

Digital Image Processing (2nd Edition)

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Miscellanea

- **Lectures: Class A**
 - Tuesday 6-7
 - Thursday 1-2
- **Lectures: Class B**
 - Monday 1-2
 - Wednesday 6-7
- **Labs:**
 - Tuesday for Class A and Wednesday for Class B
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Contents for Chapter 1

- This lecture will cover:
 - What is digital image processing? 1
 - The origins of digital image processing? 3
 - Examples of fields that use digital image processing? 7
 - Fundamental Steps in Digital Image Processing 25
 - Components of an image processing system 28
 - Summary 30

Introduction

“One picture is worth more than ten thousand words”

Anonymous

Preview

- Digital image processing methods are interested by two major applications:
 - i. Improvement of pictorial information for human perception and processing of image data for storage, transmission
 - Noise filtering
 - Content Enhancement
 - Contrast enhancement
 - Deblurring
 - Remote sensing
 - ii. Representation for autonomous machine perception

Objectives

- i. To define the scope of the field that we call image processing
- ii. To give a historical perspective of the origins of this field
- iii. To give an idea of the state of the art in image processing by examining some of the principal areas in which it is applied
- iv. To discuss briefly the principal approaches used in digital image processing
- v. To give an overview of the components contained in a typical, general-purpose image processing system
- vi. To provide direction to the books and other literature where image processing work normally is reported

What is Digital Image Processing?

- 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, discrete quantities, we call the image a digital image.
- The field of digital image processing refers to processing digital images by means of a digital computer.
- Digital image is composed of a finite number of elements, each of which has a particular location and value.
- These elements are referred to as picture elements, image elements, and pixels. Pixel is the term most widely used to denote the elements of a digital image.

The Origins of Digital Image Processing

- Early 1920s: One of the first applications of digital imaging was in the newspaper industry
- In 1920s Submarine cables were used to transmit digitized newspaper pictures between London and New York using Bartlane systems.
- Specialized printing equipments were used to code the images and reproduced at receiver using telegraphic printers.
- In 1921, photographic printing press improved the resolution and tonal quality of images.
- Bartlane system was capable of coding 5 distinct brightness levels.
- It increased to 15 by 1929.

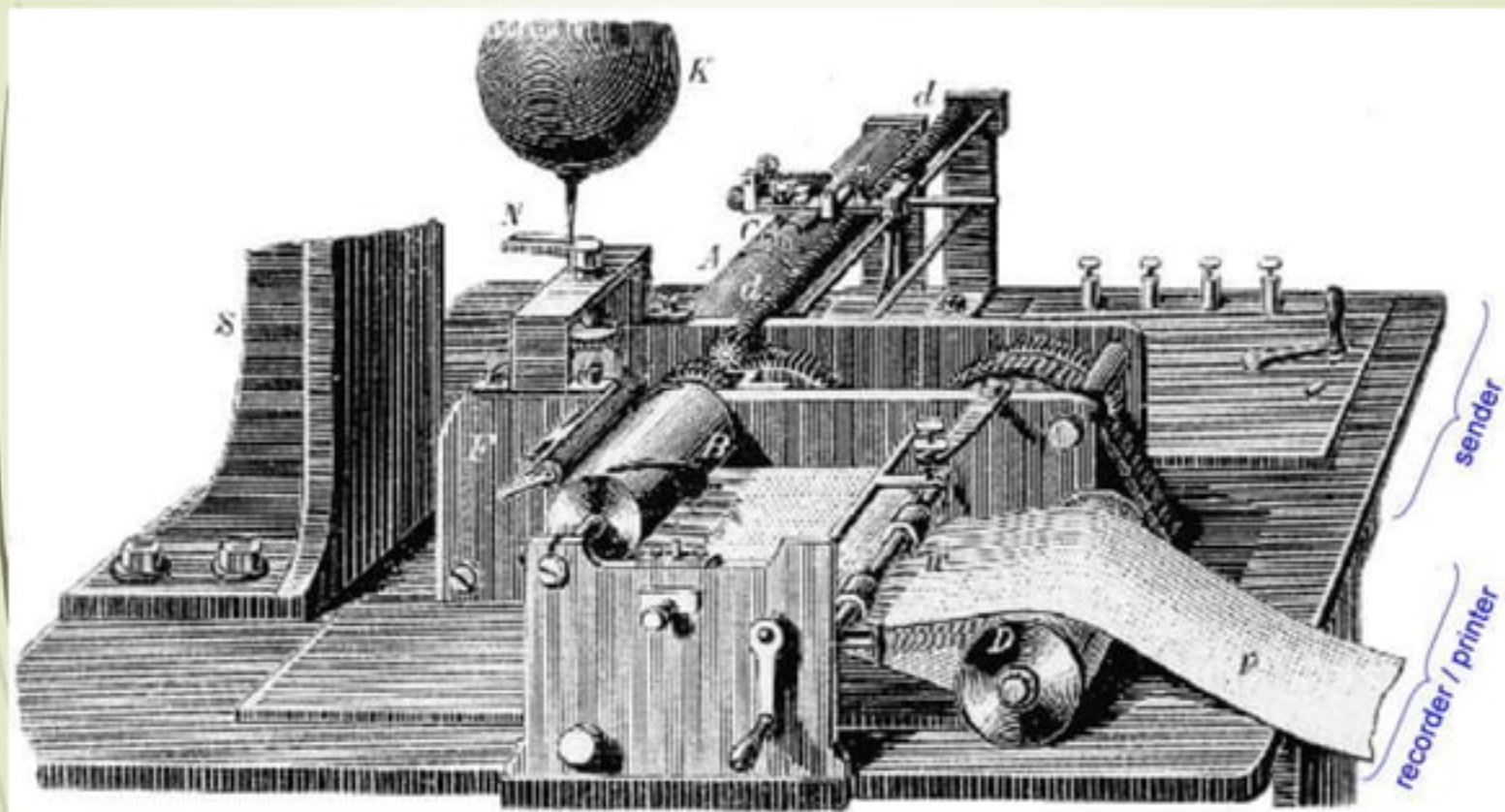


Fig. telegraphic printer

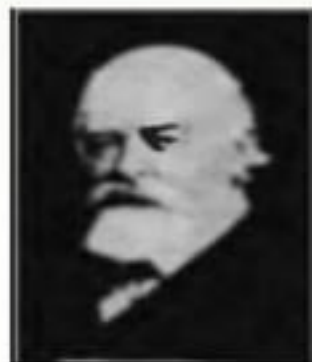


Fig. A digital picture produced using telegraphic printer
(in 1921, 1922 - Atlantic, 1929 – London to New York)

- After 35 years of improvement in processing technique
- In 1960s, Improvements in computing technology and the onset of the space program during the period.
- In 1964, Computer processing techniques were used to improve picture of moon transmitted by *Ranger 7* at JPL.

This was the basis of modern image processing technique.

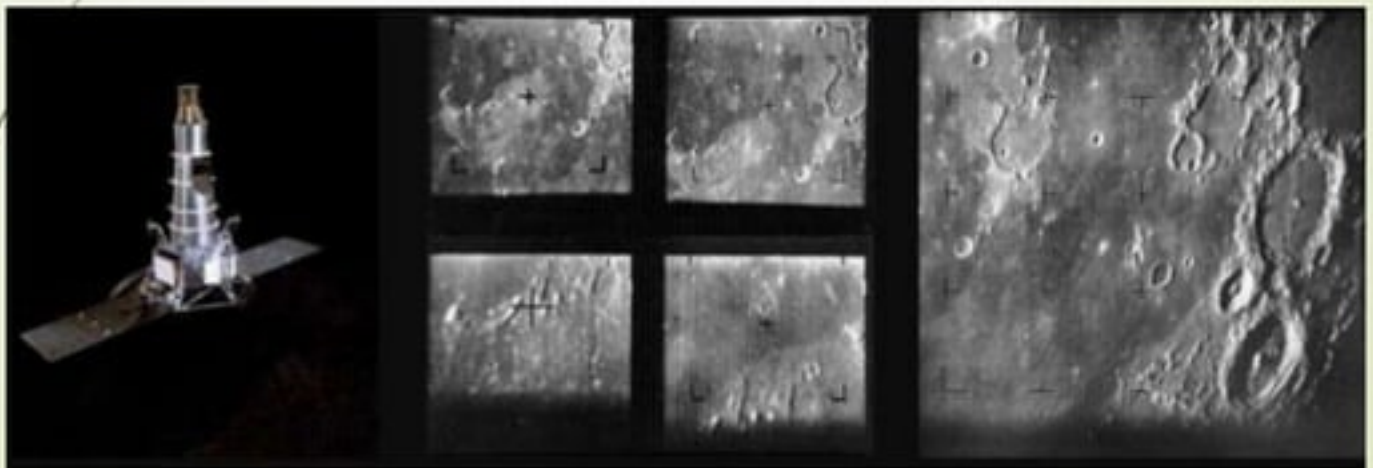


Fig. The first picture of the moon by a U.S. spacecraft

- **1970s:** Digital image processing begins to be used in medical applications
- **1979:** Sir Godfrey N. Hounsfield & Prof. Allan M. Cormack share the Nobel Prize in medicine for the invention of tomography, the technology behind Computerised Axial Tomography (CAT) scans

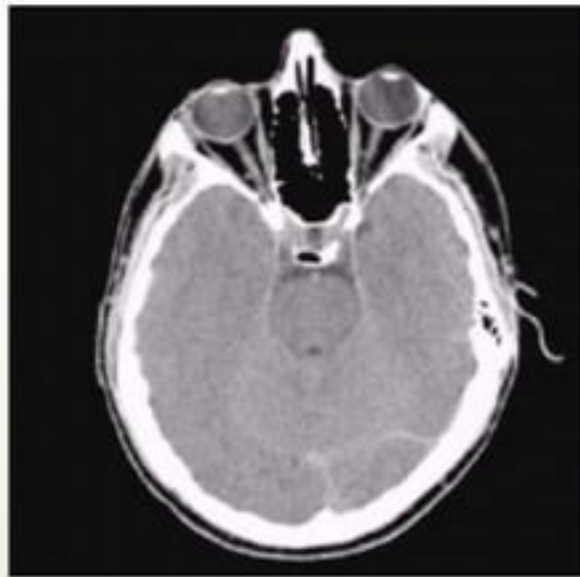


Fig. Typical head slice CAT image

- **Today:** The use of digital image processing techniques has exploded and they are now used for all kinds of tasks in all kinds of areas
 - Image enhancement/restoration
 - Artistic effects
 - Medical visualisation
 - Industrial inspection
 - Law enforcement
 - Human computer interfaces

