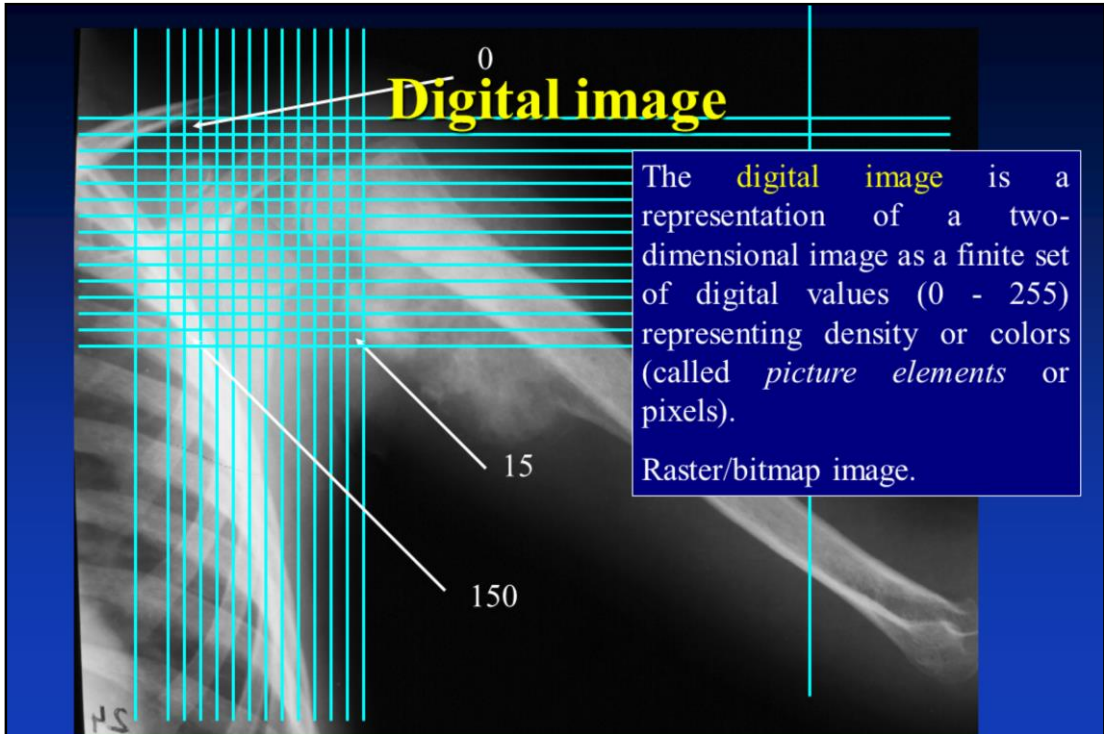


Medical digital imaging
Digital image processing



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Informatics



A digital image is discretized both in spatial coordinates and brightness.

Digital image processing

To search and enhance the information stored in the pictures.

Consists of three parts:



Enhancement for human perception



Segmentation, classification



Recognition




The aim of the digital image processing is to search and enhance the information stored in the pictures.

A main objective of Image Processing is to help a user to interpret an image.

The ultimate aim is the autonomous machine application, computer or machine vision

Image enhancement


Enhancing pictorial information for human interpretation and analysis




- Point Operations (Single Operand)
- Point Operations (Dual Operands)
- Neighbors Operations
 - Linear
 - Non-linear

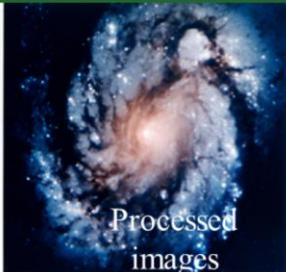
- Brightness adjustment
- Contrast enhancement
- Gamma correction
- Windowing
- Magnification, zoom
- Noise filtering, deblurring

Hubble telescope
Launched
in 1990





Incorrect mirror
made images



Processed
images

The most common aim of using digital image processing techniques is to improve quality, remove noise etc.

Point Operations (Single Operand)

Point Operations (Dual Operands)

Neighbors Operations

Linear

Non-linear

Launched in 1990 the Hubble telescope can take images of very distant objects.

However, an incorrect mirror made many of Hubble's images useless.

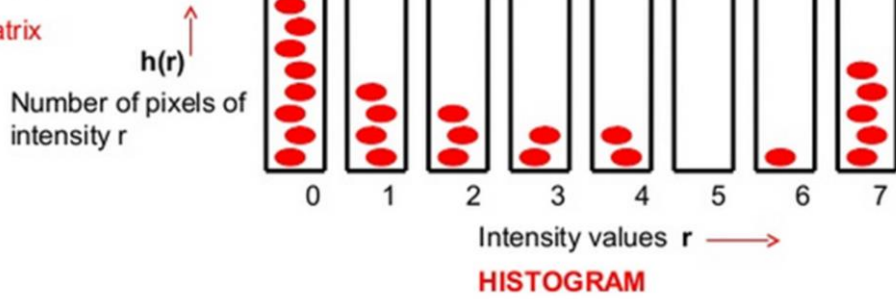
Image processing techniques were used to fix this

What is histogram?

0 7 3 2 3
0 0 0 6 7
7 7 2 2 0
1 1 0 4 1
0 0 7 4 1

Image matrix

r	0	1	2	3	4	5	6	7
h(r)	8	4	3	2	2	0	1	5

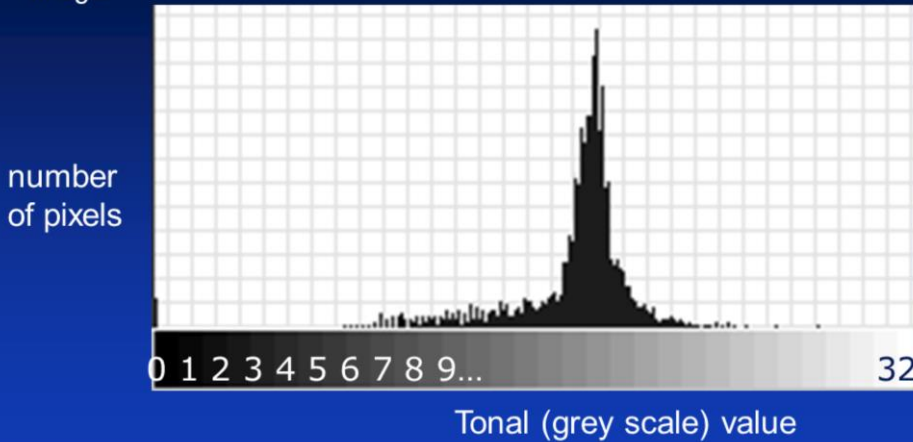


Histogram plots the number of pixels for each intensity value

Important information about the image.

Histogram

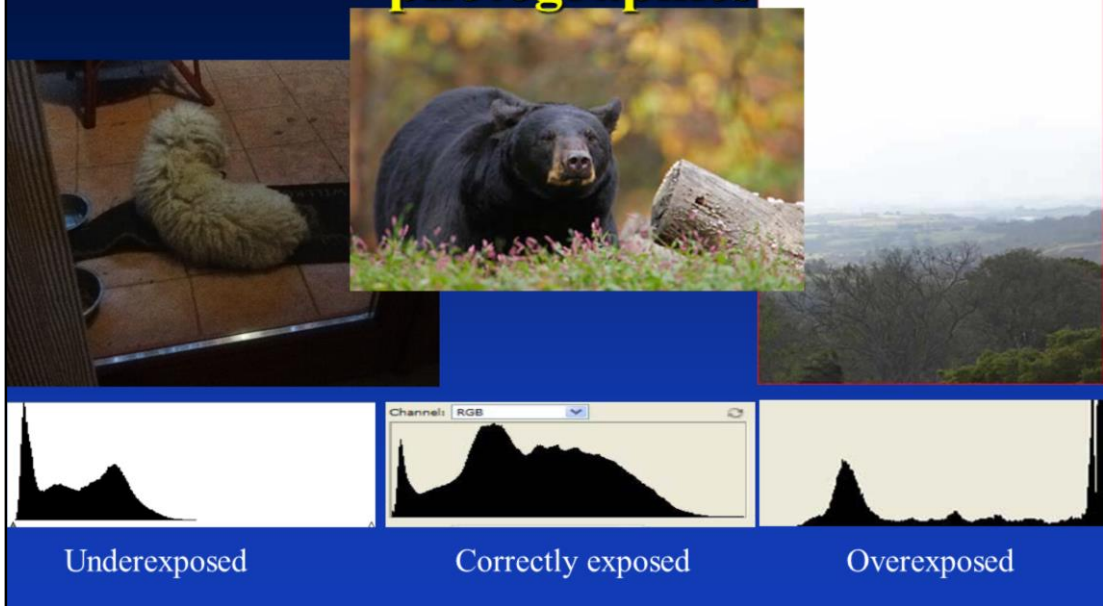
An image histogram is a graphical representation of the tonal distribution in a digital image.



