UNIVERSITY OF LONDON

GOLDSMITHS COLLEGE

B. Sc. Examination 2009

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 exam; each answer requiring code should be saved in a Processing sketch named by question number, part and sub-part: for example, `Q5_b_2.pde` *for 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.*

Question 1 Digital Images and Colour Spaces

(a) Describe what is meant by a device-dependent colour space and a device-independent colour space, giving two examples of each. [7]

(b) Describe in detail how digital images are encoded so as to allow faithful reproduction on consumer display hardware. [6]

(c) A three-colour design is made of colours specified in CIE xyY (chromaticity-luminance) colour space as

- $\{0.62, 0.33, 0.22\}$;
- $\{0.30, 0.59, 0.22\}$; and
- $\{0.16, 0.08, 0.03\}$.

By first converting the colour specifications into the CIE XYZ colour space, and then applying the transformation given below, transform these colour specifications into the sRGB colour space, and comment on the choice of colours. [12]

Transformation from CIE XYZ values to sRGB is achieved by a matrix multiplication

$$\begin{pmatrix} R_l \\ G_l \\ B_l \end{pmatrix} = \begin{pmatrix} 3.2410 & -1.5374 & -0.4986 \\ -0.9692 & 1.8760 & 0.0416 \\ 0.0556 & -0.2040 & 1.0570 \end{pmatrix} \begin{pmatrix} X \\ Y \\ Z \end{pmatrix}$$

followed by a non-linear scaling

$$C_{\mathrm{sRGB}} = \begin{cases} 12.92 C_l & C_l < 0.00304 \\ 1.055 C_l^{1/2.4} - 0.055 & \text{otherwise} \end{cases}$$

Question 2 Multimedia Information Retrieval

(a) In the context of Multimedia Information Retrieval, what is a *feature*? Give an example of a scalar feature and an example of a vector feature in each of the image and audio domains. [8]

(b) A collection of images is stored on disk; in addition, you may assume that a representation in CIE $L^*a^*b^*$ space of each image's predominant colour has been precomputed.

(i) Describe a data structure and an algorithm that will allow the retrieval of the image whose predominant colour is perceptually closest to a query colour given; [6]

(ii) Comment on the efficiency of your solution to part b(i) above; [3]

(iii) The database contains four images, with predominant $L^*a^*b^*$ colour coordinates $\{\{47.3, 12.2, 49.5\}, \{61.3, -16.2, 57.9\}, \{57.7, 37.9, 53.8\}, \{41.7, -12.1, 43.2\}\}$ corresponding to filenames {`first.png`, `second.png`, `third.png`, `fourth.png`} respectively. Which filename should be retrieved for a query colour with $L^*a^*b^*$ coordinates $\{51.7, -14.2, 50.7\}$? [8]

Question 3 Signals and Octave

(a) What is a signal? Give an example of a one-dimensional signal and one example of a three-dimensional signal. [3]

(b) Describe the difference between continuous-time and discrete-time signals. [3]

(c) Explain how a one-dimensional discrete-time signal can be represented as a vector in *Octave*. Include in your answer how to relate the *Octave* vector index to a moment in time. [4]

(d) The provided data file contains a record of the daily average temperature for London over 14 years, as an *Octave* variable. Using the `load` function, import that signal into your *Octave* session. Some of the data points are missing, indicated by an entry having the value -99; manipulate the signal so that the value for that day is the value of the day before, and save the result using the `save` function. [6]

(e) By taking the Fourier Transform of the signal from your answer to part (d), or otherwise, identify the period of the highest-amplitude sinusoidal oscillation present in the signal. Describe your method, and comment on your answer. [9]

Question 4 Sound and Hearing

Write a short essay on **each** of the following topics. You may wish to include diagrams to help you in your descriptions. [25]

(a) the ear and the function of its components relating to sound perception;

(b) audio compression.

Each essay is worth half the marks for this question.

Question 5 Filters and Convolution

(a) In the context of signal processing, what is a *filter*? Give one example of a filter commonly used in musical audio signal processing. [4]

(b) Define, either in words or in symbols, the convolution of two one-dimensional signals x and h. [3]

(c) Describe how a Finite Impulse Response filter can be implemented using the convolution operator. [3]

(d) A filter for images has the kernel

$$\frac{1}{4}\begin{pmatrix} 0 & 0 & 0 & 1 \\ 0 & 0 & 1 & 0 \\ 0 & 1 & 0 & 0 \\ 1 & 0 & 0 & 0 \end{pmatrix}$$

Using *Octave*, write a function to implement the processing of a grayscale image with this filter. You may assume that your function receives a two-dimensional matrix argument representing the pixel data, one element per pixel, and should return the new image in the same format. [8]

(e) Apply this filter to the data in the image file provided, and save the resulting image data to file in `png` format. [5]

(f) What effect does the filter in part (d) represent? [2]

Question 6 Animation

(a) construct a *Processing* sketch as follows: [5]

- the sketch has dimensions 800×500;
- along the whole of the bottom of the sketch is a right-angled triangle filled in black, forming a 26.6° slope downwards to the right;
- centered at (0,89) is a green circle of radius 10, itself containing a yellow circle of radius 2 centered at (0,84).

(b) starting from your answer to part (a), construct a sketch with a linearly-interpolated keyframed animation of the circles, such that the centre of the green circle is at the following positions at the given times: [12]

time in seconds	centre coordinates
0	(0,89)
1	(10,94)
2	(40,109)
3	(90,134)
4	(160,169)
5	(250,214)
6	(360,269)
7	(490,334)
8	(640,409)
9	(810,494)

(c) The sketch in part (b) is intended to represent the rolling of a cylinder down an inclined plane. Discuss the successes and failures of the sketch in this respect, and suggest ways to improve it. [8]

You may find the following expression for linear interpolation helpful:

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