

# Digital Image Processing (DIP)

## CSE-453

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# About Myself

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  - 019-1474-5508 (only in emergency)



# Administration

- Class time :
- Section A +B :
  - Monday (11:50 - 13:30) Theory
  - Tuesday (09:50 -10:40) Theory
  - Sunday (8:10 - 10:40) Sessional [Compiler Lab]
  - Sunday (14:30 - 17:00) Sessional [Compiler Lab]
- Classroom : Level-4 [Academic Building-3 (3<sup>rd</sup> Floor)]



# Requirements

- Prerequisites
  - Data Structures and Algorithms
  - Linear Algebra, Basic probability theory
  - Experience with MATLAB or C Programming Language
- Text
  - Digital Image Processing by R. C. Gonzalez and R. E. Woods (Latest Edition or 2<sup>nd</sup> or 3<sup>rd</sup> Ed.)
  - Any other book with a similar title is fine
  - Web is the best and greenest “textbook”
- References
  - will be given in the class



# Weekly Plan (Rough)

Cycle /Day	Topics & Contents
1 <sup>st</sup>	Introduction to DIP
2 <sup>nd</sup> , 3 <sup>rd</sup> and 4 <sup>th</sup>	Digital image fundamental and Binary image analysis
5 <sup>th</sup> and 6 <sup>th</sup>	Color model
7 <sup>th</sup>	Edge detection
8 <sup>th</sup> and 9 <sup>th</sup>	Image filtering and Transforms
10 <sup>th</sup>	Image segmentation and representation
11 <sup>th</sup> and 12 <sup>th</sup>	Image Restoration
12 <sup>th</sup> and 13 <sup>th</sup>	Image compression and Others



# Goal

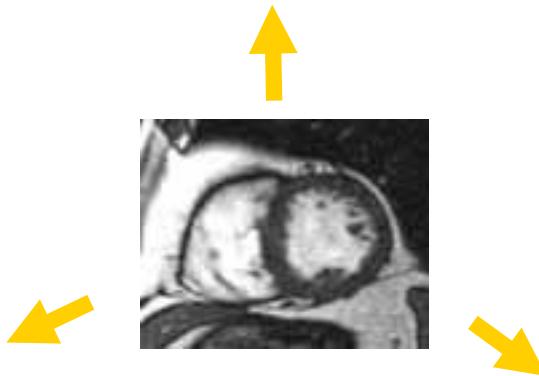
- Understand various basic image processing **concepts** and **algorithms**
- Grasp the **basics** of digital image processing and its **connections** to other scientific and technological fields such as psychology, morphology, photography and so on



# Goal of Image Processing

## Visualization

Enhancement, 3-D display



## Quantification

Quantification, measurement

## Automation

Minimize human intervention

# Digital image

- An image may be defined as a two dimensional function,  $f(x, y)$ , where  $x$  and  $y$  are *spatial (plane) coordinates* and the *amplitude* of  $f$  at any pair of coordinates  $(x, y)$  is called the intensity or gray level of the image at that point
- When  $x$ ,  $y$ , and the amplitude values of  $f$  are all finite (*having limits or bounds*), discrete quantities (*separate and distinct, a value that may be expressed in numbers*) we call the image a *digital image*



# The Birth of Digital Computers

- What do we mean by *Digital Image Processing (DIP)*
  - **Processing digital images by a digital computer**
- DIP has been dependent on the development of digital computers and other supporting technologies (*e.g., data storage, display and transmission*).



# Beautiful and world largest sea beach



# **Image Processing and Analysis**

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**One picture is worth more than  
ten thousand words**



# Taj Mahal and Pyramid



# The first photograph in the world



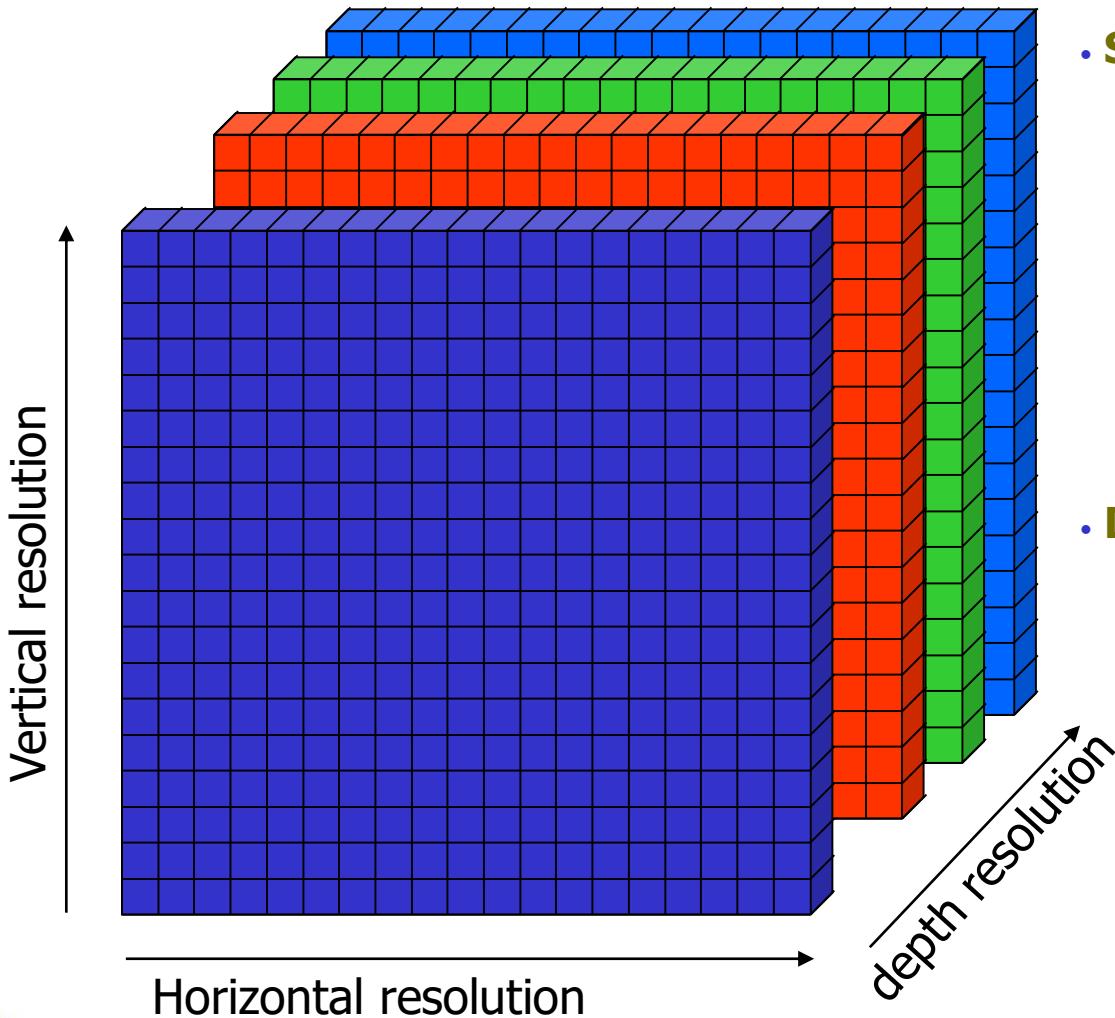
Joseph Nicéphore Niépce, *View from the Window at Le Gras*, 1826.