Image Enhancement

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Fig. Noisy Image



Fig. Filtered Image



Fig. Low Contrast Image



Fig. Enhanced Image

Image Enhancement



Restoration



Fig. Motion Blurred



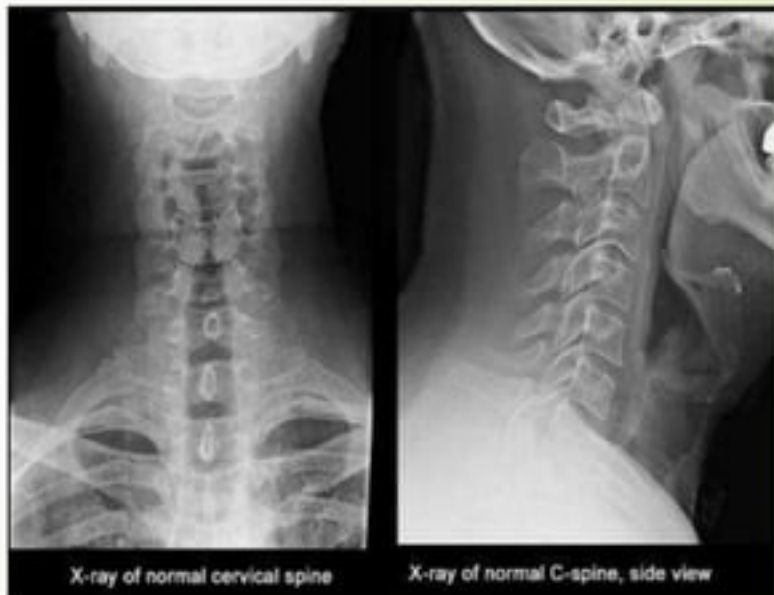
Fig. Deblurred

Artistic Effects

- Artistic effects are used to make images more visually appealing, to add special effects and to make composite images.

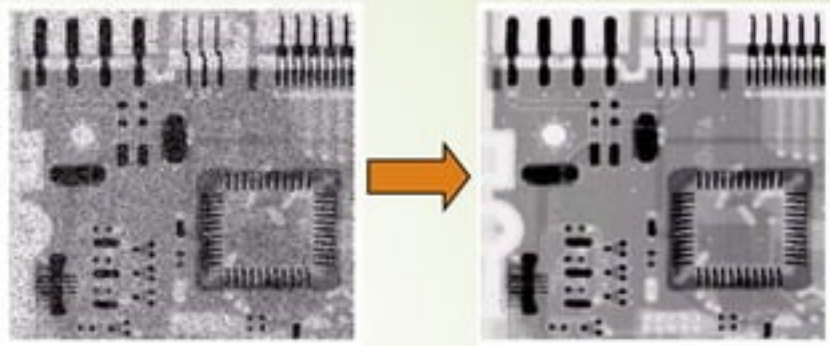


Medical Visualisation



Industrial Inspection

- Human operators are expensive, slow and unreliable
- Make machines do the job instead
- Industrial vision systems are used in all kinds of industries
- Can we trust them?



Law Enforcement

- Image processing techniques are used extensively by law enforcers
 - Number plate recognition for speed cameras/automated toll systems
 - Fingerprint recognition
 - Enhancement of CCTV images



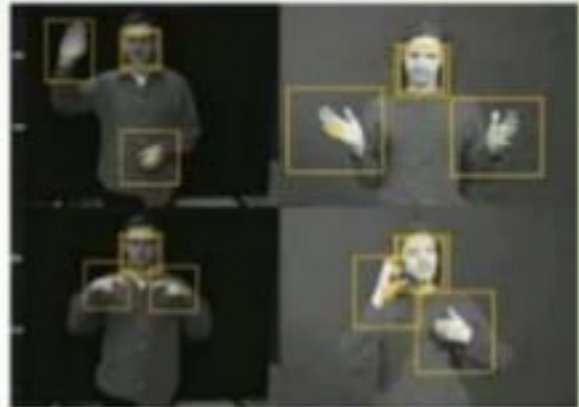
HCI

Try to make human computer interface more natural

- Face recognition
- Gesture recognition

Does anyone remember the user interface from “Minority Report”?

These tasks can be extremely difficult



Examples of Fields that Use Digital Image Processing

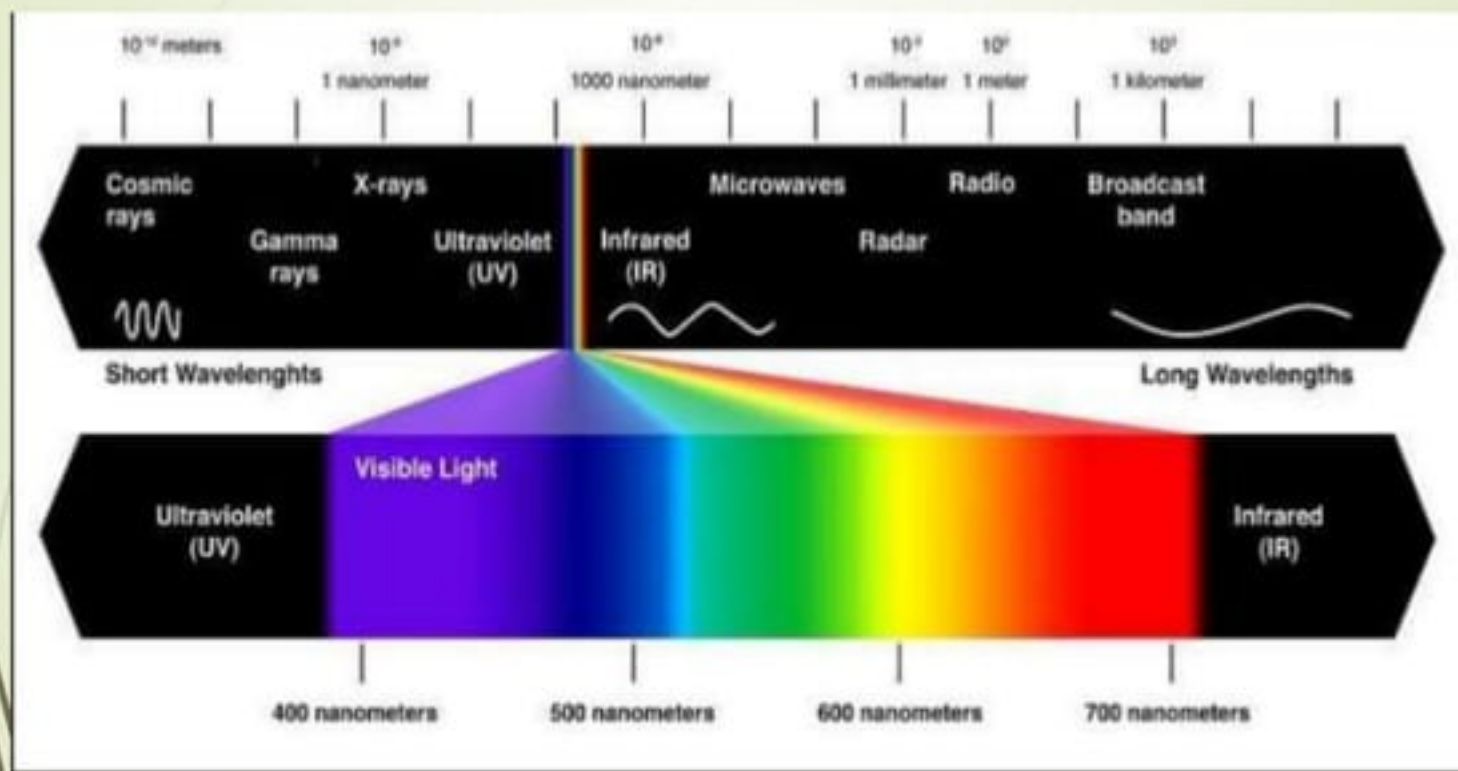
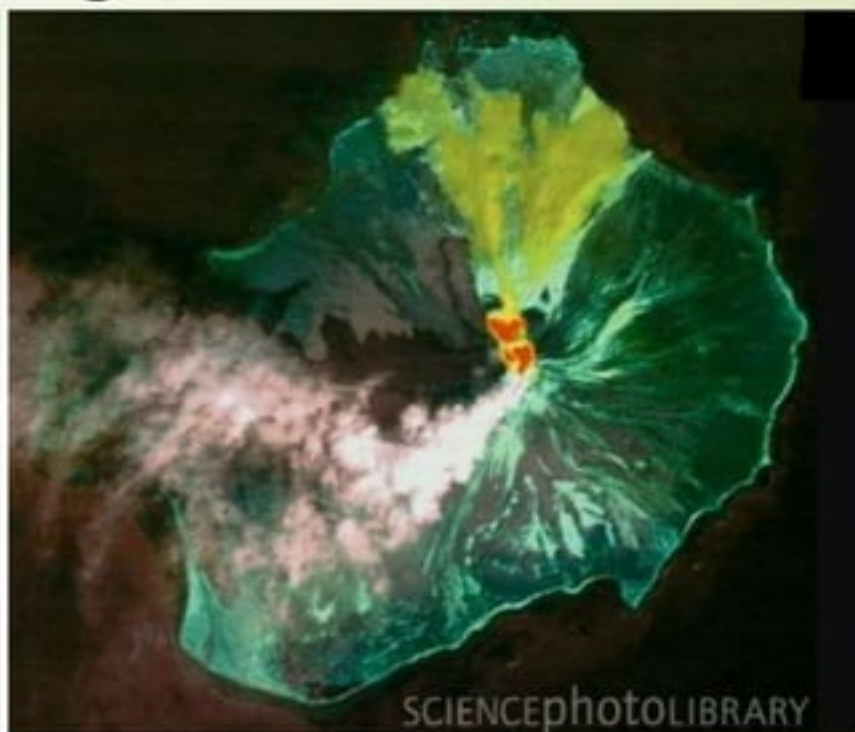
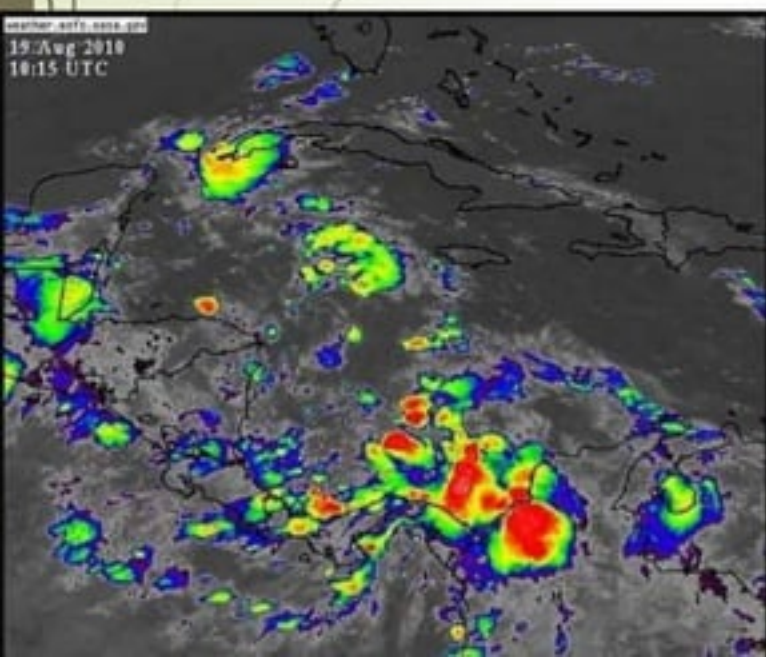
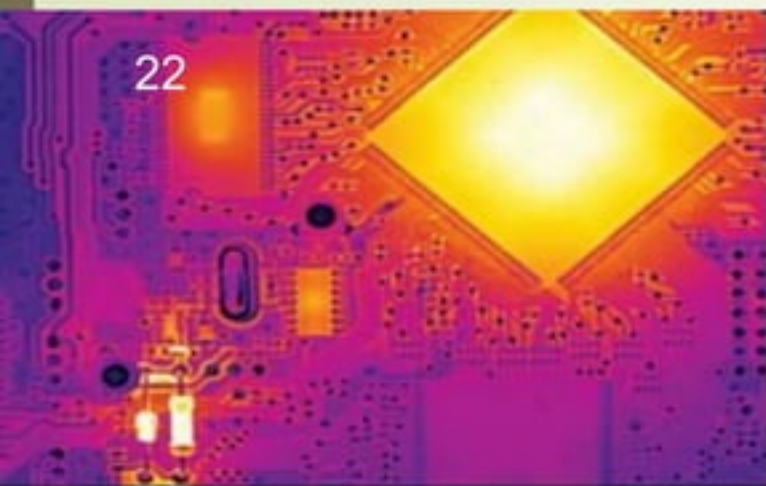


