Types of Image

- Monochrome image(Binary Image)
- Grey scale image
- Color image (24 bit)
- Half toned image

- **Monochrome image(Binary Image):**

Pixel is stored as a single bit (0 or 1). 0 represent black and 1 represent white.

These image are also called bit mapped images.

- **Grey Scale Image:**

Each pixel is stored as byte(8 bits).each pixel have values ranging from 0 (black) to 255 (white).

The image have black , white and various shades of grey .

- **Color image(24 bit):**

Each pixel is composed of RGB values and each of these color require 8 bits for its representation. Hence each pixel is represented by 24 bit { R(8bit), G (8 bit) , B(8 bits)}

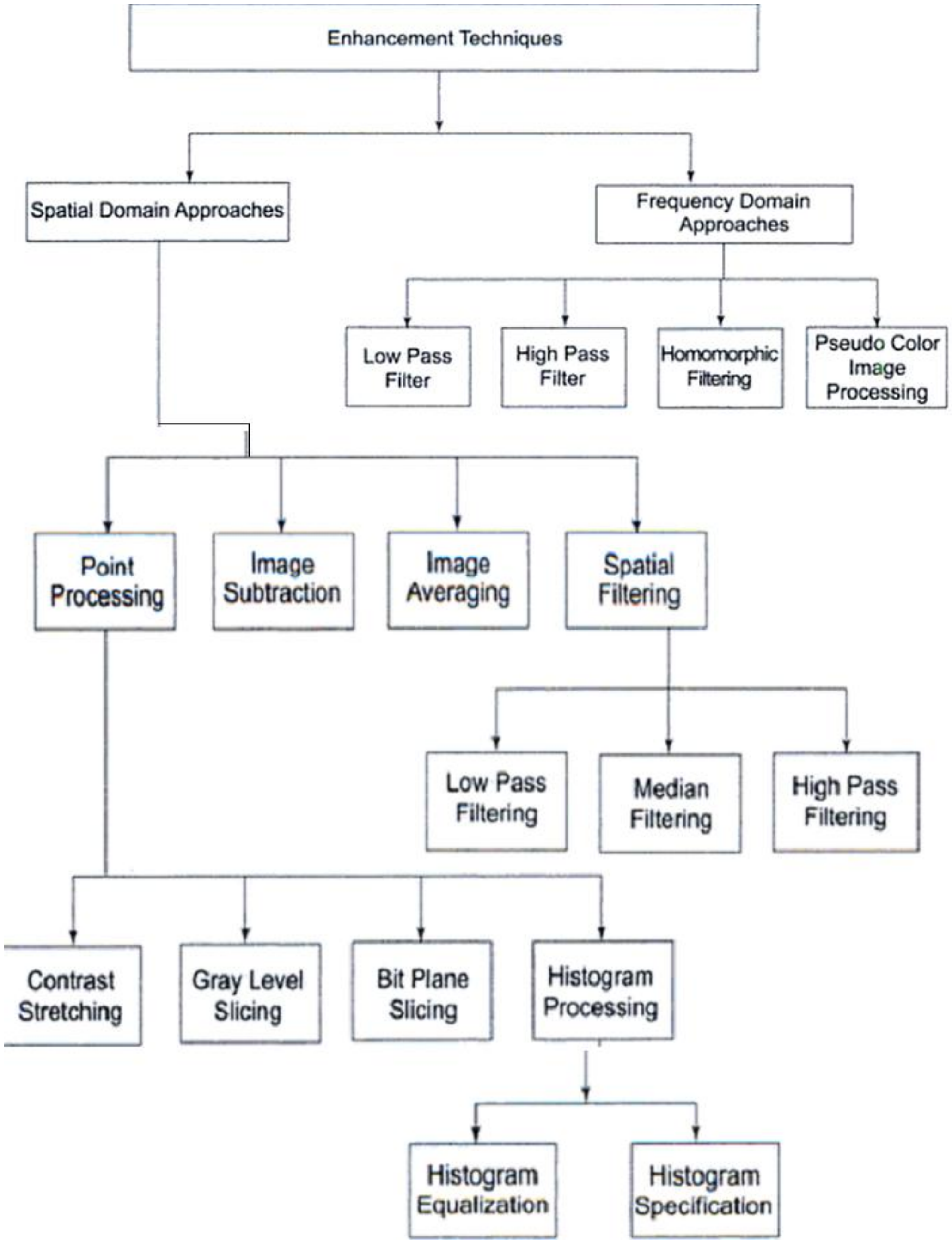
Image Enhancement in the Spatial Domain

INTRODUCTION : IMAGE ENHANCEMENT

- The principle objectives of image enhancement techniques is to process an image so that the result is more suitable than the original image for a specific application .
- Image enhancement techniques can be divided into two broad categories:

    1.Spatial domain methods .

    2. Frequency domain methods.



Enhancement Techniques
Spatial Domain Approaches
Frequency Domain Approaches
Low Pass Filter
High Pass Filter
Homomorphic Filtering
Pseudo Color Image Processing
Point Processing
Image Subtraction
Image Averaging
Spatial Filtering
Low Pass Filtering
Median Filtering
High Pass Filtering
Contrast Stretching
Gray Level Slicing
Bit Plane Slicing
Histogram Processing
Histogram Equalization
Histogram Specification

SPATIAL DOMAIN METHODS

- The term spatial domain refers to the aggregate of pixels composing an image.
- Spatial domain methods are procedures that operate directly on these pixels.
- Spatial Domain processes will be denoted by the expression

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

Where f(x,y) is an input image ,g(x,y) is an output image and T represents an operation on 'f' define over some neighborhood of (x ,y)

- Let us consider ,

r = intensity of the pixel in given original image and

s = intensity of the pixel in the enhanced image.

Basic Intensity Transformation functions

- Image Negative
- Log transformation
- Pawerlaw transformation

IMAGE NEGATIVES

- Negatives of digital images are useful in numerous applications, such as displaying medical images.

  For eg. Displaying X Ray image.

- Negative means inverting grey levels that is, black in original image will looks white and vice versa .

