Image Enhancement

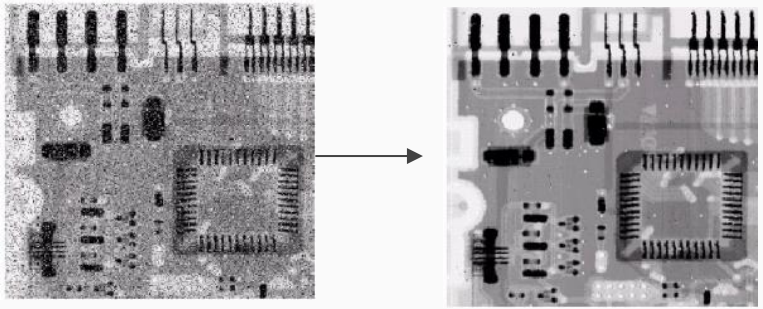
Objective

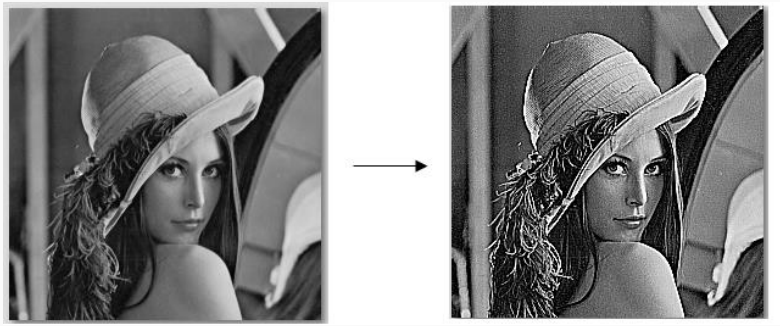
In this session we will

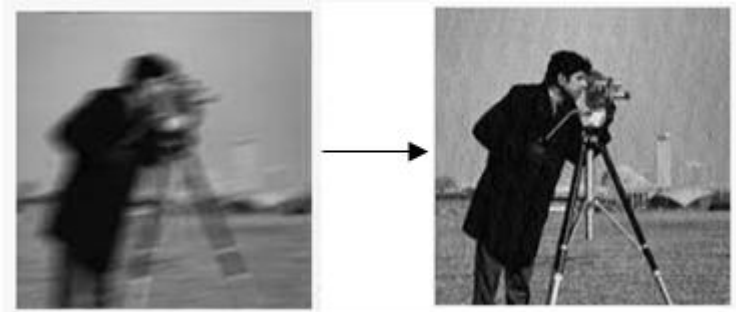
- ➔ Learn about image noise ..
- ➔ Learn how to remove noise
- ➔ Learn how to enhance image contrast

Image enhancement

It is the process of improving the quality and the information content of original data before processing and removing unnecessary information according to specific needs. For example, removing noise, revealing blurred details, sharpening the image and contrast enhancement.







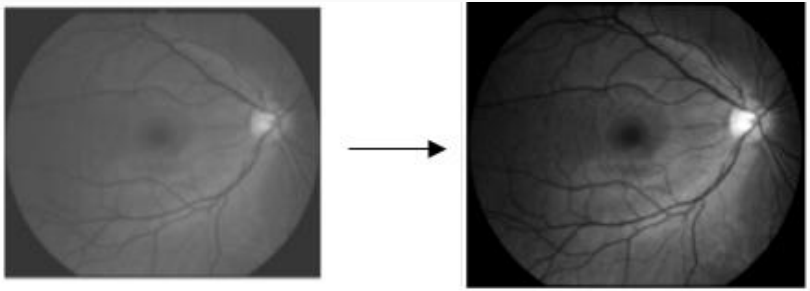


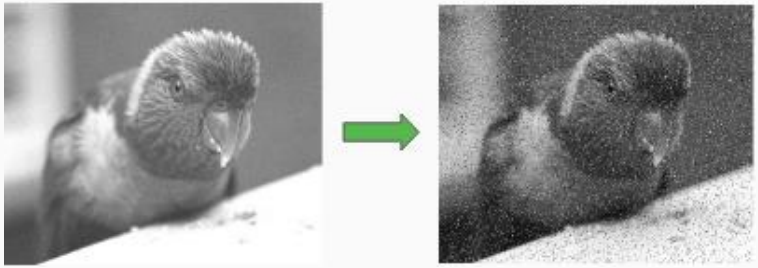
Image Noise

What is image Noise?