5-bit grayscale image (32 different possible intensities)
the histogram displays 32 numbers showing the distribution of pixels
amongst those grayscale values.

It plots the number of pixels for each tonal value. By looking at the histogram for a specific image a viewer will be able to judge the entire tonal distribution at a glance.

Histograms of digital photographs



Some histogram of digital photographs.

Underexposed, correctly exposed and overexposed images

The light grey part of the histogram is absent.

The considerable predominance of mid grey colors can be seen in the histogram of the correctly exposed image.

The histogram is sliding towards the light part.

Operations on pictures

- Point Operations (Single Operand)
- Point Operations (Dual Operands)
- Neighbors Operations (filtering)

The most common aim of using digital image processing techniques is to improve quality, remove noise etc.

Point Operations (Single Operand)

Point Operations (Dual Operands)

Point Operations (Single Operand)

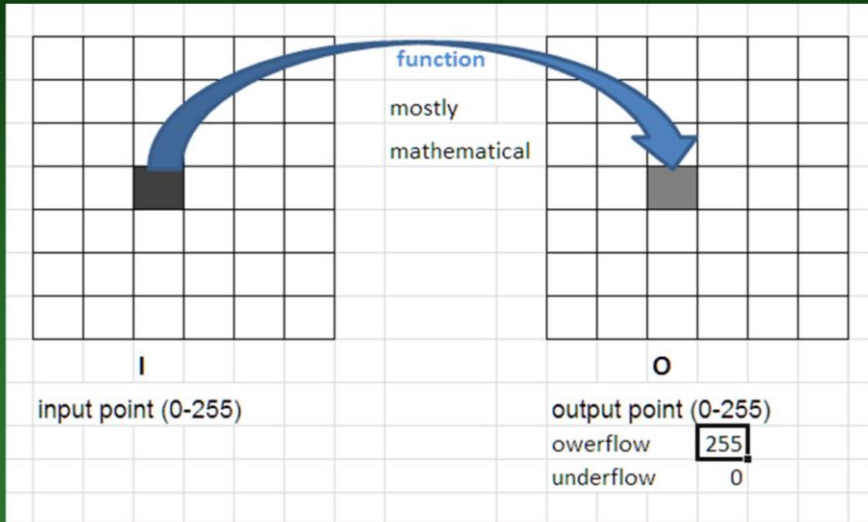
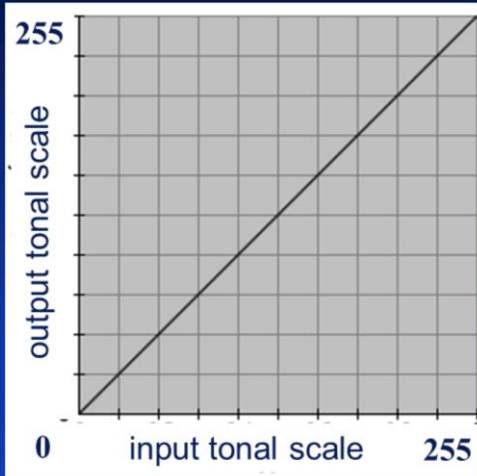


Image manipulation presented by graph



Point-wise Intensity Transformation

The horizontal gradient represents the input tonal scale (0-255).

The vertical gradient represents the destination, the output tonal scale (0-255)



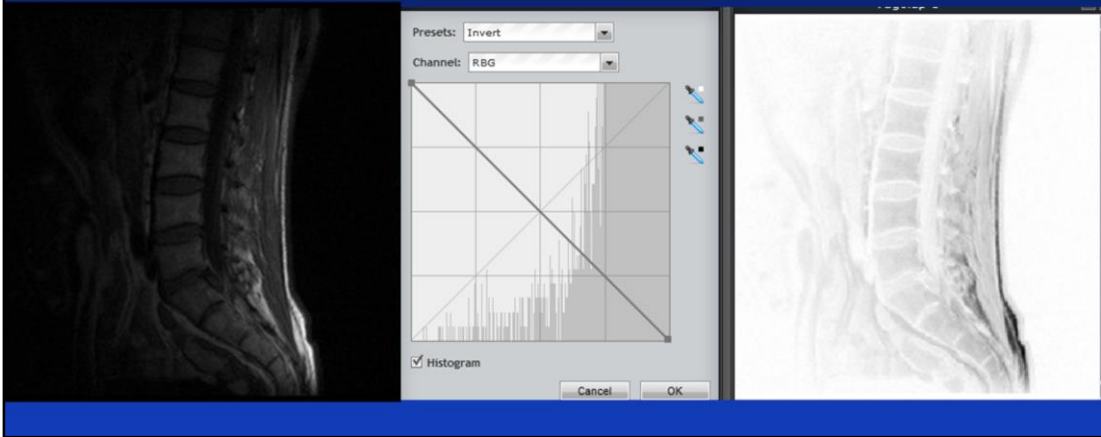
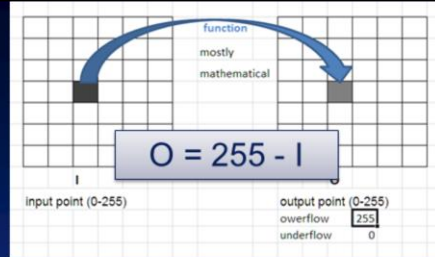
The horizontal gradient represents the input tonal scale. It, too, ranges from 0 (black) to 1 (white), from Shadows to Highlights. When you adjust the curve, it splits up into two parts; the upper part then represents the *tonal balance* of the layer or selection.

The vertical gradient represents the destination, the output tonal scale. It ranges from 0 (black) to 255 (white), from shadows to highlights.

The curve is drawn on a grid and goes from the bottom left corner to the top right corner.

This curve is straight, because every input level corresponds to the same output tone.

