UNIVERSITY OF COLOMBO, SRI LANKA

UNIVERSITY OF COLOMBO SCHOOL OF COMPUTING

**DEGREE OF BACHELOR OF INFORMATION TECHNOLOGY (EXTERNAL)**
***Academic Year 2007/2008 – 3rd Year Examination – Semester 5***

# *IT5502: Image Processing and Computer Vision*

***Structured Question Paper***
**30th March, 2008**
**THREE HOURS**

**To be completed by the candidate**

BIT Examination Index No: .....

**Important Instructions:**

- The duration of the paper is **3 (Three) hours**.
- The medium of instruction and questions is English.
- This paper has **4 questions** and **15 pages**.
- **Answer all 4 questions: Each question carries 25 marks.**
- **Write your answers** in English using the space provided **in this question paper**.
- Do not tear off any part of this answer book.
- Under no circumstances may this book, used or unused, be removed from the Examination Hall by a candidate.
- Note that questions appear on both sides of the paper.
  If a page is not printed, please inform the supervisor immediately.
- **Non-programmable Calculators may be used.**

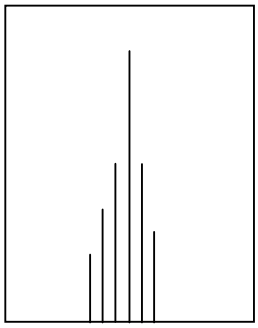
**Questions Answered**

Indicate by a cross (×), (e.g. [X]) the numbers of the questions answered.

| | Question numbers | | | | |
|---|---|---|---|---|---|
| **To be completed by the candidate by marking a cross (×).** | 1 | 2 | 3 | 4 | |
| To be completed by the examiners: | | | | | |
| | | | | | |
| | | | | | |

Index No: ……...

1) (a) The following diagram shows the intensity histogram of a grey-scale image.



(i) What can you say about the contrast of this image?

**(02 marks)**

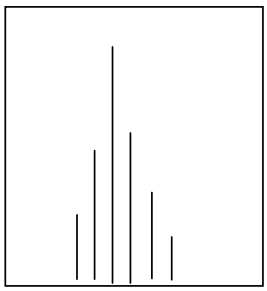
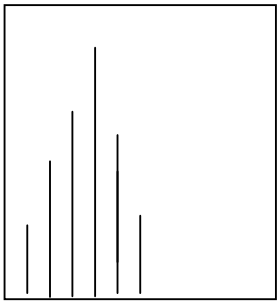
**ANSWER IN THIS BOX**

**The contrast of the image is very low.**

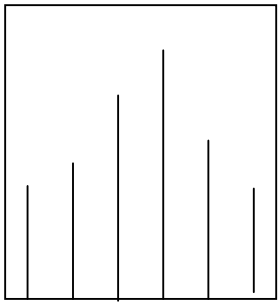
(ii) Sketch the approximate intensity histograms of the new images when the following operations are applied to this image.

**(06 marks)**

**ANSWER IN THIS BOX**

| | |
|---|---|
| Negation (obtaining the negative image) |  |
| Reduction of the intensity levels by half |  |

**Continued…**

| | |
|---|---|
| Histogram Equalization |  |

(b) f(x,y) is a discrete function with $0 \leq x \leq X$, $0 \leq y \leq Y$, and g(m, n) is a discrete function with $0 \leq m \leq M$ and $0 \leq n \leq N$. Write the formula for the convolution of the two functions f*g.

**(02 marks)**

**ANSWER IN THIS BOX**

$$f(x,y)*g(x,y) = (1/MN) \sum_{m=0}^{M} \sum_{n=0}^{N} g(m,n)\, f(x-m, y-n)$$

**x=0….X, y=0…Y**

(c) Give the formula for the Fourier Transform of the function f(x,y) given in (b) above.

