Unit 2: - Image Transformation & filtering. ①

Spatial domain → Plane containing the pixels of an image. (Image plane itself)

Generally, spatial domain techniques are more efficient computationally and require less Processing resources to implement.

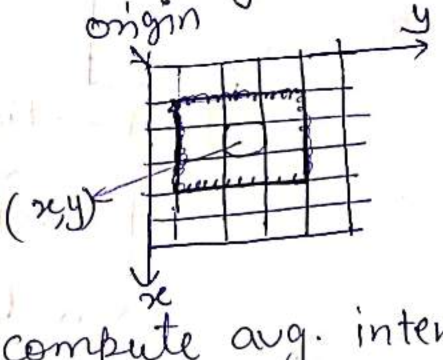
or

Image processing tasks are easier or more meaningful to implement in the spatial domain. (Manipulation of pixel values)

It's expressed as

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

$g(x,y)$ → Output image; $f(x,y)$ → input image; T → Transform func/operator over a neighborhood of point (x,y).



Two categories of spatial domain

(i) Intensity Transformation (modification of pixel value)

(ii) Spatial filtering (manipulation of pixel value using mask)

eg:- T – compute avg. intensity of neighbors
Let g(100, 150) → How you calculate?

if, we are taking about origin or corner in image, pad with 0 and calculate $g(x,y)$

↳ so this procedure is called spatial filtering with predefined operation, spatial filter (mask, kernel, template or window)

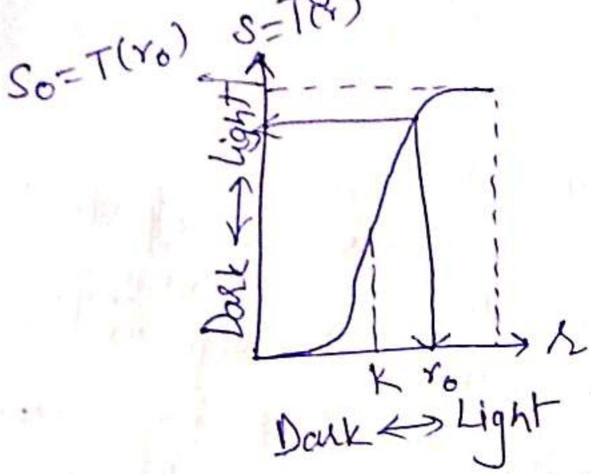
If neighbor window 1X1, then g & f at same point (x, y)

$$S = T(r)$$ or

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

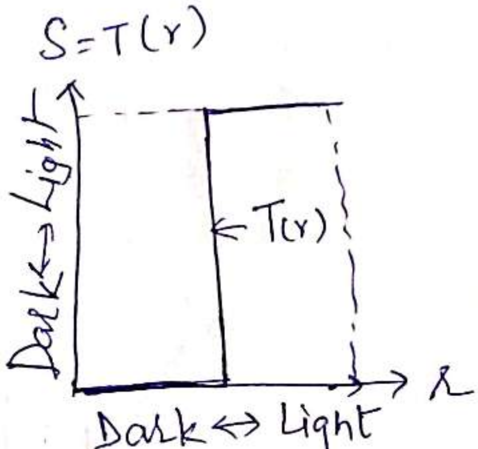
Here T is an intensity transformation func.
grey-level transformation func
mapping transformation func

S and r variables denote intensity of g and f at any point (x, y)



(1) Contrast Stretching

In this case below k the intensity value is darking and above k it's brightening.



(2) Thresholding func.

Give binary value using the threshold value.