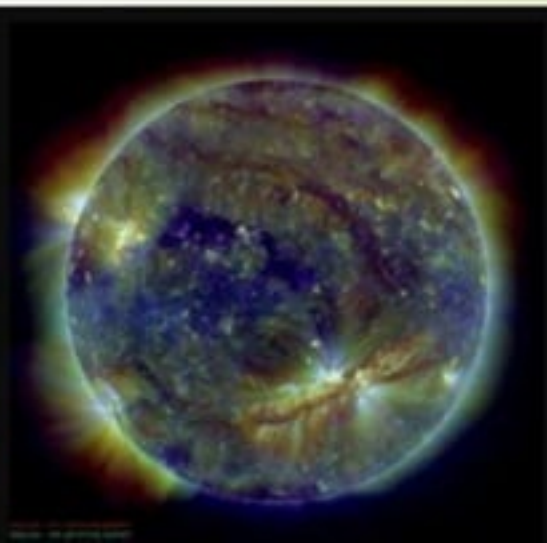
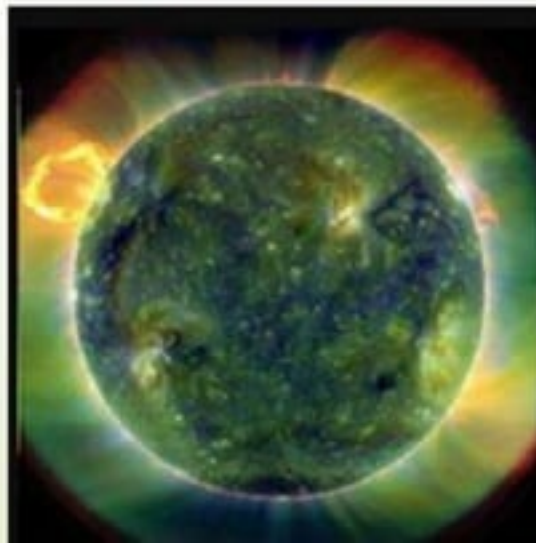
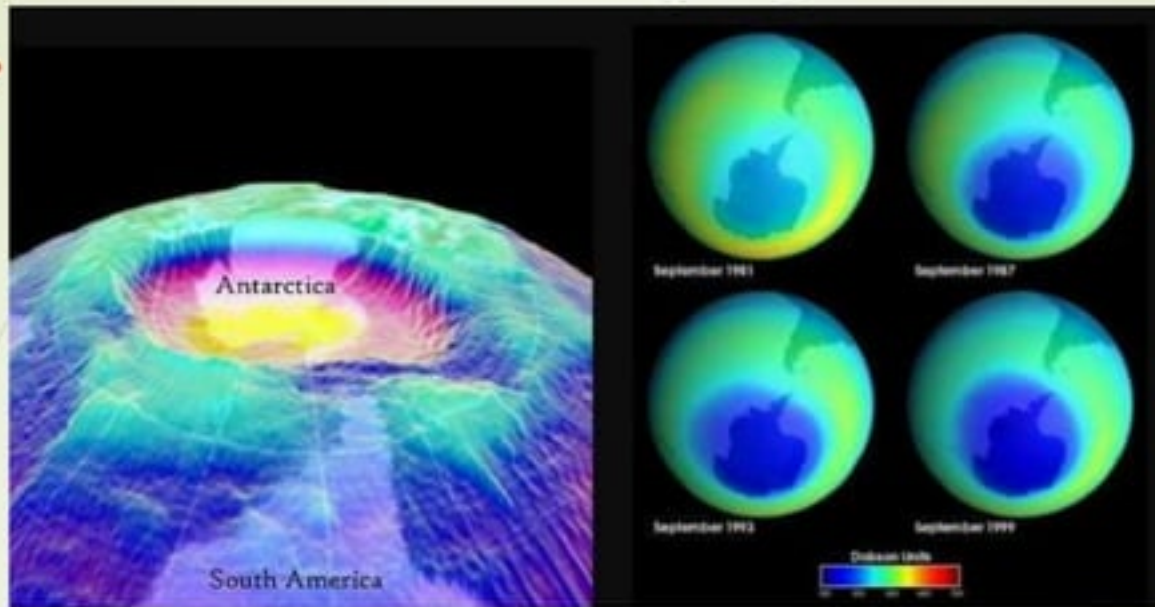
Fig. The electromagnetic spectrum arranged according to energy per photon

Infrared Imaging (Performance)

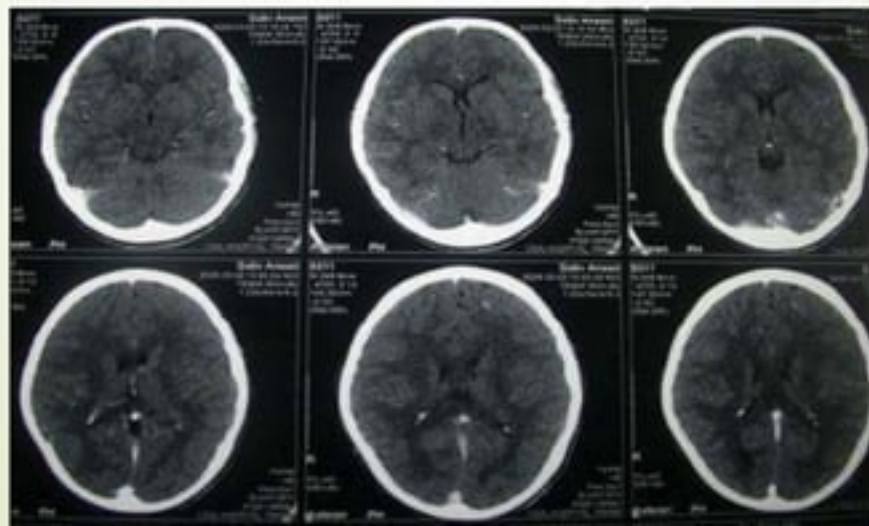
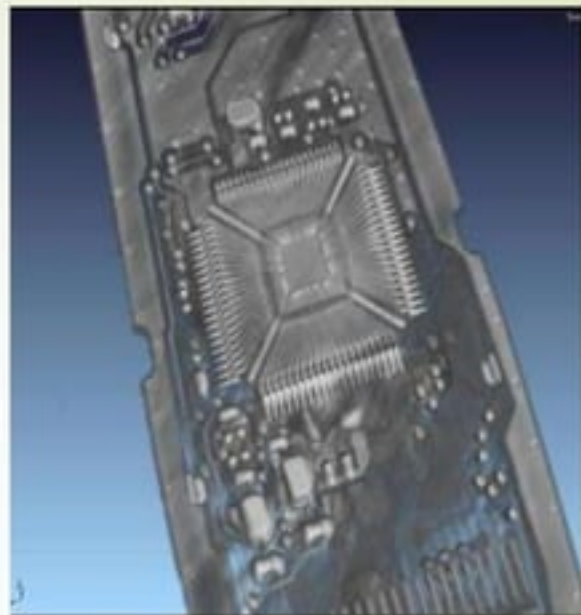


