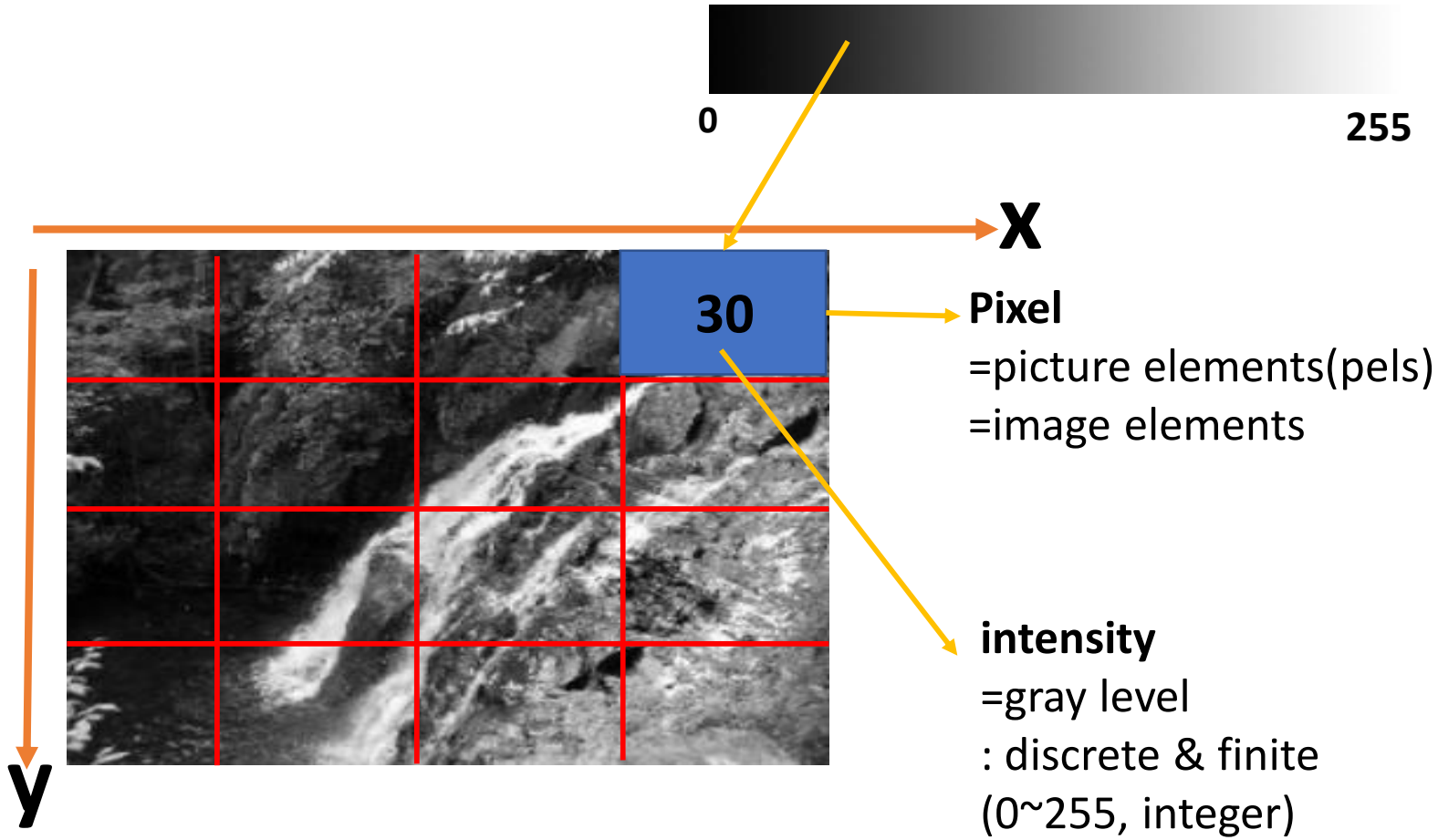
Digital Image processing

Introduction

sunwoo Kim

What is the Image?

An image may be defined as a two-dimensional function f(x,y)



What is bound between DIP and CV(computer vision)

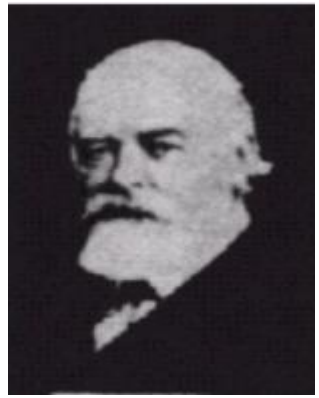
Low Level Process	Mid Level Process	High Level Process
Input : Image **Output** : Image	**Input** : Image **Output** : Attributes	**Input** : Attributes **Output** : Understanding
Examples : Noise	**Examples** : Object	**Examples** : Scene
Removal, image sharpening	recognition, segmentation	Understanding, autonomous navigation

Origins of DIP : 1920s

- One of the first applications of digital images was in the newspaper industry
  - The Bartlane cable picture transmission service
  - Images were transferred by submarine cable between London and New York

Computer didn't involved in their creation
(they don't considered DIP)

Improvement of Bartlane Systems

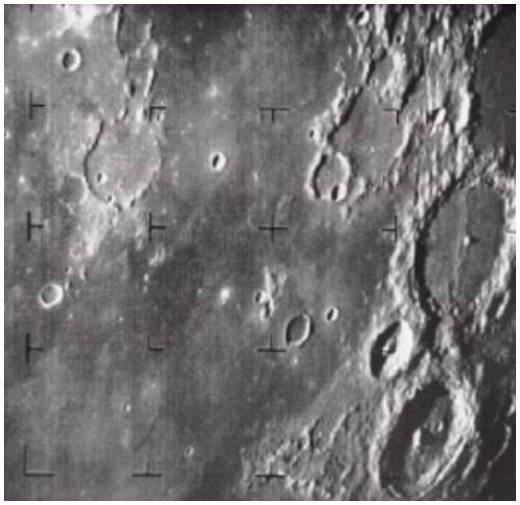


<Early 1920s>

<Late 1920s>

Origins of DIP : 1960s

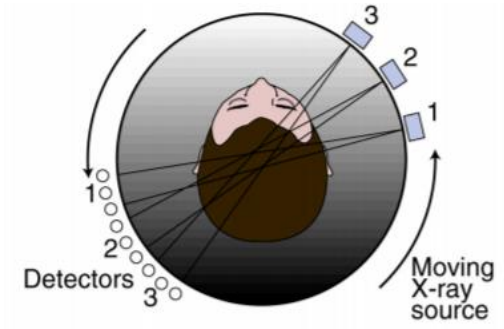
- Improvements in computing technology and onset of the space led to surge of work in DIP
  - DIP was used to correct various types of image distortion inherent in the on-board television camera

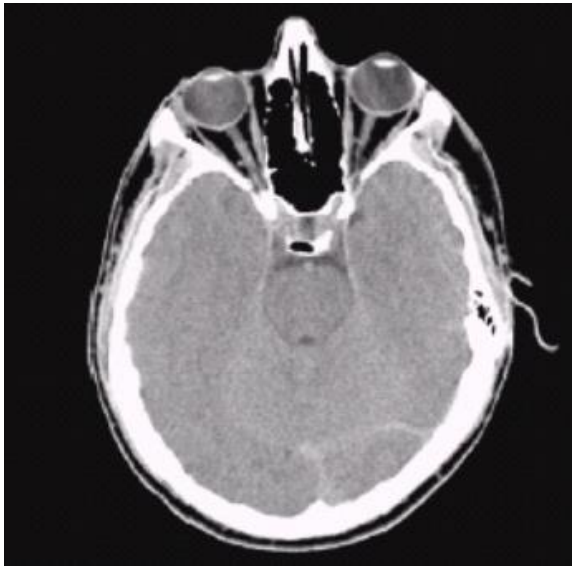


<First image of the moon taken by Ranger 7 on July 31, 1964 at 9:09 AM>

Origins of DIP : 1970s

- DIP begins to be used in medical applications
  - The invention of Computerized Axial Tomography(CAT), we call also ‘CT’