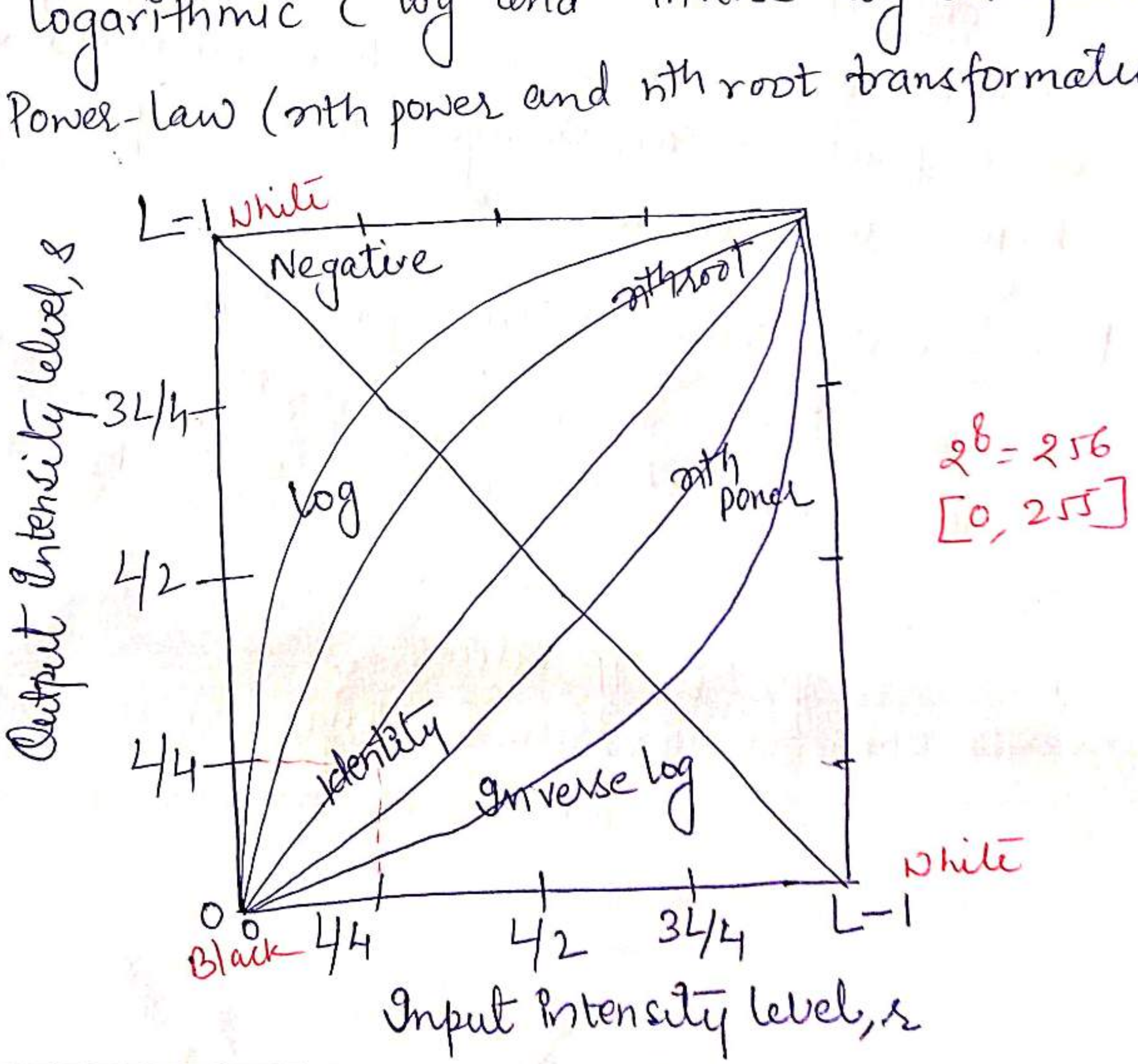
T is a transformation that maps a pixel value r into a pixel value s.

- Intensity transformation & spatial filtering are application to image enhancement.
- Enhancement is the process of manipulating an image so that the result is more suitable than the original for a specific application.

  eg:- enhancing x-ray image use different method than enhancing satellite images.

Three basic type of transformation used for image enhancement.

(1) linear (negative and identity transformation)
(2) logarithmic (log and inverse- log transformation)
(3) Power-law (nth power and nth root transformation)



(i) Image Negatives:-

The negative of an image with intensity levels in the range [0, L-1] can be expressed as

$$S = L-1-r$$

{identity means same as input value}
negative means inverse
Let $r=0$, $S=L-1$ } in graph
$r=L-1$, $S=0$
Black in white & White in Black

eg:- In X-ray.

(ii) Log Transformation:-

General form of log transformation

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

c is constant and $r \geq 0$

- It maps a narrow range of intensity values in input into a wider range of output levels.
- The opposite is true for high intensity input values.
- This transformation is used to expand the values of dark pixels in an image while compressing the higher-level values.

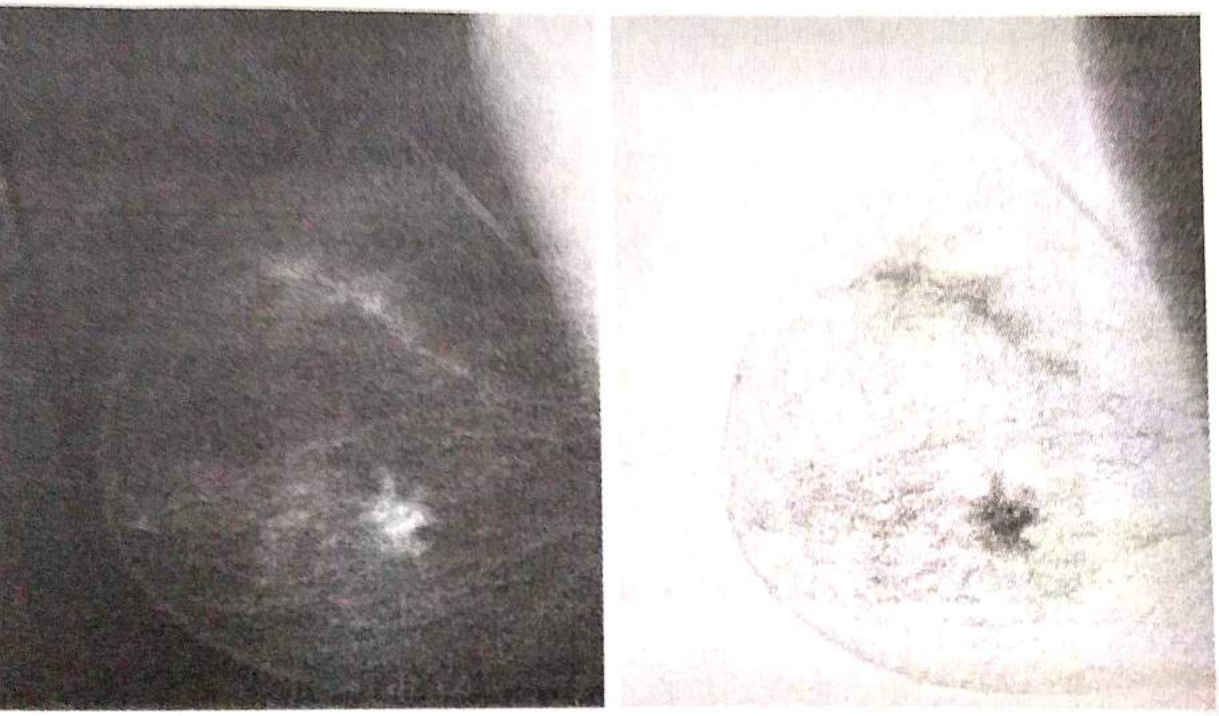
(iii) Power-Law (Gamma) Transformations:

Basic form $S = cr^{\gamma}$

where c and γ are positive constants

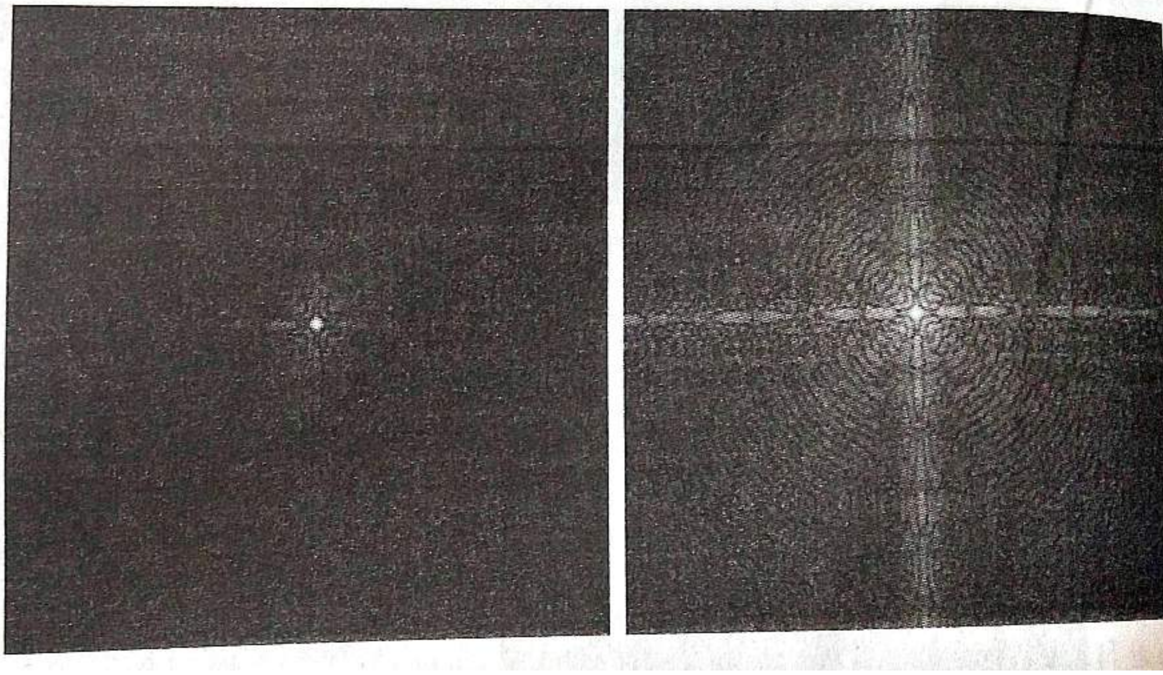
$\gamma > 1$ - nthpower
$\gamma < 1 \rightarrow$ nthroot

- It maps a narrow range of intensity values to a wider range of o/p values.
- The opposite is true for higher values of input levels exists a family of possible transformation curves by varying γ.



a b

FIGURE 3.4
(a) Original digital mammogram.
(b) Negative image obtained using the negative transformation in Eq. (3.2-1).
(Courtesy of G.E. Medical Systems.)



a b

FIGURE 3.5 (a) Fourier spectrum. (b) Result of applying the log transformation in Eq. (3.2-2) with $c = 1$.

