Q.2. What are the fundamental steps in digital image processing? (refer image after Q.4)

→ 1] Image acquisition -
This is the first step of digital image processing.
Image acquisition could be as simple as being
given an image that is already in digital form.
This stage involves preprocessing such as
scaling.

2] Image enhancement -
This is simplest & most appealing areas of
digital image processing. The idea behind enhance
ment is to bring out detail that is obscured,
or simply to highlight certain features of
interest in an image such as brightness,
contrast etc.

3] image restoration -
This is an area that also deals with improving
the appearance of an image. It is objective, in the
sense that restoration techniques tend to be
based on mathematical or probabilistic models of

image degradation.

4] color image processing -

color image processing is an area that has been gaining its importance because of significant increase in the use of digital images over the internet. This may include color modeling & processing in digital domain.

5] wavelets & multiresolution processing -

Wavelets are foundation for representing images in various degrees of resolution. Images subdivide successively into smaller regions for data compression & for pyramidal representation.

6] compression -

compression deals with techniques for reducing the storage required to save an image or bandwidth to transmit it.

7] Morphological processing -

It deals with tools for extracting image components that are useful in the representation & description of shape.

8] segmentation -

segmentation procedures partition of image into its constituent parts or objects. Autonomous segmentation is one of the most difficult tasks in digital image processing.

9] Representation & description -

Choosing a representation is only part of solution for transforming raw data into a form suitable for subsequent computer processing.

Description deals with extracting attributes that result in some quantitative info of interest.

10] Object recognition -

Recognition is process that assigns a label such as 'vehicle' to an object based on its descriptors.

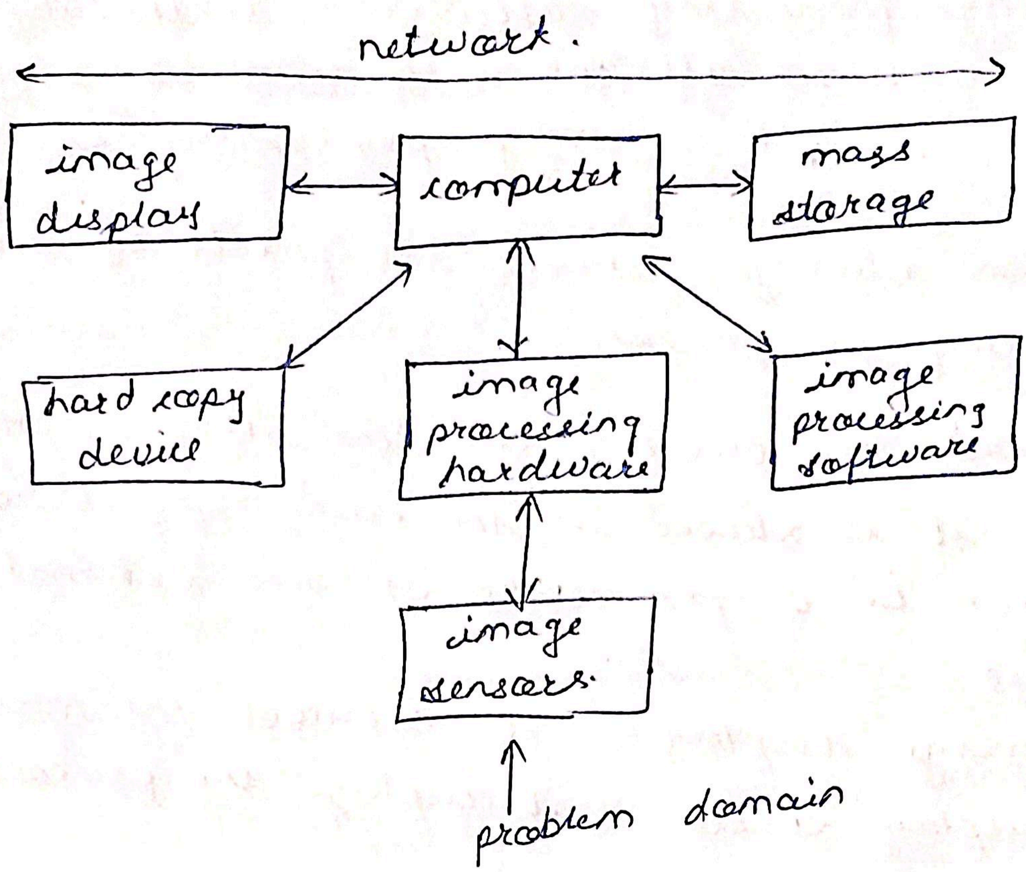
11] Knowledge base -

Knowledge may be as simple as detailing regions of an image where the info of interest is known to be located, thus limiting the search that has to be conducted in seeking the information.

Q.3. What are the components of image processing system?

→ Digital image processing is the processing of an image by means of digital computer. Image processing system is the combination of different elements involved in the digital image processing components -

It consists of following



1] image sensors -
Image sensors senses the intensity, amplitude, coordinates & other features of the images & passes the result to the image processing hardware.
It includes problem domain.

2] Image processing hardware -
Image processing hardware is the dedicated hardware that is used to process the inst^n obtained from image sensors. It passes the result to general purpose computer.

3] computer -
computer used in image processing system is the general purpose computer that is used by us in our daily life.