Image noise is undesired variation in pixel intensity values in a captured or transmitted image.

What are the reasons of image noise?

- Sensors of digital cameras
- Problems with the data acquisition process
- Transmission
- Compression.



Technically, some amount of noise will **always** be in every photo. There is nothing you can do to prevent this; it is a physical property of light and photography.

Image Noise

Types of noise in images:

Salt and Pepper Noise: this noise is added to an image by addition of both random bright (with 255 pixel value) and random dark (with 0 pixel value) all over the image.

Image Noise

Types of noise in images:

Gaussian Noise is a statistical noise having a probability density function equal to normal distribution. Random Gaussian function is added to Image function to generate this noise. It is a normally distributed random value is added to each pixel

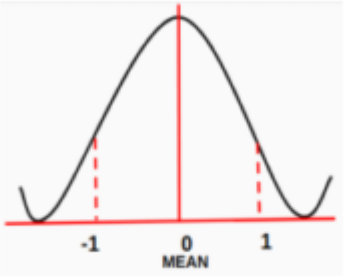


Fig.4 Plot of Probability Distribution Function

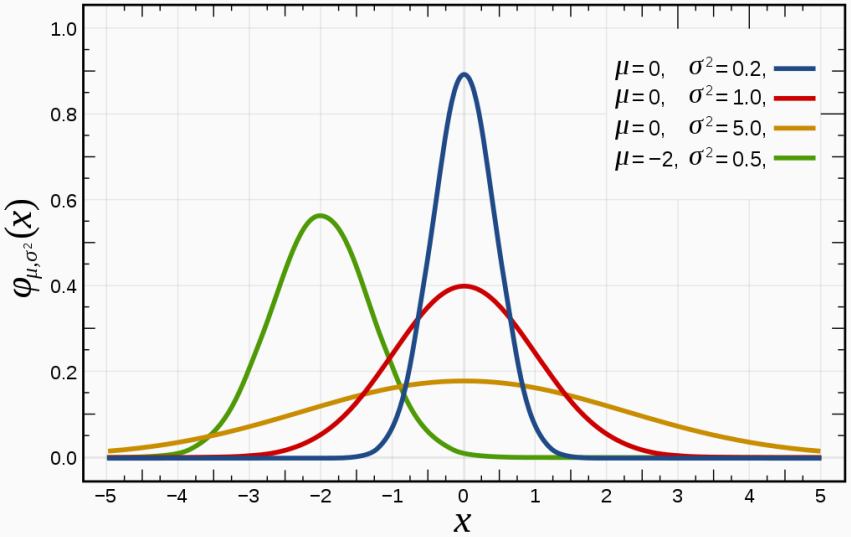


Image Noise

Types of noise in images:

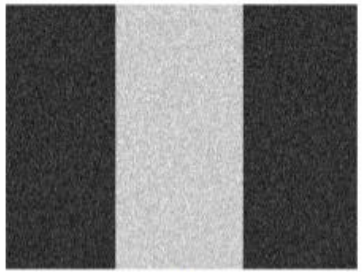
Gaussian Noise

When noise is added, notice how "gaussian-like" the histogram becomes. Each spike in the original image "turns" into something similar to a Gaussian distribution. That is exactly the reason why it is called Gaussian noise.

In next figure:
(a) Original image, (b) histogram of original image
(c) Image with Gaussian noise
(d) Histogram for noisy image


(a)


(b)


(c)


(d)

