THIS PAPER IS NOT TO BE REMOVED FROM THE EXAMINATION HALLS

UNIVERSITY OF LONDON **CO2226 ZB**

BSc Examination

COMPUTING AND INFORMATION SYSTEMS, CREATIVE COMPUTING and COMBINED DEGREE SCHEME

Software engineering, algorithm design and analysis

Date and Time: Thursday 11 May 2017: 14.30 – 17.30

Duration: 3 hours

This paper is in two parts: Part A and Part B. There are a total of THREE questions in each part. You should answer **TWO** questions from Part A and **TWO** questions from Part B.

Full marks will be awarded for complete answers to a total of **FOUR** questions, TWO from Part A and TWO from Part B. The marks for each part of a question are indicated at the end of the part in [.] brackets.

Only your first **TWO** answers from Part A and first **TWO** answers from Part B, in the order 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 the 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.

Part A

Question 1

a) Briefly compare and contrast sequence and state diagrams.

[5]

b) MoveHouse.com is an online start-up that specialises in assisting people who need to move out of their current house; the online company aims to provide assistance from the early stages of the process (*e.g.* packing) to the final stages where the packed belongings are transferred to the new address. The following rules apply:

- The interested user would have to register online with the company; this will include providing their first and last names, address, mobile phone number and e-mail address. They will also have to create a username and a password so that they can sign in and check on the progress of the move preparations. The user might register with multiple addresses (as it is possible that they will have used the company in other moves) but they do not have to create new accounts – the username and password should stay the same.
- Once the user is logged in, in order to initiate a move they will select the address they are moving out of (in the case of multiple addresses), otherwise the system will pick up the only address available. The user will then be presented with the various moving options (*e.g.* categorising, purchasing of packing materials, packing, interfacing with third parties, storage, *etc.*) and will next indicate which of these they are interested in. They will then specify when they plan to move out and, depending on the requirements, a timetable will be built according to the options they have selected.
- Once all the information has gone in regarding the date of the move and the options the user needs help with, a "move manager" will be appointed who, in turn, will appoint staff who will be responsible for each of the move options that the user has requested help with. In some cases, more staff may be needed, so additional staff might be allocated to each phase of the move.
- Before the user commits to anything, they will receive a quote detailing the total cost, and the number of people involved in the move, as well as the breakdown per each different move option.
- Assuming that the user agrees to the quote, a schedule will be drawn up showing the proposed dates for each phase and the responsibilities of each party (company and customer) and this will have to be agreed by the user.

- In the case that there is any delay, the customer has the right to claim compensation of up to 20% of the remaining cost of the move, depending on its severity. If this happens, then the full claim details must be logged with the system.
- A job supervisor will monitor the system in order to see the progress of all jobs and the tasks left on each of them, as well produce reports on the revenue generated. Consequently, an administrator login to the system is required. For added security the job supervisor will use a PIN number for identification, in addition to the password. High-level figures from the report – *e.g.* month profits, number of jobs completed, number of jobs in progress, will have to be saved in the system along with the identity of the administrator who created the report.

Develop a class diagram for the above scenario using the appropriate naming conventions, *e.g.* class names starting with a capital letter, and suggest class attributes with name and type, as well as methods with name and return type. Illustrate associations, aggregations, and generalisation relationships between the objects. Please state any assumptions you make during the development of the diagram.

[20]

Question 2

a) In which stage of the UML process would you look at a use-case diagram? Why?

[5]

b) Prepare an activity diagram to illustrate the process of initiating a move for the scenario described in **Question 1**. The following rules apply:

- The process starts when a customer has logged in.
- The system will check if the user has any moves in the initiation stage and if they do, will present a list of moves and ask if it is one of these moves that they are interested in. If it is, then the details of this move will be loaded up on the system. If not, the system will simultaneously look up the user's address and create an empty move.
- The user will specify whether this address is the address they are moving out from or moving in to.
- The system will present the user with all the options for the new move (or the details already entered if the move was already in the system).
- The user fills in (or updates) the information for the move.
- Once the process of adding information is complete, the user should click on an Add Move button.

- The system will then proceed to calculate the quote based on the information entered.
- If the projected cost is over £1,000 the system will request a deposit of 10% from the user and present them with a payment form for entering the payment details.
- The user enters the payment details into the form.
- The system processes the information. If the payment is successful, then at the same time the receipt is displayed on the screen and the information is entered in the database. If the payment is not successful, then the user is asked to re-enter their payment details. If this fails, the information is saved as provisional and the user is asked to contact a company representative within two days, after which the quotation will be deleted.
- The system displays the outcome to the user.

