UCSC

BIT

UNIVERSITY OF COLOMBO, SRI LANKA

UNIVERSITY OF COLOMBO SCHOOL OF COMPUTING

(Successor to the Institute of Computer Technology (ICT))

DEGREE OF BACHELOR OF INFORMATION TECHNOLOGY (EXTERNAL)

Academic Year 2004/2005 – 3rd Year Examination – Semester 5

IT5101: Visual Computing

19th March, 2005

(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 **24 pages**.
- **Answer all 4 questions**. The first two questions carry 30 marks each and the other two questions carry 20 marks each.
- **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.

To be completed by the candidate by marking a cross (×).	1	2	3	4	
To be completed by the examiners:					

Index No: ………………...

1) (a) State three (03) major differences between raster graphics and vector graphics.

(03 marks)

ANSWER IN THIS BOX

Raster Graphics:

1. **Raster Graphics are digital images created or captured. (Scanning, Camera)**
2. **2D (X, Y) or 3D (X, Y, Z)…raster decides which coordinates to illuminate.**
3. **Usually referred to as a Bit map since the information is mapped directly onto the grid**
4. **Not easy to edit or manipulate image**

Vector Graphics:

1. **Vector graphics are created through a sequence of mathematical statements.**
2. **It can be in 2D or 3D but the information saved is in the form of Vectors. (Direction and Quantity or Weight)**
3. **Since information contains vectors, file is small.**
4. **Easy to edit and manipulate**

(b) What is a frame buffer and how is it used to show an image on a display?

(02 marks)

ANSWER IN THIS BOX

A frame buffer is simply the video memory that holds the pixels from which the video display (frame) is refreshed.

This memory area holds the set of intensity values for all the screen points.

Stored intensity values are then retrieved from the refresh buffer and painted on the screen one row (scan line) at a time.

Pictures or images are painted on the screen by retrieving the information from the frame buffer as the electron beam in the CRT sweeps across each scan line from left to right, top to bottom.

(c) Explain how a cathode ray tube (CRT) works, including details of how colour is displayed.

(03 marks)

ANSWER IN THIS BOX

A cathode-ray tube (CRT) is a specialized vacuum tube in which images are produced when an electron beam strikes a phosphorescent surface.

A CRT works by moving an electron beam back and forth across the back of the screen. Each time the beam passes across the screen, it lights up phosphor dots on the inside of the glass tube, thereby illuminating the active portions of the screen. By drawing many such lines from the top to the bottom of the screen, they create an entire screen of images.

A CRT consists of several basic components. The electron gun generates a narrow beam of electrons. The anodes accelerate the electrons. Deflecting coils produce an electromagnetic field that allows for constant adjustment of the direction of the electron beam. There are two sets of deflecting coils: horizontal and vertical. The intensity of the beam can be varied.

(d) Consider three different raster systems with resolutions of 640 by 480, 1280 by 1024 and 2560 by 2048. What size frame buffer (in bytes) is needed for each of these systems to store 12 bits per pixel?

(03 marks)

ANSWER IN THIS BOX

640 x 480 x 12 = 3686400=460800 bytes

1280 x 1024 x 12 =15728640=1966080 bytes

2560 x 2048 x 12 = 62914560= 7864320 bytes

(e) What is a Digital Difference Analyser (DDA) and how is it used to draw a line?

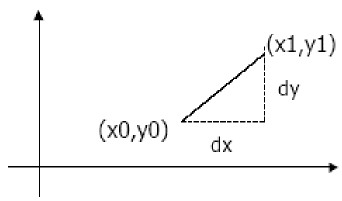
(05 marks)

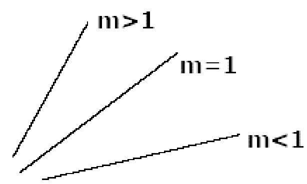
ANSWER IN THIS BOX

DDA is a scan conversion line algorithm based on calculating either Δy or Δx.

$\Delta y = m \, \Delta x$

We sample the line at unit intervals and in one coordinate and then determine the corresponding integer values nearest the line path for the other coordinate.





