Contrast Enhancement

Image Enhancement

- **Modification of an image** to alter its impact on viewer
- Enhancement makes it easier for **visual interpretation and understanding** of imagery.
- Process of making an **image more interpretable** for a particular application to accentuate certain image features for subsequent analysis or for image display
- Useful since many satellite images give inadequate information for image interpretation.
- **Attempted after image is corrected for distortions (Geometric error).**
- May be performed ***temporarily*** or ***permanently***.

Enhancement Types

- **RADIOMETRIC ENHANCEMENT**

  Modification of brightness values of each pixel in an image data set independently (Point operations).

- **SPECTRAL ENHANCEMENT**

  Enhancing images by transforming the values of each pixel on a **multiband basis**

- **SPATIAL ENHANCEMENT**

  Modification of pixel values based on the values of **surrounding pixels**. (Local operations)

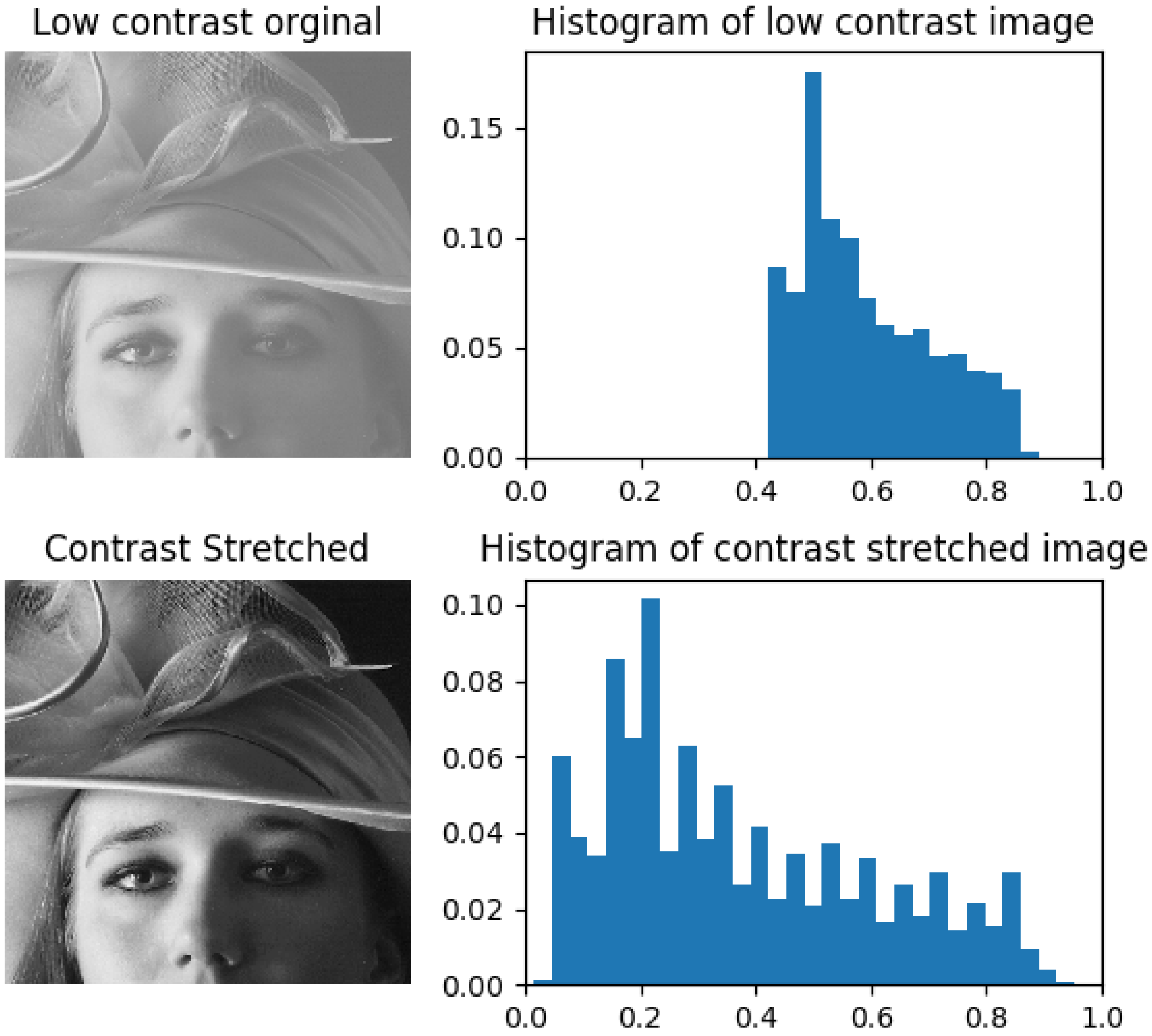
Radiometric Enhancement

- Brings out **contrast** in the image
- **Applied separately** to each **band** of data.
- Enhancement applied to one band may not be appropriate to other bands.
- ***Contrast Enhancement*** falls under Radiometric enhancement

