Q.1) For the following image data of 8 bits pixel per image find :- ($L = 2^8 = 256$)
k is bit value

i) image negative
ii) Threshold result (Threshold Value = 150)

120	135	215	220	125
135	20	187	50	80
250	215	55	120	45
30	180	200	46	20
60	119	120	255	135

i) Negative Image :-

$s = [L-1] - r$

where

r = input intensity value

L = maximum intensity range

s = output image

$L = 2^B$

Here $B = 8$

$L = 2^8$

$= 256$

① $s = (L-1)\ r$

$= (256-1) - 120$

$= 255 - 120$

$= 135$

② $s = (L-1) - r$

$= (256-1) - 135$

$= 255 - 135$

120

③ (256-1) -215
= 255 -215
= 40

4) 255 -220
= 35

5) 255 -120
= 135

Similarly do for all rows & columns

135	120	40	35	135
120	235	68	205	175
5	40	200	135	210
225	75	55	209	235
195	136	135	0	120

ii) Threshold with threshold Value = 150

S=0   T ≤ 150
= L-1   T > 150

$L = 2^8 = 256$

S = L-1
= 256-1
= 255

o/p

0	0	255	255	0
0	0	255	0	0
255	255	0	0	0
0	255	255	0	0
0	0	0	255	0

Q2. What is a histogram? explain the technique of histogram

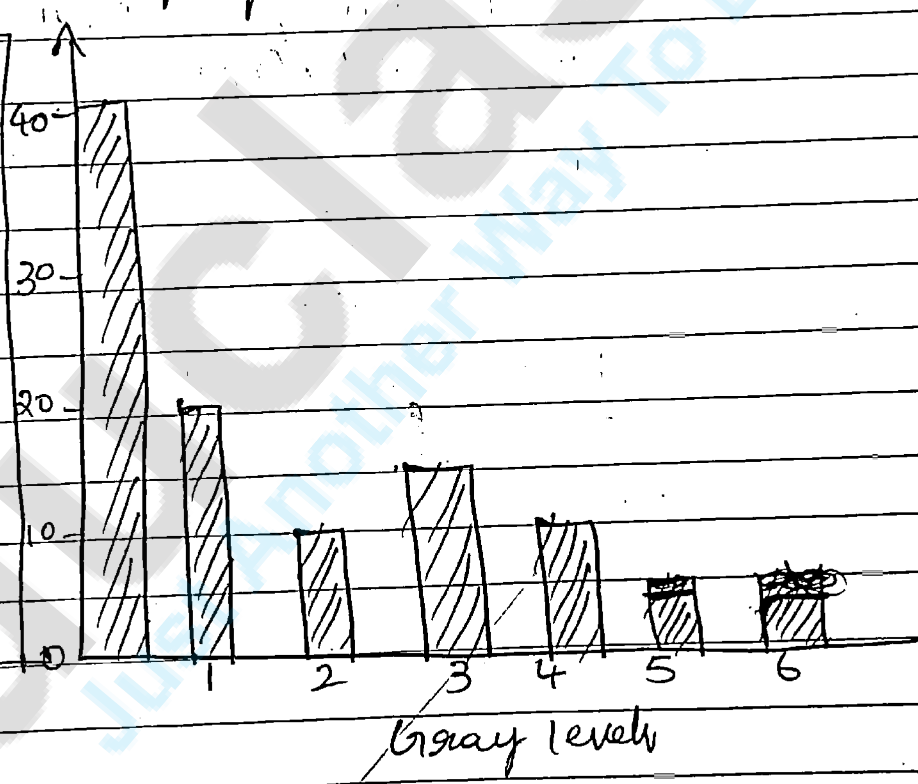
The histogram of an image represents the relative frequency of occurance of the various grey levels in the image.

↳ Histogram can be plotted in two ways

↳ Histogram : Method 1

* It is bar chart with x-axis contain grey levels and y-axis has the number of pixels in each gray level

Gray level	No. of Pixels
0	40
1	20
2	10
3	15
4	10
5	3
6	2



Histogram :- Method 2

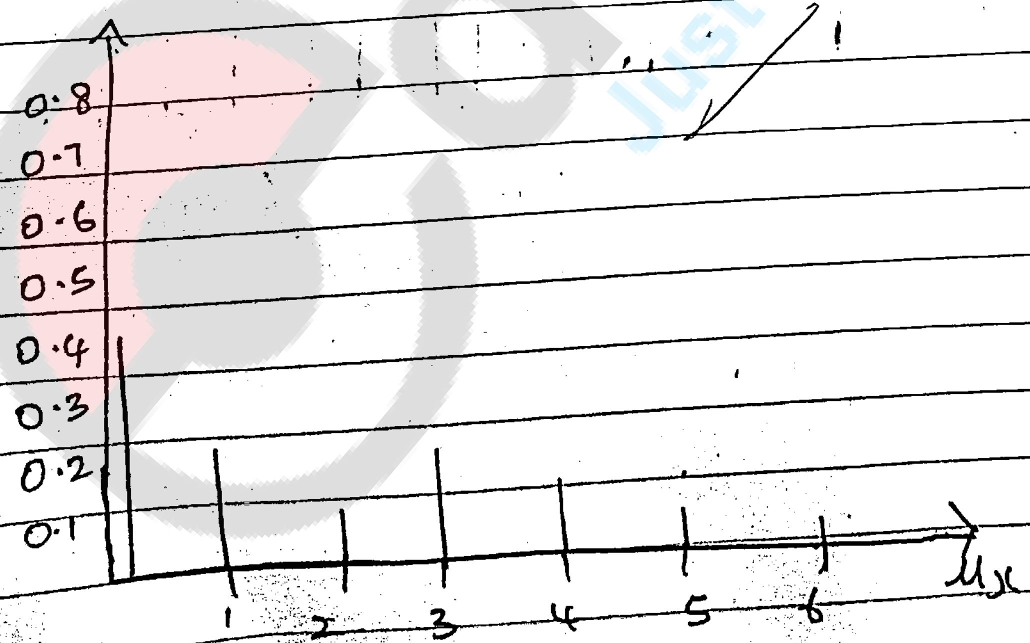
→ x-axis contain gray levels and y-axis represents the probability of occurrences of that gray level.