Invert (negative image)



Brightness

Low



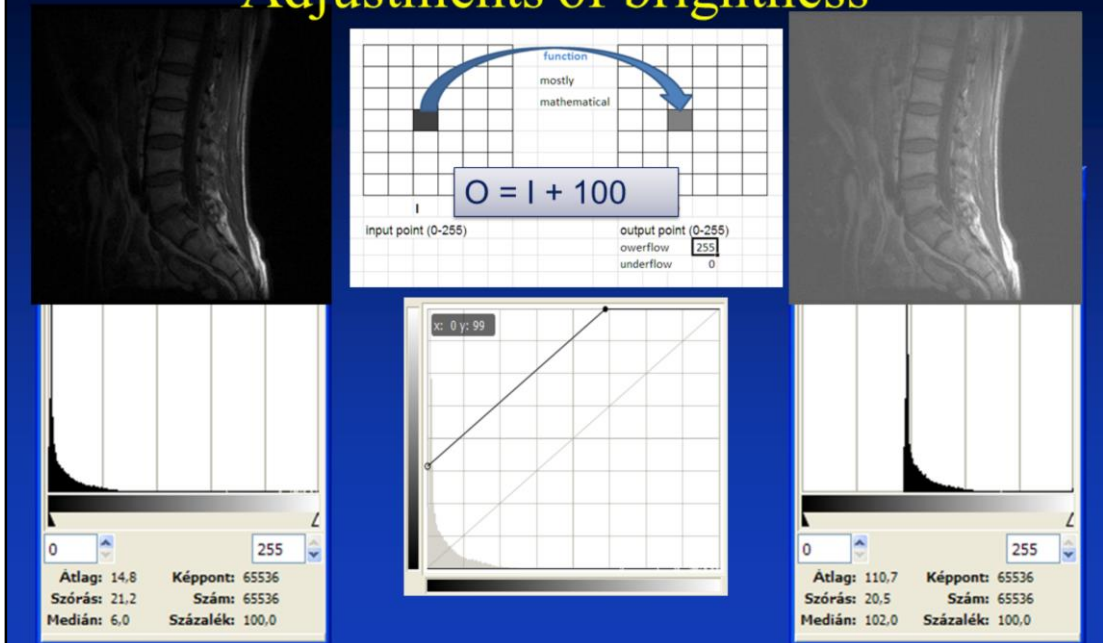
High



The brightness shows that from the given part of the picture how much light (luminance) is coming to our eye.

Brightness is an attribute of visual perception in which a source appears to be radiating or reflecting light. In other words, brightness is the perception resulted by the luminance of a visual target.

Adjustments of brightness

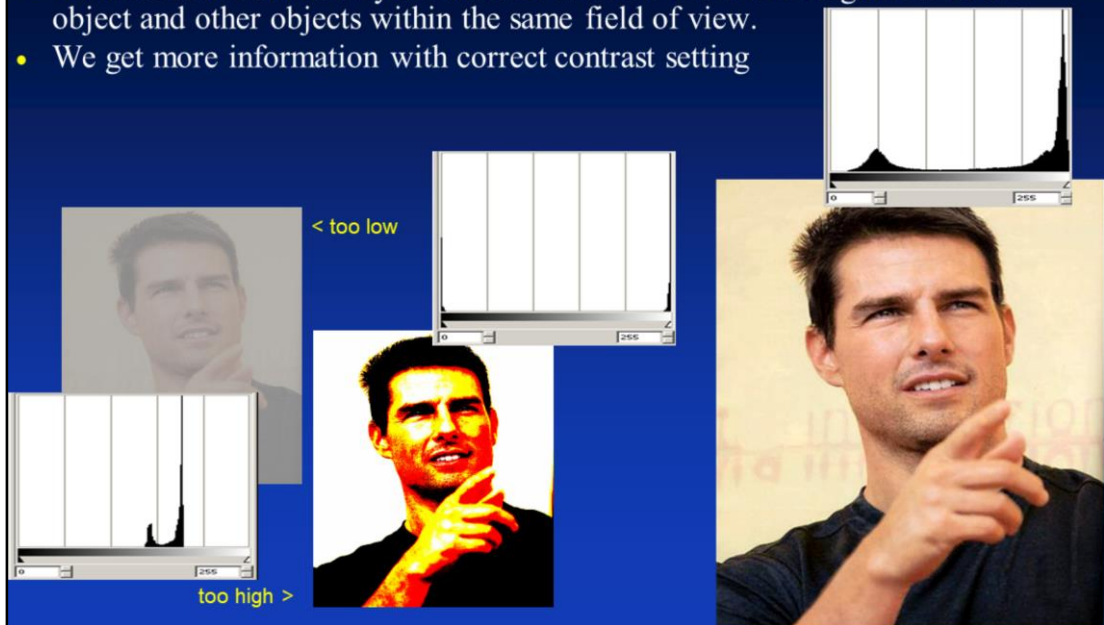


Manipulating the brightness lets you make simple adjustments to the tonal range of an image. This makes the same adjustment to every pixel in the image.

The image processing program generally adds a constant to the picture if we increase the brightness so it will be brighter.

Contrast

- Contrast is determined by the difference in the color and brightness of the object and other objects within the same field of view.
- We get more information with correct contrast setting

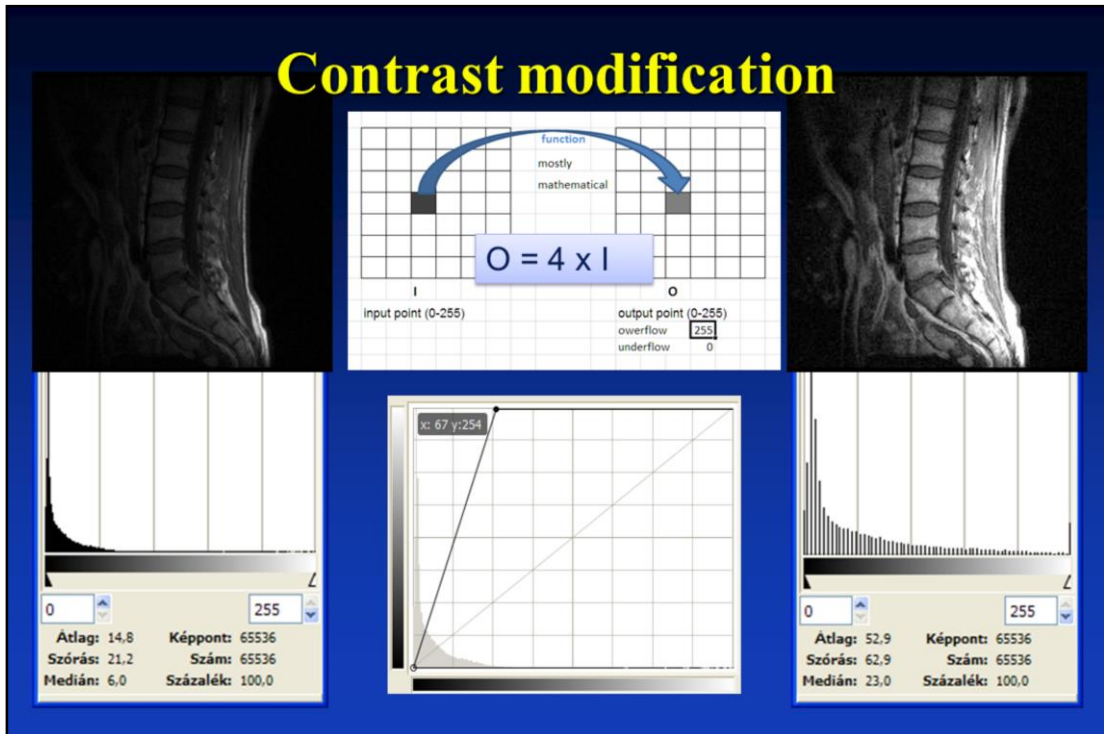


Contrast is the difference in luminance or colour that makes an object (or its representation in an image) distinguishable from other objects and the background. In visual perception of the real world, contrast is determined by the difference in the color and brightness of the object and other objects within the same field of view.

