2020 DIP

1 (a) Define : discrete image, contrast, dynamic range

(3) **Discrete image:-** A digital image that is represented by a finite set of pixels. Each pixel has a discreted value, which represents the intensity of the light at the point in the image. Discrete image are stored as arrays of numbers, where each number represents the intensity of a single pixel.

Contrast: The difference in intensity between the brightest and darkest parts of the image. A high-contrast image has a large difference between the brightest & darkest part, while a low-contrast image has a small difference.

Dynamic range: The ratio between the brightest and darket parts of the image. It is a measure of image's ability to represent a wide range of light intensity. A high dynamic range image can represent a wide range of light intensity, from very bright to very bright to very dark, without losing details. A low dynamic range image can only represent a narrow range of light intensity and may lose detail in the brightest & darkest parts of image.

book- D.R of an imaging system is the ratio of the maximum measurable intensity to the minimum detectable intensity level in the system. The upper limit is called Saturation & lower limit by noise.

tanveer.ah ...

1(b) Discuss how sampling and quantization affects the quality of digital image.? (3)

Solno: To create a digital image, we need to convert the continuous sensed data into digital form. This involves two processes: sampling and quantization.

An image may be continuous ~~or~~ ~~dis~~ with respect to the x- and y- coordinates, and also in amplitude. To convert it to digital form, we have to sample the function in both coordinates and in amplitude.

* Digitizing the ~~amp~~ Co-ordinate values is called sampling.
* Digitizing the amplitude value is called quantization or gray-level ~~~

Black = 0 · White = 255

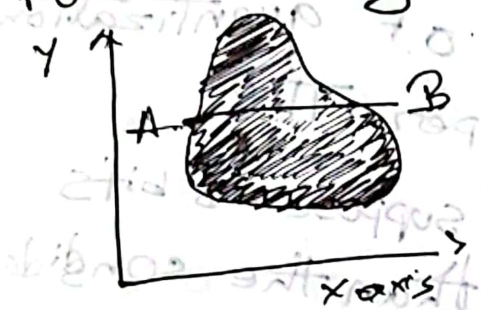
Digitization of spatial co-ordinates (x,y) is called image sampling.

* The quality of digital image is determined to a large degree by the number of samples and discrete gray levels used in sampling & quantization.

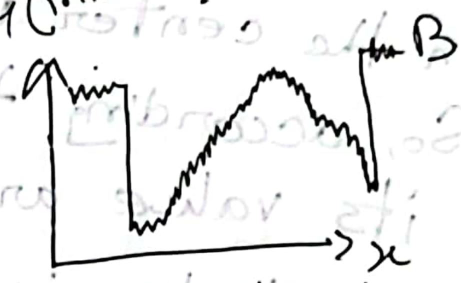
No. of samples - related to sampling of co-ordinates.
No. of gray-levels related to quantization of the amplitudes of the samples.

Quality depends on how many samples have been ~~takens~~ done & how many discrete gray levels have been created in any image.