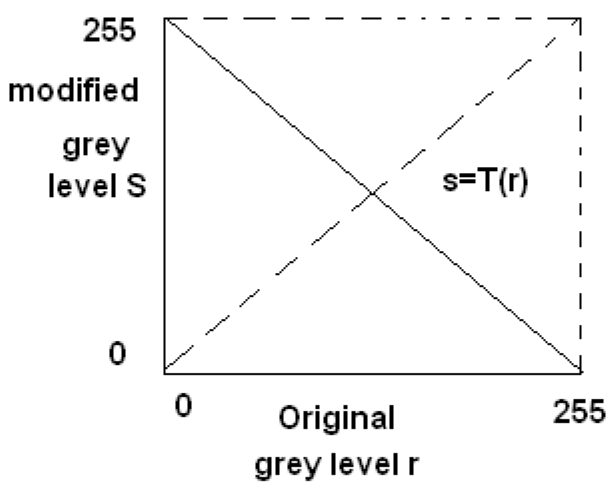
  Transform function , s= (L-1)-r where L is grey level (L=256)

Digital negative image cab be obtained

Using, s= 255-r

r=0 then s=255

r=255 then s=0



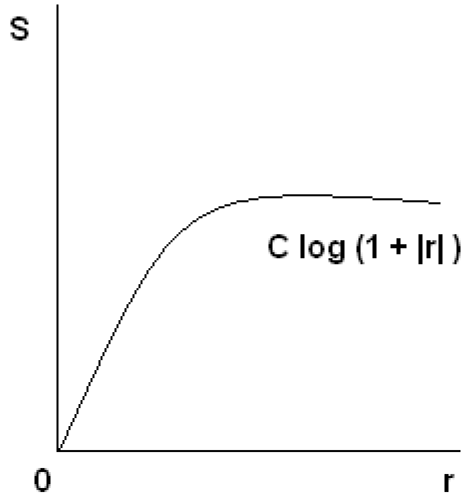
Log Transformation
(Compression of dynamic range)

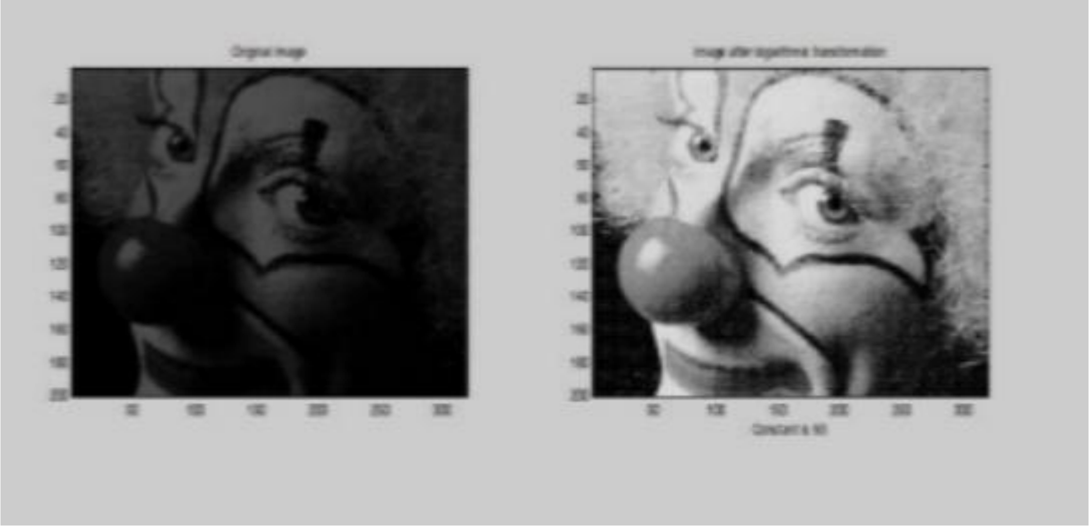
Log Transformation:-

- Sometimes the dynamic range of a processed image far exceeds the capability of the display device, in which case only the brightest parts of the images are visible on the display screen.
- For example , Stars are not visible in daytime due to intensity of sun.
- An effective way to compress the dynamic range of
- pixel values is using log operator is known as log transformation
- Transformation function:

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

where c is a scaling constant, and the logarithm function performs the desired compression.


S
C log (1 + |r|)
0
r



Power low transformation (Gamma transformation)

- The basic formula for power low transformation is ,

$$S= c\, r^{\gamma}$$

Where , γ is called gamma, and due to this transformation is also called gamma transformation

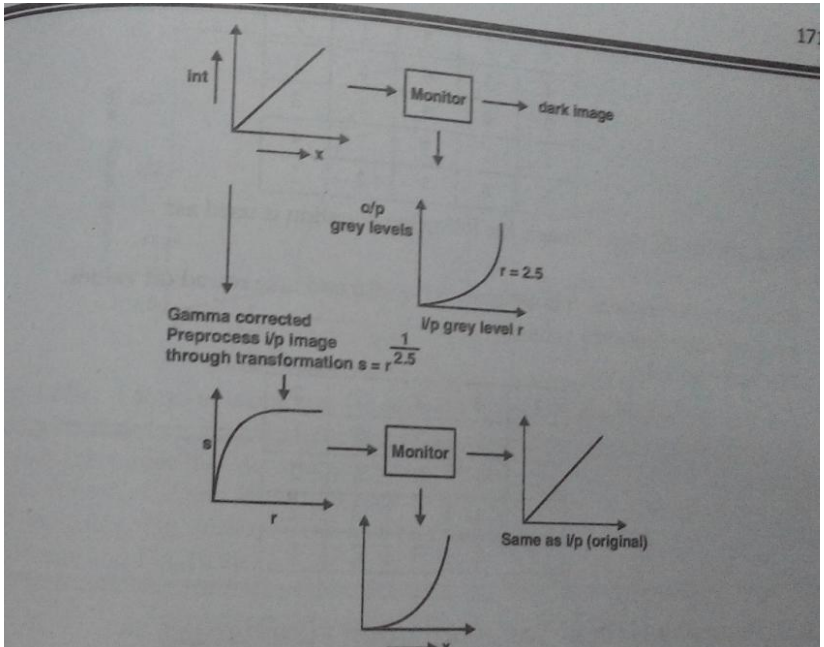


Fig. 10.5: Display of an image before and after gamma correction

FIGURE 3.9
(a) Aerial image
(b)–(d) Results (
applying the
transformation i
Eq. (3.2-3) with
$c = 1$ and
$\gamma = 3.0, 4.0,$ and
5.0, respectively.

