Digital Image Processing

Image Enhancement

by

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Background

- ❑ Very first step in Digital Image Processing.
- ❑ It is purely subjective.
- ❑ It is a cosmetic procedure.
- ❑ It improves subjective qualities of images.
- ❑ It has two domains:
  - ❑ Spatial domain
  - ❑ Frequency domain

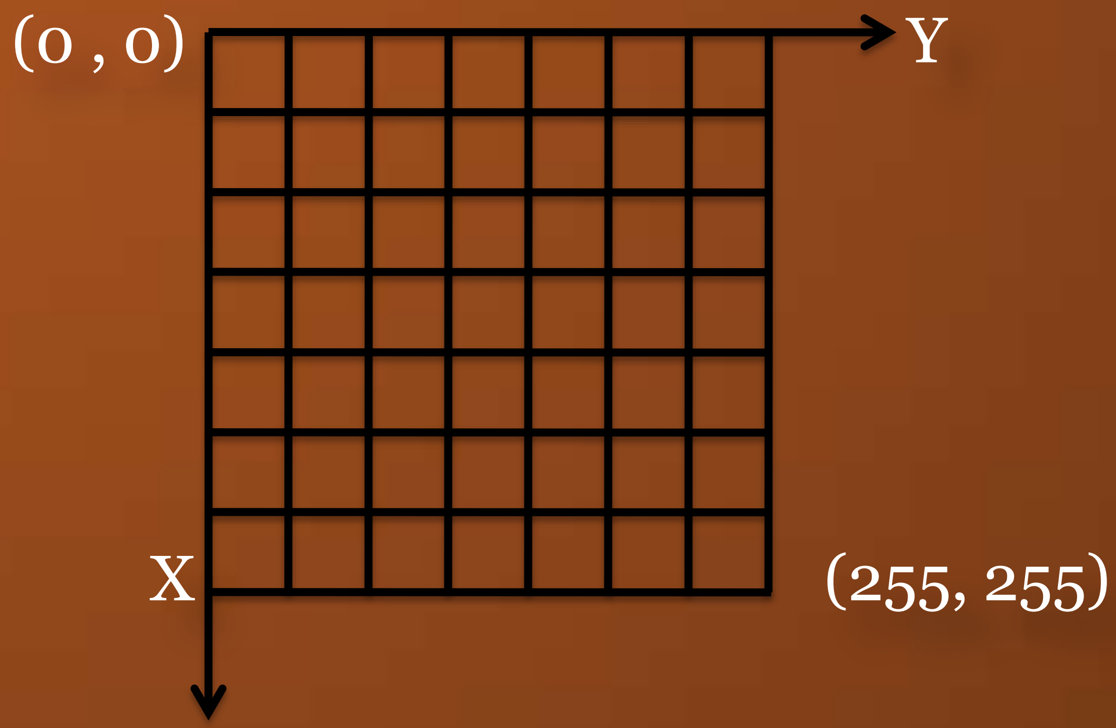
Spatial Domain

- Spatial means working in space i.e. (given image).
- It means working with pixel values or raw data.
- Let g(x, y) be original image
- where g is gray level values & (x, y) is co-ordinates
- For 8-bit image, g can take values from 0 – 255

  where 0 – BLACK ,
  255 – WHITE &
  others - shades of GRAY

Spatial Domain

- In an image with size 256 x 256, (x, y) can assume any value from (0 , 0) to (255 , 255).



Spatial Domain

- Applying transform modifies the image

$$f(x,y) = T\,g(x,y)$$

where,

g(x,y) is original image
T is transformation applied on g(x,y)
f(x,y) is new modified image

- In spatial domain techniques simply T changes.

