Lecture 2:

Image Enhancement

Why Enhancement?

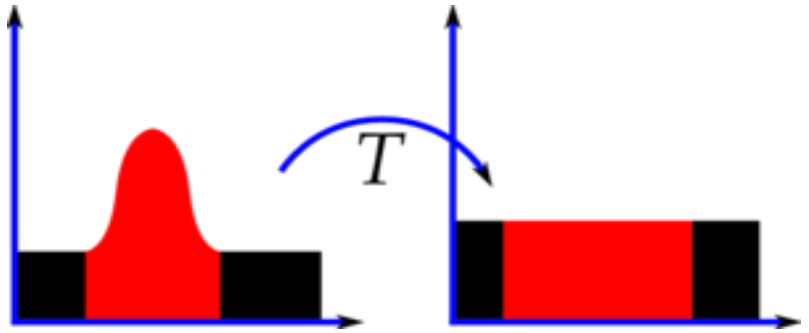
- Images may suffer from the following degradations:
  - **Poor contrast** due to poor illumination or finite sensitivity of the imaging device
  - Electronic **sensor noise** or atmospheric disturbances leading to broadband noise
  - Aliasing effects due to **inadequate sampling**
  - Finite aperture effects or motion leading to spatial

Cont..

- There are various and simple algorithms for image enhancement based on lookup tables
  - ***Contrast enhancement***
- Other algorithms also work with simple linear filtering methods
  - ***Noise removal***

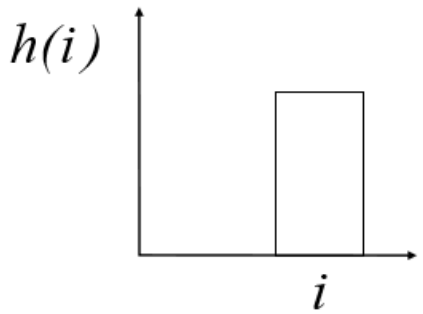
Histogram equalisation

- Equalization increases the global **contrast** of many images, especially when the usable **data** of the image is represented by close contrast values.
- Through this adjustment, the **intensities** can be better distributed on the histogram.This allows for areas of lower local contrast to gain a higher contrast.
- Histogram equalization accomplishes this by effectively ***spreading out the most frequent intensity values***.
  - ✓The method is useful in images with backgrounds and foregrounds that are both bright or both dark. In particular, the method can lead to better views of **bone** structure in **x-ray** images

