THIS PAPER IS NOT TO BE REMOVED FROM THE EXAMINATION HALLS

UNIVERSITY OF LONDON **CO2227 ZA**

BSc Examination

CREATIVE COMPUTING AND COMBINED DEGREE SCHEME

Creative Computing II: Interactive Multimedia

Monday 14 May 2018: 10.00 – 13.00

Time allowed: 3 hours

There are **SIX** questions on 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.

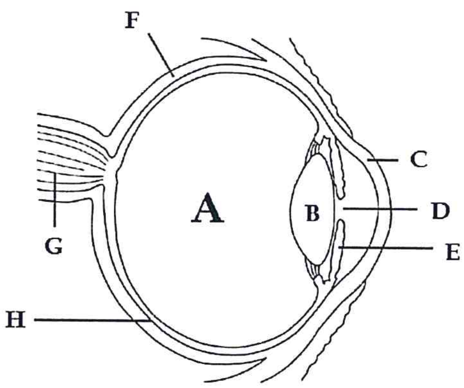
Question 1 Colour and Light

(a) Name the parts of the eye that correspond to the following labels: [3]

i. B

ii. D

iii. G



(b) Describe the role of the fovea in human sight. [2]

(c) Describe the role of the iris in human sight. [2]

(d) What are hue, saturation and brightness? [3]

(e) Using the equations below, convert the RGB value R=0.0, G=0.5, B=0.2 into HSB values, where R, G, and B here are expressed in the range [0,1]. Show your working.

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

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

$$\beta = max.$$

[4]

(f) For each of the following descriptions, indicate whether it describes a rod cell or a cone cell: [6]

i. This cell is important for peripheral vision.

ii. This cell has a relatively fast response time.

iii. There are three types of this cell, each of which is sensitive to a different wavelength of light.

iv. This cell is less sensitive to light.

v. This cell is absent from the centre of the retina.

vi. This cell is sensitive to motion but has poor spatial discrimination.

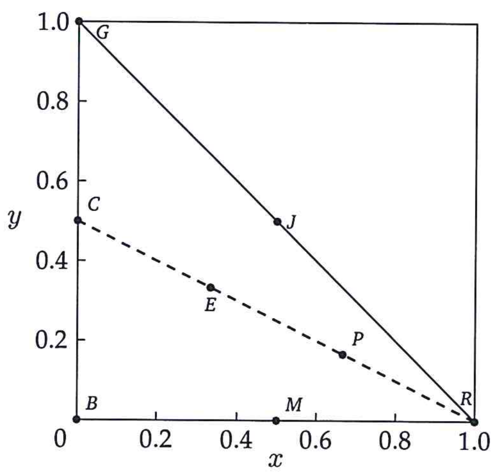
(g) The figure below shows a Maxwell triangle representing the colour space of red, green, and blue primaries.

i. What is point J? [1]

ii. What is the dashed line? [1]

iii. What is the name for the set of points that lie within or on the edge of this triangle? [1]

iv. What is so special about this set of points? [2]



Question 2 Animation

(a) Let Point A have the coordinates $(90, 10)$ and Point B have the coordinates $(10, 210)$. 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 125, 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 55? Show your working. [2]

iii. If linear interpolation is used, what will be the y coordinate of the car in frame 55? Show your working. [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]

$$x(f) = ?$$

(b) **Splines**

i. What are cubic Hermite splines (csplines), and why are they used in animation? [3]

ii. Describe the specific perceptual effect of using a spline instead of linear interpolation to animate the car in part (a) above. [1]

iii. The equation below is used to compute a Catmull-Rom spline. What is $P(t_{k-1})$? [2]

$$m(t_k) = \frac{P(t_{k+1}) - P(t_{k-1})}{2}$$

(c) **Animation techniques**

i. Describe the process of flat animation [3]

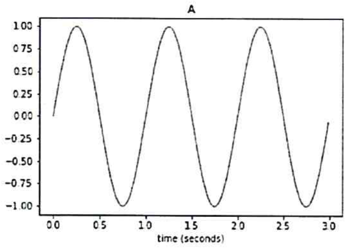
ii. Describe how you would choose whether to use stop-motion or flat animation for a particular project. [3]

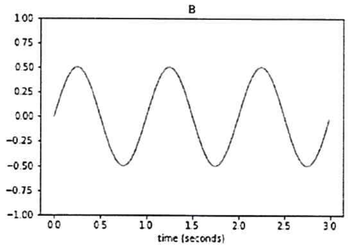
(d) Describe how we are able to perceive motion from a sequence of stills when watching a film. Include in your answer a discussion of frame rate and flicker rate. [4]