Notice the relationships between the images and their histograms

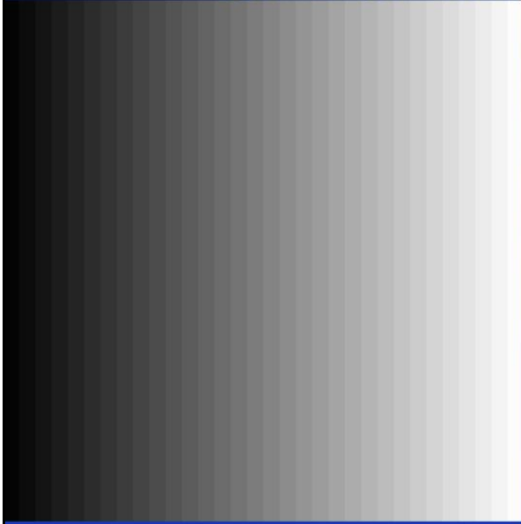
Note that the high contrast image has the most evenly spaced histogram

Contrast modification

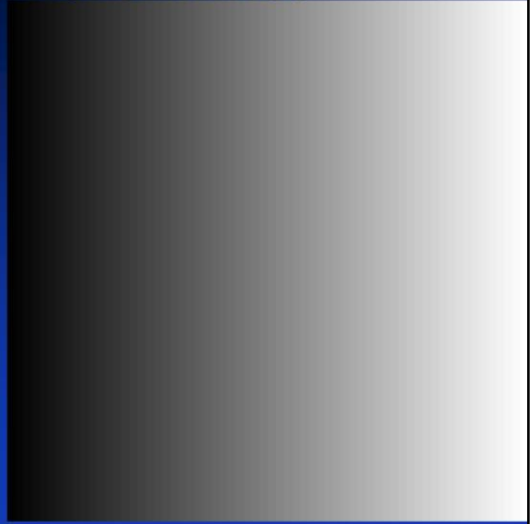


Contrast enhancement increases the total contrast of an image by making light colors lighter and dark colors darker at the same time. It does this by setting all color components below a specified lower bound to zero, and all color components above a specified upper bound to the maximum intensity (that is, 255). Color components between the upper and lower bounds are set to a linear ramp of values between 0 and 255. Multiplying - the histogram is widening.

How many different gray levels can humans differentiate?



32

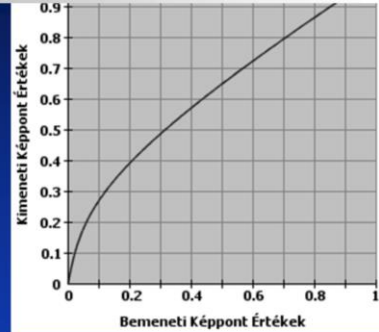


64

Gamma correction

1. The intensity of pixel 64 is approximately two times brighter than that of pixel 32.
2. Our eye does not perceive the light grades linearly, it can less distinguish grades in the dark field.

$$O = I^{1/\text{gamma}}$$

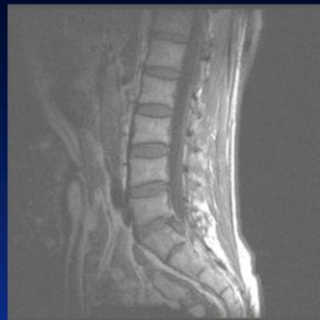
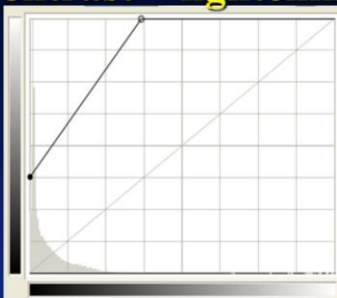
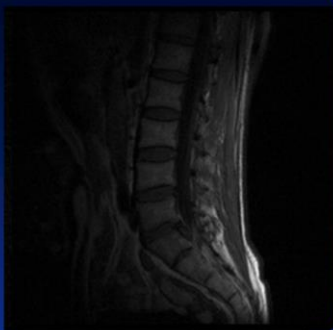


The figure shows the gamma 1.7 correction graph. The originally dark pixels are lighted up more strongly. The corrected picture seems more natural and the chance of losing information is smaller.

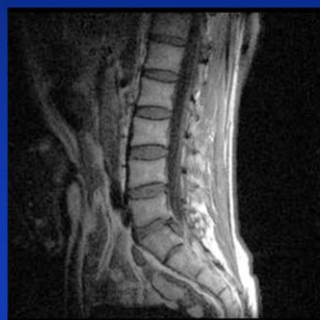
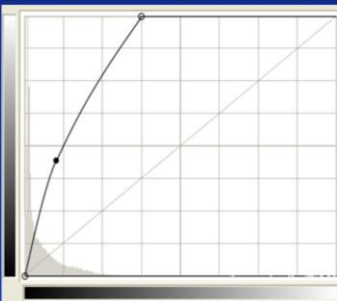
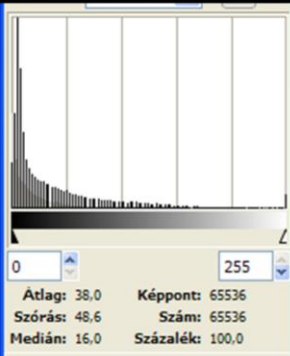
Gamma is the brightness of the midtone values.

The originally dark pixels are lighted up more strongly. The corrected picture seems more natural and the chance of losing information is smaller

