The LNM Institute of Information Technology
ECE and CCE

ECE4141: Introduction to Image Processing
Mid Term

Time: 1.5 hours	**Date:** 26/09/2017	**Max. Marks: 35**

Instruction: *1) Start each answer on a fresh page of your answer book and highlight your answer number.*
2) Check that your Question paper has ***6 Questions****. All Questions are compulsory.*

Q1. Suppose that a digital image is subjected to histogram equalization. Show that the second pass of histogram equalization (on the histogram-equalized image) will produce exactly the same result as the first pass. [5]

Ans:

Let n be the total number of pixels and let n_{r_j} be the number of pixels in the input image with intensity value r_j. Then, the histogram equalization transformation is

$$s_k = T(r_k) = \sum_{j=0}^{k} n_{r_j}/n = \frac{1}{n}\sum_{j=0}^{k} n_{r_j}.$$

Since every pixel (and no others) with value r_k is mapped to value s_k, it follows that $n_{s_k} = n_{r_k}$. A second pass of histogram equalization would produce values v_k according to the transformation

$$v_k = T(s_k) = \frac{1}{n}\sum_{j=0}^{k} n_{s_j}.$$

But, $n_{s_j} = n_{r_j}$, so

$$v_k = T(s_k) = \frac{1}{n}\sum_{j=0}^{k} n_{r_j} = s_k$$

which shows that a second pass of histogram equalization would yield the same result as the first pass. We have assumed negligible round-off errors.

Q2. Write the steps to perform unsharp masking. Show that subtracting the Laplacian from an image is proportional to unsharp masking. [3+5=8]

Ans:

1st part:

Steps

- Blur $f_b(x,y)$
- Subtract from original image (unsharp mask)

$$mask = f(x,y) - f_b(x,y)$$

- add resulting mask to original image

$$f_{sharp}(x,y) = f(x,y) + mask$$

$$\boxed{f_{sharp}(x,y) = 2f(x,y) - f_b(x,y)}$$

2nd part:

Consider the following equation:

$$\begin{aligned} f(x,y) - \nabla^2 f(x,y) &= f(x,y) - [f(x+1,y) + f(x-1,y) + f(x,y+1) \\ &\quad + f(x,y-1) - 4f(x,y)] \\ &= 6f(x,y) - [f(x+1,y) + f(x-1,y) + f(x,y+1) \\ &\quad + f(x,y-1) + f(x,y)] \\ &= 5\{1.2f(x,y) - \\ &\quad \frac{1}{5}[f(x+1,y) + f(x-1,y) + f(x,y+1) \\ &\quad + f(x,y-1) + f(x,y)]\} \\ &= 5\left[1.2f(x,y) - \overline{f}(x,y)\right] \end{aligned}$$

where $\overline{f}(x,y)$ denotes the average of $f(x,y)$ in a predefined neighborhood that is centered at (x,y) and includes the center pixel and its four immediate neighbors. Treating the constants in the last line of the above equation as proportionality factors, we may write

$$f(x,y) - \nabla^2 f(x,y) \sim f(x,y) - \overline{f}(x,y).$$

The right side of this equation is recognized as the definition of unsharp masking given in Eq. (3.7-7). Thus, it has been demonstrated that subtracting the Laplacian from an image is proportional to unsharp masking.

Q3. a) Explain how image compression can be achieved through a frequency domain transform. [5]

b) Find the output intensity values for the given histogram of the input and output images. [5]

Intensity (input image)	Histogram of input image
0	0.19
1	0.25
2	0.21
3	0.16
4	0.08
5	0.06
6	0.03
7	0.02

Histogram of output image
0
0
0
0.15
0.20
0.30
0.20
0.15

Ans:

a) Any one of the compression technique can be explained. (KL Transform, DCT, Walsh Transform or Hadamard Transform). Other than KLT, you need to also explain the ways to apply basis function to an image.