1) image processing software - is the software that includes all the mechanisms & algorithms that are used in image processing system.

2) mass storage - stores the pixels of image during the processing.

3) hard copy device - once the image is processed then it is stored in the hard copy device. It can be a pen drive or any external ROM device.

4) image display - It includes the monitor or display screen that displays the processed images.

4] Network - is the connection of all the above elements of image processing system.

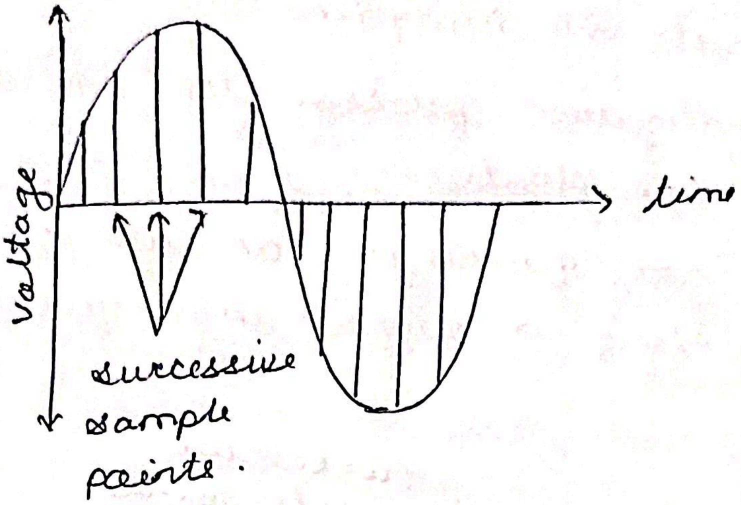
Q.4. Explain about image sampling & quantization process?

→ In order to become suitable for digital processing, an image function f(x,y) must be digitized both spatially & in amplitude. Typically, a digitizer is used to sample & quantize the analogue video signal. Hence in order to create an image which is digital, we need to convert continuous data in digital form. There are two steps in which it is done:

① sampling
② quantization

1] Sampling-

- Digitizing the coordinate value is called sampling.
- It is done on independent variable.
- for eg. if $y = \sin x$, then it is done on ~~isat~~ x variable.



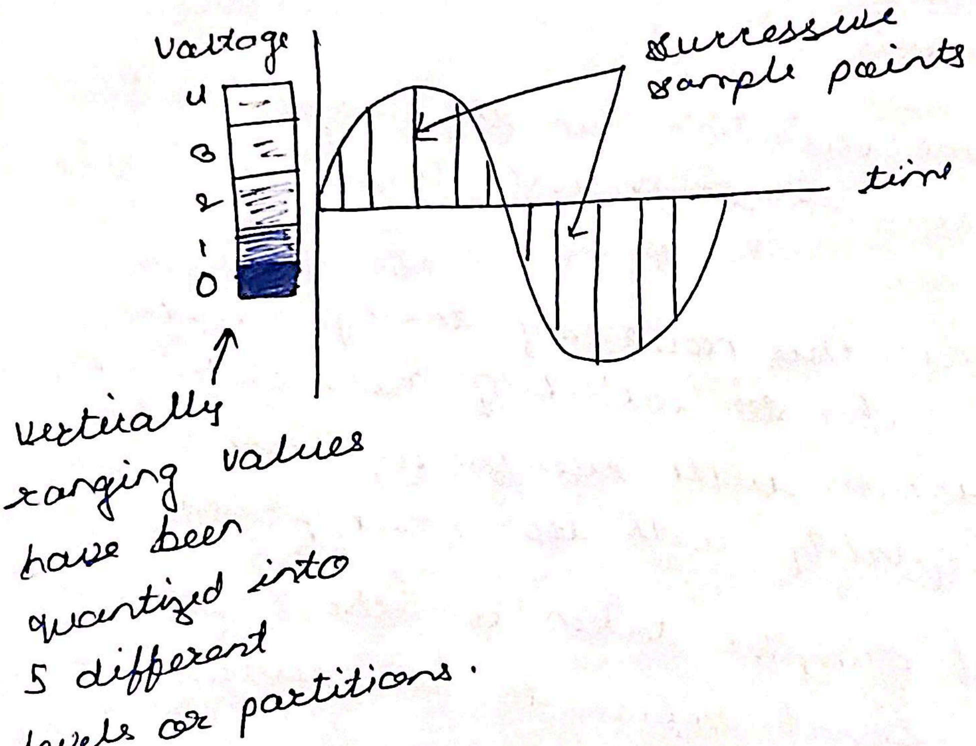
- There are some variations in the sampled signal which are random in nature. These variations are due to noise.
- We can reduce this noise by taking samples. More samples refer to collecting more data i.e., more pixels which will eventually result in better image quality with less noise present.
- The number of samples taken on the x-axis of a continuous signal refers to the number of pixels of that image.

total number of pixels = total no. of rows × total no. of columns.