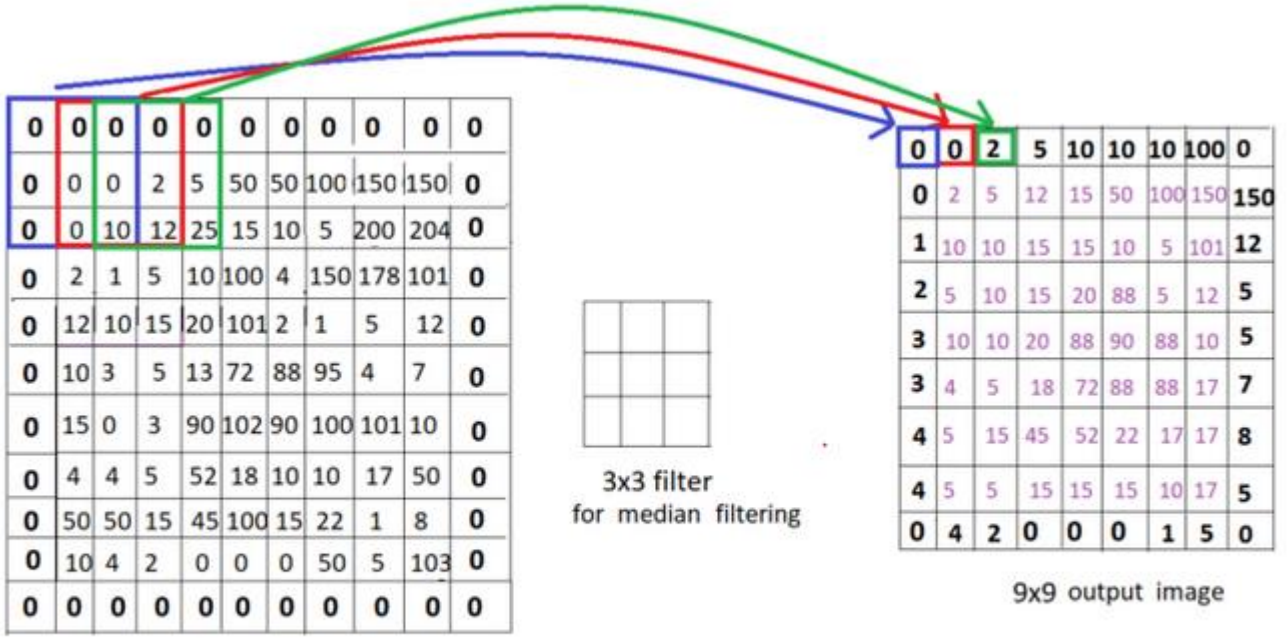
How to remove noise

Median Filter: is a **nonlinear process useful in reducing** salt-and-pepper noise.

To run a median filter:

For each pixel in the image

1. Sort the neighbouring (3*3) pixels based upon their intensities
2. Replace the original value of the pixel with the median value from the list

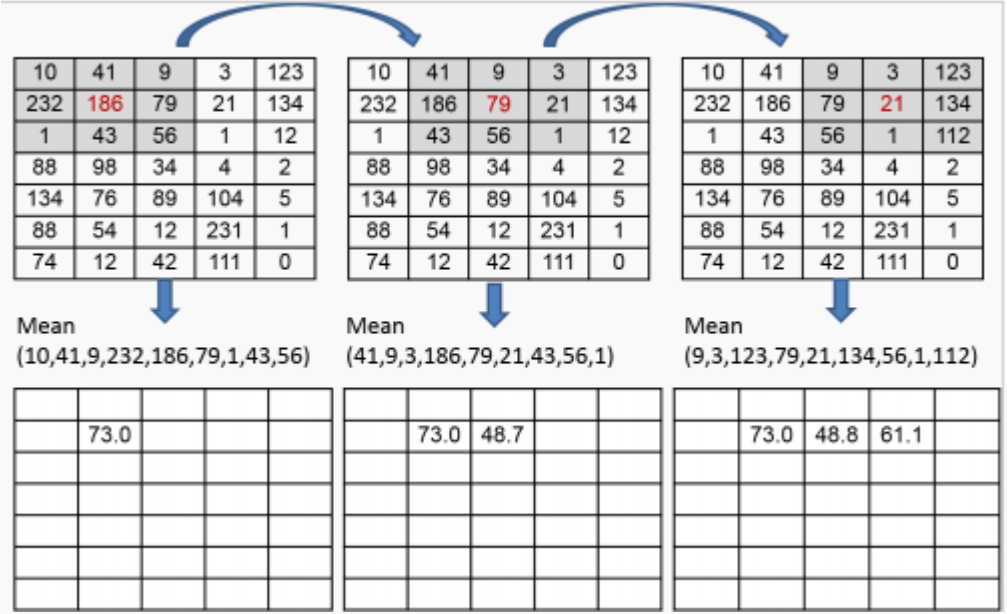


How to remove noise

Mean Filter (Average filter): it is a method for reducing the amount of intensity variation between neighbouring pixels. It **useful in reducing** grain noise, for example: Gaussian noise.