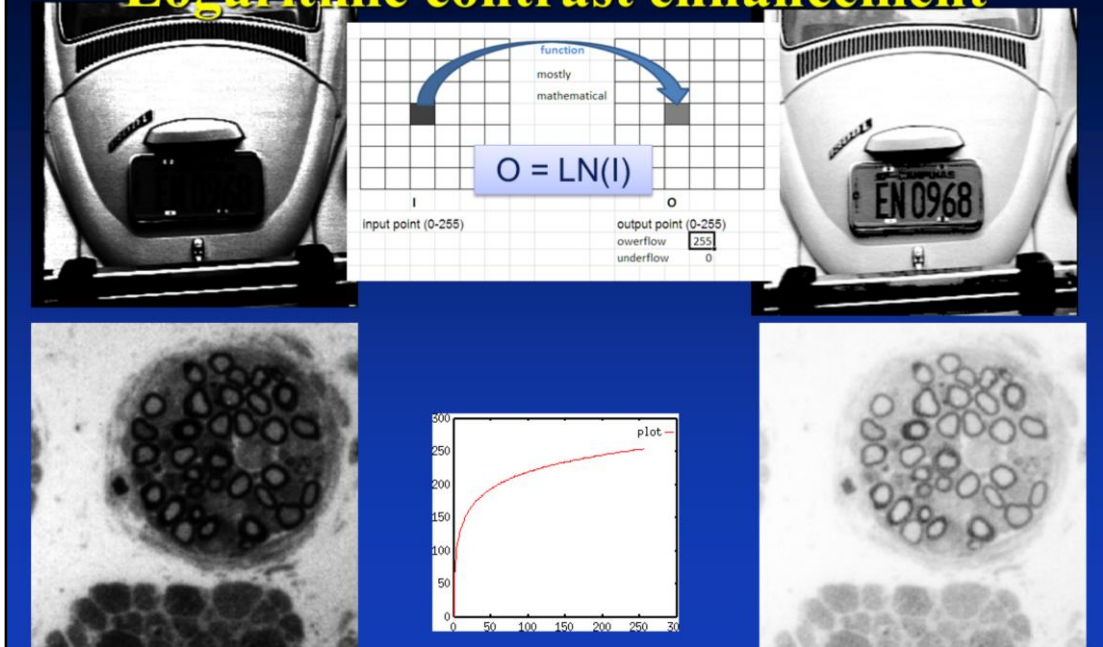
Contrast + lightening



Gamma correction



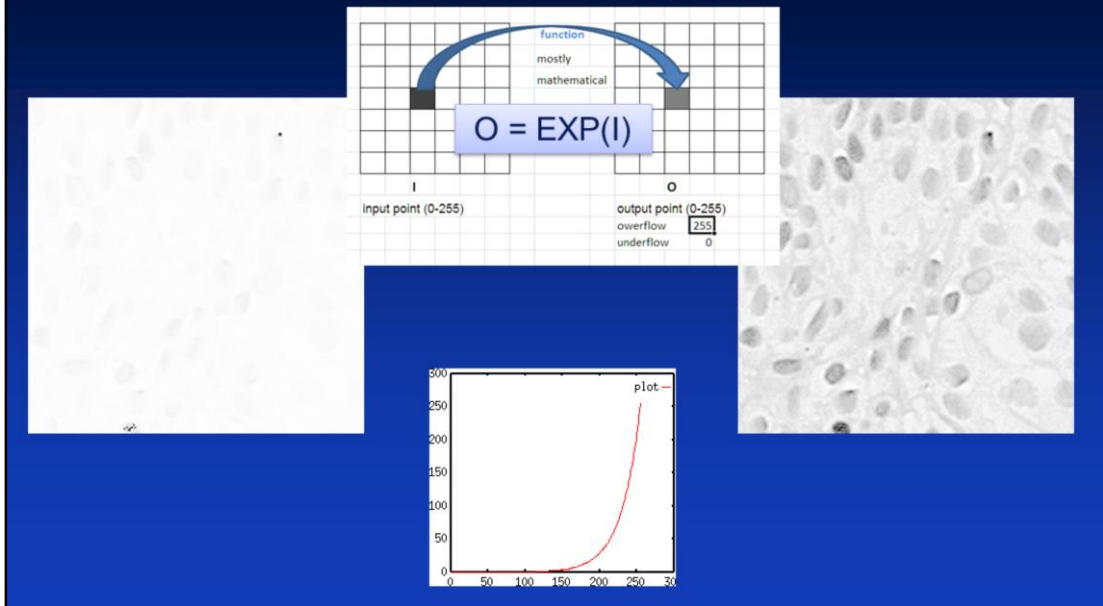
Logarithmic contrast enhancement



Contrast enhancement using the log function explicitly.

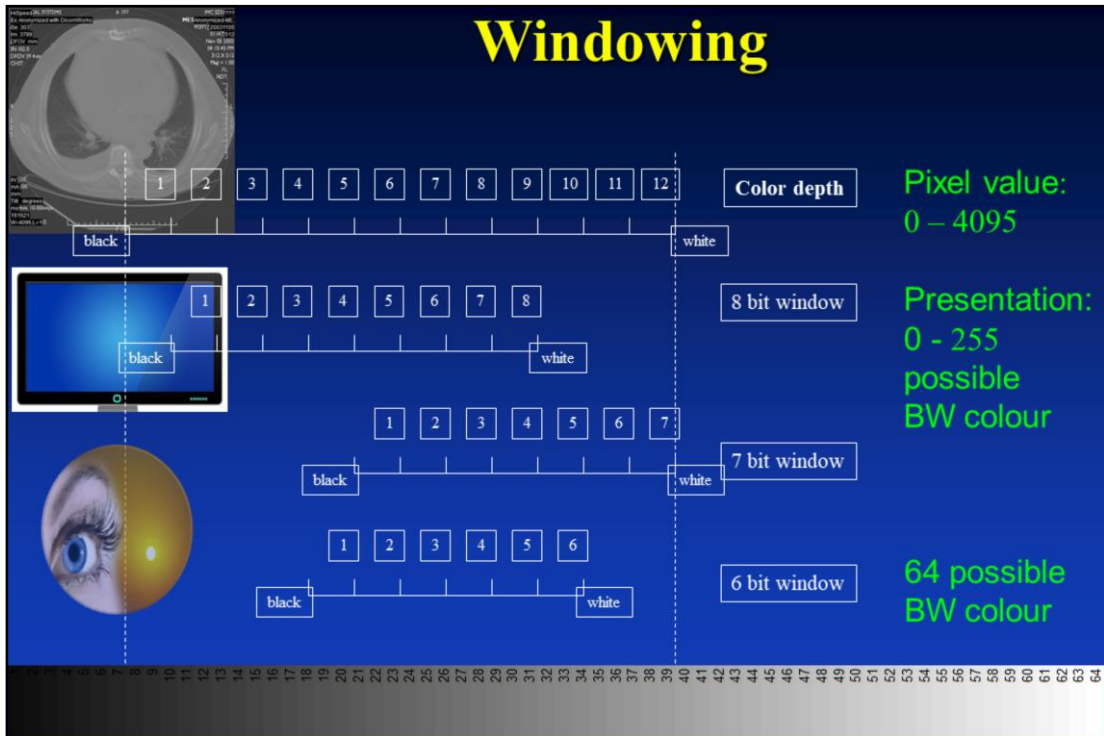
It is very useful and widely used in displaying dark image or dark image parts.

Exponential contrast



When images too bright, a contrast enhancement table like the exponential function can be used to darken the image.

We want to map the pixel values of the original image using the exponential color table.



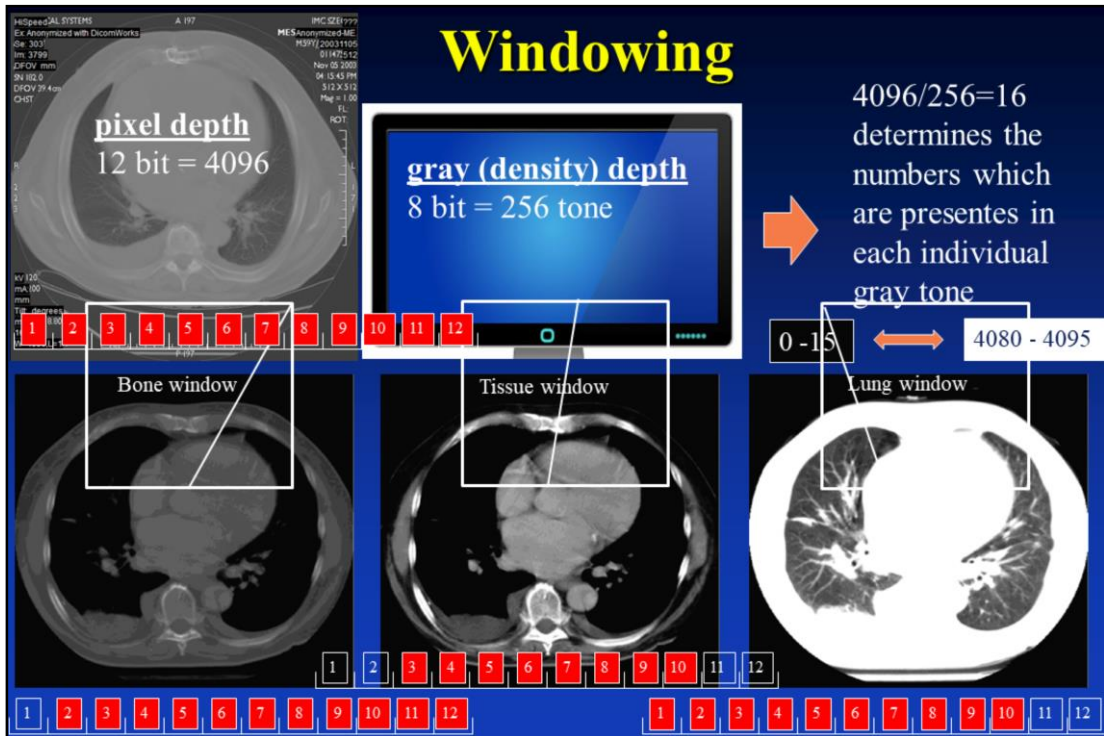
Physiologically, humans only perceive about from sixty (60) to one hundred and forty (140) levels of gray (average 100).

A normal monitor can distinguish 8 bit (256) colour density level.

If we presented all pixel values 4096 we could see about 400 density step (density number) same gray tone.

Any structure which was within that four hundred (100) density step we would have seen as the same gray tone on the picture.

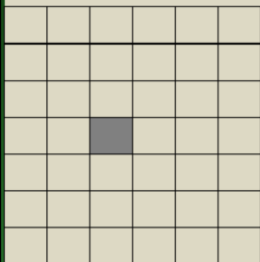
If we established a 8 bit window with 256 colours, each gray tone would cover a range of 2-3 density level.



The colour depth of the upper left CT image is 4096 (twelfth power of two) is divided by 256 (fourth power of two) = 16 which determines the numbers which are included in each individual gray tone in a normal display.