Contrast

- **Rate of change of tone**
- More the **tonal variation** more the **contrast** in the image
- Amount of **difference between average gray level of an object** and that of surroundings
- Ratio of **Maximum Intensity to Minimum Intensity**
- Larger the ratio more easy it is to interpret the image

$$\text{Contrast} = \frac{\text{Max. Grey Value}}{\text{Min. Grey Value}}$$


Low contrast orginal
Histogram of low contrast image
0.15
0.10
0.05
0.00
0.0
0.2
0.4
0.6
0.8
1.0
Contrast Stretched
Histogram of contrast stretched image
0.10
0.08
0.06
0.04
0.02
0.00
0.0
0.2
0.4
0.6
0.8
1.0

Contrast Enhancement

- Expands the original input values to make use of the total range of the sensitivity of the display device.
- The **density values in a scene are literally pulled farther apart**, that is, expanded over a greater range.
- The effect is **to increase the visual contrast** between two areas of different uniform densities.
- This **enables the analyst to discriminate easily** between areas initially having a small difference in density.

Contrast Enhancement Types

Linear Contrast Stretch

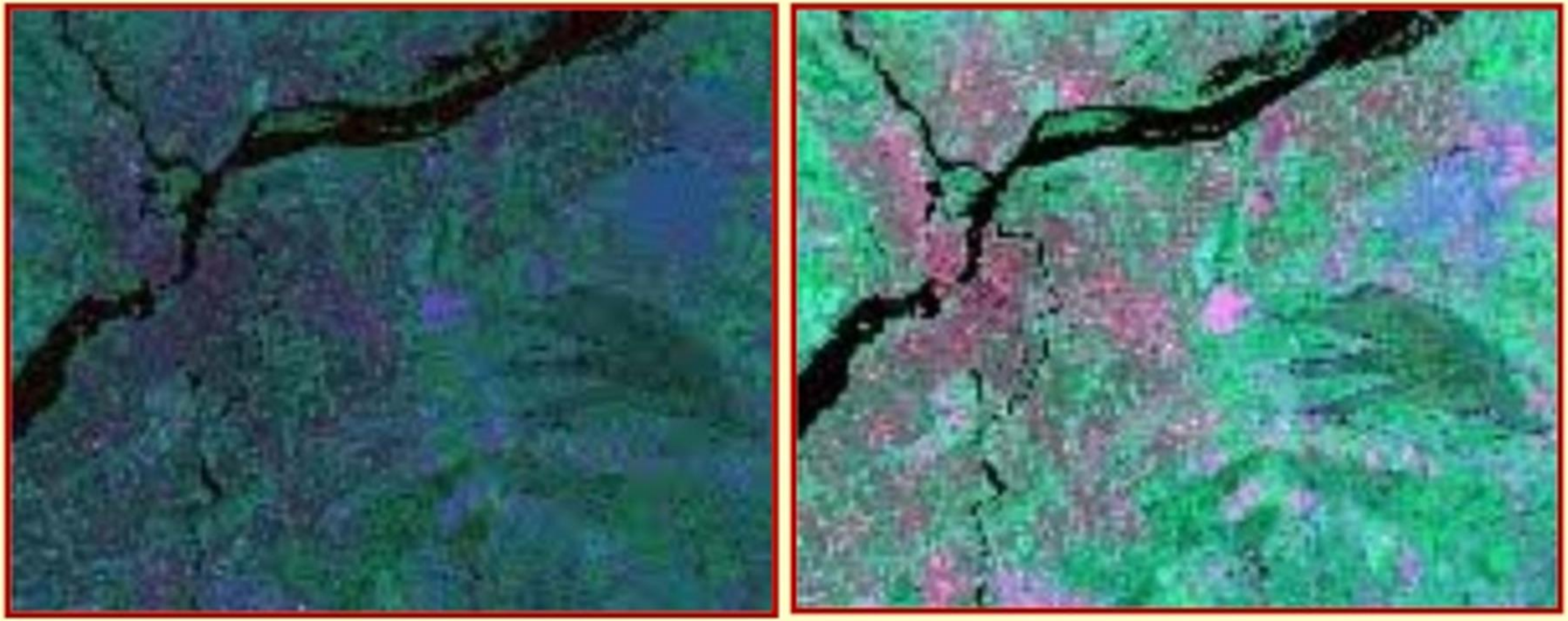
- Input and Output Data Values follow a **linear relationship**
- Min – Max Stretch
- Percent stretch
- Std. deviation Stretch
- Piecewise Linear Stretch