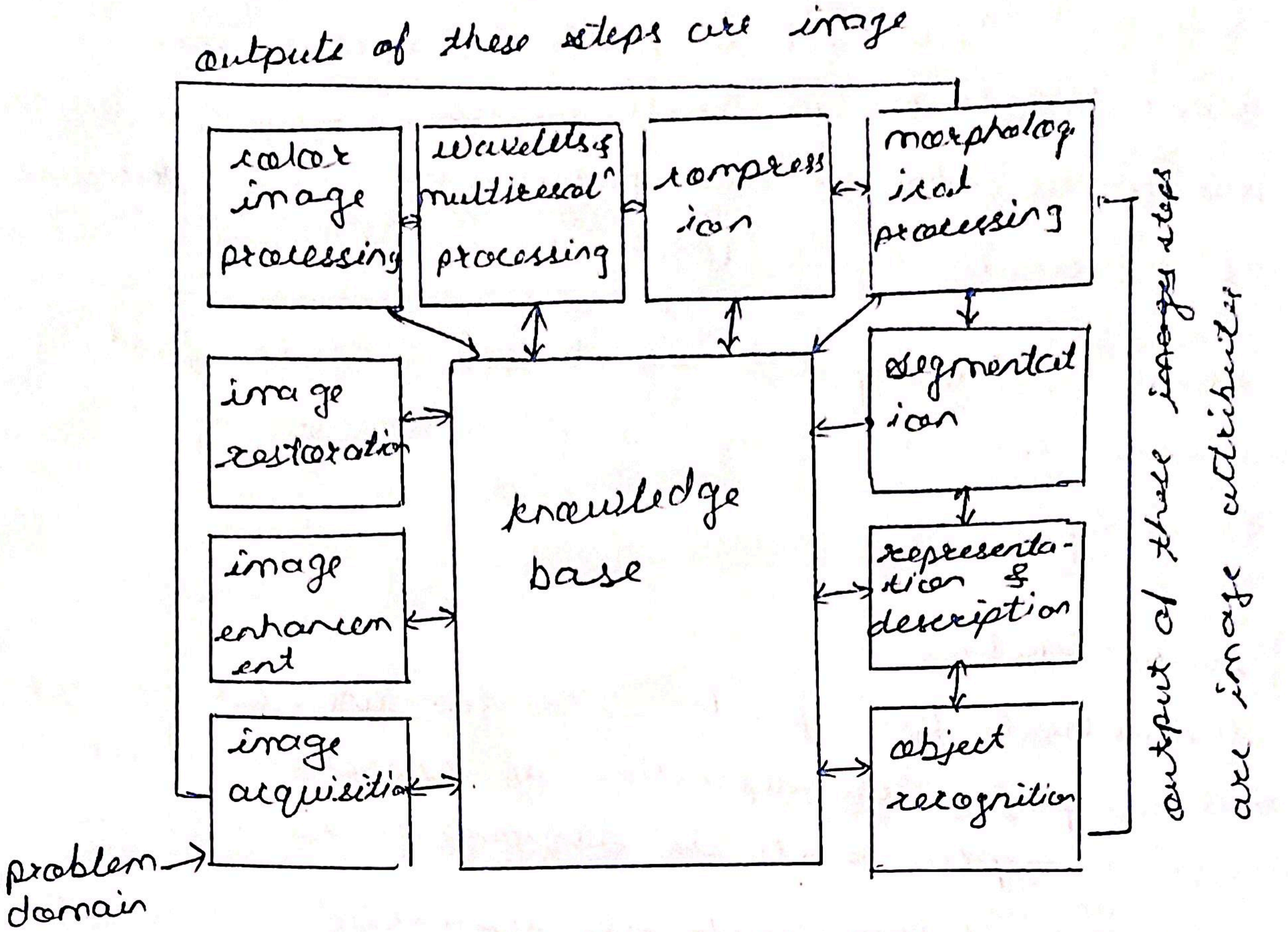
- Oversampling is used for zooming. The difference b/w sampling & zooming is that sampling is done on signals while zooming is done on digital image.

quantization -

- Digitizing the amplitude value is called quantization.
- It is opposite to sampling.
- Under quantization process the amplitude values of image are digitized.
- When we are quantizing an image, we are actually dividing a signal into quantas. (partitions)



Q. 2. image -



Q. 5. Explain about the basic relationships & distance measures bet^n pixels in a digital image.

→ i] Neighbours of a pixel -

- A pixel p at coordinates (x, y) has four horizontal & vertical neighbours whose coordinates are given by (x+1, y), (x-1, y), (x, y+1), (x, y-1). This set of pixels is called 4- neighbours of p & is denoted by $N_4(p)$.

- Each pixel is at unit distance from (x, y) & some of the neighbours of p lie outside the digital image if (x, y) is on the border of image.

- The four diagonal neighbours of p have coordinates $(x+1, y+1)$, $(x+1, y-1)$, $(x-1, y+1)$, $(x-1, y-1)$. This set of pixels is ~~called~~ are denoted by $N_D(p)$. These points, together with the 4-neighbours are called the 8-neighbours of p, denoted by $N_8(p)$.

- Some of the points in $N_D(p)$ & $N_8(p)$ fall outside the image if (x, y) is on the border of image.

2] connectivity.

- Connectivity bet^n pixels is a fundamental concept that simplifies the definition of numerous digital image concepts, such as regions & boundaries.

- To ~~satisfy~~ check if two pixels are connected, it must be determined if they are neighbours & if their gray levels satisfy a specified criterion of similarity.

- For eg., in a binary image with values 0 & 1, two pixels may be 4-neighbours, but they are said to be connected only if they have the same value.