# Images Application Area

- Office automation:** optical character recognition, document processing, logo and icon recognition, identification of address area on envelop etc.
- Industrial automation :** automatic inspection systems, automatic assembling, oil and natural gas exploration etc.
- Satellite Imagery:** Meteorological (short term weather forecasting), long term climate change detection from satellite and other sensing data , cloud pattern analysis , etc.
- Information technology:** facsimile image transmission, video conferencing
- Bio-medical :** ECG, EEG, X-ray image analysis, CT, MRI, PET, Ultrasound, and other tomographic etc.
- Military applications :** missile guidance and detection, target identification, navigation of pilot less vehicle, etc.



# Image Format



- **Spatial resolution**
  - horizontal/vertical
    - **$256 \times 256, 512 \times 512$**
    - **$1024 \times 768, 1280 \times 1024$**
    - **$2048 \times 2048$**
    - **$1800 \times 1200$**
- **Depth resolution**
  - B/W: **8bits, 12bits**
  - Color: **24bits(true color)**  
**16bits(high color)**  
**8 bits (256colors)**

# Resolution and color depth

- Monitors display images with several characteristics that you can control: *resolution, brightness and contrast, and color depth.*
- Resolution and color depth* are usually adjusted with the software driver that works with the computer's operating system through the graphics adapter card.
- Resolution* is *how many pixels* your screen displays for a given size dimension, and is given in pixel dimensions, such as 640 x 480.
- Color depth* describes *how many colors* that can be displayed on a monitor's screen. Color depth is usually talked about in bits. A bit is an abbreviation for "binary digit"



# What's the difference between 16-bit, 24-bit, and 32-bit color?

- All three color depths use red, blue and green as standard colors, **but its the number of color combinations and alpha channel that makes the difference.**
- **16-bit color**
- With 16-bit color, also called **High color**, computers and monitors can display as many as 65,536 colors, which is adequate for most uses.
- **24-bit color**
- Using 24-bit color, also called **True color**, computers and monitors can display as many as 16,777,215 different color combinations.



- **32-bit color**
- Like 24-bit color, 32-bit color supports 16,777,215 colors but has an alpha channel it can create more convincing gradients, shadows, and transparencies. With the alpha channel 32-bit color supports 4,294,967,296 color combinations.
- Most users cannot tell much of a difference between 16-bit and 32-bit. However, if you are using a program that has gradients, shadows, transparency, or other visual effects that require a wide range of colors you may notice a difference.

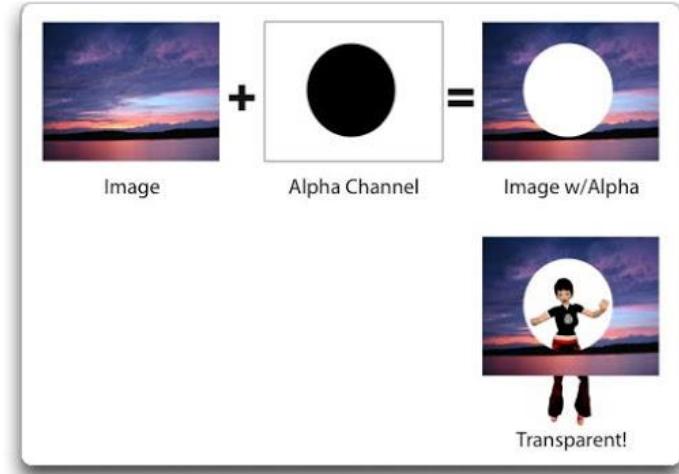
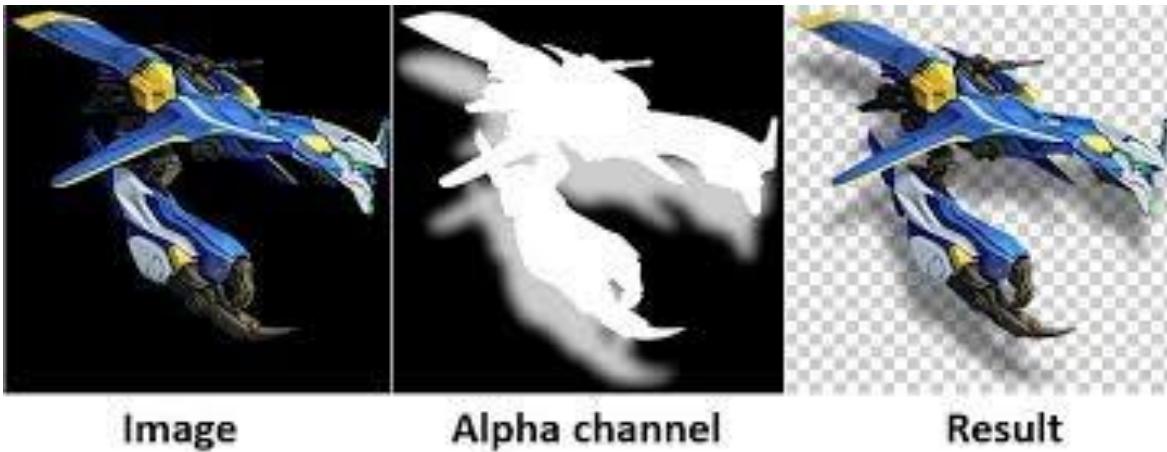


# Alpha Chanel

- A pixel in a typical image has 3 values: red, green and blue. Usually, they range from 0 to 255. So a pixel which has the values 255, 0, 0 is pure red — maximum value for the red component, minimum values for both green and blue.
- With an image that has an alpha channel, each pixel has four components: red, green blue and alpha. **Alpha of 255 is opaque, while alpha of 0 is transparent.**
- The term “alpha channel” refers to the alpha components of all pixels taken together as a whole.
- PNG format allows for an alpha channel, while JPEG does not. GIF images can have transparency, but it is all or nothing, each pixel will be completely transparent (and therefore have no color), or completely opaque.



