UNIVERSITY OF LONDON

GOLDSMITHS COLLEGE

Department of Computing

B. Sc. Examination 2013

IS52020B
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.

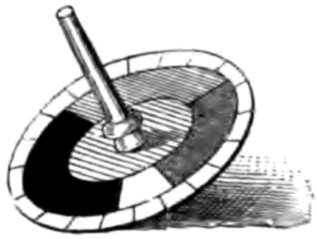
There are 100 marks available on this paper.

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 Systematization

(a) The figure below shows a 'colour top', sometimes known as Maxwell's disc. Describe the use of this device in the systematization of colour. [4]



(b) Construct a *Processing* sketch to illustrate the mixture of equal amounts of the sRGB colours {255, 0, 0} and {0, 190, 127} for colour averaging by time, and comment on how well the sketch illustrates the phenomenon of colour averaging by time. [6]

(c) Draw the CIE chromaticity diagram in xyY coordinates, indicating on your diagram the following features: [7]

- the spectral locus;
- the line of purples;
- the general locations of red, green and blue chromaticity.

(d) The CIE XYZ coordinates of the sRGB colours from part (b) are {0.4124, 0.2126, 0.0193} and {0.2224, 0.3836, 0.2631} respectively. Calculate the xyY coordinates of these colours and plot their location on your diagram from part (c). [3]

(e) Calculate the xyY coordinates of the colour resulting from the mixture of equal amounts of the two source colours; plot the colour on your diagram, and comment on its location. [5]

Question 2 Digital media

(a) Define lossy and lossless compression in the context of digital media. [2]

(b) Give one example of each of lossy and lossless compression in the context of image file formats. [2]

(c) Describe channel decorrelation and predictive coding in the context of the FLAC audio file format. [6]

(d) A user has 15 days, 17 hours and 14 minutes' worth of CD-quality stereo audio in FLAC format, taking up 104.7GB of storage space. Calculate the average bitrate, and hence the compression ratio achieved by FLAC over the raw PCM. [5]

(e) Give one example of a situation where lossless compression of audio is preferred over lossy compression, and one example where lossless compression is preferred, and explain those preferences. [4]

(f) DVD video consists of 25 frames per second of image resolution 720×576. Compute the bit rate of uncompressed video, stating your assumptions, and compare your answer with a transfer rate of 8Mbps supported by DVD readers. [6]

Question 3 Hearing and the Ear

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

i. Beating, critical bands and dissonance;
ii. sound source location

Each essay is worth half the marks for this question.

Question 4 Systems and Convolution

(a) in the context of systems operating on grayscale image data represented as two-dimensional tables, define the terms

i. linear [3]

ii. time-invariant [3]

iii. linear time-invariant [1]

(b) Explain how the impulse response of a linear time-invariant system completely determines its operation on any input signal, and how the Fourier Transform and its inverse can be used to implement the operation of such systems. [6]

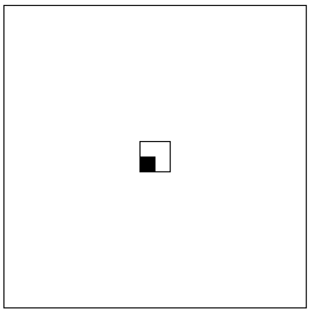
(c) An image of size 1024×1024 pixels is used as input to a system with an impulse-response kernel of size 8×8 pixels, taking 1s to compute using direct convolution and 0.1s using the Fast Fourier Transform. Explain how the time taken would change if both the image and kernel were to double in size both horizontally and vertically. [6]

(d) A linear time-invariant system for images has the following kernel:

$$\begin{pmatrix} 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0.1 & 0.2 \\ 0 & 0.1 & 0.2 & 0.1 & 0 \\ 0.2 & 0.1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \end{pmatrix}.$$

Name and describe the image effect this filter implements. [2]

(e) Sketch (on paper) the result of the application of this system to the figure below. [4]



Question 5 Information Retrieval

(a) Define the Hamming and Levenshtein distance measures in the context of comparisons of strings. [4]

(b) Suggest two distinct uses of the Levenshtein distance in Multimedia Information Retrieval systems [4]

(c) Describe the constant-Q transform, and explain its role in constructing pitch-based numerical features for Music Information Retrieval [6]

(d) A Music Information Retrieval system specialized for exact matching is used for 10 queries; for 7 of the queries the exact match (and nothing else) was returned; for 2 queries no result was returned, and for 1 query a non-relevant match was returned.

i. what is the name given to non-relevant returned results? [1]

ii. calculate the average precision and recall of the system over the ten queries, assuming that for each query there is exactly one relevant item in the database. [4]

iii. suggest an application of this system, and for that application discuss which of average precision and average recall is a more appropriate measure of system performance. [6]

Question 6 Animation and visualization

(a) Describe the keyframing and the physical modelling techniques for creating animations. [7]

(b) An animator wishes to construct an animation based on motion data captured from a dancer by tracking the locations of reflective pads. Explain how the data captured is related to the key framing animation technique. [5]

(c) Write a *Processing* sketch to visualise the motion of a weight attached to a spring, with the following equation of motion: [6]

$$\ddot{y} = -k(y - 200)$$

with the constant $k = 0.5$ and the following initial conditions:

$$\begin{aligned} y(0) &= 200 \\ \dot{y}(0) &= 10\,\text{pixels/s} \end{aligned}$$

(d) Refine your *Processing* sketch to take account of overstretching: if the y position ever goes beyond 300, alter the equation of motion for subsequent evolution to

$$\ddot{y} = -k(y - 250)$$

(save a separate sketch in your answer folder for this part). [3]

(e) By experiment or otherwise, find the smallest positive initial $\dot{y}(0)$ which triggers the change in behaviour in part (d). [4]