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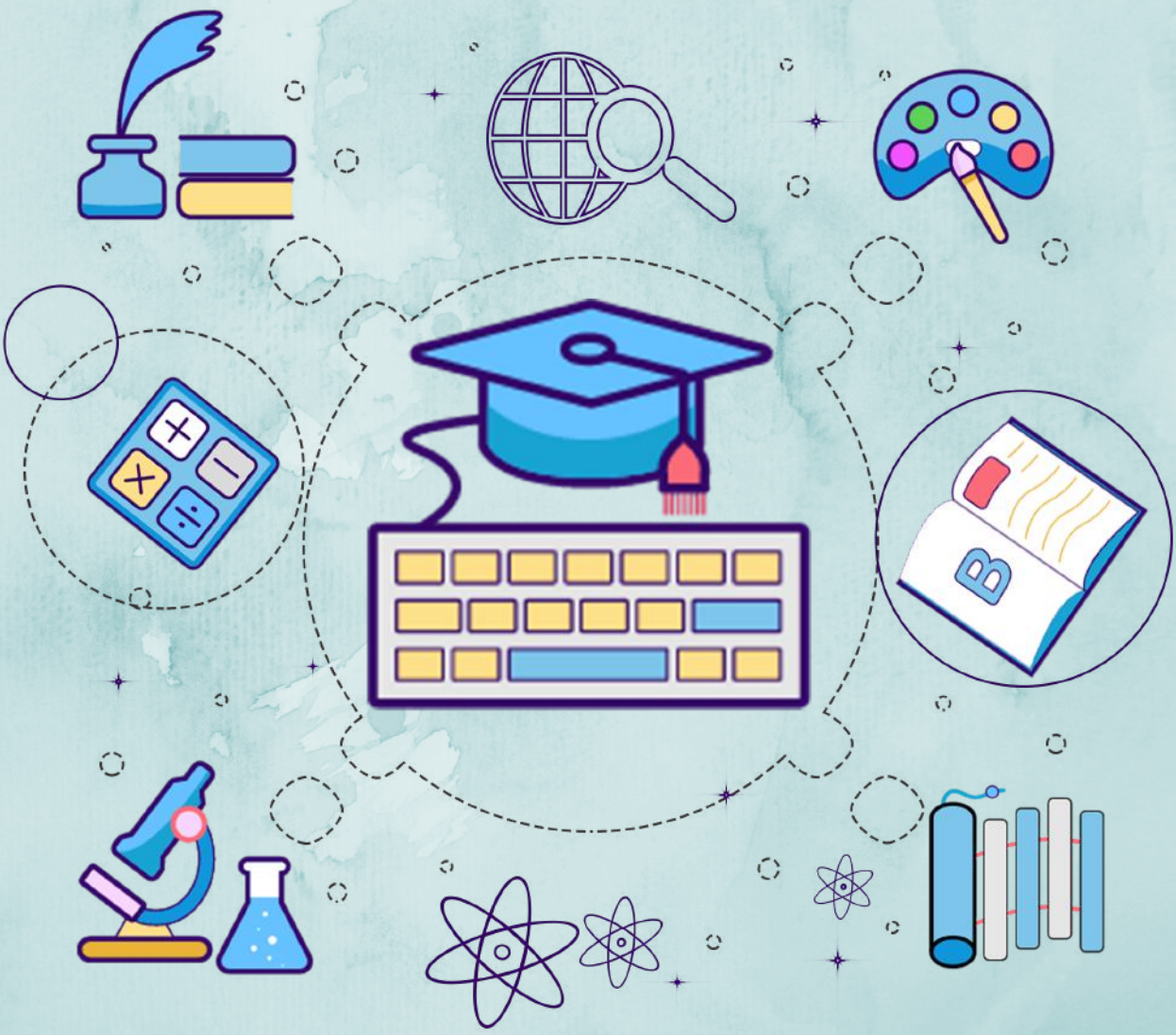

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COMPUTER GRAPHICS AND IMAGE PROCESSING

CST 304

Module 5

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Module - 5 (Image Enhancement in Spatial Domain and Image Segmentation)

- Basic gray level transformation functions - Log transformations, Power-Law transformations, Contrast stretching.
- Histogram equalization.
- Basics of spatial filtering - Smoothing spatial filter-Linear and nonlinear filters, and Sharpening spatial filters-Gradient and Laplacian.
- Fundamentals of Image Segmentation. Thresholding - Basics of Intensity thresholding and Global Thresholding.
- Region based Approach - Region Growing, Region Splitting and Merging.
- Edge Detection - Edge Operators- Sobel and Prewitt.