$P(u_k) = n_k/n$; where ; u_k - gray level

n_k = no. of pixels in k^{th} gray level

n = total number of pixels in an image

Gray Level	No. of pixels (n_k)	$P(u_k)$
0	40	0.4
1	20	0.2
2	10	1
3	15	0.15
4	10	0.1
5	3	0.03
6	2	0.02



Histogram Equalization :-

↳ We have to search for a transform that converts any random histogram into flat histogram

$$S = T(r)$$

↳ We have to find 'T' which produces equal values in each gray levels

↳ The transform should satisfy following 2 conditions :

i) $T(r)$ must be single value & monotonically increasing in the interval $0 < r \leq 1$

ii) $0 \leq T(r) \leq 1$ for $0 \leq r \leq 1$

$0 \leq S \leq 1$ for $0 \leq r \leq 1$

Here, range of r is $(0,1)$ (Normalized range) instead of $[0,255)$

↳ The first condition preserve the order from black to white in the gray scale.

↳ The second condition guarantees a mapping that is consistent with given range of pixel values.

↳ Since the transformation is single value & monotopically increasing the inverse transformation exists

$$r = T^{-1}(s) \; ; \; 0 \leq S \leq 1$$

↳ Gray levels for continuous variables can be characterized by their probability density $P_r(r)$ & $P_s(s)$

↳ from probability theory we know that if $P_r(r)$ & $P_s(s)$ are known & if $T^{-1}(s)$ satisfies condition (i) then the probability density of transferred gray level is

$$P_s(s) = \left[P_r(r) \cdot dr/ds\right]_{r=T^{-1}(s)} \quad \text{---(a)}$$

$$s = T(r)$$

$$s = \int_0^r (P_r(r)\,dr \; ; \quad 0 \leq r \leq 1$$

diff w.r.t. r

$$ds/dr = P_r(r) \quad \text{---(b)}$$

Equating eq^n (a) & eq^n (b) we get

$$P_s(s) = [1] \; ; \quad 0 \leq s \leq 1$$

i.e $P_s(s) = 1$

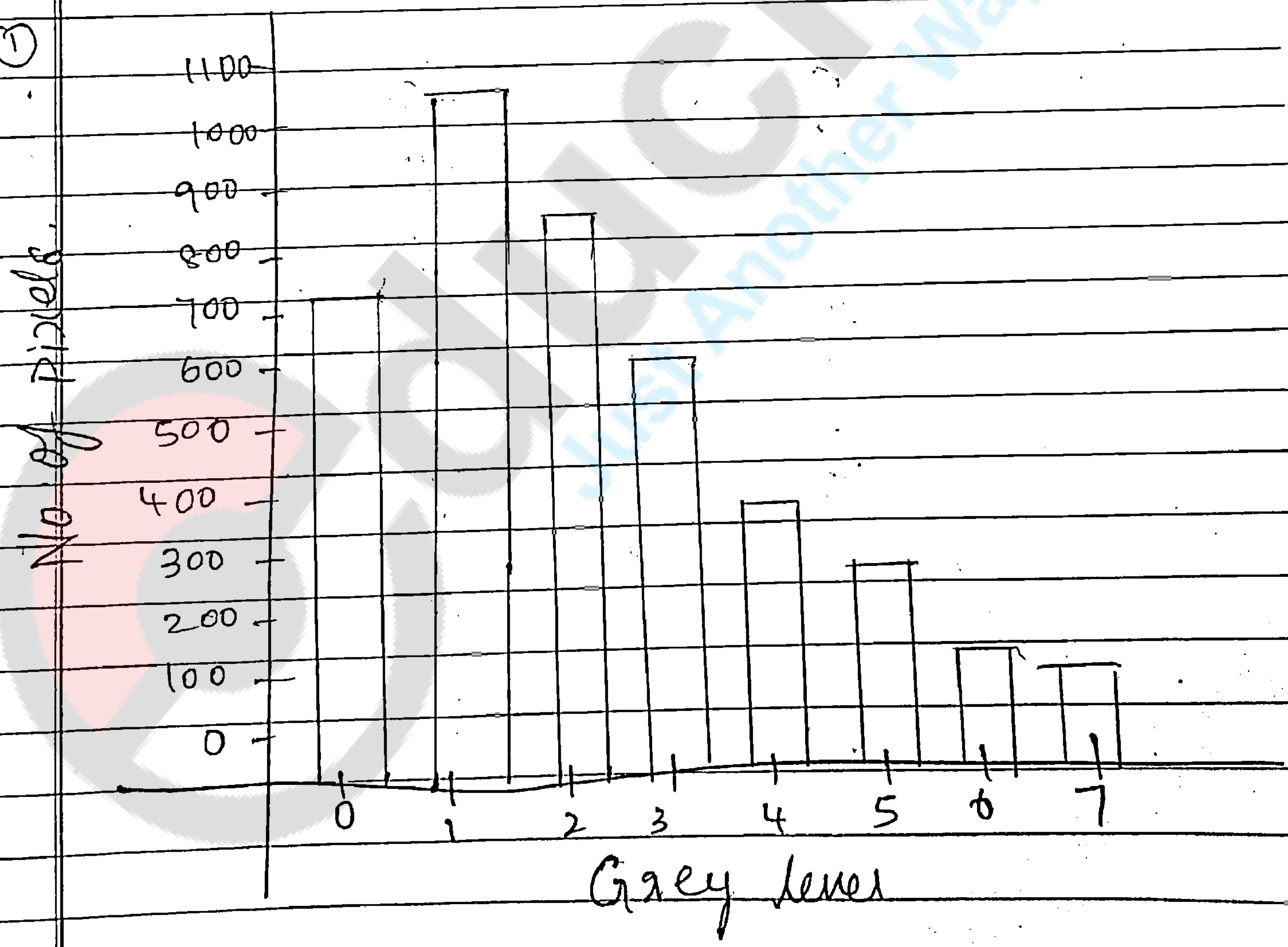
Q. 3) Equalize the given histogram ?