3] distance measures -

- For pixels p, q & z with coordinates (x, y), (s, t) & (v, w) resp., D is a distance fun^n or metric if

(a) $D(p,q) \geq 0$ $(D(p,q) = 0$ iff $p=q)$

(b) $D(p,q) = D(q,p)$

(c) $D(p,z) \leq D(p,q) + D(q,z)$.

- The Euclidean distance betⁿ p & q is defined as

$$D_e(p,q) = [(x-s)^2 + (y-t)^2]^{1/2}$$

- The D_4 distance (also called city-block distance) betⁿ p & q is defined as

$$D_4(p,q) = |x-s| + |y-t|$$

- The D_8 distance (also called chessboard dist.) betⁿ p & q is defined as

$$D_8(p,q) = \max(|x-s|, |y-t|).$$

Q.6. How to measure distance betⁿ two pixels in an image? Explain with ex.

→ - For pixels p, q & z with coordinates (x,y), (s,t) & (v,w) resp., D is distance funⁿ or metric if

(a) $D(p,q) \geq 0$ $(D(p,q) = 0$ iff $p=q)$

(b) $D(p,q) = \cancel{D(p,q)}$ $D(q,p)$

(c) $D(p,z) \leq D(p,q) + D(q,z)$

- The Euclidean distance betⁿ p & q is defined as

$$D_e(p,q) = [(x-s)^2 + (y-t)^2]^{1/2}$$

- The D_4 distance (also called as city block dist.) bet^n p & q is defined as

$$D_4(p,q) = |x-s| + |y-t|$$

- In this case, the pixels having D_4 distance from (x, y) less than or equal to some value r form a diamond centered at (x, y).

- for eg., the pixels with D_4 distance ≤ 2 from (x, y) form following contours -

$$\begin{array}{ccccc} & & 2 & & \\ & 2 & 1 & 2 & \\ 2 & 1 & 0 & 1 & 2 \\ & 2 & 1 & 2 & \\ & & 2 & & \end{array}$$

- The D_8 distance (also called chessboard dist.) bet^n p & q is defined as

$$D_8(p,q) = \max(|x-s|, |y-t|)$$

- In this case, the pixels with D_8 distance from (x, y) less than or equal to some value r form a square centered at (x, y).

- for eg., the pixels with D_8 distance ≤ 2 from (x, y) form following contours -

$$\begin{array}{ccccc} 2 & 2 & 2 & 2 & 2 \\ 2 & 1 & 1 & 1 & 2 \\ 2 & 1 & 0 & 1 & 2 \\ 2 & 1 & 1 & 1 & 2 \\ 2 & 2 & 2 & 2 & 2 \end{array}$$

- m-adjacency (D_m) distance bet^n two points is defined as shortest m-path bet^n the points. In this case, the distance bet^n two pixels will depend on values of pixels along the path as well as values of their neighbours.

$$\begin{array}{ccccc} & & p_3 & & p_4 \\ & p_1 & & p_2 & \\ & & p & & \end{array}$$

- Assume that p, p_2, p_4 have value 1 & p_1, p_3 can have value 0 or 1.
- Suppose, we consider adjacency of pixel valued 1. If p_1 & p_3 are 0 then length of shortest m-path bet^n p & p_4 is 2.
- If p_1 is 1 then p_2 & p will no longer be m-adjacent & the length of shortest m-path becomes 3.

Ex - compute distance bet^n the 2 pixels using the 3 distances.

	1	2	3
1	q		
2		p	
3			

q : (1,1)
p : (2,2)

euclidean distance $= [(1-2)^2 + (1-2)^2]^{1/2} = \text{sqrt}(2)$

D_4 distance $= |1-2| + |1-2| = 2$

D_8 distance $= \max(|1-2|, |1-2|) = 1$

Q. 7. Explain with example.

1] Neighbours of pixel

→ The neighbours of pixel is the collection of pixel which surround it. The neighbourhood of pixel is required for pixel such as morphology, edge detection, median filter etc. Many computer vision algorithms allow the programmer to choose an arbital neighbourhood.

There are two different ways to define neighbours of a pixel p located at (x, y):

① 4 - neighbours ② 8 - neighbours

same as in Q. 5.

2] Connectivity

→ Same as in Q. 5.

Two dimensional connectivity -

① 4 - connected.

- Pixels are connected if their edges touch.
- Pixels are connected part of the same object
- Two adjoining pixels are part of the same object if they both are connected along the horizontal or vertical direction.

② 8 - connected

- Pixels are connected if their edges or corners touch
- Pixels are part of the same object
- Two adjoining pixels are part of the same object, if they both are connected along the horizontal, vertical or diagonal direction.

Three dimensional connectivity

① 6 - connected.

- Pixels are connected if their <u>faces</u> touch.
- Two adjoining pixel are part of the same object if they are connected in <u>one of</u> these direction: in, out, left, right, up, down.

② 18 - connected.

- Pixels are connected if their <u>faces</u> or <u>edges</u> touch
- Pixels are part of the same object
- Two adjoining pixel are part of these if they are connected in <u>combination</u> of these directions: in, out, right, left, up, down.

③ 26 - connected

- Pixels are connected if their <u>edges</u>, <u>faces</u> or <u>corner</u> touch.
- Two adjoining pixels are part of same obj if they are connected in -
  ① one of these direction: up, down, in, out, right, left.
  ② a combination of 2 directions
  ③ a combination of 3 directions.