Image enhancement is a process to improve the given image into a more suitable form for specific application.

- Image enhancement makes an image more noticeable by enhancing the features such as edges, boundaries or contrast.
- While enhancement ,data does not increase , but dynamic range is increased of choosen features by Which it can be detected easily.

Image Enhancement Methods

- **Spatial Domain Methods (Image Plane)**
  Techniques are based on direct manipulation of pixels in an image
- **Frequency Domain Methods**
  Techniques are based on modifying the Fourier transform of the image.
- **Combination Methods**
  There are some enhancement techniques based on various combinations of methods from the first two categories

Spatial Domain Methods

- As indicated previously, 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:

  $g(x,y) = \boldsymbol{T}[f(x,y)]$

  Where f(x,y) in the input image, g(x,y) is the processed image and ***T*** is as operator on f, defined over some neighborhood of (x,y)
- In addition, ***T*** can operate on a set of input images.

Some Basic Intensity (Gray-level) Transformation Functions

- Grey-level transformation functions (also called, intensity functions), are considered the simplest of all image enhancement techniques.
- The value of pixels, before and after processing, will be denoted by *r* and *s*, respectively.
- These values are related by the expression of the form:

  $$s = T(r)$$

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

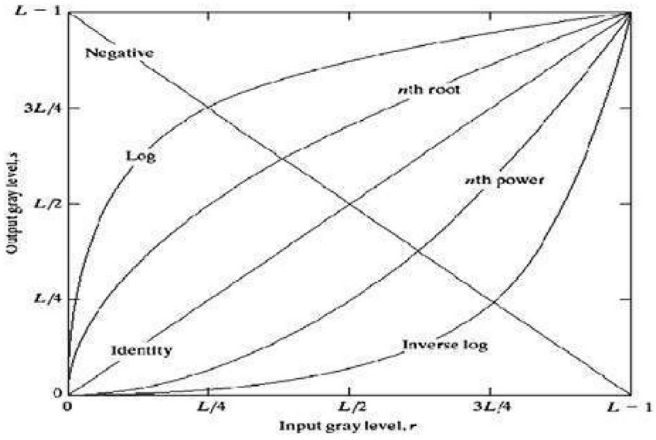
Some Basic Intensity (Gray-level) Transformation Functions

- The three basic types of functions used frequently for image enhancement:
  - **Linear Functions:**
    - **Negative Transformation**
    - **Identity Transformation**
  - **Logarithmic Functions:**
    - **Log Transformation**
    - **Inverse-log Transformation**
  - **Power-Law Functions:**
    - **n^{th} power transformation**
    - **n^{th} root transformation**

There are three basic gray level transformation.

- Linear
- Logarithmic
- Power – law

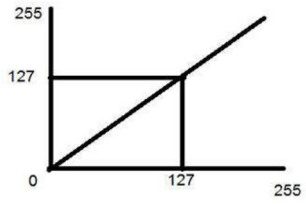
The overall graph of these transitions has been shown below.



Linear transformation

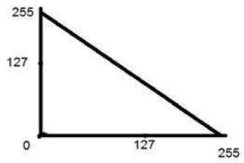
Linear transformation includes simple identity and negative transformation.

- ***Identity transformation*** is shown by a straight line. In this transition, each value of the input image is directly mapped to each other value of output image. That results in the same input image and output image. And hence is called identity transformation. It has been shown below:

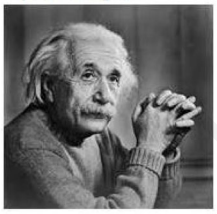


- ***Negative transformation***

The second linear transformation is negative transformation, which is invert of identity transformation. In negative transformation, each value of the input image is subtracted from the L-1 and mapped onto the output image.
The result is somewhat like this.