Grey level	No. of pixels
0	790
1	1023
2	850
3	656
4	329
5	245
6	122
7	81

Grey level = 8

$\therefore L-1 = 8-1 = 7$

(1)

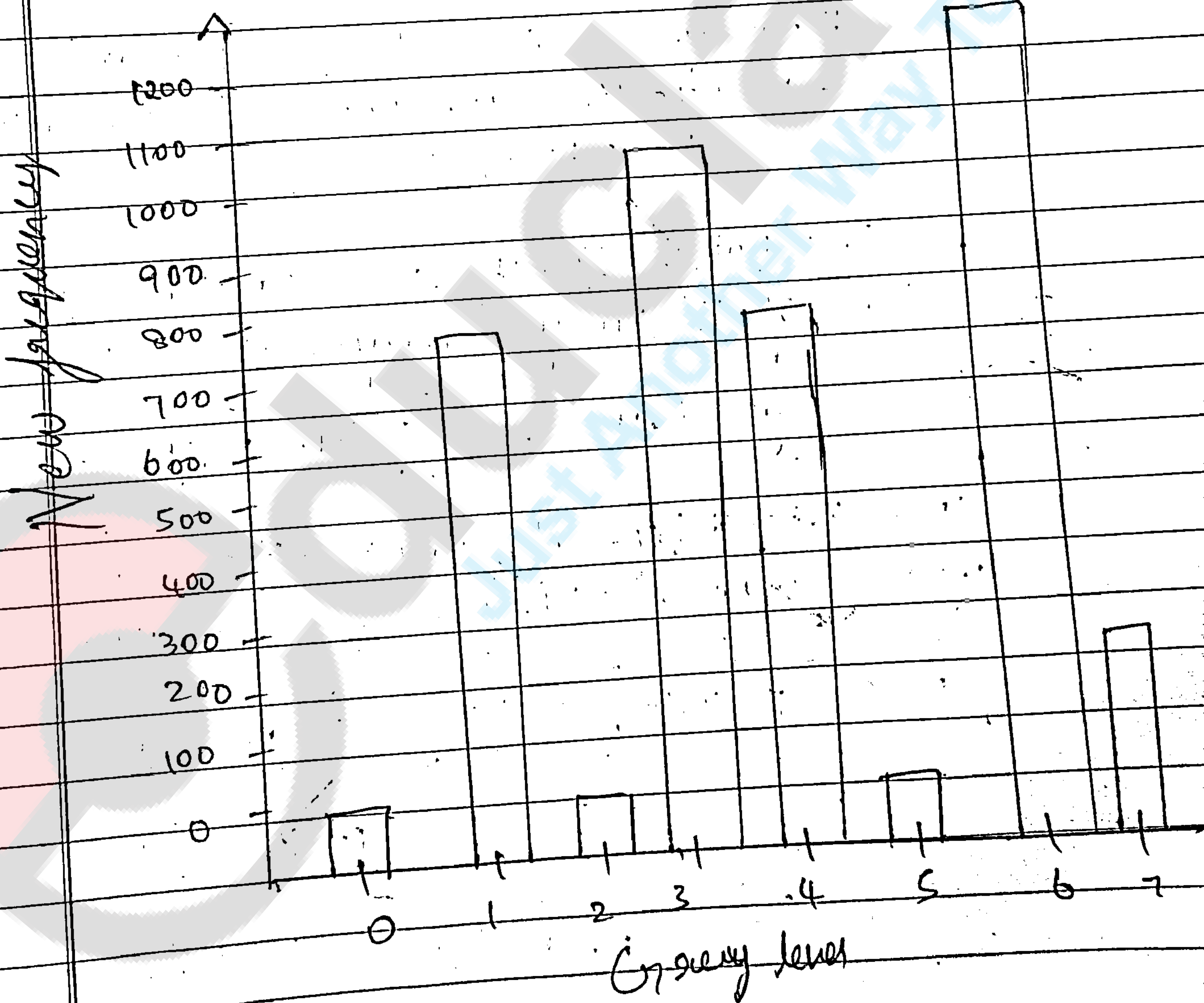


Grey level	nk	$P_k(r_k) = \frac{n_k}{n}$	$S.C = \sum P_k(r_k)$	$\frac{S.C[L-1]}{SC(7)}$	Round of
0	790	0.19	0.19	1.33	1
1	1023	0.24	0.19+0.24=0.43	3.01	3
2	850	0.20	0.63	4.41	4
3	656	0.16	0.79	5.53	6
4	329	0.08	0.87	6.09	6
5	245	0.05	0.92	6.44	6
6	122	0.02	0.94	~~6.58~~	7
7	81	0.01	0.95	~~6.65~~	7

Old Grey level	No. of pixels	New Grey level
0	790	1
1	1023	3
2	850	4
3	656	6
4	329	6
5	245	6
6	122	7
7	81	7

Grey level	New frequency
0	0
1	790
2	0
3	1023
4	850
5	0
6	1230
7	203

Equilized Histogram :-



Q.4) Write short notes on :-

i) Image Averaging :-

↳ Image averaging is used to eliminate Pixel vibration or high frequency image & changes

↳ The noisy image $z(x,y)$ is obtained by adding some noise term $n(x,y)$ to the original image $f(x,y)$

↳ Let $g(x,y)$ denote a corrupted image by adding noise $n(x,y)$ to a Noiseless image $f(x,y)$ (1)

$$g(x,y) = f(x,y) + n(x,y) \longrightarrow (1)$$

↳ The noise has zero mean value

$$E[z_i] = 0$$

↳ At every pair of co-ordinates $z_i = (x_p\ x_i)$ the noise is uncorrelated

$$E[z_i z_j] = 0$$

↳ The noise effect is reduced by averaging a set of K noisy images. The new image is