UV Imaging

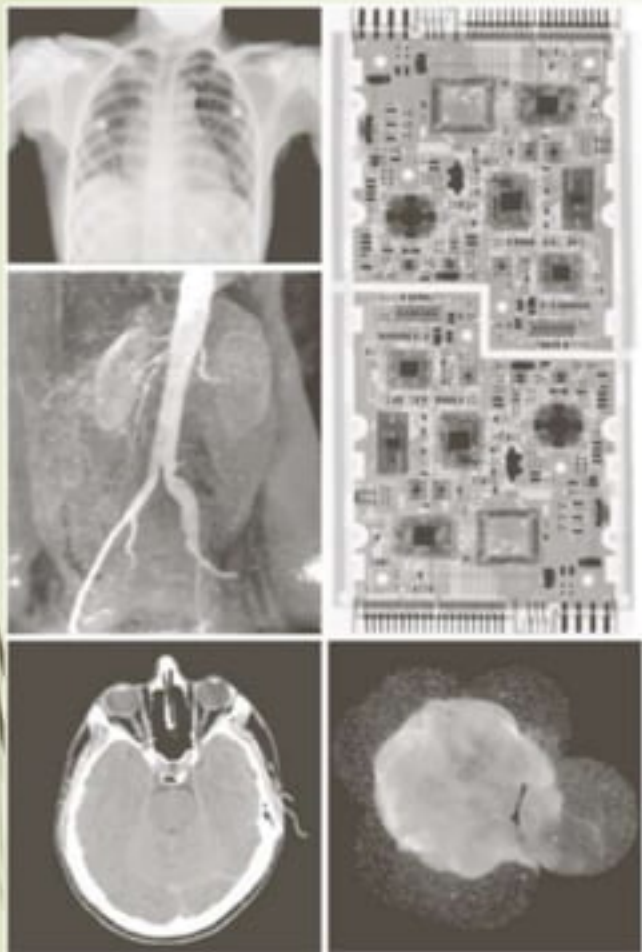
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X-Ray Imaging

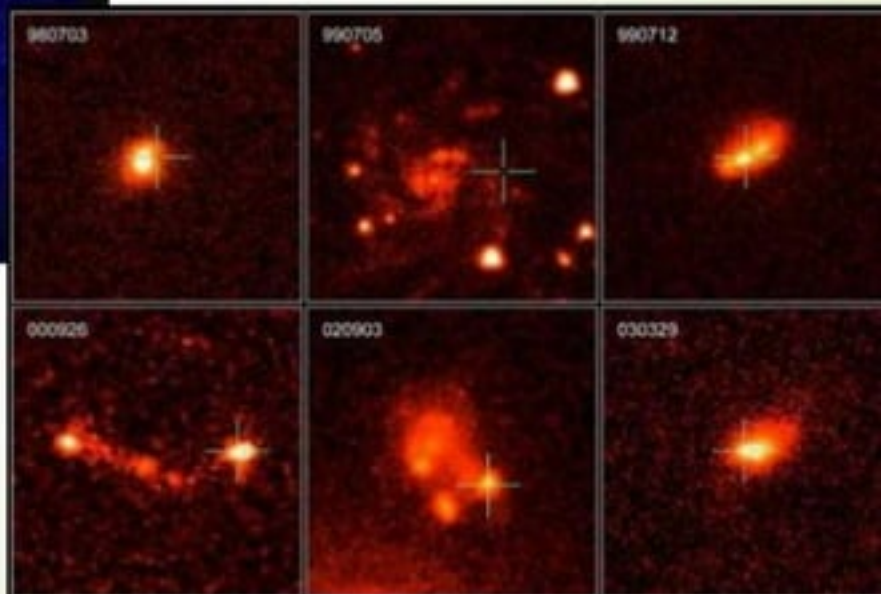


X-Ray Imaging



Gamma Ray Imaging

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Gamma-Ray Burst Host Galaxies
Hubble Space Telescope

Gamma-Ray Imaging

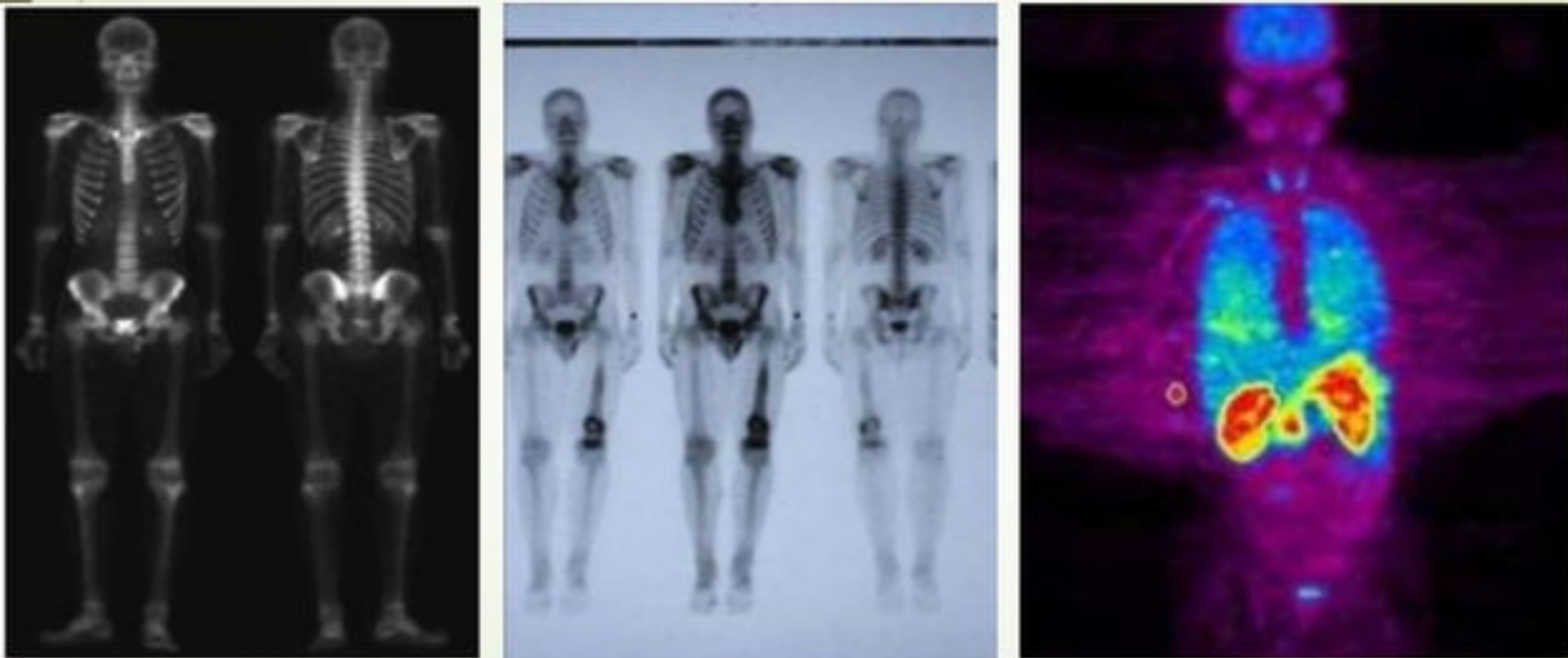


Fig. Examples of gamma-ray imaging. (a) Bone scan. (b) PET image

Imaging in the Visible and Infrared Bands

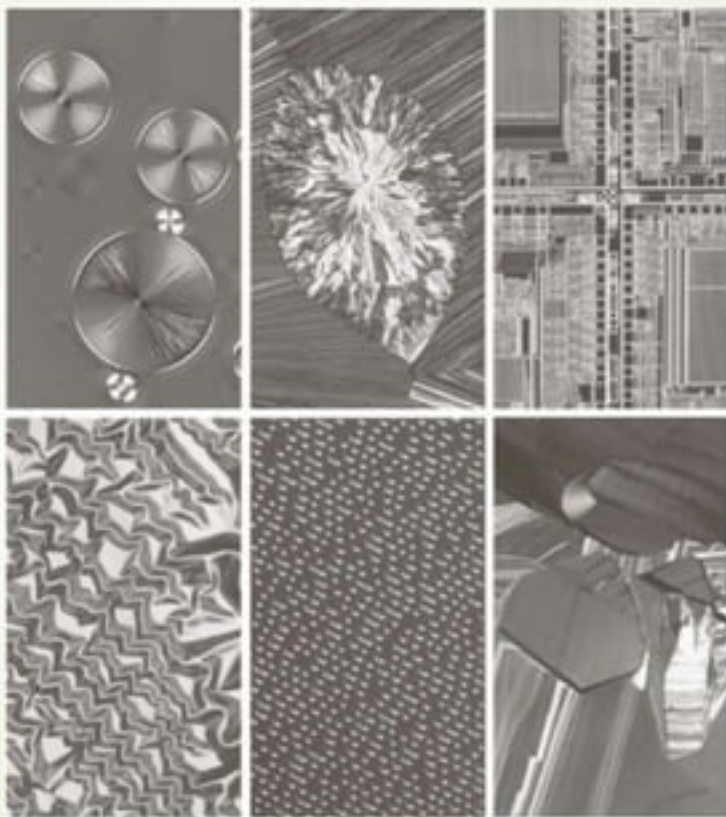


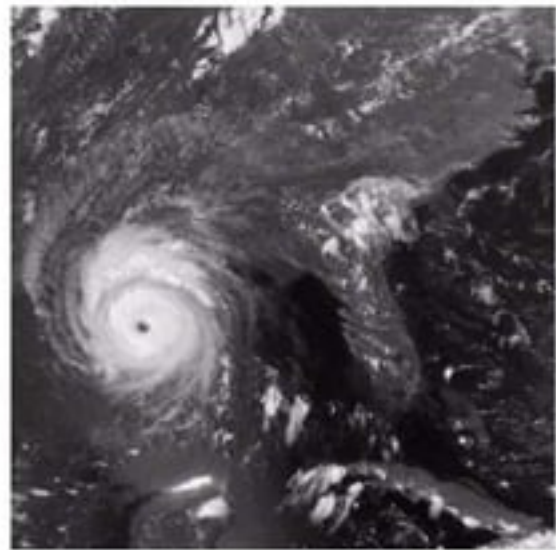
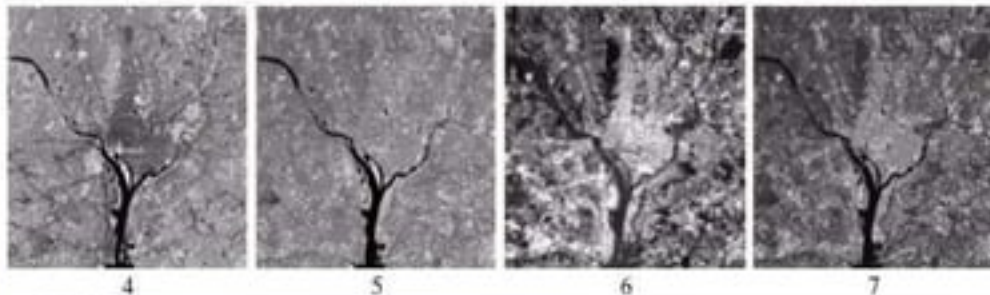
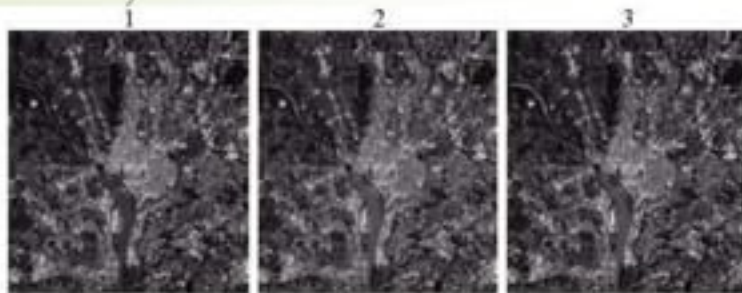
Table : Thematic bands in NASA's LANDSAT satellite