Input Image



Output Image

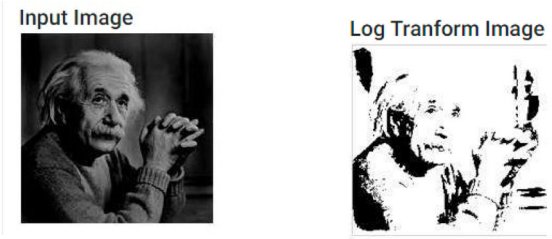
In this case the following transition has been done.
s = (L – 1) – r, since the input image of Einstein is an 8 bpp image, so the number of levels in this image are 256. Putting 256 in the equation, we get this
s = 255 – r
So each value is subtracted by 255 and the result image has been shown above. So what happens is that, the lighter pixels become dark and the darker picture becomes light. And it results in image negative.

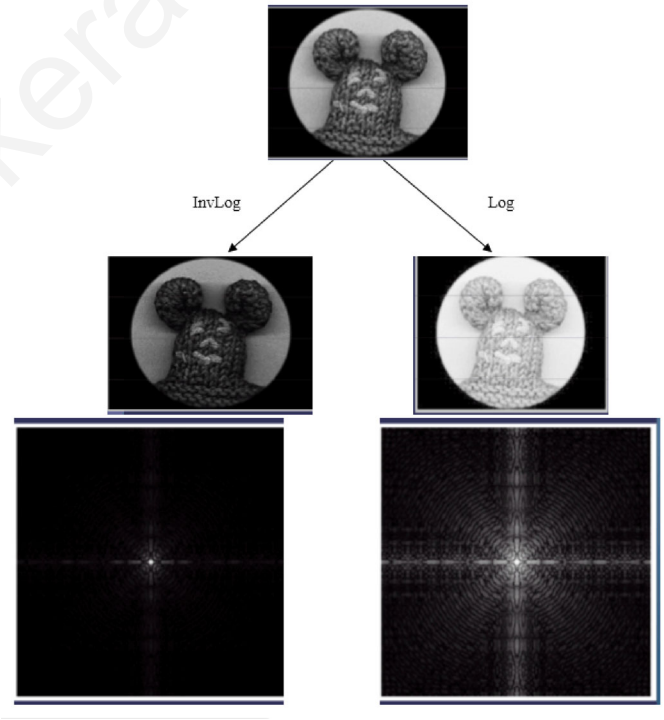
Logarithmic transformations

Logarithmic transformation further contains two type of transformation. Log transformation and inverse log transformation.

- ***Log transformation***

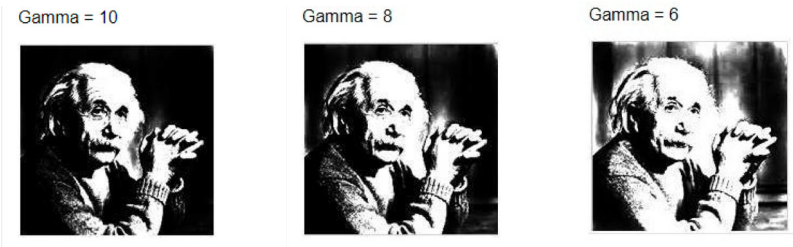
The log transformations can be defined by this formula
s = c log(r + 1).
Where s and r are the pixel values of the output and the input image and c is a constant. The value 1 is added to each of the pixel value of the input image because if there is a pixel intensity of 0 in the image, then log (0) is equal to infinity. So 1 is added, to make the minimum value at least 1.
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 transform adjust the kind of enhancement you are looking for.
The inverse log transform is opposite to log transform.

