Intensity Transformation and Spatial filtering

- **Spatial domain:**
  - Spatial domain refers to the image plane itself
  - Image processing methods are based on direct manipulation of pixels in an image.

There are generaly two principle catagories of spatial processing,

- Intensity transformation
- Spatial filtering.

Some image processing task are easier or more meaningful to implement in the spatial domain. Generally, spatial domain techniques are more efficient computationally and requires less processing resources to implement. The spatial domain processes can be denoted by the following expression,

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

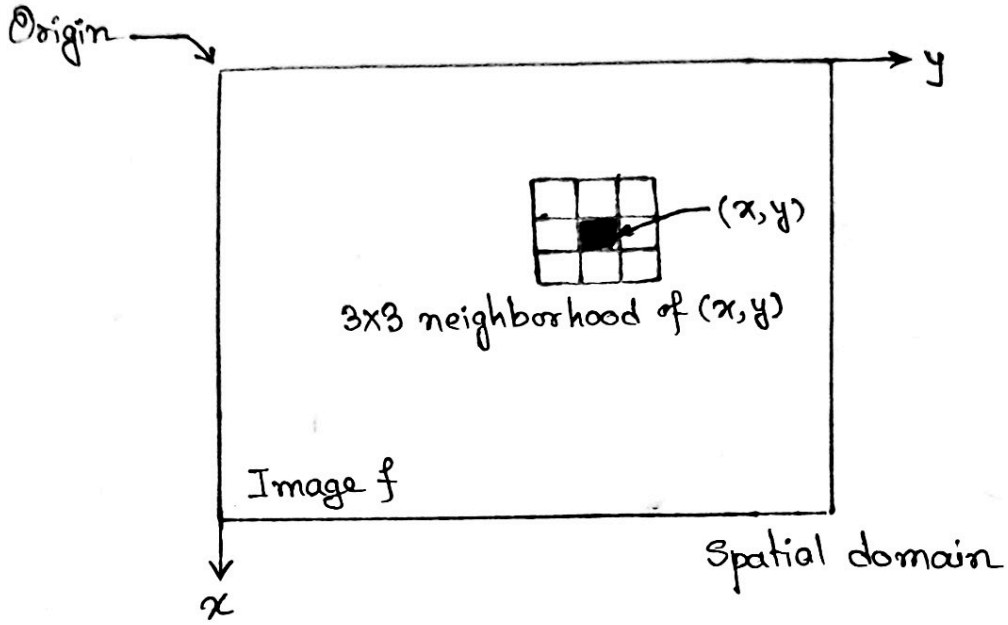
where,

$f(x,y)$ is the input image

$g(x,y)$ is the output image

T is an operator on 'f' defined over a neighborhood of pixel (x,y)

The operator can be applied to a single image or to a set of images, such as performing the pixel-by-pixel sum of a sequence of images for noise reduction.



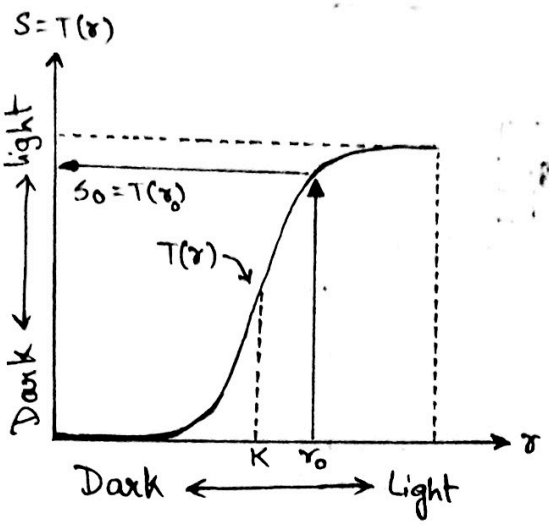
A 3×3 neighborhood about a pixel point (x,y) in an image in spatial domain. The neighborhood is moved from pixel-to-pixel in the image to generate an output Image.

The point (x,y) is an arbitary location in the image, and the small region shown containing the points is a neighborhood of Pixel (x,y). Typically the neighborhood is rectangular, centered on (x,y) and much smaller in size than the input Image.