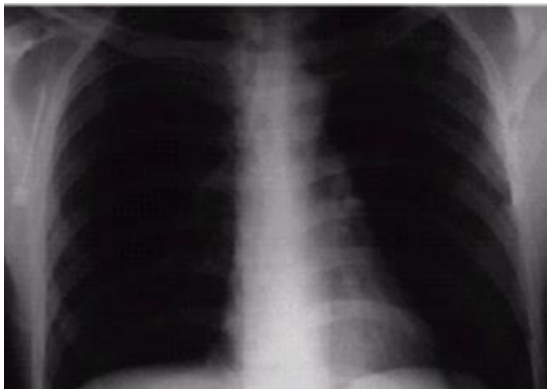
<Head slice CAT image>

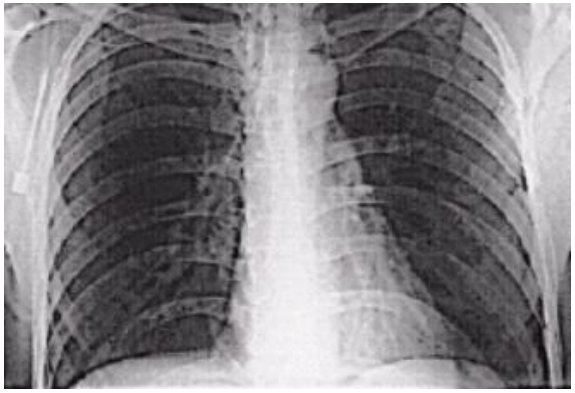
Origins DIP : 1980s -

- The use of digital image processing techniques has exploded and they are now used for all kinds of tasks in all kinds of areas
  - Geographic use : pollution pattern study
  - Physics : enhance image of high-energy plasma images
  - Archeology : restore blurred pictures
  - Machine perception
  - Industrial inspection
  - Medical visualization
  - HCI(Human computer interaction)