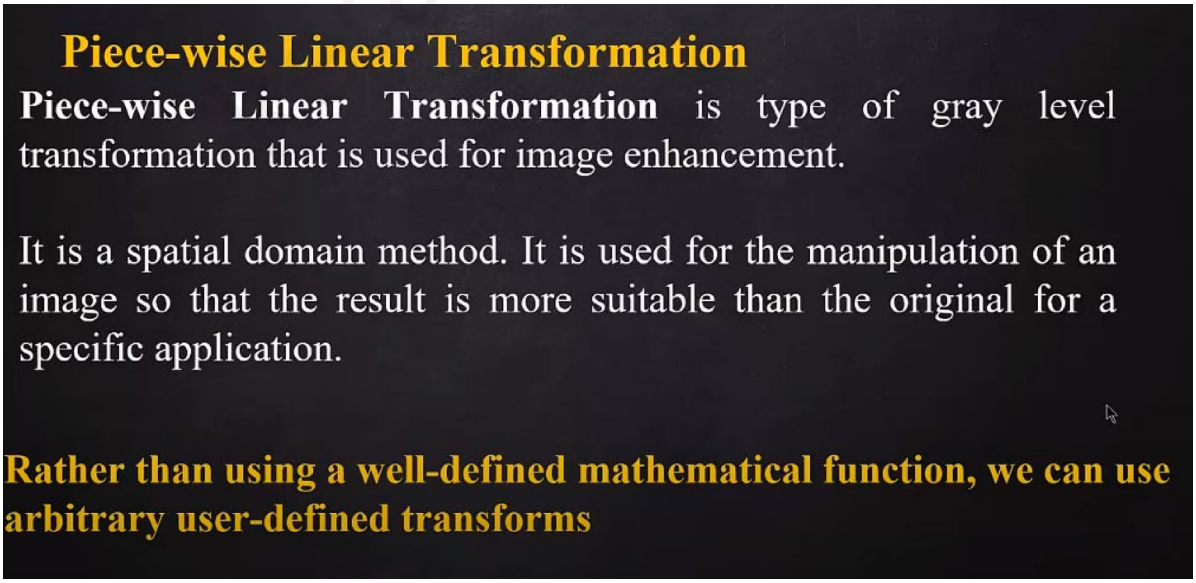




Power – Law transformations

There are further two transformation is power law transformations, that include ***nth power and nth root transformation.*** These transformations can be given by the expression:
s=cr^γ
This symbol γ is called gamma, due to which this transformation is also known as gamma transformation.
Variation in the value of γ varies the enhancement of the images. Different display devices / monitors have their own gamma correction, that's why they display their image at different intensity.
This type of transformation is used for enhancing images for different type of display devices. The gamma of different display devices is different. For example Gamma of CRT lies in between of 1.8 to 2.5, that means the image displayed on CRT is dark.
Correcting gamma.
s=cr^γ
s=cr^(1/2.5)
The same image but with different gamma values has been shown here.

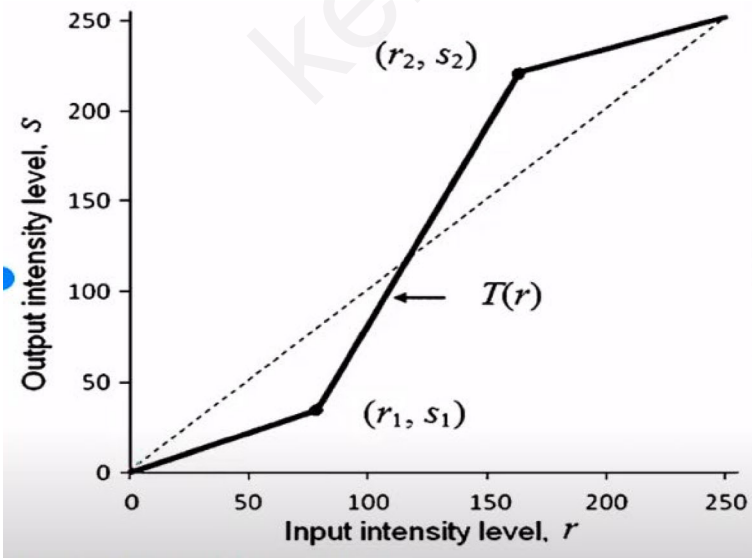




Contrast Stretching:

Low contrast images occur often due to improper illumination or non-linearly or small dynamic range of an imaging sensor. It increases the dynamic range of grey levels in the image.

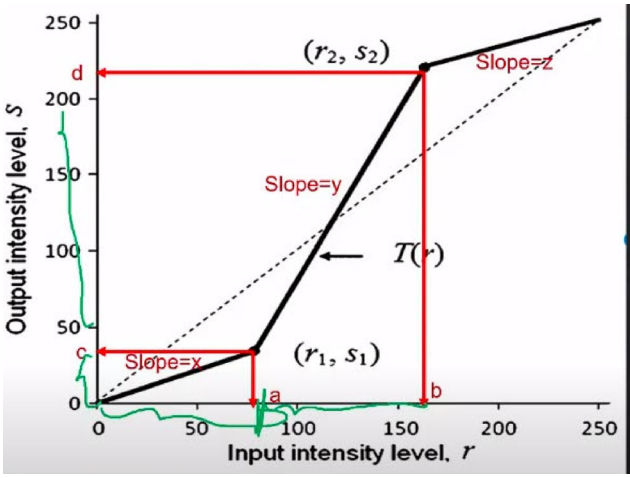
Contrast stretching is a process that expands the range of intensity levels in an image so that it spans the full intensity range of the recording medium or display device.



