THIS PAPER IS NOT TO BE REMOVED FROM THE EXAMINATION HALL

UNIVERSITY OF LONDON

CO2227 ZA

BSc EXAMINATION

CREATIVE COMPUTING and COMBINED DEGREE SCHEME

Creative Computing II: Interactive Multimedia

Monday 13 May 2019: 10.00 – 13.00

Time allowed: 3 hours

DO NOT TURN OVER UNTIL TOLD TO BEGIN

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 a total of **FOUR** questions. The marks for each part of a question are indicated at the end of the part in [.] brackets.

Only your first **FOUR** answers, in the order that they appear in your answer book, will be marked.

There are 100 marks available on this paper.

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

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Question 1 Colour and Light

(a) Hue, saturation, and brightness

i. What are hue, saturation, and brightness? [3]

ii. Using the equations below, convert the RGB value (r=0.2, g=0.0, b=0.5) into HSB values, where R, G and B are expressed in the range [0,1]. Show your work. [6]

H = ?

S = ?

B = ?

$$max = max(r, g, b);$$

$$min = min(r, g, b);$$

$$h = \begin{cases} 0 & max = min; \\ \frac{\pi}{3} \times \frac{g-b}{max-min} \mod 2\pi & max = r; \\ \frac{2\pi}{3} + \frac{\pi}{3} \times \frac{b-r}{max-min} & max = g; \\ \frac{4\pi}{3} + \frac{\pi}{3} \times \frac{r-g}{max-min} & max = b; \end{cases}$$

$$s = \begin{cases} 0 & max = 0; \\ 1 - \frac{min}{max} & otherwise \end{cases}$$

$$\beta = max$$

(b) Gestalt laws can be useful in web design to create more friendly user interfaces:

i. Give an example of a user interface design where this is the case. [2]

ii. List and explain how two Gestalt laws could be used in the example. [4]

(c) CMYK

i. Describe how subtractive mixing is used in the CMYK model of colour printing. [3]

ii. Describe how CMYK inks are used to print the colour red. [2]

iii. Describe how CMYK inks are used to print the colour black. [2]

(d) What is *deuteranomaly*? How does this affect design of multimedia systems? [3]

Question 2 Animation

(a) A two-dimensional animation of a circle is being drawn using cubic Hermite interpolation. The keyframes for the circle are given in the following table:

time (seconds)	coordinates (pixels)	tangent
0	(400, 300)	(100, 200)
1	(250, 350)	(-10, -70)
2	(200, 100)	(100, 40)

On a single unit interval ($0 \leq t \leq 1$), cubic Hermite interpolation can be defined as:

$$p(t) = (2t^3 - 3t^2 + 1)p_k + (t^3 - 2t^2 + t)m_k + (-2t^3 + 3t^2)p_{k+1} + (t^3 - t^2)m_{k+1}$$

where p_k at $t = 0$ is the starting point, p_{k+1} at $t = 1$ is the ending point, m_k is the tangent at $t = 0$ and m_{k+1} is the tangent at $t = 1$. Calculate the position of the circle at the following timepoints. Show your work. [6]

i. 0.8 seconds

ii. 1.5 seconds

(b) Describe why we are able to perceive motion from a sequence of still images when we are watching a film. Include a discussion of frame rate and flicker rate in your answer. [4]

(c) Animation techniques

i. Describe the process of flat animation. [3]

ii. Describe how you would choose whether to use stop-motion or flat animation for a particular project. [3]

(d) Let Point A have the coordinates $(300, 130)$ and Point B have the coordinates $(630, 490)$. An animation shows a car stopped at Point A from frame 0 until frame 45. Frame 45 is the last frame at which the car is at Point A; from frame 46 to frame 90, the car moves from Point A to Point B. It then stays at Point B.

i. Sketch the keyframes that could be used for this animation. [3]

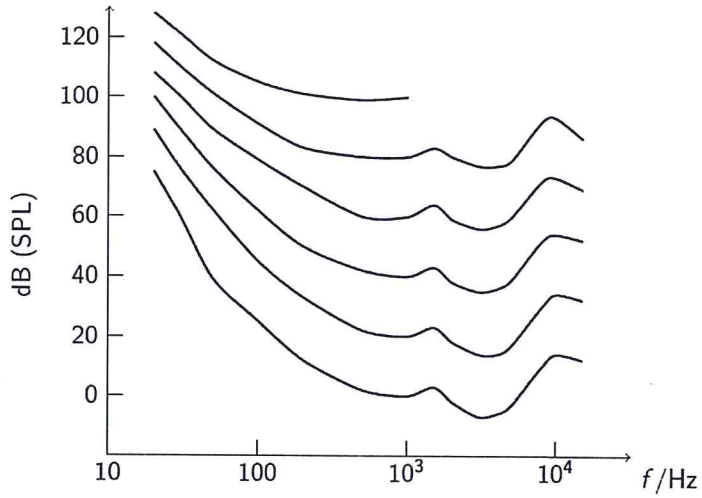
ii. If linear interpolation is used, what will be the x coordinate of the car in frame 60? Show your work. [2]