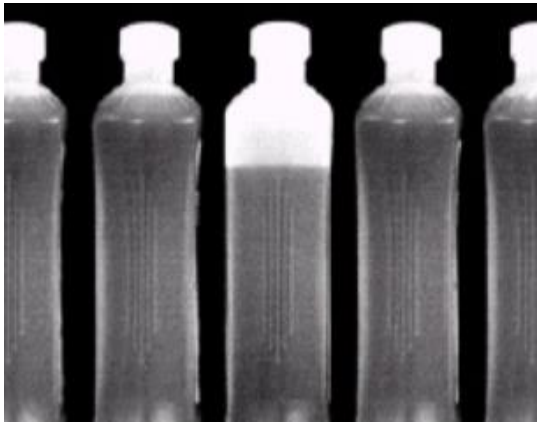
Examples

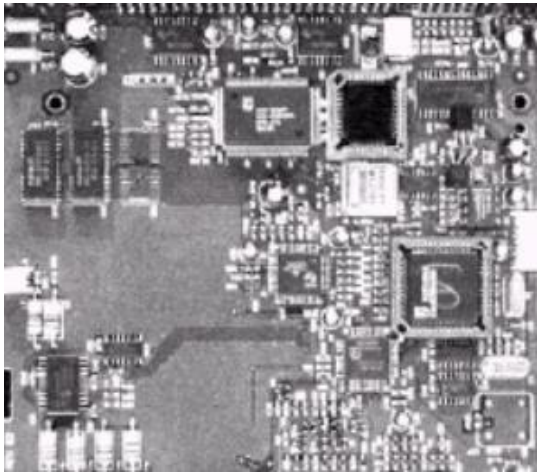
<Image enhancement>



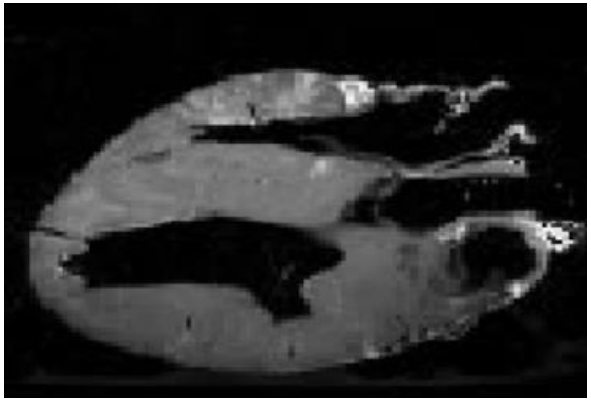


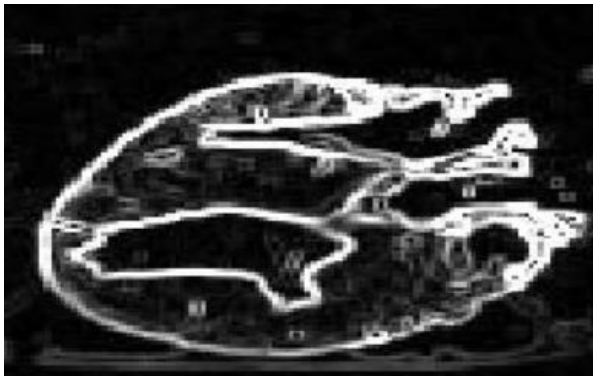
<Industrial inspection>





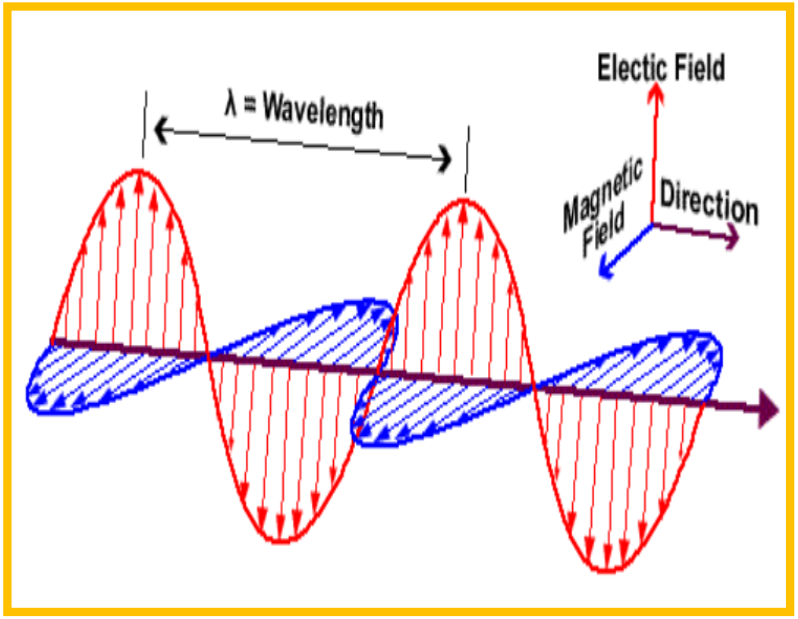
<Edge detection>





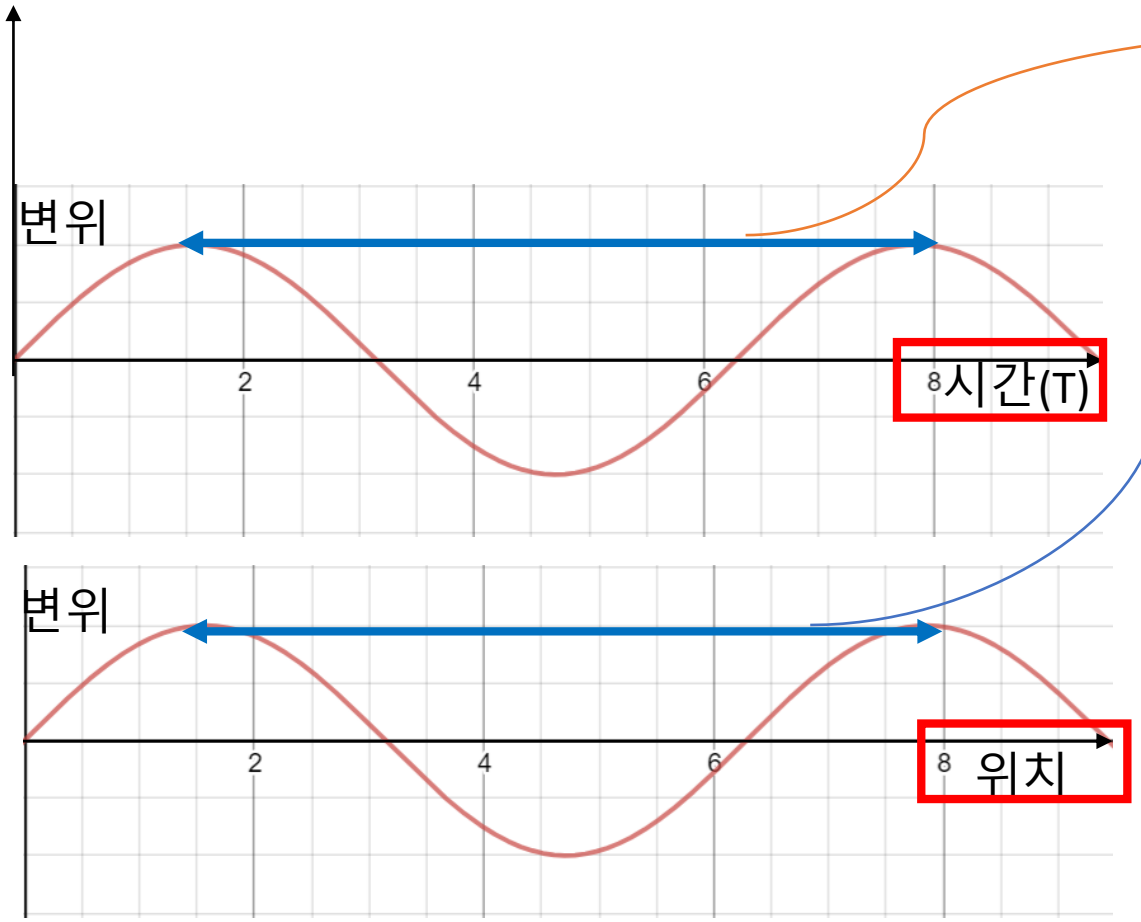
What is the electromagnetic wave ?

Definition : One of the waves that are propagated by simultaneous periodic variations of electric and magnetic field intensity



Properties
- EF and MF are vertical
- Don't need medium (transferred through space itself)
- It can be regarded as both particle and wave
- It can be defined as one of them, Gamma ray, X-ray, Ultraviolet, Visual, Infrared, Micro and Radio wave, by frequency

Properties of Wave (Energy and wavelength)

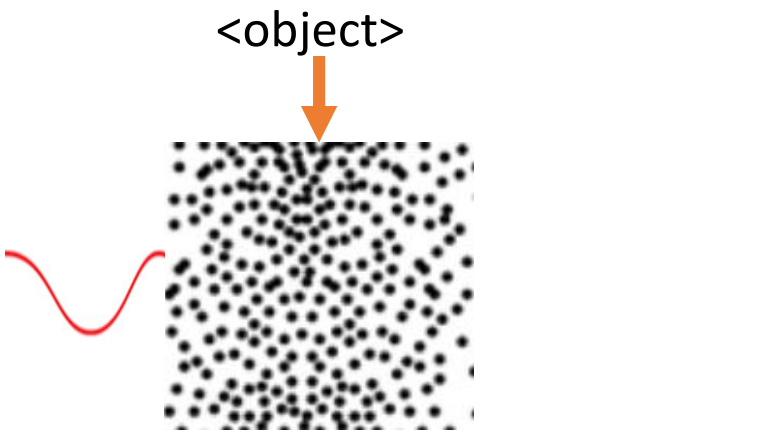


$$E = hc/\lambda$$

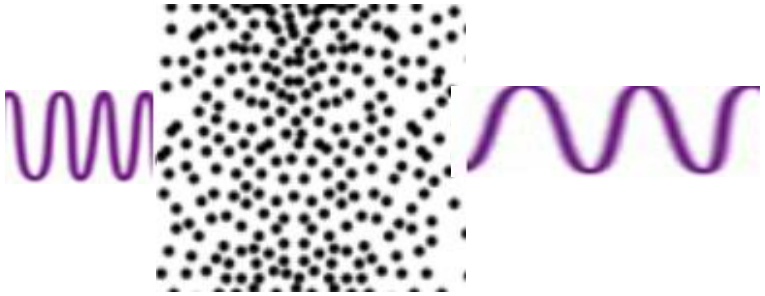
E = Energy of photon
H = Planck constant
= 6.626×10^{-34} (joule*s)
C = Speed of light
= 2.993×10^{8} (m/s)

It is important to know that Energy is in inverse proportion to Wavelength(λ)

Properties of Wave (Energy and transmittance)



<low energy wave>



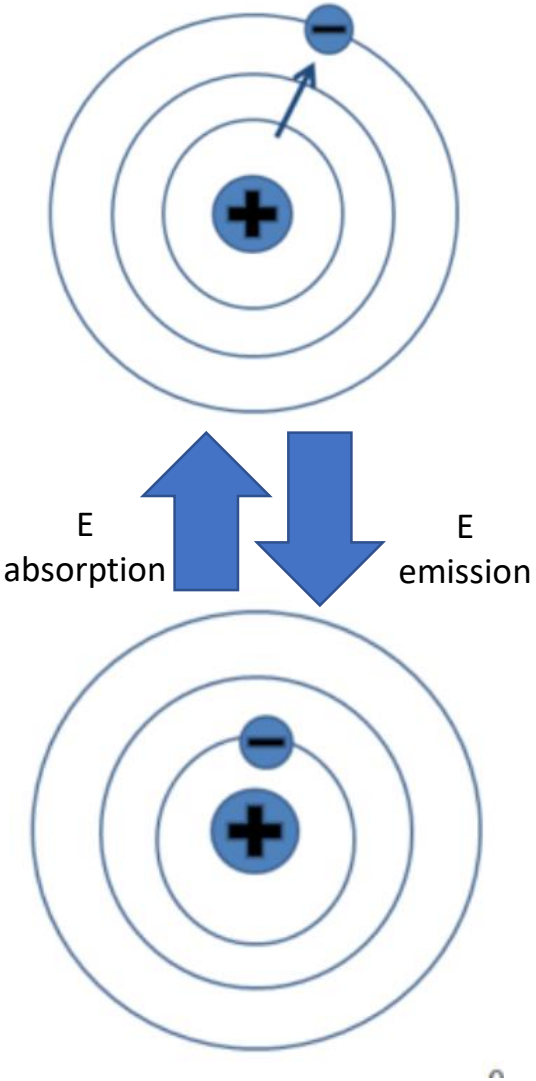
<High energy wave>

Usually, wave like sound is transferred through medium(air, water etc.) but, as you can see in the PPT.page9, EM wave transferred through space. Because of its property, particles in object interrupt EM wave transfer.