Q. 8. Explain relationship amongst pixel.

→ Basic relationship betⁿ pixels :

1] neighbours of pixel

2] ~~adjacency~~ connectivity

3] Paths

A path from pixel p with coordinates (x, y) to pixel q with coordinates (s, t) is a sequence of distinct pixel with coordinates

$(x_0, y_0), (x_1, y_1), (x_2, y_2) \dots (x_n, y_n)$ where

$(x_0, y_0) = (x, y)$ & $(x_n, y_n) = (s, t)$

(x_i, y_i) is adjacent to ~~(x_i, y_i)~~, (x_{i-1}, y_{i-1}) for $1 \le i \le n$, where n is the length of path.

4] Region & boundaries -

A subset R of pixel in an image is called a region of image R in a connected set.

The boundary of region R is the set of pixel in the region that have one or more neighbours that are not in R.

Q. 9. Explain type of connectivity in pixels using ex.

→ Q. 7.

Q. 10. Explain types of path & distance with ex.

→ Q. 8 - path

Q. 5 - distance measure

Q.11. Explain logical operation on images. Give its application.

→ - Logical operations deal with True (typically denoted by 1) & False (typically denoted by 0) variables & expressions.

- For our purposes, this means binary images are composed of foreground (1- valued) pixels & a background composed of 0- valued pixels.

- We work with set & logical operators on binary images using one of two basic approaches:

① We can use the coordinates of individual regions of foreground pixels in a single image as sets.

② We can work with one or more images of the same size & perform logical operations betⁿ corresponding pixels in those arrays.

- When dealing with binary images, the 1- valued pixels can be thought of as foreground & 0- valued pixel as background.

- Now consider two regions A & B composed of foreground pixels -

① The OR operation of these two sets is the set of coordinates belonging either to A or to B or to both.

② The AND operation is the set of elements that are common to both A & B.

③ The NOT operation on set A is the set of elements not in A.

- The logical operations are performed on two regions of same image, which can be irregular & of different sizes.

-

a	b	a AND b	a OR b	NOT(a)
0	0	0	0	1
0	1	0	1	1
1	0	0	1	0
1	1	1	1	0

applications - motion detection, objects extraction, ALOImage Pro (Arithmetic logical Operations for images processing) application is developed as Java plugin.

Q.12. Explain set operations.

→ - The set operations involve complete images.
- For gray scale images, set operations are array operations.
- Let set A represent a gray scale image whose elements are the triplets (x, y, z) where (x, y) is the location of pixel & z is its intensity.

- Union - The union operation betⁿ two images are defined as maximum of corresponding pixel pairs respectively.

$$A \cup B = \{ \max_z (a, b) \mid a \in A, b \in B \}$$

- intersection - The intersection operation betⁿ two images are defined as minimum of corresponding pixel pairs resp.

$$A \cap B = \{ \min_z (a, b) \mid a \in A, b \in B \}$$

- complement - The complement operation on an image is defined as the pairwise differences betⁿ a constant & the intensity of every pixel in the image.

$$A^c = \{ (x, y, K - z) \mid (x, y, z) \in A \}$$

- difference - The difference of two sets A & B is the set of points in A & not in B. These are points that are in A & in complement of B.

Q.13. Write note on following, also give its appliⁿ.

i] image negatives

→ - A negative image is a total inversion, in which light area appears dark & vice versa.

- When negative film images are brought into the digital realm, their contrast may be adjusted at the time of scanning.

- Image negative is produced by subtracting each pixel from the max intensity. For ex, for an 8-bit image, the max intensity value is $2^8 - 1 = 255$. Thus each pixel is subtracted from 255 to produce the output image.

- appl^n - In photography, a negative image is usually on a strip or sheet of transparent plastic film, in which the lightest areas of subject appear darkest & the darkest areas appear lightest.

2] log transformations

→ - log transformation of an image means replacing all pixel values present in the image with its logarithmic values.

- It is used in image enhancement.
- The log transformation can be defined by the formula $s = c \cdot \log(r+1)$ where s & r are the pixel values of the output & input image resp. & c is a constant. The value 1 is added to r because if there is a pixel intensity of 0 in image, then log(0) is equal to infinity. So 1 is added to make min value 1.

- Properties - For lower amplitude of input image the range of gray level is expanded.
For higher amplitude of input image the range of gray level is compressed.

- application - ① expands the dark pixels in the image while compressing the bright pixels.
  ② compress dynamic display.

3] Power - law transformation.

→ - Power - law transformation can be mathematically expressed as $s = c r^{\gamma}$.

- Gamma correction is imp for displaying images on a screen correctly, to prevent bleaching or darkening of images when viewed from different types of monitors with different display settings.
- This is done because our eyes perceive images in a gamma shaped curve, whereas cameras capture images in linear fashion.
- A variety of devices for image capture, printing & display respond according to power-law transformⁿ.
- applⁿ - image enhancement.

4] contrast stretching.

→ - contrast stretching is an image enhancement method which attempts to improve an image by stretching the range of intensity values.
- We stretch the min & max intensity values present to possible min & max intensity values.
- Eg. - If the min intensity value (r min) present in the image is 100 then it is stretched to possible min intensity value 0.

- If the max intensity value (r max) is less than possible max intensity value 255 then it is stretched out to 255.