$$\bar{g}(x,y) = \frac{1}{K}\sum_{i=1}^{K} g_i(x,y) \longrightarrow (2)$$

The intensities at each pixel of the new image may be viewed as random variables

- $E[\bar{g}(x,y)] = E\left[\frac{1}{K}\sum_{i=1}^{K} g_i(x,y)\right]$

↳ from (=) (2)

$$= \frac{1}{K} E\left[\sum_{i=1}^{K} f(x,y) + n_i(x,y)\right] \longrightarrow \text{from (1)}$$

$$= \frac{1}{K} E\left[\sum_{i=1}^{K} f(x,y)\right] + \frac{1}{K} E\left[\sum_{i=1}^{K} n_i(x,y)\right]$$

$$= \frac{1}{K} K f(x,y) + \frac{1}{K} \times 0$$

$$= f(x,y)$$

Standard deviation of new image is

$$\sigma_{\bar{g}(x,y)} = E\left[(\bar{g}(x,y))^2\right] - \left[E[\bar{g}(x,y)]\right]^2$$

$$= \frac{1}{\sqrt{K}} \sigma_{n(x,y)}$$

As K increases the variability of the pixel intensity decreases & remains close to the noiseless image values $f(x,y)$

ii) Sampling & Quantization:-

The basic idea behind sampling and Quantization shows a continuous image $f(x,y)$, that we want to convert to digital form. An image may be continuous with respect to the x-co-ordinate & y-co-ordinate & also an amplitude.

↳ To convert it to digital form, we have to sample the function in both co-ordinates & in amplitude.

↳ Digitizing the co-ordinate values is called quantization.

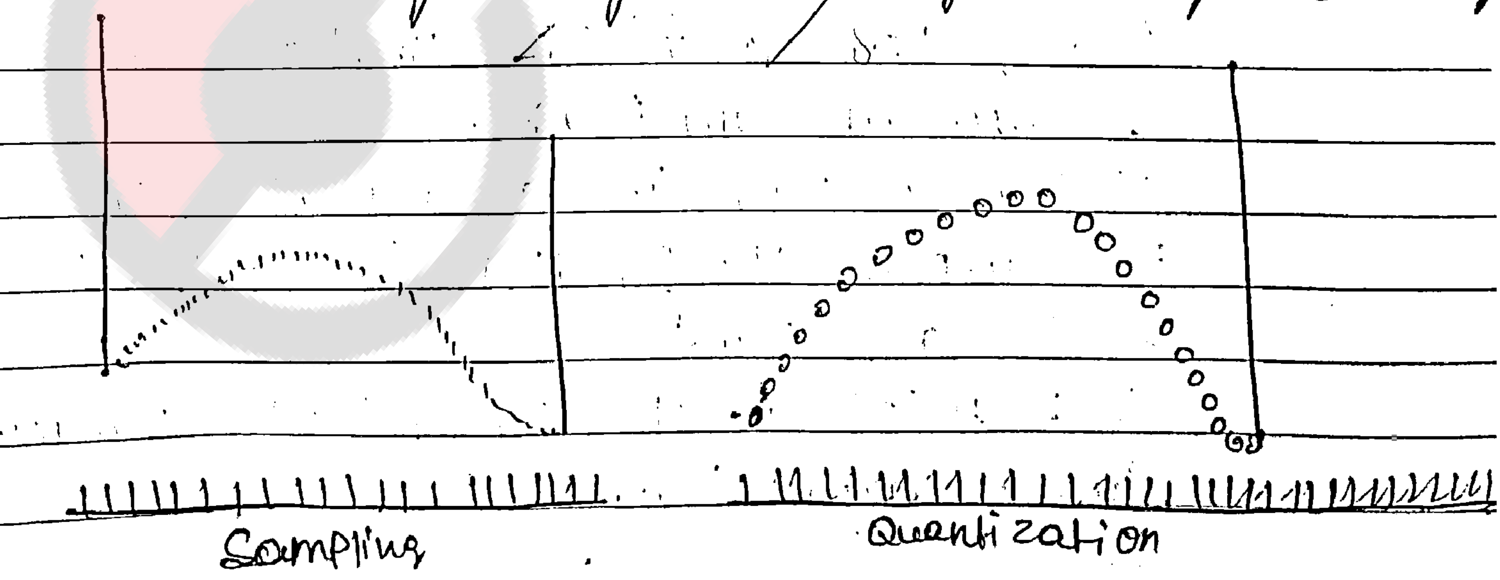
↳ The one-dimensional function is a plot
of amplitude values of the continuous
image along the line segment AB.

