The University of Nottingham

SCHOOL OF COMPUTER SCIENCE

A LEVEL 2 MODULE, AUTUMN SEMESTER 2015-2016

INTRODUCTION TO IMAGE PROCESSING

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 THREE Questions from FOUR

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: NONE

1. Image Enhancement

(a) In the context of linear intensity transforms, what are gain and bias?

(2 marks)

How do they affect

i) the appearance of an image and
ii) its histogram?

(6 marks)

(b) A 3-bit per pixel image has a normalized histogram as listed in the following table

Pixel value	Normalized frequency
0	0.1
1	0.4
2	0.2
3	0.1
4	0.1
5	0
6	0
7	0.1

Apply histogram equalization to this data, showing the mapping from input pixel values to output pixel values and how you obtained it.

(12 marks)

2. Image Filtering

(a) Many image processing operations rely on convolution of the image with some operator. Briefly describe the convolution process as performed in the spatial domain.

(4 marks)

(b) Compute the result of applying

i) a 3 x 3 mean filter
ii) a 3 x 3 median filter

to the image fragment shown below

9	8	6
9	6	3
8	5	1

(6 marks)

(c) Explain how the second derivative Laplacian filter is used to construct an edge enhancement filter.

(10 marks)

3. **Thresholding and Binary Image Processing**

(a) When thresholding an image to produce a binary image, manual determination of a suitable threshold can be difficult. Many automatic threshold determination techniques have therefore been developed. Briefly describe the principle behind and operation of Rosin's Unimodal method.

(8 marks)

(b) Thresholding produces binary images. These are often noisy, in the sense that they contain incorrectly classified pixels. The mathematical morphology operations of erosion and dilation can be used to reduce such effects. The image fragment below shows a binary image in which pixels labelled 1 are considered foreground and those labelled 0 are considered background.

0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	1	0	0
0	0	1	1	0	0
0	0	0	0	0	0
0	0	0	0	0	0

image fragment

Briefly explain the algorithm used to erode the foreground of a binary image, and show the result of applying this algorithm to this image fragment using the structuring element shown below.

1	1	1
1	1	1
1	1	1

structuring element

(8 marks)

(c) How can dilation be used to detect image edges?

(4 marks)

4. Image Compression

(a) Sketch a block diagram of a general image compression system, briefly describing each component.

(10 marks)

(b) An image has the following normalized histogram. Derive a Huffman code for each pixel value, showing how you obtained your code.

Pixel value	Normalised Frequency
0	0.3
1	0.2
2	0.2
3	0.1
4	0.1
5	0.05
6	0.05
7	0

(10 marks)

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