For each pixel in the image

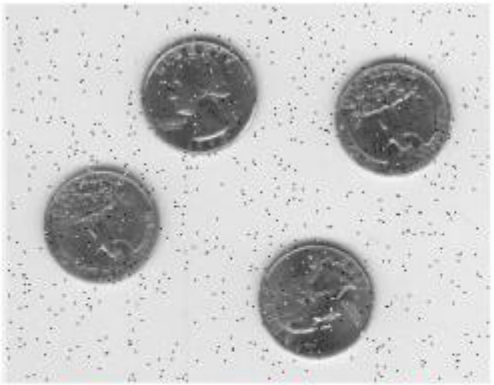
- Replace each pixel value in an image with the mean (`average') value of its (3*3) neighbors, including itself.



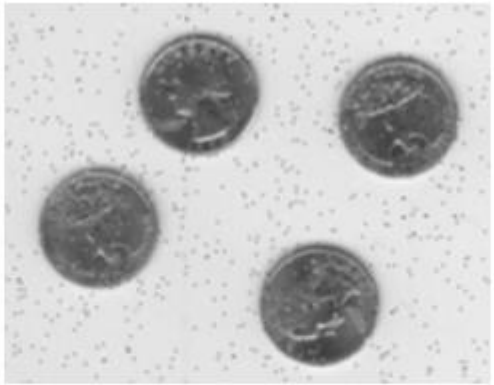
Advantages of Median filter

By calculating the median value of a neighborhood rather than the mean filter, the median filter has two main advantages over the mean filter:

- A single very unrepresentative pixel in a neighborhood will not affect the median value significantly.
- Since the median value must actually be the value of one of the pixels in the neighborhood, the median filter does not create new unrealistic pixel values when the filter straddles an edge.



Corrupted by salt and pepper noise

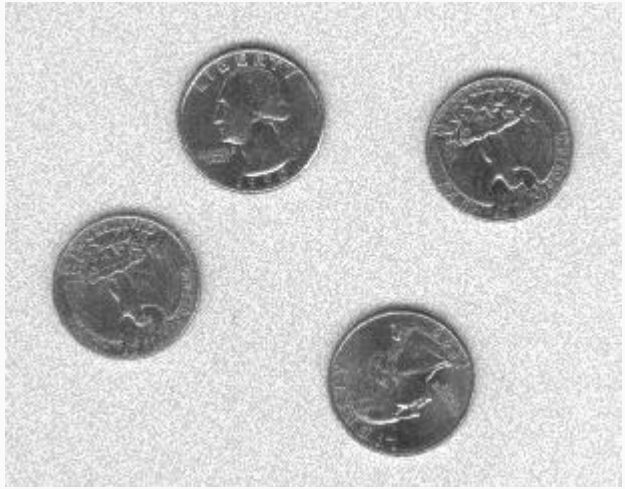


Averaging filter

Median filter

python code

Suppose you have these two images: one with salt & pepper noise, and the other one with Gaussian noise.
Write a python code to remove noise from each image according to its noise type.



Contrast enhancement

What is it?

An image processing technique in which the **contrast** of the image, or the difference in color and light between parts of image, is **improved** in order to enhance its perception by human eye.

Contrast manipulations involve changing the **range of values** in an image in order to increase contrast.

Usage:

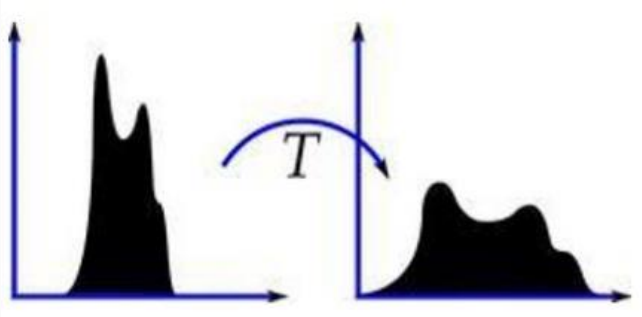
- ✓ To improve the quality of an image.
- ✓ If the contrast of an image is highly concentrated on a specific range, e.g. an image is very dark; the information may be lost in those areas which are excessively and uniformly concentrated
- ✓ Enhance medical images.

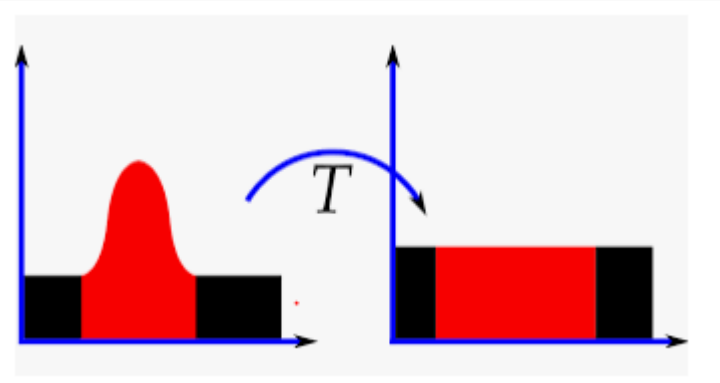
How to enhance image contrast?