iii. If linear interpolation is used, what will be the y coordinate of the car in frame 60? Show your work. [2]

iv. Write an equation that can be used to compute $x(f)$, the x coordinate of the car for any frame f between 45 and 90: [2]

$$x(f) = ?$$

Question 3 Audio and Music Perception



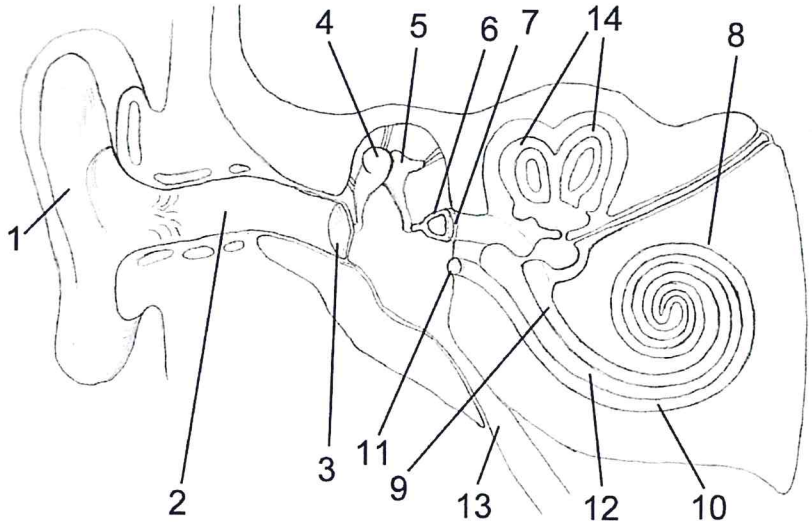
(a) The figure shows the Fletcher-Munson curves. What do the curves show and how this could be useful in application design? Explain with examples. [6]

(b) Name the parts of the ear corresponding with the following numbers: [3]

i. 1

ii. 3

iii. 14



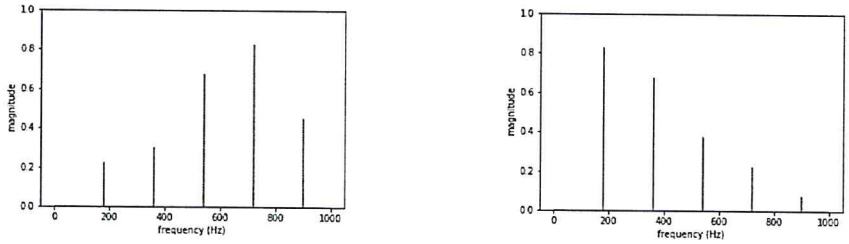
(c) Describe the role of the basilar membrane in hearing. [3]

(d) Briefly describe (simultaneous) auditory masking. [3]

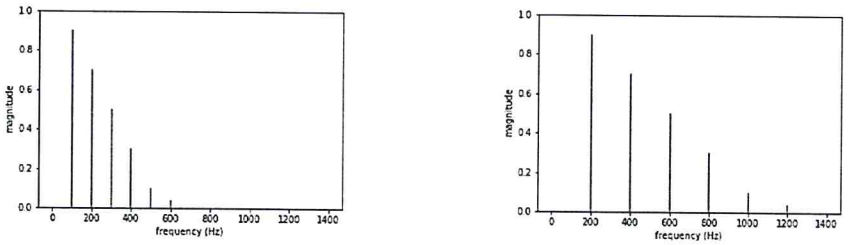
(e) What is melody? [3]

(f) Each row below shows FFTs for two example sounds. Describe as precisely as you can the difference between how the left and right examples will sound. Assume that the sounds do not change in volume or frequency content over time. [3]