Show on the activity diagram the flow of control using specialised UML components, like activities, decisions, merges, forks and joins. Please state any assumptions you make about the system.

[20]

Question 3

a) When would it be a good idea to use sub-states? You might provide an example to illustrate your answer.

[5]

b) Create a state machine diagram describing the behaviour of an instance of the Move class for the scenario described in **Question 1.** The following rules apply:

- The move will be in a new state once created and will then become inprogress as the user adds information.
- Once the user finishes providing the information and submits it, the move becomes awaiting payment if the cost is over £1,000; if this is the case, it becomes confirmed if the deposit payment is successful and provisional otherwise.
- If the move is provisional and two days pass without payment confirmation, it becomes onhold and after a further week cancelled and deleted from the database.
- If a move is confirmed and its start date has been reached then it becomes in working progress.
- After the work is finished, it will become complete, and a day later it will then become awaiting feedback as an automated e-mail will be sent out to the user asking them to provide feedback for quality assurance purposes.
- Once the e-mail goes out, there is a week for the customer to provide feedback; if this happens, the move becomes full and it is closed otherwise it moves to complete but no feedback.
- After the feedback is finalised (one way or the other) and three months have passed the move becomes archived.

Design the state machine diagram using state transitions and labels with three parts. Please state any assumptions you make about the system.

[20]

Part B

Question 4

This question focuses on optimisation.

a) In the context of optimisation, what is meant by a greedy algorithm? Contrast it with an exhaustive search and give one advantage for each.

[5]

b) The Asymmetric Travelling Salesman Problem (ATSP) is a combinatorial optimisation problem. There are N cities and each city has to be visited **ONCE ONLY** before returning to the origin (City A in this case).

All cities are connected to each other but not themselves.

The intercity distances are asymmetric; in other words, the distance from city B to C may be different from C to B.

The aim of the ATSP is to find the cyclic path (*e.g.* A-C-D-B-A) that minimises the distance travelled.

Given the above description of the optimisation problem:

i. Give the corresponding decision problem for the ATSP.

ii. Explain what it means for the ATSP decision problem to be NP-complete.

[8]

c) The adjacency matrix with intercity distances for an ATSP instance is given below:

		(To) A	B	C	D
	A	0	1	4	2
(From)	B	1	0	2	3
	C	1	2	0	1
	D	4	3	2	0

Draw a search tree using depth-first search marking clearly the optimal path(s).

[6]

d) Devise a simple greedy algorithm of your choosing and demonstrate its operation on the above ATSP instance. Show the steps at each stage.

[4]

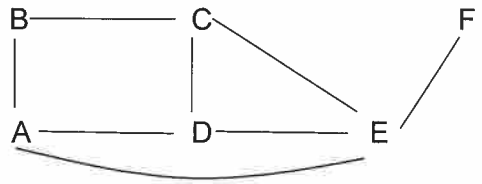
e) Compare and discuss the outcomes of the algorithms in (c) and (d).

[2]

Question 5

This question focuses on graphs and sorting lists.

a) Consider the graph below.



Represent the graph **BOTH** as an adjacency list and as an adjacency matrix.

[6]

b) For the graph above, starting from vertex A, write the vertex sequence in the order that each vertex is visited when applying the breadth-first traversal algorithm. Show the steps at each stage.

[4]

c) Consider the partially sorted list below.

1 2 4 3 5 7 6

Apply **BOTH** insertion sort and quicksort to the list above. Take care to show the steps taken for each.

Report which of the two methods is faster in this case.

[9]

d) Give the worst case performance for **BOTH** of the two sorting methods. In the case of mostly sorted lists, which method would you expect to give better average-case performance. Give your reason(s).

[6]

Question 6

This question focuses on iteration/recursion and binary (search) trees.

a) Write in pseudocode **BOTH** iterative and recursive implementations for the factorial of n, where n is a positive integer.

[4]

b) What is meant by a recursive algorithm being 'tail-recursive'. Explain whether your recursive implementation in (a) is tail-recursive or not.