Use histogram Equalization

Contrast enhancement

Histogram Equalization is a method which increases the dynamic range of the gray-levels in a low-contrast image to cover full range of gray-levels and increase its contrast.
By accomplishing this, histogram equalization allows the image's areas with lower contrast to gain a higher contrast.

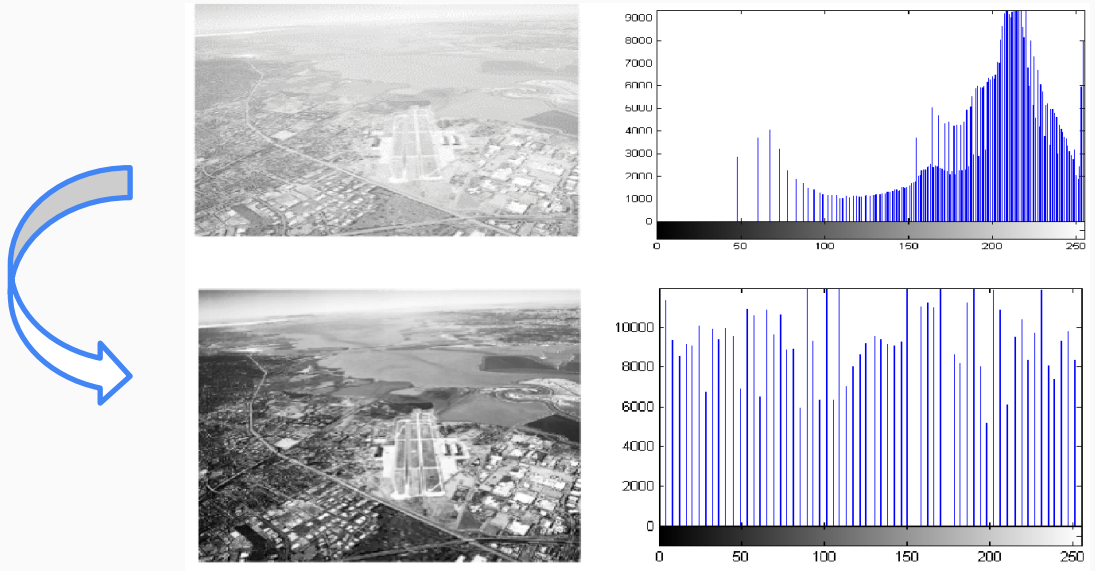




Contrast enhancement

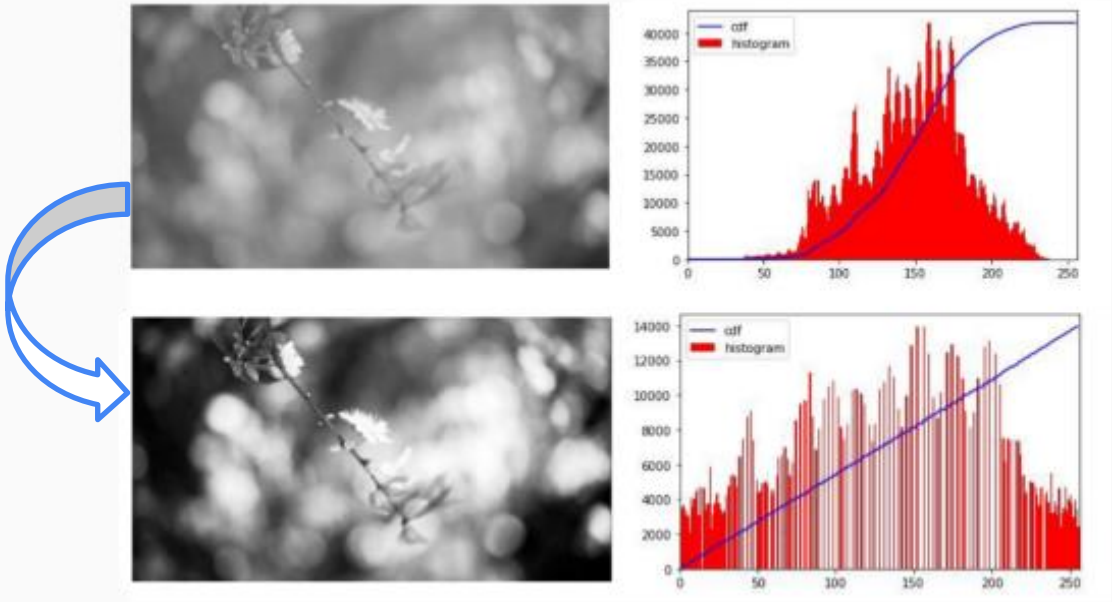
How to Do it

It uses Cumulative Density Function of the image then changes brightness of an image by flattening the histogram and stretching the image contrast to be distributed over all grey levels
Example:



Contrast enhancement

Another example:



Contrast enhancement

How Histogram Equalization Works?

1. Obtain the histogram.

$h(i) = p_i$

= (number of pixels of intensity level i / total number of pixels)

2. Obtain the cumulative distribution function CDF.

$$CDF = H(j) = \sum_{i=0}^{j} h(i) \qquad where\ j = 0, 1, \ldots\ldots, 254, 255$$

3. Calculate the transformation T to map the old intensity values to new intensity values.

$T(j) = round((L-1)*CDF_j)$

4. Now we can map each pixel in the input image to a new intensity

Contrast enhancement

Suppose that a 4-bit image block (L=16) of size 5*5 pixels (M*N = 25) has the intensity values (x_i) and their corresponding frequency (n_i).