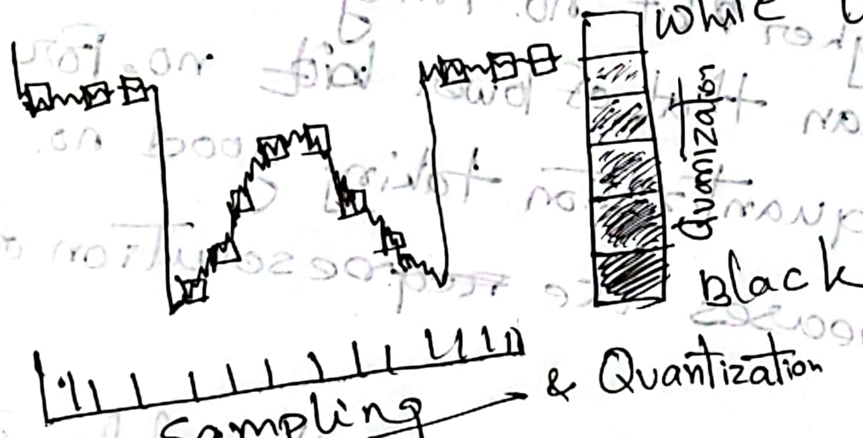
For an image below:-



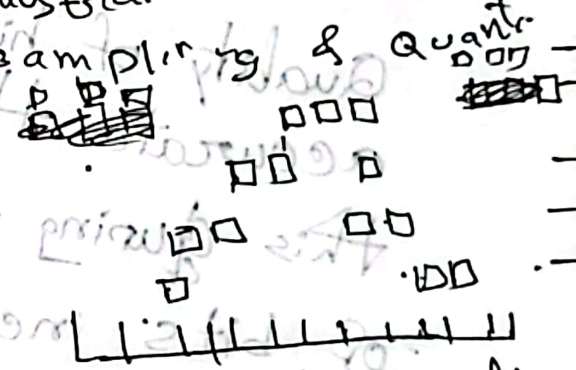
(a) Continuous image



(b) A scaling line from A to B in continuous image, used to illustrate concept of sampling & quant.



& Quantization



Digital scan line

the main way of sampling is taking the standard level. If less no. of sample are taking the actual ~~shape~~ ~~shap~~ color component can be retrived.

By taking many bits level of the quantization in range. ∴ if n = no. of bits then no. of level = 2^n.

So, higher number of levels represents more precise ~~no.~~ of color set.

(⟶)
sampling along spatial co-ordinates &
Quantization (↑) along digitization of the
amplitude.
In the center most region there is whitish.
So, according to level of quantization
its value are at upper. Tho
If quantization is taken as suppose - 8 bits
it will be more precise than the considering
1 bit (0 - Black, 1 - White).
Quality of higher bit no. image is more
accurate than that of lower ~~bit~~ no. For
this during quantization taking good no.
of bits increases the ~~reg~~ resolution of
that image.
It is always better to analyze the data of
desired image and considering sufficient
no. of bits and information must be
present for good quality image
If not then doing operation like reducing
size of image it will compromise the image
quality & information may be lost.

interpolaton - converting / inserting i.e. changing

Sampling → <u>Down Sampling</u>:- scaled down by half by reducing the sampling rate (sub sampling)

→ <u>Up sampling</u>:- Scaled up using replication or interpolation

1(c) How digital image is represented? The amount of light reflected from any object represents its intensity. Explain. 2.75

2.75

Soln An ~~Digital Image~~ is ~~represented in a~~ 2D signal

An image can be defined as a 2D signal that varies over the spatial co-ordinates x and y, and can be written mathematically as $f(x,y)$

$$\begin{matrix} 1 & 1 & 1 & 1 \\ 0 & 1 & 1 & 0 \\ 0 & 1 & 1 & 0 \end{matrix}$$

Digital image representation.

Small binary digital image

Equivalent image contents in matrix form.

Any 3D image can be repensted with $f(x,y,z)$ here x, y, z are spatial co-ordinates

$$f(x,y) = \begin{bmatrix} f(1,1) & \cdots & f(1,N) \\ \vdots & & \\ f(M,1) & \cdots & f(M,N) \end{bmatrix}$$

value of func $f(x,y)$ at every point is grey value intensity of the image

For an image we must digitize it so that it can be processed by computers. For an image, we usually use the intensity function $f(x,y)$ to represent it.

$p(x,y)$ - the location of a point in image

$f(x,y)$ - the intensity of the point (x,y) ;

$0 < f(x,y) < \infty$

$i(x,y)$ - intensity of incident light

$f(x,y) = i(x,y)\, r(x,y)$

$r(x,y)$ - the co-efficient of the reflection depends on object light casts

Q. The amount of light reflected from any object represents its intensity - explain

A. Intensity is the measure of the brightness of light and it is determined by the number of pixels per ~~unit~~ unit area. When light hits an object, some of it is absorbed, some of it is transmitted, some are reflected. The amount of light that is reflected depends on the properties of the object, such as color, surface texture and orientation.

Objects that reflects a lot of light appear bright, while objects that reflect very little light appear dark.

The amount of light reflected from the object represents it's intensity because it directly relates to brightness of the object.