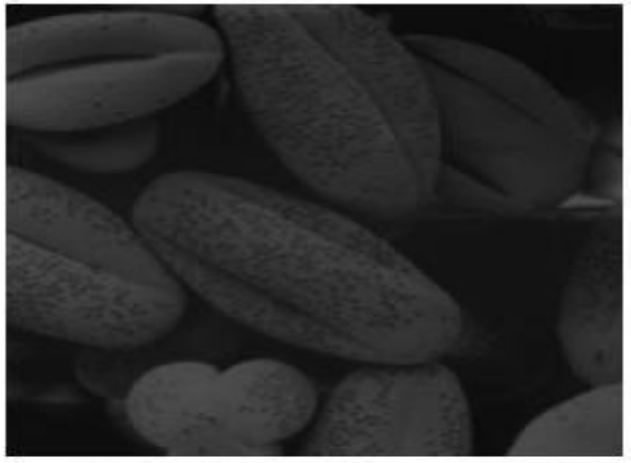


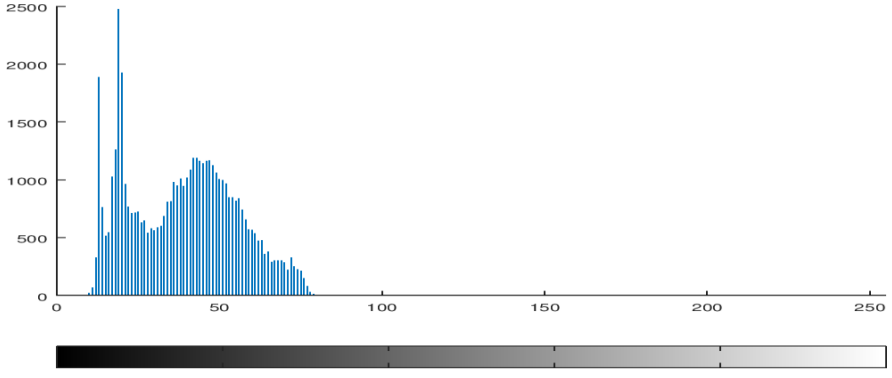
Histogram equalisation

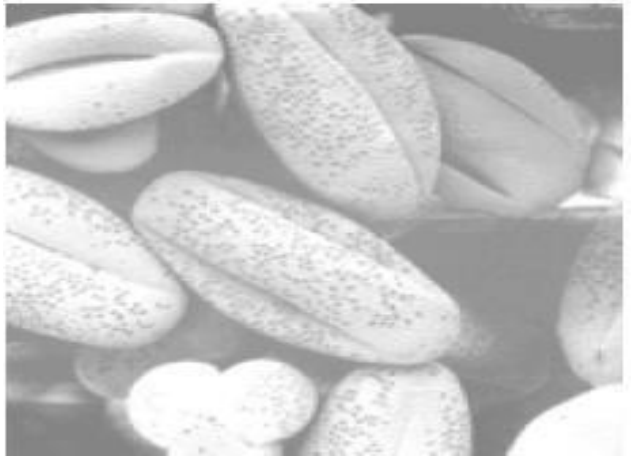
- In an image of low contrast, the image has grey levels concentrated in a narrow band
  - *The grey-levels are not too dark or too bright but in the middle. And it covers only few grey-level intensity range*
- Define the grey-level histogram of an image *h(i)* where :
  - *h(i)*=number of pixels with grey level = *i*
- Graphically, the histogram for a specific grey-level will be:

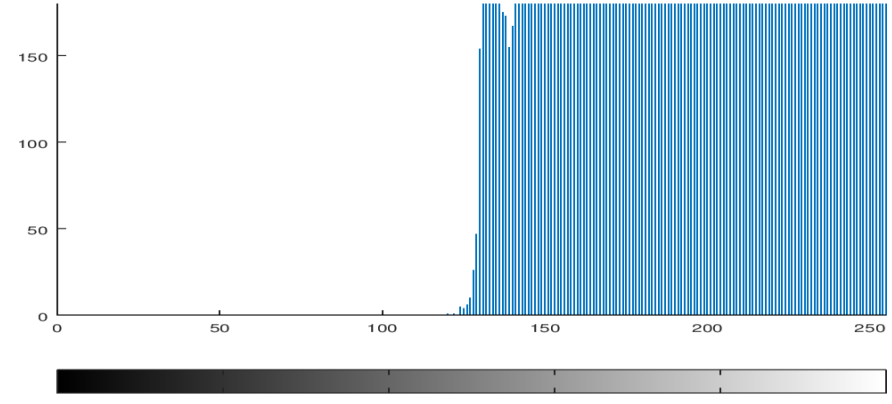


Darker vs BrightImage

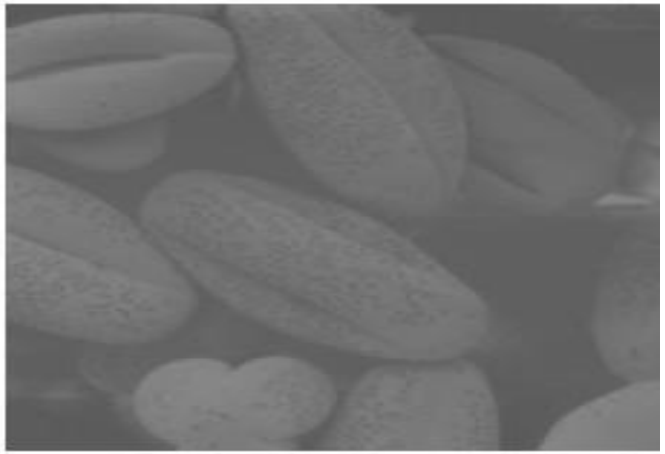


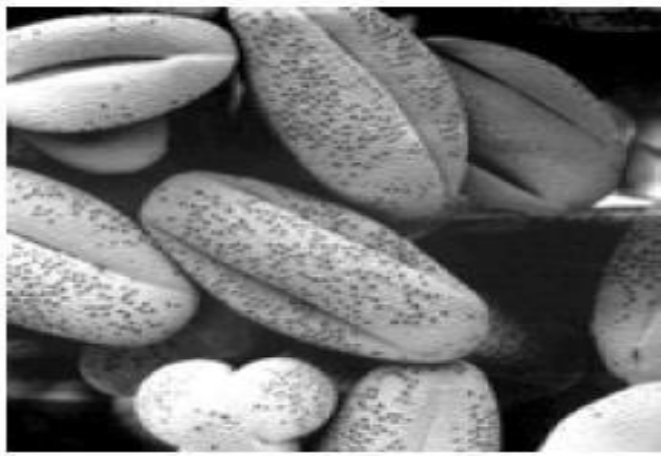


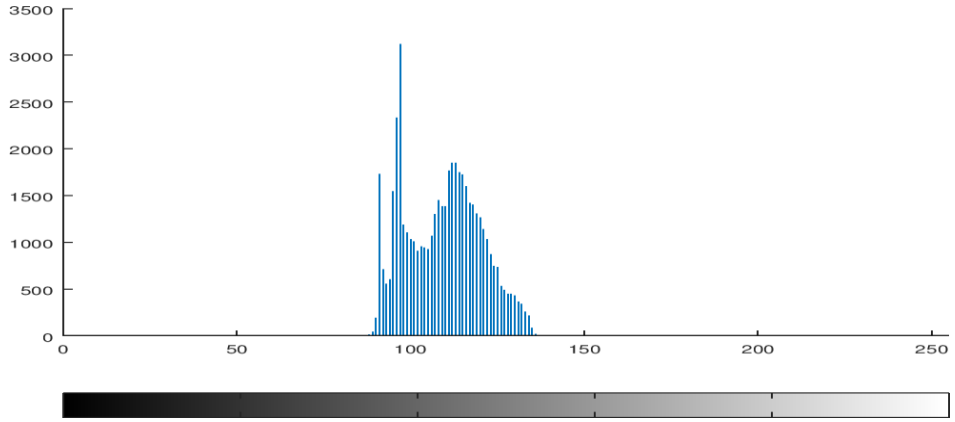


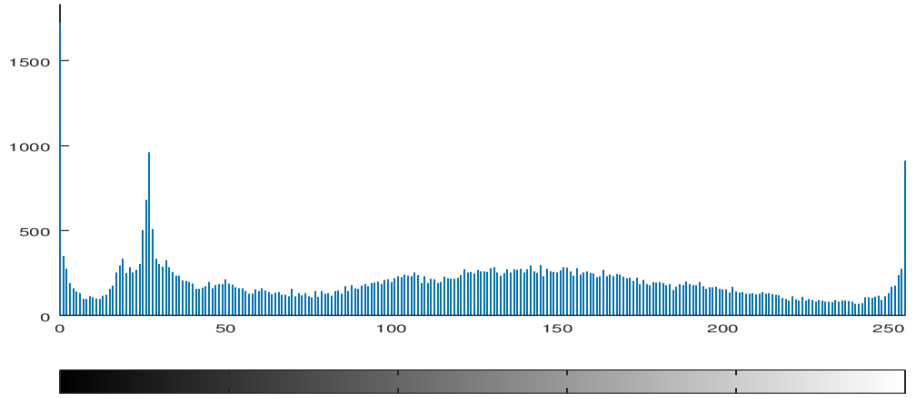


Low vs High Contrast Image









Histogram equalisation

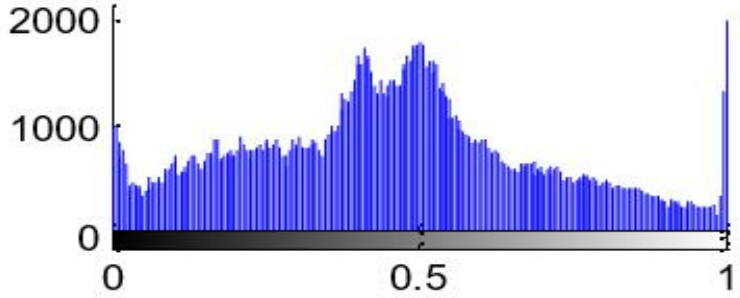
Original

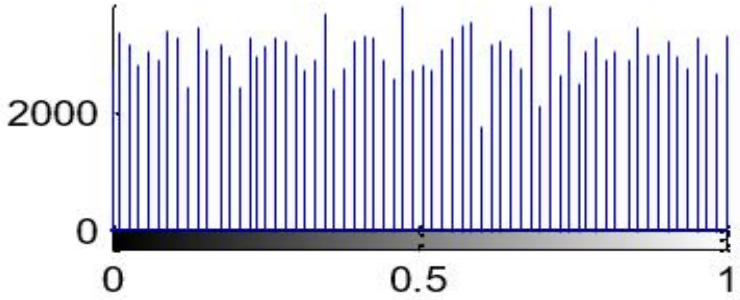