# Alpha channel



# Depth resolution



24 bit.png  
16,777,216 colors  
98 KB



8 bit.png  
256 colors  
37 KB (-62%)



4 bit.png  
16 colors  
13 KB (-87%)

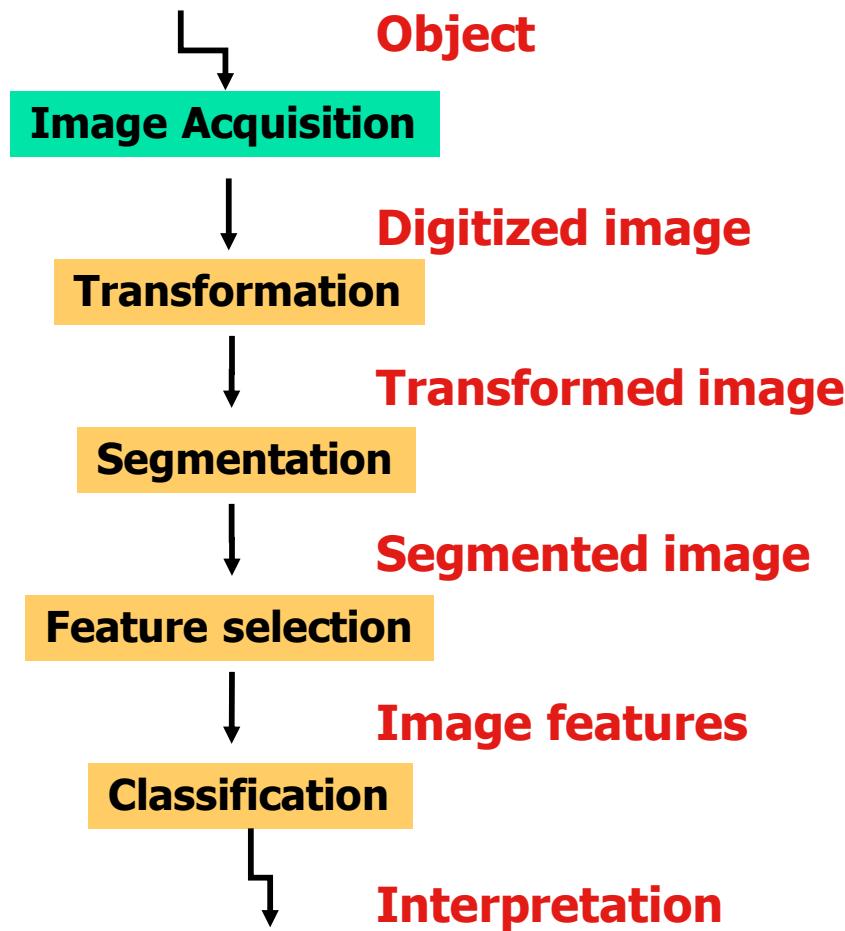


2 bit.png  
4 colors  
6 KB (-94%)

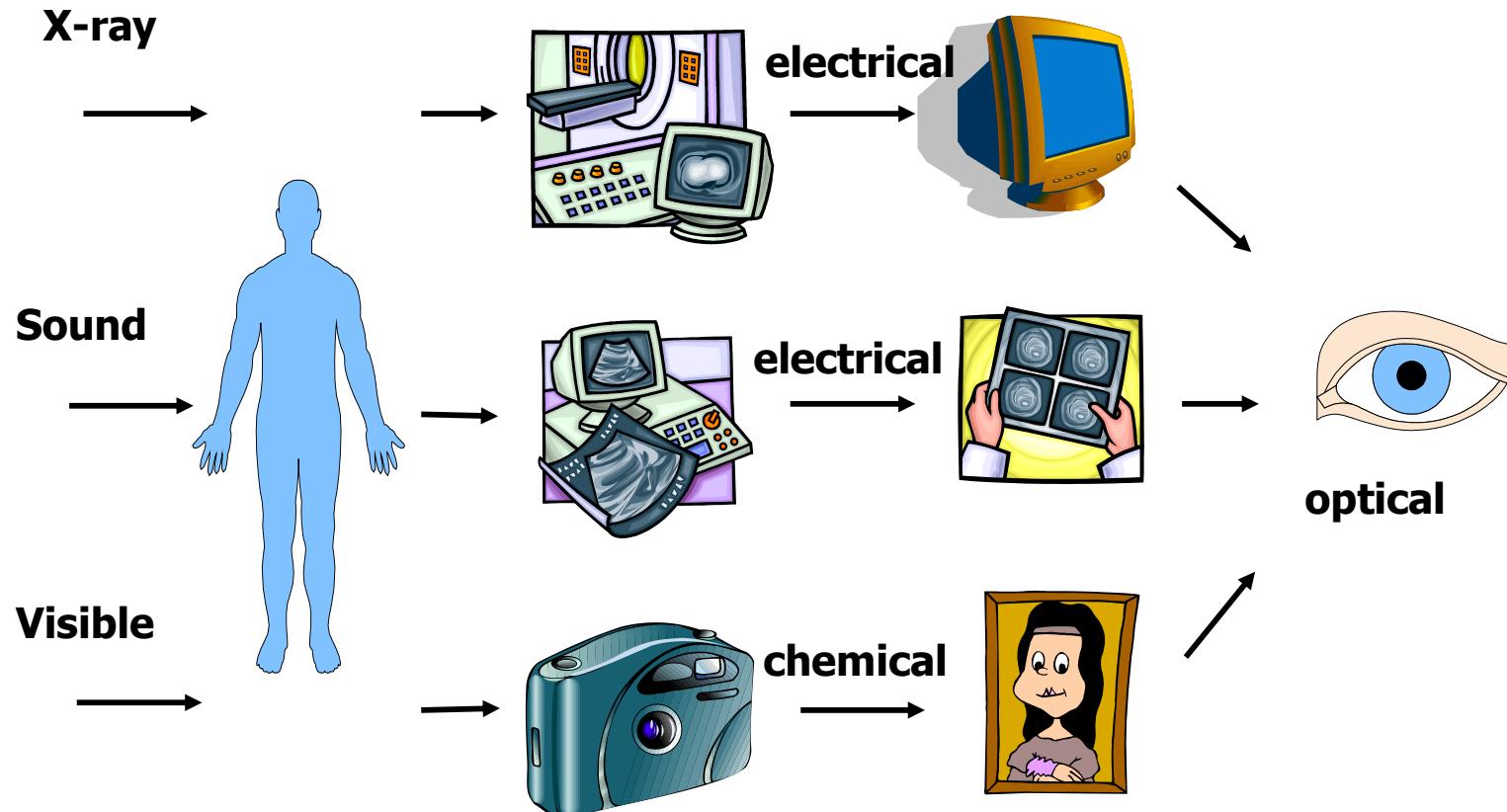


1 bit.png  
2 colors  
4 KB (-96%)