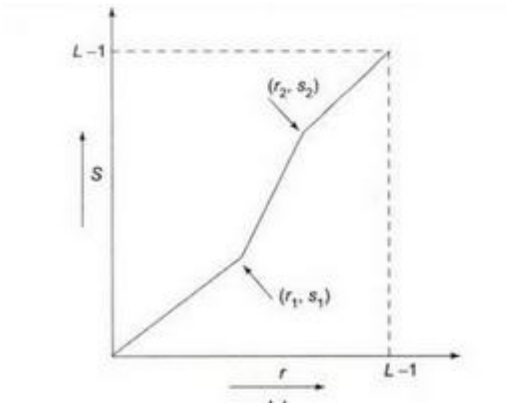
Piecewise Linear Transformation Function

- Contrast stretching and thresholding
- Grey level slicing
- Bit Plane Slicing

Contrast stretching and thresholding

- Low-contrast images can result from poor illumination, lack of dynamic range in the image sensor, or even wrong setting of a lens aperture during image acquisition.
- The idea behind contrast stretching is to increase the dynamic range of the gray levels in the image by making the dark portion darker and the bright portions brighter.

- The location of the points (r1 , s1) and (r2 ,s2) controls the shape of the transformation function. if r1=r2 and s1=0 and s2=l-1, the transformation becomes the thresholding function and creates the binary image.



Low cost Image

Threshold Image
Threshold values of
R,G,B= 127 ,127 ,127

Image after contrast stretching

EXAMPLE

- Calculate the threshold image .

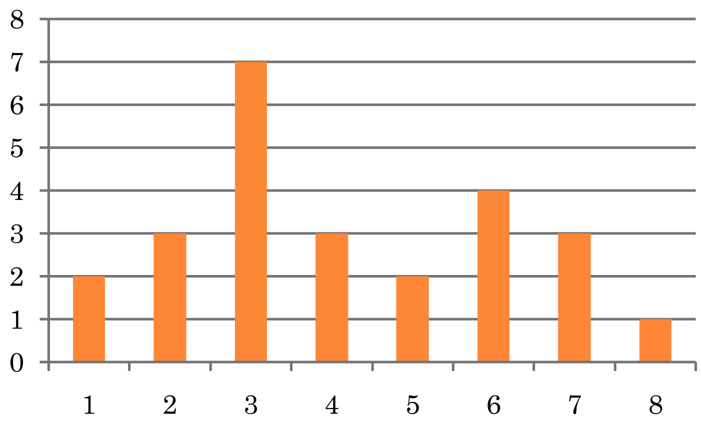
1	2	3	1	6
5	2	4	5	2
4	6	0	7	0
2	3	6	5	1
5	2	3	2	2

EXAMPLE

- Calculate the threshold image .

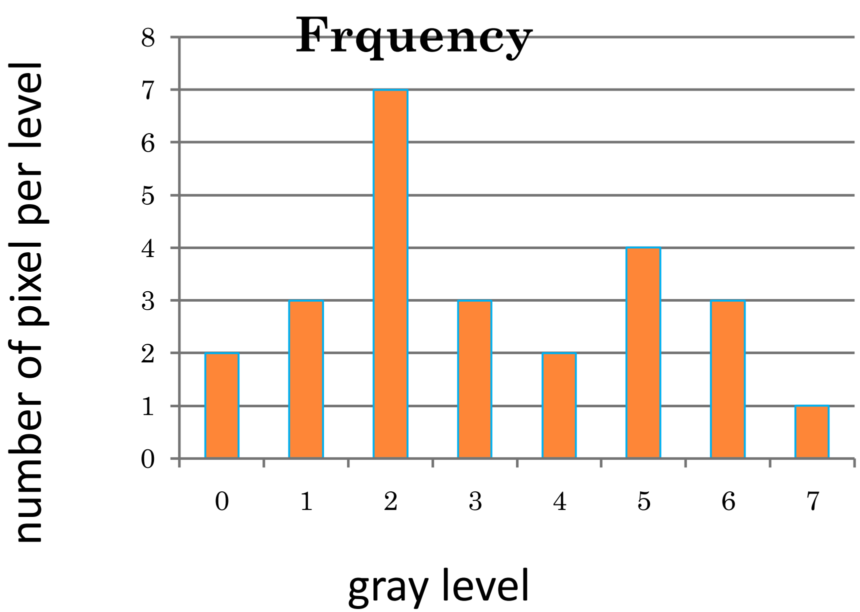
1	2	3	1	6
5	2	4	5	2
4	6	0	7	0
2	3	6	5	1
5	2	3	2	2

gray level	number of pixel per level
0	2
1	3
2	7
3	3
4	2
5	4
6	3
7	1



Answer:

gray level	number of pixel per level
0	2
1	3
2	7
3	3
4	2
5	4
6	3
7	1



From the histogram of image , largest two values are occur at gray level 2 and 5 and minimum between these two values occur at gray kevel 4. there fore threshold value will be at T=4

$f_{new}(x,y) = 0 \quad \text{if } f_{old}(x,y) <= 4$

$f_{new}(x,y) = L-1 \quad \text{if } f_{old}(x,y) > 4$

This transformation makes all gray level less than or equal to 4 will be black (0)

And >4 will be white(7).

0	0	0	0	7
7	0	0	7	0
0	7	0	7	0
0	0	7	7	0
7	0	0	0	0

Gray-level slicing

Highlighting a specific range of gray levels in an image

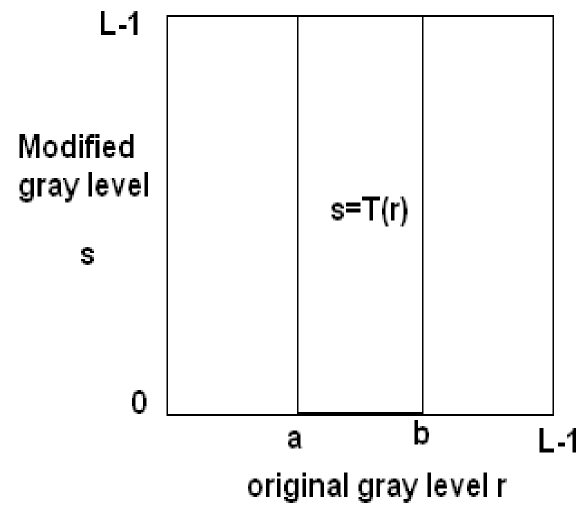
Applications include enhancing flaws in x-ray image.