Black/White

Grey Level

Histogram Equalized

Histogram Equalized Image

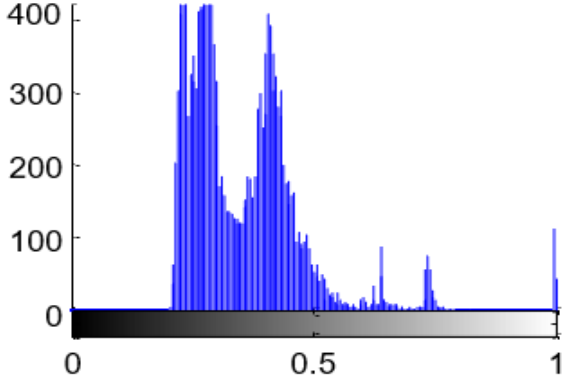




Improving a Low Contrast Image

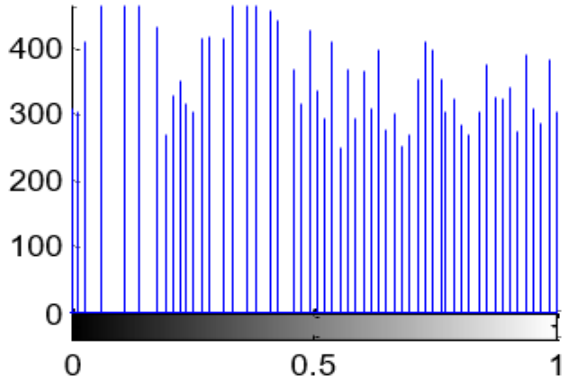
Original

Histogram of Low Contrast Image

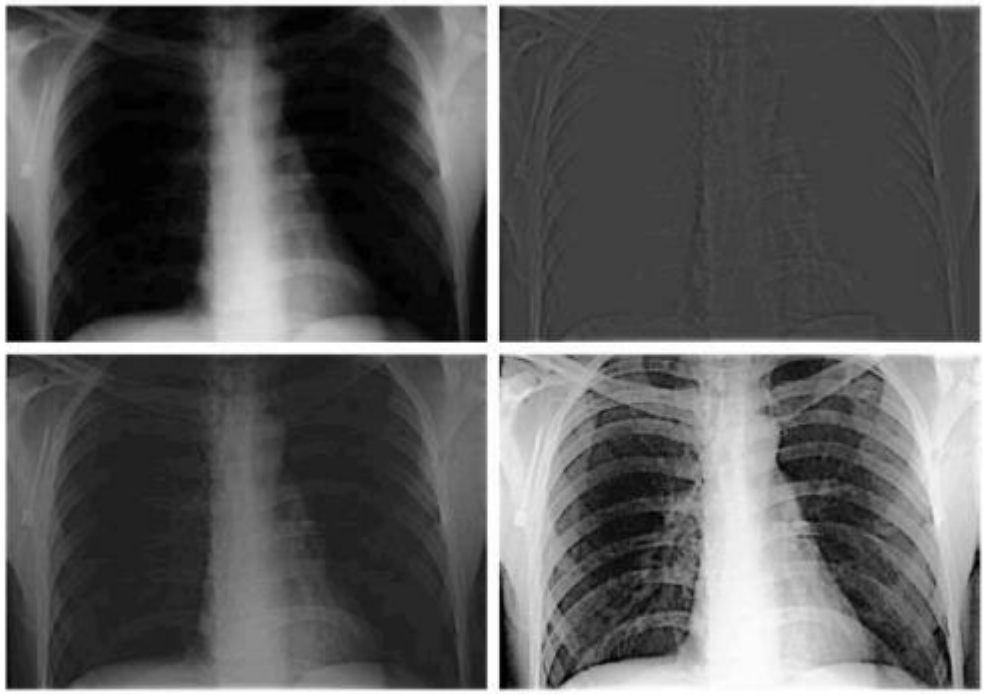


Histogram Eqalizedl

Histogram of Equalized Image



Histogram equalisation



Gaussian highpass filtering