Non Linear Contrast Stretch

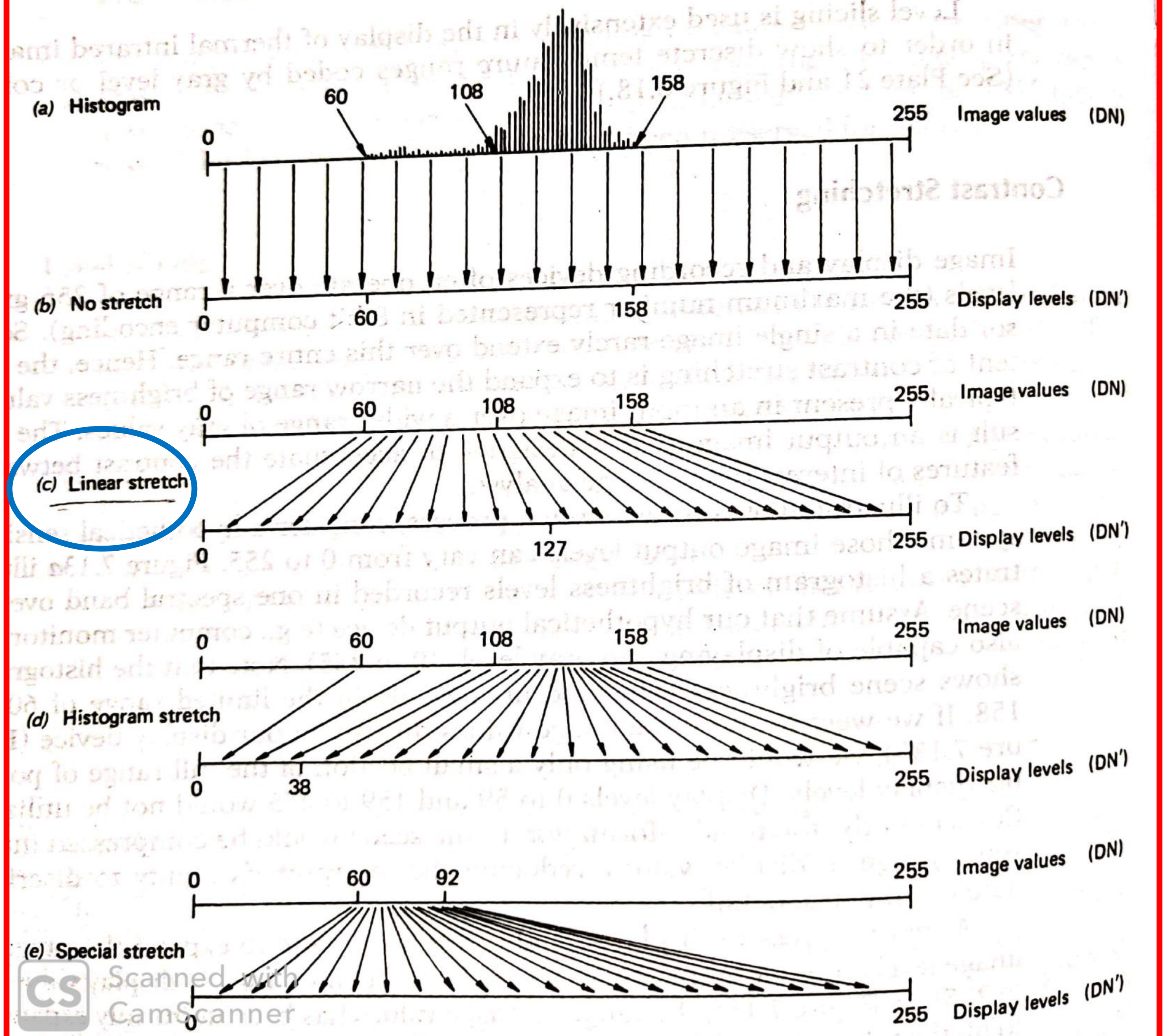
- Input and Output Data Values do not follow a linear relationship
- Logarithmic
- Inverse Log
- **Histogram Equalization**
- Exponential
- Square
- Square root etc ....

Linear Contrast Stretch

- A DN in the
  - ✓ **low range** of the original histogram is assigned to **extreme black**, and
  - ✓ value at the **high** end is assigned to **extreme white**.
- The **remaining pixel values are distributed linearly** between these two extremes
- *By expanding the original input values of the image, the total range of sensitivity of the display device can be utilized.*
- Linear contrast enhancement also makes **subtle variations** within the data more obvious.



This enhances the contrast in the image with **light toned areas appearing lighter** and **dark areas appearing darker**, making visual interpretation much easier. This graphic illustrates the increase in contrast in an image before (left) and after (right) **Linear contrast stretch**.



- Range 60 -158
- Mid value 108
- Display levels possible 256 (0-255)
- Mid value 127
- Unused grey levels (0-59) & (159-255)
- Stretching over unused display ranges in a linear manner is called linear stretching

- ✓ Image display and recording devices often operate over a range of **256 gray levels**.
- ✓ Sensor data in a single image **rarely extend over this entire range**.
- ✓ Hence, the intent of **contrast stretching is to expand the narrow range of brightness values**
- ✓ The result is an output image that is designed to accentuate the contrast between features of interest to the image analyst.
- ✓ *Illustration in Figure*
- ✓ This **uniform expansion is called a linear stretch**.