If $0 < m \leq 1$, then taking unit steps in x direction,

$y_{i+1} - y_i = m * 1 = m$

$y_{i+1} = y_i + m$ ……….. (1)

If m>1, then taking unit steps in y direction

$x_{i+1} - x_i = 1/m$

$x_{i+1} = x_i + 1/m$ …… (2)

If m<0

If $|m| \leq 1$ use (1)

If $|m| > 1$ use (2)

If $\Delta x = -1$, $y_{i+1} = y_i - m$ ……….. (3)

If $\Delta y = -1$, $x_{i+1} = x_i - 1/m$ ..……….. (4)

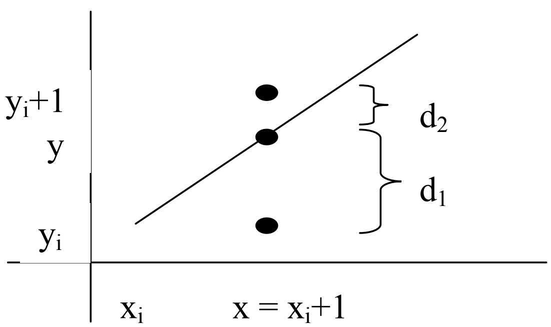
(f) What are the differences between the DDA algorithm and Bresenham's algorithm?

(02 marks)

ANSWER IN THIS BOX

- **The DDA algorithm includes floating point arithmetic (since m is a real number). Therefore, it is inefficient and can produce a wrong line path due to rounding off errors.**
- **Bresenham algorithm**
  - **Incremental algorithm: current value uses previous value**
  - **Integers only: avoids floating point arithmetic**

(g)



Bresenham's line drawing algorithm looks for the next possible pixel to be plotted by searching for the minimum distance out of d_1 and d_2. The above figure illustrates this case.
(i) Find the value of (d_1-d_2).
(ii) Evaluate a decision parameter, P_i, only in terms of Δy , Δx, y_i, and x_i . Note that P_i is equal to $\Delta x(d_1-d_2)$.
(iii) Finally, show that $P_1=\Delta x - 2\Delta y$.

(06 marks)

ANSWER IN THIS BOX

(i) $d_1 = y_i+1 - y$

$d_2 = y - y_i$

$d_1 - d_2 = 2y_i - 2y + 1$

$= 2y_i - 2(m(x_i+1)+c)+1$

$= 2y_i - 2(\Delta y/\Delta x)x_i - 2(\Delta y/\Delta x) - 2c+1$

Continued..

(ii) $P_i = \Delta x\,(d_1 - d_2)$

$P_i = \Delta x\,(2\,y_i\ -2\,(\Delta y/\,\Delta x)\,x_i\ -2\,(\Delta y/\,\Delta x)-2c+1)$

$= 2\,\Delta x\,y_i - 2\,\Delta y\,x_i - 2\,\Delta y\,-2c\,\Delta x + \Delta x$

$= 2\,\Delta x\,y_i - 2\,\Delta y\,x_i + A$ where $A= \Delta x - 2c\,\Delta x - 2\Delta y$ is constant

(iii) P1= $2\,\Delta x\,y1 - 2\,\Delta y\,x1 - 2\,\Delta y\,-2c\,\Delta x + \Delta x$

Since c=y-mx where $m=\Delta y/\,\Delta x$, $c=y1-(\Delta y/\,\Delta x)x1$

P1= $2\,\Delta x\,y1 - 2\,\Delta y\,x1 - 2\,\Delta y\,-2(y1-(\Delta y/\,\Delta x)x1)\Delta x + \Delta x$

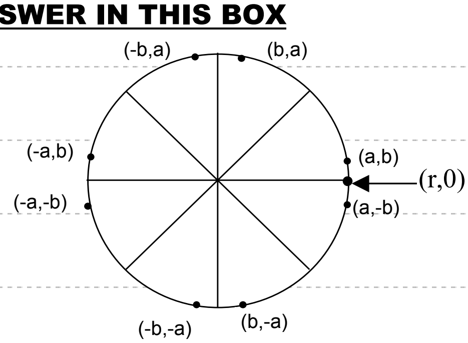
P1= $2\,\Delta x\,y1 - 2\,\Delta y\,x1 - 2\,\Delta y - 2y1\Delta x + 2\Delta y x1 + \Delta x$

P1= $\Delta x - 2\,\Delta y$.

(h) Give an algorithm for drawing the part of a circle which lies in the first octant. Assume that the circle has integer radius and is centred at the origin. Assume that you have a function *setpixel(x, y)* which turns on pixel (x, y).

