University of Nottingham Malaysia

SCHOOL OF COMPUTER SCIENCE
A LEVEL 2 MODULE, SPRING SEMESTER 2021-2022

INTRODUCTION TO IMAGE PROCESSING (COMP 2032)

Time allowed: **ONE** Hour

An additional 30 minutes to cover IT issues and upload time

Answer ALL questions

Submit your answers containing all the work you wish to have marked as a **single PDF file, with each page in the correct orientation, to the appropriate Dropbox on the module's Moodle page.**

Use the standard naming convention for your document: **[Student ID]_[Module Code]**. Write your student ID number at the top of each page of your answers. Do not include your name.

Although you may use any notes or resources you wish to help you complete this open-book examination, the academic misconduct policy that applies to your coursework also applies here. You must be careful to avoid plagiarism, collusion, or false authorship. This statement refers to, and does not replace, the University policy which stipulates severe penalties for academic misconduct.

Staff are not permitted to answer assessment or teaching queries during the period in which your open-book examination is live. If you spot what you think may be an error on the exam paper, note this in your submission but answer the question as written.

IMPORTANT: Lateness penalties will not be applied, and late submission will not be accepted.

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

No calculators are permitted in this examination

1. Intensity Transform, Filtering & Thresholding [30%]

(a) (b)

Figure 1

(a) Intensity transformations operate on single pixels of an image for the purpose of contrast manipulation, as shown in Figure 1(a) and 1(b), respectively. Based on your understanding, explain the concept of **contrast manipulation,** inclusive of the commonly used formula. Please make sure to elaborate the parameters used in the formula. [**5 marks**]

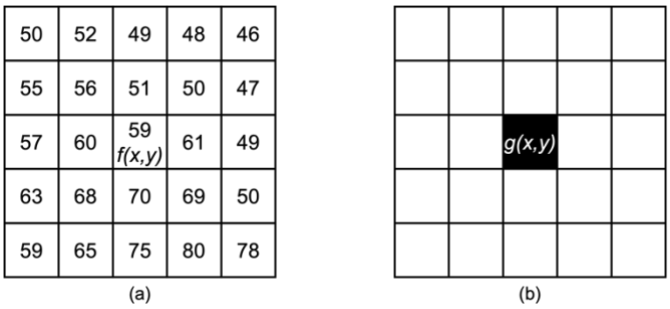

Figure 2

(b) Using the formula you introduced in (a), compute the value for *g(x,y)* in Figure 2(b), using intensity values provided in Figure 2(a). Please make sure you show your workings, listing the respective intensity values for each parameter(s) used. [**5 marks**]

(c) What is **convolution**? Please use examples to support your explanation [**5 marks**]

(d) Given the intensity of a local region, as shown in Figure 3 below:

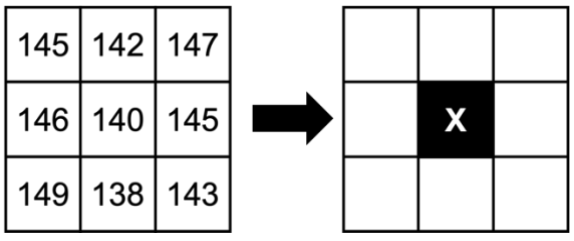

Figure 3

By showing your working, compute the value of **X** when using the following approach:

i. Mean filtering [**3 marks**]
ii. Median filtering [**3 marks**]

(e) What is Bilateral filtering? [**5 marks**]

P.T.O

(a) Input Image

(b) *Output 1*

(c) *Output 2*

Figure 4

(f) Results shown in Figure 4(b) and (c) is generated using the Otsu Thresholding method by using a threshold level of 0.09 and 0.75, respectively. What is Otsu Thresholding method? Explain why application of Otsu to Figure 4(a) produces the results seen in Figures 4(b) and (c)? [**4 marks**]

2. Derivatives, Edges and Whole Image Methods [40%]

(a) Explain the difference between 1st and 2nd derivative methods. Please indicate **one** associated filter for each measure. [**7 marks**]

(b) Based on your understanding of the 1st and 2nd derivative, complete Table 1:

Table 1

Raw Data	1st Derivative	2nd Derivative
9	-	-
9		
7		
5		
4		
3		
0		
8		
0		
1		
0		

[**10 marks**]

(c) Give the 3x3 Sobel filter for detecting **anti-diagonal** edges of an image. [**2 marks**]

(d) Compute the result of applying the filter you provided in (c) to the central pixel of the image fragment shown in Figure 5. Show your workings. [**3 marks**]

33	29	27
30	32	28
31	27	29

Figure 5

(e) What is the **significant difference** between histogram equalisation and contrast stretching in terms of transformation function? [**4 marks**]

P.T.O

(f) A 3-bit per pixel image has a normalised histogram as listed in Table 2.

Table 2

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

Apply histogram equalisation to this data, showing you working, and compute

i. The mapping from input pixel values to output pixel values
ii. The normalised histogram of the output image

[**14 marks**]

3. Segmentation and Superpixels [30%]

(a) Why and how do we perform **image segmentation**? [**2 marks**]

(b) What are the common approaches used to solve segmentation problems? Please provide **one** example algorithm for each approach listed. [**9 marks**]

(a) Input Image (b) Superpixels Regions

Figure 6

(c) Figure 6(b) is the result of applying a classical **superpixels** approach. Why is superpixels a better alternative to segmentation? Name the approached used to produce Figure 6(b)? [**4 marks**]

(d) How is the basic concept of Watershed applied to image segmentation? Please list all steps clearly. [**5 marks**]

P.T.O

5	4	4	3	3
3	5	3	4	3
2	3	5	2	4
1	2	3	5	1
1	1	2	3	5

Figure 7

(e) Consider the image fragment in Figure 7 (in which the numbers represent intensity values). Using letters of the alphabet to label regions, show how this image fragment would be segmented by the **Watershed** algorithm. [**10 marks**]

END