So, EM wave which has high energy can transmit the object

Energy that wave has is in direct proportion to its transmittance.

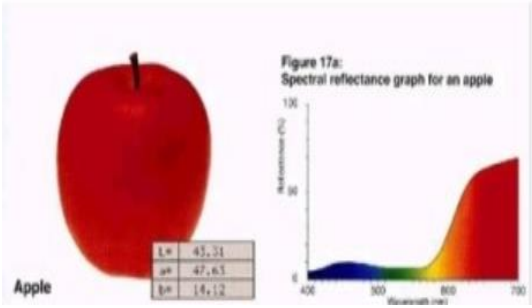
Properties of Wave (Energy level transfer)

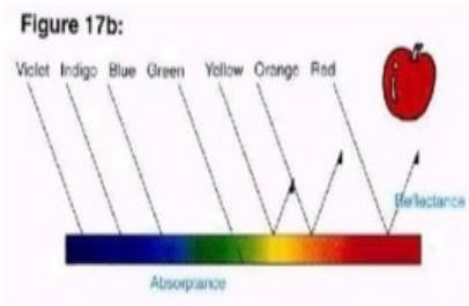


All materials absorb the specific light (because electron is quantized) and then electron would be excited state.

The excited electron consumes its energy to return to the base state.(Energy emission)

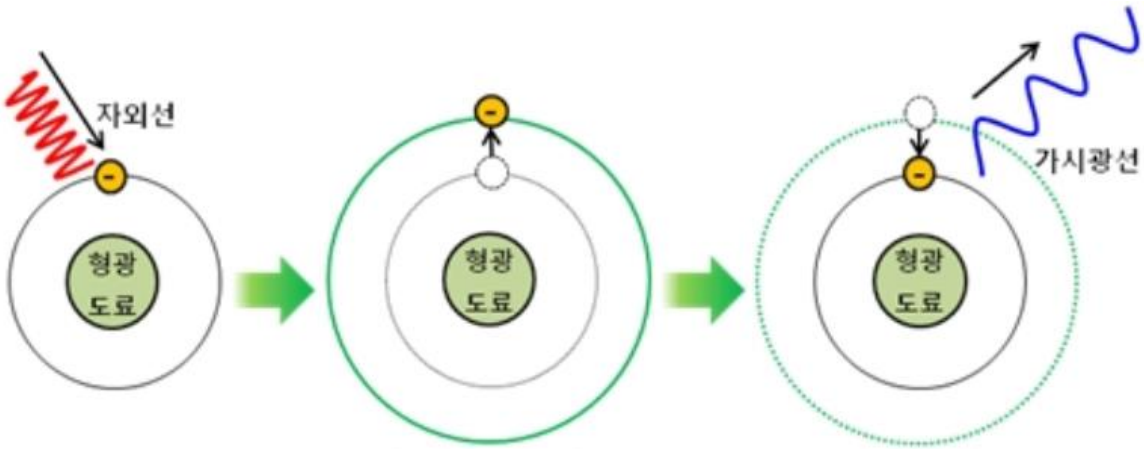
Normally, its energy is consumed by vibrating itself and crashing other electrons. Let's see example.



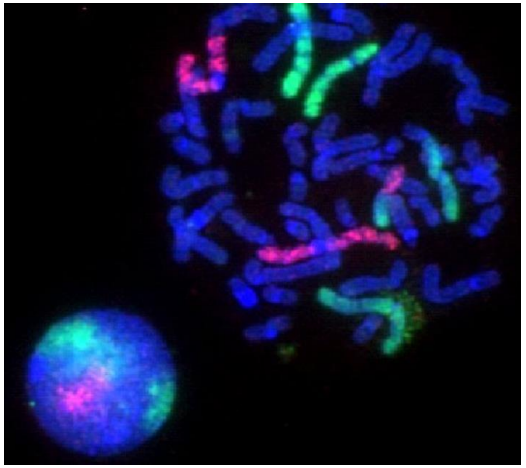


Red apple absorbs all light except the light which has the wavelength in red area(absorbing specific light) and then all absorbed energy is consumed in itself, resulting that no energy is emitted. Finally, We see red apple.

Properties of Wave (Energy level transfer)

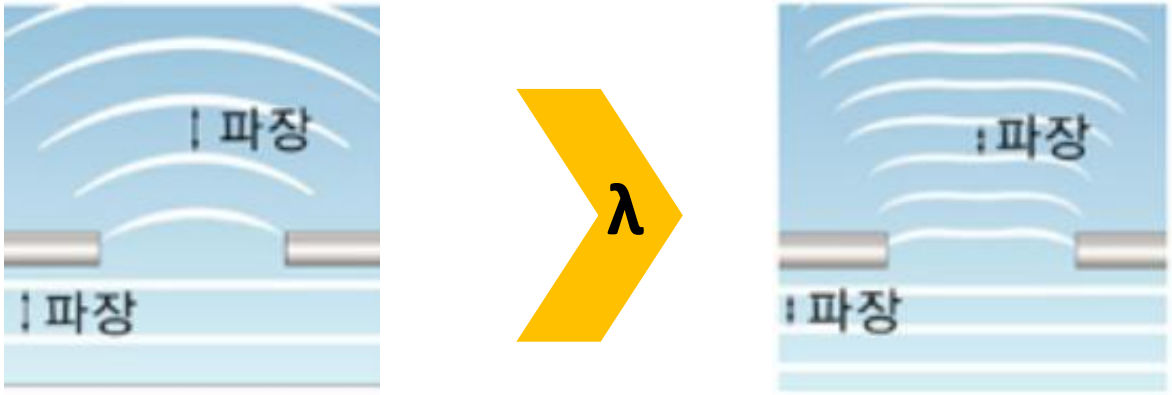


But, specifically in the case of some materials, when it absorb specific EM wave, absorbed energy is not consumed in itself instead, emitted with the form of photon. One of its phenomena is called ‘Fluorescence’



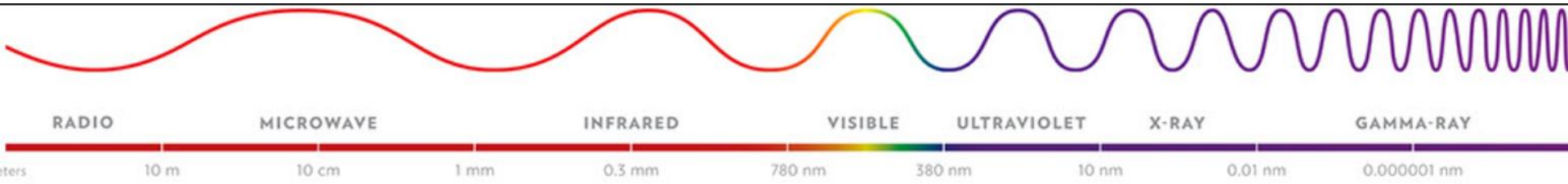
Properties of Wave (Diffraction)

Definition : When some waves encounter an obstacle or a list, wave is not disappeared and continue its progress over the objects.



