University of Nottingham Malaysia

SCHOOL OF COMPUTER SCIENCE
A LEVEL 2 MODULE, SPRING SEMESTER 2022-2023

INTRODUCTION TO IMAGE PROCESSING (COMP 2032)

Time allowed: **ONE** Hour

Candidates may complete the front cover of their answer book and sign their desk card but must NOT write anything else until the start of the examination period is announced.

Answer ALL Questions

This module has 40% coursework assessment.

Marks available for sections of questions are shown in brackets in the right-hand margin.

No calculators are permitted in this examination.

Dictionaries are not allowed with one exception. Those whose first language is not English may use a standard translation dictionary to translate between that language and English provided that neither language is the subject of this examination. Subject specific translation dictionaries are not permitted.

No electronic devices capable of storing and retrieving text, including electronic dictionaries, may be used.

DO NOT turn your examination paper over until instructed to do so.

ADDITIONAL MATERIAL:

None

INFORMATION FOR INVIGILATORS:

Questions papers should be collected in at the end of the exam – do not allow candidates to take copies from the exam room.

1. Intensity Transform, Linear & Non-Linear Filtering & Thresholding [40%]

Figure 1

(a) Figure 2 is the results obtained when applying **gamma correction** onto Figure 1.

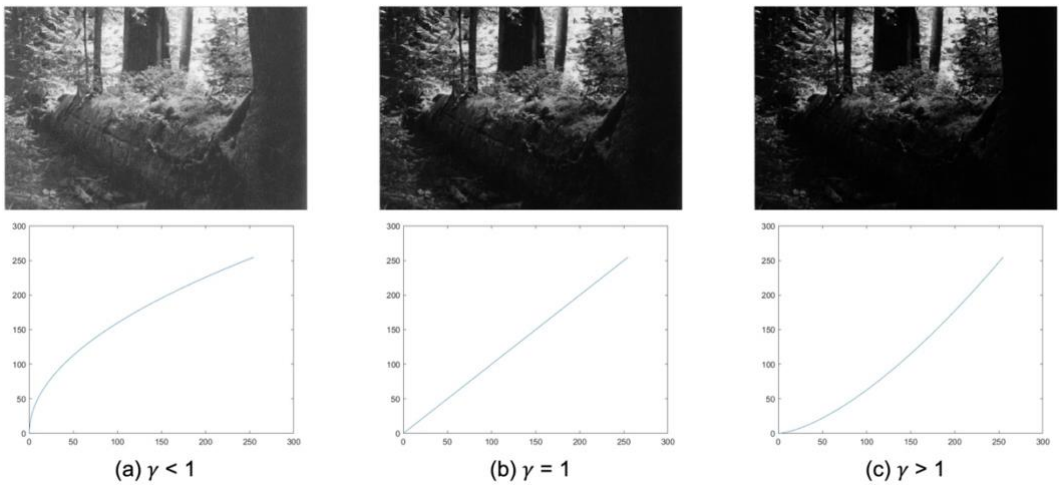

Figure 2

i. What is gamma correction, when is it needed and why? [**4 marks**]

ii. Based on your understanding of gamma correction, explain what is happening to the results presented in Figure 2. [**6 marks**]

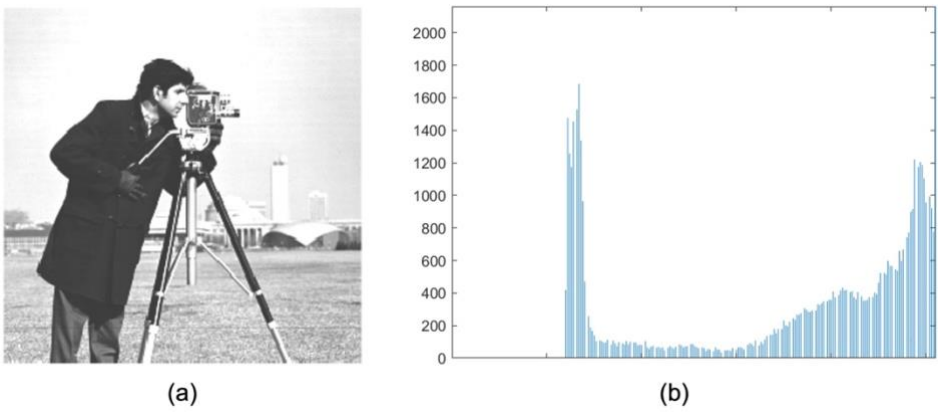

Figure 3

(b) In the context of linear intensity transforms, what are gain and bias? How do they affect Figure 3 (a) the appearance of the image and (b) its histogram? [**6 marks**]

P.T.O

(a) (b)

Figure 4

(c) Intensity transformation can operate on single pixels of an image as shown in Figure 4. Explain how you would convert a very dark image whose grey levels were in the range 50 – 100 to one that made use of the full range of available pixel values (0-255). What is this process called? [**4 marks**]

(d) The Gaussian function is famously used for filtering in Image Processing. What does it mean for a 2D filter to be separable? Explain why separability is a desirable property in image filtering. [**6 marks**]

(e) Explain the roles of the two Gaussian functions used in Bilateral filter, and the differences between the bilateral filter and a simple Gaussian filter in terms of the convolution masks they apply. [**10 marks**]

(f) In thresholding, the terms unimodal and bimodal are often associated to threshold. What are they? Given **an example** threshold to represent each. [**4 marks**]

2. Morphology and Edges [30%]

(a) Original (b) Dilate (c) Erode

Figure 5

(a) Figure 5 shows the results of performing dilation and erosion to an original image.
   i. What is dilation and erosion? [**3 marks**]
   ii. What are the input and process to obtain the results shown in Figure 5 (b) and (c), respectively? [**6 marks**]

(b) Sobel operator is a famous edge detection technique that is still in use to date. By providing example of the kernels used, **explain** how the following approximations of derivatives are calculated:
   i. **anti-diagonal** [**2 marks**]
   ii. **vertical** [**2 marks**]
   iii. **horizontal** [**2 marks**]

P.T.O

(c) Compute the result of applying the kernels you provided in (b)(i), (ii) and (iii) to the central pixel of the image fragment shown in Figure 6. Show your workings.
[**9 marks**]

53	49	47
50	52	48
51	47	49

Figure 6

(d) Canny operator effectively solves the edge detection problem. What makes the Canny operator an **optimal** solution? [**6 marks**]

3. Line Finding, Frequency Domain and Image Compression [30%]

(a) The Hough Transform is a general method which can in principle (though not always in practice) be used to detect any parameterizable curve. Explain how a Hough Transform based on the equation $\rho = x.\cos\theta + y.\sin\theta$ detect straight lines in a grey-level image? [**13 marks**]

(b) What difficulty would you face when attempting to detect vertical lines with a Hough Transform based on $y = mx + c$? [**5 marks**]

(c) How is filtering done in frequency domain? [**2 marks**]

(d) An image has the following normalised histogram, as listed in Table 1.

Table 1

Pixel Value	Normalised Frequency
0	0.2
1	0.05
2	0.35
3	0
4	0.15
5	0.1
6	0.05
7	0.1

Derive a Huffman code for each pixel value, showing how you obtained your code.
[**10 marks**]

END