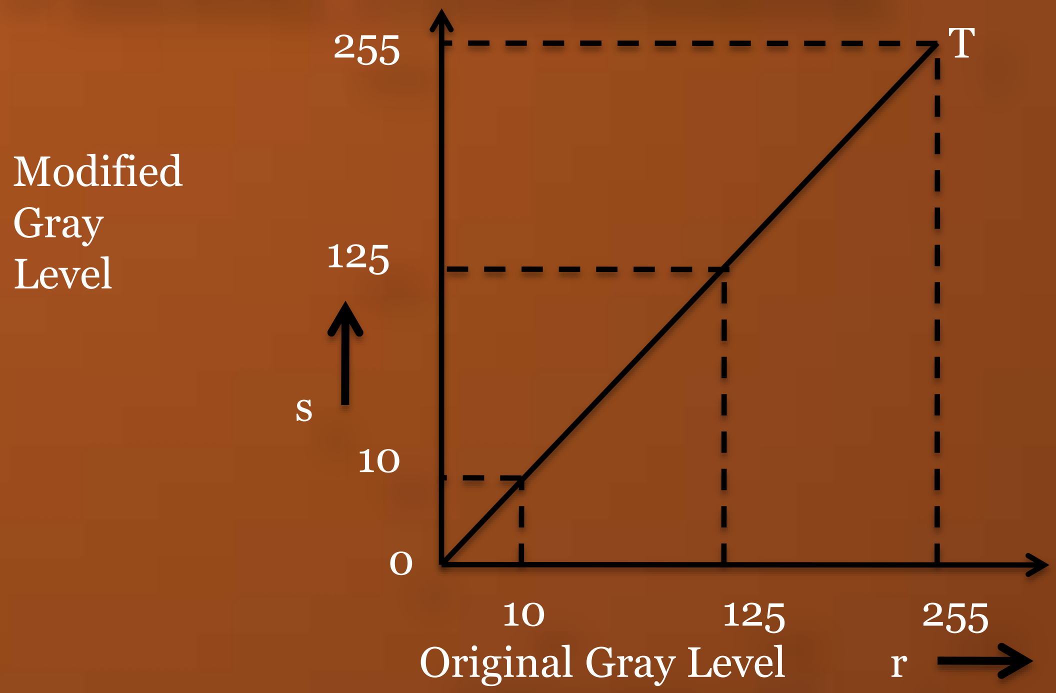
- Spatial domain enhancement is carried out in two ways:
  - Point processing
  - Neighborhood processing

Point Processing

- Here, we work on singe pixel i.e. T is 1 x 1 operator.
- New image depends on transform T and original image.
- Some important examples of point processing are:
    - Digital Negative
    - Contrast Stretching
    - Thresholding
    - Gray level slicing
    - Bit plane slicing
    - Dynamic range compression