2500, 350, 1500

Point Operations (Dual Operands)



I1

input point (0-255)

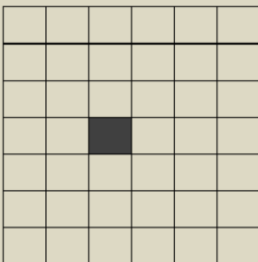
function

mostly
mathematical

+

-

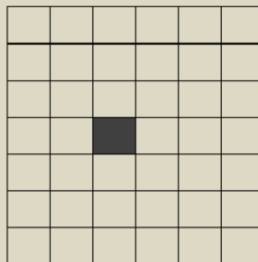
...



I2

input point (0-255)

=



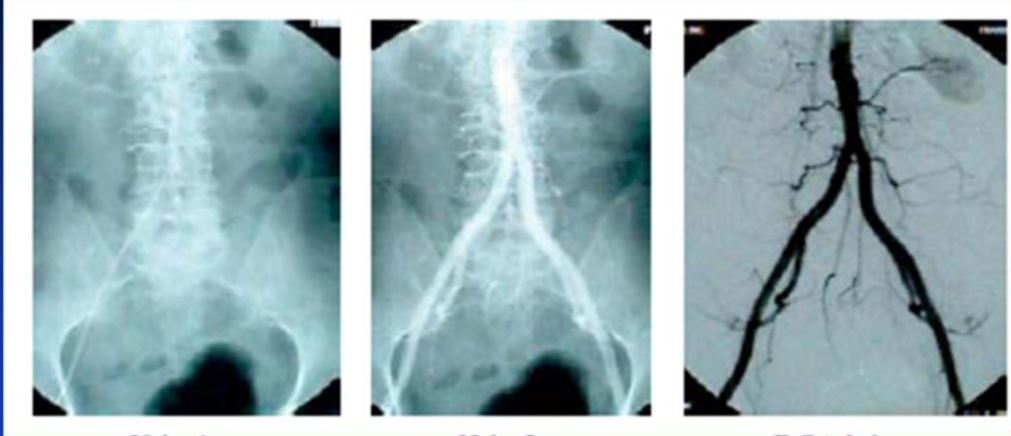
O

output point (0-255)

overflow 255

underflow 0

Digital image subtraction



'pre-contrast' image

'contrast' image

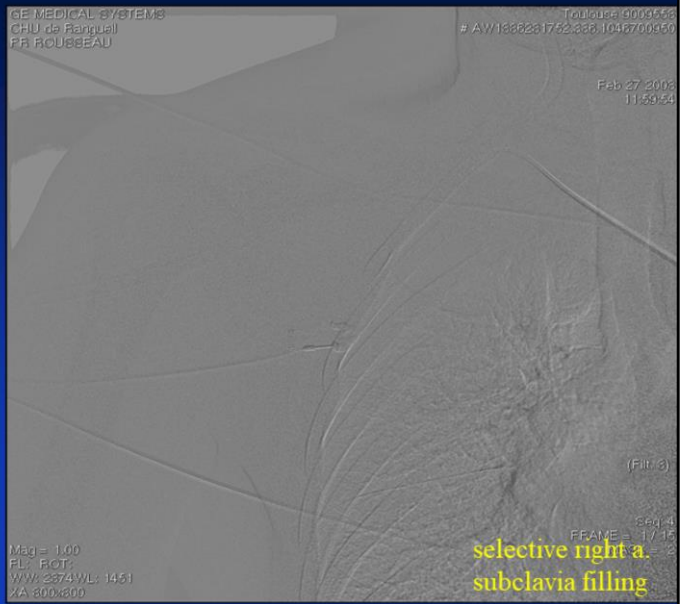
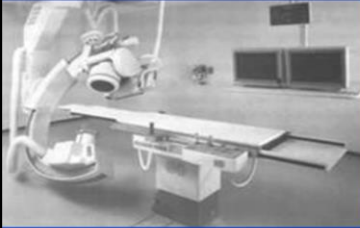
Contrast - pre contrast image

Images are produced using contrast medium by subtracting a 'pre-contrast image' from later images, once the contrast medium has been introduced into a structure.

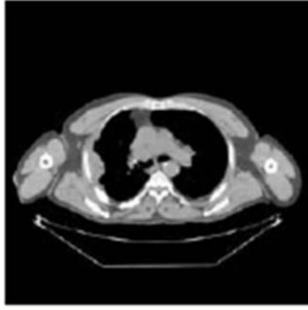
Clearly visualize blood vessels in a bony or dense soft tissue environment.

Digital Subtraction Angiography

distracting shadows can already be subtracted in the moving image



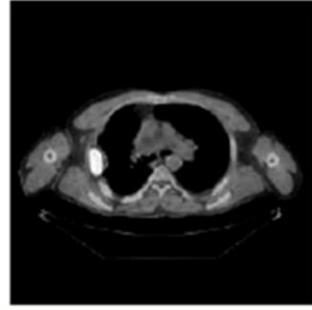
Addition



CT



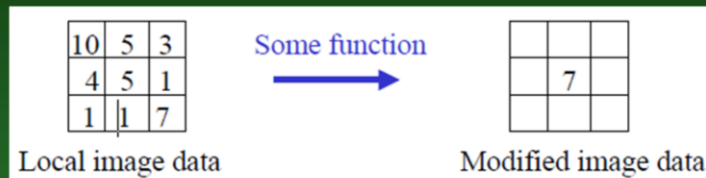
PET



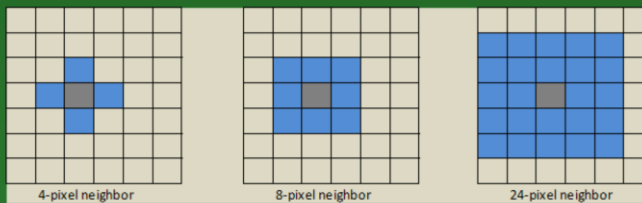
CT + PET

Neighbors Operations (filtering)

Modify the pixels in an image based on some function of a local neighborhood of the pixels.



- Linear
- Non-linear



Until now we used point processing methods (histogram processing).

Neighbourhood operations

Modify the pixels in an image based on some function of a local neighborhood of the pixels.

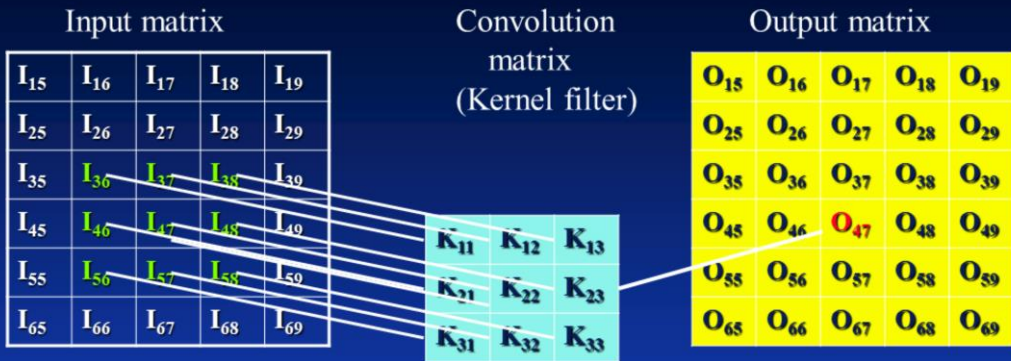
Some simple neighbourhood operations include:

Min: Set the pixel value to the minimum in the neighbourhood

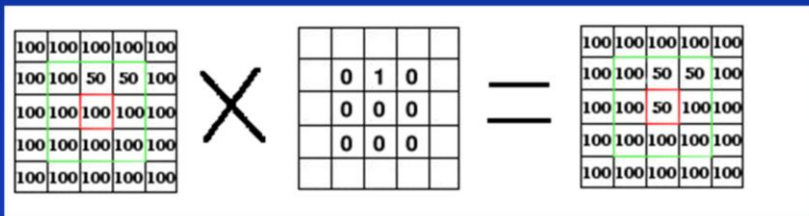
Max: Set the pixel value to the maximum in the neighbourhood

