

Time allowed: Three Hours

1. (a) Describe briefly in your own words what is forward chaining and what is backward chaining.

(b) Consider the following two facts and eighteen rules:

Facts: b. c.

Rules: $a \rightarrow e$. $b \rightarrow f$. $b \rightarrow g$. $c \rightarrow h$. $(c, d) \rightarrow i$. $e \rightarrow j$. $e \rightarrow k$. $f \rightarrow l$. $f \rightarrow m$.
 $g \rightarrow n$. $(g, h) \rightarrow p$. $i \rightarrow q$. $j \rightarrow r$. $j \rightarrow s$. $k \rightarrow t$. $(k, l) \rightarrow u$. $q \rightarrow v$. $q \rightarrow w$.

where ' $(a1, a2) \rightarrow c1$.' means 'if (a1 and a2) then c1.', and ' $a1 \rightarrow c1$.' means 'if (a1) then c1.'

i. Verify whether each of the following can be derived using forward chaining as well as backward chaining (separately): i. p ii. u iii. w

ii. In the cases where the conclusions cannot be derived, explain briefly which way of chaining would be more helpful to detect the situation.

(c) Write the stages of converting predicate calculus expressions into clauses.

(d) Consider the following:

Hamsa, aged 32, is intelligent; Keerthi, aged 23, is shrewd.

Hamsa is good in Mathematics and Planning but not in Music.

Keerthi is good in English and History but not in Mathematics.

Those who are intelligent and good in Planning or

those who are shrewd and good in Mathematics are eligible for the post of ADS.

Shrewd persons aged less than 25 and good in Mathematics can also be eligible for the post.

i. Represent the above as predicate calculus expressions and convert them into clauses.

ii. Prove that Hamsa is eligible for the post of ADS.

iii. Discuss briefly about finding an answer to the query:

Is Keerthi eligible for the post of ADS?

(e) Consider the fact that Professor Nanthi passed away in 2005.

Discuss briefly what additional facts/rules would be necessary to answer the query:

Is Professor Nanthi alive now?.

2. (a) State clearly what is meant by *semantic nets* and what is meant by *partitioned semantic nets*, and state clearly the advantage(s) of partitioned semantic nets against ordinary semantic nets.

(b) Consider the following statements about birds:

Birds are animals, have vertebrates & feathers, lay eggs and typically imitate human voice. Parrots are medium size birds that are intelligent and are able to imitate human voice. Hummingbird is a small bird native to the Americas. This has the ability to fly backwards. Ostriches and Emus are large birds native to Africa and Australia respectively. Ostriches and Emus cannot fly, but the ostrich has the ability to run at speeds of about 65 km/h. Penguins are birds but cannot fly.

i. Represent the above as semantic nets suitably.

ii. Discuss briefly how the following queries would be answered using your representation.

(α) Which bird can fly backward?

(β) Can the parrot fly forward?

(γ) Do Penguins have feathers?

(δ) Which is the speediest bird on the land?

[You may have to indicate what additional data, which are not possibly inferred from your representation, are needed.]

(c) Represent the following as partitioned semantic nets, and state clearly how the representation can be useful.

i. All birds have feathers.

ii. John likes all girls in his class.

iii. Not all students like AI.

iv. Everyone has a phone.

- (a) Conceptual Dependency is a theory of how to represent the knowledge about events.
- i. List the primitive acts considered for representing actions in Conceptual Dependency.
 - ii. What are the primitive conceptual categories from which dependency structures can be built?
 - iii. Represent the following statements as conceptual dependency diagrams:

(α) John ran to school .	(β) John came home yesterday.
(γ) John gave a book to Mary.	(δ) Mary took a book.
(ϵ) John ate ice-cream with a spoon.	(ζ) John ate ice-cream with Mary.
(η) John saw Mary smoking.	(θ) Since running is good, John runs everyday.
 - iv. State the disadvantages of Conceptual Dependency model as a representation of events.

(b) *Script* is a structure that describes a stereo typed sequence of events in a given context.

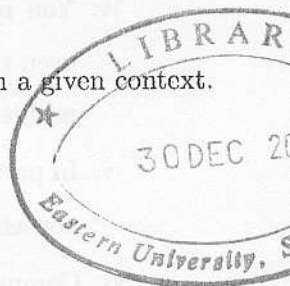
- i. What are the important components of Script?
- ii. Describe the merit of Script in two or three sentences.
- iii. Consider the scenario of getting services at a saloon:

You go to a saloon where many hair-dressers work. You get services from any of your favourite hair-dressers if he/she is free. Otherwise, you wait in the queue until you are called. If the hair dresser who is calling you is not your favourite, you would still wait until any of your favourite hair dresser is free and calling you. In such a case, the next person behind you may get services before you. If you get your hair-dressed, you pay the fee and exit the saloon. If your favourite hair-dresser is absent or if you wait too long for a service, then you exit without paying any fee.