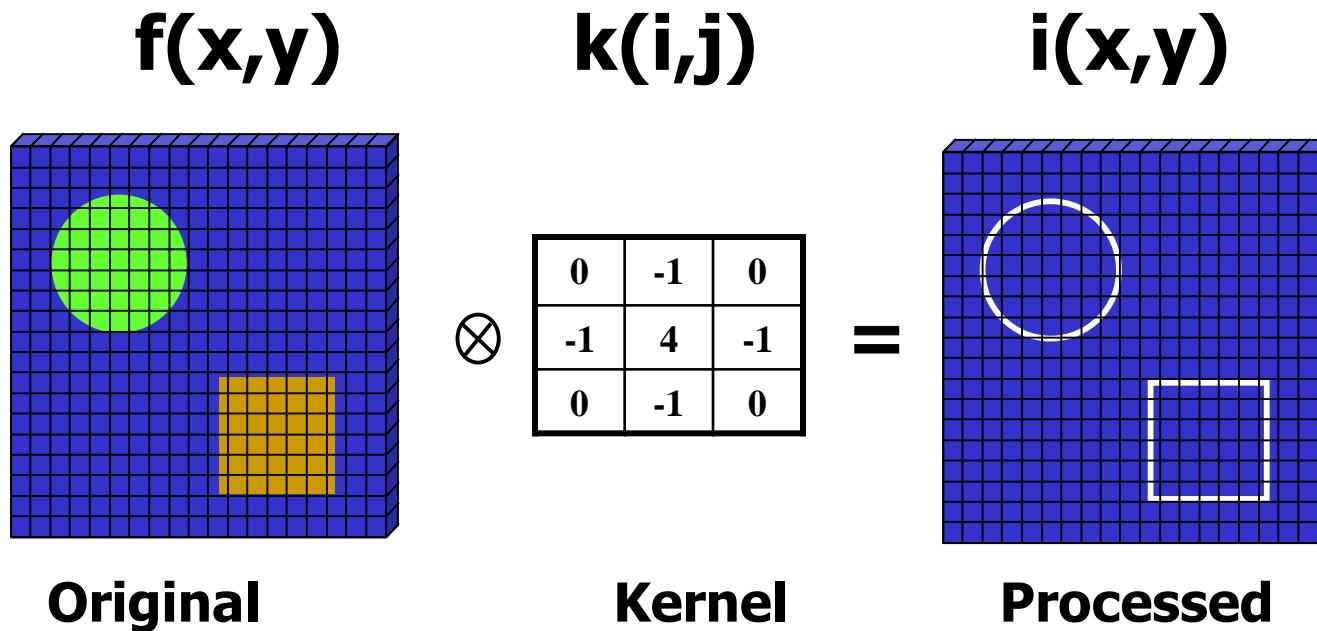
# Image Processing Steps



# 1. Image Acquisition

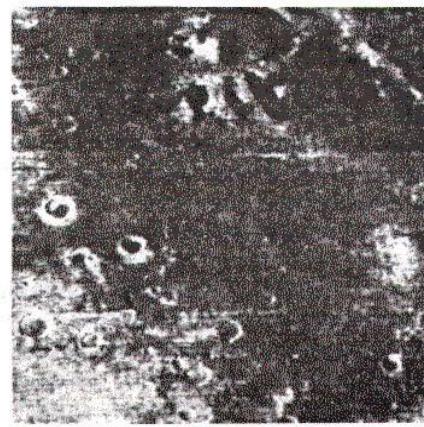
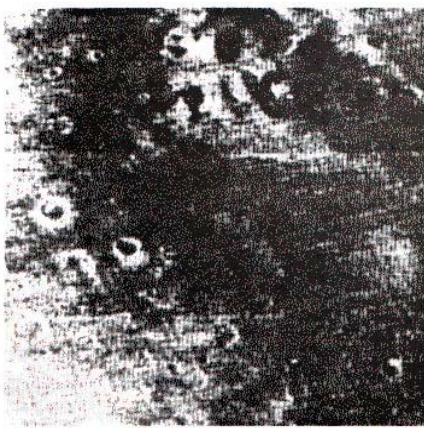


## 2. Local Transformation



$$i(x,y) = \sum \sum k(i,j) f(x+i, y+j)$$

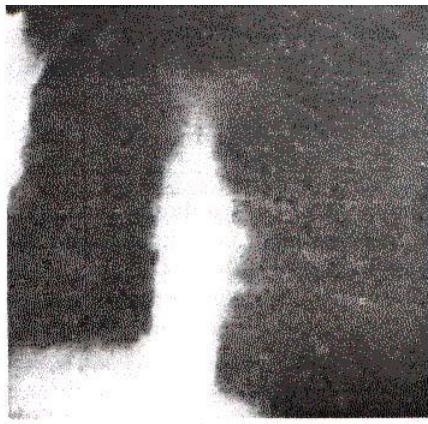
# 3. Image Restoration



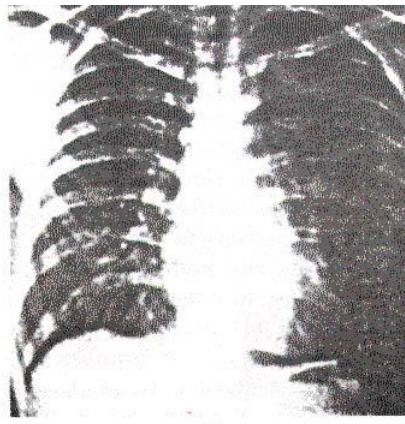
- **Correction for the degradation**
- **Based on a model**
- **Improve quality**
  - for visual inspection
  - for further processing

**denoising**

# Image Restoration



(e)



(f)



(g)



(h)