- The longer the wave has wavelength, the better diffraction would be made
  : because, the number of waves which returns is less

Properties of EM waves



Wavelength ↑

Energy ↓

Transmittance ↓

Diffraction ↑

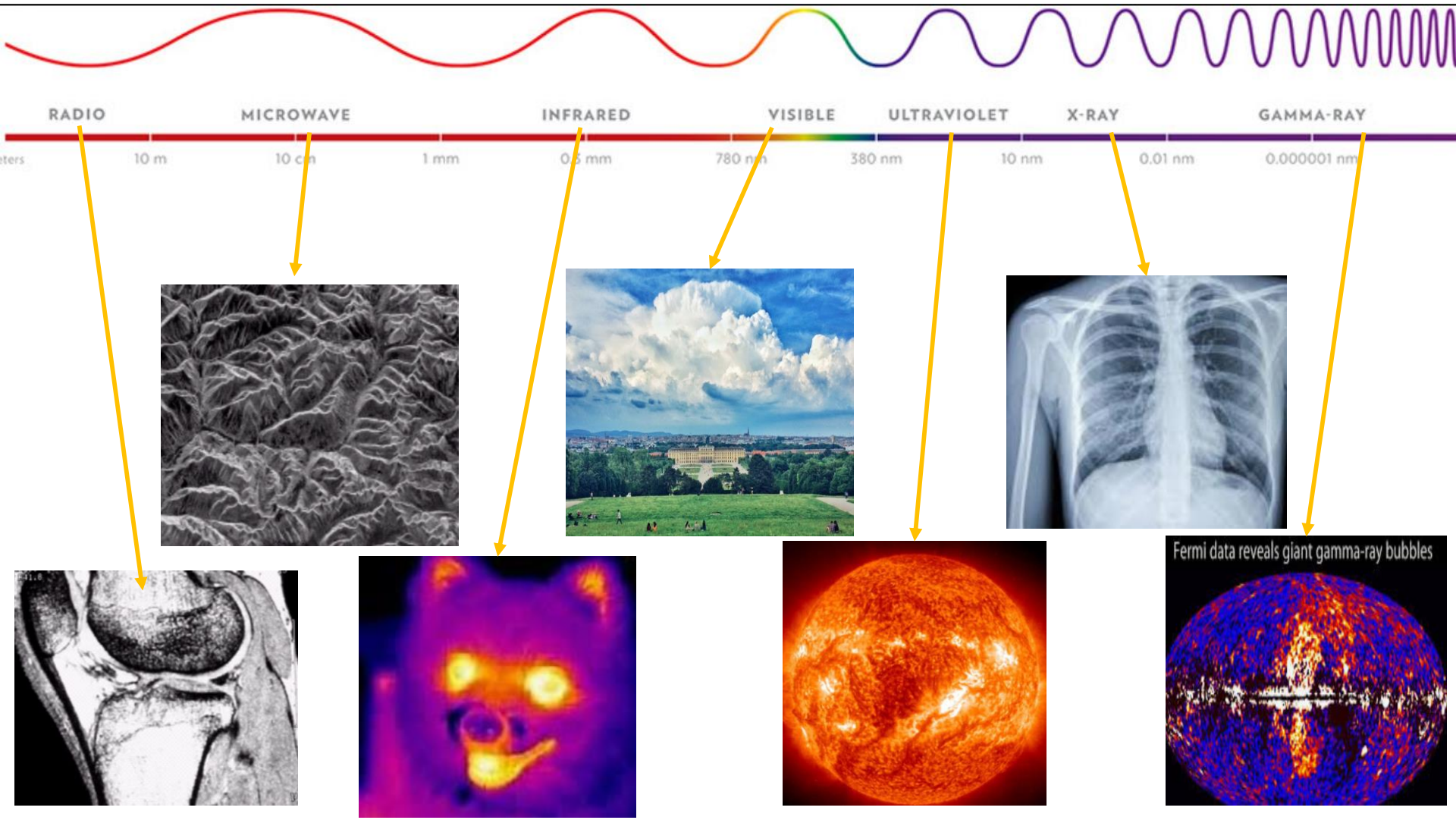
Wavelength ↓

Energy ↑

Transmittance ↑

Diffraction ↓

Images from each electromagnetic waves area



In the book…

- Gamma-Ray Imaging
- X-Ray Imaging
- Imaging in Ultraviolet band
- Imaging in the Visible and Infrared bands
- Imaging in the Microwave Band
- Imaging in the Radio Band
- Examples in which Other Imaging Modalities are used

X-ray (and Gamma ray) (High transmittance)

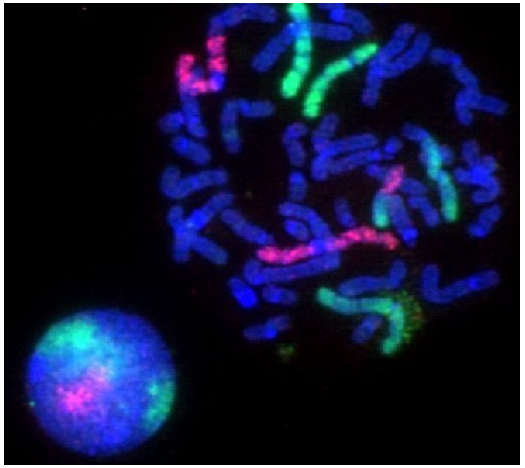
X-ray use difference of transmittance of each materials.
Different material and different density interrupt X-ray's progress differently.

Ex) X-ray

white area : not totally transmitted

black area : totally transmitted

Ultraviolet wave (Specific energy that makes Fluorescence)



When some materials absorb ultraviolet wave, they emit photon with specific color. Refer ppt-page12,13

Microwave (High diffraction than other waves)

<Spaceborne radar image of mountains in southeast Tibet. (Courtesy of NASA.)>

If wave has high diffraction, it can search more regions. Because, although it would be interrupted some obstacles, it can continues its progress to destination but, in the case of wave with low diffraction, it has so straightly progressing property that it would be easily stop its progress