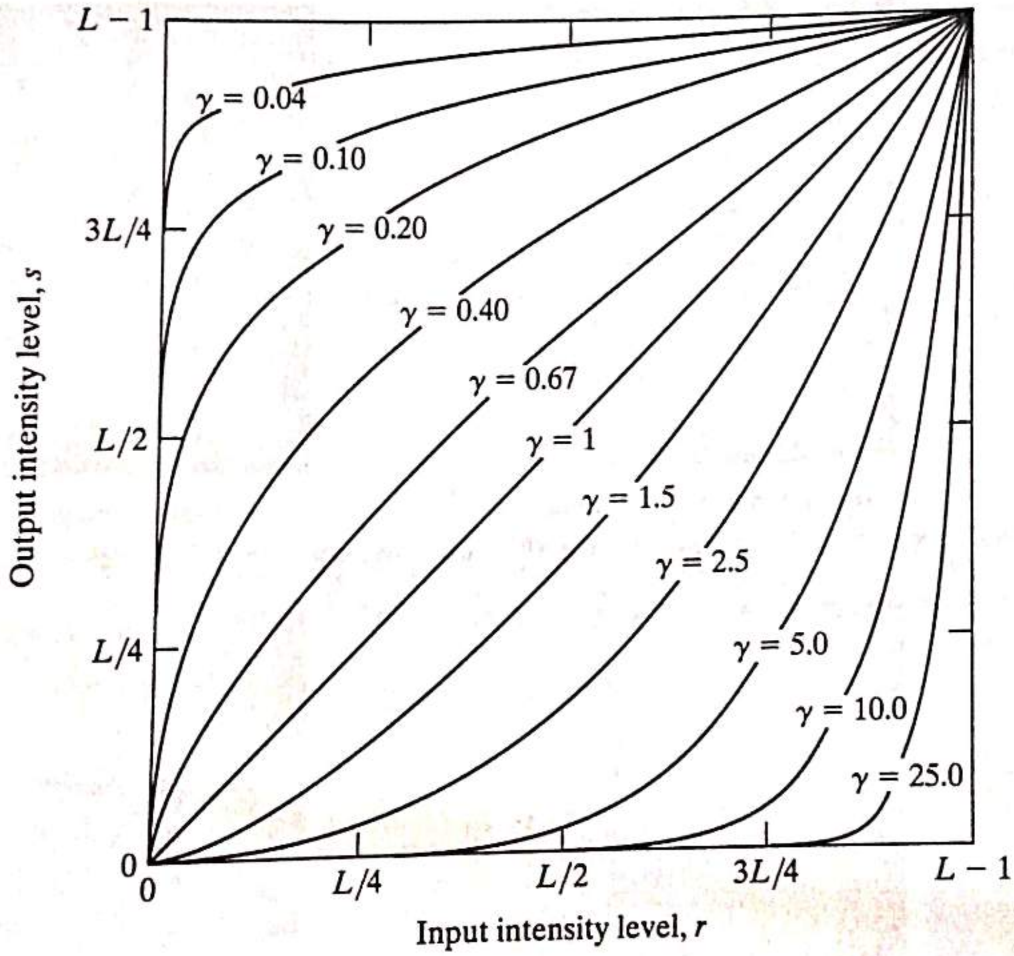


FIGURE 3.6 Plots of the equation $s = cr^{\gamma}$ for various values of γ ($c = 1$ in all cases). All curves were scaled to fit in the range shown.

- Many devices used for Image capture, display and printing respond according to a power law.
- Eg: CRT device have an intensity-to voltage response that is a power function (exponents typically range from 1.8 – 2.5). Gamma correction in this case could be achieved by applying the transformation

$S = r^{1/2.5} = r^{0.4}$

- The exponent in the power-law equation is referred to as gamma. The process of correcting for the power-law response is referred to as gamma correction.

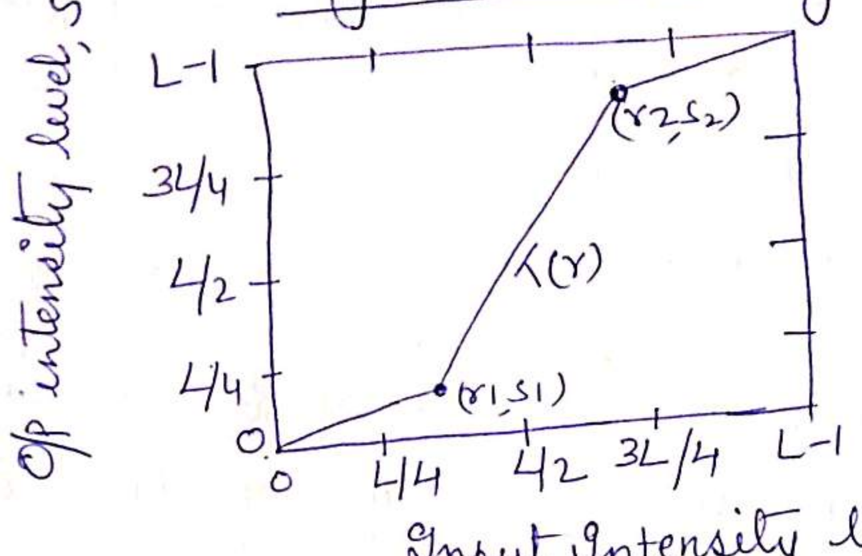
(iv) Piecewise-linear Transformation :-

- Complementary approach of transformation is piecewise linear func.
- Advantage of piecewise linear transformation is that they are arbitarily complex.
- Disadvantage of piecewise func is that their specification requires more user input.