~~↳ The one dimensional function is a plot of amplitude values of the continuous image along the line segment AB.~~

↳ The location of each sample is given by a vertical tick mark in the bottom part of the figure. The sample is shown as small white squares superimposed on the function.

↳ The set of these discrete locations gives the sampled function. However the values of the samples still span (vertically) a continuous range of gray level values also must be convert into discrete quantities.

↳ Sampling in the manner just described assumes that we have a continuous image in both co-ordinate directions as well as in amplitude. In practice, the method of sampling is determined by the sensor arrangement used to generate the image. When an image is generated by a single sensing



(iii) Image Substraction

The pixel substraction operator takes two images as input and substract a constant value from all the pixels. Some versions on the operator will just output the absolute difference between pixel values rather than the straight forward signed O/P.

The substraction of two images is performed straight forwardly in a single pass. The O/P pixel values are given by:

$$Q(i,j) = P_1(i,j) - P_2(i,j)$$

OR

if the operator computes absolute differences between the two input images then:

$$Q = |P_1(i,j) - P_2(i,j)$$

(OR)

if the operator computes absolute differences between the two input images then

$$Q = |P_1(i,j) - P_2(i,j)|$$

If it is simply desired to subtract a constant value from a single image then

$$Q = P_1(i,j) - C$$

If the pixel values in the input images are actually vectors rather than scalar values (e.g for color images) then the individual components (eg. red, blue & green) components) are simply substracted separately produce that output value

iv) Image Digitization:-

Conversion of sensor signals that carry information on natural objects into digital communication channels and eventually used for creating sufficiently perfect images. The conversion is called image digitization

↳ The two-dimensional sensor can be represented by a 2D function f(x,y) of light intensity at the spatial location (x,y). However in order for the continuous scene to be represented and processed digitally in a computer it need to be digitized specifically, the digitization includes the quantization of the intensity function value of the sampling of the two spatial dimensions correspondingly, the digital processing of the image can be, classified into intensity (gray level) operations applied to the pixel values & geometric operations in the two spatial dimensions

↳ Digitization is a process of converting information into a digital format

↳ In this format information is organized into discrete units of data called bits that

Scanned by CamScanner

can be separately addressed.
↳ This is the binary data that computers and many devices with computing capacity can process text & images can be digitized).
Similarly a scanner captures an image and converts it to an image file such as a bitmap. An optical character recognition (OCR) program analyzes a text image for light and dark areas in order to identify alphabetic letter or numeric digit & converts each character into an ASCII code.

iv) Power Law Transformation:-
Image Enhancement :-
Enhancing an image provides better contrast & a more detailed image as compare to non-enhanced image. Image enhancement has very applications. It is used to enhance medical images captured in remote sensing etc.
The transformation function has been given below.

$$S = T(u)$$

where is the pixels of the input image And S is the pixels of the output image T is a transformation function that maps each value of r to each value of S through gray level transformation which are discussed below

Gray Level Tranformation :-

There are three basic gray level tranformation

- Linear
- Logarithmic
- Power - law tranformation.

There are further two tranformations is Powerlaw tranformation that include nth power law tranformations These tranformation can be given by the expression

$$S = Cr^{\wedge} y$$

The symbol y is called gamma due to which this tranformation is also known as gamma tranformation.

Variations in the values of x varies the enhancement of the image different display device.

$$S = Cr^{1} y$$
$$S = Cr^{1} (1/2.5)$$

(VI) Log Transformations :-

Enhancing an image provides better contrast and more details image as compare to no enhanced image. Image enhancement has every applications. It is used to enhance medical images captured in remote sensing image from satellite.

The transformation function has been given below.

$$s = T(r)$$

Logarithmic Transformation :-

Logarithmic transformation further contains two types of transformation log transformation & inverse log transformation

The log transformations can be defined by this formula

$$s = c\log(r+1)$$

Where s & r are the pixels values of the output & the input image, and c is a constant. The value 1 is added to each of the pixel value of the each image because if there is a pixel intensity of 0 in the image: then log (0) is equal to infinity so 1 is called to make the minimum value at least.

