0	0	0	1	1	1	1	1	1	1	1	1	0	0	0
0	0	0	1	1	1	1	1	1	1	1	1	0	0	0
0	0	0	1	1	1	1	1	1	1	1	1	0	0	0
0	0	0	1	1	1	1	1	1	1	1	1	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	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Figure 4(a)

0	-1	0
-1	4	-1
0	-1	0

Figure 4(b)

[ME5405 Nov 09 – Q 4(a)]

5. Figure 5(a) shows an image of a ball-bonded die. The image has gone through two image processing procedures to segments the balls; Figure 5(b) is an intermediate step and Figure 5(c) shows the desired results. Describe the operation required in achieving each of the steps.

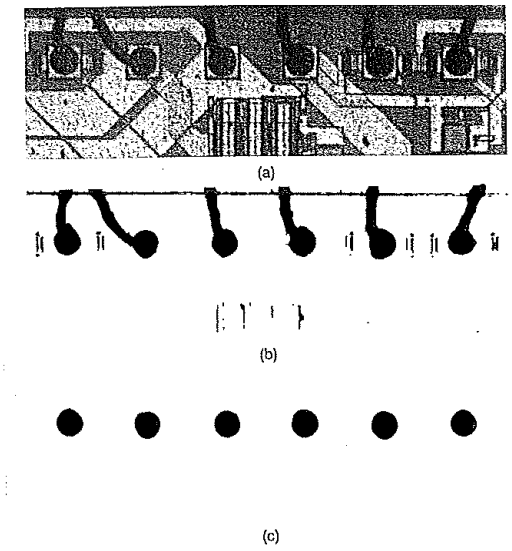


Figure 5 (a), (b) and (c)

\

[ME5405 Nov 11 – Q 4(a)]

6.

(a) Figure 6(a) shows a 7×7 image. Determine:

(i) The gradients of the image in both *x* and *y* direction using the Sobel Derivative operators.

(ii) The strength of the gradient at every pixel location and indicate the probable edge pixels.

(iii) The direction of the gradient at all the edge pixels that you have chosen in Part (ii) above.

(iv) The orientation of the edge(s)

[You need not process the one-pixel thick boundary of Figure 6(a)]

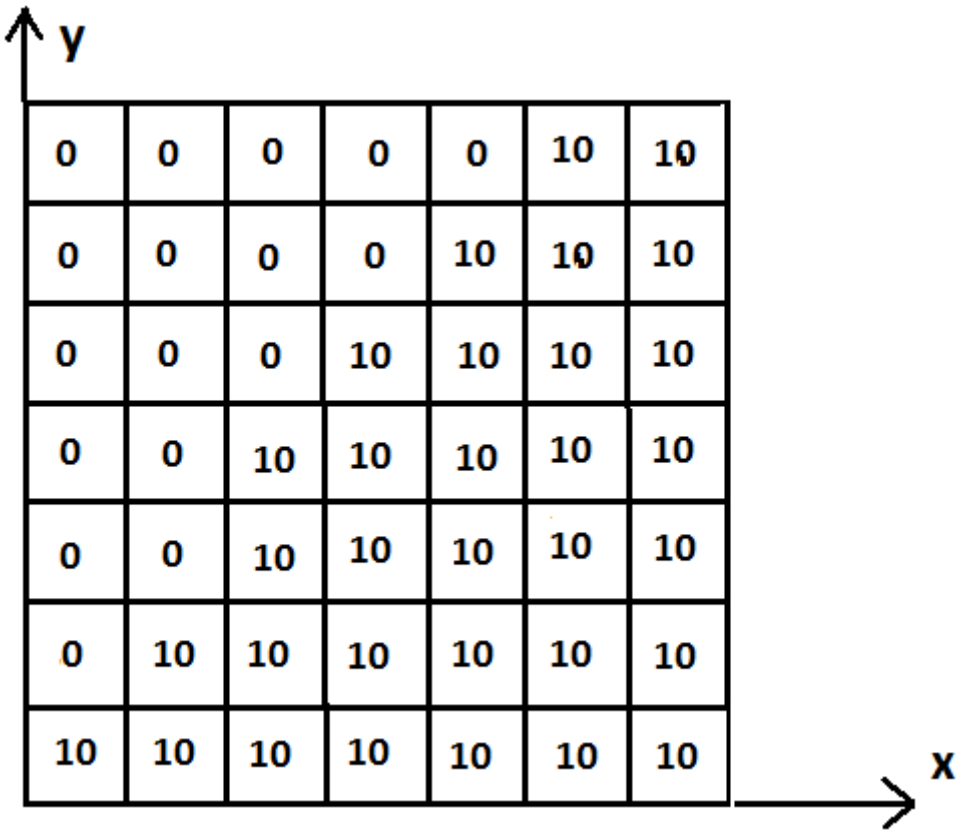


Figure 6 (a)

(b) Assuming that you have an image containing the edge map marking the outlines of equilateral traingles. We further assume that the traingles are of a fixed size with edge length of 10 pixels, and can only appear in an "upright" position with their base horizontal and one of the vertices at the top. Figure 6(b). shows the configuration of one of the traingles. Describe in detail how you would use the Hough Transform to detect the equilateral traingles in the image.