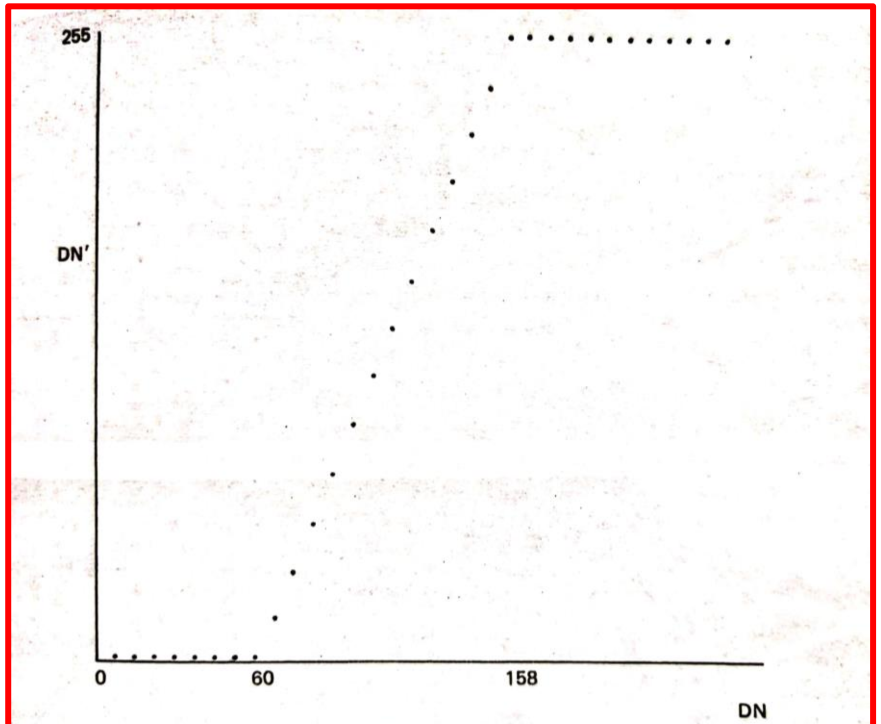
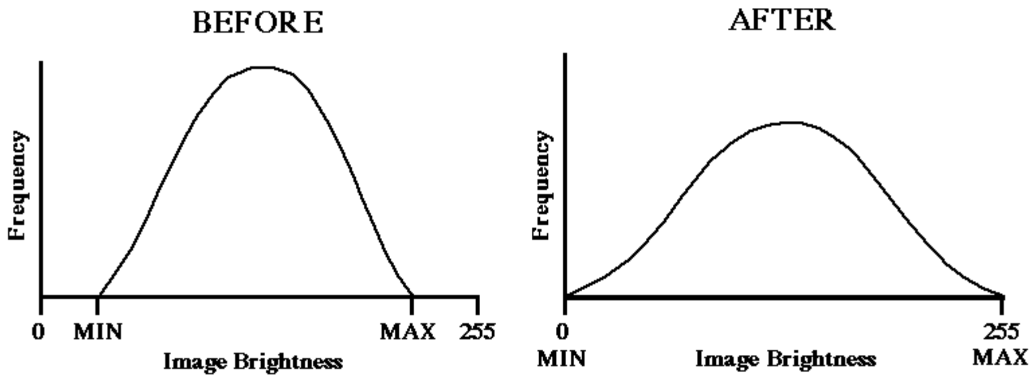


Figure 7.14 Linear stretch algorithm. Each point represents several discrete digital numbers.



Computations to stretch the data between 0- 255:

$$Y = \frac{X - X_{min}}{X_{max} - X_{min}} \times (255 - 0)$$

✓ Where

Y = DN assigned to pixel in *output* image

X = original DN of pixel in *input* image

X_{min} = minimum value of input image, to be assigned a value of 0 in the output image (*60 in our example*)

$Xmax$ = maximum value of input image, to be assigned a value of 255 in the output image (*158 in our example*).