More light reflected means the object is bright & so it doesnt absorb. ~~So it's~~ And high intensity object reflects more light. representing it's own intensity level.

slide 1-37
book-20

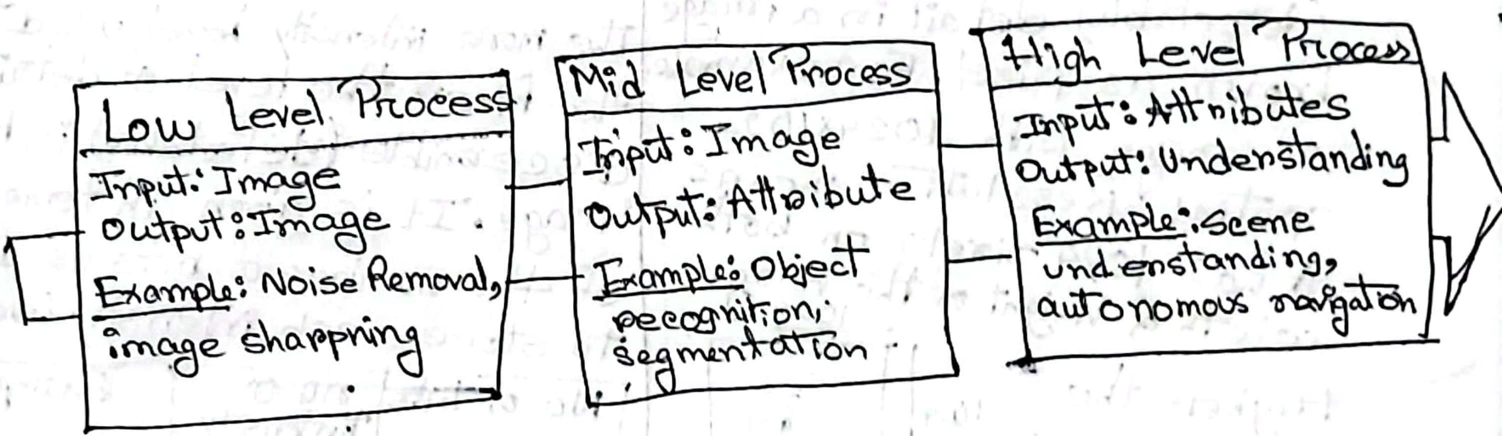
2(a) There are 3 levels ~~of~~ in image processing and (3) computer vision - Illustrate with examples 3

Ans- The continum from image processing to computer vision can be broken up into 3 levels: low, Mid & high level processes.

Low level: Cleaning up the image, ~~of scene~~ It involves primitive operations such as image preprocessing to reduce noise, contrast enhancement & image sharpning.

Mid level: Involves tasks such as segmentation (partitioning a ~~object~~ image into regions or objects), description of those objects to reduce them to a form suitable for computer processing & classification of individual objects.

Higher level: Involves "making sense" of an ensemble of recognized objects, as in image analysis ~~and at the~~.



2(b) What is resolution of an image? Explain
Q spatial resolution and intensity level resolution

Ans. Resolution of an image:- Resolution is the level of detail contained in an image. More specifically, it refers to the number of pixels that ~~exit~~ exist within the image. The higher the resolution, and the richer the pixel count, the more detail and definition ~~you will see~~ It can be calculated by:- ~~Pip~~ Pixel per inch (PPI). & For printing, dots per ~~~~ inch (DPI).

Spatial Resolution: Refers to the number of pixels used in making a image
It Refers to the amount of smallest discernible (noticeable) (detectable) detail in a image known as pixel. For example: a image with 1024X1024 spatial Resolution means it has 1024 pixels on both width & height of the image.

Higher the spatial resolution, higher the image quality & higher the amount of pixels required to represent the image.

~~Pinch~~

Intensity level resolution: Means the number of pixels per square inch, which determi the clarity or shapness of an ima The number of intensity levels used to represent the image. The more intensity level used, the finer the level of detail discernible (detectable) in the image. It is given in terms of the number of bits used to store each intensity level

No. of bits	no of Intensity level	Example
1	2	0, 1
2	$2^2=4$	00, 01, 10, 11
4	$2^4=16$	0000, 0010, ...
8	256	01010111,
16	65536	1110101110111

Higher the intensity level, higher the image quality & size.
Measurement unit: Bit per pixel

2(c). Define histogram of an image. What type of information of Image is represented by histogram?