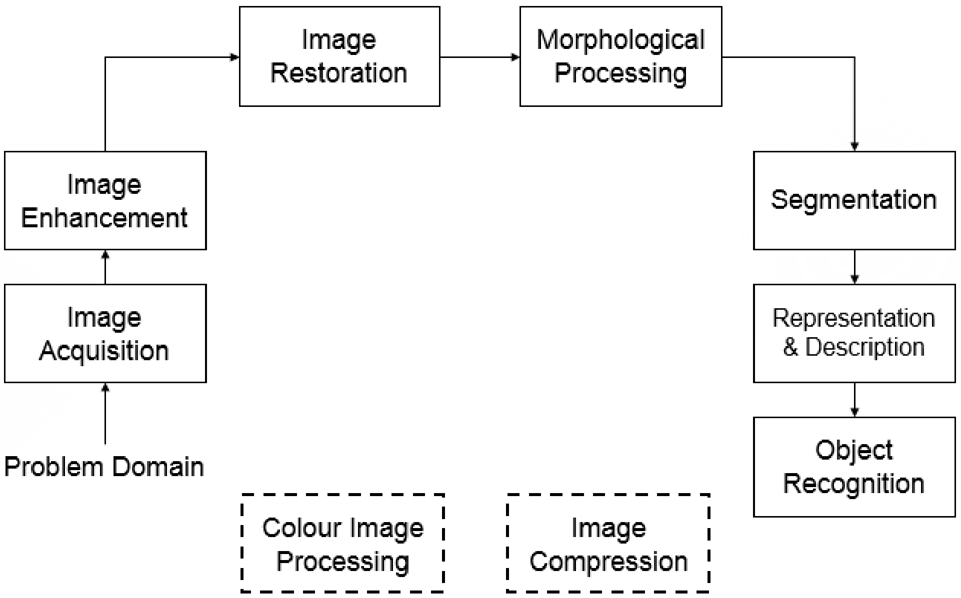
By removing some of the weak coefficients after performing the forward transform, the image can be reconstructed back approximately to the original form by using inverse transform to it. The removal of the coefficients results in compression of the image.

b)

Intensity (input image)	Histogram of input image	s	Histogram of output image	G	Output intensity
0	0.19	0.19	0	0	4
1	0.25	0.44	0	0	5
2	0.21	0.65	0	0	5
3	0.16	0.81	0.15	0.15	6
4	0.08	0.89	0.20	0.35	7
5	0.06	0.95	0.30	0.65	7
6	0.03	0.98	0.20	0.85	7
7	0.02	1	0.15	1	7

Q4. What are the stages through which an image passes in an image processing system? Briefly explain each stage. [5]

Ans:



You need to explain briefly about each blocks.

a) Image Acquisition : This is the first step or process of the fundamental steps of digital image processing. Image acquisition could be as simple as being given an image that is already in digital form. Generally, the image acquisition stage involves preprocessing, such as scaling etc.

b) Image Enhancement: Image enhancement is among the simplest and most appealing areas of digital image processing. Basically, the idea behind enhancement techniques is to bring out detail that is obscured, or simply to highlight certain features of interest in an image. Such as, changing brightness & contrast etc.

c) Image Restoration : Image restoration is an area that also deals with improving the appearance of an image. However, unlike enhancement, which is subjective, image restoration is objective, in the sense that restoration techniques tend to be based on mathematical or probabilistic models of image degradation.

d) Morphological Processing: Morphological processing deals with tools for extracting image components that are useful in the representation and description of shape.

e) Segmentation: Segmentation procedures partition an image into its constituent parts or objects. In general, autonomous segmentation is one of the most difficult tasks in digital image processing. A rugged segmentation procedure brings the process a long way toward successful solution of imaging problems that require objects to be identified individually.

f) Representation and Description: Representation and description almost always follow the output of a segmentation stage, which usually is raw pixel data, constituting either the boundary of a region or all the points in the region itself. Choosing a representation is only part of the solution for transforming raw data into a form suitable for subsequent computer processing. Description deals with extracting attributes that result in some quantitative information of interest or are basic for differentiating one class of objects from another.

g) Object recognition: Recognition is the process that assigns a label, such as, “vehicle” to an object based on its descriptors.

Q5. What is the difference between first order and second order derivative filter? [3]

Ans: Generally, the first order derivative operators are very sensitive to noise and produce thicker edges whereas 2nd Order Derivative filter have stronger response to finer details. If there is a significant spatial change in the second derivative, an edge is detected. 2nd Order Derivative operators are more sophisticated methods towards automatized edge detection, however, still very noise-sensitive. 1st order derivatives have stronger response to gray level step 2nd order derivatives produce double response to step changes.

Q6. a) The enhancement technique used to highlight specific range of intensities and suppress other intensity values is ***intensity level slicing***. [1]

b) Large value of gamma will produce ***darker*** image. (darker/brighter) [1]

c) Consider the two image subsets, S_1 and S_2, shown below. For V={1}, determine whether these two subsets are i) 4 adjacent ii) 8 adjacent iii) m adjacent [2]

	S_1				S_2				
0	0	0	0	0	0	0	1	1	0
1	0	0	1	0	0	1	0	0	1
1	0	0	1	0	1	1	0	0	0
0	0	1	1	1	0	0	0	0	0
0	0	1	1	1	0	0	1	1	1

Ans: 8 adjacent and m adjacent