- General formula is

$$s = (r - r_{min}) \frac{(I_{max} - I_{min})}{(r_{max} - r_{min})} + I_{min}$$

where r = current pixel intensity value
r_{min} = min intensity value
r_{max} = max intensity value.

- appliⁿ - image enhancement.

5] intensity - level slicing.

→ - means highlighting a specific range of intensities in an image.
- We segment certain gray level regions from the rest of image.
- The technique of intensity - level slicing can be explained by interpreting a gray scale image as 3D image being sliced by a plane parallel to the coordinate plane of image.

- It is a process that highlights pixel in an arbitary range of intensities.

- appliⁿ - Mostly used for enhancing features in satellite & x-ray images.

6] bit-plane slicing -

→ - Bit plane slicing is method of representing an image with one or more bits of the byte used for each pixel.

- One can use only MSB to represent the pixel, which reduces the original gray level to binary image.

- The 3 main goals of bit-plane slicing are:

① converting a gray level image to binary image

② representing image with fewer bits & corresponding the image to a smaller size.

③ enhancing the image by focusing.

- For an 8 bit image, a pixel value of 0 is represented as 00000000 in binary form & 255 is represented as 11111111. Here, the leftmost bit is known as most significant bit (MSB) & rightmost bit is known as least significant bit (LSB)

- In bit-plane slicing, we divide the image into bit plane. This is done by first converting pixel value in binary form & then dividing it into bit plane.

- applⁿ - image compression.

7] Histogram processing -

→ - In digital image processing, the histogram is used for graphical representation of digital image.

- A graph is plot by the number of pixels for each tonal value.

- Nowadays, image histogram is present in digital cameras. Photographers use them to see the distribution of tones captured.
- In a graph, the horizontal axis of the graph is used to represent tonal variations whereas the vertical axis is used to represent no. of pixels.
- Black & dark areas are represented in the left side of horizontal axis, medium gray color is represented in the middle & the vertical axis represents the size of area.
- appli^n - ① In DIP, histograms are used for simpler calculations in software.
  ② It is used to analyze an image. Properties of an image can be predicted by the detailed study of histogram.
  ③ Histograms are used in thresholding as it improves the appearance of image.

Q.14. Explain types of gray level transformation used for image enhancement.

→ All image processing techniques are focused on gray level transformation as it operates directly on pixel. The gray level image involves 256 levels of gray & in a histogram, horizontal axis spans from

0 to 255 & vertical axis depends on number of pixels in the image.

- There are 3 types of transformation -

1] linear transformation -

Linear transformation includes identity transformation & negative transformation.

In identity transformation, each value of image is directly mapped to each value of output image.

Negative transformation is opposite of identity transform^n.

Here, each value of input image is subtracted from L-1 & then it is mapped to output img.

2] logarithmic transformation - same as in Q.13.

3] power-law transform^n - same as in Q.13.

Q.15. What do you mean by contrast stretching? Explain using one ex.

→ same as in Q.13.

Q.16. What is meant by image enhancement by point processing? Discuss any two methods in it.

→ Point processing fun^n is also called as intensity transformation or gray-level mapping fun^n.

It is categorized into 2 types -

① linear fun^n ② non-linear fun^n.

for this, explain gray level transformation, image negative, log transform, contrast stretching, bit plane slicing.

Q.17. Explain CMY & CMYK color model.

→ 1] CMY

- This model contains the secondary colors.
- In this model, any secondary color when passed through white light will not reflect the color from which a combination of colours is made.
- For eg. - When cyan is illuminated with white light, no red light will be reflected from the surface which means that the cyan subtracts the red light from the reflected white light.

$$\begin{bmatrix} C \\ M \\ Y \end{bmatrix} = \begin{bmatrix} 1 \\ 1 \\ 1 \end{bmatrix} - \begin{bmatrix} R \\ G \\ B \end{bmatrix}$$

- It is used in color printing as it uses coloured ~~tints~~. inks.
- It is used in most commercial printing like magazines, books, etc.
- CMY model is used by printing devices & filters.

2] CMYK -

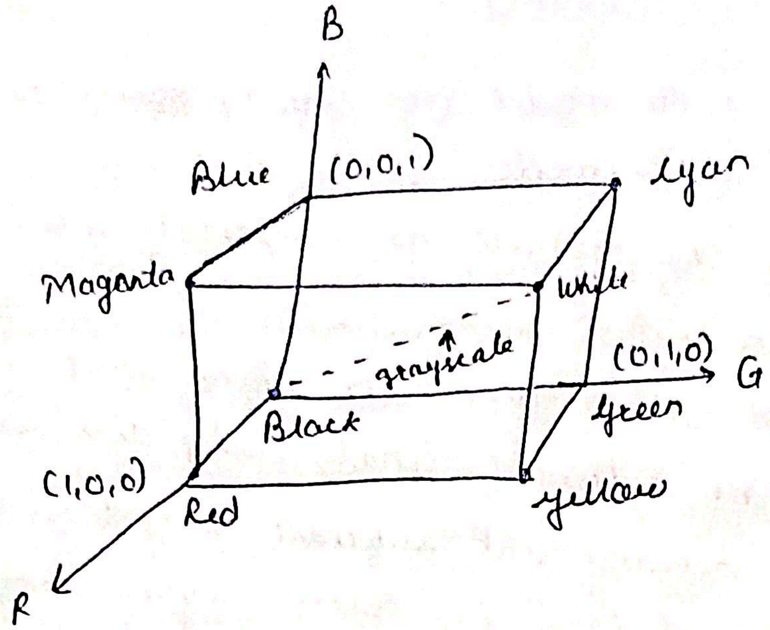
- The CMYK color model (4-color process) is a subtractive color model.
- CMYK works by partially or completely masking colors on a white background.
- The printed ink reduces the light that would otherwise be reflected. That's why this is called subtractive because ink subtract brightness from a white background from four colors: cyan, ~~mogne~~ magenta, yellow & black.
- CMYK is able to produce the entire spectrum of visible colors due to process of half-toning.
- In this process, each color is assigned a saturation level & dots of each of 3 colors are printed in tiny patterns.
- This enables the human eye to perceive a specific color made from their combination. In order to improve print quality & reduce large-scale interference patterns, the screen for each color is set at different angle.