2.75

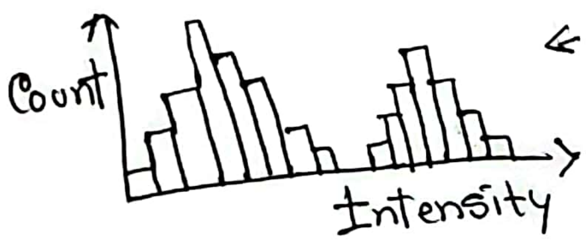
Histogram of a digital image with intensity levels in the range $[0, L-1]$ is a discrete function $h(r_k) = n_k$. where r_k is the k^{th} intensity value and n_k is the number of pixels in the image with intensity r_k. It is common practice to normalize a histogram by dividing each of its components by total number of pixels in the image, denoted by the product MN, where, as usual M & N are the row and column dimensions of image.

Normalized histogram, $p(r_k) = \frac{n_k}{MN}$,

$k = 0, 1, 2, \ldots, K-1$

The histogram plots the number of pixels in the image (vertical axis) with a particular brightness or tonal value (horizontal axis).

The histogram of an image normally refers to a histogram of pixel intensity values.



A graph showing no. of pixels in image at each diff. intensity value found in that image

• Quality → Normalizing → Histogram → Flat profile

3 (a) Consider a 4X4 image segment having the gray scale between [0,9]. Find the histogram equalized image and draw the image histogram before & after equalization.

$f(x,y) =$

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

I/P image.

Teresa

(1) Maximum = 6. [highest value]

to represt it, $2^3 = 8 \rightarrow 3$ bits [0 to 7]

(2)

gray level	0	1	2	3	4	5	6	7
no. of pixel (n_k)	0	3	4	4	3	1	1	0

M=4
N=4
MN=16

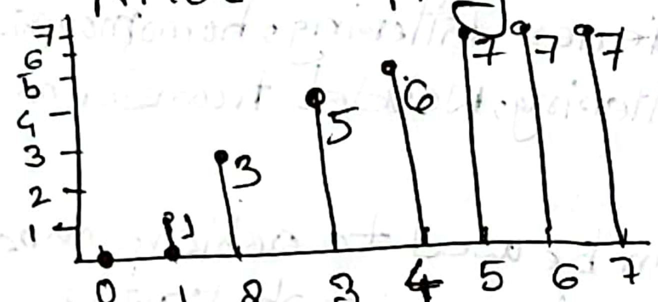
(3) Before.

$P_r(r_k) = \frac{n_k}{MN}$

(4)

gray level	no. of pixel n_k	Pdf = n_k/MN	(a) CDF = S_k	(b) → round: $S_k \times 7$ CDF * (Level-1)	Histogram equa. level
0	0	0/16=0	0	0	0
1	3	3/16=0.187	0.1875	1.3125	1
2	4	4/16=.25	0.4375	3.062	3
3	4	4/16=.25	0.6875	4.8125	5
4	3	3/16=.1875	0.875	6.125	6
5	1	1/16=.0625	0.9375	6.562	7
6	1	1/16=.0625	1	7	7
7	0	0/16=0	1	7	7

After-mapping-



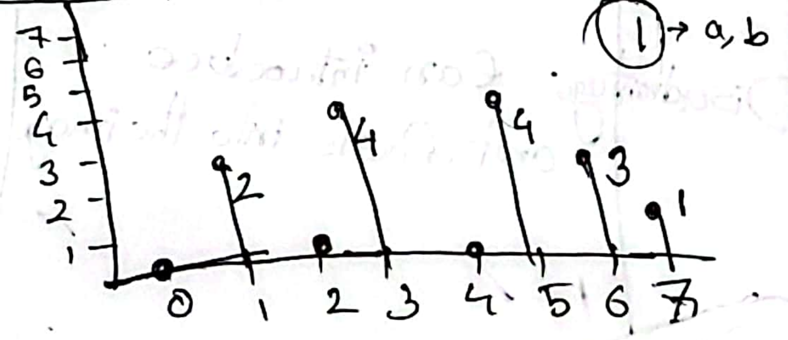
$$CDF = S_k = T(r_k) = \underbrace{\overbrace{(L-1)}^{8-1=7}\sum_{j=0}^{k} P_r(r_j)}_{7 \times CDF}$$

