UNIVERSITY OF LONDON

GOLDSMITHS COLLEGE

B. Sc. Examination 2011

Creative Computing

IS52020A (CC227) Creative Computing 2

Duration: 3 hours

Date and time:

There are six questions in this paper. You should answer no more than four questions. Full marks will be awarded for complete answers to a total of four questions. Each question carries 25 marks. The marks for each part of a question are indicated at the end of the part in [.] brackets.

There are 100 marks available on this paper.

This is a practical examination; each answer requiring code or other computational material should be named according to question number, part and sub-part: for example, `Q5_b_2.pde` *for a Processing sketch in answer to part (b) sub-part (ii) of question 5. Save your answer to the exam submission folder. You are responsible for ensuring that your answers have been saved in the correct location.*

THIS PAPER MUST NOT BE REMOVED FROM THE EXAMINATION ROOM

Question 1 Colour Perception

(a) Describe the opponent model of colour perception, and briefly describe **two** aspects of colour perception that the opponent model assists in explaining. [6]

(b) Describe the intended function of the CIE LAB colour space. Include in your answer interpretations of the meanings of the $L*$, $a*$ and $b*$ 'directions' in the colour space. [6]

(c) Two colours have CIE xyY (chromaticity-luminance) coordinates

- colour A: $x = 0.43$, $y = 0.46$, $Y = 45$
- colour B: $x = 0.20$, $y = 0.12$, $Y = 14$

Using the equations below and your own knowledge, convert these colour specifications into CIE LAB coordinates, assuming reference values for X_0, Y_0 and Z_0 of 100. [9]

(d) Which of the two colours A and B would you use to contrast against a colour specified by CIE LAB coordinates $L* = 59$, $a* = 20$, $b* = 40$? Explain your reasoning. [4]

The conversion from CIE XYZ to CIE LAB coordinates is defined as follows:

$$\text{let } f(t) = \begin{cases} \sqrt[3]{t} & t > \left(\frac{6}{29}\right)^3 \\ \frac{1}{3}\left(\frac{29}{6}\right)^2 t + \frac{4}{29} & \text{otherwise} \end{cases}$$

$$\begin{aligned} L^* &= 116 f\left(\frac{Y}{Y_0}\right) - 16 \\ a^* &= 500\left[f\left(\frac{X}{X_0}\right) - f\left(\frac{Y}{Y_0}\right)\right] \\ b^* &= 200\left[f\left(\frac{Y}{Y_0}\right) - f\left(\frac{Z}{Z_0}\right)\right] \end{aligned}$$

Question 2 Digital Music

Write a short essay on **each** of the following topics: [25]

i. Information stored in digital music files;

ii. Information Retrieval for sound and music.

Each essay is worth half the marks for this question.

Question 3 Systems and Convolution

(a) In the context of Linear Time-Invariant Systems, define the following terms:

i. unit impulse; [2]

ii. impulse response; [2]

iii. unit delay. [2]

(b) Define the convolution of two signals, and explain how it can be used to compute the response of a Linear Time-Invariant system to an input signal $x(t)$, given the impulse response $h(t)$ of that system. [4]

(c) A particular implementation of convolution by direct computation takes 0.9s to compute the convolution of two signals of length 1024. Estimate how long the same implementation would take to convolve two signals of length 2048. [3]

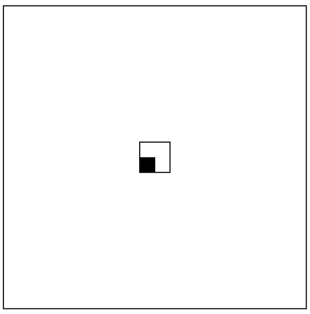
(d) Explain how the Fourier Transform and its inverse can be used to implement convolution. [3]

(e) Explain how the Fast Fourier Transform can be used to implement convolution more efficiently than direct computation. [4]

(f) The following matrix represents the kernel of an image filter.

$$\begin{pmatrix} 0 & 0 & 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 1 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 1 & 0 & 0 & 0 & 0 & 0 & 0 \end{pmatrix}$$

Draw the result of applying this filter to the image below, and name the effect generated by the filter. [5]



Question 4 Information Retrieval

(a) Describe how

i. stopword removal; [2]

ii. Levenshtein distances; [2]

are used in the context of text-based Information Retrieval.

(b) Calculate the Levenshtein distance between the words ‘`comments`’ and ‘`command`’, when

i. the cost for additions and deletions is 1 and that for substitutions is 0.5; [4]

ii. the cost for additions and deletions is 1 and that for substitutions is 2.5. [2]

(c) The provided folder contains the retrieved set of images for a textual query of ‘`ship`’. For each retrieved image, state whether it should be considered a true positive, a false positive, a true negative, or a false negative for this query. (Include a brief explanation in uncertain cases.) [6]

(d) Calculate the precision and recall for this query, in the cases that

i. the database contains 200 images, of which 7 are of ships; [2]

ii. the database contains 100,000 images, of which 3829 are of ships. [2]

(e) In which of the two scenarios above should precision be considered more important than recall? Explain your answer. [5]

Question 5 Signals and Hearing

(a) Two sinusoidal signals of the same amplitude, one with frequency 439Hz and one with frequency 441Hz are played simultaneously through the same audio channel. Describe, as precisely as you can, what someone listening to this would hear. [4]

(b) What would the listener hear if the signals from part (a) were modified to have frequencies 219.5Hz and 220.5Hz respectively? [2]

(c) What would the listener hear if the signals from part (a) instead were played separately, one in each stereo channel, listened to on headphones? [4]

(d) Describe, in terms of the structure of the inner ear, how human hearing can decompose sound into different frequency components. [4]

(e) For each of the musical notes with fundamental frequencies 220Hz, 275Hz and 330Hz, tabulate the harmonics of those fundamentals below 1200Hz. [3]

(f) The critical bandwidth of regions of the basilar membrane is given by

$$b = 24.7 \times (4.37\frac{f}{1000} + 1)$$

where b and f are measured in hertz. Calculate the critical bandwidth at 825Hz and at 1100Hz, and hence explain why the musical interval between notes whose fundamentals have a 5:4 ratio with each other is considered more dissonant than that between notes with a 3:2 fundamental ratio. [8]

Question 6 Animation

(a) Briefly describe the following animation techniques, both with respect to traditional and to computer-aided animation.

i. Cel animation; [4]

ii. Keyframing. [6]

(b) You are provided with an image to form the background to an animation. The image is 2500 pixels wide and 238 pixels high; the viewing window is to be 300 pixels wide and 238 pixels high, will start at the background's left-hand edge, and will move 22 pixels rightwards per frame.

i. Calculate the duration (in frames) of the animation. [2]

ii. Write a *Processing* sketch to display this animation of the background. [5]

(c) The foreground to this animation is a filled black circle of radius 2, with the following key frames:

Frame	Center (x, y)
0	(10,238)
30	(10,58)
90	(250,58)

Extend your answer to part (b) to include this foreground animation, using linear interpolation to place the circle between keyframes, and keeping the circle stationary in frames after the final keyframe. [8]

Linear interpolation between coordinates x_0 and x_1 at times t_0 and t_1 can be performed using:

$$x(t_0 < t < t_1) = x_0 + \frac{t - t_0}{t_1 - t_0}(x_1 - x_0)$$