Band No.	Name	Wavelength (μm)	Characteristics and Uses
1	Visible blue	0.45–0.52	Maximum water penetration
2	Visible green	0.52–0.60	Good for measuring plant vigor
3	Visible red	0.63–0.69	Vegetation discrimination
4	Near infrared	0.76–0.90	Biomass and shoreline mapping
5	Middle infrared	1.55–1.75	Moisture content of soil and vegetation
6	Thermal infrared	10.4–12.5	Soil moisture; thermal mapping
7	Middle infrared	2.08–2.35	Mineral mapping

GIS

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- Geographic Information Systems
 - Digital image processing techniques are used extensively to manipulate satellite imagery
 - Terrain classification
 - Meteorology

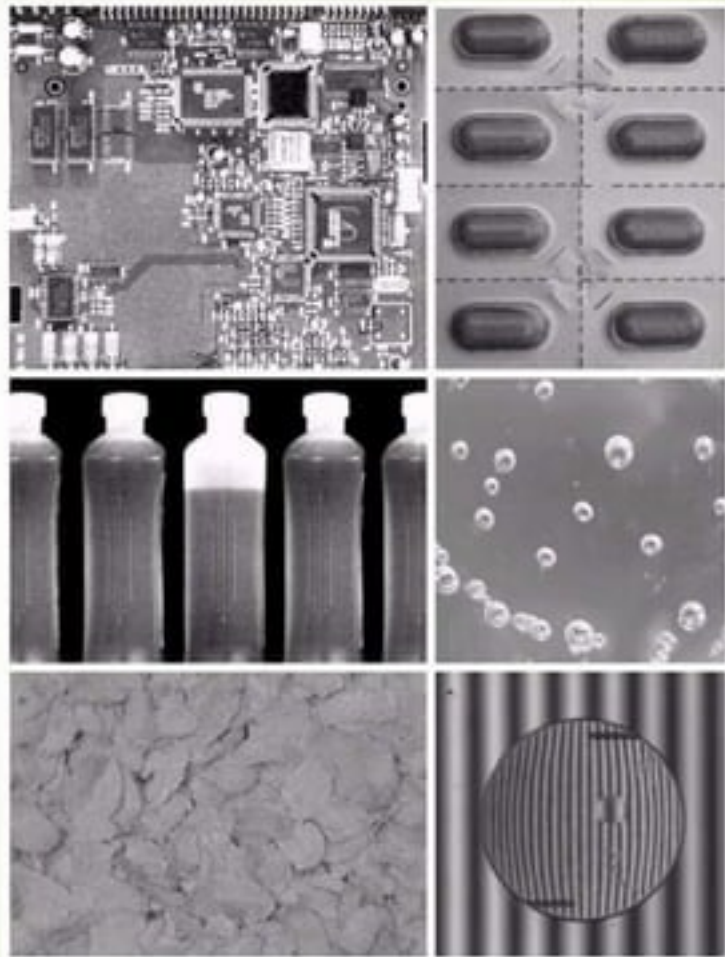


- *Night-Time Lights of the World* data set
 - Global inventory of human settlement
 - Not hard to imagine the kind of analysis that might be done using this data

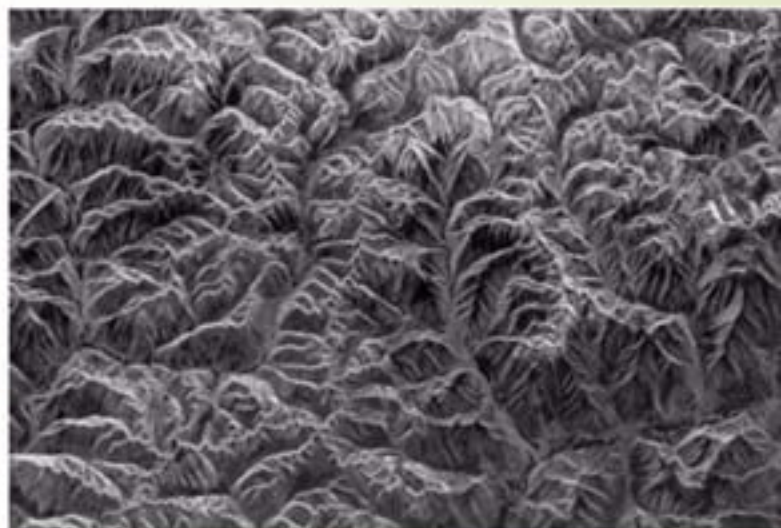


Industrial Inspection

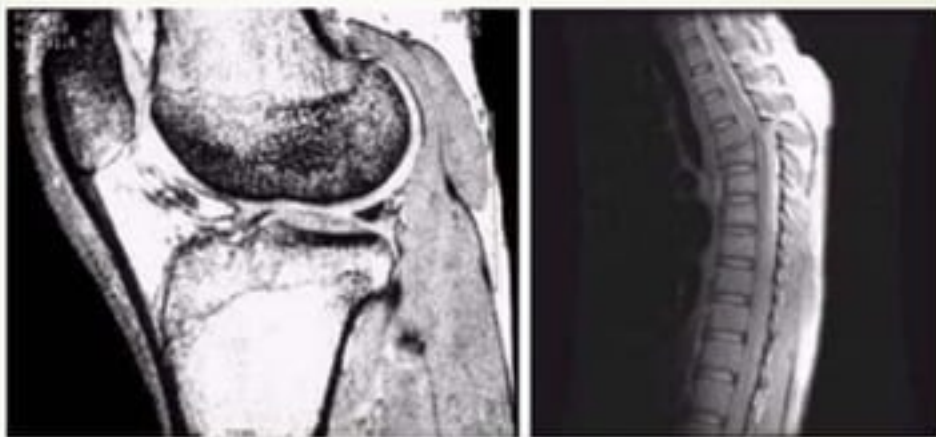
- Human operators are expensive, slow and unreliable
- Make machines do the job instead
- Industrial vision systems are used in all kinds of industries
- Can we trust them?



Imaging in the Microwave Band



Imaging in the Radio Band



Gamma



X-ray



Optical



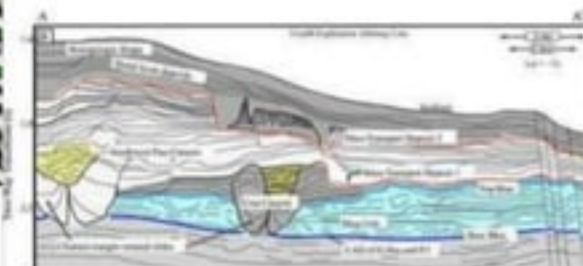
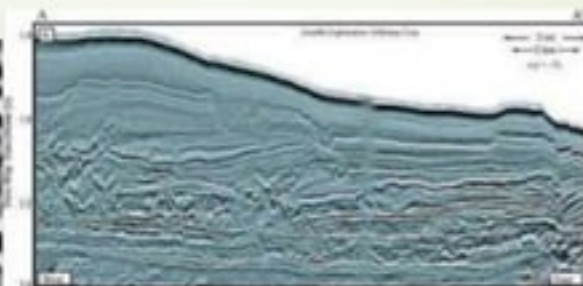
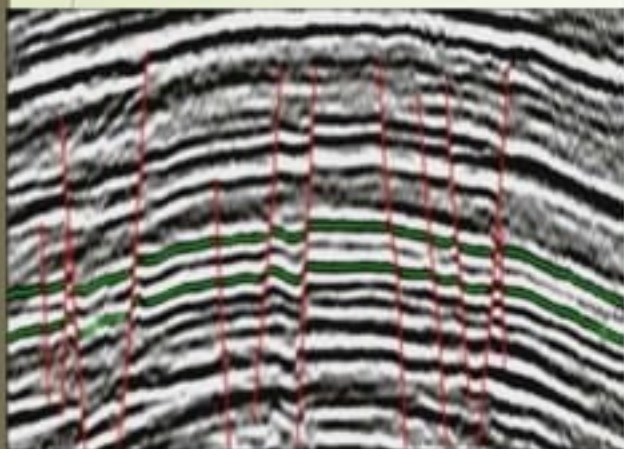
Infrared



Radio

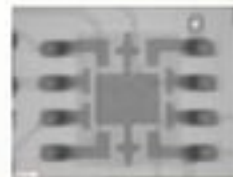
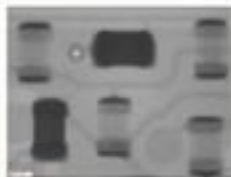
Examples in which other imaging modalities are used