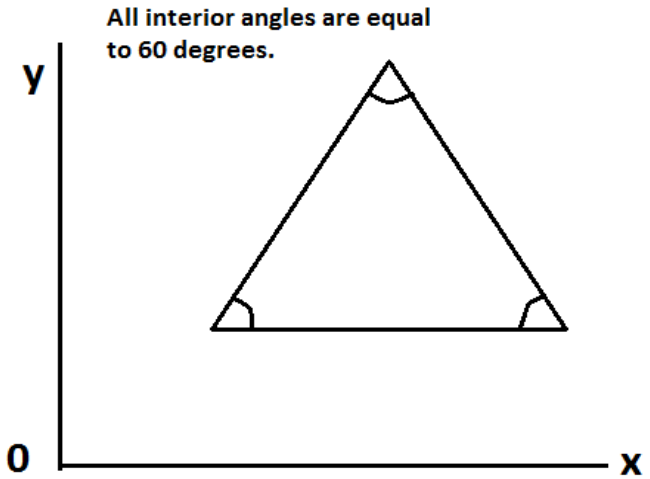


Fig. 6(b)

[ME5405 Nov 13 – Q 4]

7.

Consider the problem of detecting arcs of circles that pass through the origin of the *x-y* coordinate system. The equation of the circle is given by:

$$(x-a)^2+(y-b)^2=a^2+b^2$$

where (*a, b)* are the coordinates of the centre of the circle.

(i) In a given image, the pixels P_i's that lie on a circle have been determined by an edge operator, how would you use the Hough Transform to determine the coordinates of the center of the circle?

(ii) If we know not only the coordinates (x_i , y_i), but also the slope m_i at each point P_i, derive the expressions for *a* and *b* in terms of x_i , y_i and m_i.

[ME5405 Nov 15 – Q1(b)]

8.

Fig. 8(a) shows a 500 by 500 pixel size image. Each of the vertical bars (enclosed in the box) are 5 pixels wide and 100 pixels high. Their separation is 20 pixels exactly. Fig. 8(b) shows the profile of part of a horizontal scan line through the vertical bars.

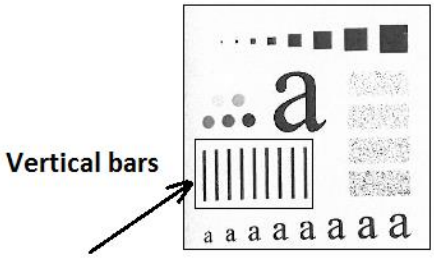


Fig. 8(a)

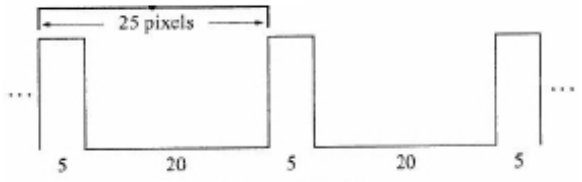


Fig. 8(b)

Fig. 3(a) is now smoothed with square averaging filter masks of size 23, 25 and 45. The resulting images are shown in Fig. 3(c), (d) and (e), respectively.

Fig. 8(c)

Fig. 8(d)

Fig. 8(e)

The vertical bars in Fig. 8(c) and Fig. 8(e) are blurred, but a clear separation exists between them. However, the vertical bars in Fig. 8(d) has merged into one single region. Explain the reason for this observation.

[ME5405 Nov 16 – Q3(b)]

Colour Image Processing

1.

In an industrial application, a certain class of images (Gray Levels from 0 to 255) produced by the machine vision system used has the following problems:

i. Bright and isolated noise spots which are of no interest;
ii. Lack of sharpness;
iii. Low or insufficient contrast in some of the images;
iv. Shift in the average gray-level value from a pre-determined value.

An engineer is asked to correct these problems, and he has decided to use Image Enhancement techniques. In addition, he has decided to colour in constant green all gray levels between a band between 80 and 120; and in constant red all gray levels between a band between 180 and 230, while keeping the gray levels outside the said range unchanged.

[ME5405 Nov 14 – Q 3(b)]

Connected Component Analysis

Fig. 1 shows a binary image containing several regions shown in gray. Using Classical Algorithm, connect and label the different regions based on **4-connectivity.**
You must:

(a) Show the resulting image after the first pass, and the final image on the page provided.
(b) Present the Table of Equivalence and explain how you resolve the equivalence during the labelling step.

