Intensity Transformations and Spatial Filtering

Chapter 3

The Basics of Intensity Transformations and Spatial Filtering

- Intensity transformation as the name suggests, we transform the pixel intensity value using some transformation function or mathematical expression.

- Intensity transformation operation is usually represented in the form

  - **s = T(r)**

- where, r and s denotes the pixel value before and after processing and T is the transformation that maps pixel value r into s.

- Basic types of transformation functions used for image enhancement are

  - Linear (Negative and Identity Transformation)

  - Logarithmic (log and inverse-log transformation)

  - Power law transformation

- This is a spatial domain technique which means that all the operations are done directly on the pixels.
- Also known as a point processing technique (output depend only on the single pixel) as opposed to neighbourhood processing techniques(like filtering).
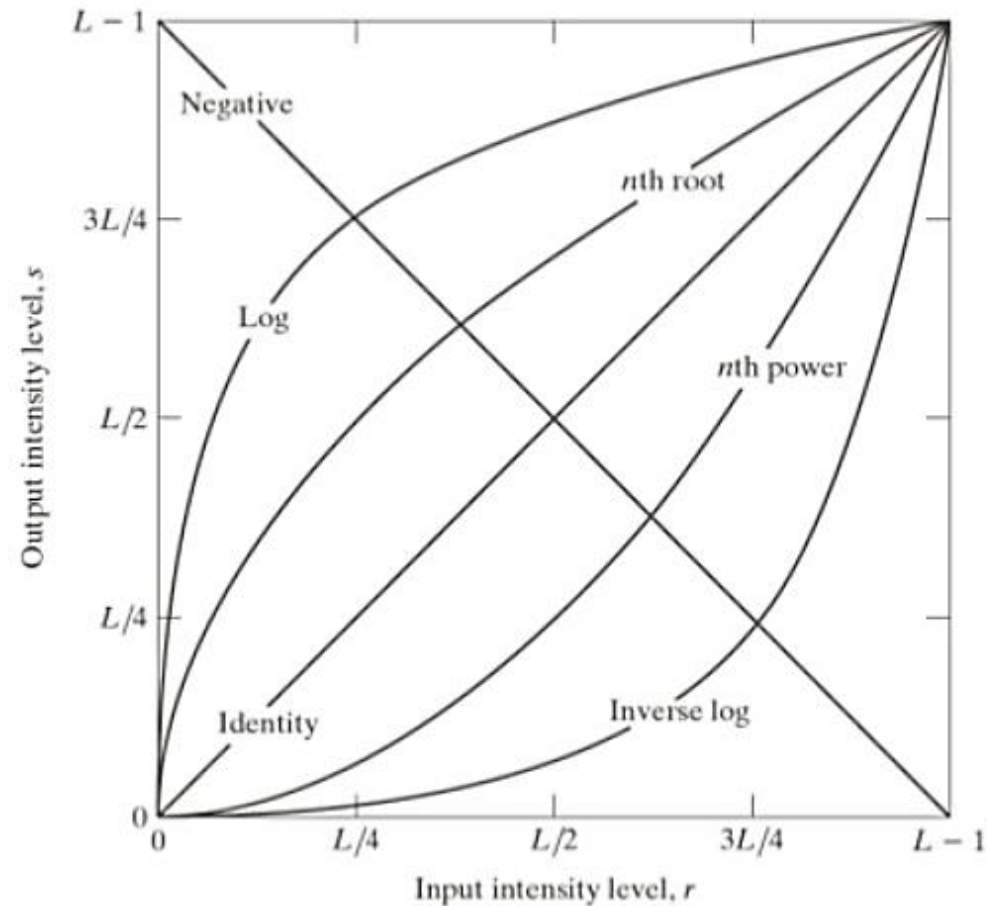
- **s = T(r)**

- Filter term in "Digital image processing" is referred to the sub-image. There are others term to call sub-image such as mask, kernel, template, or window. The value in a filter sub-image are referred as coefficients, rather than pixels.

- Spatial filtering term is the filtering operations that are performed directly on the pixels of an image

- The process consists simply of moving the filter mask from point to point in an image. At each point (x,y) the response of the filter at that point is calculated using a predefined relationship

- Spatial filtering modifies an image by replacing the value of each pixel by a function of the values of the pixel and its neighbours. If the operation performed on the image pixels is linear, then the filter is called a linear spatial filter. Otherwise, the filter is a nonlinear spatial filter.