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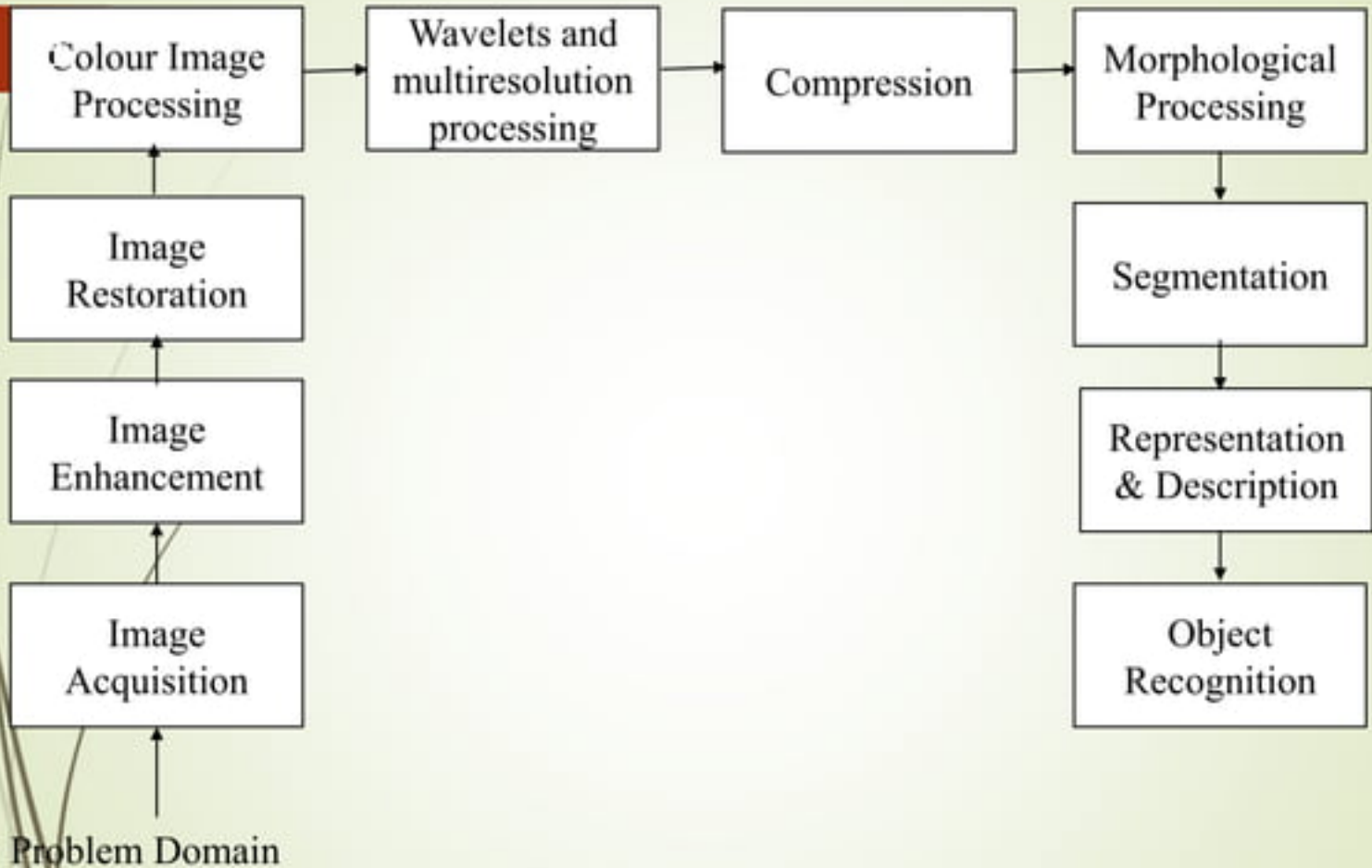


PCB Inspection

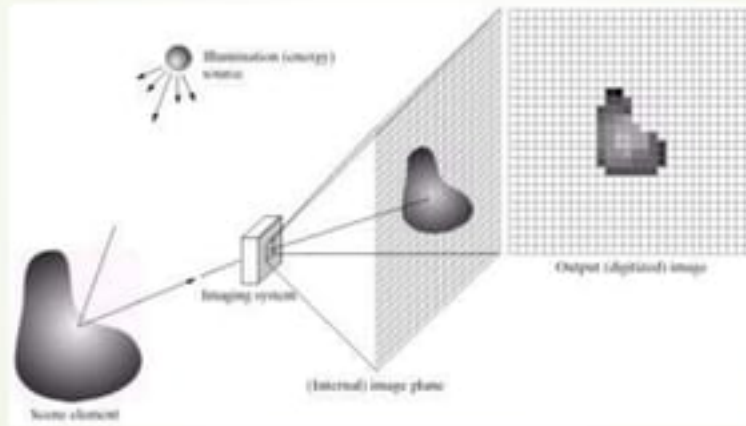
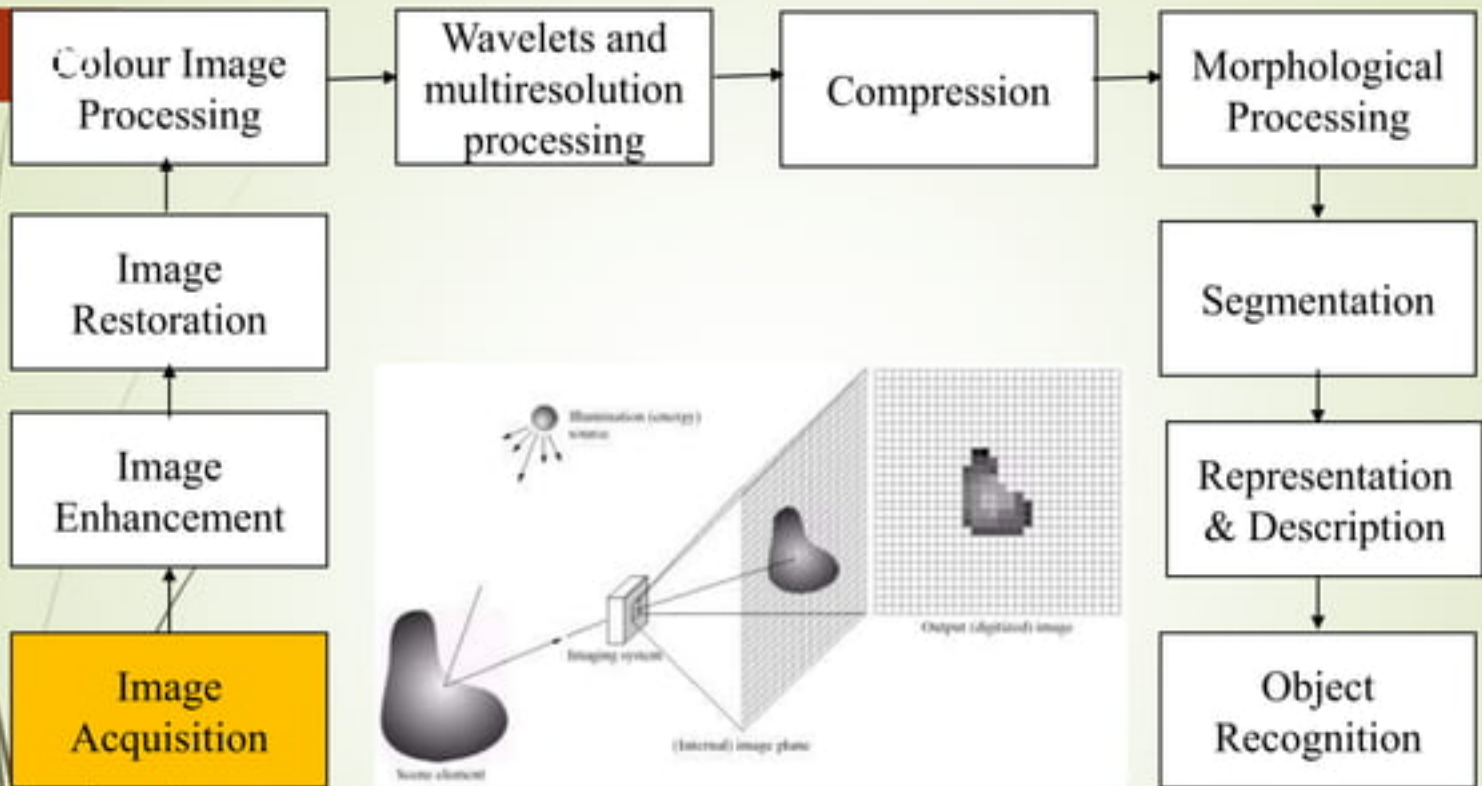
- Printed Circuit Board (PCB) inspection
 - Machine inspection is used to determine that all components are present and that all solder joints are acceptable
 - Both conventional imaging and x-ray imaging are used



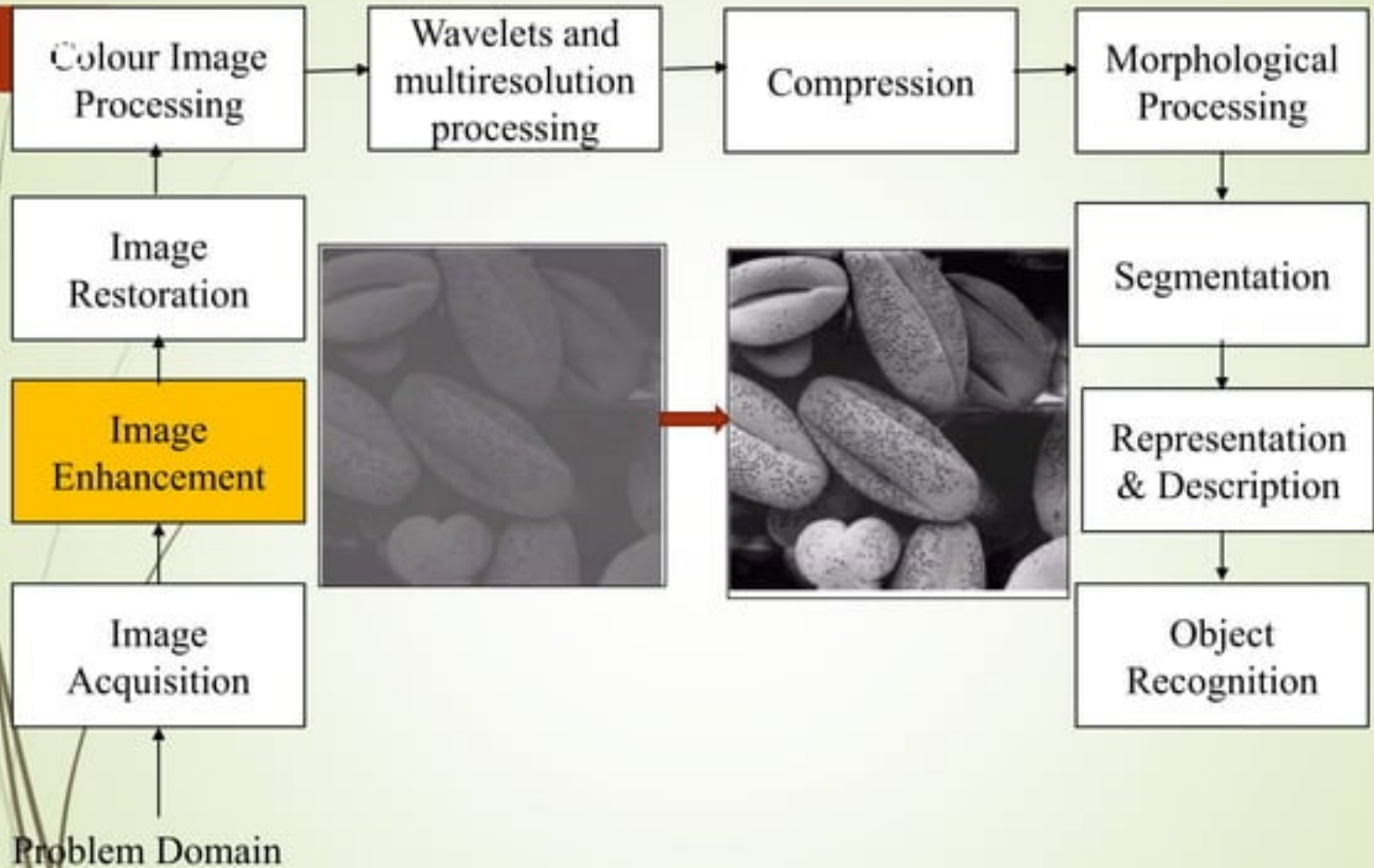
Fundamental Steps in Digital Image Processing



