THIS PAPER IS NOT TO BE REMOVED FROM THE EXAMINATION HALLS

UNIVERSITY OF LONDON **291 0227 ZB**

BSc/Diploma Examination
for External Students

CREATIVE COMPUTING

Creative Computing II: interactive multimedia

Dateline: Friday 22 May 2009 : 2.30 – 5.30 pm

Duration: 3 hours

There are six questions in this paper. Candidates should answer **FOUR** questions. All questions carry equal marks and full marks can be obtained for complete answers to **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.

A hand held calculator may be used when answering questions on this paper but it must not be pre-programmed or able to display graphics, texts or algebraic equations. The make and type of machine must be stated clearly on the front cover of the answer book.

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

- {0 276, 0.168, 0 25}
- {0 420, 0.420, 0.25}; and
- {0.300, 0 500, 0.50}.

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

$$C_{\mathrm{sRGB}} = \begin{cases} 12.92C_l & C_l < 0.00304 \\ 1\ 055C_l^{1/2\ 4} - 0.055 & \text{otherwise} \end{cases}$$

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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 audio files is stored on disk; in addition, you may assume that each sound file has had its average (root-mean-square) amplitude precomputed.

(i) Describe a data structure and an algorithm that will allow the retrieval of the sound file whose root-mean-square amplitude is perceptually closest to a query amplitude [7]

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

(iii) The disk store contains four sound files, with root-mean-square amplitudes {0.6, 0.5, 0.44, 0.39} corresponding to filenames {`first.wav`, `second.wav`, `third.wav`, `fourth.wav`} respectively. Which filename should be retrieved for a query root-mean-square amplitude of 0.4695? [7]

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) A sound signal is measured using a microphone at a sampling rate of 8kHz, and the measurements stored in an *Octave* vector named `s`. If the sound signal in continuous time is given by

$$\frac{1}{6}\sin(830\pi t) + \frac{1}{10}\sin(1660\pi t)$$

and the first sample is taken at $t = 0$, give an *Octave* expression to construct the same measured values for a sampling period of two seconds. [4]

(e) Compute the value of the following Octave expressions, where `s` names the signal measurement vector as above.

(i) `s[1];`

(ii) `s[2];`

(iii) `s[50];`

(iv) `s[8001];`

[6]

(f) For the continuous-time signal given by

$$\frac{1}{6}\sin(16830\pi t) - \frac{1}{15}\sin(14340\pi t)$$

sampled as above and stored in the *Octave* vector `v`, compute the values of the `v[2]` and `v[50]` that would be measured, and comment on how your answers relate to the answers in part (e) [5]

Question 4 Sound and Hearing

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

(a) melody, harmony and rhythm;

(b) digital music file formats

Each essay is worth half the marks for this question.

Question 5 Filters and Convolution

(a) In the context of systems and signal processing, define the following terms:

  (i) impulse response; [3]

  (ii) a linear system; [3]

  (iii) a time-invariant system; [3]

  (iv) an LTI system [1]

(b) An LTI system applied to images has the kernel

$$\frac{1}{3}\begin{pmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{pmatrix}$$

State the format of the representation of grayscale image data in *Octave*, and write a function for *Octave* to implement processing a grayscale image with this filter, returning as its single result the processed image data in the same format. [9]

(c) What effect does the filter in part (b) represent? Justify your answer. [6]

Question 6 Animation

(a) In the context of cinematic projection, explain the difference between *frame rate* and *flicker rate*, including in your explanation the different perceptual effects causing the distinction to be necessary, and typical rates chosen in current systems [8]

(b) A two-dimensional animation of a cylinder rolling down a slope is to be made. The lead animator decides to identify a number of key frames, and you are required to generate the frames in between these key frames

The cylinder's centre position in pixels is given by the following table:

time / seconds	coordinates
0	(86.6, 50)
1	(80.9, 46 7)
2	(64.0, 36.9)

Using the following formula for linear interpolation

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

compute the cylinder's positions in pixels by interpolation between these given values for a two-second animation at a frame rate of 3Hz. [8]

(c) Assess how realistically the animation generated in this way would represent the intended scene; for any problems that you identify, suggest a way of improving the animation. [9]