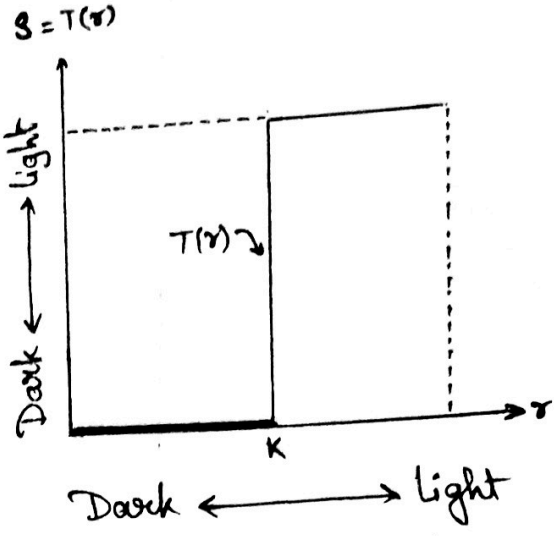
The smallest possible neighborhood is of size 1×1. In this case g(x,y) [output image] depends only on the value of f(x,y) [Input image] at a single point (x,y) and T becomes an intensity tranformation function of the form

$$\boxed{S = T(r)}$$

where for simplicity of notation s and r are variable denoting g(x,y) and f(x,y) respectively.



Contrast-stretching function



Thresholding function

If the effect of applying the transformation to every pixel of 'f' to generate the corresponding pixels in 'g' to produce an image of higher contrast than the original by darkening the intensity levels below K and brightening the levels above K, this technique is called contrast Stretching.

Spatial Filtering:

- It is the procedure of moving the location of neighbourhood and performing a predefined operation.
- The neighbourhood; along with the predefined operation is called Spatial filter
- Other names for spatial filter are spatial mask, kernel, templete.

Intensity Transformation Function:

There are three basic types of functions used frequently for image enhancement,

i) Linear (Negative and Identity transformation)
ii) Logarithmic (log and inverse-log transformation)
iii) Power-law (n^{th} power and n^{th} root transformation)

Image Negatives:

The negative of an image with intensity levels in range $[0, L-1]$ is obtained by using the negative transformation which is given by the expression,

$$\boxed{S = L - 1 - r}$$

Reversing the intensity levels of an image in this manner produces the equivalent negative image. This type of processing is particularly suited for enhancing white or gray details embedded in dark regions of an image, especially when the black areas are dominant in size.

Log Transformation:

The general form of log transformation is expressed as,

$$\boxed{S = c \log(1+r)}$$

where c is a constant and it is assumed that $r \geq 0$. It maps a narrow range of low intensity values in the input into a wider range of output levels. The opposite is true for higher values of input levels. This type of transformation

is used to expand the values of dark pixels in an image while compressing the higher-level values.

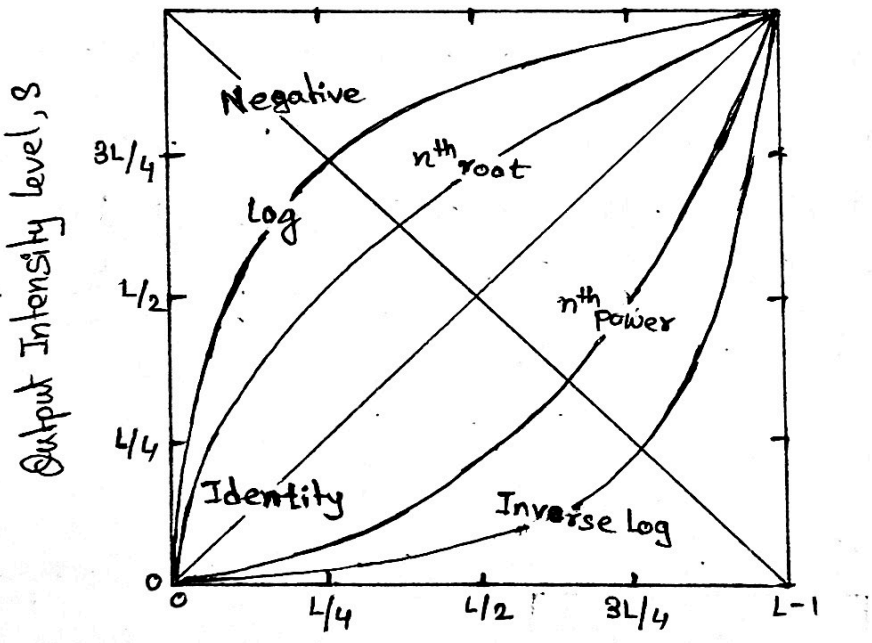
Power-law (Gamma) Transformation:

Power-law (Gamma) transformation have the basic form

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

where,

c and γ are positive constants. Sometimes the above equation is written as $s = c(r+\varepsilon)^{\gamma}$ to account for an offset value. In case of power-law transformation, with fractional values of γ map a narrow range of dark input values into a wider range of output values, with the opposite being true for higher values of input levels.



Input intensity level, r