- (α) Formulate the above events as a script with the indication of the important components.
- (β) Given the facts

John goes to the saloon where one lady and one gent work, usually gets his hair dressed by the lady.

Discuss briefly about the possible reasons if he returned without getting any service, by using your script. Explain briefly how you would deduce that he did not make any payment in such a situation.



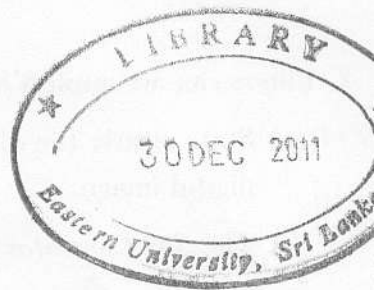
4. (a) Natural Language process has a major role in AI related fields.
- i. State clearly what is meant by *syntax analysis* in natural language processing.
 - ii. Define a context-free grammar which is good enough to parse the following sentence
 - (A) John likes ice-cream.
 - (B) Cats like rats.
 - (C) Mary goes to Hotel.
 - (D) Children go to School.
 - iii. Show how your grammar would successfully parse each of the following sentence (draw parse trees):
 - (A) Children go to School.
 - (B) Mary like ice-cream.
 - (C) Mary likes to School.
 - (D) Ice-cream likes rats.
 - iv. You may realise that in part(iii), (B) is syntactically incorrect in English language even though it conforms to the above context-free grammar. Discuss briefly how problems can be overcome.
 - v. In part(iii), (D) is syntactically correct in English language too, but it is semantically nonsense. Discuss briefly how such problems can be resolved.
 - vi. Comment on correctness of the sentence (C) of part (iii), and how you would handle such sentences.
- (b) Expert systems are programs of special kind.
- i. Define in your own word what an *expert system* is, and draw a diagram to show its main components.
 - ii. State clearly how an expert system differs from conventional programs.
 - iii. Compare and contrast 'human experts' and 'expert systems'.
 - iv. What is meant by 'inference engine' in an expert system.
 - v. Give names of three expert systems with their purposes, and state clearly how knowledge is represented in each system.

(End of Course Examination)

CS404: Image Processing

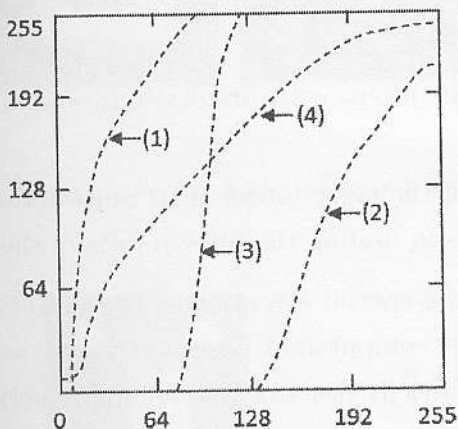
Answer all questions

This paper has 4 questions in a total of 4 pages



Allowed: Two Hours

- 1) Define what a *histrogram* is and describe the *histrogram equalisation* method used for digital image enhancement. [20%]
- 2) Consider the following transformations (1) through (4) which were obtained from the histograms of four images using histogram equalization method.



Comment on the four original images. [20%]

- 3) Suppose that a 64×64 , 8-level image has the gray-level distribution as shown in the table given below:

Gray-level	0	1	2	3	4	5	6	7
Frequency	80	128	240	336	548	848	1024	792

With regard to the gray-level distributions answer the following:

- Draw the original histogram. [10%]
- Draw the equalised histogram of these gray-levels showing your work in detail. [30%]
- State briefly how the final image will differ from the input image. [10%]
- Suppose that a second pass of histogram equalisation is applied (on the histogram-equalised image). Comment briefly on the resultant image. [10%]

2. Filters can accomplish the task of sharpening and smoothing a digital image.

(a) State clearly the difference between *filters* and *point operations* that are performed on a digital image.