Tyr to increase the contrast using histogram equalization.

x_i	n_i
0	2
1	2
2	1
5	4
6	5
8	6
10	5

Contrast enhancement

Suppose that a 4-bit image block (L=16) of size 5*5 pixels (M*N = 25) has the intensity values (x_i) and their corresponding frequency (n_i).
Try to increase the contrast using histogram equalization.

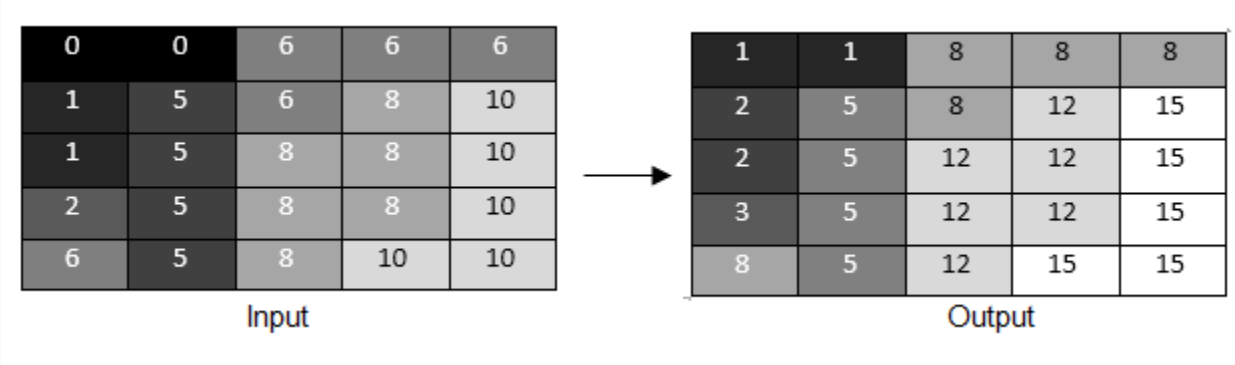
x_i	n_i
0	2
1	2
2	1
5	4
6	5
8	6
10	5

Probability	CDF	CDF*(L-1)	New value
0.08	0.08	1.2	1
0.08	0.16	2.4	2
0.04	0.2	3	3
0.16	0.36	5.4	5
0.2	0.56	8.4	8
0.24	0.80	12	12
0.2	1	15	15

Contrast enhancement

Suppose that a 4-bit image block (L=16) of size 5*5 pixels (M*N = 25) has the intensity values (x_i) and their corresponding frequency (n_i).
Try to increase the contrast using histogram equalization.

Input	Output
0	1
1	2
2	3
5	5
6	8
8	12
10	15



Contrast enhancement

Another way to improve the contrast for low contrast image is to use:

Log transform:

- a transformation used for image enhancement as it expands dark pixels of the image as compared to higher pixel values.
- It can be applied in images where low pixel values are more than higher ones or low contrast images.

The formula is:
S=c*log(1+p)
p :pixel value
c is 255 **or** maximum value in the image