If slope=1 ,output image=input image

If slope>1 , output image is brighter than the input image

If slope<1, output image is darker than input image

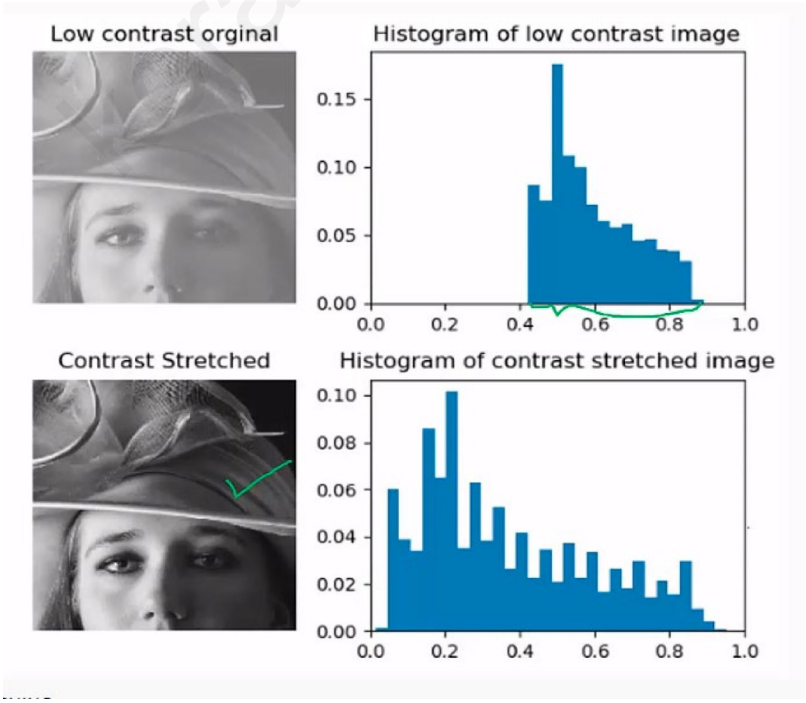


If slope=1 ,output image=input image

If slope>1 , output image is brighter than the input image

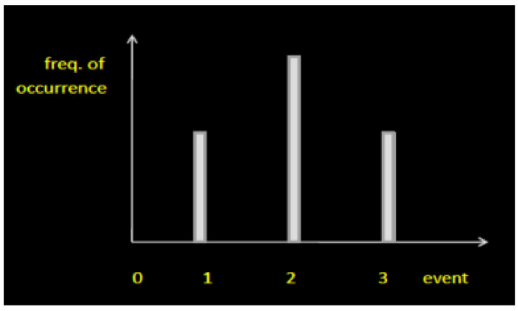
If slope<1, output image is darker than input image

$$S = \begin{cases} x \cdot r, & 0 <= r <= a \\ y.(r-a)+c, & a < r <= b \\ z.(r-b)+d, & b < r <= L-1 \end{cases}$$



Gray level histogram

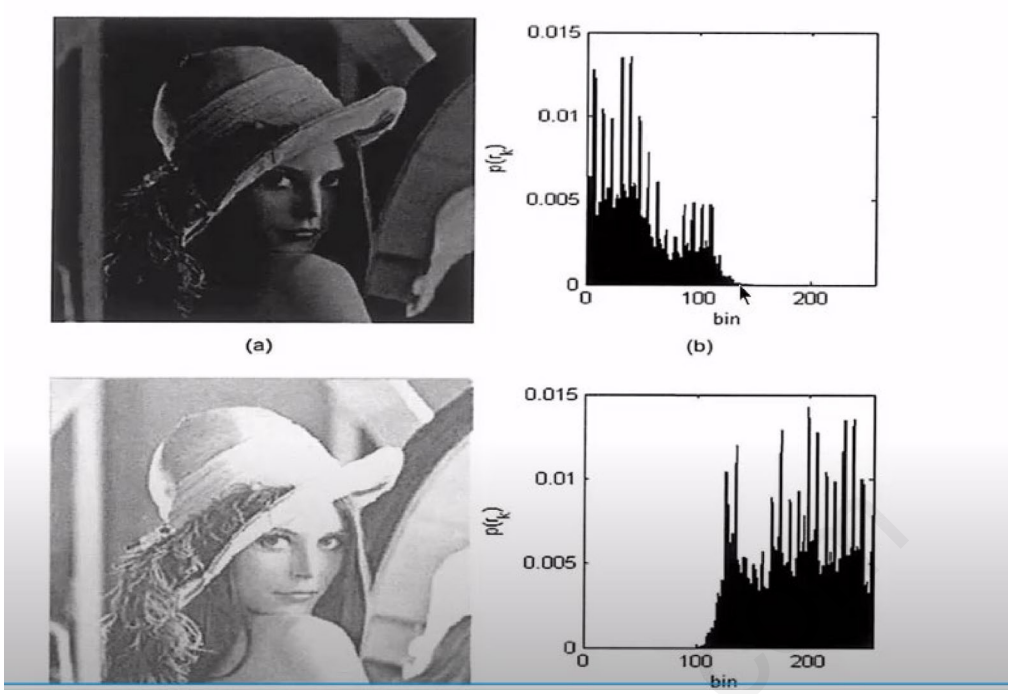
- In Statistics, **Histogram** is a graphical representation showing a visual impression of the distribution of data.