This technique is having two approaches:

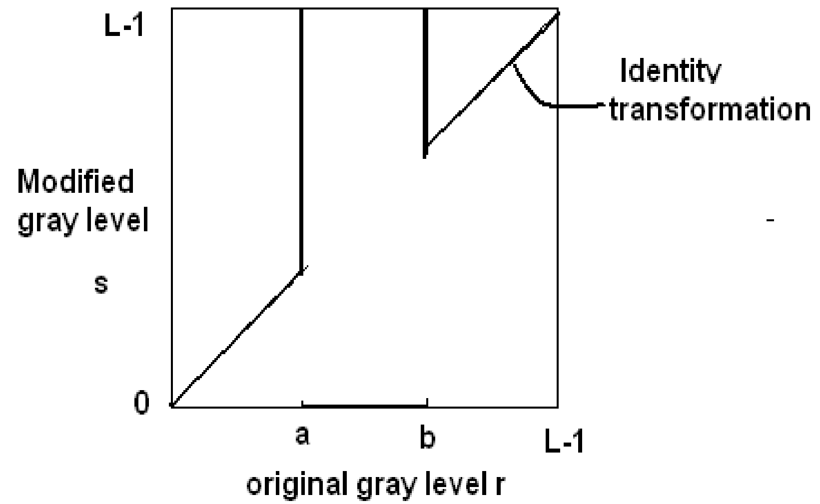
1. Gray level slicing without background

2. Gray level slicing with background

1. **Gray level slicing without background:** All the gray levels in the range of requirement are displayed using a high value and all other gray level values are displayed using low values. That is we completely loss the background.
2. **Gray level slicing with background:** we only enhance the band of gray levels along with background.



