The University of Nottingham

SCHOOL OF COMPUTER SCIENCE

A LEVEL 2 MODULE, SPRING SEMESTER 2010-2011

INTRODUCTION TO IMAGE PROCESSING

Time allowed: **Two Hours**

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

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 your examination paper over until instructed to do so

Question 1

(a) Image Processing, Computer Vision and Computer Graphics are three closely related disciplines. Briefly explain what they have in common and how they differ from each other.

(6 marks)

(b) In the context of digital image processing, explain the concepts of **sampling** and **quantization**, and discuss how they may affect the visual appearance of a digital image.

(8 marks)

(c) Explain the following statement and briefly discuss its implications for image processing.

"Subjective brightness is a logarithmic function of the light intensity incident on the eye".

(6 marks)

Question 2

(a) Let $I(x, y)$, x=1, 2, …, M, y = 1, 2, …N, be an M x N grayscale image, the pixel values are within the range $0 \leq I(x, y) \leq 1$. The image is processed by the following point processing to produce a new image $I'(x, y)$

$$I'(x,y) = [I(x,y)]^r$$

Discuss how you will choose the value of r in order to make the dark regions of the input image more visible in the output. You must justify your answer.

(10 marks)

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

Pixel Value	% of pixels
0	0%
1	70%
2	10%
3	5%
4	5%
5	5%
6	5%
7	0%

Histogram equalization is applied to process the image. List the histogram of the output image and discuss whether histogram equalization is a suitable processing for this image. You must explain and justify your conclusions.

(10 marks)

Question 3

(a) Sketch the steps of a frequency domain low-pass filtering operation. Using illustrations and diagrams as appropriate. Your answer must contain sufficient details.

(5 marks)

(b) Down-sampling an image can cause aliasing artifact. To avoid aliasing, one can first apply a low-pass filtering operation and then down sample the filtered image. True or False? Discuss and justify your answer.

(10 marks)

(c) Sketch the concept of bilateral filtering and explain why it is often better than Gaussian filtering.

(5 marks)

Question 4

The major building blocks of JPEG image compression is illustrated in Fig.Q4.

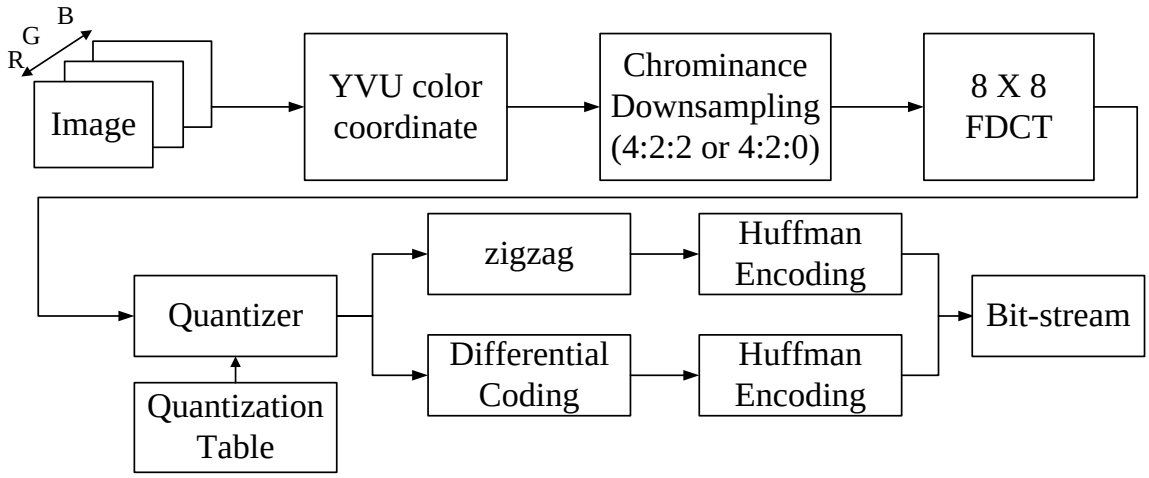

Fig.Q4

(a) Briefly describe the operations within the "Chrominance Downsampling" block and explain why these operations are included.

(8 marks)

(b) Explain the purposes of the "Quantizer + Quantization Table" blocks and discuss the principles of designing the quantization table.

(12 marks)

Question 5

(a) Sketch the principles of Laplacian of Gaussian (LoG) edge detection. Give as much detail as possible.

(6 marks)

(b) Design a simple 3 x 3 filter to detect the horizontal edges. Using the following 6x6 image as an example, explain how edge detection using the filter you have just designed works.

100	100	100	10	10	10
100	100	100	10	10	10
100	100	100	10	10	10
100	100	100	100	100	100
100	100	100	100	100	100
100	100	100	100	100	100

(6 marks)

5 Using a simple example, sketch how a connected component labeling algorithm works.

(8 marks)

End