The University of Nottingham

SCHOOL OF COMPUTER SCIENCE

A LEVEL 2 MODULE, SPRING SEMESTER 2017-2018

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 ALL THREE Questions

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. Histogram-based Methods

(a) What is the goal of histogram equalization?

(2 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	0.5
2	0.1
3	0.1
4	0.1
5	0
6	0.05
7	0.05

Apply histogram equalization to this data and show

(i) the mapping from input pixel values to output pixel values
(ii) the normalised histogram of the output image

(10 marks)

(c) Why are colour histograms considered to be good representations upon which to base image retrieval methods?

(6 marks)

(d) Two images are being compared using Histogram Intersection. Their histogram representations are H1: [10,20,0,0,5,5,5] and H2: [5, 25, 4, 3, 5, 10, 2]. What score does Histogram Intersection assign to this match?

(2 marks)

2. 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)

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

(4 marks)

3. Image Filtering and Enhancement

(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.

(5 marks)

(b) Compute the result of applying

i) a 3 x 3 mean filter
ii) a 3 x 3 Sobel filter measuring gradient in the horizontal direction (to highlight vertical lines)
iii) a 3 x 3 Laplacian filter

to the central pixel in the image fragment shown below

7	8	4
8	6	3
8	5	1

(6 marks)

(c) Explain with the aid of a diagram how Gaussian smoothing may be used to enhance image edges via unsharp masking.

(5 marks)

(b) What does it mean to say that the 2D Gaussian filter is "separable"?

(4 marks)