Slicing without background

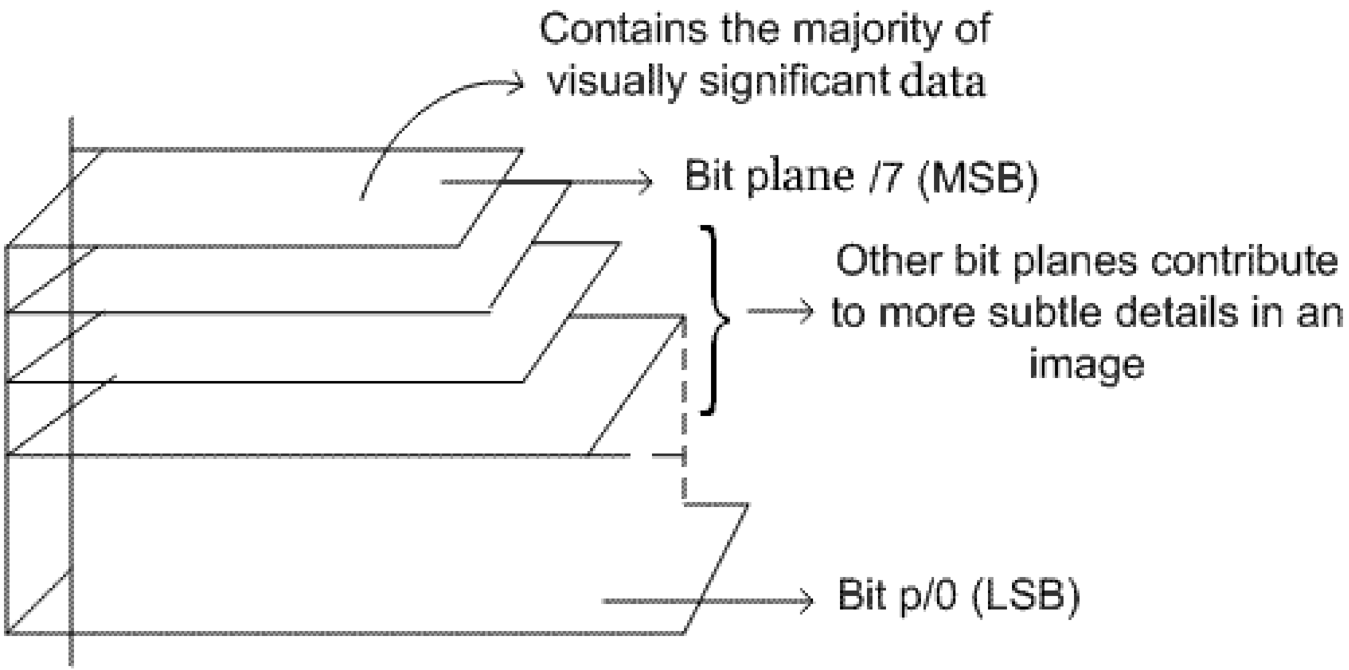


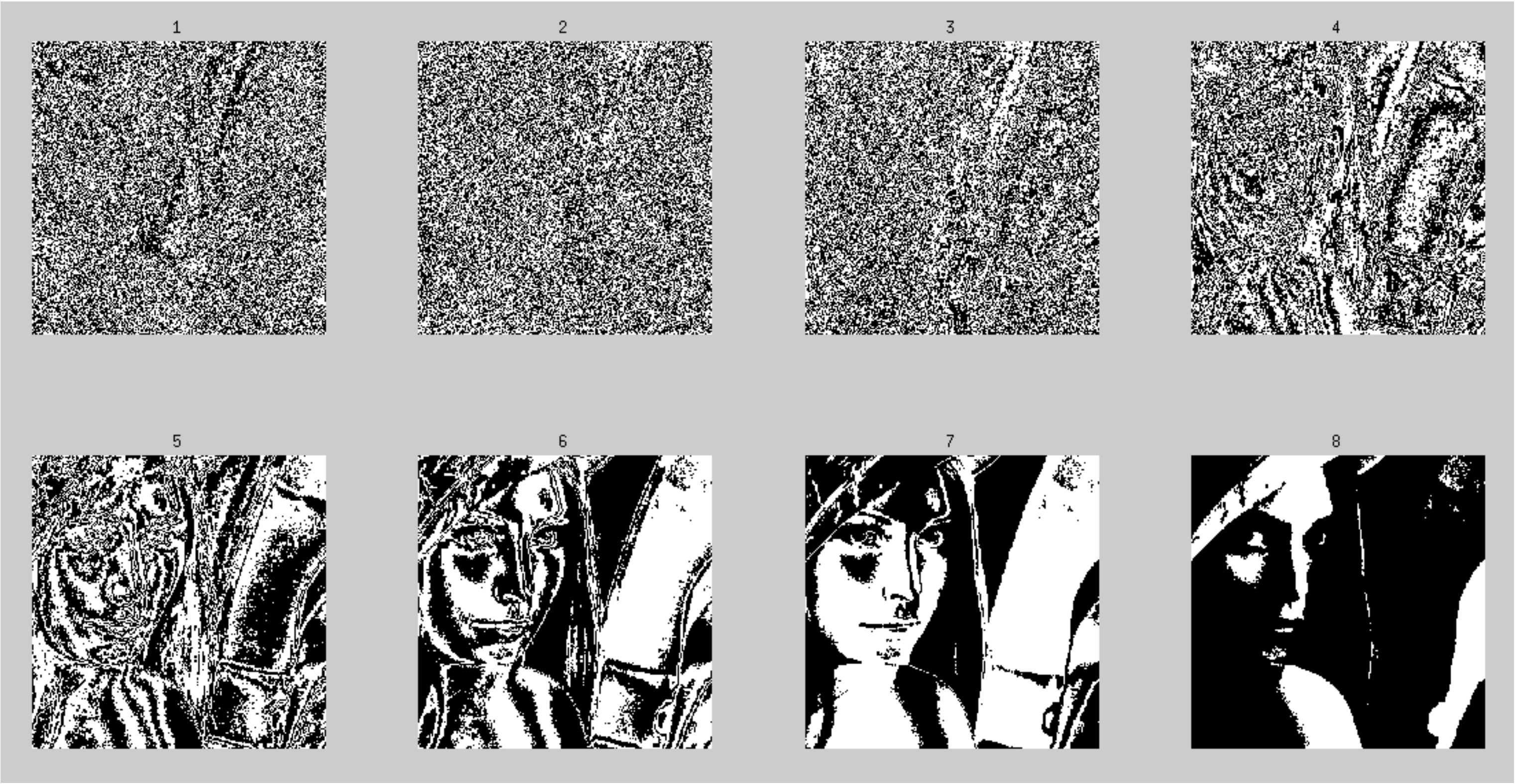
Slicing with background

Bit Plane Slicing:

Q. EXPALIN IN BRIEF PROCESS OF BIT PLANE SLICING

- In which we can find out contribution made by each bit to final image.
- Each pixel will be represented by 8 bits.
- Black is represented with 00000000
- White will be 11111111
- Consider the LSB value of each pixel and draw the image.
- Continue doing this for each bit till we come to MSB .we will get 8 different images


Contains the majority of visually significant data
Bit plane /7 (MSB)
Other bit planes contribute to more subtle details in an image
Bit p/0 (LSB)


1
2
3
4
5
6
7
8

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

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

MSB plane

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

Centre bit 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

LSB plane

Image Subtraction

- It takes two images as input and produce difference between two image pixel values as a output.
- This method is used for background removal and illumination equalization.
- Function : $Z(x,y) = f(x,y) - g(x,y)$

0	1	2
5	6	4
3	4	7

Original Image

0	1	1
4	5	3
1	1	6

Blur Image

0	0	1
1	1	1
2	3	1

Subtracted Image

Blurred (Unsharp) Mask Subtraction
Original
Enhanced
Visibility of Detail
Digital
Subtraction
(Original - Mask)
=
Blurring
by
Digital Processing
Blurred Mask Image

IMAGE AVERAGING

- It average multiple image to create a stable image
- It is used to eliminate pixel vibration or high frequency image changes.
- The noisy image Z(x,y) is obtained by adding some noise term $\eta(x,y)$to the original image f(x,y).
- Function: $z(x,y)=f(x,y)+ \eta(x,y)$.
- The noisy term can be taken randomly , hence average value of noisy result in zero value. So averaging technique is used to remove noise from image.

- Let us assume that there are m number of noisy images available and it is denoted as,

$$\overline{Z}(x,y) = \frac{1}{M}\sum_{i=1}^{M} Z_i(x,y)$$

- As M increases, the variability of the pixel values at each location decreases.

QUESTION:

- Consider a 3 bit image

$$\begin{pmatrix} 5 & 3 & 6 \\ 0 & 7 & 4 \\ 6 & 5 & 1 \end{pmatrix}$$

what will be the output image of this after performing following operations,

Image negative transformation

Threshold T=4

Intensity level slicing with background a=3 and b=5

Question:

- For the following 4 bit image perform following transformation

$$\begin{pmatrix} 2 & 13 & 4 \\ 15 & 6 & 12 \\ 0 & 9 & 3 \end{pmatrix}$$

Image negative transformation

Threshold T=8

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

HISTOGRAM

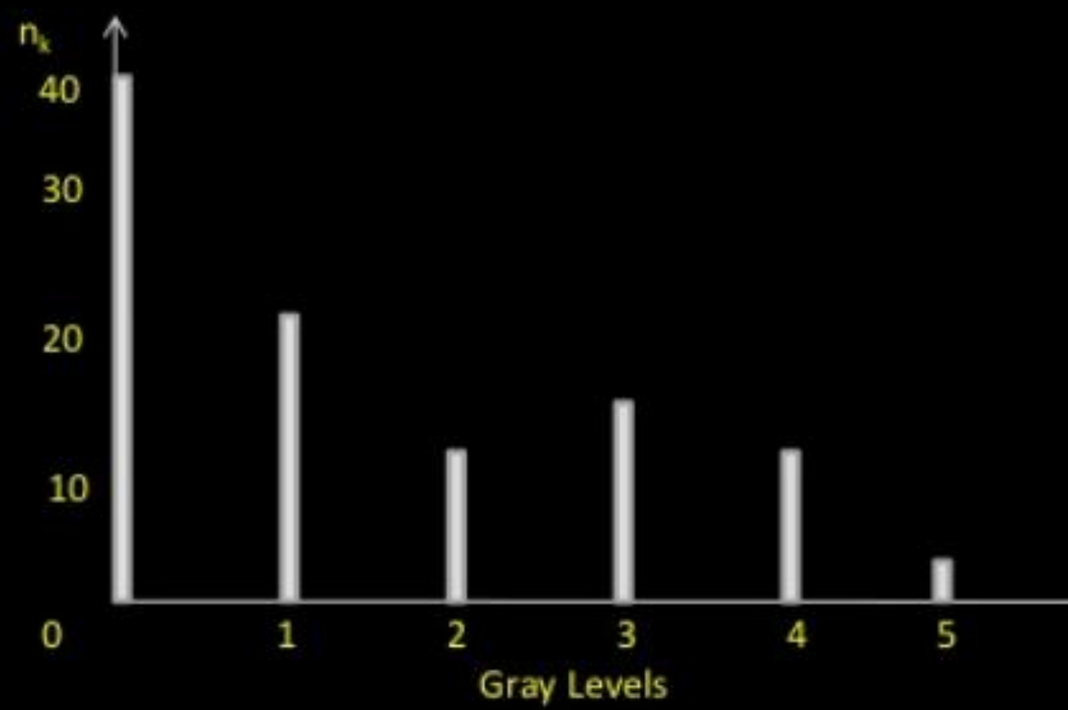
Image Histogram:

