EEE 221: First Exam
Due Date 03/17/2015

- Work alone.
- Show and discuss your results.
- Organization is very important.

Problem 1
Morphological operations can be used for quality control as shown in figure 1-left where defects in gear teeth are detected. Suggest a method based on morphological operations to detect the abnormalities in the gear shown in figure 1-right. You can download the image from the instructor website. Discuss your method and results.

Problem 2
It is possible to perform edge detection using morphological operations. The following operations can be used
\[
A \oplus B - A \ominus B \\
A \oplus B - A \\
A - A \ominus B
\]
where \( A \) is the image and \( B \) is the structuring element.

1) Implement each one of these methods to detect the edges in figure 2. You can download the image from the instructor website.
2) How to control the thickness of the edge? Give a simulation example.
3) Discuss your results.

Problem 3
The three point approximation of the Laplacian is given by
\[
h^2 f''(x) = f(x - h) - 2f(x) + f(x + h)
\]
For a 2D image, this approximation is translated to
\[
\nabla^2_x f = f(i, j + 1) - 2f(i, j) + f(i, j - 1)
\]
\[
\nabla^2_y f = f(i + 1, j) - 2f(i, j) + f(i - 1, j)
\]

Fig. 1. Gear inspection using morphological operations
Fig. 2. The apple problem

Laplacian is obtained by $\nabla^2 f = \nabla_x^2 f + \nabla_y^2 f$. The mask in this case is a 3 by 3 matrix. It can be used as an operator for edge detection.

Find the mask for the five point Laplacian approximation that can be used for edge detection. Recall that for a 1D function, the five point Laplacian approximation is given by

$$h^2 f''(x) = \frac{-f(x - 2h) + 16f(x - h) - 30f(x) + 16f(x + h) - f(x + 2h)}{12}$$

(5)

Take $h = 1$ and ignore the division by 12.

1) Implement the filter in the frequency domain to detect the edges on the image shown in 2.
2) Implement the filter in the space domain to detect the edges on the image shown in 2.
3) Discuss your results

Problem 4

The image of figure 3 shows the edges of another image. Our goal is to recover the original image from its edges. The horizontal Roberts mask is used to obtain the edges. The first row and column of the original image are also available to us. In order to perform arithmetic operations on images, it is more practical to convert them to double.

1) Develop and implement an algorithm to recover the original image
2) Discuss your method and your results

The edge image, the first row and first column of the original image are available from the instructor’s website in xlsx format. Hint: you can use Matlab functions xlswrite and xlsread.

Problem 5

For the image shown in figure 4, do the following

1) Remove the noise
2) Perform morphological operations to remove all shapes except the squares. It is fine if the squares are reduced in size or reduced to a single pixel.
3) Replace the squares by the shapes shown in figures 4-bottom.
4) Discuss your method and your results at each step.

Problem 6

Figure 5 has several gears, we want to perform morphological operations to detect and isolate specific one. You cannot perform more than 4 basic morphological operations (dilation and erosion) to isolate the desired gear. This means that hit and miss, opening, and closing are seen as 2 operations. You are restricted to the following morphological functions in this problem: imcrop, imdilate,imerode, imopen, strel, imclose, and bwhitmiss. There is no restriction on non-morphological functions such as rgb2gray, imread, imwrite, im2bw, and imcompliment, etc.

1) Perform morphological operations to achieve the following
Fig. 3. Edges of an image

Fig. 4. Original image and desired outputs
a) Find the gear shown in figure 5-right, remove all other gears.
b) Replace the gear by a small elephant. The other gears should be present in the image.

2) Discuss your choice of the operation(s) and the structuring element(s), and your results.