(03 marks)

ANSWER IN THIS BOX




```
Begin  {Circle}
        x := r;
        y := 0;
        d := 1 - r;
        Repeat
                setpixel(x,y);
                y := y + 1;
```

Continued..

```
            If d < 0 Then
                  d := d + 2*y + 1
            Else Begin
                  x := x - 1;
                  d := d + 2*(y-x) + 1
            End
      Until x < y
End;  {Circle}
```

(i) In ray tracing, ambient, diffuse and Phong's specular shading can be used to define the illumination at a point on a surface. Derive an equation for the overall illumination of the point with necessary contributions from each component of reflection.

(Note: You may state any assumptions made and define the lighting parameters as required.)

(03 marks)

ANSWER IN THIS BOX

Diffuse contribution at point P

$I_{diff} = k_a I_a + k_d I_l (N.L)$

(Assumption: I_l is the illumination of the light source)

Specular contribution at point P

$I_{spec} = k_s I_l (V.R) n_s$

Overall Illumination at P

$I_{overall} = I_{diff} + I_{spec}$

Where

k_a **material's ambient coefficient**

Continued..

I_a ambient light (R, G and B)

k_d material's diffuse coefficient

I_l Intensity of the light(R, G and B)

N surface normal at point of intersection

L vector to the light from point of intersection

k_s material's specular coefficient

V vector to viewer from point of intersection

R vector L reflected at point of intersection

n_s material's specular reflection parameter

2) (a) Homogeneous coordinates are used to represent transformations in 3D space.
How does one convert homogeneous coordinates to standard 3D coordinates? Give an example.

(02 marks)

ANSWER IN THIS BOX

The 3D points (x,y,z) will be represented in homogeneous coordinates as a coordinate quadruple (x_u,y_u,z_u,w_u).

$x= x_u/w_u$ and $y= y_u/w_u$ where w_u is a scaling factor.

$(x_u,y_u,z_u,w_u) \rightarrow (x_u/w_u,\ y_u/w_u,\ z_u/w_u)$

(b) Consider the following matrix:

$$\begin{bmatrix} x'_H \\ y'_H \\ z'_H \\ w'_H \end{bmatrix} = \begin{bmatrix} a_{11} & a_{12} & a_{13} & b_1 \\ a_{21} & a_{22} & a_{23} & b_2 \\ a_{31} & a_{32} & a_{33} & b_3 \\ c_1 & c_2 & c_3 & d \end{bmatrix} \begin{bmatrix} x_H \\ y_H \\ z_H \\ w_H \end{bmatrix}$$

Describe the types of transformations provided by the following four blocks of coefficients in the above matrix:

(i) $\begin{matrix} a_{11} & a_{12} & a_{13} \\ a_{21} & a_{22} & a_{23} \\ a_{31} & a_{32} & a_{33} \end{matrix}$ (ii) $\begin{matrix} b_1 \\ b_2 \\ b_3 \end{matrix}$ (iii) $c_1 \quad c_2 \quad c_3$ (iv) d

(04 marks)

ANSWER IN THIS BOX

i. **the 3x3 array** $\begin{matrix} a_{11} & a_{12} & a_{13} \\ a_{21} & a_{22} & a_{23} \\ a_{31} & a_{32} & a_{33} \end{matrix}$ **performs affine transformations such as scaling, rotation and shearing.**

ii. $\begin{matrix} b_1 \\ b_2 \\ b_3 \end{matrix}$ **performs translations**

iii. $c_1 \quad c_2 \quad c_3$ **performs perspective transformations.**

iv. ***d* is the global scaling factor.**

(c) Explain what transformation is produced by each of the following matrices:

$$\begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 1 & 0 \end{bmatrix} \qquad \begin{bmatrix} 1 & 0 & p & -p(1+r) \\ 0 & 1 & q & -q(1+r) \\ 0 & 0 & 1+r & -r(1+r) \\ 0 & 0 & 1 & -r \end{bmatrix}$$

(i) (ii)

(02 marks)

ANSWER IN THIS BOX

(i) **performs a perspective transformation projecting about the origin onto the plane z=1**

(ii) **performs a perspective transformation, projecting about the point (p,q,r) onto the plane z=r+1**

Continued..

(d) Derive a matrix, or a product of matrices, to perform a clockwise 2D rotation of arbitrary angle θ about an arbitrary point, (x_c, y_c) of an object.

(05 marks)

ANSWER IN THIS BOX

First translate the object so that the arbitrary position is moved to the coordinate origin.