- A straight line equation of expression

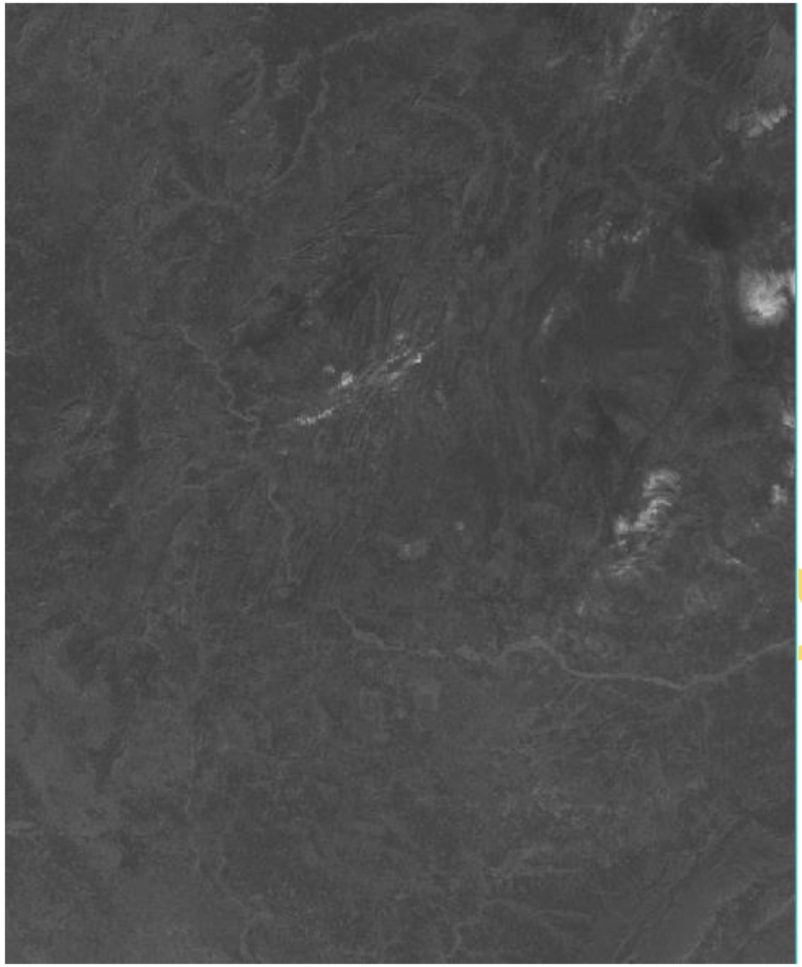
y = mx

- Where **m** is the slope of the straight line

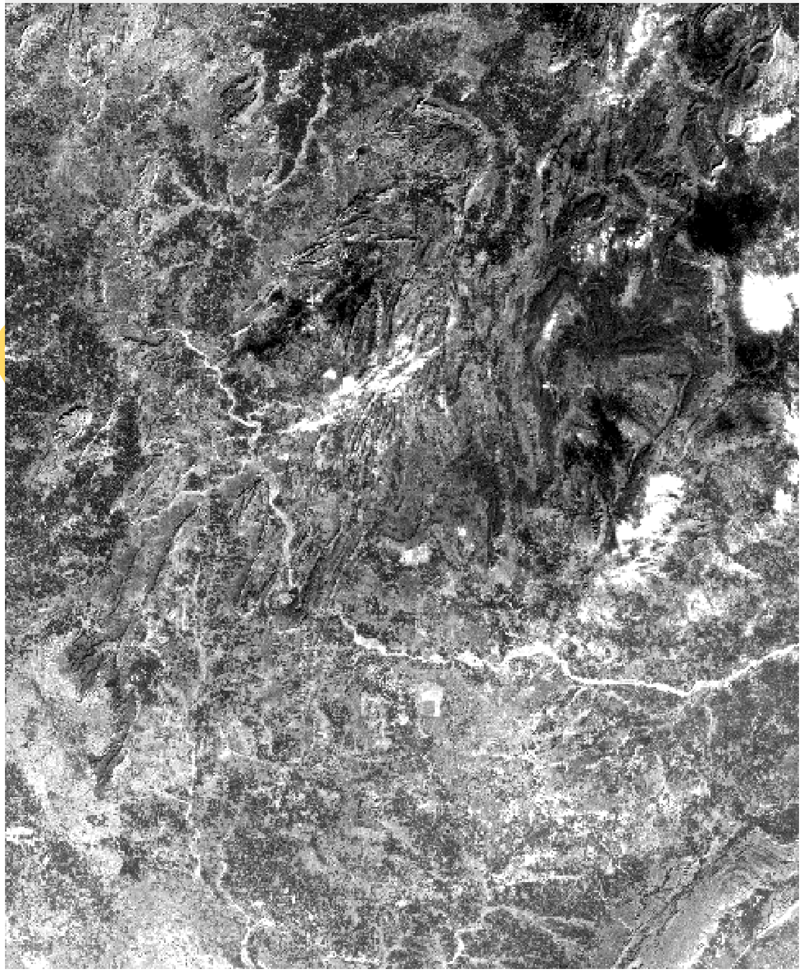
Drawback of the linear stretch

It assigns as many display levels to the rarely occurring image values as it does to the frequently occurring values

- ✓ For example, as shown in Figure c, **half of the dynamic range** of the output device (**0 to 127**) **would be reserved for the small number** of pixels having image values in the range **60 to 108**.
- ✓ The **bulk of the image data** (values **109 to 158**) are confined to half the output display levels (**128 to 255**).