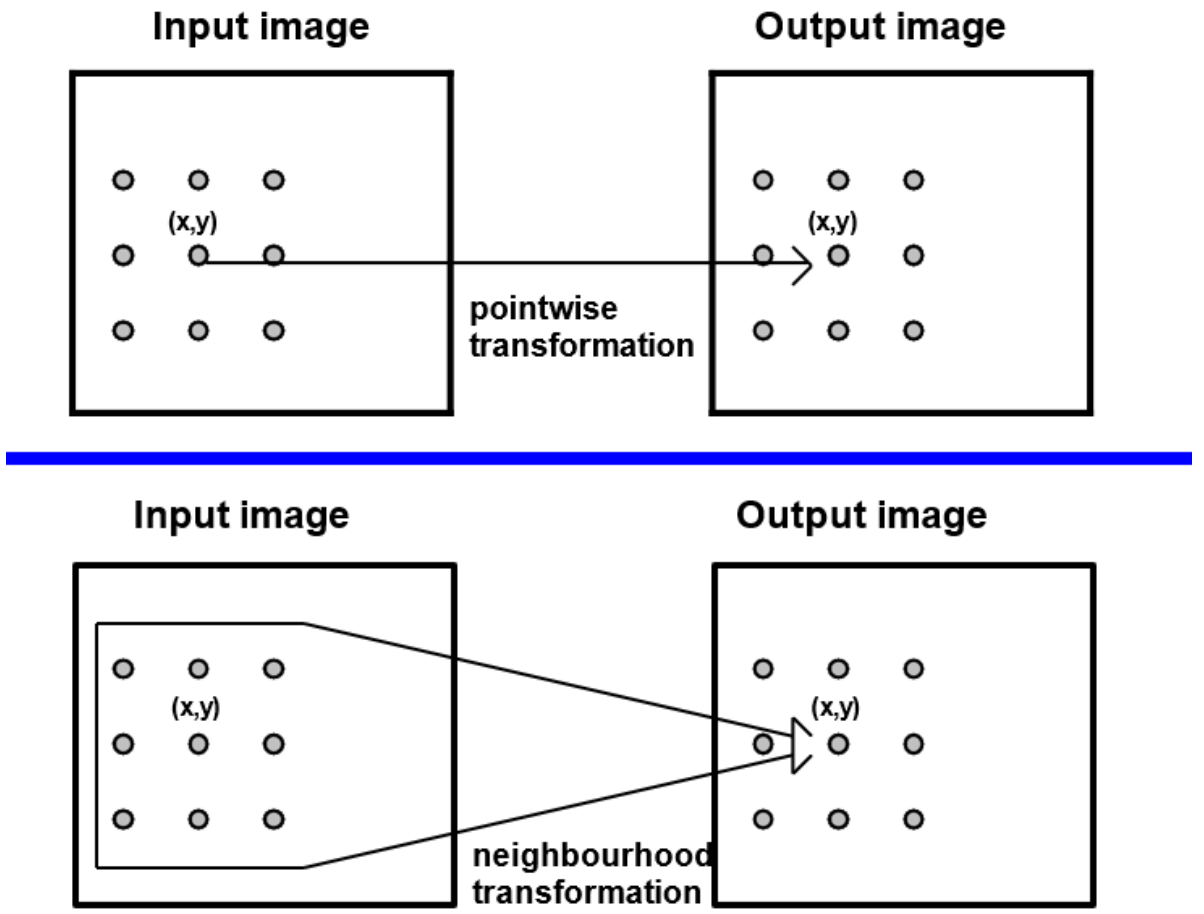
High-frequency emphasis filtering

Histogram Equalisation

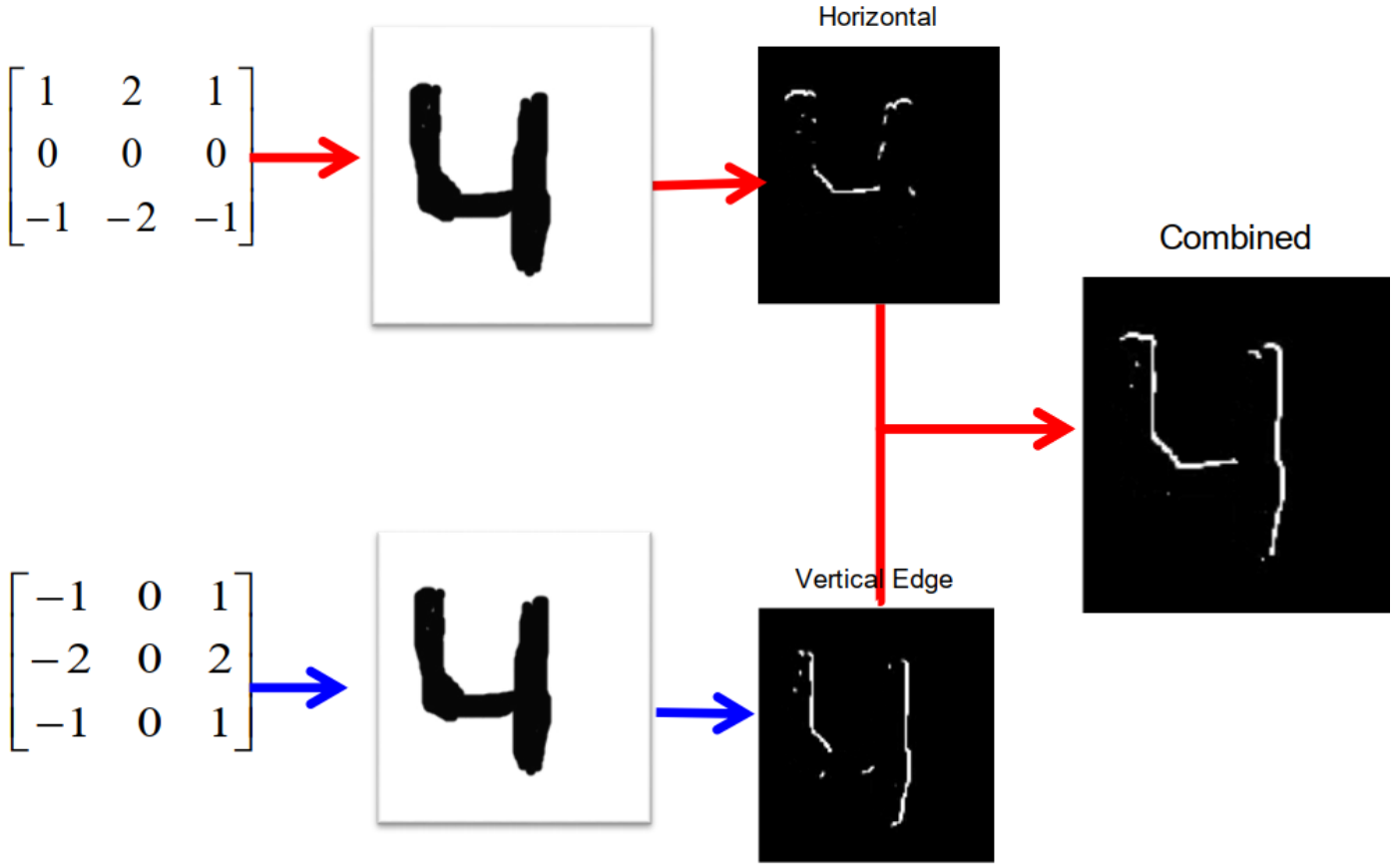
Image Filtering

- Simple image operators can be classified as:
  - **'pointwise'** which changes a pixel independent of the others;
  - **'neighbourhood'** (filtering) which changes the pixel value by consulting some or all of its neighbours