- **Objective enhancement**

**Motion artifact rejection**

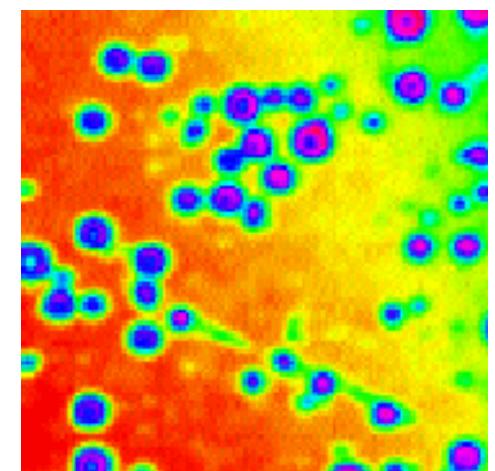
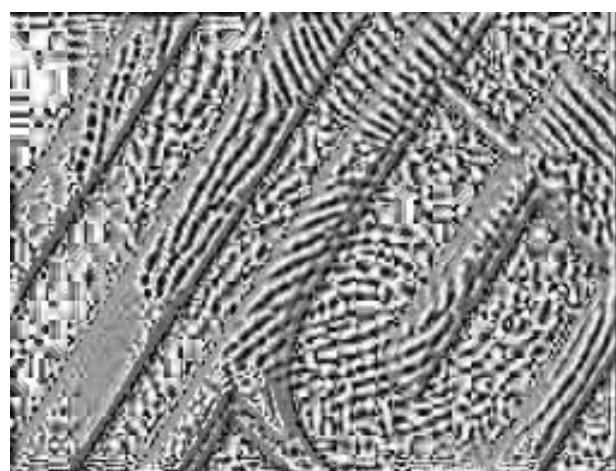
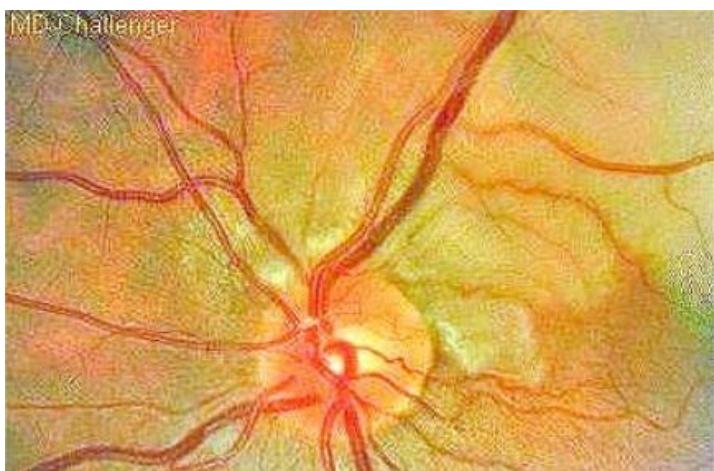
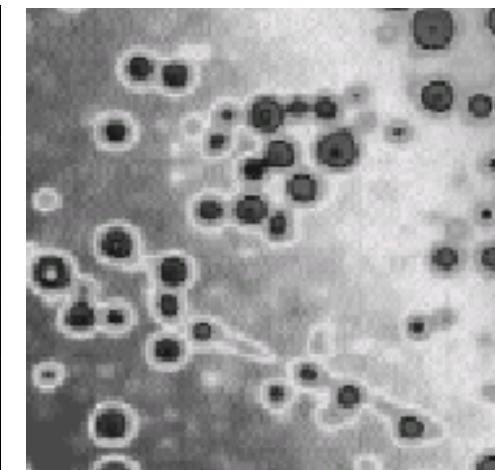
# 4. Image Enhancement

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- **Improve quality in some way**
- **with different objectives:**
  - for visual inspection
    - : contrast enhancement(windowing)
  - for further image processing
- **Subjective image enhancement**
- **global/local**



# Image Enhancement



Color contrast enhancement

Equalization filter

Pseudo coloring

# Image Enhancement



Original image



Image enhancement



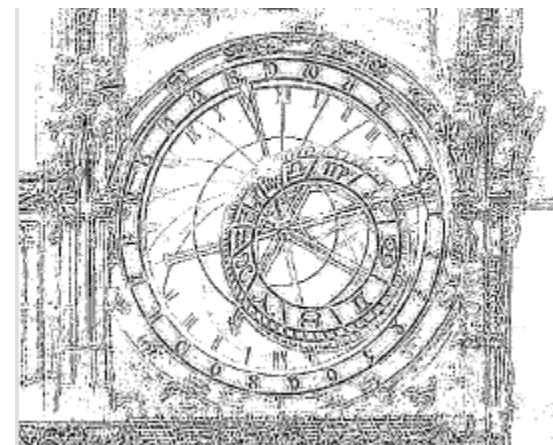
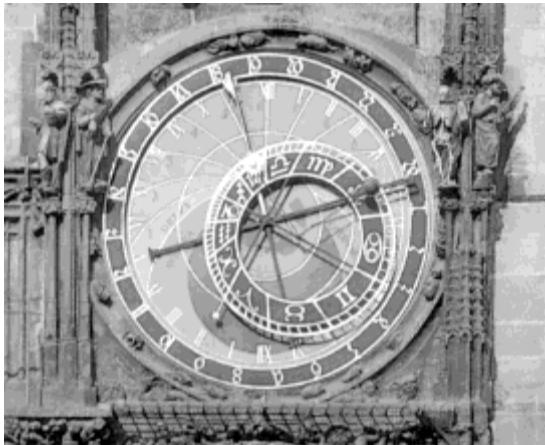
Image sharpening



Enlargement

# 5. Edge/Contour detection

- **Detection of line-like structure**
- **Preprocessing to segmentation**
- **Gradient operator**
  - Horizontal, vertical, Laplacian



# 6. Image segmentation

- Decompose image into its components
- Histogram segmentation
  - thresholding
- Region growing
  - seed points
  - check similarity of neighboring points
  - enlarge region
- Gradient method
  - following the edge detection



# Image segmentation

-1	0	1
-2	0	2
-1	0	1

-1	-2	-1
0	0	0
1	2	1

**Sobel operator**



**Original Image**

**X-gradient**

**Y-gradient**

**Total Gradient**

**Bilevel Thresholding**

# 7. Measurements in Images

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- **Geometric features:** length, area, shape
- **Intensity features:** grey levels, mean
- **Color features:** multispectral information
- **Texture:** fine structure in image



# 8. Image Compression

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- **Save in storage space**
  - and transmission time
  - by removing redundancy
- **Loss-less Compression**
  - decompression without error
  - 2~3: 1
- **Lossy Compression**
  - without noticeable differences
  - 5:1, 10:1, 20:1



# 9. Image registration

- **Alignment for comparison**

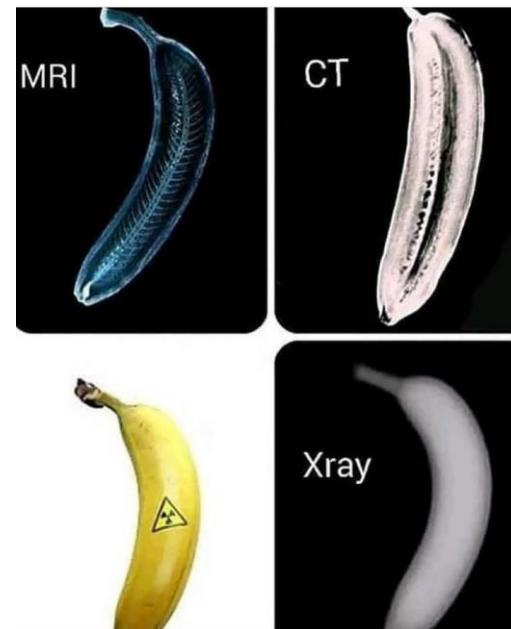
- Intra-modal registration: X-ray
- Inter-modal registration: PET-MRI, CT-PET