Point Processing

❑ <u>Identity Transformation:</u>

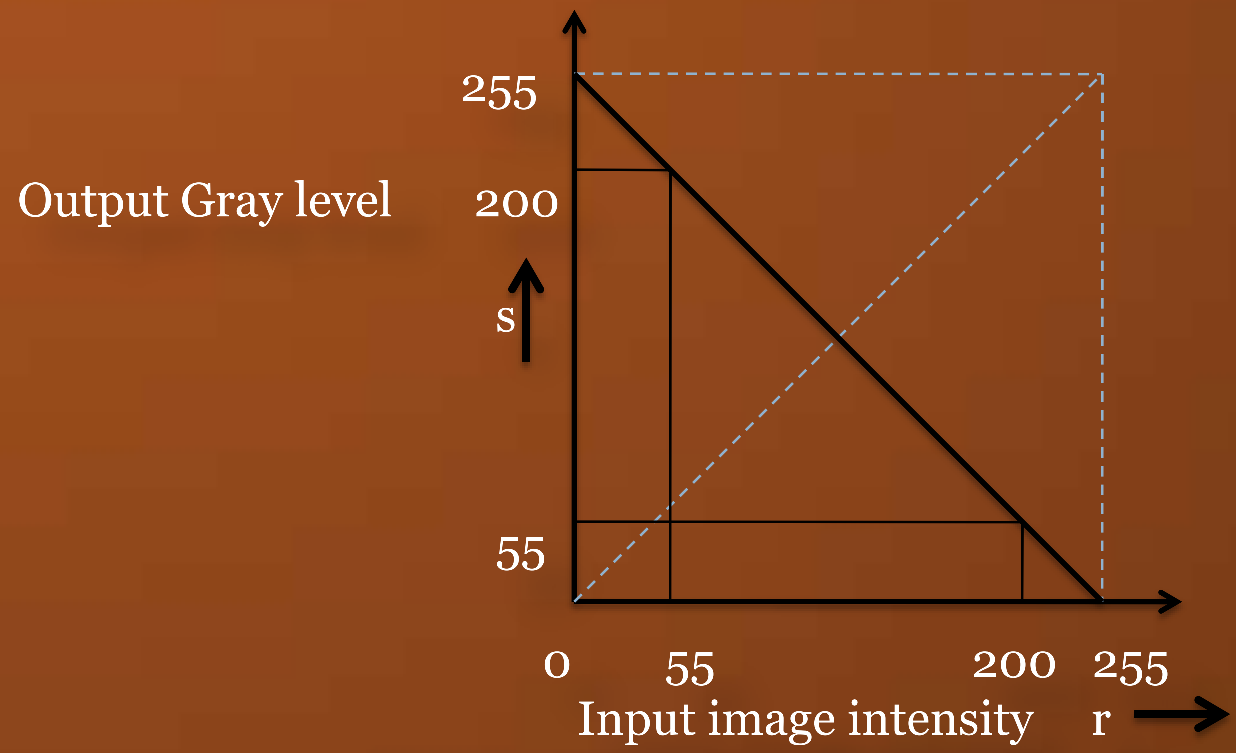


- It does not modify the input image at all.
- In general, $s = r$

Point Processing

1) Digital Image Negative:

- Useful in large applications e.g. X-ray images.
- Negative means inverting gray levels.



Point Processing

- Digital Negative can be obtained by:

