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 PAPER MUST NOT BE REMOVED
FROM THE EXAMINATION ROOM

Question 1 Colour Systematization

(a) Describe the HSB representation of colour, including its spatial representation. [5]

(b) Describe the intended function of the CIE XYZ colour space. Include in your description any relevant features of the primaries in that space. [6]

(c) State Grassmann's empirical laws of colour vision with respect to coloured lights, and describe the conditions under which they hold. [5]

(d) Two reference lights have CIE XYZ coordinates as follows

- light A: $X = 40$, $Y = 100$, $Z = 60$
- light B: $X = 70$, $Y = 100$, $Z = 30$

Describe how to use those two reference lights to match a light with XYZ coordinates

i. $X = 60$, $Y = 100$, $Z = 40$; [3]

ii. $X = 10$, $Y = 100$, $Z = 90$. [3]

(e) Using a suitable example, or otherwise, explain why three reference lights are needed in general to be able to match any given light. [3]

Question 2 Sound and Music

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

i. audio compression;

ii. melody, harmony and rhythm.

Each essay is worth half the marks for this question.

Question 3 Systems and Convolution

(a) In the context of systems, define the properties:

i. linearity; [2]

ii. time-invariance; [2]

iii. linear time-invariance. [1]

(b) Define using mathematical notation the convolution of two signals. 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. Explain how convolution can be implemented in terms of the delay, scale and sum basic signal processing operations. [6]

(c) A particular implementation of convolution by direct computation takes 0.7s to compute the convolution of two signals of length 1024. Estimate how long the same implementation would take to convolve two signals of length 4096. [3]

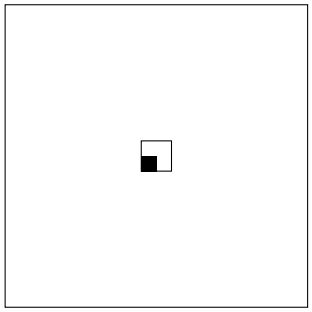
(d) Explain in words the Fourier Transform and inverse Fourier Transform. [4]

(e) Explain how the Fourier Transform and its inverse can be used to implement convolution. [2]

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

$$\begin{pmatrix} 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0.7 & 0 & 0 & 0 & 0 \\ 0 & 0.5 & 0 & 0 & 0 & 0 & 0 \\ 0.3 & 0 & 0 & 0 & 0 & 0 & 0 \end{pmatrix}$$

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) Outline how text-based Information Retrieval techniques can be used to build a spelling checker. [4]

(b) Calculate the Levenshtein distance between the words '`copter`' and '`chopper`', 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 appendix contains a subset of the images in a database. A user enters the textual query '`house`' in a content-based search of this database. State whether each image 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 300 images, of which 11 are of houses; [2]

ii. the database contains 77,000 images, of which 9283 are of houses. [2]

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

Images used in this question were taken by Dave Adams, Stefano A., Andy Roberts, Isidro Vila Verde and Ryan Woolies, and used here under the terms of the Creative Commons Attribution 2.0 Licence.

Question 5 Signals and Hearing

(a) Describe, in terms of the structure of the inner ear, how human hearing can decompose sound into different frequency components. [8]

(b) Beating is a phenomenon which occurs when two sinusoids with frequencies that are close to each other are superimposed. Describe as precisely as you can what a listener would hear if two sinusoidal signals of the same amplitude, one with frequency 439Hz and one with frequency 441Hz were played simultaneously through the same audio channel. [4]

(c) Describe what you would expect the listener to hear if the two signals were played separately over headphones, one sinusoid in each stereo channel? What would this tell you about where beating occurs in the auditory system? [4]

(d) The first few harmonics of three fundamental frequencies are listed in the following table:

196Hz	245Hz	294Hz
392Hz		
	490Hz	
588Hz		588Hz
	735Hz	
784Hz		
		882Hz
980Hz	980Hz	

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 735Hz and at 882Hz, 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. [9]

Question 6 Animation

(a) Describe the perceptual effects known as *beta motion* and the *phi phenomenon*, with particular reference to typical timescales and the responses that they elicit. [6]

(b) You are provided with an image to form the background to an animation. The image is 2900 pixels wide and 483 pixels high; the viewing window is to be 200 pixels wide and 483 pixels high, will start at the background's left-hand edge, and will move 18 pixels rightwards per frame; the animation will stop when the viewing window's right edge meets the right-hand edge of the background.

Calculate the number of frames in the animation. [3]

(c) The foreground to an animation consists of a filled black circle of radius 7, presented at a frame-rate of 5 Hz with the following key frames:

Frame	Center (x, y)
0	(93,19)
50	(457,19)
150	(457,71)

i. how long does the animation last? [2]

ii. Using the following formula for linear interpolation between coordinates x_0 and x_1 at times t_0 and t_1:

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

compute the circle's position in pixels after:

5s; [2]

25s; [2]

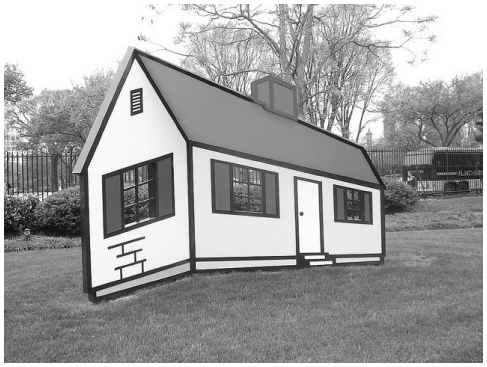
(d) Linear interpolation has an undesirable side effect that can be solved using *csplines*. Describe the problem and explain how splines provide a solution. [5]

(e) Describe the animation technique known as *physical modelling*, giving an example where the technique is applicable and one where physical modelling is unsuitable. [5]

Appendix

These are the images referred to in question 4.

1. 

2. 

3. 

4. 

5.