Secondly, rotate the object about the coordinate origin.

Finally, translate the object so that the arbitrary point is returned to its original position.

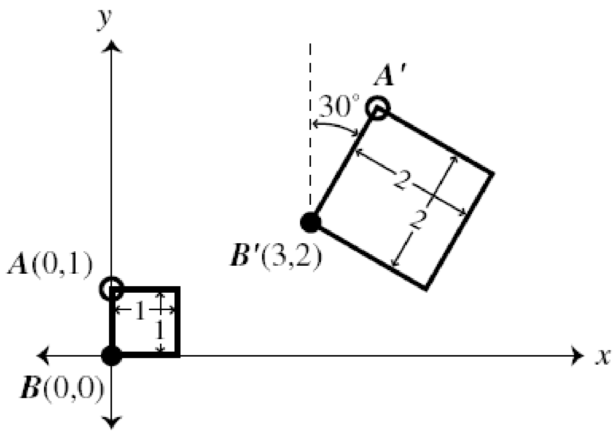
The sequence of the matrices for the above 3 steps are:

$$\begin{bmatrix} 1 & 0 & x_c \\ 0 & 1 & y_c \\ 0 & 0 & 1 \end{bmatrix} . \begin{bmatrix} \cos\theta & -\sin\theta & 0 \\ \sin\theta & \cos\theta & 0 \\ 0 & 0 & 1 \end{bmatrix} . \begin{bmatrix} 1 & 0 & -x_c \\ 0 & 1 & -y_c \\ 0 & 0 & 1 \end{bmatrix}$$

It gives us the final matrix:

$$\begin{bmatrix} \cos\theta & -\sin\theta & x_c(1-\cos\theta)+y_c\sin\theta \\ \sin\theta & \cos\theta & y_c(1-\cos\theta)-x_c\sin\theta \\ 0 & 0 & 1 \end{bmatrix}$$

(e) Consider the following diagram:



The above diagram shows a compound 2D transformation applied to a unit square. The overall transformation can be described in terms of a number of simpler transformations. Describe each of these simple transformations and give a matrix representation of each using homogeneous coordinates.

(03 marks)

ANSWER IN THIS BOX

Scaling by factor of 2 is given by the matrix $\begin{bmatrix} 2 & 0 & 0 \\ 0 & 2 & 0 \\ 0 & 0 & 1 \end{bmatrix}$

Rotation by 30˚ clockwise is given by the matrix $\begin{bmatrix} \cos 30^0 & \sin 30^0 & 0 \\ -\sin 30^0 & \cos 30^0 & 0 \\ 0 & 0 & 1 \end{bmatrix}$ **=**

$\begin{bmatrix} \sqrt{3}/2 & 1/2 & 0 \\ -1/2 & \sqrt{3}/2 & 0 \\ 0 & 0 & 1 \end{bmatrix}$

Translation of $\begin{bmatrix} 3 \\ 2 \\ 1 \end{bmatrix}$ **is given by the matrix** $\begin{bmatrix} 1 & 0 & 3 \\ 0 & 1 & 2 \\ 0 & 0 & 1 \end{bmatrix}$

(f) Use the matrices from 2(e) to find the coordinates of point A', the image of point A under the overall transformation.

(04 marks)

ANSWER IN THIS BOX

Apply scale, then rotation and then translation.

A1 = [0 1 1]^T in homogeneous coordinates.

$$A2 = \begin{bmatrix} 2 & 0 & 0 \\ 0 & 2 & 0 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} 0 \\ 1 \\ 1 \end{bmatrix} = \begin{bmatrix} 0 \\ 2 \\ 1 \end{bmatrix}$$

$$A3 = \begin{bmatrix} 0 \\ 2 \\ 1 \end{bmatrix} = \begin{bmatrix} \sqrt{3}/2 & 1/2 & 0 \\ -1/2 & \sqrt{3}/2 & 0 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} 1 \\ \sqrt{3} \\ 1 \end{bmatrix}$$

$$A4 = \begin{bmatrix} 1 & 0 & 3 \\ 0 & 1 & 2 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} 1 \\ \sqrt{3} \\ 1 \end{bmatrix} = \begin{bmatrix} 4 \\ \sqrt{3}+2 \\ 1 \end{bmatrix}$$

Therefore, A'= (4, $\sqrt{3}$ +2).

(g) State 4 things one can do to control the shape of a B-spline.