(1) Contrast Stretching :-

- It is simplest piecewise linear func.
- low contrast images due to poor illumination, lack of dynamic range in imaging sensors or wrong setting of lens aperture.
- Contrast stretching expands the range of intensity level in an image so it spans the full intensity range of recording medium or display device.

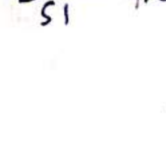
fig. Contrast stretching.



contrast stretching
- make dark portion more darker &
- bright portion more brighter

- The location of points (r_1, s_1) and (r_2, s_2) control the shape of the transformation fun^c.
- If $r_1 = s_1$ and $r_2 = s_2$, the transformation is a linear fun^c that produces no changes in intensity level.

- If $r_1 = r_2$, $s_1 = 0$ and $s_2 = L-1$, the transformat becomes a thresholding fun^c → create binary image.



- In below figure u can see the contrast stretching, obtained by setting

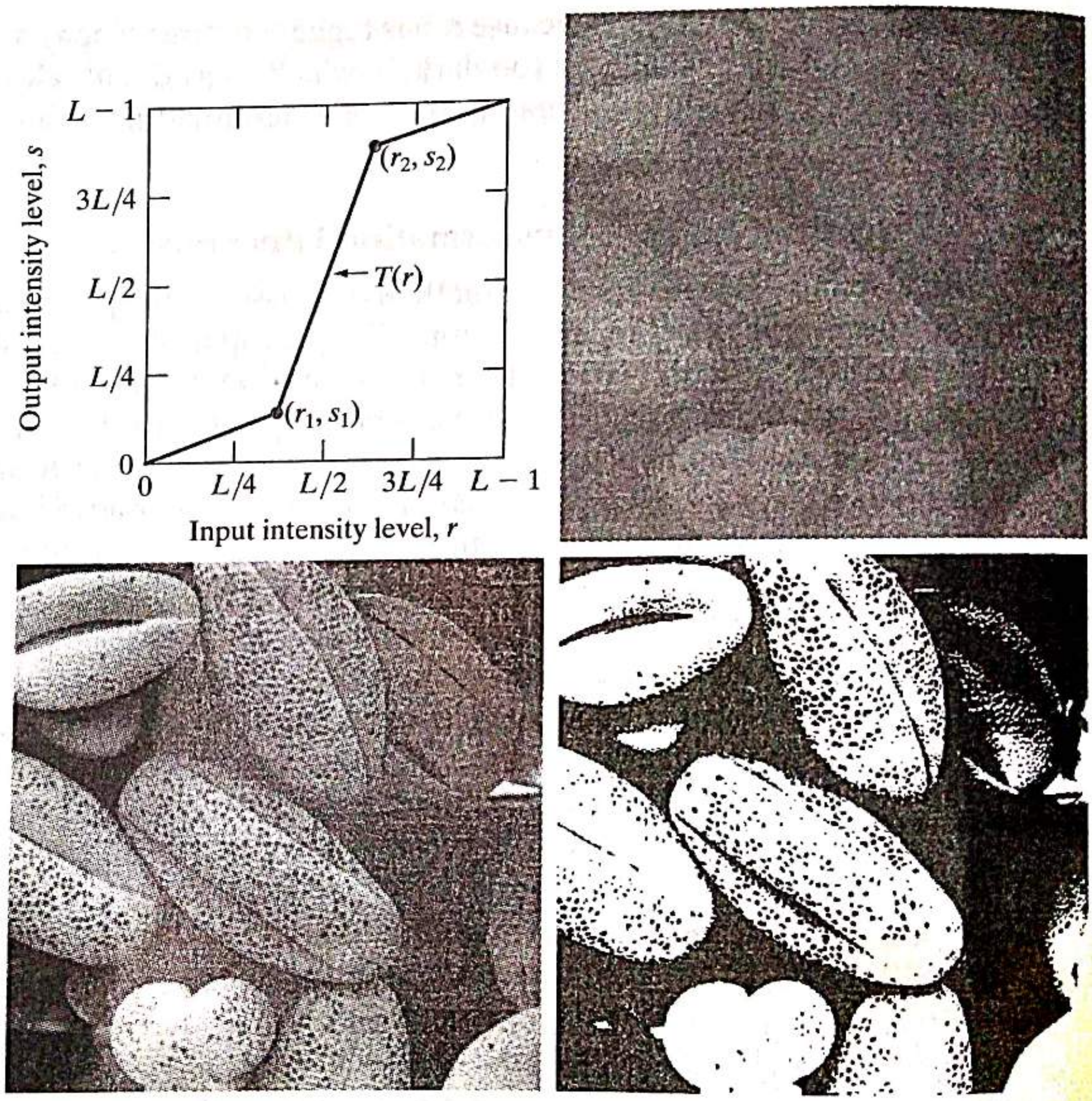
$(r_1, s_1) = (r_{min}, 0)$ &

$(r_2, s_2) = (r_{max}, L-1)$

where r_{min} & r_{max} intensity level in the image respectively.