- Histogram of image provide a global description of the appearance of the image.
- Histogram can be plotted in two ways.

HISTOGRAM : METHOD 1

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

Gray Level	No. of Pixels (n_k)
0	40
1	20
2	10
3	15
4	10
5	3
6	2



HISTOGRAM : METHOD 2

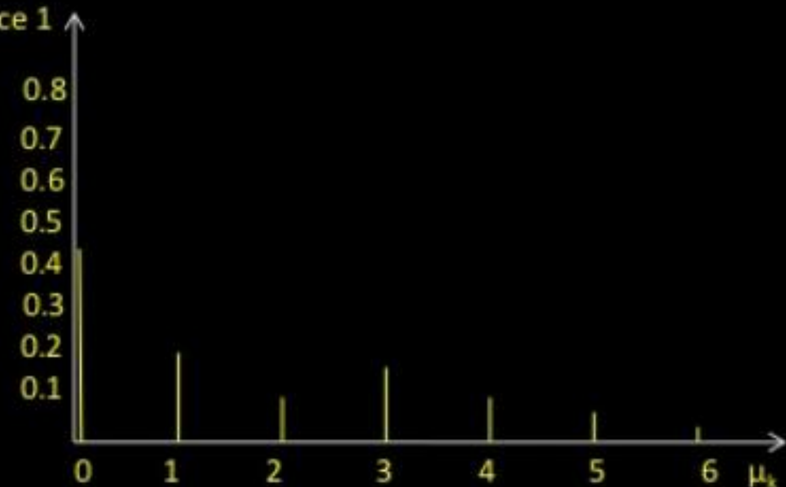
- x axis contain gray levels and y axis represents the probability of occurrences of that gray level.

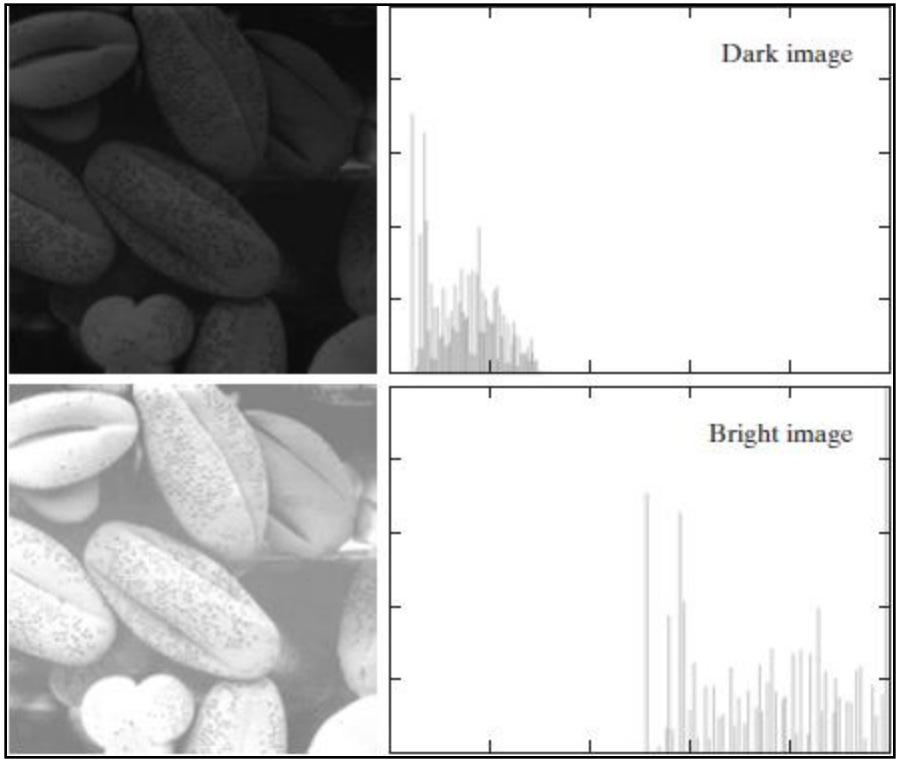
$P(\mu_k) = n_k / n$; where, μ_k – gray level

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)	$P(\mu_k)$
0	40	0.4
1	20	0.2
2	10	0.1
3	15	0.15
4	10	0.1
5	3	0.03
6	2	0.02
	n = 100	1





Dark image
Bright image

Image Equalization:

- Perfect image is one which has equal number of pixels in all its gray level s.
- The technique used to have equal pixel in all gray level is known as histogram equalization.
- It is used t obtained uniform histogram for the output image .

Image 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, $0 \le r \le 1$.

(ii) $$0 \le T(r) \le 1 \quad \text{for} \quad 0 \le r \le 1$$
$$0 \le S \le 1 \quad \text{for} \quad 0 \le r \le 1$$

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
- Second condition guarantees a mapping that is consistent with given range of pixel values.

- Since, the Transformation is single value & monotonically increasing, the inverse Transformation exists.

