UNIVERSITY OF LONDON

GOLDSMITHS COLLEGE

Department of Computing

B. Sc. Examination 2014

IS52020A/B
Creative Computing 2 / Perception and Multimedia Computing

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

(a) Describe as precisely as possible Grassman's axioms of colour perception for each of the following properties: [3]

- additivity
- proportionality
- transitivity

(b) When do Grassman's axioms hold? [2]

(c) Why do Grassman's laws matter for digital colour production? [2]

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

(e) Describe the intended function of the CIE LAB colour space, and say how it relates to the CIE XYZ colour space. Include in your answer interpretations of the meanings of the $L*$, $a*$ and $b*$ 'directions' in the colour space. [7]

(f) Three colours have the following CIE LAB coordinates:

- Colour A: $L* = 78, a* = -70, b* = 30$
- Colour B: $L* = 52, a* = 81, b* = -39$
- Colour X: $L* = 63, a* = 60, b* = -10$

Which colour—A or B—would you choose if you needed a high contrast against colour X? Explain your reasoning. [5]

Question 2 Animation

(a) Keyframe animation and physical modeling

i. Describe how keyframe animation is used in digital animation to animate the position of an object over time. [3]

ii. Describe how physical modeling is used in digital animation to animate the position of an object over time. [3]

iii. Describe one scenario in which keyframe animation would be preferable, and one in which physical modeling would be preferable. Justify your answers. [2]

(b) Imagine you are being asked to use **linear interpolation** to animate an object that appears at point $(10, 50)$ at time $t = 0$ and at point $(30, 20)$ at time $t = 100$. Complete the equations below to express $x(t)$, the x-coordinate of the object at time t, and $y(t)$, the y-coordinate of the object at time t, for any values of t between 0 and 100. (That is, don't worry about your equation being valid for $t < 0$ or $t > 100$). [4]

- $x(t) = ?$
- $y(t) = ?$

(c) Write a Processing sketch that animates a circle of radius 10, where the centre point of the circle is determined using linear interpolation between the following keyframes. Keep the circle stationary at the point $(100, 20)$ after the final keyframe. [9]

Frame Number	Center (x, y)
0	(10,50)
100	(30,20)
125	(100,20)

(d) Choose one of Thomas and Johnston's 12 Principles of Animation that you might use to make this moving circle seem more life-like. Describe the principle, and then discuss specifically how you would change the Processing sketch above to employ that principle. You can use a written description, pseudocode, and/or Processing code. [4]

Question 3 Digital Audio

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

i. Describe in detail each step in the process of converting analog changes in sound pressure level into a digital PCM representation on a computer, and back (i.e., analog-to-digital and digital-to-analog audio conversion). Include a specific discussion of how one should go about making an appropriate choice of sample rate and quantization level for analog-to-digital conversion.

ii. Describe lossless and lossy audio compression. Why are lossy and lossless compression used, and what are some tradeoffs between different types of compression algorithms? Describe how data compression is achieved by one specific lossy format, and by one specific lossless format.

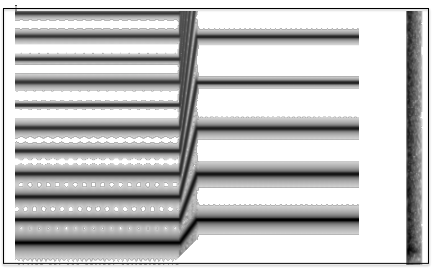
Each essay is worth half the marks for this question.

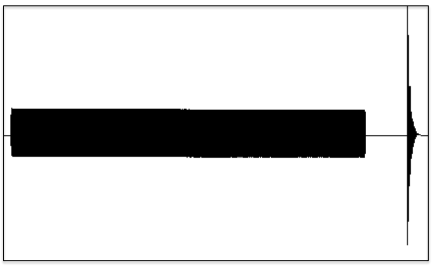
Question 4 Sound and Image Perception and Representation

(a) Name 3 Gestalt principles that relate to visual perception. For each principle, describe in writing how it relates to visual perception and draw a sketch to illustrate the principle. [6]