[3]

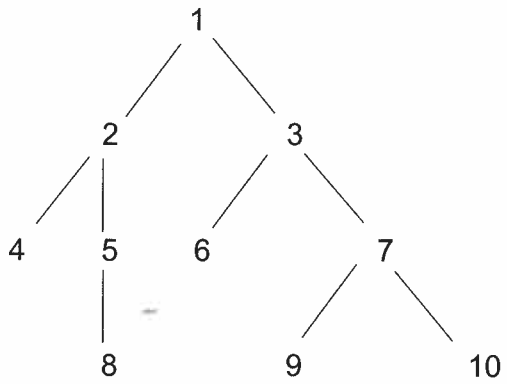
c) Describe what is meant by the terms Binary Tree and Binary Search Tree.

[4]

d) Give pseudocode for the post-order traversal of a binary search tree, in **BOTH** iterative and recursive versions. Comment briefly on the elegance of the implementations.

[6]

e) List the sequence of numbers visited in the post-order traversal of the binary tree below.



Is the tree a **COMPLETE** binary tree? Explain briefly your answer.

[5]

f) Draw the binary search tree for the sequence below, inserted from left to right.

5 3 7 4 1 6 9

[3]

END OF PAPER

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UNIVERSITY OF LONDON **CO2227 ZA**

BSc Examination

CREATIVE COMPUTING AND COMBINED DEGREE SCHEME

Creative Computing II: Interactive Multimedia

Date and Time: Monday 15 May 2017: 10.00–13.00

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 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 hand held 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.

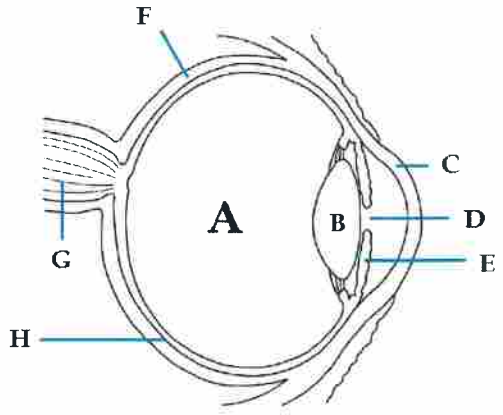
Question 1 Colour and Light

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

i. A

ii. C

iii. G



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

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

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

- additivity
- proportionality
- transitivity

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

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

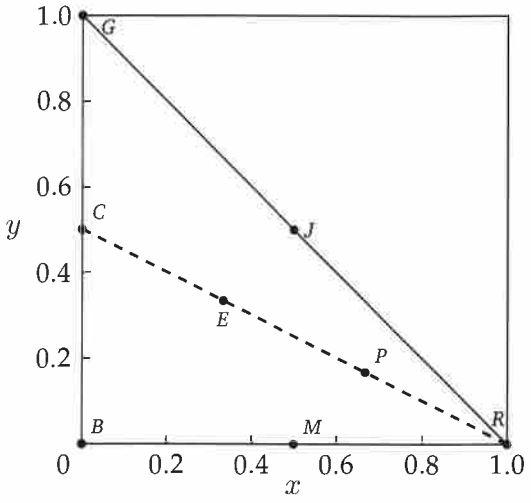
(g) The figure below shows a Maxwell triangle representing the colour space of red, green, and blue primaries.

i. What is the dashed line? [1]

ii. What is point B? [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]



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

i. This cell has a relatively fast response time

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

iii. This cell is less sensitive to light

iv. This cell is important for peripheral vision

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

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

Question 2 Animation

(a) Explain what is meant by *layering* in the context of animation. [3]

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

(c) Let Point A have the coordinates $(30, 100)$ and Point B have the coordinates $(130, 150)$. An animation shows a car stopped at Point A from frame 0 until frame 30. Frame 30 is the last frame at which the car is at Point A; from frame 31 to frame 80, 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 40? Show your work. [2]

iii. If linear interpolation is used, what will be the y coordinate of the car in frame 40? 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 30 and 80: [2]

$$x(f) = ?$$

(d) 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 (c) above. [1]

iii. The equation below is used to compute a Catmull-Rom spline. What is $m(t_k)$? [2]

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

(e) Persistence of Vision

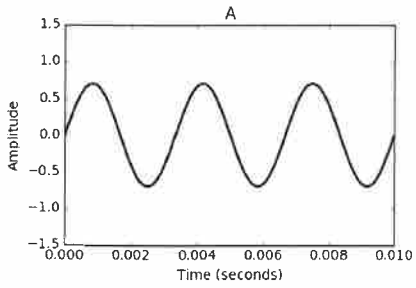
i. What is "persistence of vision" ? [2]