Fundamental steps in DIP

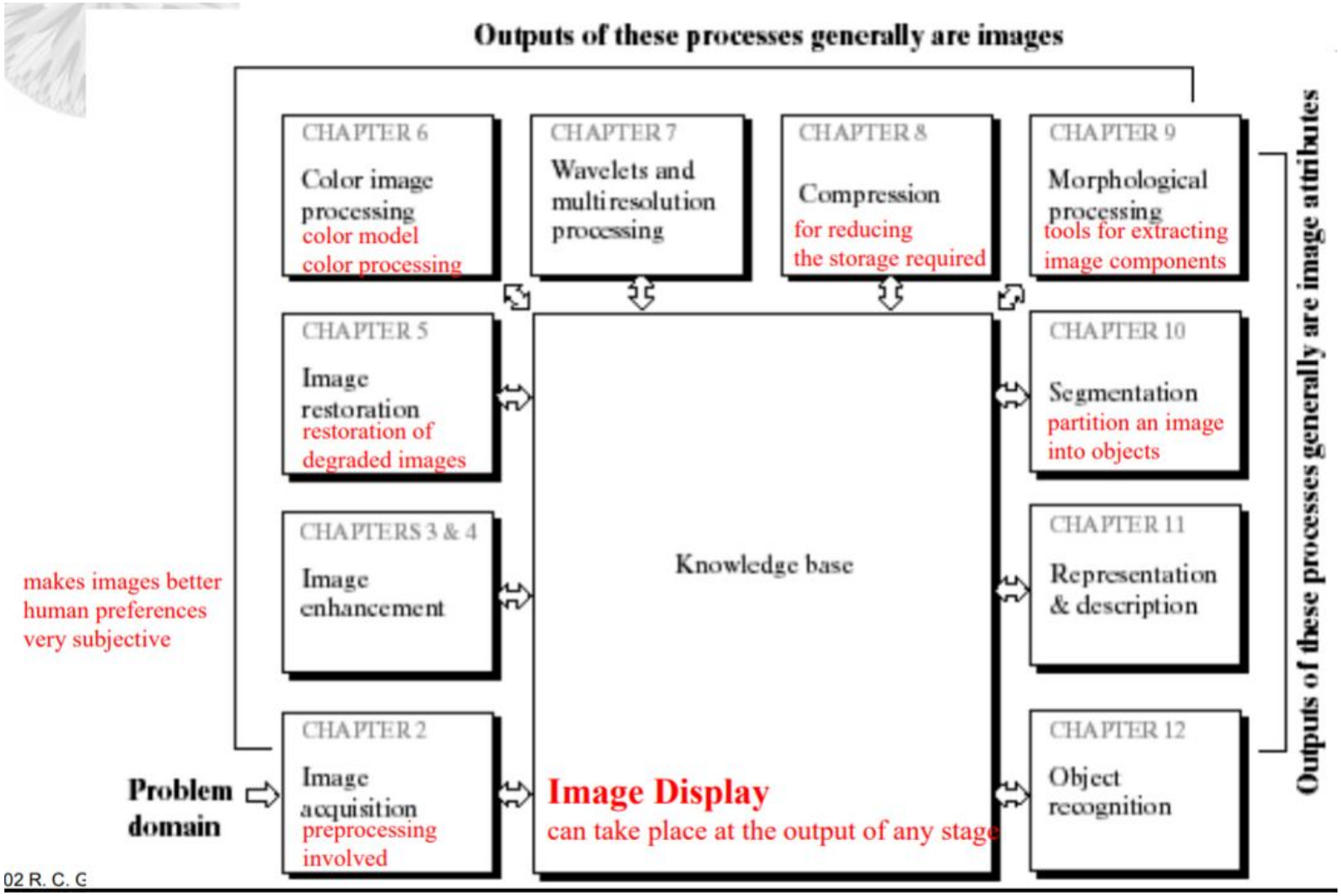
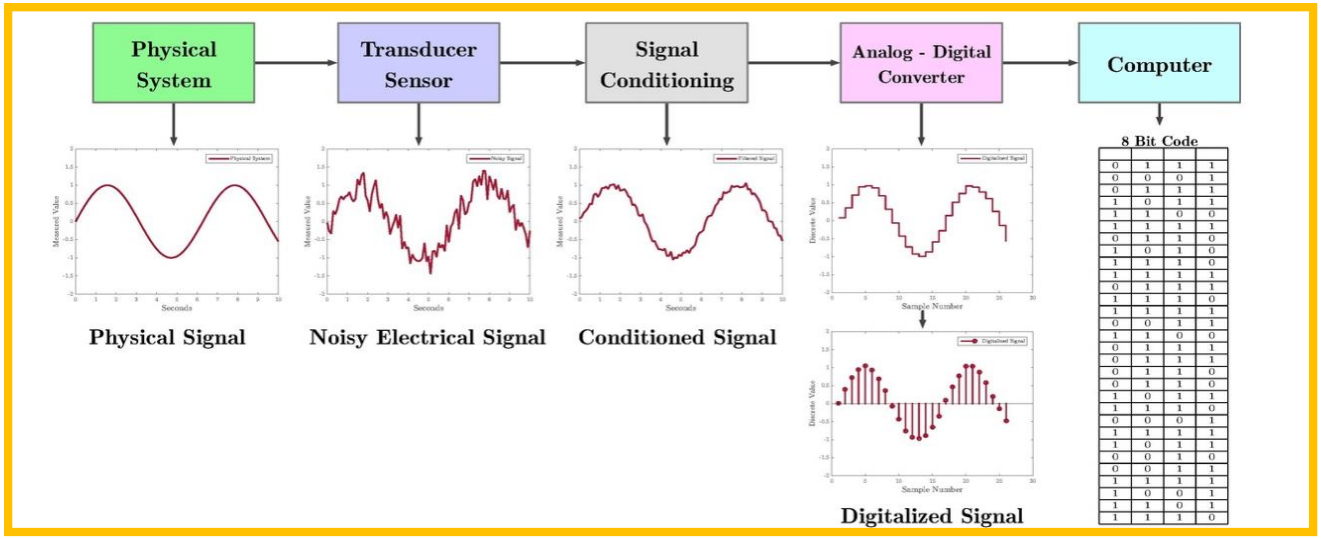


Image acquisition



Physical system – Collect signals from radar, microscopy, X-ray machine, MRI etc.. (It can be EM wave, ultrasound etc)

Transducer Sensor – It converts physical signals to electrical signal

Signal conditioning – Manipulating an signal in such a way it meets the requirements of the next stage for further processing by filtering, amplification, attenuation etc.

Image enhancement

<fingerprint image enhancement>

It is the process that manipulate image that would show better representation to make our purpose

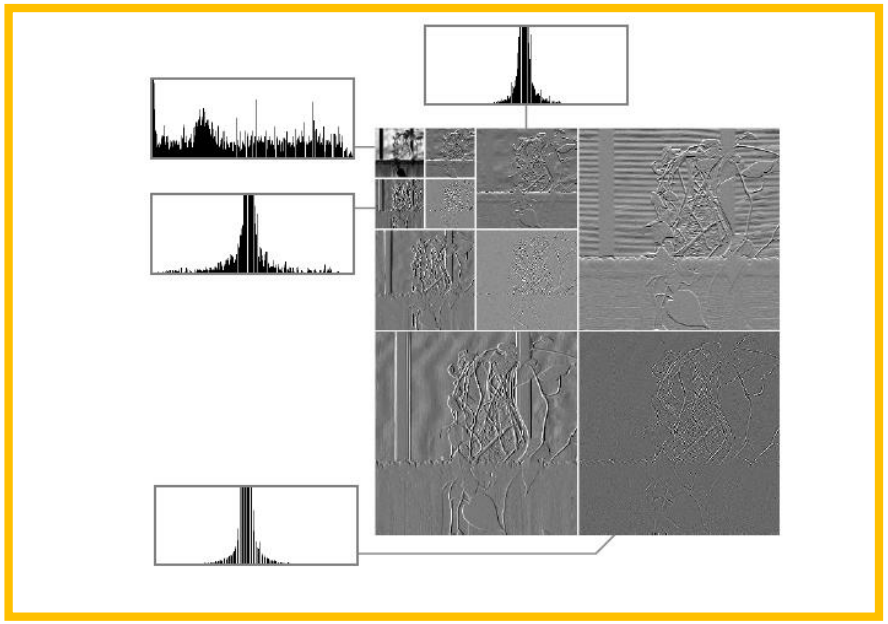
It is not objective rather subjective. (It doesn't performed by statistical model rather by researcher's thinking and intention. For example, It would be fine if researcher think that the features are extracted well)

Image restoration

<Restoration ID picture>

In contrast to Image enhancement, it is objective process.
In this process, statistical and mathematical model is used
Its purpose is to remove effects of sensing environment.