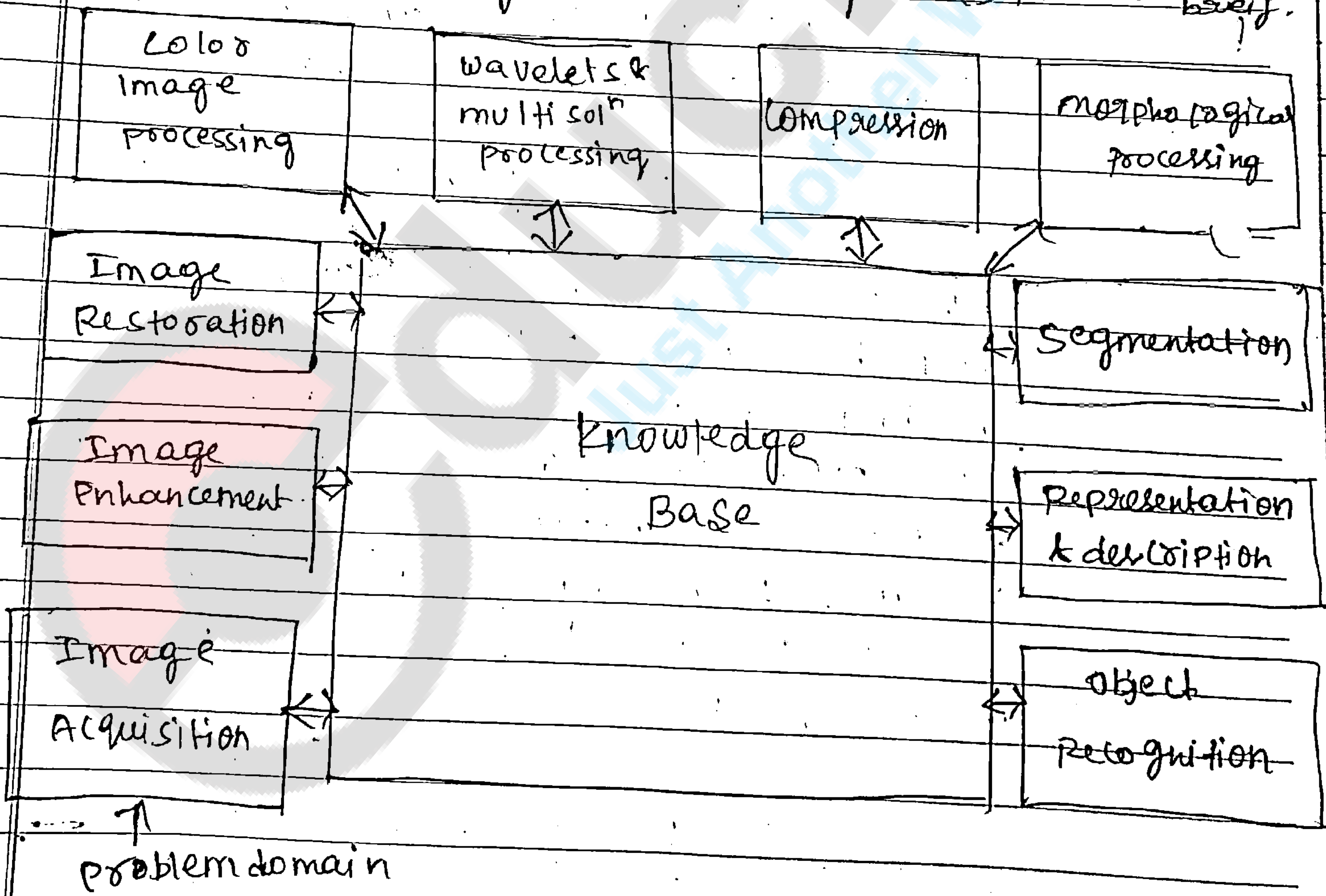
During log transformation the dark

Pixels in an image are expanded as compare to the higher pixel values. The higher pixel values are kind of compressed in log transformation. This result in following image enhancement.

The value of c in the log transformation adjust the kind of enhancement you are looking for.

The inverse log transformation is opposite to log transform.

Q5) What are the ~~following~~ fundamental steps in digital image processing. Explain in brief.



Explanation :-

1) Color image processing :-

It is an area that has been gaining its importance because of the significant increase in the use of digital images over the internet. This may include color modelling & Processing in a digital domain

2) Wavelets & multi - Resolution processing :-

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

3) Compression :-

Compression deals with technique for reducing the storage required to save an image on the bandwidth to transmit it particularly in use of internet it is very much necessary to compress data.

4) Morphological processing :-

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

5) Segmentation :-

Segmentation procedures partition an image into its constituent parts or objects. In general autonomous segmentation is one of the most difficult task in digital image processing. A rugged segmentation procedure brings the process a long way towards successful solution of image problems that require objects to be identified individually.

6) Representation & Description :-

Representation & description almost always follow the output of a segmentation stage, which usually is raw pixel data, constituting either the boundary of a region or all the points in the region itself. Choosing a representation is only part of the solution for transforming raw data into a form suitable for subsequent computer processing.

7) Object Recognition :-

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

8) Knowledge Base :-

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

9) Image Acquisition :-

This is the first step or process of the fundamental steps of digital image processing. Image acquisition could be as simple as being given an image that is.