**(02 marks)**

**ANSWER IN THIS BOX**

$$\mathbf{f(x,y)} = \sum_{u=0}^{X-1} \sum_{v=0}^{Y-1} \mathbf{F(u,v)} \exp\left( j2\pi\left(\frac{ux}{X} + \frac{vy}{Y}\right)\right)$$

**Where $j^2 = -1$.**

(d) Apply (convolute) the following filters to the image segment given below and give the filtered image.

1 2 4 5 2
5 2 5 6 2
5 4 2 7 1
1 1 3 5 6
2 4 6 4 7

**(09 marks)**

**ANSWER IN THIS BOX**

Roberts Cross Gradient

| | |
|---|---|
| 1 | 0 |
| 0 | -1 |

**-1 -3 -2 -3**

**-1 0 -2 5**

**4 1 -3 1**

**-3 -5 -1 -2**

Prewitt Operator

| | | |
|---|---|---|
| -1 | -1 | -1 |
| 0 | 0 | 0 |
| 1 | 1 | 1 |

**4 2 -1**

**-7 -5 1**

**1 1 7**

Laplacian Operator

| | | |
|---|---|---|
| 0 | 1 | 0 |
| 1 | -4 | 1 |
| 0 | 1 | 0 |

**8 -6 -5**

**-6 11 -14**

**8 2 0**

(e) Explain how a colour image is represented in the computer.

**(04 marks)**

**ANSWER IN THIS BOX**

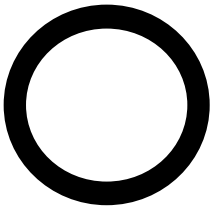
**A colour image is represented using three primary colours Red, Green and Blue (RGB). Every pixel is represented using three colour bands (set of bits).**

**Red**

**Green**

**Blue**

2) (a) A manufacturing company produces high-precision washers of the form shown below.



Using image based techniques, how can you decide whether a given washer has the standard size? State any assumptions that you would make.

**(06 masks)**

**ANSWER IN THIS BOX**

**Assumption : In all the images, the washer is at the same position and the lighting conditions are similar.**

**Let the standard Image be S and A be the image of a produced washer.**

**Subtract the two images S-A = B**

**If B is nearly zero then the dimensions are similar.**

**Continued…**

**Alternative answer : Compare the intensity distribution of the standard image (S) and the washer image(A). Compare their statistics such as mean & standard deviation.**

(b) An image consists of a circuit diagram. It is necessary to detect the lines in this image in four different directions, namely Horizontal, Vertical, Diagonal ($+45^0$) and Diagonal ($-45^0$). Give 3x3 four directional masks which an be used to detect lines in the four directions in the image.

**(04 marks)**

**ANSWER IN THIS BOX**

| | |
|---|---|
| Horizontal → | $\begin{bmatrix} -1 & -1 & -1 \\ 2 & 2 & 2 \\ -1 & -1 & -1 \end{bmatrix}$ |
| Vertical ↑ | $\begin{bmatrix} -1 & 2 & -1 \\ -1 & 2 & -1 \\ -1 & 2 & -1 \end{bmatrix}$ |
| Diagonal ($+45^0$) ↗ | $\begin{bmatrix} -1 & -1 & 2 \\ -1 & 2 & -1 \\ 2 & -1 & -1 \end{bmatrix}$ |
| Diagonal ($-45^0$) ↘ | $\begin{bmatrix} 2 & -1 & -1 \\ -1 & 2 & -1 \\ -1 & -1 & 2 \end{bmatrix}$ |

(c) Explain how, in a circuit diagram image, lines in four different directions can be detected using the directional masks given in (b).