Median: The median value of a set of numbers is the midpoint value in that set (e.g. from the set [1, 7, 15, 18, 24] 15 is the median). Sometimes the median works better than the average

Convolution (Linear)



$$O_{47} = I_{36} \times K_{11} + I_{37} \times K_{12} + \dots + I_{58} \times K_{33}$$



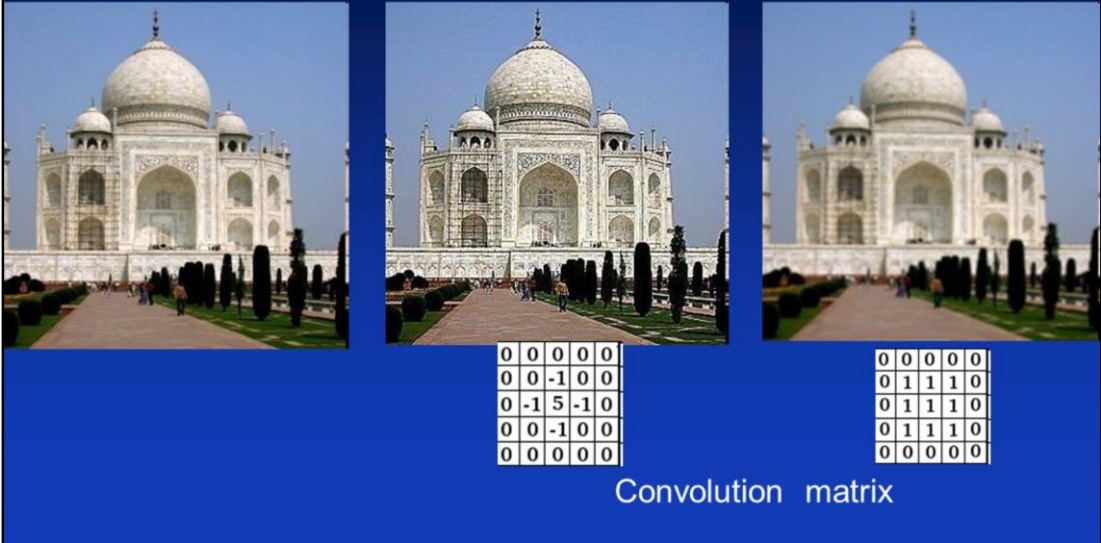
Simplest: linear filtering.

–Replace each pixel by a linear combination of its neighbors.

–The prescription for the linear combination is called the “convolution kernel”. Replace each pixel by a linear combination of its neighbors.

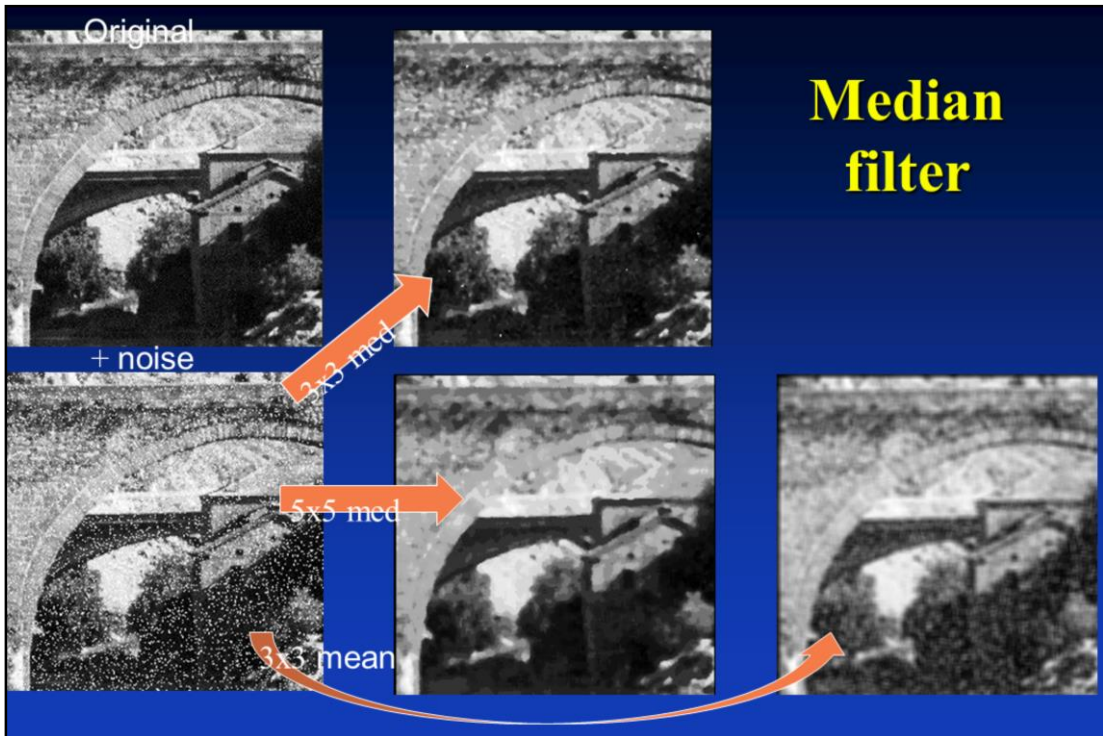
The prescription for the linear combination is called the “convolution kernel”.

Sharpening, noise reduction, smoothing



Original, sharpened and smoothed image.

Depending on the convolution matrix.



Non-linear filtering

Objective: Enhance image by reducing noise

Digital image processing



Enhancement for human perception



Segmentation, classification



Recognition

Segmentation

dividing for parts

- Global methods:
 - Thresholding (based on histogram - Single Operand Point Operations)
- Local methods:
 - Edge detecting
 - Homogen regions detecting

Segmentation means partitioning a digital image into multiple segments.

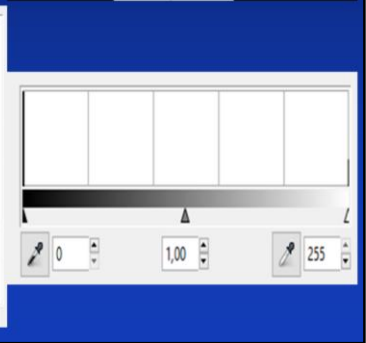
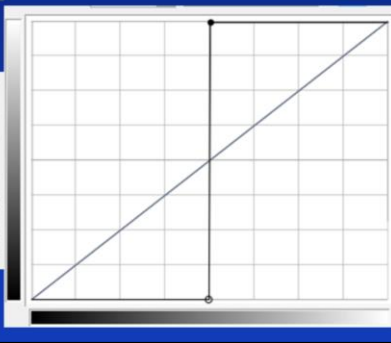
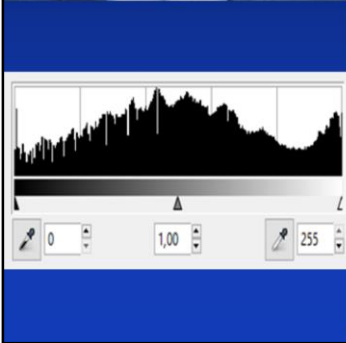
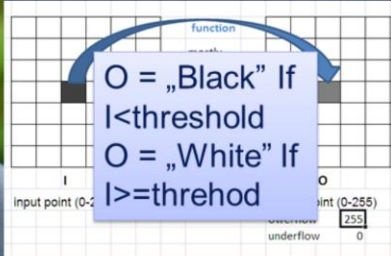
The goal of segmentation is to simplify and/or change the representation of an image into something that is more meaningful and easier to analyze.