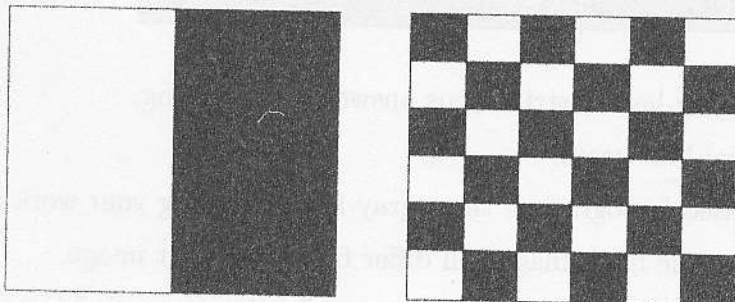
(b) The *Sobel operator* uses the following 3×3 filters:

$$H_x = \begin{bmatrix} -1 & 0 & 1 \\ -2 & 0 & 2 \\ -1 & 0 & 1 \end{bmatrix} \quad \text{and} \quad H_y = \begin{bmatrix} -1 & -2 & -1 \\ 0 & 0 & 0 \\ 1 & 2 & 1 \end{bmatrix}$$

Filters that are orientation-insensitive tend to respond to nonedge structures while most discriminating edge filters such as the simple Sobel operator only respond to edges in a narrow range of orientations. One solution is to use a larger set of filters with more narrowly spaced orientations.

- i. Write down the 3×3 eight filters with orientations spaced at 45° of the extreme Sobel operator.
 - ii. Only the results of four of the eight filters in (i) must actually be computed. Explain the computational savings in finding the filter results of the eight filters.
- (c) The borders of an image require special attention in most filter implementations. Theoretically, no filter results can be computed at positions where the filter matrix is not fully contained in the image array. Briefly describe and compare methods for handling such a situation when performing any filter operation.

(d) The images shown below are quite different, but their histograms are the same. The images have size 60×60 , with black (0) and white (1) pixels. Note that, the black pixels are used to signify the boundaries of the two images but not part of them. Suppose each image is blurred with a 3×3 average mask. How would the histograms of the blurred images differ, and why? Draw the two histograms and explain your answer.



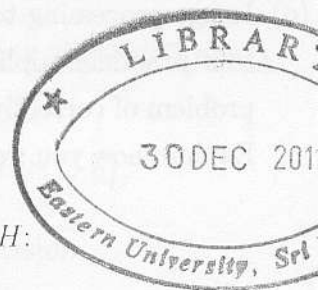
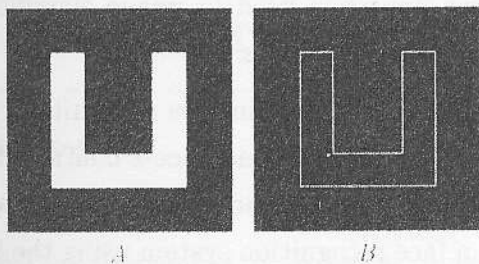
opening and closing are two important operations in mathematical morphology.

Define *opening* and *closing* in terms of dilation and erosion.

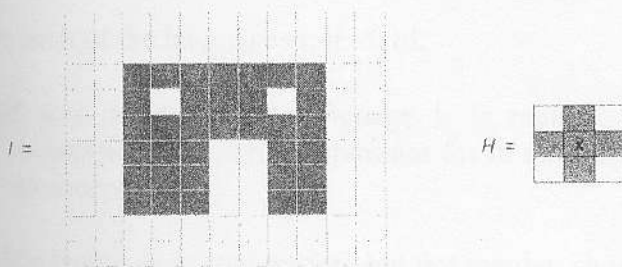
Prove the validity of the expression:

$$(A \circ B) \circ B = (A \circ B)$$

The image A was processed by a morphological transform to produce the image B by using a structuring element H of size 3×3 . B satisfies $B \subseteq A$. Specify the morphological operations that were used to obtain B .



Consider the following binary image I and the structural element H :



Sketch the results of the following for I and H .

- i. Dilation
- ii. Erosion
- iii. Opening
- iv. Closing

4. The process of generating features from an image corpus is called feature extraction.
- (a) Discuss the motivation for *feature extraction* in image processing, and give examples of features that could be useful in an image recognition system.
 - (b) Write down the equations for the following metrics that can be used to measure distance between images in feature space.
 - i. Euclidean distance
 - ii. Chi-squared distance
 - (c) Describe the *nearest neighbour* approach used in image classification when the images are represented by fixed-length feature vectors.
 - (d) Image processing techniques are widely used in face recognition which has many important practical applications, like surveillance and access control. It is concerned with the problem of correctly identifying face images and assigning them to persons in a database. Explain how you would build a face recognition system using the ideas in (a), (b) and (c).