**(07 marks)**

**ANSWER IN THIS BOX**

**Repeat**

**Apply (Convolute) all four masks to a pixel.**

**If the value of all masks are nearly zero then,**

**it is not an edge pixel.**

**Else**

**Select the direction of mask which gives the highest value**

**and label the pixel which has in line at that direction.**

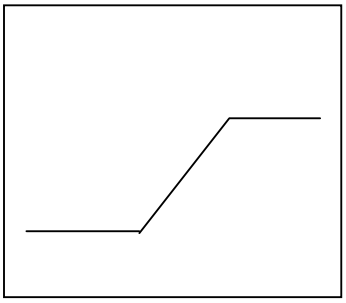
**Continue until all the pixels are proceed.**

(d) The diagram (A) shows the grey-level profile at an edge in an image. Draw the first derivative and second derivative of this profile in the diagrams (B) and (C) respectively.

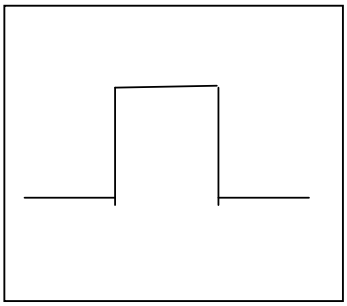
**(04 marks)**

**ANSWER IN THIS BOX**

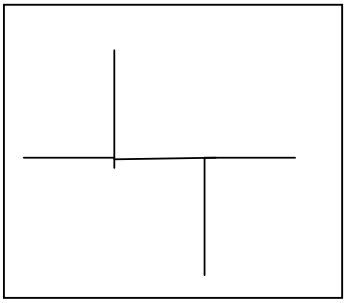
(A) Grey-level profile



(B) First derivative



(C ) Second derivative



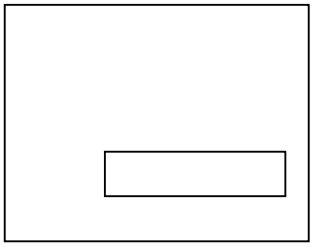
(e) Name four edge detection techniques. Two of these techniques should be based on the first derivative of the image function and the other two based on the second derivative.

**(04 marks)**

**ANSWER IN THIS BOX**

| | |
|---|---|
| Based on the first derivative | **(i) Sobel operator**<br>**(ii) Canny operator** |
| Based on the second derivative | **(i) Laplacian operator**<br>**(ii) Marr-Hildreth operator** |

3) (a) In a handwritten character recognition system, the characters are written in a rectangular box. It is necessary to detect the location of this rectangle first. A sample image is given below.



Explain a technique to detect the location of the rectangle in the image.

**(06 marks)**

**ANSWER IN THIS BOX**

**Scan the image horizontally and count the number of black pixels along each horizontal line. Then draw the histogram**

**The two line positions give the horizontal location of the rectangle.**

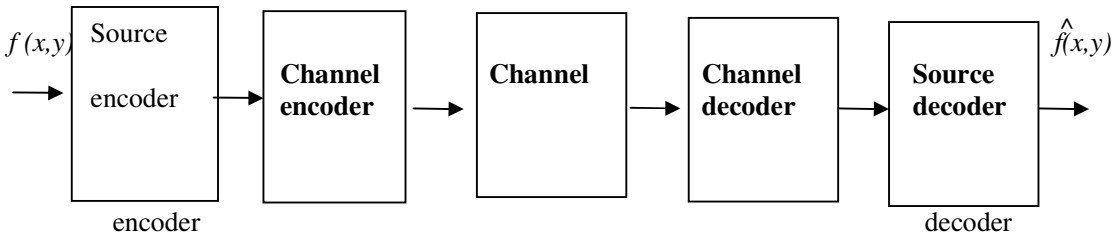
**Continued…**

**Similarly, scanning vertically, two vertical positions can be located.**

(b) The following diagram shows the general compression system model. Fill the blank boxes with the correct words.

**04 marks)**

**ANSWER IN THIS BOX**

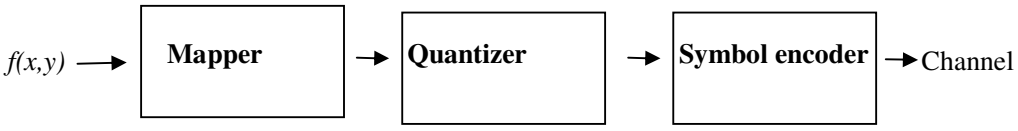



(c) The following diagram shows (A) source encoder and (B) source decoder model. Fill the blank boxes with correct words.