- **By image manipulation**

- translation, rotation, scaling, stretching, warping

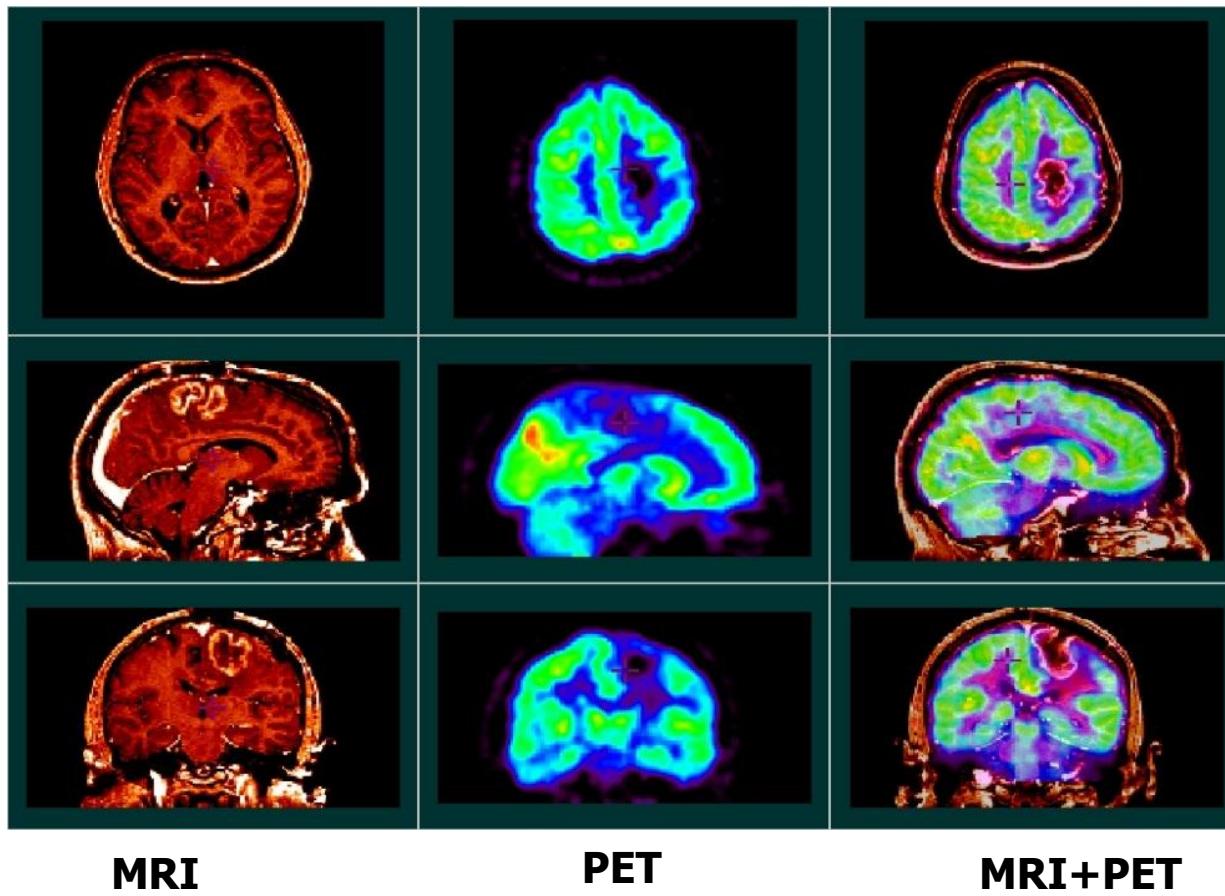
- **Methods**

- using special mark points(fiducial marks)
- correlation technique: noise sensitive



# Image registration

**Image registration** is the process of aligning two or more **images** of the same scene. This process involves designating one **image** as the reference **image**, also called the **fixed image**, and applying geometric transformations or local displacements to the other **images** so that they align with the reference.



# 10. Image Database

- Not just a collection of images
- Indexing, retrieving image
  - by pictorial contents
- Distance measure
  - $d(X,Y)=\text{distance}(\text{image } X, \text{ image } Y)$
  - color histogram, texture, object recognized
  - whatever measurable

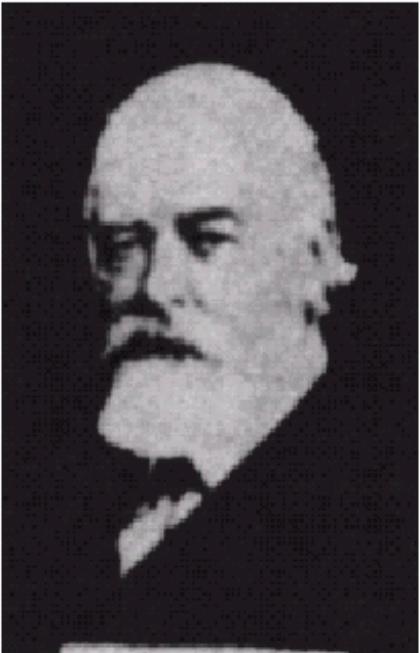


# A Historical Overview of DIP



Newspaper industry used Bartlane cable picture transmission system to send pictures by submarine cable between London and New York in 1920s

# Early Improvement



The number of distinct gray levels coded by Bartlane system was improved from 5 to 15 by the end of 1920s

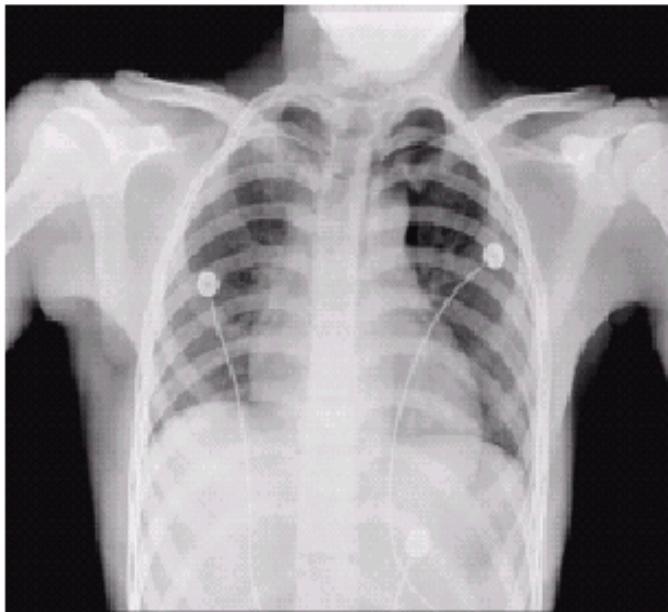
# Soar Into Outer Space



The first picture of moon by US spacecraft *Ranger 7* on July 31, 1964 at 9:09AM EDT

# The Born of Computer Tomography

**Tomography (Medicine): Obtaining pictures of the interior of the body** or the imaging of a three dimensional body using many two-dimensional slices



Sir Godfrey N. Housefield and Prof. Allan M. Cormack shared 1979 Nobel Prize in Medicine for the invention of CT

# Tomography

A technique **for displaying a representation of a cross section** through a human body or other solid object using X-rays or ultrasound.