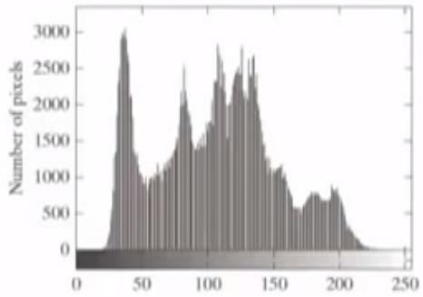
Wavelets and multiresolution processing



Images in computer originally come from analog signals and handled by transforming digital signals. In that perspective, If we can represent image to original signals, we would get better results. We study image processing in signal processing perspective.

As we know, FT(Fourier Transform) is popular method to processing signal. But FT has some limit. Improved method of FT is ‘Wavelet transform’

Image Compression

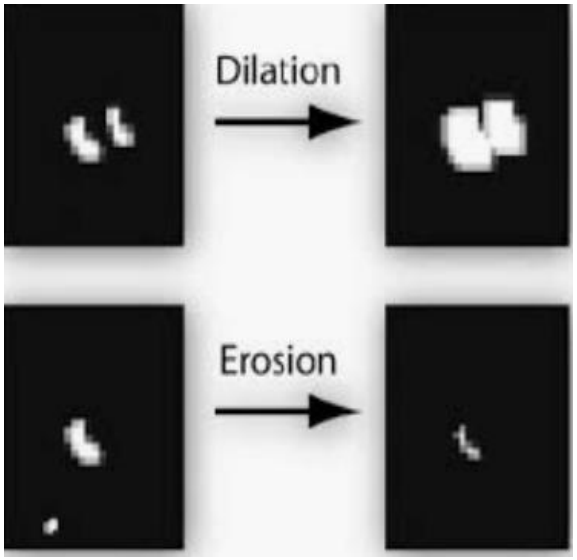


Original source			Source reduction							
Symbol	Probability	Code	1		2		3		4	
a_2	0.4	1	0.4	1	0.4	1	0.4	1	0.6	0
a_6	0.3	00	0.3	00	0.3	00	0.3	00	0.4	1
a_1	0.1	011	0.1	011	0.2	010	0.3	01		
a_4	0.1	0100	0.1	0100	0.1	011				
a_3	0.06	01010	0.1	0101						
a_5	0.04	01011								

<Huffman Coding>

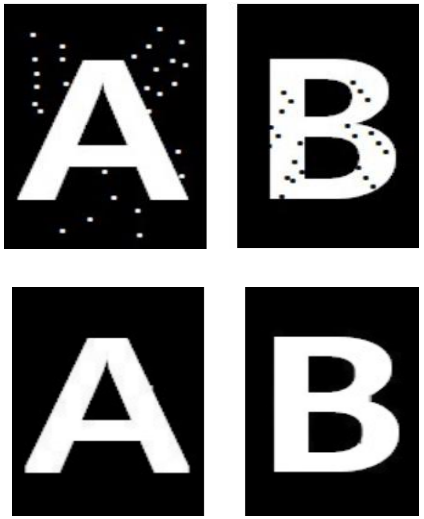
We will learn image compression. There are some compression methods for example, Huffman coding, arithmetic coding, LZW coding, Run-length coding, CCITT compression and Symbol based coding also image watermarking.

Morphological processing



<Image erosion & dilation>

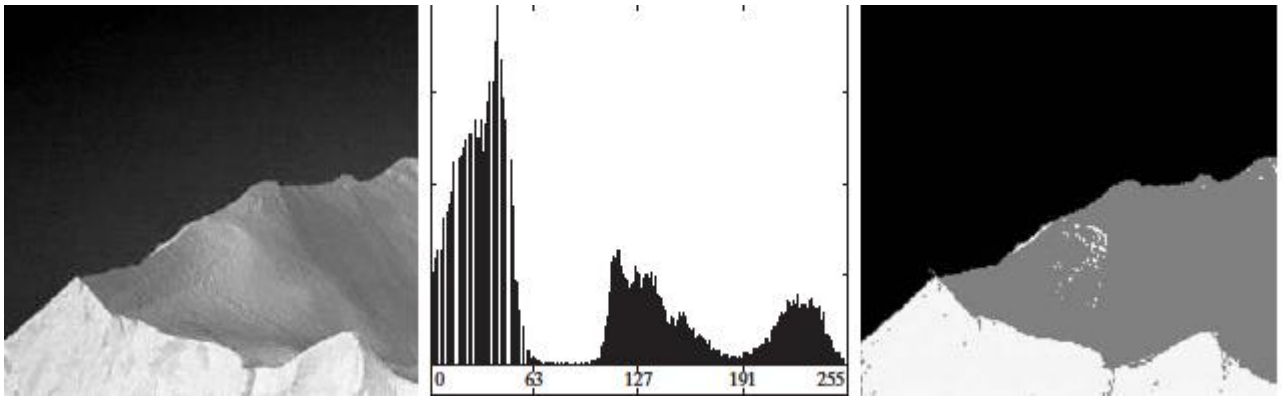
<Process of Erosion>



<Erosion -> Dilation>
(Eliminating Noise)

The word *morphology* commonly denotes a branch of biology that deals with the form and structure of animals and plants. We use the same word here in the context of ***mathematical morphology*** as a tool for extracting image components that are useful in the representation and description of region shape, such as boundaries, skeletons, and the convex hull.

Image Segmentation



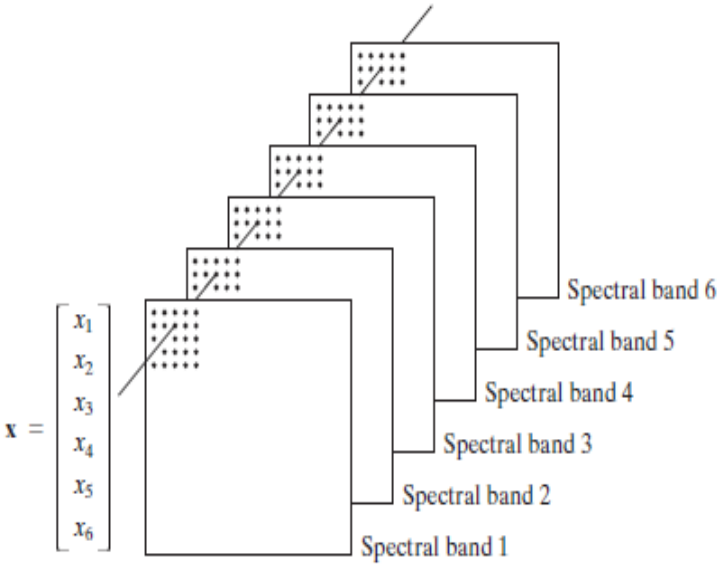
(a) (b) (c)

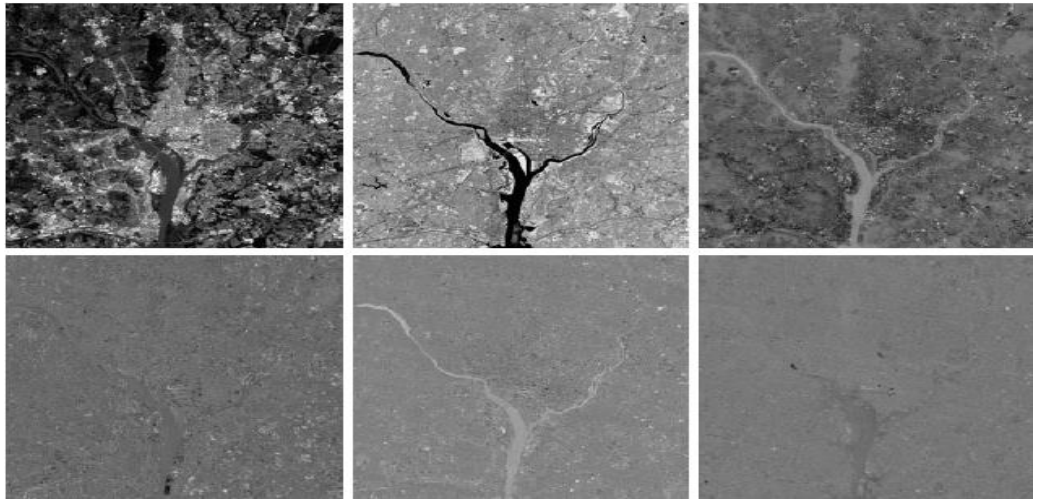
(a) Image of iceberg. (b) Histogram. (c) Image segmented into three regions using dual Otsu thresholds. (Original image courtesy of NOAA.)