After image -

1	5	3	3
6	3	6	1
5	5	6	7
3	1	5	7

0	1	2	3	4	5	6	7
·	3	0	4	0	4	3	2

(1) → a, b



2020

3 (b) Define Image ~~ehan~~enhancement and compare it's two broad categories. (3)

Ans: Image enhancement is the process of making images more useful. The reasons of doing this include:-

- Highlighting interesting details in image
- Removing noise from images
- Making images more visually appealing.

The two broad categories of image enhancement techniques -

① Spatial domain techniques: Direct manipulation of image pixels

② Frequency domain techniques: Manipulation of Fourier transform.

	S.D.T.	F.D.T.
Definition	Directly manipulates the pixel values of an image	Transforms the image into the frequency domain, where it is manipulated using various mathematical operations
Common techniques	Contrast adjustment, brightness & u, histogram equalization, mean filtering sharpening	Wiener filtering, homomorphic filtering, wavelet transform.
Advantages	Simple & easy to implement	Can be used to achieve more complex and sophisticated enhancement effects
Disadvantage	Can introduce artifacts into the image	More computationally extensive than spatial domain enhancement

Spatial Domain Enhancement: Also known as point processing, operates directly on the pixel values of an image. It involves changing the pixel values based on their positions within the image.

=> ~~Contrast~~ Histogram Processing (Equalization):- It redistributes pixel values in the histogram to make the image's intensity levels more evenly distributed improving overall contrast.

=> Point Processing :- Aka pixel-wise processing involve adjusting the pixel values of images: (Contrast streetching, histogram equalization).

=> Spatial Filtering:- Processes an image by applying a filter or kernel to each pixel and its neighboring pixels. The filter co-efficient are used to compute a new pixel value based on a weighted combination of surrounding pixel. Smoothing Filter: Reduce noise - blurr Shapning filter: enhance edge & fine details.

Frequency Domain Enhancement- Involves the transfor-mation of image into frequency domain and manipulating that frequency components. the methods are- Image smoothing, Sharpning, -Fast fourier transform.

4-11 book-126.

3 ⓒ Illustrate the application logarithmic transfor
(2) -mation with suitable example.

The general form of log transformation is

$$S = c * \log(1+r)$$

Useful when the input grey level values may have an extremely large range of values.

Example - Medical x-ray image.

Why used:-

① Compression of intensity Range: x-ray images often have a wide range of intensity levels, from very low-Intensity areas to very high-intensity area.

② Improved visibility: enhances the visibility of fine details and low contrast structures within the image, such as soft tissues. By enhancing the darker regions, it can bring out subtle variation in low-intensity features

/

$\log_x a = y \Rightarrow x^y = a$

DIP - $\boxed{\text{CH-3}}$: Prev. Q. Analysis.

2021 I (b) - image size : 380X260

how much memory to store - (i) B/W (ii) 48 gray level
(iii) Color with 4 bit quan.

(i) B/W. Requires only 1 bit.
∴ Total memory required = 380X260X1 = 98800 bit
= 12350 byte
= 12 kb

(ii) gray image 48 gray level.
We know, $2^n = L$ where
n = no. of bit, L = level of image.

∴ $n = \log_2(L)$

$\Rightarrow n = \log_2(48)$

$n = 5.58$

≈ 6

380X260 = 98800 pixels

∴ Total no. of memory = 98800 X6
= 592800 bits
= 74100 bytes
= 72 Kb

(iii) Color image with 4 bit quantization.
There are 3 channels in the Color image, Red, Green, blue. 4 bit required for each channel
∴ No of bits - 4X3 = 12.

∴ Memory required = (98800X12) = 1185600 bit
= 148200 byte (÷8).

Spatial resolution: The ability of an imaging system to distinguish betn two closely spaced object. It is measured in pixel per inch. or lines per millimeter (lp mm).

2021: 2@ What is histogram equalization? Is histogram equalization a linear system?