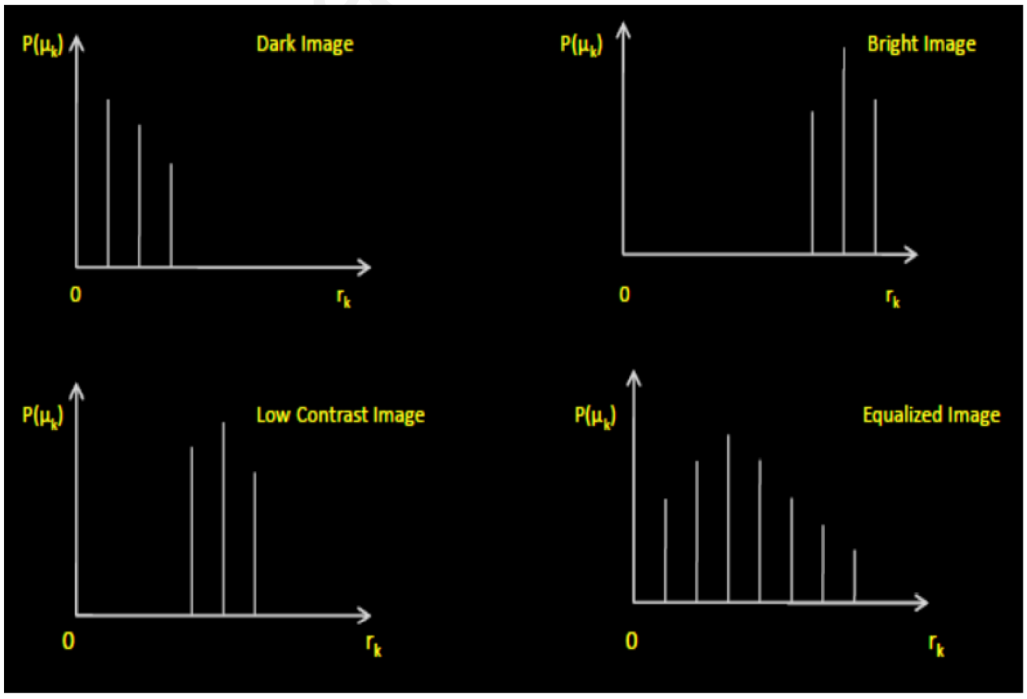
- An **Image Histogram** is a type of histogram that acts as a graphical representation of the lightness/color distribution in a digital image.
- It plots the number of pixels for each value.
- Histogram of images provide a global description of their appearance.
- Histogram of an image represents relative frequency of occurrence of various gray levels.

Applications of histogram

- It is used to analyze an image .Properties of an image can be predicted by detailed study of histogram.
- The brightness of the image can be adjusted by having details of histogram.
- The contrast of the image can be adjusted according to the need by having details of x axis of a histogram.
- Used for image equalization.
- Histogram are used in thresholding as it improves the appearance of image.