$$s = 255 - r \qquad \text{(where, } r_{max} = 255\text{)}$$

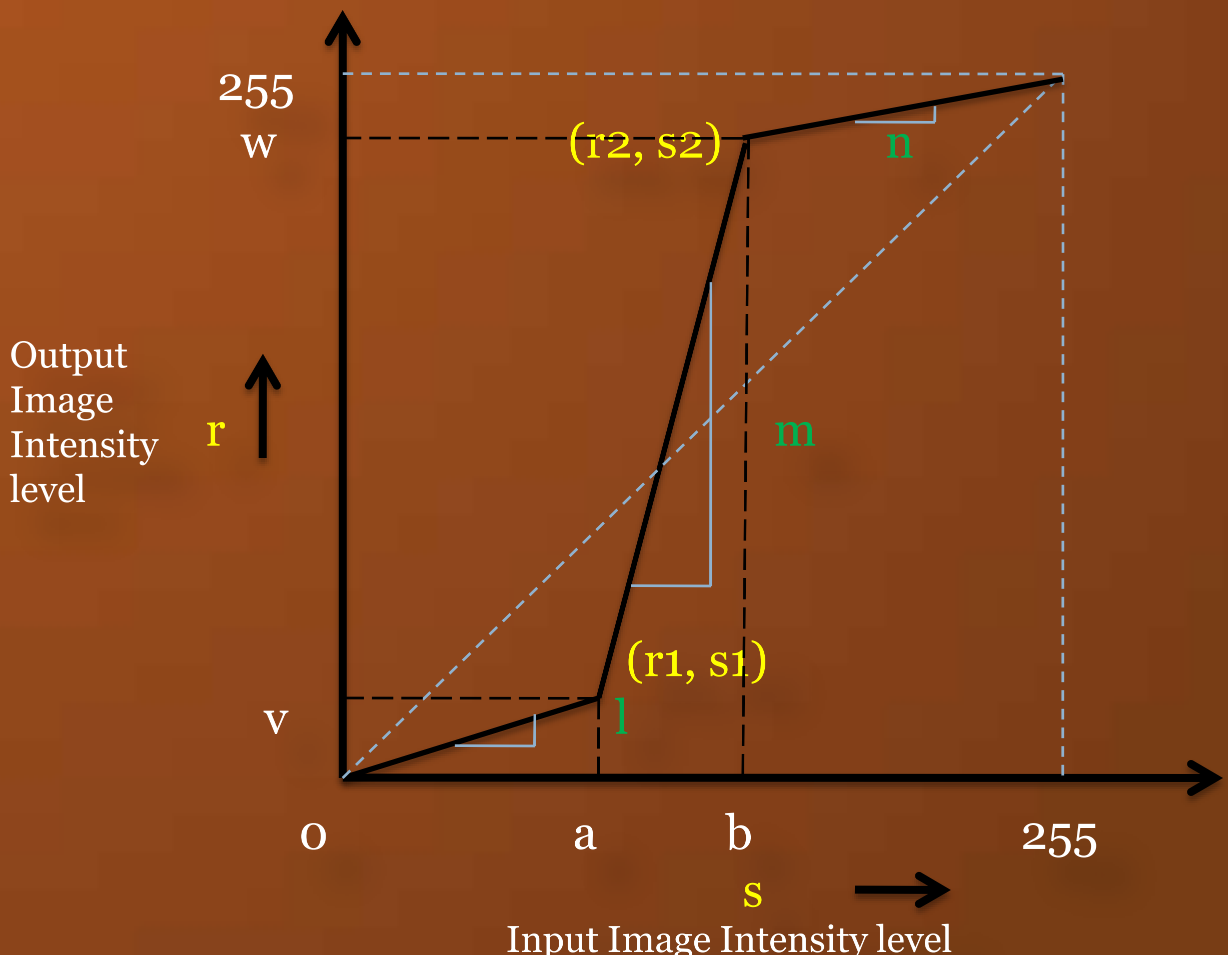
when, $r = 0$; $s = 255$
& if $r = 255$; $s = 0$

Generally, $$s = (L-1) - r$$

where, L – total number of gray levels (e.g. 256 for 8-bit image)

Point Processing

2) Contrast Stretching:



Point Processing

- Reasons:
  - Poor Illumination
  - Wrong setting of lens aperture