(04 marks)

ANSWER IN THIS BOX

Any 4 of the following.

1. **Move the control points.**
2. **Add or remove control points.**
3. **Use multiple control points.**
4. **Change the order of the B-spline.**
5. **Change the type of knot vector.**
6. **Change the relative spacing of the knots.**
7. **Use multiple knot values in the knot vector.**

(h) What is a Bezier curve? What is the relationship between the shape of the curve and the position of the control points?

(03 marks)

ANSWER IN THIS BOX

A Bezier curve is a polynomial of degree one less than the number of control point used.

For Example, a cubic Bezier curve consists of four control points used to position and modify the curve, P0 through P3. The two intermediate points P1 and P2 are used to specify the endpoint tangent vectors, hence the curve interpolates (passes through) P0 and P3 while approximating the other two control points.

No matter the degree of the curve, there is no local control property. All control points affect the shape of the curve.

Irrespective of the manipulation of the control points, we can always rely on the curve to lie within the convex hull defined by the control points.

(i) Obtain the parametric representation of a cubic Bezier function for four points in 3 dimensional space. Represent it in matrix form.

(03 marks)

ANSWER IN THIS BOX

Let $P_0, P_1, \ldots, P_n$ be (n+1) control points. Then the Bezier curve is defined as:

$$P(u) = \sum_{k=0}^{n} P_k \, {}^{n}C_k u^k (1-u)^{n-k}, \quad 0 \le u \le 1$$

The cubic Bezier curve function is:

$$P(u) = \sum_{k=0}^{3} P_k \, {}^{3}C_k u^k (1-u)^{3-k}$$

$$= P_0 \, {}^3C_0 u^0(1-u)^3 + P_1 \, {}^3C_1 u^1(1-u)^2 + P_2 \, {}^3C_2 u^2(1-u) + P_3 \, {}^3C_3 u^3(1-u)^0$$

$$= P_0 (1-u)^3 + P_1 3u(1-u)^2 + P_2 3u^2(1-u) + P_3 u^3$$

It can be given in the matrix form as

Continued..

$$P(u) = \begin{bmatrix} u^3 & u^2 & u & 1 \end{bmatrix} . \begin{bmatrix} -1 & 3 & -3 & 1 \\ 3 & -6 & 3 & 0 \\ -3 & 3 & 0 & 0 \\ 1 & 0 & 0 & 0 \end{bmatrix} . \begin{bmatrix} P_0 \\ P_1 \\ P_2 \\ P_3 \end{bmatrix}$$

3) (a) Give three applications of Digital Image Processing (DIP) and explain briefly the role of DIP in these applications.

(03 marks)

ANSWER IN THIS BOX

Any 3 of the following:

1. Nuclear Medicine: Inject a patient with a radioactive isotope that emits gamma rays as it decays. Images are produced from the emissions collected by gamma ray detectors.

2. X-rays: X-rays are mainly used in medical diagnostics, but they are also used in industry and other areas like astronomy. X-rays for medical and industrial imaging are generated using an X-ray tube. The intensity of the X-rays is modified by absorption as they pass through the patient, and the resulting energy falling on the film develops it, much in the same way that light develops photographic film.

3. Angiography: Used to obtain images of blood vessels. Image subtraction is used to enhance further the blood vessels.

4. Image enhancement: Image enhancement is done to enhance images for computer vision.

- **scientific filtering**
- **forensic science: Image enhancement has been used by forensic scientists for years to pull information from seemingly hopeless images.**
- **Medical Imaging**

5. Multipart composition: Image composition is popular in art world, as well as in tabloid news world. It takes parts of several images and creates single image.

6. Character Recognition: Extracting boundaries, feature points or edges for recognition of characters

7. Aerial Photography: Aerial photographs are processed further to create maps, etc.

8.Desk-top Publishing: Enhancing, clipping, adjusting color or gray scale images, cropping, scaling, masking of images can be done digitally before publishing.

9. Computer vision: Many applications such as edge detection, enhancement, transformations and motion detection used in computer vision applications.

(b) What is meant by a Gray level Histogram?

(02 marks)

ANSWER IN THIS BOX

The histogram is a graph showing the number of pixels in an image at each different intensity value found in that image. For an 8-bit gray-scale image there are 256 different possible intensities, and so the histogram will graphically display 256 numbers showing the distribution of pixels amongst those gray-scale values.