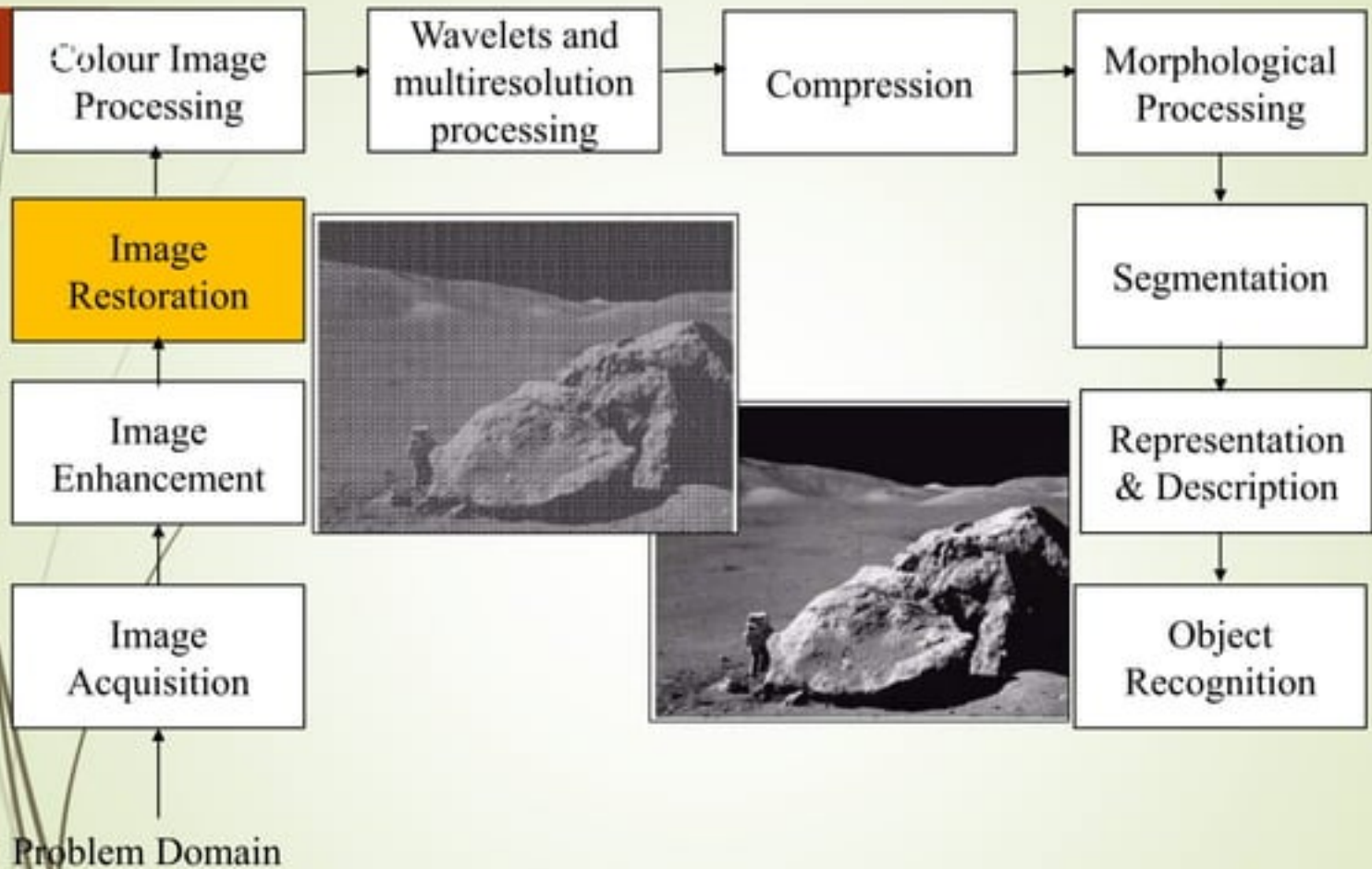
Fundamental Steps in Digital Image Processing