Image segmentation is typically used to locate objects and boundaries (lines, curves, etc.) in images. More precisely, image segmentation is the process of assigning a label to every pixel in an image such that pixels with the same label share certain visual characteristics.

The result of image segmentation is a set of segments that collectively cover the entire image, or a set of contours extracted from the image (see edge detection). Each of the pixels in a region are similar with respect to some characteristic or computed property, such as color, intensity, or texture. Adjacent regions are significantly different with respect to the same characteristic(s).

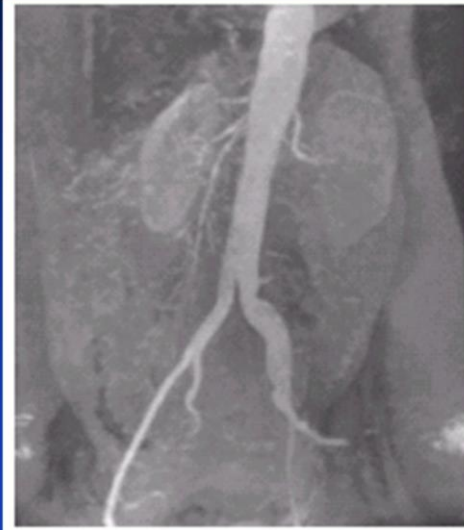


Thresholding

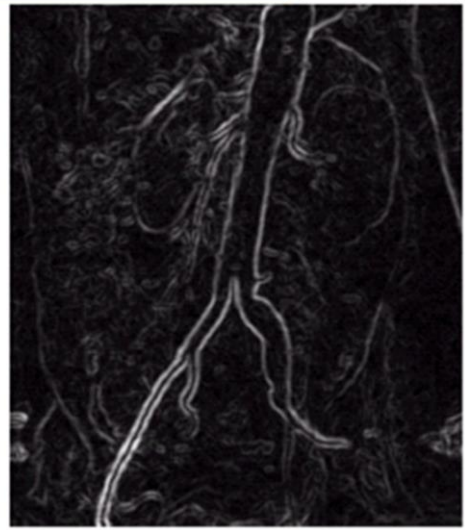


Edge detection

Original
Image



Laplacian
filter



-1	-1	-1
-1	8	-1
-1	-1	-1

Images taken from Gonzalez & Woods, Digital Image Processing (2002)

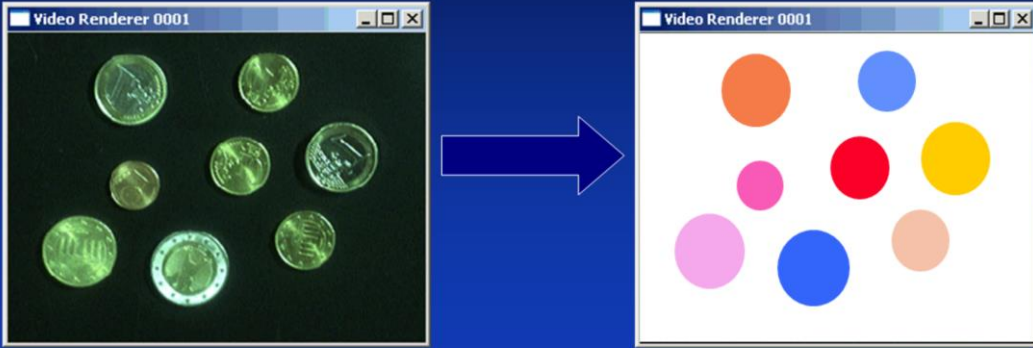
The Laplacian of Gaussian (or Mexican hat) filter uses the Gaussian for noise removal and the Laplacian for edge detection.

(Here only the original and the result images can be seen.)

Edge detection is massively important as it is in many cases the first step to object recognition

Segmentation

Homogen regions detecting



- Segmentation attempts to partition the pixels of an image into groups that strongly correlate with the objects in an image
- Typically the first step in any automated computer vision application

Digital image processing



Enhancement for human perception



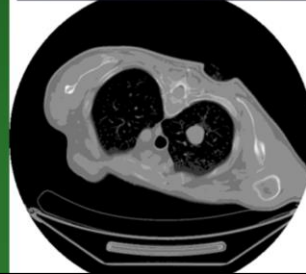
Segmentation, classification



Recognition

Image recognition, pattern (shape) recognition

- Whether or not the image data contains some specific object, feature, or activity.
- Object recognition ([video](#))
- [Identification](#)
- Detection (tumor, OCR, ...)
- Motion detection



The classical problem in computer vision, image processing, and machine vision is that of determining whether or not the image data contains some specific object, feature, or activity.

This task can normally be solved robustly and without effort by a human, but is still not satisfactorily solved in computer vision for the general case: arbitrary objects in arbitrary situations.

The existing methods for dealing with this problem can at best solve it only for specific objects, such as simple geometric objects (e.g., polyhedral), human faces, printed or hand-written characters, or vehicles, and in specific situations, typically described in terms of well-defined illumination, background, and pose of the object relative to the camera.

<http://news.bbc.co.uk/2/shared/spl/hi/guides/456900/456993/html/nn3page1.stm>

Face, Iris and Fingerprints Identification

BBC NEWS Watch One-Minute World News **News services** Your news when you want it

News Front Page **BIOMETRIC TECHNOLOGY**

Introduction | **Face** | **Iris** | **Finger** | **Glossary**


Biometric technology uses computerised methods to identify a person by their unique physical or behavioural characteristics.

Developments and uses have increased with demand to match concerns over international, business and personal security.

Biometrics is more personal than a passport photo or Pin, using traits such as fingerprints, face or eye "maps" as key identifying features.

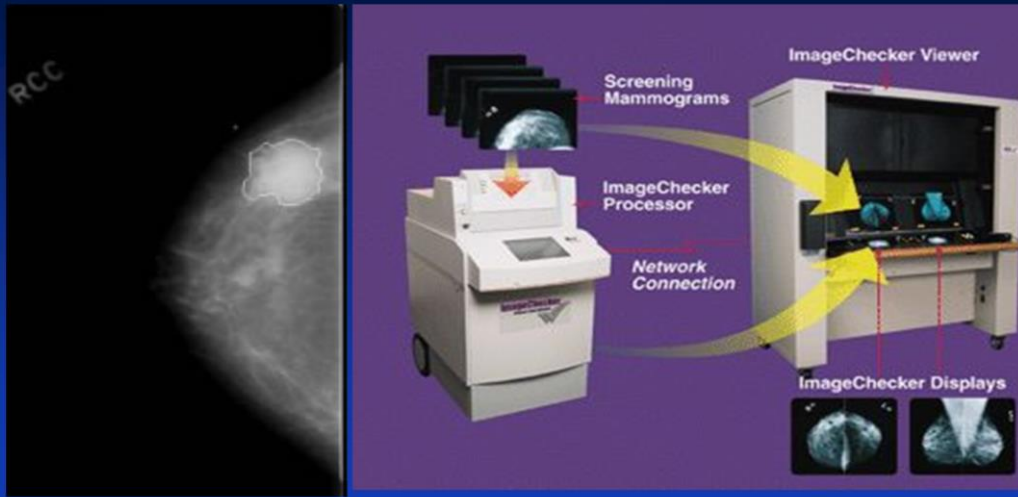
Uses range from building access and laptop security to identity cards and passports.

However, there are concerns about the storing of biometric data and its possible misuse.



<http://news.bbc.co.uk/2/shared/spl/hi/guides/456900/456993/html>

CAD Computer aided diagnosis



1998: First commercial software for mammography reporting

1998: First commercial software for mammography reporting.
Computer assisted lesion findings.

Motion detection



Kinect

Related questions

- Image manipulation presentation
 - Histogram
 - Graph
- Operation types on pictures
- Brightness, contrast, gamma correction
- Windowing
- Filtering
- Segmentation
- Aim and main types of image recognition