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

- 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 the transferred gray level is

$$P_s(S) = [P_r(r).\, dr/\, ds]_{\, r = T^{-1}(S)} \qquad \text{----(a)}$$

$$S = T(r)$$

$$S = \int_0^r Pr(r)\,dr \quad ; \quad 0 \le r \le 1$$

diff. wrt. r

$$ds / dr = Pr(r) \qquad \text{---------(b)}$$

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

$$Ps(s) = [1] \; ; \; 0 \le S \le 1$$

i.e. $Ps(s) = 1$

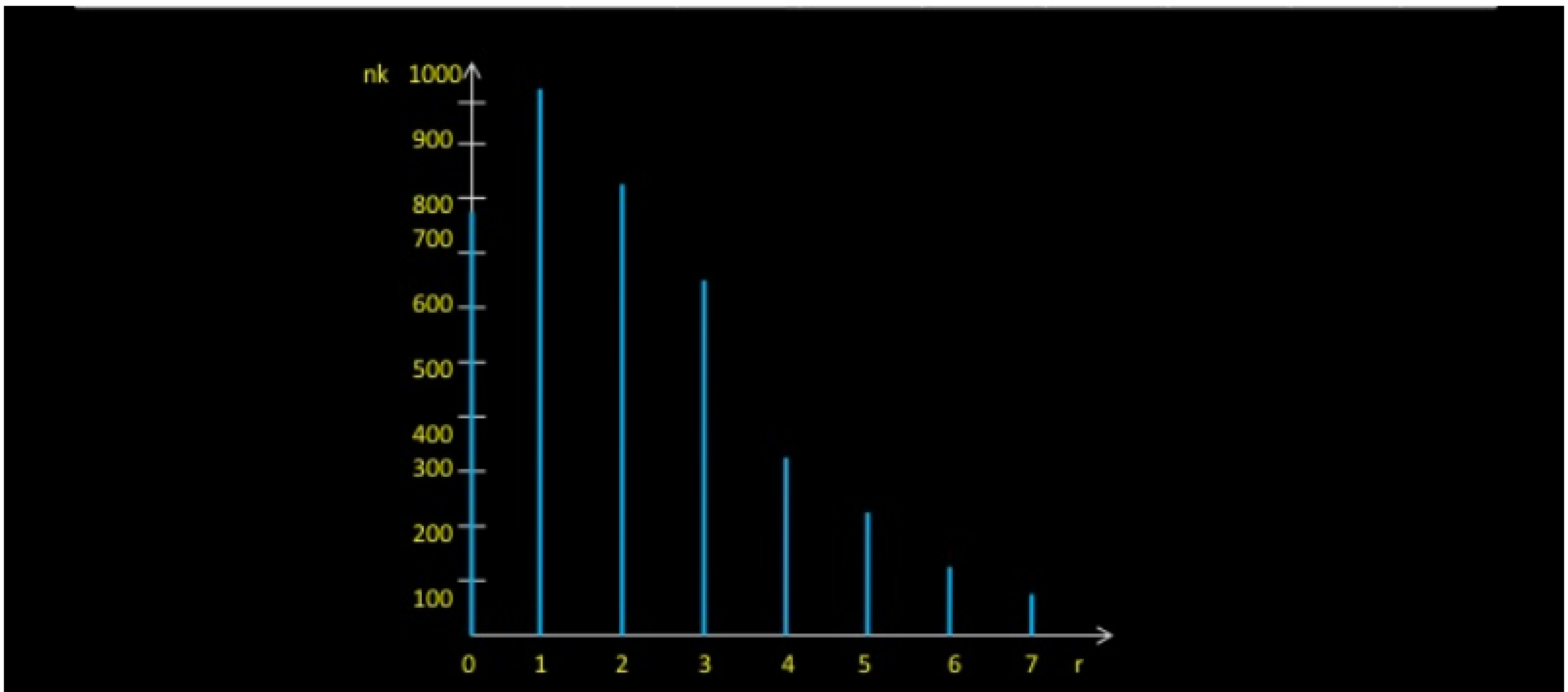
Histogram Equalization

Prob. 1) Equalize the given histogram

Gray Levels (r)	0	1	2	3	4	5	6	7
No. of Pixels	790	1023	850	656	329	245	122	81

l= 8 = number of gray levels

Original histogram is,



- Remember that take rounded value of pr
- sk should always end with 1

Gray Levels (r_k)	No. of Pixels n_k	(PDF) Pr(rk) = nk/n	(CDF) Sk =∑ Pk(rk)	(L-1) Sk = 7 x Sk	Rounding off
0	790	0.19	0.19	1.33	1
1	1023	0.25	0.44	3.08	3
2	850	0.21	0.65	4.55	5
3	656	0.16	0.81	5.67	6
4	329	0.08	0.89	6.23	6
5	245	0.06	0.95	6.65	7
6	122	0.03	0.98	6.86	7
7	81	0.02	1	7	7
	n = 4096	1			

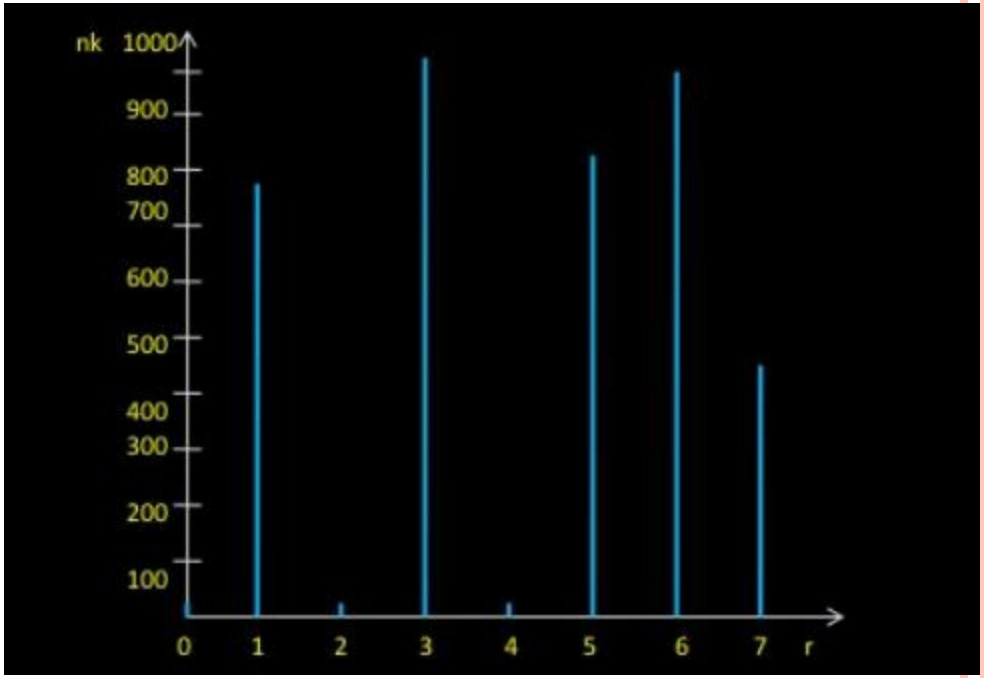
- Take 1st 2nd and last column

Gray Levels (r_k)	No. of Pixels n_k	Rounding off
0	790	1
1	1023	3
2	850	5
3	656	6
4	329	6
5	245	7
6	122	7
7	81	7
	n = 4096	

New gray levels have pixels only at 1,3,5,6,7 . There are no pixel in gray levels 0 , 2 and 4.