Question 3 Audio and Music Perception

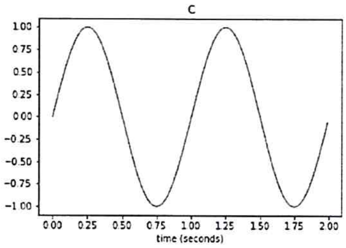
(a) For each row of waveforms below, describe as precisely as you can the difference in how the left waveform will sound from the right one. (Assume that all sinusoids are at suitable amplitudes, frequencies, and phases to be audible.) [3]

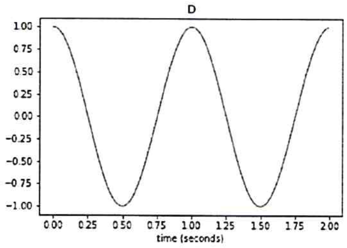
i. A vs B:



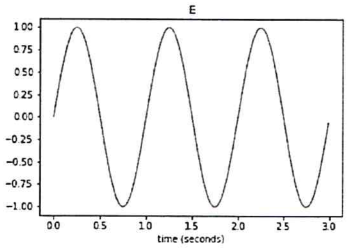


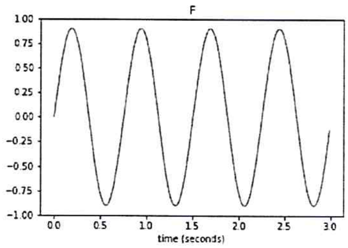
ii. C vs D:





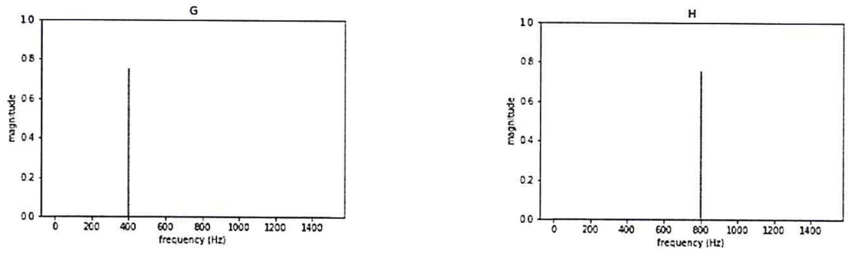
iii. E vs F:



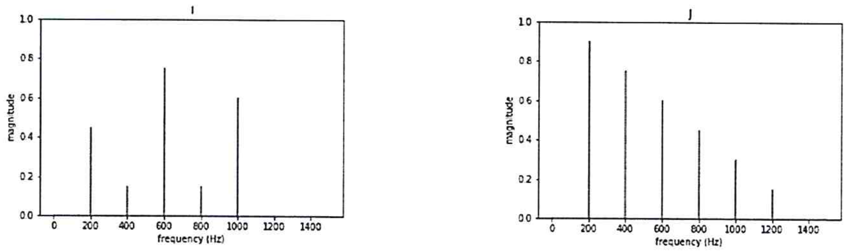


(b) Each row below shows FFTs for two example sounds. Describe as precisely as you can the difference between how the left and right examples will sound. (You can assume that the sounds don't change in volume or frequency content over time.) [3]

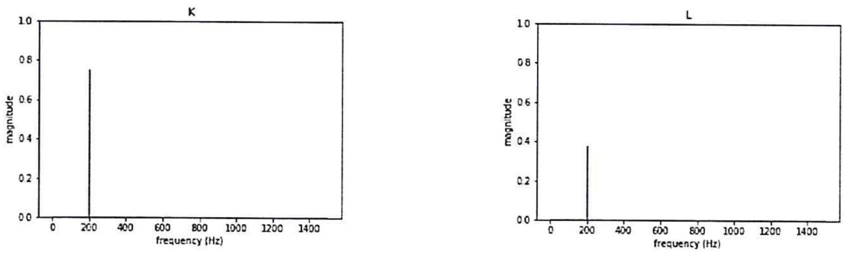
i. G vs H:



ii. I vs J:



iii. K vs L:



(c) Choose **TWO** parts of the inner ear, and describe the role each one plays in hearing. [6]

(d) A saxophonist plays a note whose pitch is perceived to be the same as a 250Hz sine wave.

i. List **THREE** frequencies that are likely to be present in the sax sound. [3]

ii. Explain your answer above. [1]