H.E is an image processing technique that improves the contrast of an image by stretching the intensity range of the image so that the most frequent intensity values are more evenly distributed. This done by creating a mapping func that assigns new intensity values to each pixel in the image based on frequency of that intensity value in the original image.

Not Linear: Because the mapping func is Not linear. ~~The mapping~~ It involves non-linear transformation of pixel values based on their distribution. The mapping func takes the frequency of each intensity value assigns a new intensity value as an output. The func is not linear because the output is not simply a multiple of the input.

H.E. used to improve the contrast of images that have low contrast or that have a wide range of intensity values.

2(b) 5X5 image segment having the gray level scale betn [0, 7]. Evalute the histogram equalized image. Also draw the image histogram before and after equalization.

L=8

4	4	4	4	4
3	4	5	4	3
3	5	6	5	3
3	4	5	4	3
4	4	4	4	4

Ans: The maximum value = 7.

to represent it, $2^3 = 8 \Rightarrow 3$ bits

[0 to 7]

graylevel	0	1	2	3	4	5	6	7
no. of pixel (n_k)	0	0	0	6	14	4	1	0

M = 5

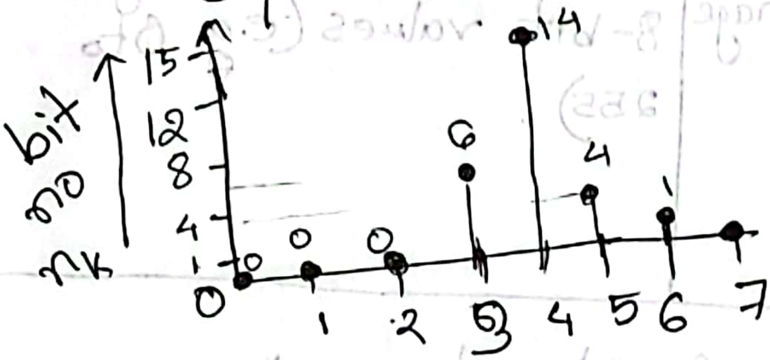
N = 5

MN = 25.

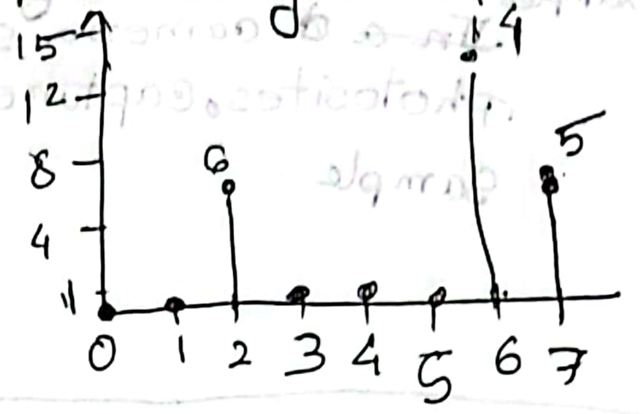
~~Before~~ equalization – $S_k = T(r_k) = (L-1)\sum_{j=0}^{k} P_r(r_j)$

gray level r_k	no. of Pixel (n_k)	Pdf = $P_r(r_k)$ = $\frac{n_k}{MN}$	cdf (cumulative) S_k	$S_k \times 7$ / $S_k \times (L-1)$	Round S_k	Histogram equalization $P(S_k)$
0	0	0	0	0	0	0
1	0	0	0	0	0	0
2	0	0	0	0	0	0
3	6	0.24	0.24	1.68	2	0.24
4	14	0.56	0.8	5.6	6	0.56
5	4	0.16	0.96	6.72	7	$\frac{4+1}{25}$
6	1	0.04	1	7	7	= 0.2
7	0	0	1	[illegible]	7	0