Types of Histograms



- In the dark Image that the components of the histogram are concentrated on the low (dark) side of the gray scale
- The components of the histogram of the bright image are biased toward the high side of the gray scale.
- An image with low contrast has a histogram that will be narrow and will be centered toward the middle of the gray scale
- The last graph represent the best image;It is a high contrast image.
- Our aim would be to transform the first 3 histograms into the 4thtype.
- In other words we try to increase the dynamic range of the image .This is called Histogram Processing

Histogram Processing

There are two methods of enhancing contrast.

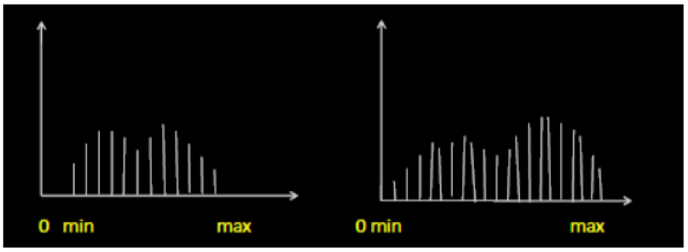
- Histogram stretching.
- Histogram equalization

Histogram stretching

- Process of histogram stretching increases the dynamic range of the image and hence improves the contrast of the image.
- In this process, the basic shape of the histogram is not modified, but the entire range of image of histogram values is stretched.
- Before stretching process, it is necessary to specify the upper and lower limits for pixels of normalized range.
- Limit values depends on type of image. For eg: if 8 bit image ,limit values ranges between 0 & 255.
- Simplest histogram function is given by:

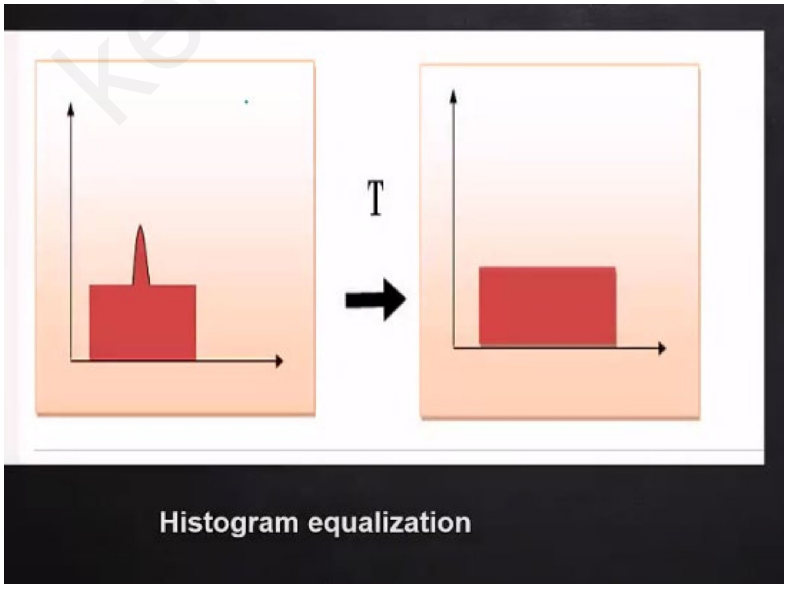
$$S = T(r) = ((S_{max}-S_{min})/(r_{max}-r_{min}))(r - r_{min}) + S_{min}$$

- Where, S_{max}–maximum limit value of image, S_{min}–minimum limit value of image, r_{max}–highest pixel value of image, r_{min}–lowest pixel value of image



Histogram equalization

- Equalisation is a process that attempts to spread out the gray levels in an image so that they are evenly distributed across their range.
- It reassigns the brightness values of pixels based on image histogram.
- The histogram of resultant image is made as flat as possible.
- Provides more visually pleasing results across a wide range of images.



Steps involved in Histogram Equalization

- Identify and list gray levels present in you image.
- Identify frequency of each gray level
- Histogram of input image.
- Evaluate PDF (Probability Density Function){Normalizing in the range of 0-1}

p(rk)=nk/n, where 'nk' is the frequency of gray level and 'n'is the maximum gray level value

- Evaluate CDF(Cumulative Distribution Function) for each PDF value.

sk= T(rk)$\sum_{j=0}^{k} \Pr(rj)\,, k = 0,1 \ldots \ldots . L-1$

- Multiply each CDF value using maximum gray value.
- Perform round off operation over each transformed value to get histogram equalized gray level.
- Using histogram equalized gray levels and the frequency value plot histogram of output image.
- We can identify output image segment by mapping histogram equalized gray levels with initial gray levels.