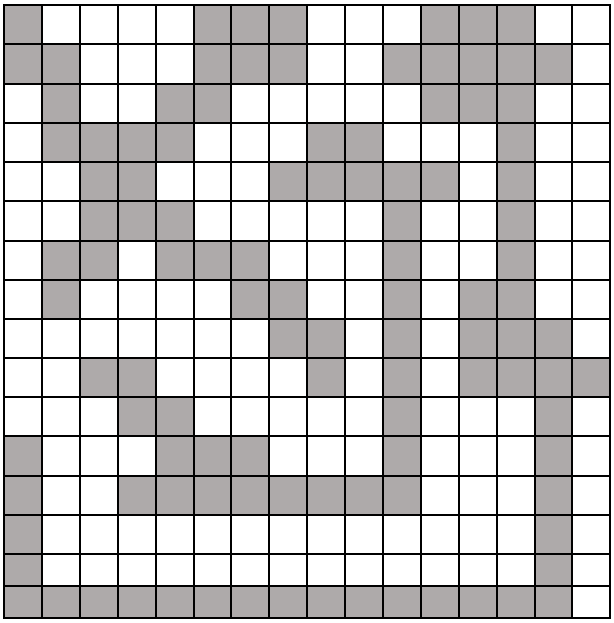
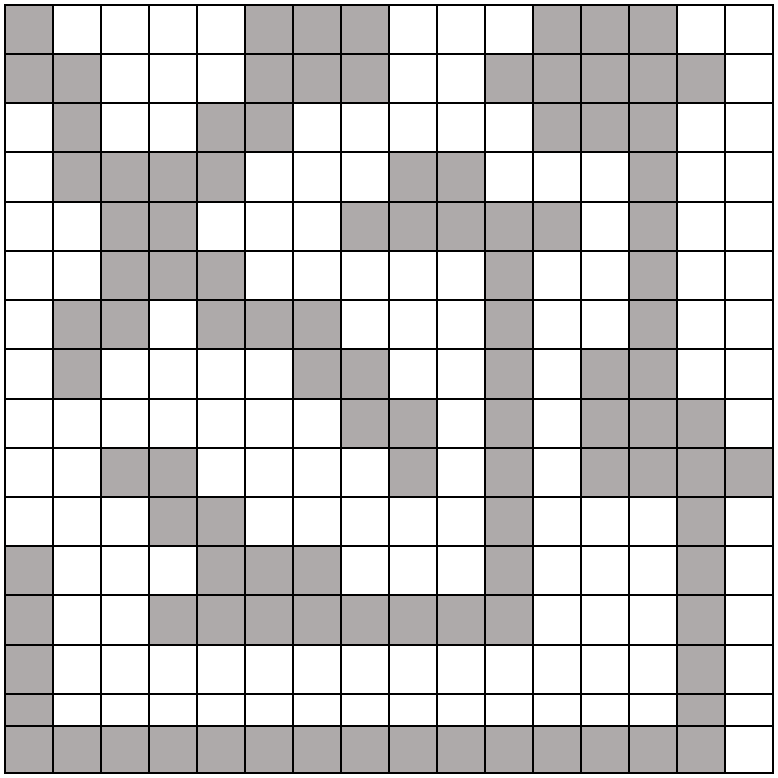
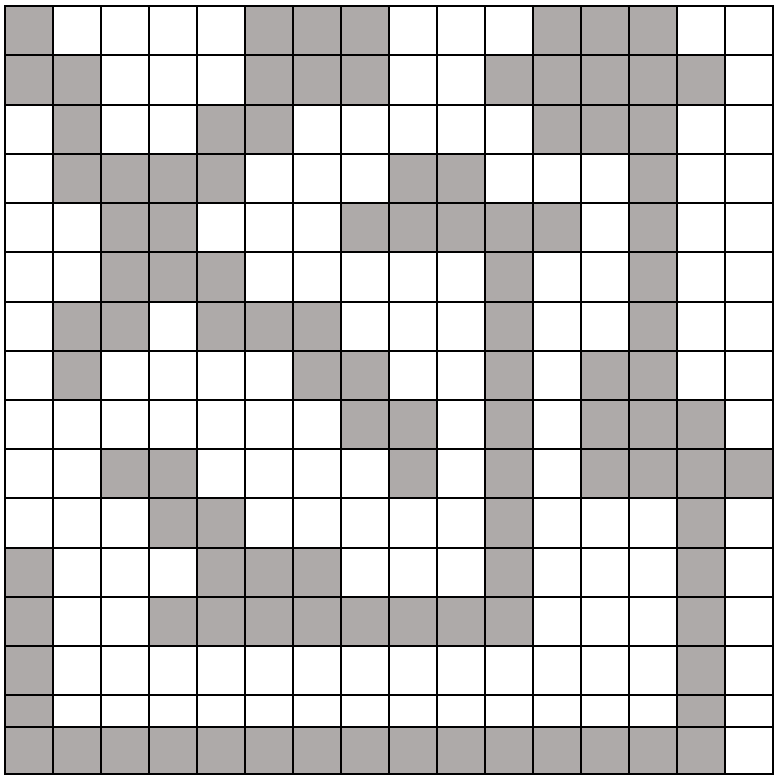


Figure 1





.

[ME5405 Nov 14 – Q 4(a)]