Image segmentation is the process of portioning a digital image into multiple segments. See above figure. '(c)'image is divided three regions.

In this book, point, line, edge detection, thresholding, region-based method, morphological and motion case segmentation technique is handled.

Representation & description

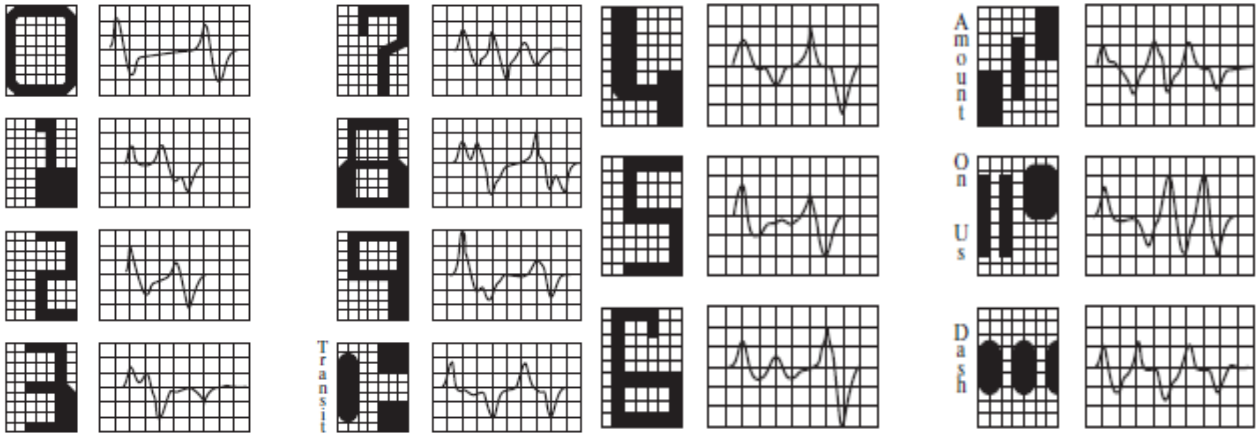




λ_1	λ_2	λ_3	λ_4	λ_5	λ_6
10344	2966	1401	203	94	31

This example is PCT(Principle Component Transform), we know as PCA, each eigenvalue(λ_1~ λ_6) means information of the image. We can think that, each eigenvalue represent and describe the image. There are other ways to represent and describe the image, for example, boundary, regional, relational descriptors

Object recognition



< American Bankers Association E-13B font character set and corresponding waveforms. >

In the last chapter, we can learn briefly about object recognition. Basyesian method, decision-theoretic method, medium distance matching, and matching by correlation etc handled.

About neural networks, it is briefly introduced.

Components of a general-purpose DIP system

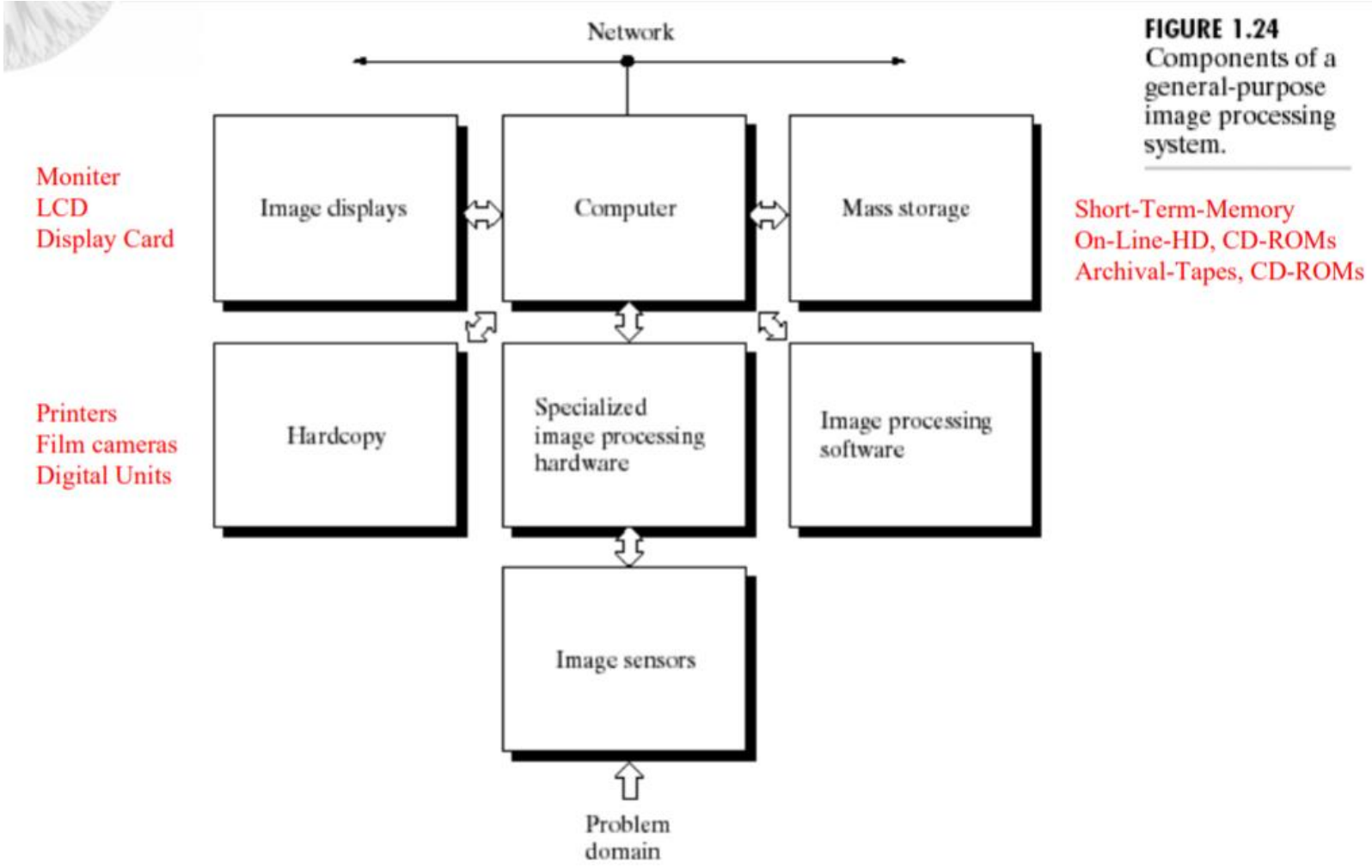


FIGURE 1.24 Components of a general-purpose image processing system.

Thanks