- ***Histogram equalisation is a pointwise operation***
- More general filtering operations use neighbourhoods of pixels

Image Filtering

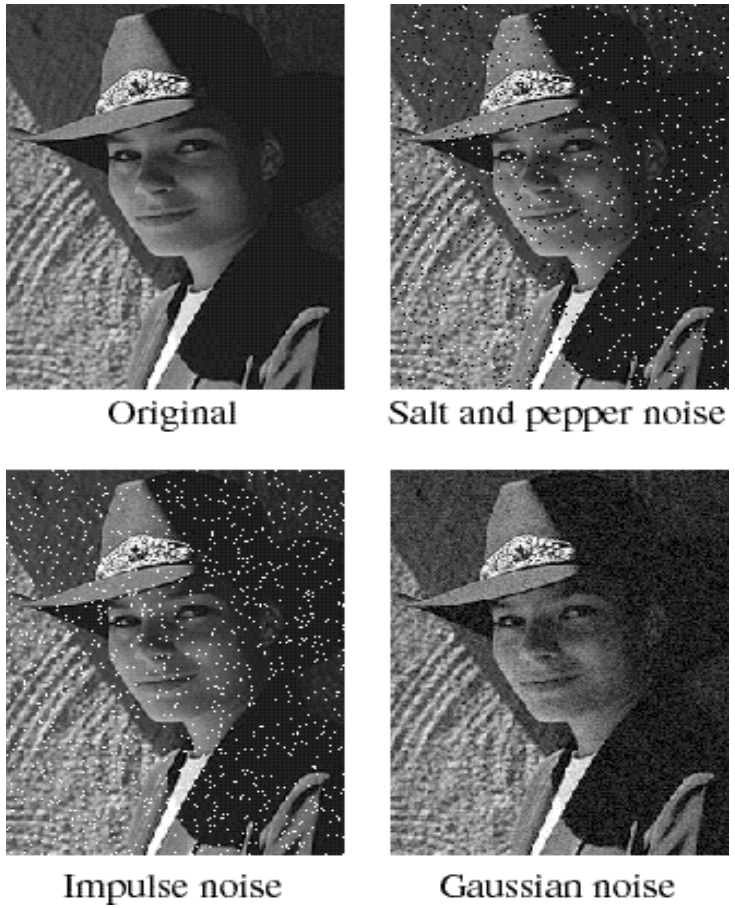


Edge Detection



Smoothing spatial filters

- Common types of noise:
  - Salt-and-pepper noise: contains random occurrences of black and white pixels.
  - Impulse noise: contains random occurrences of white pixels.
  - Gaussian noise: variations in intensity drawn from a Gaussian normal distribution.



Linear filtering and convolution

Original

Noisy

Filtered

σ=1.5

Filtered

σ=3.0

Conclusion

- We have looked at basic (low level) image processing operations
  - Enhancement
  - Filtering
- These are usually important pre-processing steps carried out in computer vision systems

The End