Before Histogram equalization:-

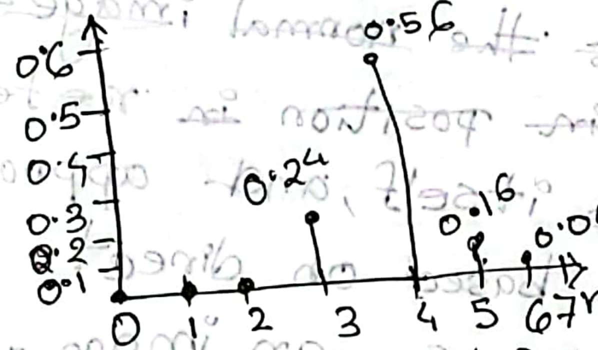


After histogram equalization:-

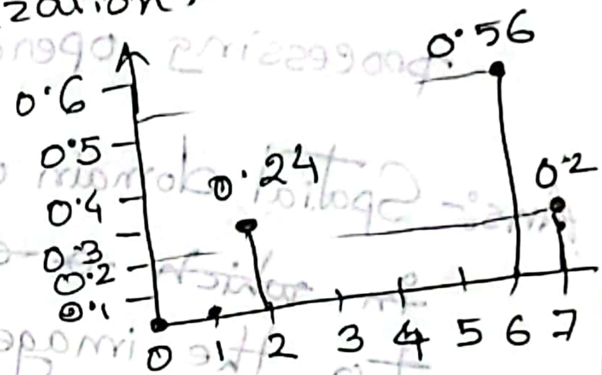


But we need to picture with probabity for showing the equalization.

draw this



Original histogram



2 (c) Distinguish betn image sampling & quantization (3)

Aspect	Image sampling	Quantization
Definition	Selection of discrete spatial point (pixels) from a continuous image	Assigment of discrete intensity or color values to image samples
Purpose	Convert a continuous image into discrete spatial point	Convert continuous intensity or color values into discrete values.
Process	Involves the spatial positioning of pixels	Involves assigment of intensity / color values
effect of image	Affect spatial resolution (detail capture).	Affect dynamic range and color accuracy

Example: ~~Correct~~ In a digital ~~In a~~ camera sensor, photosites, capture image sample	In a grayscale image pixels may be assigned 8-bit values (e.g. 0 to 255)

3 (a) Explain the general model of spatial domain image enhancement. How it can be deduced to point processing operation. (3).

Ans:- Spatial domain ~~means is~~ ~~the normal~~ image space ~~in which a change in position in~~ refers to the image plane itself, and approach in this category are based on direct manipulation of pixels in an image.

- The Spatial domain methods are procedures that operate directly on these pixels. Spatial domain processes will denoted by the expression

$$g(x,y) = T[f(x,y)]$$

f(x,y) is image image
g(x,y) is processed im
T is an operator on f defined over some neighborhood of (x,y)

The operator can apply to a single image or to a set of images, such as performing the pixel-by-pixel sum of a sequence of

Frequency domain: processing techniques based on modifying Fourier transform of an image.

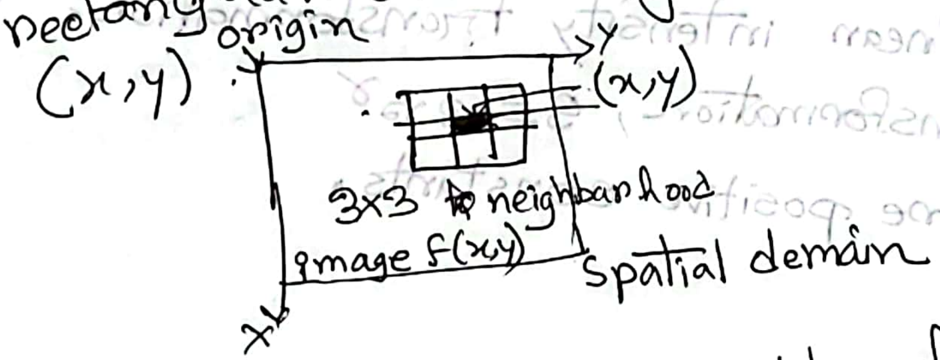
Images for noise reduction.

The general equation remains the same,

$S = T(r)$ where, S = output gray level
T = transformation function
r = input gray level.

Spatial domain works with the pixel values to get a new image based on equation. It can be carried out in 2 ways - ① Point Processing ② Neighborhood Processing

The principal approach is defining a neighborhood about a point (x,y) is to use a square or rectangular sub-image area centered at (x,y)



The smallest possible neighbourhood is of size 1x1, the transformation function T oprates on r as a gray-level or mapping function. And ultimately doing point processing operation. this approach is called local processing.