- Idea behind *Contrast Stretching* is to make dark portion darker and bright portion brighter.

- In above figure, dotted line indicated *Identity Transformation* & solid line indicates *Contrast Stretching*.

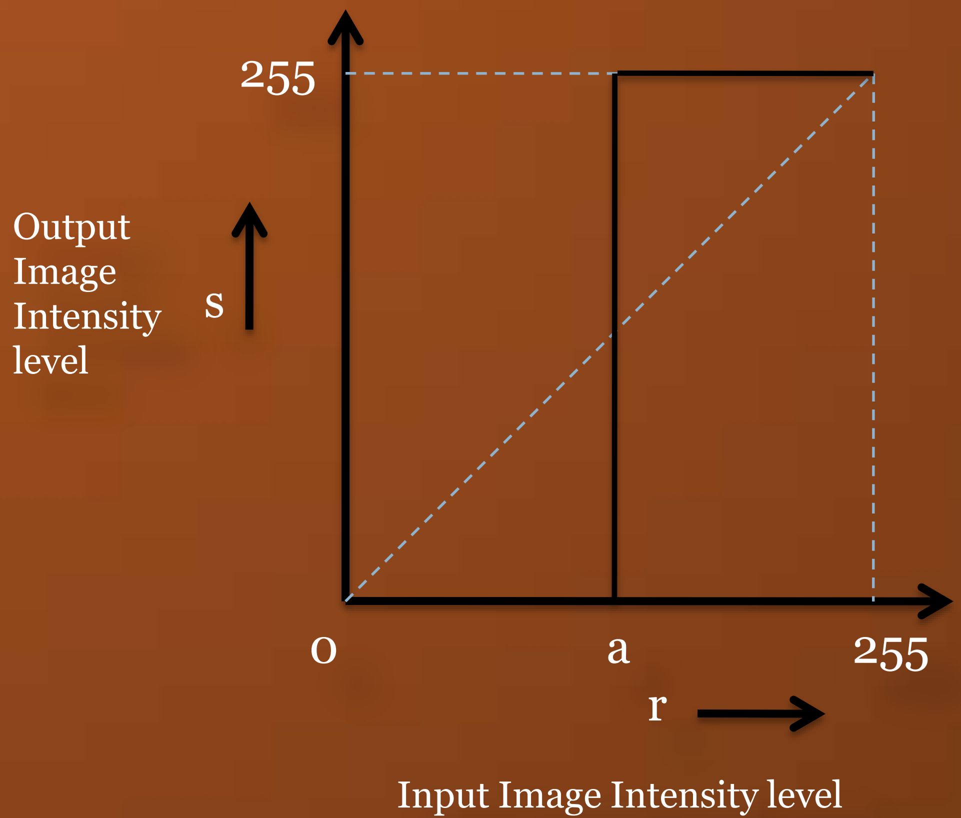
- Dark portion is being made darker by assigning slope of < 1.
- Bright portion is being made brighter by assigning slope of > 1.
- Any set of slopes cant be generalized for all kind of images.