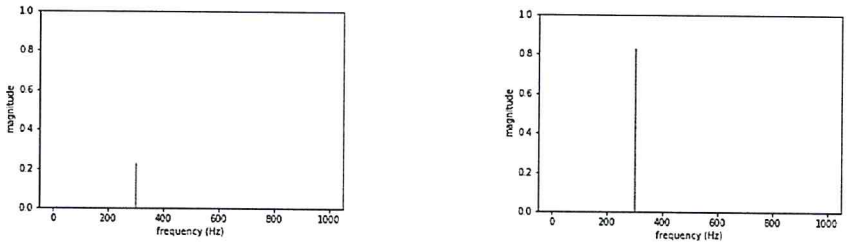
i. A vs B:



ii. C vs D:



iii. E vs F:



(g) A bassoonist plays a note whose pitch is perceived to be the same as a 70Hz sine wave. List 3 frequencies that are likely to be present in the bassoon sound [1/4] and explain your answer [3/4]. [4]

Question 4 Digital Media Signals and their representations

(a) DVDs use an audio sampling rate of 48kHz and a quantisation level of 16-bits.

i. What is the highest frequency that can be accurately reproduced on DVD audio? [2]

ii. Assuming there are two channels, how much storage space is required for 7 minutes of DVD audio, without using compression? Show your work and express your answer in MB. [3]

(b) FLAC

i. Describe how FLAC uses channel decorrelation to achieve compression. [3]

ii. What are the different channel encoding strategies it could use? [3]

(c) Compression

i. What is the difference between lossy and lossless compression? [2]

ii. Give an example of a circumstance in which you would prefer to use a lossy representation instead of a lossless one. [2]

(d) Describe how MP3 is able to achieve a higher compression ratio than FLAC. [4]

(e) Quantisation

i. What is quantisation (in the context of digital audio)? Include a diagram illustrating the quantisation process. [4]

ii. Under what circumstances would you choose to use more quantization bits? Fewer quantization bits? Be specific. [2]

Question 5 Signals and Systems

(a) Fill in the blanks:

i. If we convolve some signal, A, with another signal, B, in the time domain, this is equivalent to _____ the spectrum of signal A with the spectrum of signal B in the frequency domain. [2]

ii. The property of _____ means that a system responds in the same manner to its inputs at all instants in time. [2]

iii. A system T for which the following statement is true exhibits the property of _____. [2]

$$aTx[n] + bTy[n] = Tax[n] + by[n]$$

iv. A system which demonstrates both of the properties from ii. and iii. above is called a _____ system. [2]

v. The output of such a system for a given input signal is calculated by convolving the input signal with _____. [2]

vi. Convolving any signal with the unit impulse will produce _____. [2]

(b) A linear, shift-invariant system for images uses the following kernel. Name and describe as precisely as possible the image effect this kernel implements. [2]

$$\begin{bmatrix} -1 & -1 & -1 \\ -1 & 8 & -1 \\ -1 & -1 & -1 \end{bmatrix}$$

(c) Name two other image effects that can be achieved using an image kernel. [2]

(d) You are given the task of designing a filter to remove a low-frequency hum sound from a recording of a music concert.

i. What sort of filter might you use for this task? [2]

ii. What steps will you take to figure out how to build a good filter for this task? For example, what will you do to determine good cutoff frequency/frequencies, and to determine a good filter order? Be as specific as you can. [4]

iii. Sketch a realistic frequency response for a filter that you might build for this task. [3]

Question 6 Information Retrieval

(a) A collection of audio files is stored on a disk. The average (root-mean-square) amplitude for each audio file has been pre-calculated and stored along with the files.

i. Describe a data structure and an algorithm that will allow retrieval of a sound file whose RMS amplitude is perceptually closest to a query amplitude. [4]

ii. Comment on the efficiency of your solution. [2]

iii. The collection contains 5 audio files with the following RMS amplitudes: [0.32, 0.41, 0.53, 0.57, 0.62] with the corresponding file names: [file01.wav, file02.wav, file03.wav, file04.wav, and file05.wav]. Which filename should be returned for a query of 0.475? Show your work. [4]

(b) You are designing a system to recommend books to a user based on books that they have already read and rated.

i. What would it mean for this particular system to have high precision? [2]

ii. What would it mean for this particular system to have high recall? [2]

iii. Do you think it is more important for this kind of system to have high precision or high recall? Justify your answer. [2]

(c) Specific Features

i. Levenshtein distance:
For what specific type(s) of media might you use this feature? [1]
Describe in your own words what it would mean for two pieces of media to have similar values for this feature. [2]

ii. chromagram:
For what specific type(s) of media might you use this feature? [1]
Describe in your own words what it would mean for two pieces of media to have similar values for this feature. [2]

iii. CIE L*a*b*:
For what specific type(s) of media might you use this feature? [1]
Describe in your own words what it would mean for two pieces of media to have similar values for this feature. [2]

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