The Definition of a histogram is as follows:

A histogram of a digital image with gray levels in the range [0, L-1] if a discrete function $h(r_k) = n_k$, where r_k is the k^{th} gray level and n_k is the number of pixels in the image having gray level r_k.

(c) Describe the steps involved in performing histogram equalization.

(02 marks)

ANSWER IN THIS BOX

Define the following:

the number of pixels in the image = n

Gray-level range = 0….m

k is a gray-level where $0 \leq k \leq m$

No. of pixels having gray-level k = n_k

Let $r_k = k/m$

Then, the probability of a given pixel having gray-level value k = $P(r_k) = n_k/n$.

Define the gray-level transformation

Continued..

$$S_k = T(r_k) = \sum_{i=0}^{k} P(r_i) = \sum_{i=0}^{k} n_i / n$$

Then the gray-level transformation is defined as

For all k, k → round(S_k*m)

Thus, after histogram equalization, the output image is obtained by mapping each pixel with level r_k in the input image into a corresponding pixel with level s_k in the output image.

(d) After histogram equalization, will an image have more, the same or fewer distinct gray values? Explain your answer.

(02 marks)

ANSWER IN THIS BOX

It will have more gray values.

Histogram equalization has the general tendency of spreading the histogram of the input image so that the levels of the histogram-equalized image will span a fuller range of the gray scale.

(e) Suppose that a 64x64 image with 8 gray levels (0-7) has the following gray level distribution.

Gray Level	Number of Pixels
0	700
1	1113
2	860
3	646
4	334
5	230
6	132
7	81

Continued..

Identify the Gray-level transformation required for the Histogram Equalization of the image.

(04 marks)

ANSWER IN THIS BOX

n = 4096

$S_0 = T(r_0)$ = $\sum_{i=0}^{0} \frac{n_i}{n} = \frac{700}{4096} \Rightarrow k_{new} = round(1.19) = 1$

$S_1 = T(r_1)$ = $\sum_{i=0}^{1} \frac{n_i}{n} = \frac{1813}{4096} \Rightarrow k_{new} = round(3.09) = 3$

$S_2 = T(r_2)$ = $\sum_{i=0}^{2} \frac{n_i}{n} = \frac{2673}{4096} \Rightarrow k_{new} = round(4.56) = 5$

$S_3 = T(r_3)$ = $\sum_{i=0}^{3} \frac{n_i}{n} = \frac{3319}{4096} \Rightarrow k_{new} = round(5.67) = 6$

$S_4 = T(r_4)$ = $\sum_{i=0}^{4} \frac{n_i}{n} = \frac{3653}{4096} \Rightarrow k_{new} = round(6.24) = 6$

$\sum_{i=0}^{5} \frac{n_i}{n} = \frac{3883}{4096} \Rightarrow k_{new} = round(6.63) = 7$

S5 = T(r5) =

$\sum_{i=0}^{6} \frac{n_i}{n} = \frac{4015}{4096} \Rightarrow k_{new} = round(6.72) = 7$

S6 = T(r6) =

S7 = T(r7) = $\sum_{i=0}^{0} \frac{n_i}{n} = \frac{4096}{4096} \Rightarrow k_{new} = round(7) = 7$

(f) Briefly describe the neighbourhood averaging technique and median filtering technique in noise removal, comparing their advantages and disadvantages.

(05 marks)

ANSWER IN THIS BOX

Neighbourhood Averaging

Is also called mean filtering. Replaces each pixel value in an image with the mean ('average') value of its neighbours, including itself.

Has effect of eliminating pixel values which are unrepresentative of their surroundings.

Mean Filtering tends to blur the image and hence the sharpness of edges may be reduced.

It smoothes local variations in an image. Noise is reduced as a result of blurring.

Median Filtering

Replaces the value of a pixel by the median of the gray levels in the neighbourhood of that pixel. The original value of the pixel is included in the computation of the median.

For certain types of random noise, they provide excellent noise-reduction capabilities, with considerably less blurring than linear smoothing filters of similar size.

Median filtering has the following properties:

1. **Reduces the variance of the intensities in the image.**
2. **Intensity oscillations with a period less than the window width are smoothed.**
3. **Preserves the sharpness and location of edges.**

(g) What is the principle behind the simplest lowpass filter, the *Ideal Lowpass Filter*?

(02 marks)

ANSWER IN THIS BOX

It cuts off all high frequency components of the Fourier transform which are at a distance greater than a specified distance from the origin of the transform.