No stretch



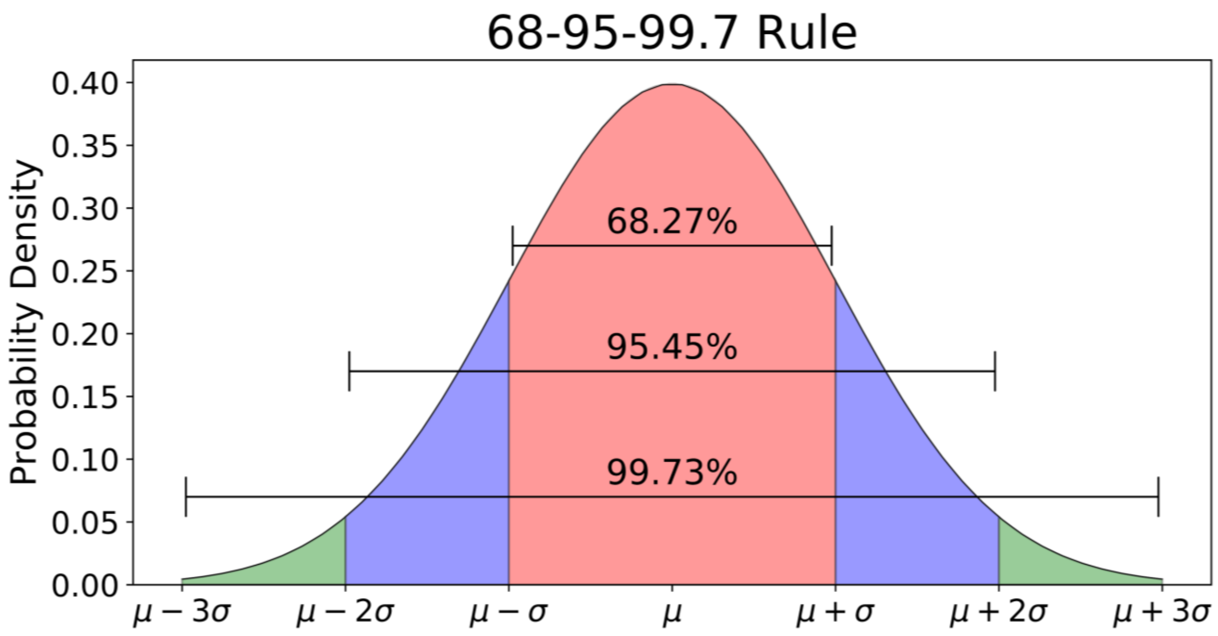
Linear stretch

Percentage Cutoff Stretch

- The percentage linear contrast stretch is similar to the minimum-maximum linear contrast stretch
- However, this method uses a **specified minimum and maximum values**
- These values (**min. or max**.) lie in a **certain percentage of pixels from the mean of the histogram**
- **Say 20 % of values on both sides of the mean**
  - ✓ **E.g. Mean DN in original image = 100**
  - ✓ **20% of 100 = 20**
  - ✓ **Min. DN value = 80 & Max. DN value = 120**

Standard Deviation Linear Stretch

- Similar to the minimum-maximum linear contrast stretch
- However, this method uses a specified minimum and maximum values
- These values **lie outside a certain standard Deviation of pixels from the mean of the histogram**.
- A standard deviation from the mean is often used to push the tails of the histogram beyond the original minimum and maximum values



In a **normal distribution**, about

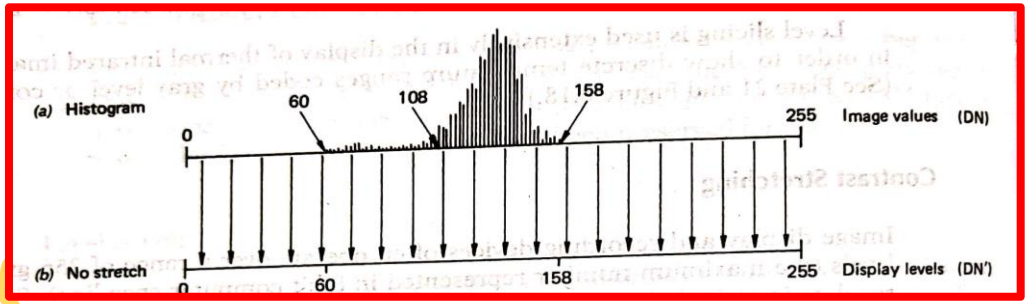
- 68% of the values are within one standard deviation (σ)of the mean
- about 95% of the values are within 2σ of the mean
- About 99% of the values lie within 3σ of the mean