- Spatial filters serve a variety of purposes, such as detecting edges along a specific direction, contouring patterns, reducing noise, and detail outlining or smoothing. Filters smooth, sharpen, transform, and remove noise from an image so that you can extract the information you need.

- Spatial filters fall into two categories:

  - High-pass filters emphasize significant variations of the light intensity usually found at the boundary of objects.

  - High-pass frequency filters help isolate abruptly varying patterns that correspond to sharp edges, details, and noise.

  - Lowpass filters attenuate variations of the light intensity.

  - Lowpass frequency filters help emphasize gradually varying patterns such as objects and the background.

  - They have the tendency to smooth images by eliminating details and blurring edges.

Thresholding

Image thresholding is the easiest way to separate image background and foreground.

Also, this image thresholding can be identified as a image segmentation technique.

To apply thresholding techniques, we should use a gray scale image.

When thresholding, that grayscale image will be converted to a binary image.

In simple thresholding, all pixel values those are greater than the specific threshold value, assign to standard value.

It compares pixel values with special threshold value. After separating the pixel, we can see the segmented images according to threshold values.

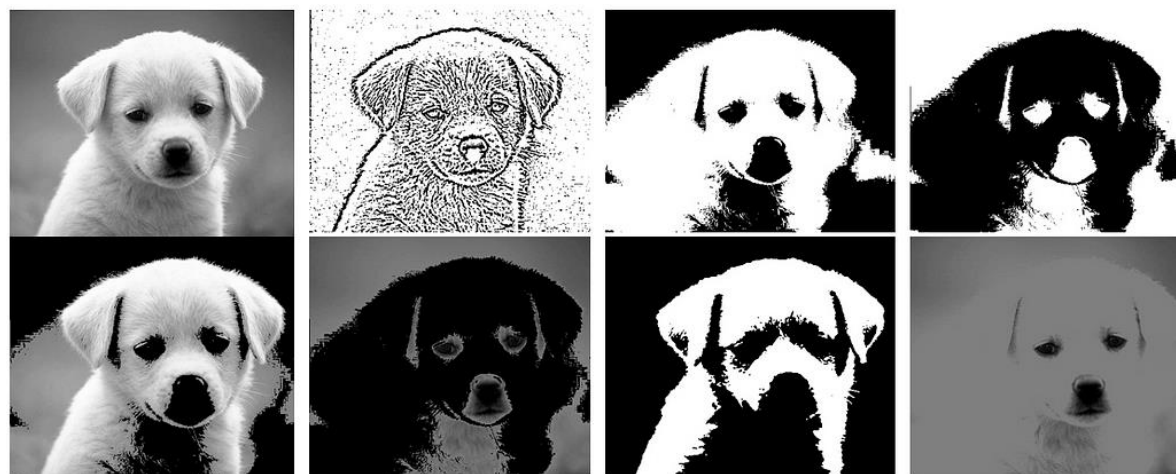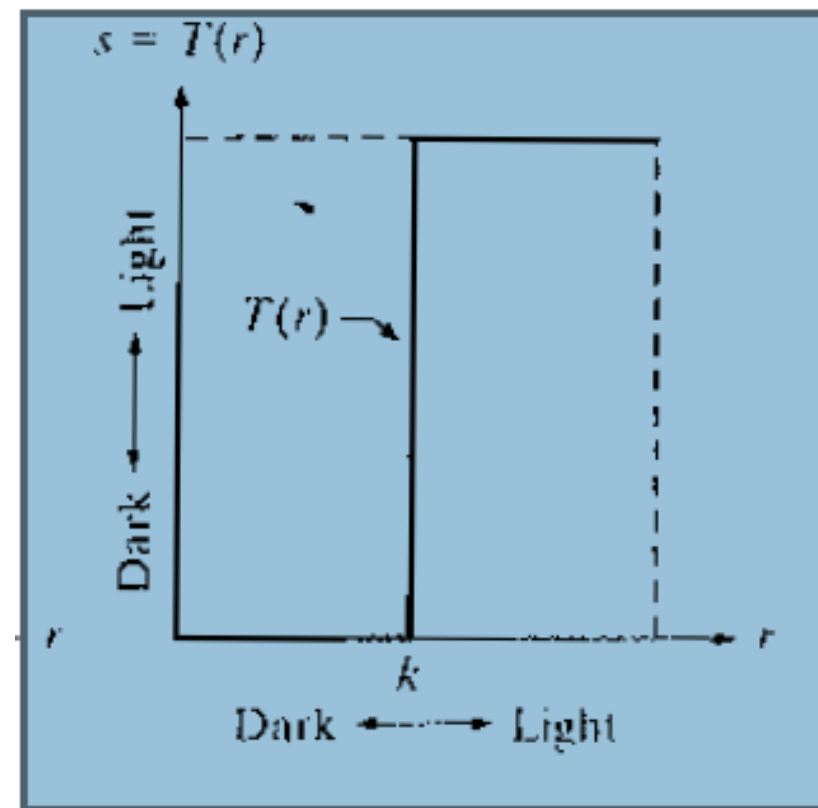**If $f(x, y) > T$ then $f(x, y) = 0$ else $f(x, y) = 255$**