4) (a) How can one detect an isolated point in an image? Write down a 3x3 mask that can be used for this purpose.

(02 marks)

ANSWER IN THIS BOX

Run a mask through the image and compute the sum (sar, R) of products of the coefficient within the gray levels contained in the region encompassed by the mask. We say that a point has been detected at the location on which the mask is centered if |R| ≥ T, where T is a nonnegative threshold.

A mask for point detection is :

-1	-1	-1
-1	8	-1
-1	-1	-1

(b) Write down a set of masks which can be used to detect each of the following lines:
(i) horizontal, (ii) vertical, (iii) in +45˚ direction and (iv) in -45˚ direction.

(02 marks)

ANSWER IN THIS BOX

(i)

-1	-1	-1
2	2	2
-1	-1	-1

(ii)

-1	2	-1
-1	2	-1
-1	2	-1

(iii)

-1	-1	2
-1	2	-1
2	-1	-1

(iv)

2	-1	-1
-1	2	-1
-1	-1	2

(c) What are chain codes? State the two principle reasons for not accepting chain codes for boundary detection in digital images?

(03 marks)

ANSWER IN THIS BOX

Chain codes are used to represent a boundary by a connected sequence of straight line segments of specified length and direction. Typically, this representation is based on 4- or 8- connectivity of the segments. The direction of each segment is coded by using a numbering scheme.

The reasons for not accepting chain codes:

(i) The resulting chain of codes of an image tends to be quite long.

(ii) Any small disturbances along the boundary due to noise or imperfect segmentation cause changes in the code that may not be related to the shape of the boundary.

(d) (i) The Laplacian generally is not used in its original form for edge detection due to several reasons. State two (02) of these reasons.

(ii) However, the role of the Laplacian is very important in edge location. State what special property the Laplacian possesses.

(03 marks)

ANSWER IN THIS BOX

(i) Any two of the following:

1.As a second order derivative, the Laplacian typically is unacceptably sensitive to noise.

2.The magnitude of the Laplacian produces double edges, an undesirable effect because it complicates segmentation.

3.The Laplacian is unable to detect edge direction.

(ii) zero crossing property

Continued..

(e) An edge detection process is usually followed by an edge linking process. Explain briefly the purpose of an edge linking process.

(02 marks)

ANSWER IN THIS BOX

Ideally, the edge detection methods should yield pixels lying on the edge. In practice, this set of pixels seldom characterizes an edge completely because of noise and other reasons. Thus, an edge linking process is required to assemble edge pixels into meaningful edges.

(f) Describe briefly, the following edge detection techniques comparing their advantages and disadvantages.

(i) Sobel Edge Detection
(ii) Canny Edge Detection

(04 marks)

ANSWER IN THIS BOX

(i) Sobel Edge Detection

-1	-2	-1
0	0	0
1	2	1

-1	0	1
-2	0	2
-1	0	1

Continued..

These two masks are called Sobel operator masks. They are applied on the images to detect the edges based on the Gradient components on X and Y directions. Sobel masks have slightly superior noise suppression characteristics.

(ii) Canny Edge Detection

Canny's edge detector is based on convolution of the image function with Gaussian operators and their derivatives. The basic principle of this method is to find the position of an image where the second derivative becomes zero. These postitions correspond to edge positions of the image.

The goals of the Canny operator are:

1. **Good detection**
2. **Good localization**
3. **Clear response**

It consists of the following steps:

1. **Smooth the image with a Gaussian filter**
2. **Compute the gradient of the smoothed image**
3. **Apply non-maximal suppression**
4. **Perform hysteresis thresholding to detect and link the edges.**

(g) Describe the following terms:

(i) Image segmentation using Region Growing
(ii) Image segmentation by Thresholding

(04 marks)

ANSWER IN THIS BOX

(i) Image segmentation using Region Growing

Region growing is a procedure that groups pixels or subregions into larger regions based on predefined criteria. The basic approach is to start with a set of "seed" points and from these, grow regions by appending to each seed those neighbouring pixels that have properties similar to the seed (such as specific ranges of gray level or color).

(ii) Image segmentation by Thresholding

The simplest of all thresholding techniques is to partition the image histogram by using a single global threshold, T. Segmentation is then accomplished by scanning the image pixel by pixel and labelling each pixel as object or background, depending on whether the gray level of that pixel is greater or less than the value of T.

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