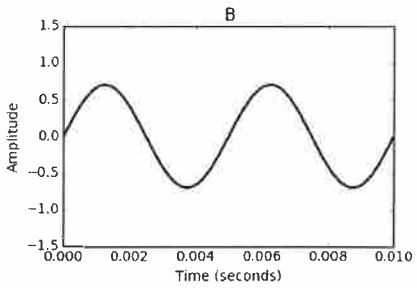
ii. Describe a human perceptual experience that can be explained by this phenomenon. [2]

Question 3 Audio and Music Perception

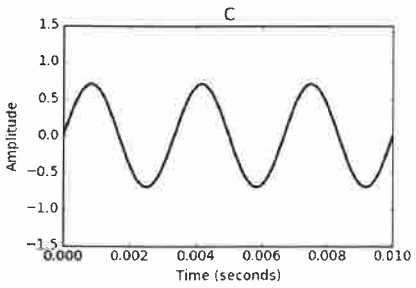
(a) For each row of waveforms below, describe as precisely as you can the difference in how the left waveform will sound from the right one. (Assume that all sinusoids are at suitable amplitudes, frequencies, and phases to be audible.) [3]

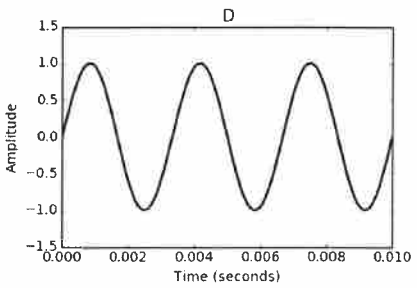
i. A vs B:



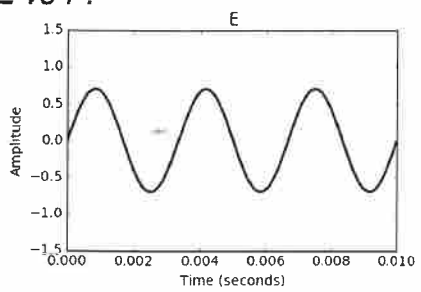


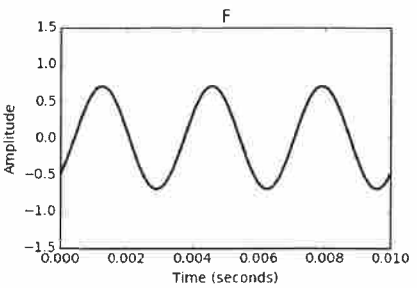
ii. C vs D:





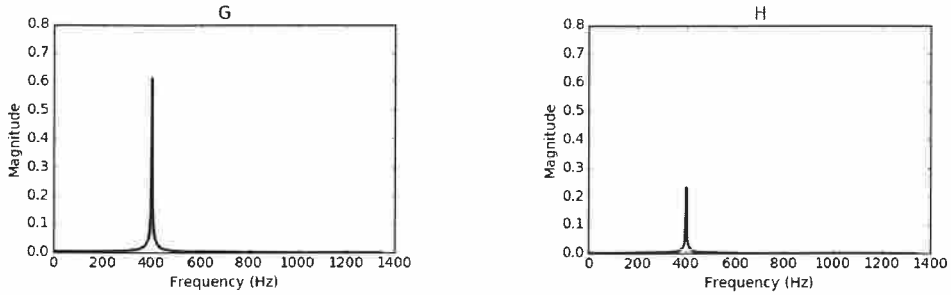
iii. E vs F:



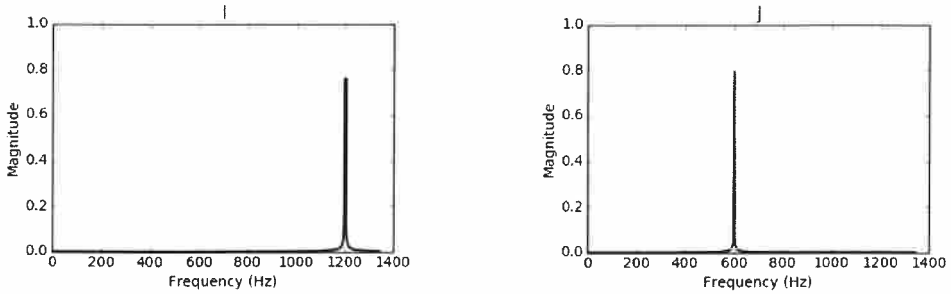


(b) Each row below shows FFTs for two example sounds. Describe as precisely as you can the difference between how the left and right examples will sound. (You can assume that the sounds don't change in volume or frequency content over time.) [3]