$T = 48$

$T_1 = 2 | T_2 = 48$

$T = 21$

$T_1 = 135 | T_2 = 255$

$s = T(r)$

$T(r)$

Light

Dark

Dark ← → Light

k

r

Histogram Processing

- Image pre-processing is an improvement of the image data that suppresses undesired distortions or enhances some image features relevant for further processing and analysis tasks.

- There are four different types of Image Pre-Processing techniques, and they are listed below.

Pixel brightness transformations/ Brightness corrections

Geometric Transformations

Image Filtering and Segmentation

Fourier transform and Image restoration

- Histogram equalization is one of the Pixel brightness transformations techniques. It is a well-known contrast enhancement technique due to its performance on almost all types of image.

- **Histogram equalization**

- A histogram is a representation of frequency distribution. It is the basis for numerous spatial domain processing techniques. Histogram manipulation can be used for image enhancement.

- Contrast is defined as the difference in intensity between two objects in an image. If the contrast is too low, it is impossible to distinguish between two objects, and they are seen as a single object.

- Histogram equalization is a widely used contrast-enhancement technique in image processing because of its high efficiency and simplicity. It is one of the sophisticated methods for modifying the dynamic range and contrast of an image by altering that image such that its intensity histogram has the desired shape. It can be classified into two branches as per the transformation function is used.

Histogram of the subimage

Gray level
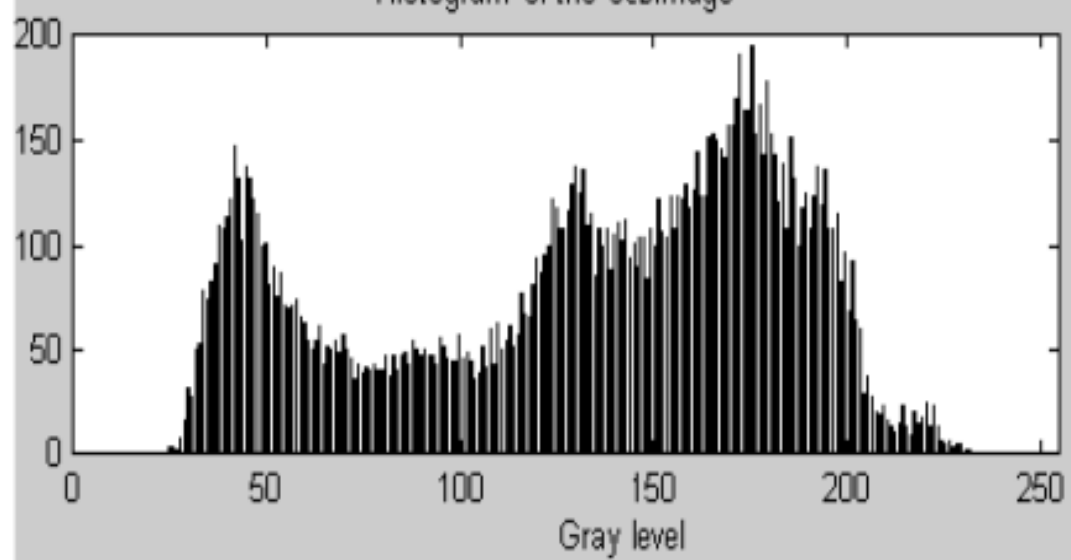
Histogram of the equalized image