- Formulation is given below:

$$
\begin{aligned}
s &= l.r & ; \quad & \text{for } 0 \le r \le a \\
&= m(r-a) + v & ; \quad & \text{for } a \le r \le b \\
&= n(r-b) + w & ; \quad & \text{for } b \le r \le L-1
\end{aligned}
$$

Point Processing

3) <u>Thresholding:</u>



Point Processing

- ❑ Extreme Contrast Stretching yields Thresholding.

- ❑ In Contrast Stretching figure, if l & n slope are made ZERO & if m slope is increased then we get Thresholding Transformation.

- ❑ If $r1 = r2$, $s1 = 0$ & $s2 = L-1$
  Then we get Thresholding function.

- ❑ Expression goes as under:

$$s = 0;\ \text{if } r \leq a$$
$$s = L - 1\ ;\ \text{if } r > a$$

where, L is number of Gray levels.

Note: It is a subjective phenomenon.
Thresholded image has maximum contrast as it has only BLACK & WHITE gray values.

Point Processing

4) <u>Gray Level Slicing (Intensity Slicing):</u>

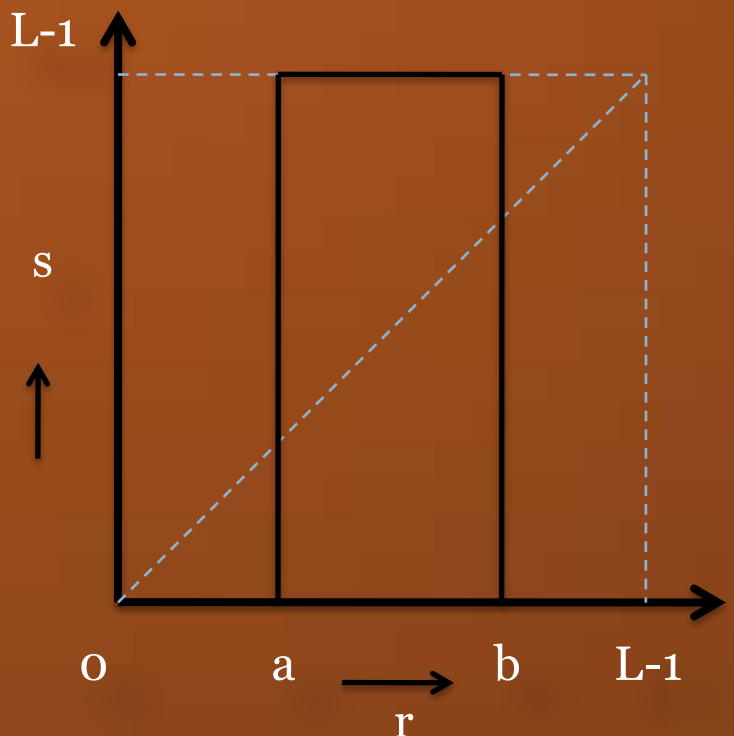


fig. (1) Slicing w/o background

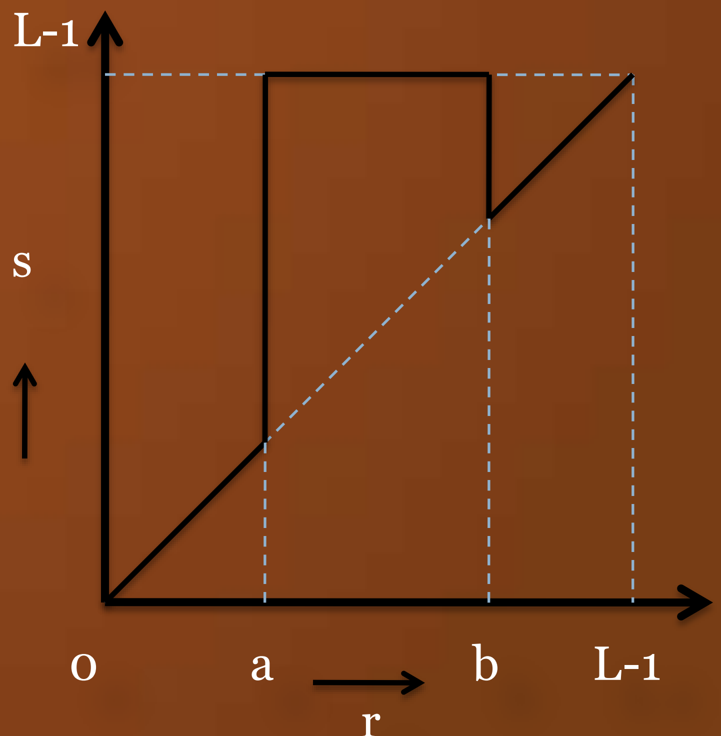


fig. (2) Slicing with background

Point Processing

- Thresholding splits the image in 2 parts

- At times, we need to highlight a specific range of gray levels.
  eg. X-ray scan, CT scan

- It looks similar to thresholding except that we select a band of gray levels.

- Formulation of Gray level slicing w/o background (fig. 1):

$$s = L-1 \quad ; \quad \text{for } a \le r \le b$$
$$= 0 \quad ; \quad \text{otherwise}$$

- No background at all.

- Sometimes we may need to retain the background.

- Formulation of Gray level slicing with background (fig. 2):

$$s = L-1 \quad ; \quad \text{for } a \le r \le b$$
$$= r \quad ; \quad \text{otherwise}$$

Point Processing

5) **Bit Plane Slicing:**

- Here, we find the contribution made by each bit to the final image.
- Consider a 256 x 256 image with 256 gray levels i.e. 8-bit reprsentation for each pixel. E.g. BLACK is represented as 0000_0000 & WHITE by 1111_1111.
- Consider LSB value of each pixel & plot image. Continue till MSB is reached.
- All 8 images will be binary.
- Observing the images we conclude that

  Higher order images contain visually sufficient data.

  Lower order bits contain suitable details of image.
- Hence, BPS can be used in Image Compression.
- We can transmit only higher order bits & remove lower order bits.
- E.g. Stignography

Point Processing

Ex. Plot bit planes of the given 3 x 3 image.