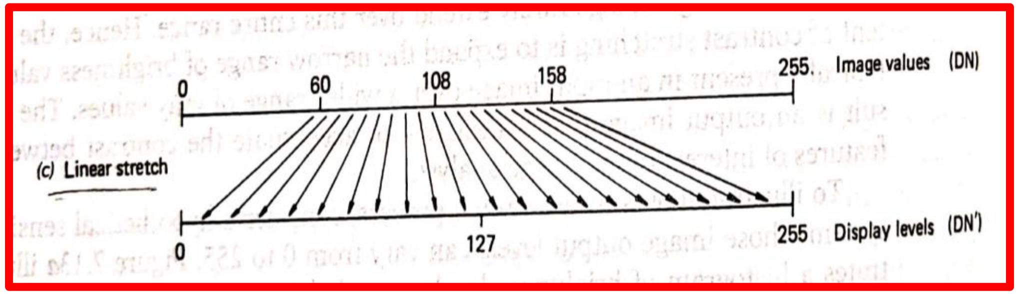
Piecewise linear Stretch

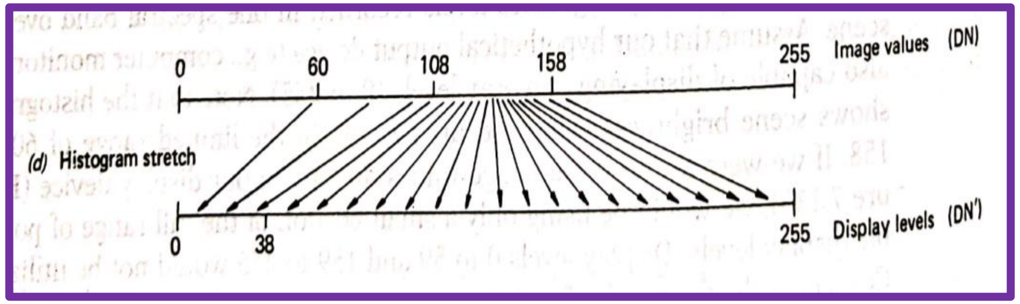
- When the distribution of a histogram in an image is **bi or tri-modal**, an analyst may stretch certain values of the histogram for increased enhancement in **selected areas**.
- This method of contrast enhancement is called a piecewise linear contrast stretch.
- A piecewise linear contrast enhancement involves the **identification of a number of linear enhancement steps that expands the brightness ranges in the modes of the histogram.**
- In the piecewise stretch, a **series of small min-max stretches** are set up within a single histogram.

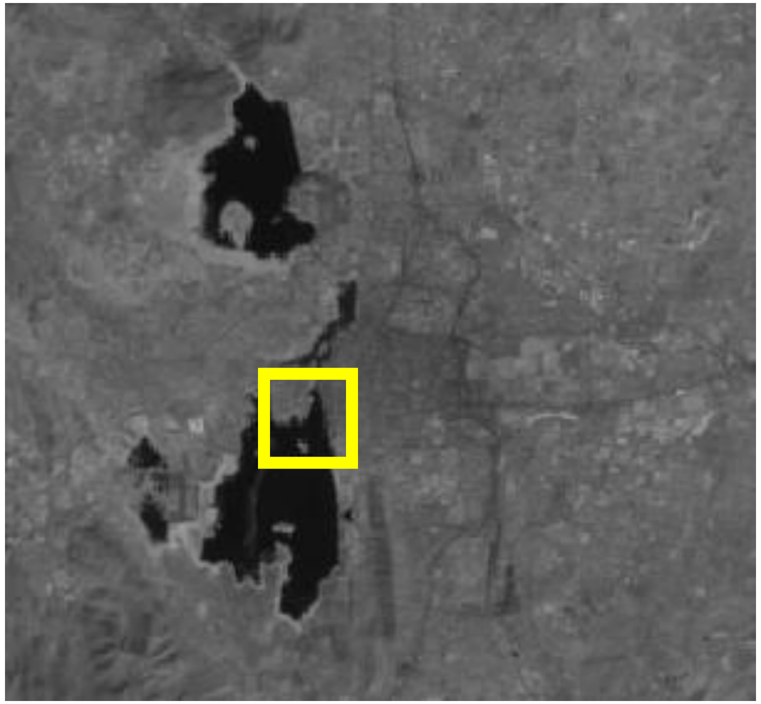
Histogram Equalization

- ✓ A **non-linear contrast stretching** method
- ✓ In this approach, image values are assigned to the display levels on the basis of their frequency of occurrence.
- ✓ As shown in Figure, more display values (and hence more radiometric detail) are assigned to the **frequently occurring portion of the histogram**.
- ✓ The image value range of **109 to 158** is now stretched over a large portion of the display levels (**39 to 255**).
- ✓ A smaller portion (**0 to 38**) is **reserved for the infrequently occurring** image values of **60 to 108**.
- ✓ For special analyses, specific features may be analyzed in greater radiometric detail by assigning the display range exclusively to a particular range of image values.

