The University of Nottingham Ningbo China

SCHOOL OF COMPUTER SCIENCE

A LEVEL 2 MODULE, SPRING SEMESTER, 2019–2020

INTRODUCTION TO IMAGE PROCESSING

Time allowed 60 Minutes

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

Answer all THREE questions. The total mark is 60.

Only silent, self contained calculators with a Single-Line Display or Dual-Line Display are permitted in this examination.

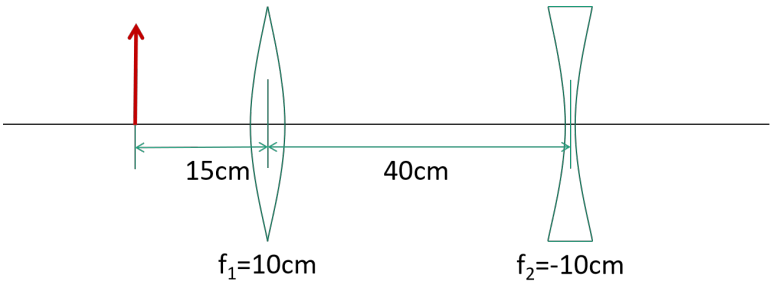
Dictionaries are not allowed with one exception. Those whose first language is not English may use a standard translation dictionary to translate between that language and English provided that neither language is the subject of this examination. Subject specific translation dictionaries are not permitted.

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

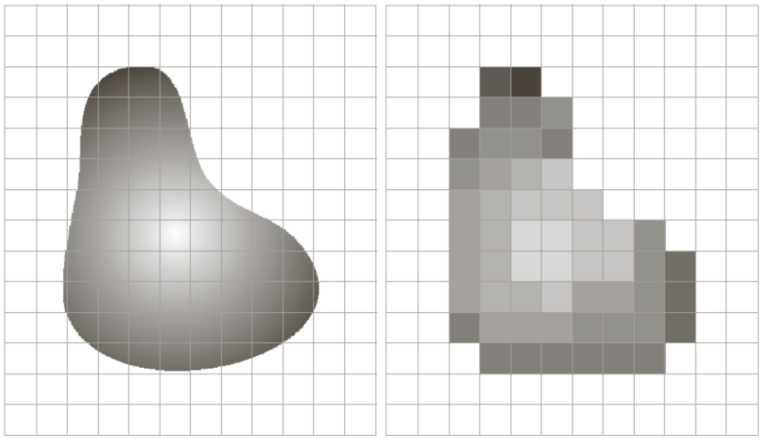
DO NOT turn examination paper over until instructed to do so

Question 1 (20 marks)

(a) Given a convex lens whose focal length is 10 cm, a concave lens whose focus length is -10cm, the object is 15 cm in front of the convex lens, and the distance between two lenses is 40cm, **find where is the image. State whether the image is real or virtual**. (7 marks)



(b) Based on the images given below, briefly describe the meaning of **spatial sampling** and **intensity quantisation** when converting the natural (analog) image on the left into the digital image on the right. (4 marks)



(c) Briefly describe the meaning of **super-resolution**. optional ? (2 marks)

(d) Briefly describe **the meaning of three channels** of the LAB colour space, and the **key motivation** of the LAB colour space. (4 marks)

(e) Explain what **linear intensity transforms** are, and how **bias** and **gain** affect the appearance of image. (3 marks)

Question 2 (20 marks)

(a) The pixel values of a small 5×5 image patch are shown below. Compute the output of the **center** pixel for the following spatial filtering operations (approximate your answer to the nearest integer).

1	2	3	2	1
2	3	4	3	2
3	4	**5**	3	3
2	13	4	3	2
1	2	3	2	1

(i) 3×3 median filter (2 marks)

(ii) 3×3 mean filter (2 marks)

(iii) Laplacian enhancement filter with the following filter mask.

-1	-1	-1
-1	9	-1
-1	-1	-1

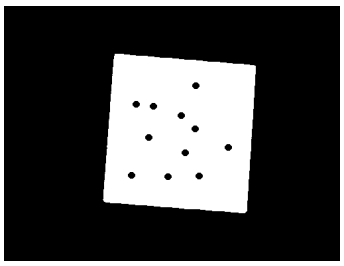
(2 marks)

(b) 1st order derivative filter and 2nd order derivative filter are often used to detect edges in images. Briefly describe what patterns in the filtered images should be detected as edges for these two filters, respectively. (2 marks)

(c) State the **four major steps** of the Canny edge detector and illustrate the **functionality** of each step. (8 marks)

(d) Briefly describe the procedures of removing the black hole in the binary image shown below using **morphological operations**, without disrupting the image structure.

(4 marks)



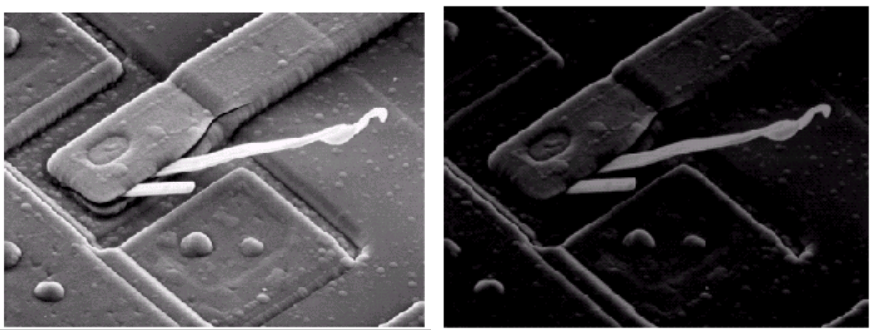
Question 3 (20 marks)

(a) A 3-bit image has a histogram as listed in the following table:

Pixel value	% of pixels	Output value
0	5%	
1	6%	
2	7%	
3	8%	
4	9%	
5	10%	
6	44%	
7	11%	

What will be the corresponding output pixel values after applying the histogram equalization on this image? (8 marks)

(b) Given the image on the left, which filter, low-pass filter or high-pass filter, could be used to obtain the image on the right? Briefly justify your answer. (4 marks)



(c) Use Huffman coding to encode the follow message: "**amalgamate**". What is the **entropy** of this messege? What is the **average number of bits per code** of the encoded message? (Round your answer to 2 decimal places.)

Character	Count	Probability	Huffman code
a			
m			
l			
g			
t			
e			

(8 marks)