Q.12. Interpret in detail about

1] RGB model

→ - In the RGB model, each color appears in its primary spectral components of red, green & blue.

- This model is based on cartesian coordinate system.



- In above fig, RGB primary values are at three corners; the secondary colors cyan, magenta & yellow are at other three corners; black is at origin & white is at corner farthest from origin.
- In this model, grayscale (points of equal RGB values) extend from black to white.
- We assume that the cube is unit cube. That is, all values R, G & B in this representation are in range [0,1].
- Images represented in RGB color model consists of three component images, one for each primary color. When fed into an RGB monitor, these three images combine on the screen to produce a composite color image.

2] HSI model.

→ - When humans view a color object, we describe it by its hue, saturation & brightness.

- Hue is a color attribute that describes a pure color.
- Saturation gives a measure of the degree to which a pure color is diluted by white light.
- Brightness is a subjective descriptor that is practically impossible to measure. It embodies the achromatic notion of intensity & is one of the key factors in describing color sensation.
- Intensity is most useful descriptor of achromatic images. This quantity is measurable & easily interpretable.
- The HSI model decouples the intensity component from the color-carrying information (hue & saturation) in a color image.
- The HSI model is a useful tool for developing image processing algorithms based on color descriptions that are natural & intuitive to humans

---

Q. 19. Discuss the procedure for conversion from RGB color model to HIS model.

→ 1. Read RGB image.

2. Each RGB component will be in the range of [0 255]. Represent the image in [0 1] range by dividing the image by 255.

3. Find the θ value.

$$\theta = \cos^{-1}\left[\frac{\frac{1}{2}[(R-G)+(R-B)}{[(R-G)^2+(R-B)(G-B)]^{1/2}}\right]$$

4. $$H(\text{hue}) = \begin{cases} \theta & \text{if } B \leq G \\ 360-\theta & \text{if } B > G \end{cases}$$

5. $$S(\text{saturation}) = \frac{3}{1-(R+G+B)}[\min(R,G,B)]$$

6. $$I(\text{intensity}) = \frac{1}{3}(R+G+B)$$

7. Display the image.

Q.20. Write short note on RGB to CMY conversion

→ Def^n of RGB

def^n of CMY.

The conversion is given by formula

$C = 255 - R \quad (\text{or } 1-r)$

$m = 255 - G \quad (\text{or } 1-g)$

$y = 255 - B \quad (\text{or } 1-b)$

$$\begin{bmatrix} c \\ m \\ y \end{bmatrix} = \begin{bmatrix} 1 \\ 1 \\ 1 \end{bmatrix} - \begin{bmatrix} R \\ G \\ b \end{bmatrix}$$

$$\begin{bmatrix} R \\ G \\ B \end{bmatrix} = \begin{bmatrix} 1 \\ 1 \\ 1 \end{bmatrix} - \begin{bmatrix} C \\ M \\ Y \end{bmatrix}$$

Q.21. What is pseudo color image processing?

→ - Pseudo color image processing - assignment of colors to gray values based on a specified criterion.

- The principal use of pseudo color is for human visualization & interpretation of gray-scale events in image.

- A principal motivation for using color is that humans can discern thousands of color shades & intensities.

- Intensity slicing & color coding is simple example of pseudo-color image processing.

- The image is a 3D function.

- Planes parallel to the co-ordinate plane are used.

- More general transformations achieve a wide range of pseudo-color enhancement results.

- Pseudo-color processing is a technique that maps each of the gray levels of a black & white image into an assigned color. This color image when displayed, can make the identification of certain features easier for the observer.

- The mappings are computationally simple & fast.

- This makes pseudo-color an attractive technique.

- Pseudo color schemes can also be designed to preserve or remove intensity info.

Q.22. Explain the procedure of converting colors from HIS to RGB.

→ Given values ~~f~~ of HSI in the interval [0, 1], we now want to find the corresponding RGB values in the same range.

There are three sectors of interest.