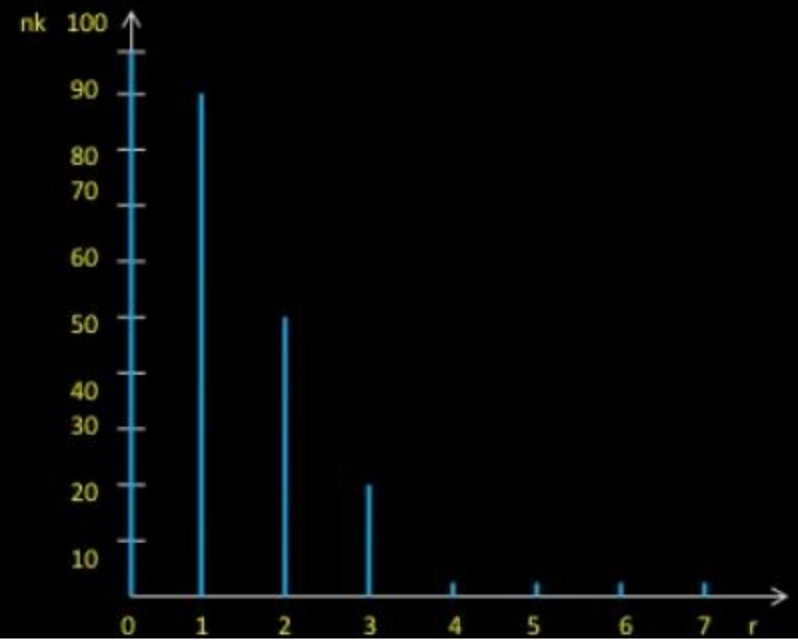
Equalized gray levels are,

Equalized gray level	Number of pixels
0	0
1	790
2	0
3	1023
4	0
5	850
6	656+329=985
7	245+122+81=448



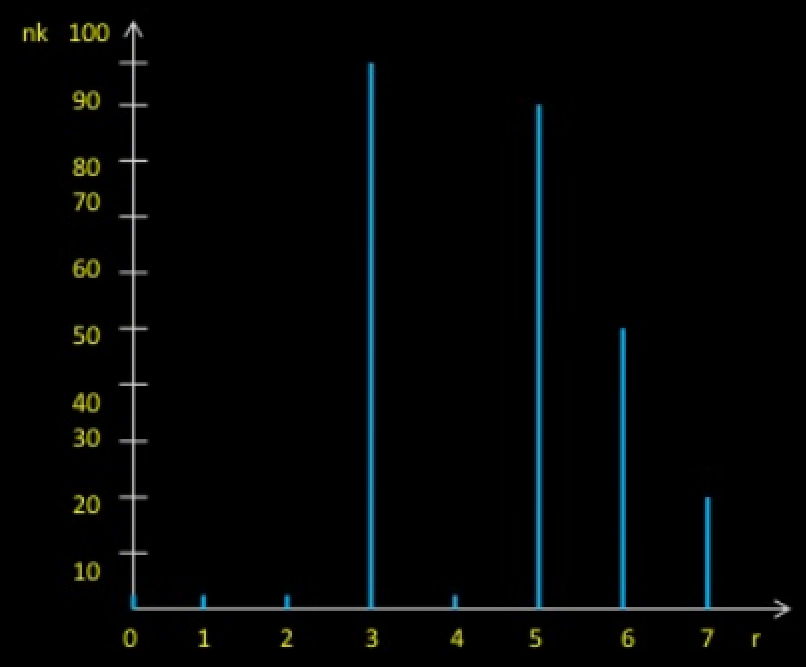
Prob. 2) Equalize the given histogram

Gray Levels (r)	0	1	2	3	4	5	6	7
No. of Pixels	100	90	50	20	0	0	0	0



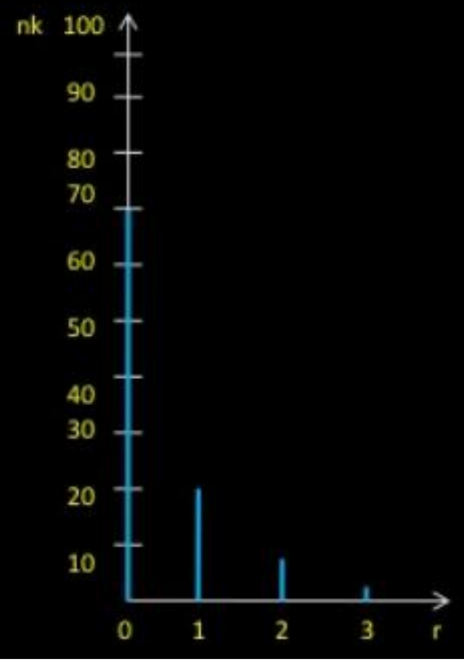
Prob. 3) Equalize the above histogram twice.

Gray Levels (r)	0	1	2	3	4	5	6	7
No. of Pixels	0	0	0	100	0	90	50	20



Prob. 3) Equalize the above histogram twice.

Gray Levels (r)	0	1	2	3
No. of Pixels	70	20	7	3



- Solution:

L=4 i.e.l-1=3

greylevel	nk	Nk/n	sk	Sk(l-1) =3*sk	Rounding off
0	70	0.7	0.7	2.1	2
1	20	0.2	0.9	2.7	3
2	7	0.07	0.97	2.91	3
3	3	0.03	1.00	3.00	3
	N=100	1.00			

- Solution:

L=4 i.e.l-1=3

greylevel	nk	Rounding off
0	70	2
1	20	3
2	7	3
3	3	3

greylevel	nk
0	0
1	0
2	70
3	20+7+3 =30