CT scans and MRIs are both used to capture images within your body. The biggest difference is that MRIs (magnetic resonance imaging) use radio waves and CT (computed tomography) scans use X-rays.



# The Boom of Digital Images in the Last 20 Years

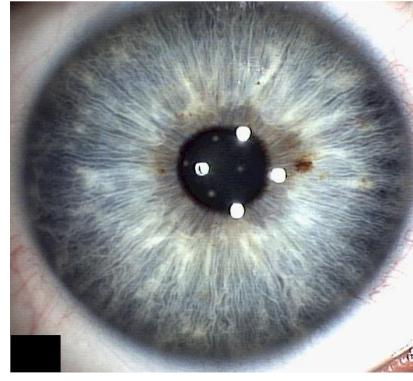
- ◆ Acquisition
  - ◆ Digital cameras, scanners
  - ◆ MRI and Ultrasound imaging
  - ◆ Infrared and microwave imaging
- ◆ Transmission
  - ◆ Internet, satellite and wireless communication
- ◆ Storage
  - ◆ CD/DVD, Blu-ray
  - ◆ Flash memory, Phase-change memory
- ◆ Display
  - ◆ Printers, LCD monitor, digital TV
  - ◆ Portable DVD player, PDAs, cell-phone



# Visible (I): Motion Pictures



# Visible (II): Biometrics and Forensics

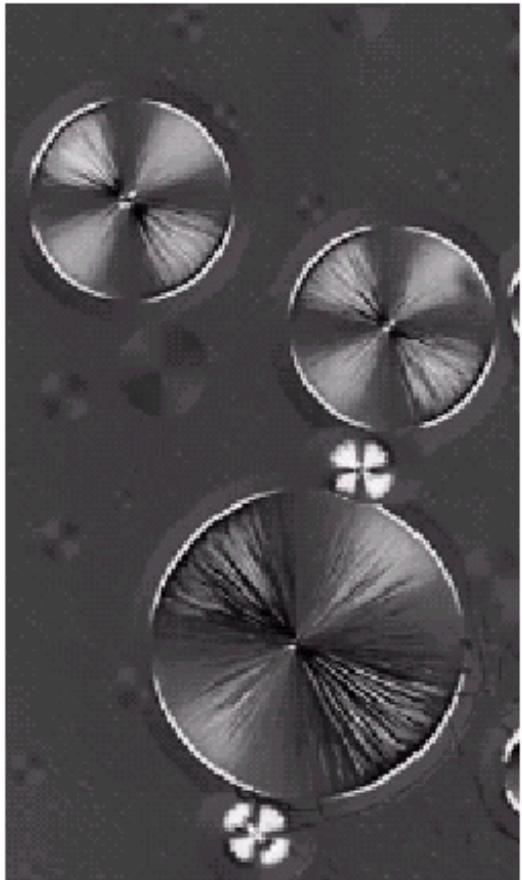


You=ID

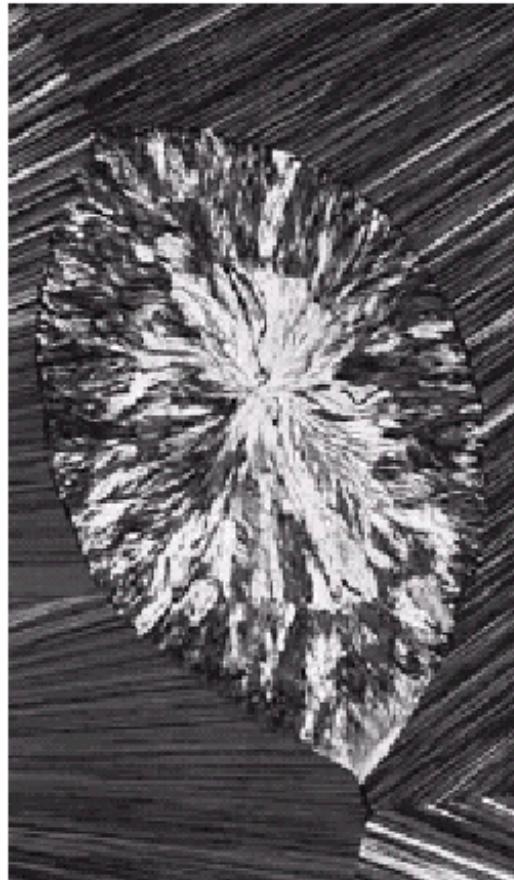


Real or PS?

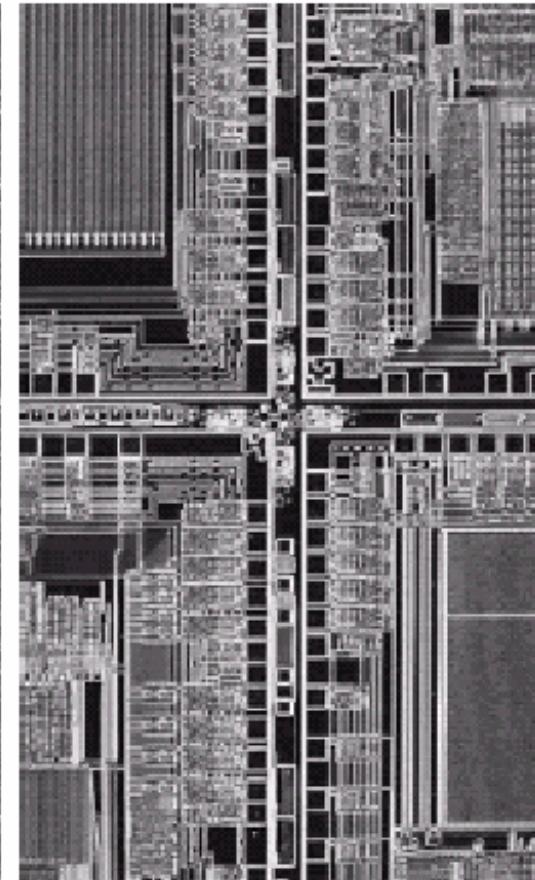
# Visible (III): Light Microscopy



Taxol (250 $\times$ )



Cholesterol (40 $\times$ )



Microprocessor (60 $\times$ )

# Visible (IV): Remote Sensing



Earth at night (Only Asia/Europe shown)