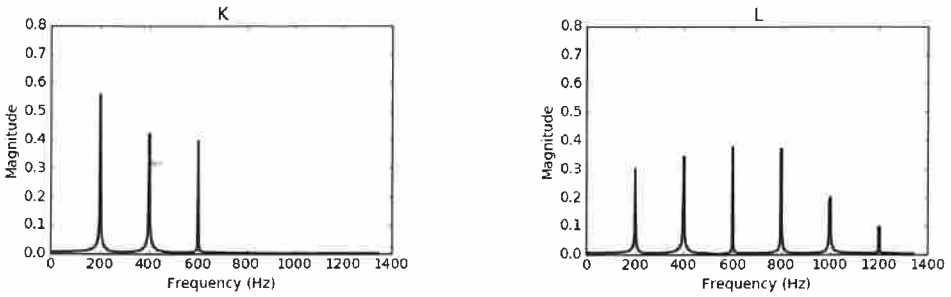
i. G vs H:



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) Critique the following statement: "The perception of dissonance is very straightforward. The closer together two sounds are in frequency, the more dissonant they are." [6]

(e) A violinist plays a note whose pitch is perceived to be the same as a 400Hz sine wave.

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

ii. Explain your answer above. [1]

(f) What is rhythm? [3]

Question 4 Digital Media Signals and Their Representations

(a) Audio representations

i. A song is 3 minutes 24 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 7.3 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. 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]

(c) Bottlenose dolphins can hear frequencies up to 160 kHz. What is the lowest sample rate you could use for analog-to-digital conversion of audio without removing frequencies noticeable to a bottlenose dolphin? [2]

(d) Aliasing

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

ii. How can aliasing be avoided in the analog-to-digital conversion process? [2]

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

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

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 work. [4]

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

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

(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]

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

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

Question 6 Information Retrieval

(a) What is a "feature," in the context of media information retrieval? [3]

(b) Specific Features

i. Parson's code

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. 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]

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

Document	Feature 1	Feature 2
A	140	152
B	80	160

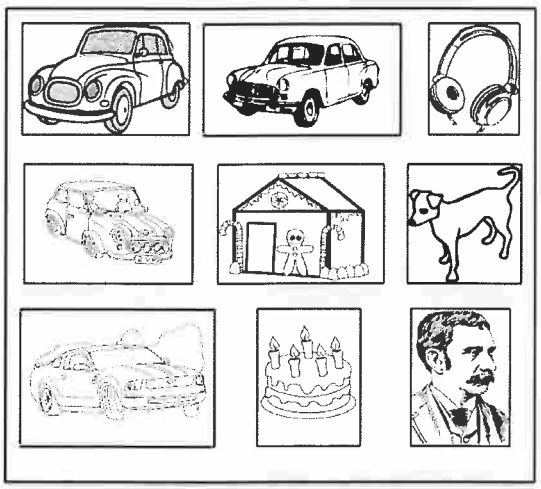
i. Compute the distance between documents A and B using Euclidean distance. Show your work. [2]

ii. A third document, C, has a Euclidean distance of 50 to document A. Which document—B or C—will be judged as more similar to A in this feature space? Why? [2]

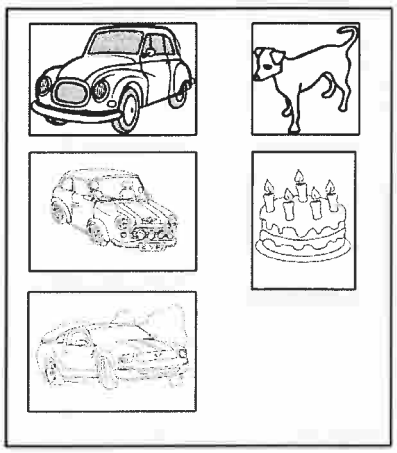
iii. Name two other distance metrics that could be used instead of Euclidean distance for these features. [2]

(d) Precision and Recall

The left side of the figure below shows the contents of a small image database of stock art. A journalist who is looking for a photo to accompany a news story about gardening searches this database using the query "car." The right side of the figure below shows the results returned to her query.



The full image database



Database images returned in response to query "car"

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

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

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

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