(b) Pick 3 Gestalt principles and describe clearly how each relates to audio perception. (You can re-use principles from part (a) if you want.) [6]

(c) The figures below show a spectogram and an amplitude envelope for the same sound file. (Note that the spectogram shows only the lower part of the frequency spectrum; some of the higher frequency content has been cropped from the image.) **Describe in detail what a listener will hear when listening to this file.** (Appropriate perceptual properties to discuss probably include some subset of the following: pitch, timbre, consonance/dissonance, loudness, number of sound sources and sound events, instrumentation, changes over time, etc.) [9]





(d) The following is a list of visual properties that you might choose to use to convey information in a visualization: angle, colour hue, area, position, slope, texture, volume, shape.

i. Name two visual properties that are probably better choices for conveying quantitative information than for conveying nominal information. [2]

ii. Name two properties that are probably better choices for conveying nominal information than for conveying quantitative information. [2]

Question 5 Signals and Systems

(a) In the context of systems, define the following terms: [4]

i. linear system;

ii. time-invariant system.

(b) Examine the following (hopefully familiar) equation:

$$X(k) = \sum_{n=0}^{N-1} x_n \cdot e^{-i2\pi kn/N}$$

Describe what this equation is computing, and how. Include in your description an explanation of the role of each of the variables. [6]

(c) A linear shift-invariant system for images has the following kernel:

$$\begin{pmatrix} 1/9 & 1/9 & 1/9 \\ 1/9 & 1/9 & 1/9 \\ 1/9 & 1/9 & 1/9 \end{pmatrix}$$

i. Name and describe as precisely as possible the image effect this filter implements. [3]

ii. Name and describe the computational procedure you would use to apply this kernel to an image (e.g., in a Processing sketch). [3]

(d) You have two wonderful audio files on your computer. One is a recording of your favourite electric guitar player, wailing away on a solo with a lot of reverb, distortion, and passion (that is, a spectrally rich and emotionally moving sound). The other is a recording of your favourite football commentator talking about how your favourite team has just won their most recent match. You would like to combine these files into the most amazing audio file ever, in which the electric guitar solo sounds like it is "speaking" the football commentary.

Describe in words an audio processing procedure (e.g., something someone could implement in R) that would achieve that basic effect. Also discuss how effective you think your procedure would be.

(Hint: Think about how this effect relates to filters, to spectral analysis, and to speech production and perception.) [9]

Question 6 Information Retrieval

(a) You are an information retrieval system engineer, and your boss has just asked you to implement an image retrieval system that allows users to query an image database by colour. That is, your system will allow users to input a target colour, then return a set of images having similar colours. Furthermore, your boss has requested that you represent each image using three features: (1) f_1, the total number of purely **black** pixels in the image; (2) f_2, the total number of purely **red** pixels in the image; (3) f_3, the number of purely **green** pixels in the image.

Write a function in Processing called computeFeatures that takes one input parameter, a PImage, and when executed prints to the screen the values of f_1, f_2, and f_3 for that image.

(Hint: We've included three 100 × 100 pixel test images—black.png, red.png, and green.png—each of which contains exactly 10,000 pixels of purely black, red, or green, to help you test your function.) [8]

(b) Use your function to compute f_1, f_2, and f_3 for the image Question6.png. [1]

(c) Discuss in detail how you could improve the feature representation for this image retrieval system, if the user's goal is really to retrieve images from the database that contain colours that are perceptually similar to a query image, where similarity is computed using Euclidean distance metric in the feature space? [4]

(d) Define (in words) the following computational techniques, and say how they might be used:

i. Media fingerprinting; [3]

ii. Levenshtein distance. [3]

(e) A searchable image database returns 1000 results for the query "Lady Gaga." 700 of the 1000 returned results are actually pictures of Lady Gaga; the rest of the returned results are pictures of lampshades. The image database contains 10,000 images in total, 2000 of which are truly images of Lady Gaga.

i. What are the number of true positives, true negatives, false positives, and false negatives for this retrieval system for this query? [4]

ii. What are the precision and recall for this query? [2]