(e) What is melody? [3]

(f) What is the harmonic series? Also, why is knowing about the harmonic series relevant to human perception of pitch and timbre, and to understanding consonance and dissonance of musical tones? [6]

Question 4 Digital Media Signals and their representations

(a) **Audio representations**

i. A song is 2 minutes 51 seconds in length. How big will a PCM representation of this song be, assuming stereo, 16-bit quantisation, and a 44.1kHz sample rate? [3]

ii. An MP3 file of this song is 6.8 megabytes. What is the compression ratio achieved over the PCM representation? [1]

iii. Describe how MP3 is able to achieve such a compression ratio. [3]

iv. Rank the following file representations for this song in likely order of size, from smallest to largest: ZIP, WAV, MP3, FLAC. [3]

(b) **Compression**

i. Name one lossy compression format for audio or image. [1]

ii. Give an example of a circumstance in which you would prefer to use a lossy representation instead of a lossless one. [1]

iii. One method FLAC uses to reduce data size is inter-channel decorrelation. Describe the different modes FLAC could use to encode stereo sound. [4]

(c) **Aliasing**

i. Bats can hear frequencies up to 120 kHz. What is the lowest sample rate you could use for analog-to-digital conversion of audio without removing frequencies noticeable to a bat? [2]

ii. What is aliasing, in the context of digital audio? Include a diagram illustrating the phenomenon of aliasing. [3]

(d) **Quantisation**

i. What is quantisation (in the context of digital audio)? [1]

ii. Include a diagram illustrating the quantisation process. [2]

iii. Under what circumstances might you choose to use more quantisation bits for an audio signal? Be specific. [1]

Question 5 Signals and Systems

(a) **Unit impulses**

i. Draw a unit impulse on a plot. Provide labels on the x- and y-axis so it is clear what the value of this signal is at each point in time. [2]

ii. What is an impulse response? [2]

iii. Why is knowing the impulse response of a linear time-invariant system useful? [2]

(b) s is a signal whose values over time are given below:

Time index t	$s[t]$
0	1
1	2
2	3

r is the impulse response of a linear, time-invariant system; its values are given below:

Time index t	$r[t]$
0	0.5
1	0.5

You can assume that s and r are zero at all other times.

i. What is the output of the given system when s is input? Show values for $t = 0, 1, 2, 3$. Show your working. [4]

ii. What type of system is this? Be as specific as you can, and explain your answer. [2]

(c) You are given the task of designing a filter to remove a low-frequency hum 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]

(d) 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]

$$\begin{bmatrix} -1 & -1 & -1 & -1 & -1 & -1 & -1 \\ -1 & -1 & -1 & -1 & -1 & -1 & -1 \\ -1 & -1 & -1 & -1 & -1 & -1 & -1 \\ -1 & -1 & -1 & 120 & -1 & -1 & -1 \\ -1 & -1 & -1 & -1 & -1 & -1 & -1 \\ -1 & -1 & -1 & -1 & -1 & -1 & -1 \\ -1 & -1 & -1 & -1 & -1 & -1 & -1 \end{bmatrix}$$

(e) Name **TWO** other image effects that can be achieved using an image kernel. [2]

Question 6 Information Retrieval

(a) **Retrieval systems**

A music database contains 20,000 songs. A user queries the database by humming a melody, intending to find all the songs in the database with that melody. 113 songs in the database actually contain this melody; of these, 96 are returned to the user. 14 other songs not containing that melody are also returned to the user.

i. What is the number of false negatives for this query? [2]

ii. What is the precision for this query? [2]

iii. Do you think it is more important to have high precision or recall for this type of query? Or are these equally important? Explain your answer. [3]

(b) **Specific Features**

i. **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]

ii. **Term-frequency**

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. **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]

(c) Two media documents have the following feature values:

Document	Feature 1	Feature 2
A	211	42
B	141	35

i. Compute the distance between documents A and B using Euclidean distance. Show your working. [2]

ii. A third document, C, has a Euclidean distance of 83.25 to document A. Which document – B or C – will be judged as more similar to A in this feature space? Why? [2]

iii. Name **TWO** other distance metrics that could be used instead of Euclidean distance for these features. [2]

(d) Describe a perceptual audio feature that you might use if you were implementing a similarity-based search engine for music. Make sure you are describing a specific feature that could be computed, not a general property of music such as "melody." Additionally, make sure you explain why the feature would be relevant for computing musical similarity. [3]

END OF PAPER