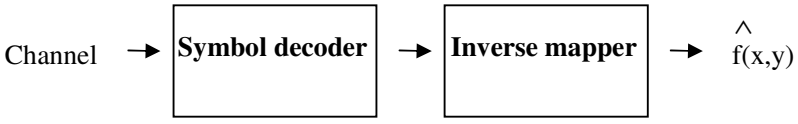
**(05 marks)**

**ANSWER IN THIS BOX**

A) Souce encoder




(B) Souce decoder



(e) Calculate the bits/pixel required if the following image (6 level) is represented using
(i) Huffman code
(ii) Run-length code

0 0 0 0 0 0
0 0 1 2 2 3
0 1 1 3 3 4
0 2 2 4 5 5
0 5 2 3 4 5
0 0 0 0 0 0

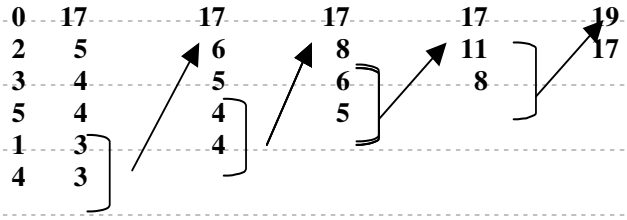
**(10 marks)**

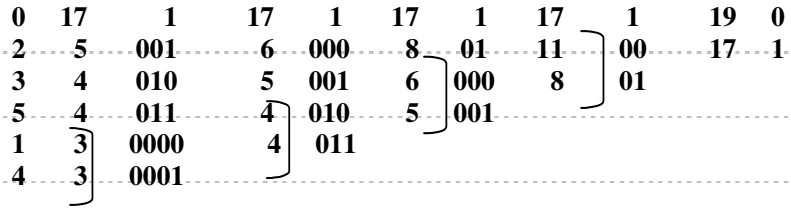
**ANSWER IN THIS BOX**

(i) **Huffman coding**

**The principle is to the give the shortest code to the most frequent symbols (grey-levels) and the longest code to the least frequent.**

| Grey -level | 0 | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|---|
| Pixels | 17 | 3 | 5 | 4 | 3 | 4 |
| Order | 1 | 5 | 2 | 3 | 6 | 4 |




**Number of bits required = 17 *1 +(5+4+4)*3+(3+3)*4 = 80**

**Bits/Pixel = 80/36 =2.22**

**Continued…**

(ii) **Run-Length coding**

**The principle is to represent the image row by row using (*grey-level, run-length*) pairs.**

| Row | Run length |
|---|---|
| 1 | (0,6) |
| 2 | (0,2), (1,1), (2,2), (3,1) |
| 3 | (0,1), (1,2), (3,2), (4,1) |
| 4 | (0,1), (2,2), (4,1), (5,2) |
| 5 | (0,1), (5,1), (2,1) (3,1), (4,1), (5,1) |
| 6 | (0,6) |

**There are 20 run-lengths, each needing 6 bits (3 to represent grey-level and 3 to represent run-length)**

**Number of bits required = 20*6 =120**

**Bits/Pixel =120/36= 3.33**

**This is more expensive than representing 6 grey-levels (3 bits each) as 6*6*3 =108**

4) (a) What is the difference between Image Processing and Computer Vision?

**(03 marks)**

**ANSWER IN THIS BOX**

**Image processing - The basic objective of image processing is to improve the appearance of images using digital computers.**

**Computer Vision – The basic objective is to identify the objects in an image and give interpretation about them. It is necessary to use intelligent systems using domain knowledge for this. Preprocessing of the image should be done using image processing techniques.**

(b) General purpose Computer Vision is difficult to achieve. Give reasons for this.