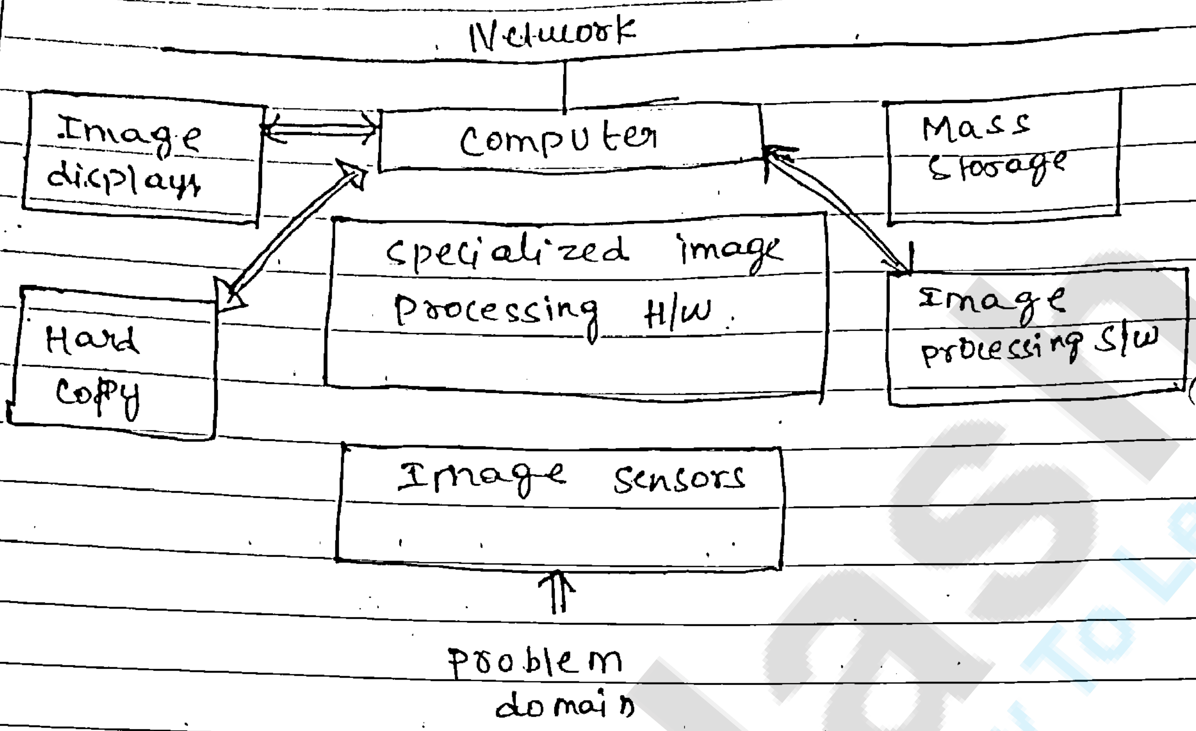
10) Image Enhancement :-

Image enhancement is among the simplest & most appearing areas of digital image processing. Basically, the idea behind enhancement technique is to bring out details that is observed, or simply to highlight certain features of interest in an image. Such as changing brightness & contrast etc.

11) Image Restoration :-

It is an area that deals with improving the appearance of an image. However, unlike enhancement which is subjective, image restoration is objective, in the mathematical or probabilistic models of image degradation.

6Q) Explain components of image processing systems



The figure shows the basic components comprising a typical general purpose system used for digital image processing.

i) Image Sensors :-

↳ with reference to sensing, two elements are required to acquire digital images.

i) Physical device :- Sensitive to the energy radiated by the object we wish to image

ii) Digitizer :- device for converting the output of the physical sensing device into digital form.

2) Specialized image processing Hardware
It usually consists of the digitizer & hardware that performs other primitive operations such as an ALU (Arithmetic logic unit) which performs arithmetic & logical operation in parallel on entire images.

3) Computer :-
The computer in an image processing system is a general purpose computer & can range from a PC to a supercomputer. They are used to achieve a required level of performance. In these system, almost any well-equipped PC-type machine is suitable for offline image processing task.

4) Image processing Software :-
Software for IP consist of specialized modules that perform specific tasks. A well-designed packaged also include the capability for the user to write code, that, as a minimum, utilizes the specialized modules.

5) Hard copy :-
Hardcopy devices for recording images include laser printers, film cameras heat sensitive devices, inkjets units and digital units, such as optical and CD-ROM disks. Images are displayed on film transparencies or in a digital medium, if image projection equipment is used.

6) Image displays :-

↳ Image displays used today are mainly color TV monitors. Monitors are driven by the outputs of image & graphics display cards that are an integral part of computer system.

7) Mass Storage :-

Mass storage capability is must in image processing applications. An image of size 1024 * 1024 pixels, in which the intensity of each pixel is an 8-bit quantity requires one megabyte of storage space, Digital image processing applications falls into three principal categories.