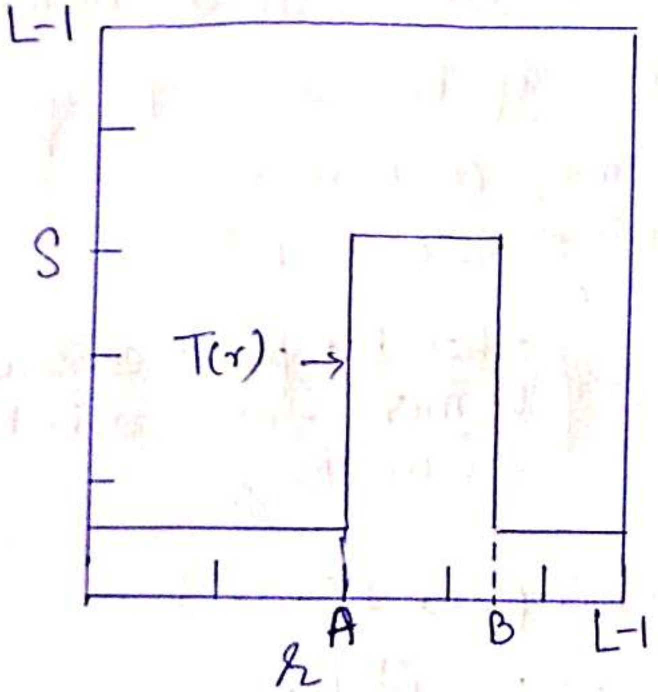
a b
c d

FIGURE 3.10 Contrast stretching. (a) Form of transformation function. (b) A low-contrast image. (c) Result of contrast stretching. (d) Result of thresholding. (Original image courtesy of Dr. Roger Heady, Research School of Biological Sciences, Australian National University, Canberra, Australia.)