1	2	0
4	3	2
7	5	2

1 - 00000001
2 - 00000010
0 - 00000000
4 - 00000100
3 - 00000011
2 - 00000010
7 - 00000111
5 - 00000101
2 - 00000010

001	010	000
100	011	010
111	101	010

Max. Intensity is 7 thus 3 – bits

1	0	0
0	1	0
1	1	0

LSB plane

0	1	0
0	1	1
1	0	1

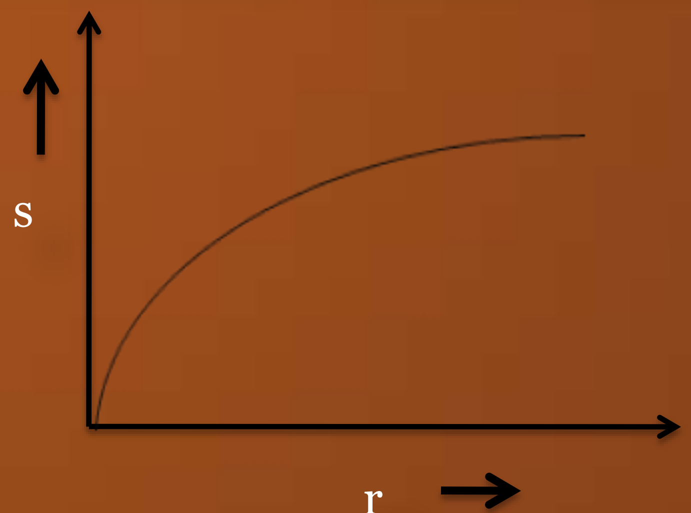
Middle Plane

0	0	0
1	0	0
1	1	0

MSB Plane

Point Processing

6) <u>Dynamic Range Compression (Log transformation)</u>:



❑ At times, dynamic range of image exceeds the capability of display device.

❑ Some pixel values are so large that the other low value pixel gets obscured.
E.g. stars in day time are not visible though present due to large intensity of sun.

❑ Thus dynamic range needs to be compressed.

Point Processing

- Log operator is an excellent compression function.

- Thus, Dynamic range compression is achieved using log operator.

- Formulation:

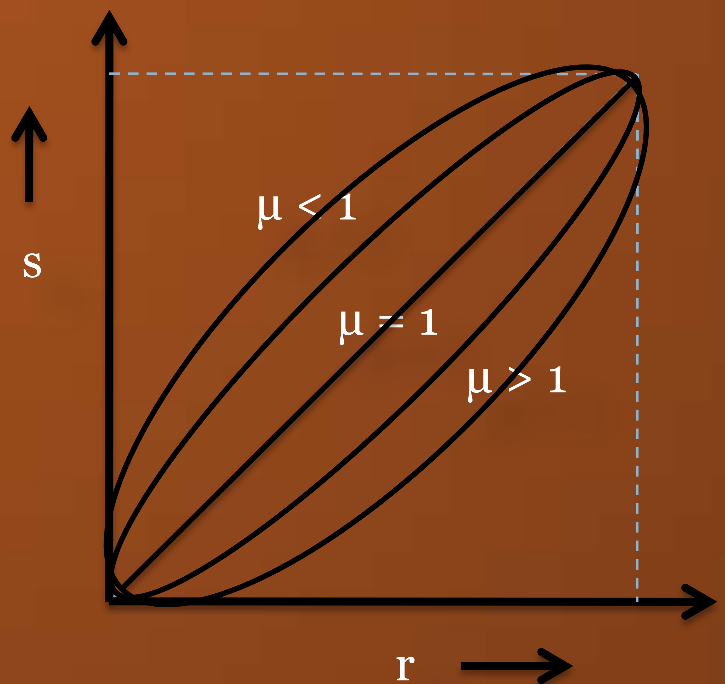
$$s = C.\log(1 + |r|)$$

where, C – normalization constant

r – input intensity

Point Processing

7) **Power law Transform:**



$$f(x, y) = C\,.g(x, y)^{\mu}$$

$s = C.\, r^{\mu}$ where, C & μ are positive constants

Point Processing

- The Transformation is shown for different values of 'μ' which is also the gamma correction factor.

- By changing μ, we obtain the family of transformation curves.

- Nonlinearity encountered during image capturing, storing & displaying can be corrected using gamma correction.

- Power Law Transform can be used to increase dynamic range of image.

End of Point Processing