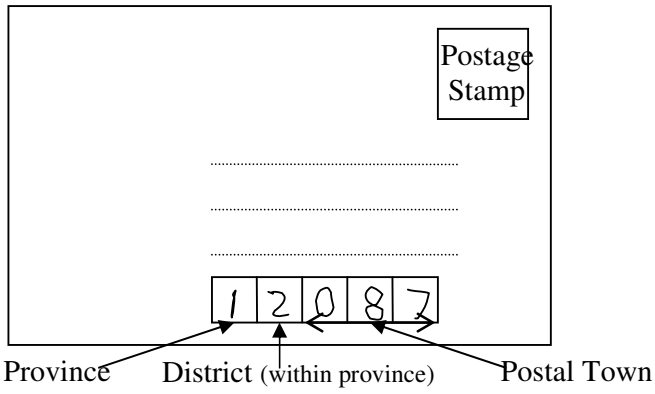
**(03 marks)**

**ANSWER IN THIS BOX**

1. **An Image gives a 2 dimensional view of a scene and hence, some details of the scene are lost.**
2. **Occlusions can occur making the interpretation difficult.**
3. **It's difficult to achieve real time results.**

**Parts (c), (d) and (e) are based on the following problem**

A Neural Network based solution has been proposed to automate the present manual 'Mail Sorting System' of the Postal Department through a process of recognising the handwritten postcode (as shown below) in the envelope. The postcode consists of 5 digits in which the first digit represents the province, the second represents the District within the Province and the last three digits represent the Postal Town.




(c) Starting from capturing the postcode image using a camera, identify the main steps involved in this process.

**(06 marks)**

**ANSWER IN THIS BOX**

**(i) Capture image**

**Continued…**

**(ii) Preprocessing**

- **Noise removal**
- **Skew correction**
- **Segmentation of postcode**
- **Segmentation of individual characters (digits)**
- **Process characters to input**

**(iii) Train network**

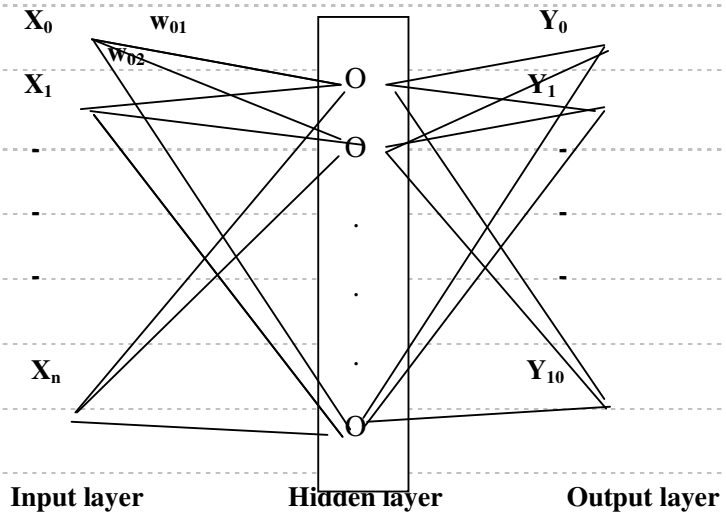
**(iv) Test network**

(d) Draw a labelled diagram of the proposed Neural Network. What are the input vector and output vector of the network?

**(07 marks)**

**ANSWER IN THIS BOX**

**Input vector - Character frame in 1-D or features**
**Output vector - 0-9 Digits assigned to 10 output nodes**



(e) Briefly explain the preprocessing of the postcode image to produce the input vector.

**(06 marks)**

**ANSWER IN THIS BOX**

**Segmentation of postcode frame using Boundary Location.**

| - | - | - | - | - |
|---|---|---|---|---|

**Segmentation of each character using Boundary Locations**

| | | | | |
|---|---|---|---|---|
| | | | | |

**Arranging the characters (pixels) matrix row- wise or column –wise to form input vector**

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