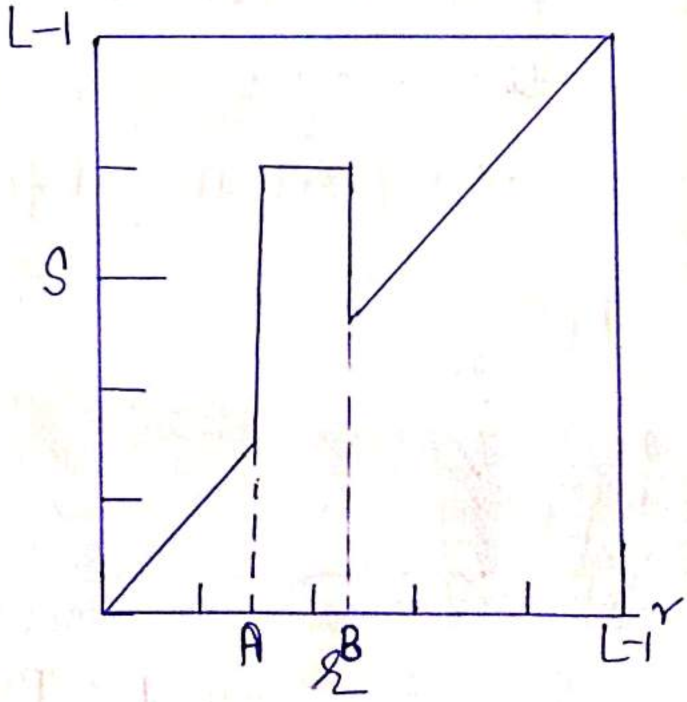


(2) Intensity-level slicing:-

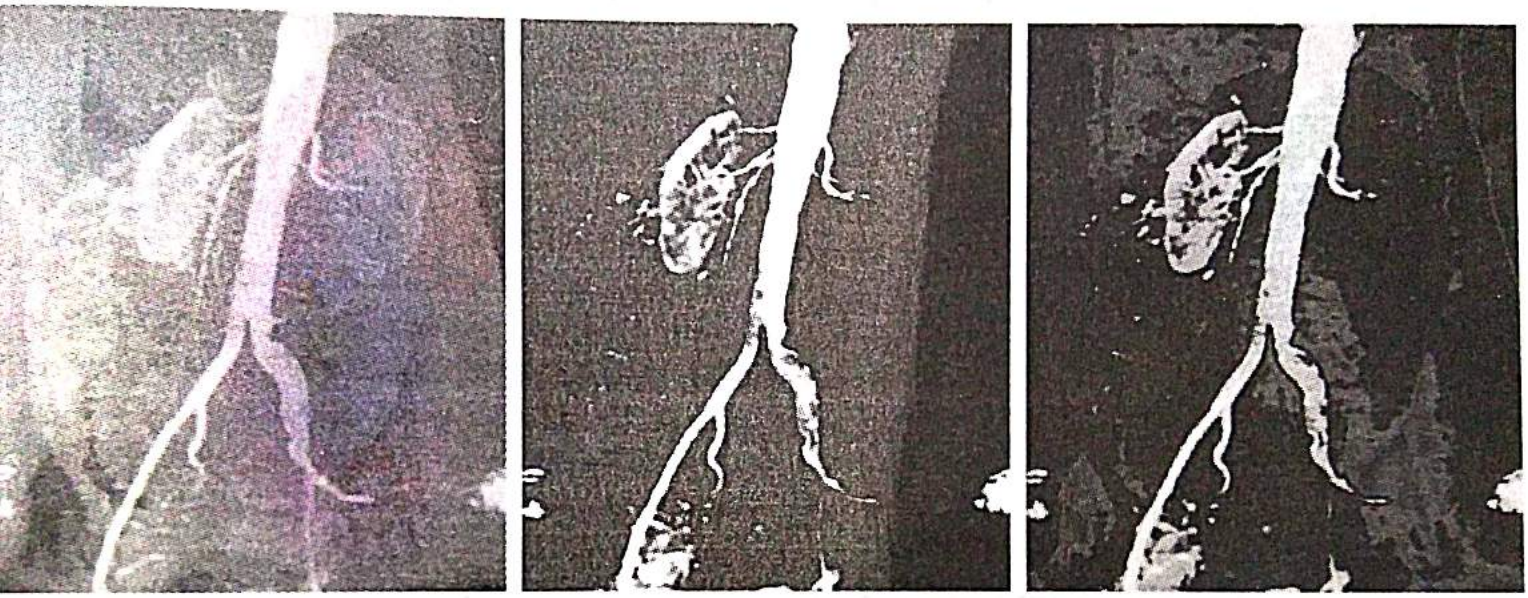
- Highlighting a specific range of intensity in an image often is of interest.
- Intensity-level slicing can be implemented several ways, but two common approches are used.
  - (i) Set all pixels values within a range of intersest to one value (white) and all others to another value (black). - Produces a binary image
  - (ii) Second approach is based on transformation, Brighten (darkens) the desired range of intensities but leaves all other intensity levels in the image unchanged.



(i) highlights intensity range (A, B) reduce all other insenties



(ii) Highligths range (A, B) and presewe all other intensity levels.



a b c

IGURE 3.12 (a) Aortic angiogram. (b) Result of using a slicing transformation of the type illustrated in Fig. .11(a), with the range of intensities of interest selected in the upper end of the gray scale. (c) Result of sing the transformation in Fig. 3.11(b), with the selected area set to black, so that grays in the area of the lood vessels and kidneys were preserved. (Original image courtesy of Dr. Thomas R. Gest, University of Michigan Medical School.)

③ Bit-plane Slicing:-

Instead of highlighting gray level images, highlights the Contribution made to total image appearance by specific bits ~~stig~~ might be desired.

eg:- The intensity of each pixel in 256-grey level gray-scale image is composed of 8 bits and it is composed of eight 1-bit planes.

- Plane 1 contains lowest-order bit (LSB) from image.
- Plane 8 contains highest-order bits (MSB) from image.

- Separating a digital image into its bit planes is useful for analyzing the relative importance played by each bit of the image, It determines the adequacy of numbers of bits used to quantized each pixel, useful for image compression.