1) Short - term storage
2) On-line storage
3) archival storage

7Q For the following 4 bit image perform following operations.

i) Threshold = 8

ii) Intensity level slicing with background a=6 and b=12

(iii) Negative

2	13	4
15	6	12
0	9	13

i) Threshold T = 8

If $r > T \rightarrow L-1$

If $r \leq T \rightarrow 0$

$2^4 = 16 = 16-1 = 15$

0	15	0
15	0	15
0	15	15

(ii) a=6 b=12

If $a \leq r \leq b \rightarrow L-1 = (16-1=15)$

else same value

a b

6 12

2	13	4
15	15	15
0	15	13

(iii.) Image Negative

2	13	4
15	6	12
0	9	13

$s = (L-1) - r$

4bpp $\quad 2^4 - 1 = 16 - 1 = 15$

$s = (L-1) - r$

$= 15 - r$

$s = 15 - 2 = 13$
$s = 15 - 13 = 2$
$s = 15 - 4 = 11$

$s = 15 - 15 = 0$
$s = 15 - 6 = 9$
$s = 15 - 12 = 3$

$s = 15 - 0 = 15$
$s = 15 - 9 = 6$
$s = 15 - 13 = 2$

13	2	11
0	9	3
15	6	2

Q.8) Explain Contrast stretching with example?

i) Constrast stretching (often called normalisation) is a simple image enhancement technique that attempt to improve the constrast in an image by stretching the range of intensity values ~~eg~~ ? it contains to span a desired range of values eg. The fullrange of pixel values that image type concerned allows. It differs from the more sophisticated histogram equalization in that it can only apply a linear scaling function to the image pixel values - As a result the enhancement is less harsh.

Working :-

Before the stretching can be performed it is neccessary to specify the upper & lower pixel limits over which the image is to be normalized often these limits will just be the minimum & maximum pixel values that the image type concerned allows ex- for 8-bit grey level images the lower & the upper limits a & b respectively.

The simplest sort of normalization then scan the image to find the lowest & highest pixel values current present in the image call these c & d - the each pixel P is scaled using the function.

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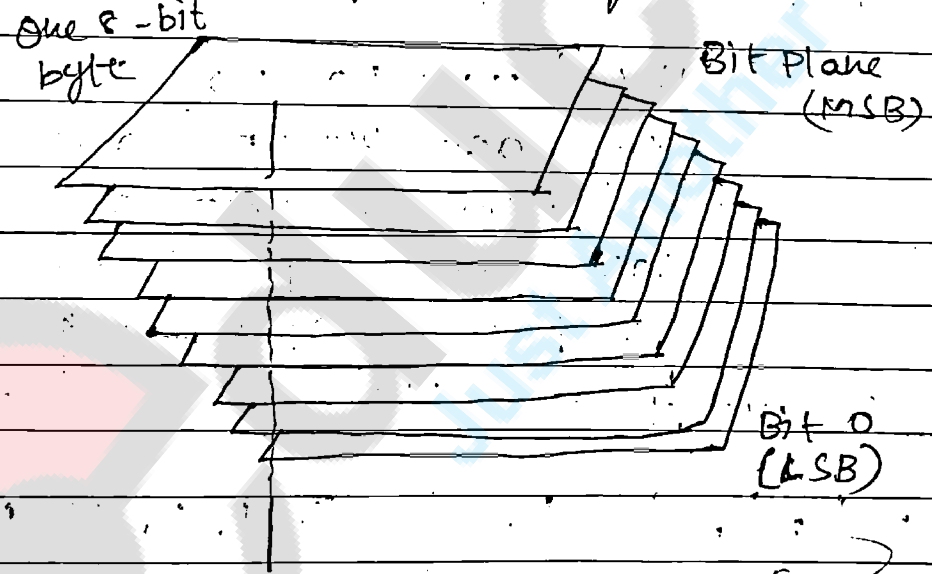
$$P_{out} = (P_{in} - c)\left(\frac{b-a}{d-c}\right) + a$$

Values below 0 are set to 0 & values above 255 are set to 255

The problem with this is a ~~that~~ single outlying pixel with either a very high or very low value can severely affect the value of c or d & this could lead to very unrepresentative scaling. Therefore a more robust approach is to take histogram of the image & then select c & d at, say, the 5th & 95th percentile in the histogram. This prevents outlier affecting the scaling so much.

Q9) Explain Bit-Plane Slicing?

→ The gray level of each Pixel in a digital image is stored as one or more bytes in a computer for an 8 bit image; 0 is encoded as 00000000 & 255 is encoded as one 11111111. Any number between 0 to 255 is encoded as one byte. The bit in the far left side is referred as the most significant Bit (MSB) because a change in that bit would significantly change the value encoded by the byte. The bit in the for right is referred as the least significant bit (LSB), because a change in this bit does not change the encoded gray value much. The bit plane representation of an eight-bit digital imag →



Bit plane slicing is a method of representing an image with one or more bits of the byte used for each pixel. One can use only MSB to represents the Pixel, which reduces the original grey level to a binary image. The three main goals of bit-Plane Slicing is:-

↳ Converting a gray level image to a binary image

↳ Representing an image with fewer bits & corresponding the image to smaller size

↳ Enhancing the image by focusing

Eg:-

6	7	6	6	7
0	0	0	1	2
1	1	1	2	3
4	5	5	4	2
6	6	6	7	7

Since the given image has a maximum gray level of 7. It is a 3 bit image. We convert the image to binary & separate the bit plane.

110	111	110	110	111
000	000	000	001	010
001	001	001	010	011
100	101	101	100	101
110	110	110	111	111

Separating the bit plane, we obtain

MSB plane

1	1	1	1	1
0	0	0	0	0
0	0	0	0	0
1	1	1	1	0
1	1	1	1	1

Centre

1	1	1	1	1
0	0	0	0	1
0	0	0	1	1
0	0	0	0	1
1	1	1	1	1

LSB plane

0	1	0	0	1
0	0	0	1	0
1	1	1	0	1
0	1	1	0	0
0	0	0	1	1