# Beyond Visible (V): Thermal Images

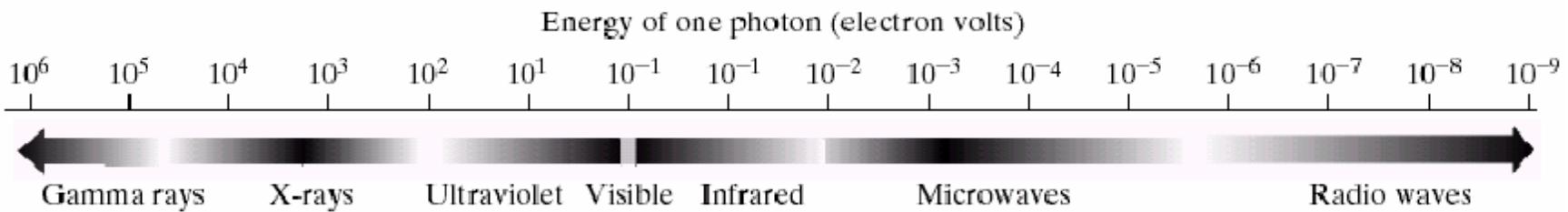
Operate in infrared frequency



Human body disperses  
heat (red pixels)

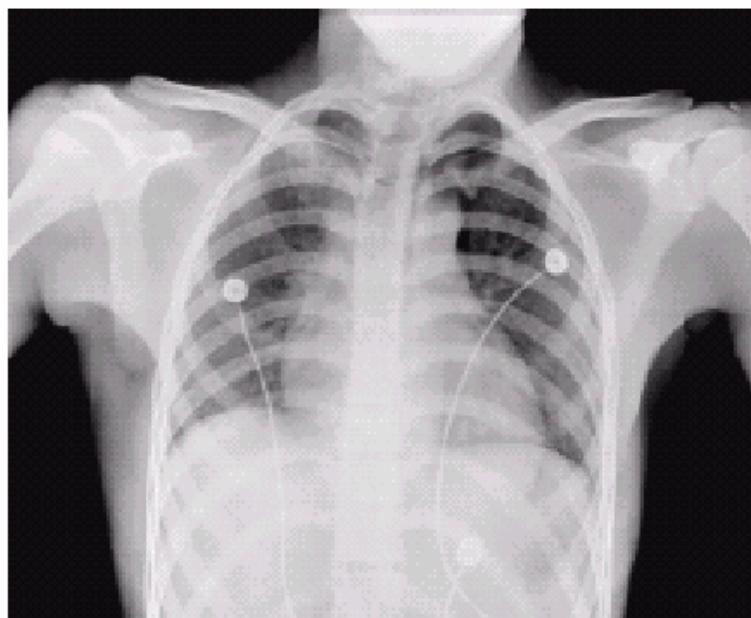


Autoliv's night vision system  
on the BMW 7 series



# Beyond Visible (VI): Medical Diagnostics

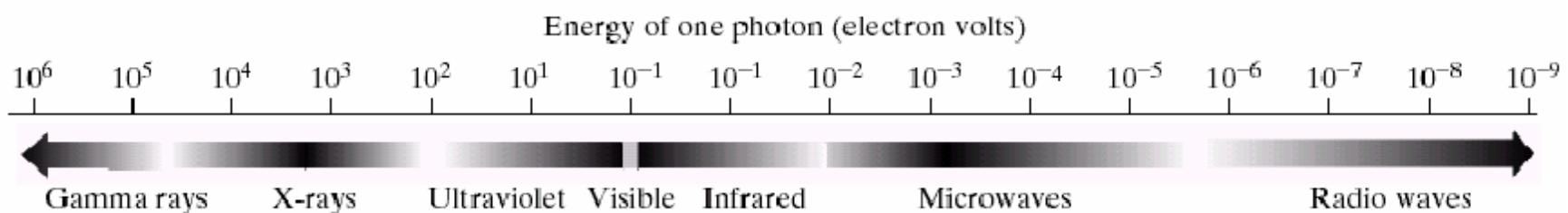
Operate in X-ray frequency



chest



head

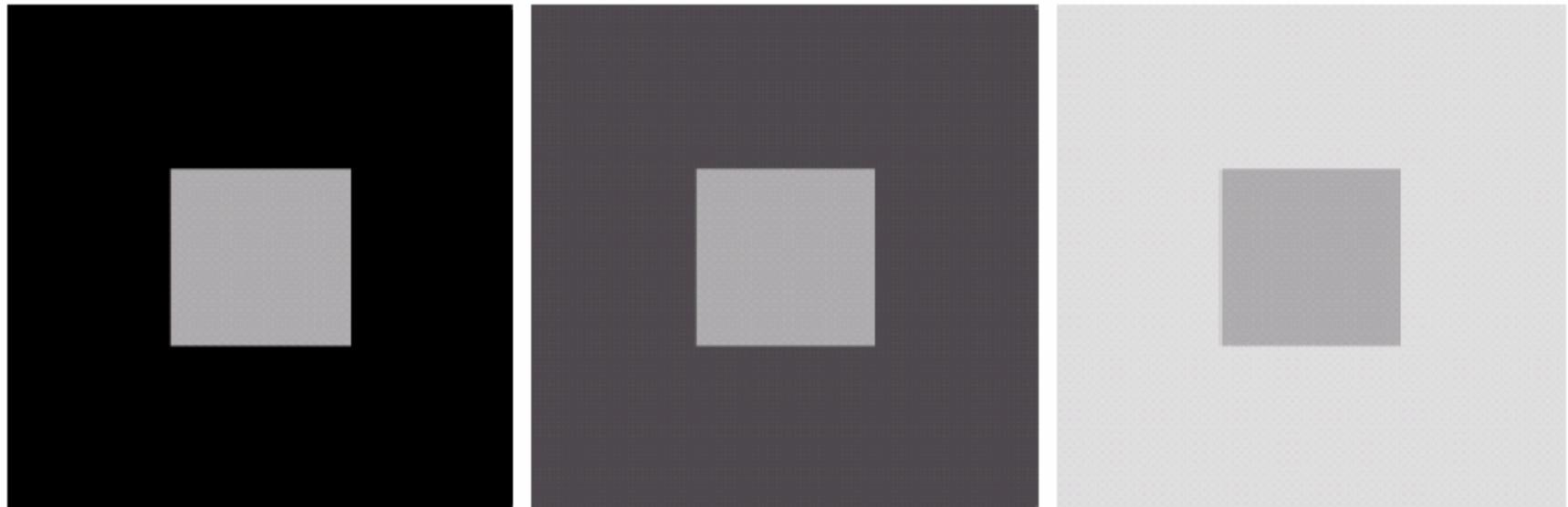


# Levels in DIP

- Low level : **Image to image**
  - filtering, noise removal, etc.
- Intermediate level : **image to sub-symbolic**
  - segmentation, line finding
- High level: **sub-symbolic to symbolic**
  - matching, scene labeling



# Human Vision System



Simultaneous contrast

# Conclusion