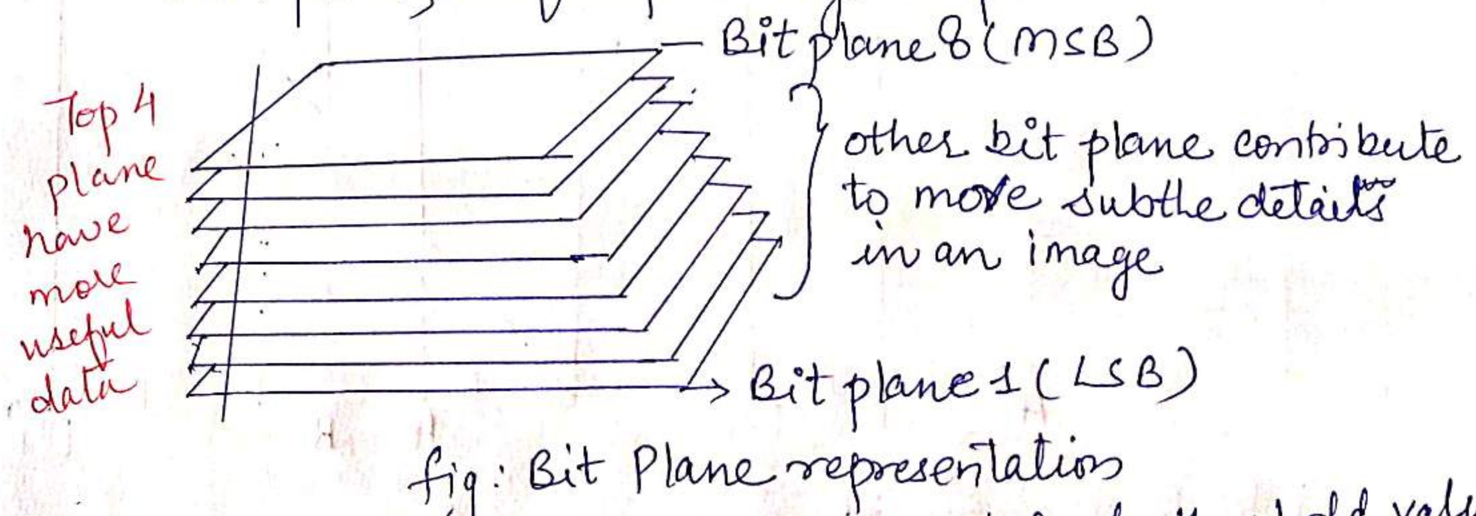
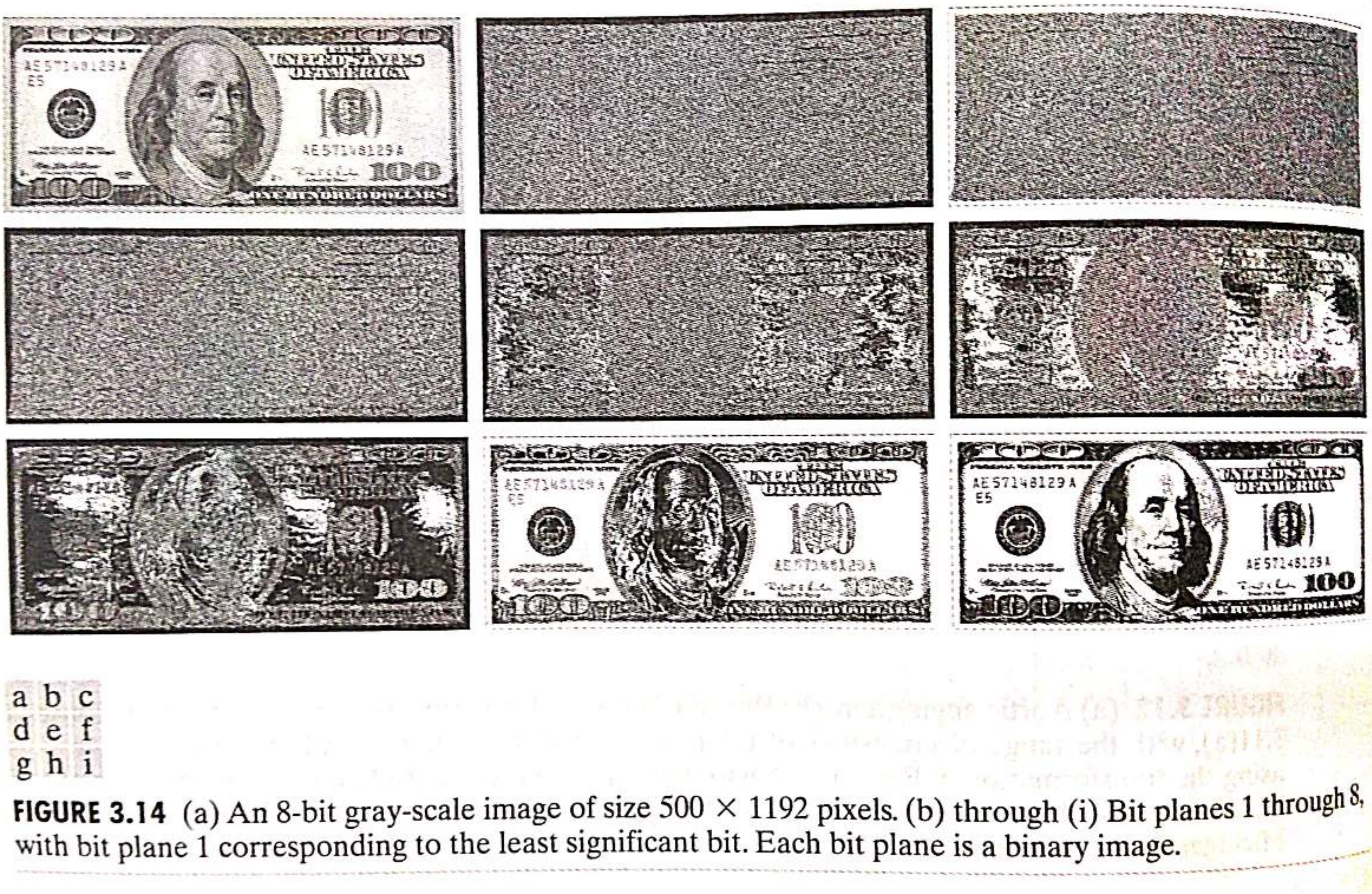


fig: Bit Plane representation

8-plane is obtained with the help of threshold value 128 - 255.

- used in image compression.



a b c
d e f
g h i

FIGURE 3.14 (a) An 8-bit gray-scale image of size 500 × 1192 pixels. (b) through (i) Bit planes 1 through 8, with bit plane 1 corresponding to the least significant bit. Each bit plane is a binary image.

a b c

FIGURE 3.15 Images reconstructed using (a) bit planes 8 and 7; (b) bit planes 8, 7, and 6; and (c) bit planes 8, 7, 6, and 5. Compare (c) with Fig. 3.14(a).