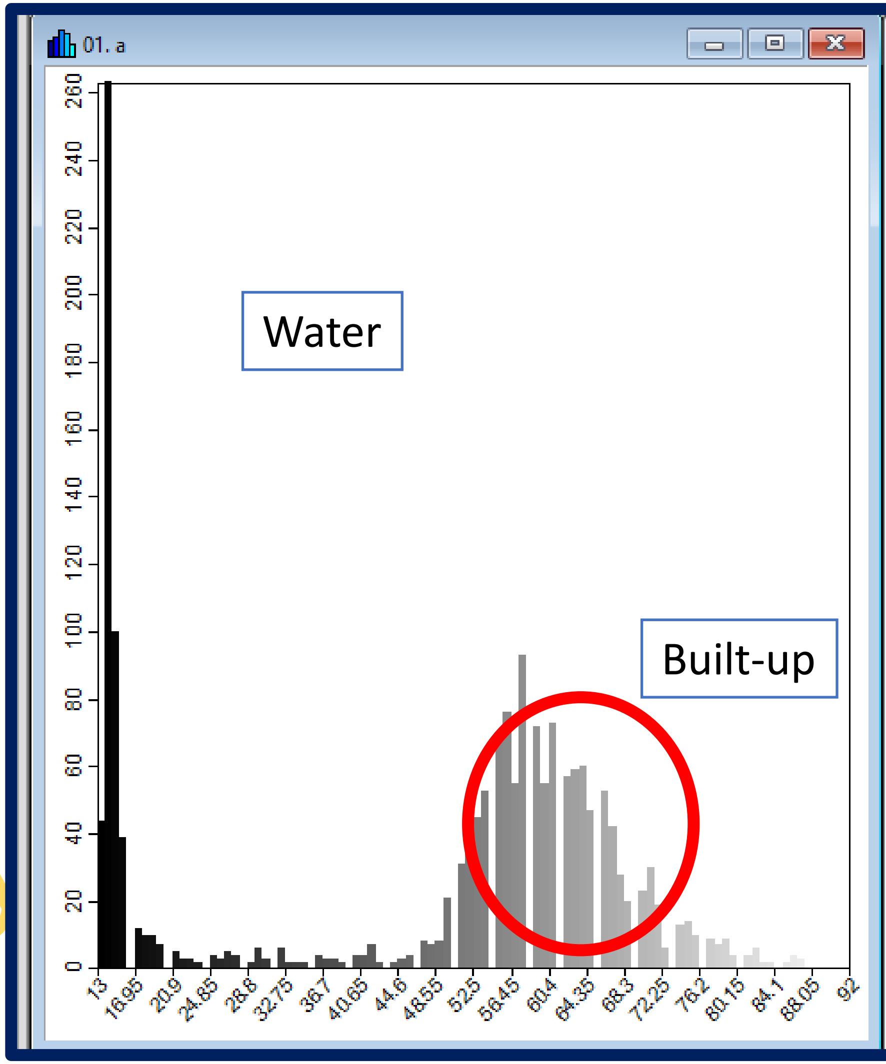


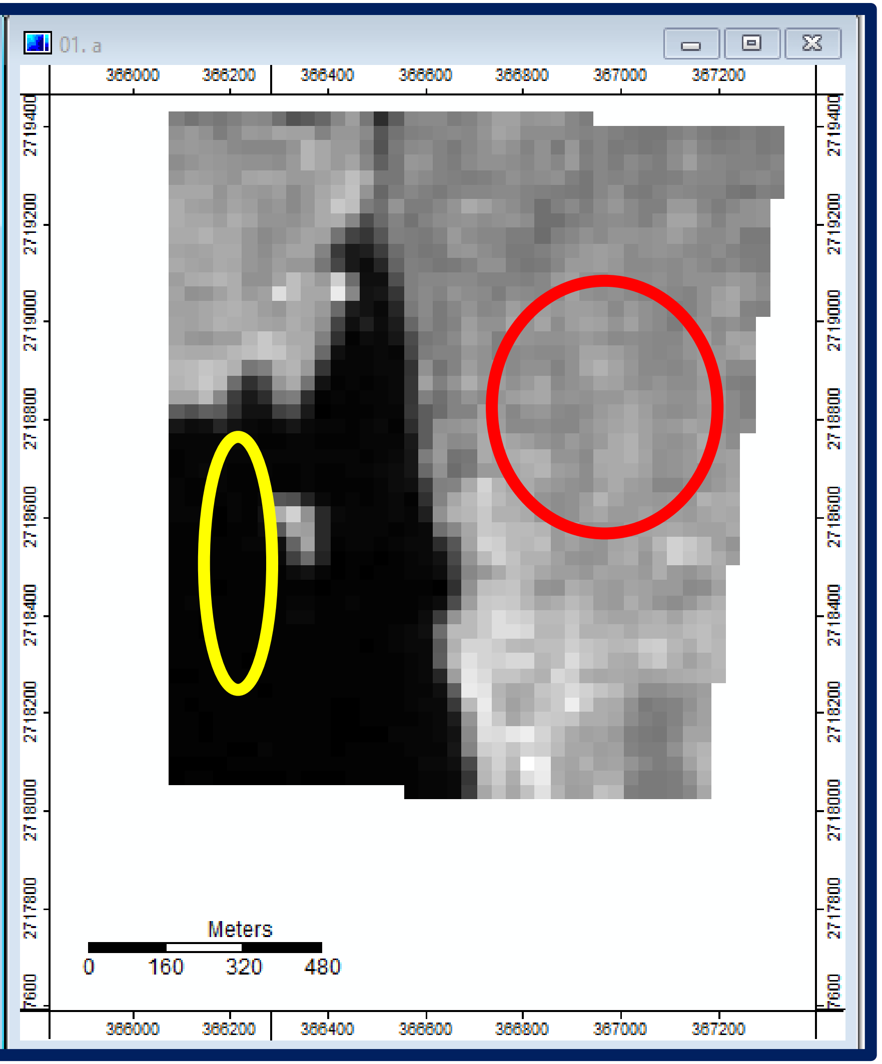






Subset of Lake Pichola, Udaipur
Landsat 7, Band NIR, 2001





Analysis of Histogram of feature of interest is important to identify which portion of DN values is to be stretched