1] RG sector ($0° \le H \le 120°$):

When H is in this sector, the RGB components are given by the eq^n

$$B = I(1-S)$$

$$R = I\left[1 + \frac{S\cos H}{\cos(60° - H)}\right]$$

$$G = 3I - (R+B)$$

2] GB sector ($120° \le H \le 240°$):

If the given value of H is in this sector, we first subtract 120° from it:

$$H = H - 120°$$

Then, the RGB components are-

$$R = I(1-S)$$

$$G = I\left[1 + \frac{S\cos H}{\cos(60° - H)}\right]$$

$$B = 3I - (R+G)$$

3] BR sector ($240^\circ \leq H \leq 360^\circ$):
Finally, if H is in this range, we subtract 240° from it.

$$H = H - 240^\circ$$

The RGB components are

$$G = I(1-S)$$

$$B = I\left[1 + \frac{S\cos H}{\cos(60^\circ - H)}\right]$$

$$R = 3I - (G+B)$$

Q.23. Explain the principal of sampling & quantization. Discuss the effect of increasing the
a) sampling frequency
b) quantization levels on image.

→

1] Principal of sampling-
① principal of Statistical Regularity-
The principal of statistical regularity is derived from the theory of probability in mathematics. According to this principal, when a large number of items is selected at random from the universe, then it is likely to posses the same characteristics as that of entire population.

② principle of 'Inertia of large numbers' -
The principle of Inertia of large number states that the larger the size of sample

the more accurate the conclusion is likely to be.

2] Principal of quantization -

Quantization is process of replacing analog samples with approximate values taken from a finite set of allowed values.

3] explain about sampling & quantization.

Q.24. What is m-connectivity among pixels? give ex.

→

Q.25. Define histogram of a digital image. Explain how histogram is useful in image enhancement!

→ same as in Q.13.

Q.26. Explain about histogram equalization.

→ - Histogram equalization is a digital image processing technique used to improve contrast in images.

- It accomplishes this by effectively spreading out the most frequent intensity values, i.e., stretching out the intensity range of the image.
- This method usually increases the contrast of images when its usable data is represented by close contrast value.

- Histogram equalization cannot be applied separately to the Red, Green & Blue components of image as it leads to dramatic changes in the image's colour balance.
- However, if the image is first converted to another color space, like HSL/HSV color space, then the algo. can be applied to value channel without resulting in changes to the hue & saturation of the image.

Q.27. What is meant by image subtraction? Discuss various areas of application of img subtraction.

→ - Img subtraction or pixel subtraction is a process whereby the digital numeric value of one pixel or whole image is subtracted from another image.

- This is done for one of the two reasons:-
  ① levelling uneven sections of image
  ② detecting changes betn two images.

- Img subtraction is used for analysis of the result i.e. identification of areas of the sample where particle movement occurs & the evolution of particle motion over the height of sample.

- Img subtraction is used widely in img. processing to segment dynamic regions from static regions for higher level processing of images for motion detection, recognition & object tracking.

Q.28. What is meant by image averaging? Discuss various areas of application of img averaging.

→ - Img averaging is a digital img processing technique that is often employed to enhance video images that have been corrupted by random noise.

- The algorithm operates by computing an average or arithmetic mean of the intensity values for each pixel position in a set of captured images from the same scene or viewfield.

- Image averaging is usually utilized for noise reduction.

Q.~~29. What is meant by image segmentation? Give two applications of image segmentation.~~

→

Q.29. Explain following mathematical operations on digital images.

i] array vs matrix operations

→ - An array operation involving one or more images is carried out on a pixel-by-pixel basis.

- Images can be viewed equivalently as matrices.

- There are many situations in which operations bet^n images are carried out using matrix theory.

- It is for this reason that a clear distinction must be made bet^n array & matrix operations.

- For ex, consider the following 2x2 images.

$$\begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix} \text{ and } \begin{bmatrix} b_{11} & b_{12} \\ b_{21} & b_{22} \end{bmatrix}$$

The array product of these two images is -

$$\begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix} \begin{bmatrix} b_{11} & b_{12} \\ b_{21} & b_{22} \end{bmatrix} = \begin{bmatrix} a_{11}b_{11} & a_{12}b_{12} \\ a_{21}b_{21} & a_{22}b_{22} \end{bmatrix}.$$

2] linear vs. non-linear operation.

→ - Consider a general operator, $\mathcal{H}$ that produces an output image $g(x,y)$ from a given input image $f(x,y)$:

$$\mathcal{H}[f(x,y)] = g(x,y).$$

- Given two arbitrary constants a & b & two arbitrary images $f_1(x,y)$ & $f_2(x,y)$. $\mathcal{H}$ is said to be linear operator if

$$\mathcal{H}[a f_1(x,y) + b f_2(x,y)] = a\mathcal{H}[f_1(x,y)] + b\mathcal{H}[f_2(x,y)]$$
$$= a\, g_1(x,y) + b\, g_2(x,y) \quad \text{—} (1)$$

- This eq^n indicates that the output of a linear operation applied to the sum of two inputs is same as performing the operation individually on the inputs & then summing the results. This property is called ~~additivity~~: additivity

- An operator that fails to satisfy eq^n (1) is said to be non-linear.

- For ex, suppose that $\mathcal{H}$ is sum operator Σ.

$$\Sigma[a f_1(x,y) + b f_2(x,y)] = \Sigma a f_1(x,y) + \Sigma b f_2(x,y)$$

$$= a \Sigma f_1(x,y) + b \Sigma f_2(x,y)$$

$$= a g_1(x,y) + b g_2(x,y)$$

Expansion of left side is equal to right side.

$\therefore$ We conclude that sum operator is linear.