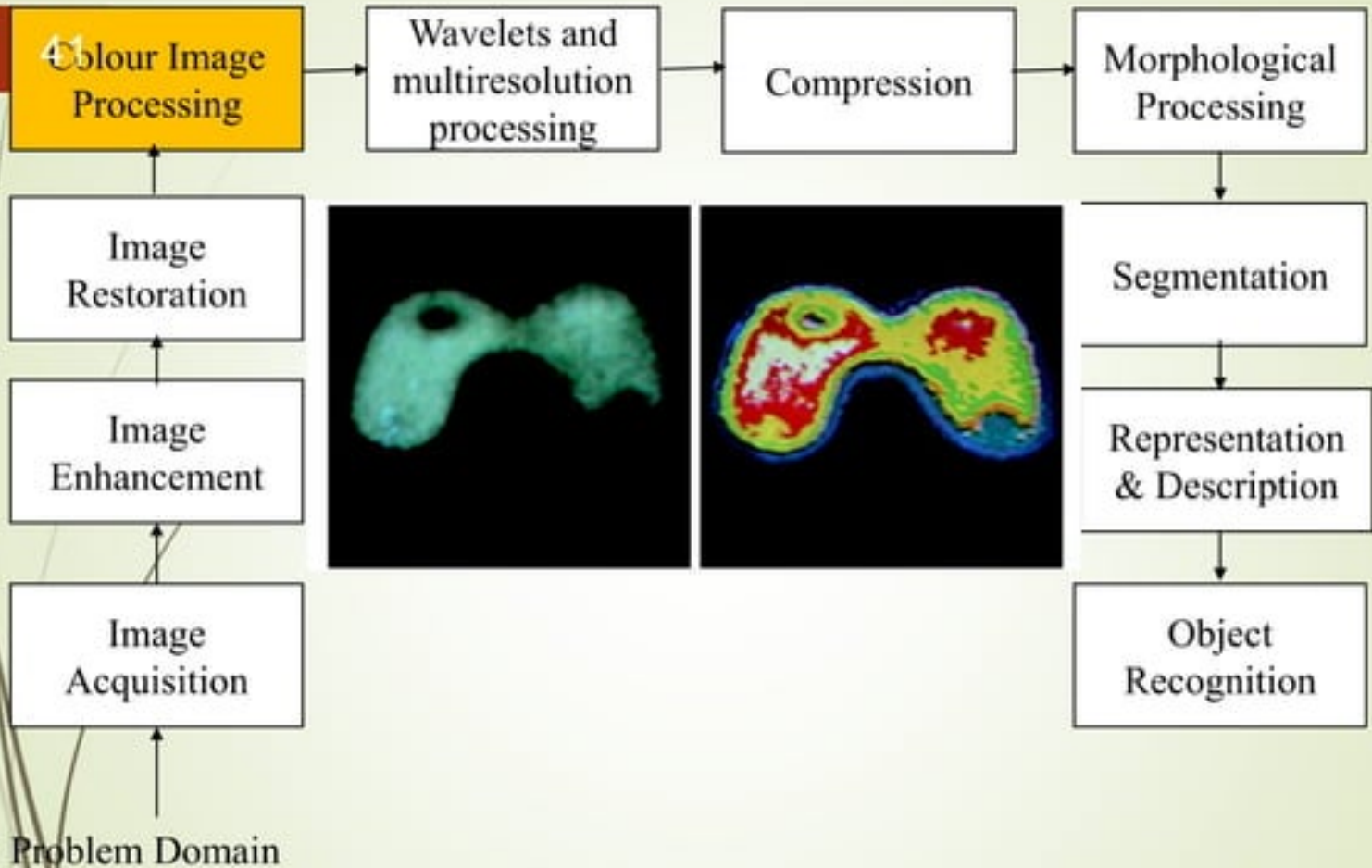
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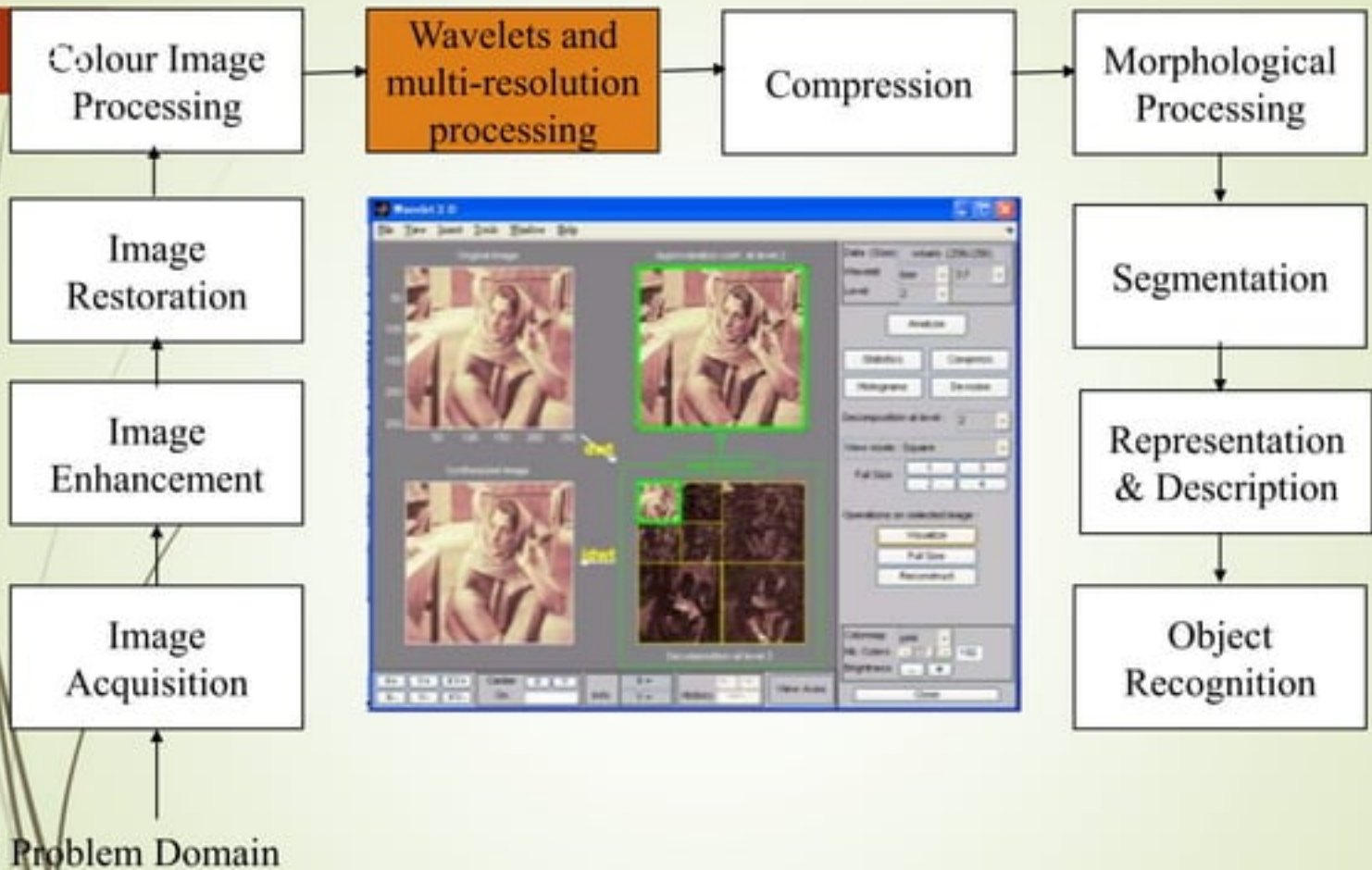
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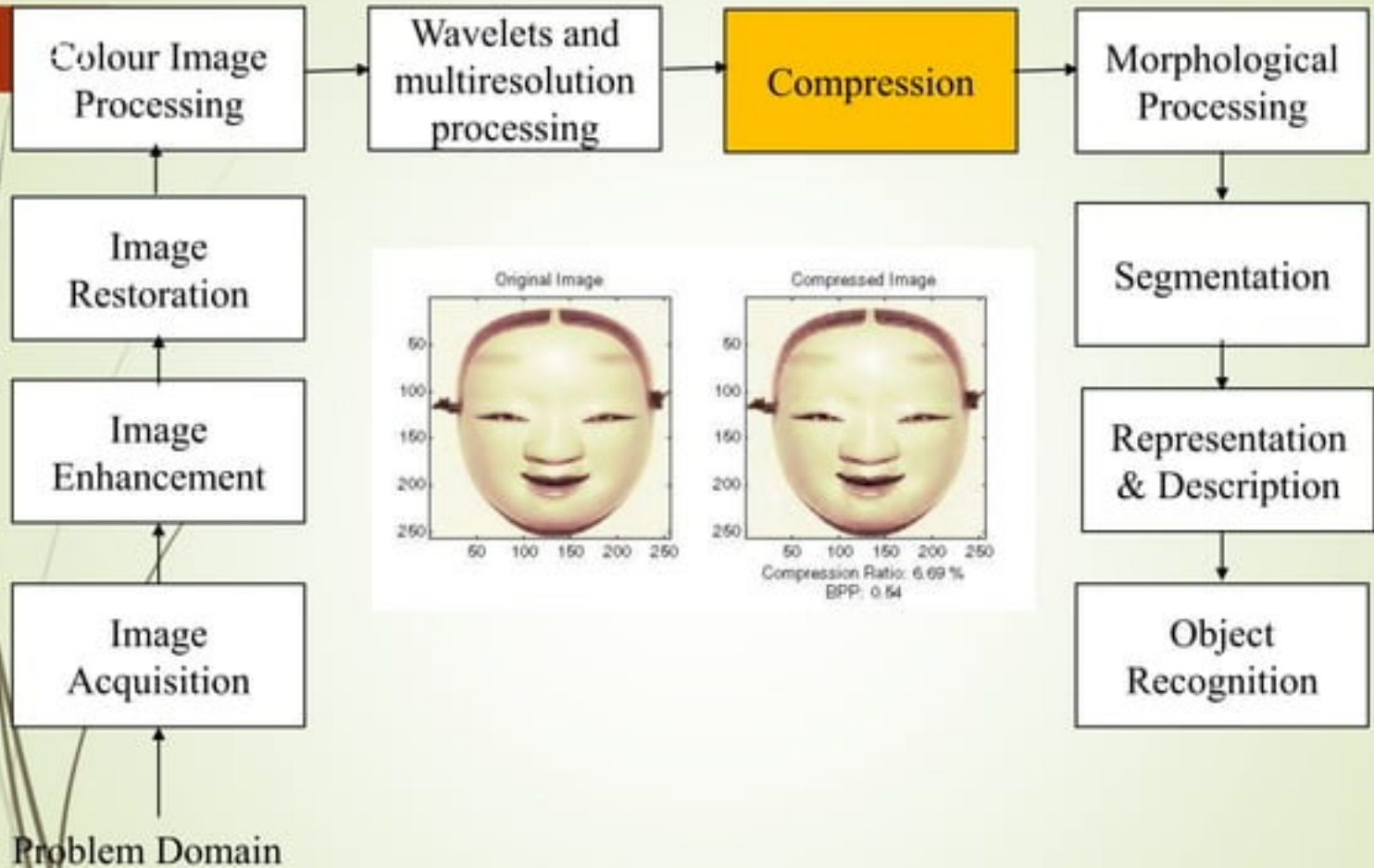
Fundamental Steps in Digital Image Processing



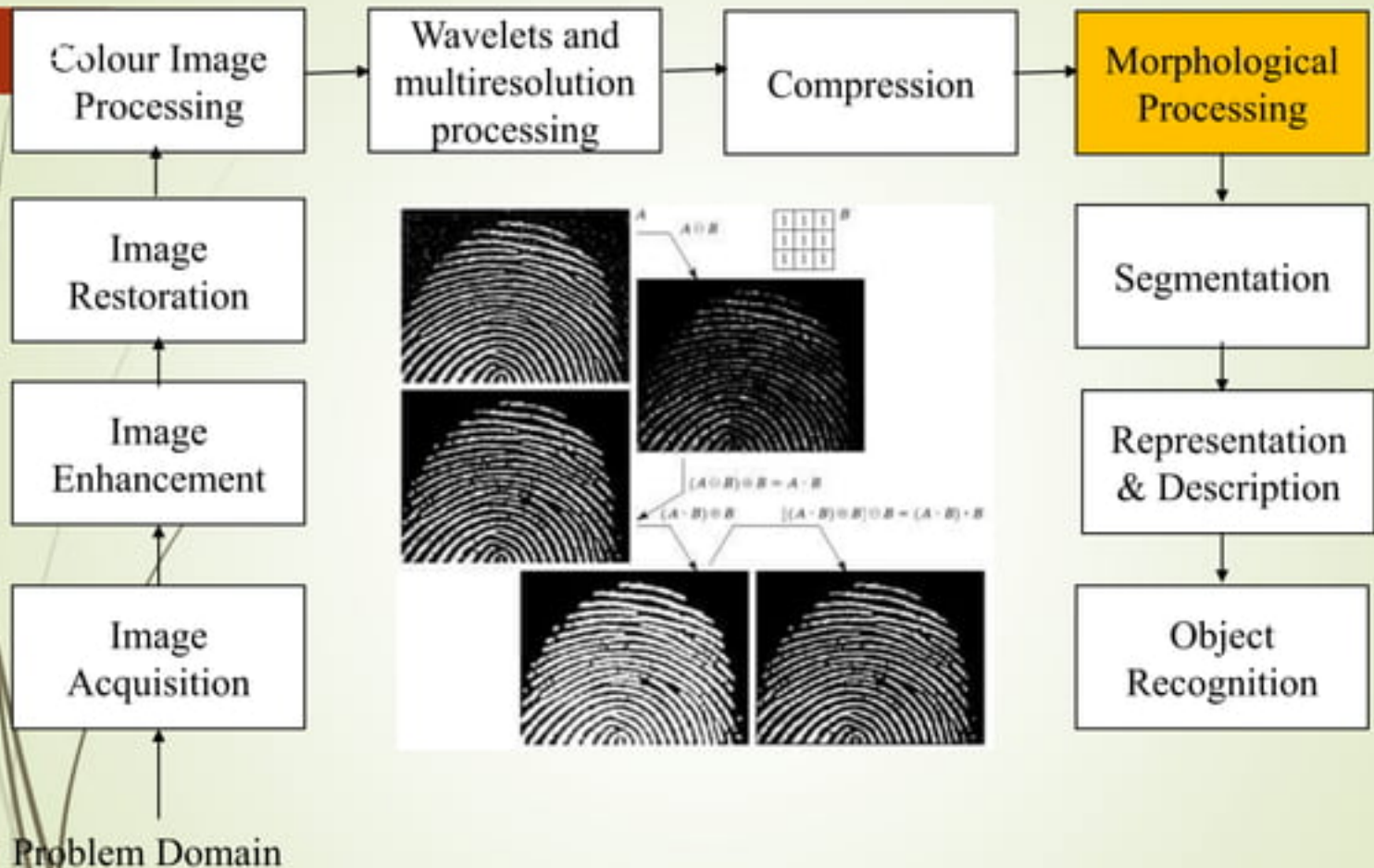
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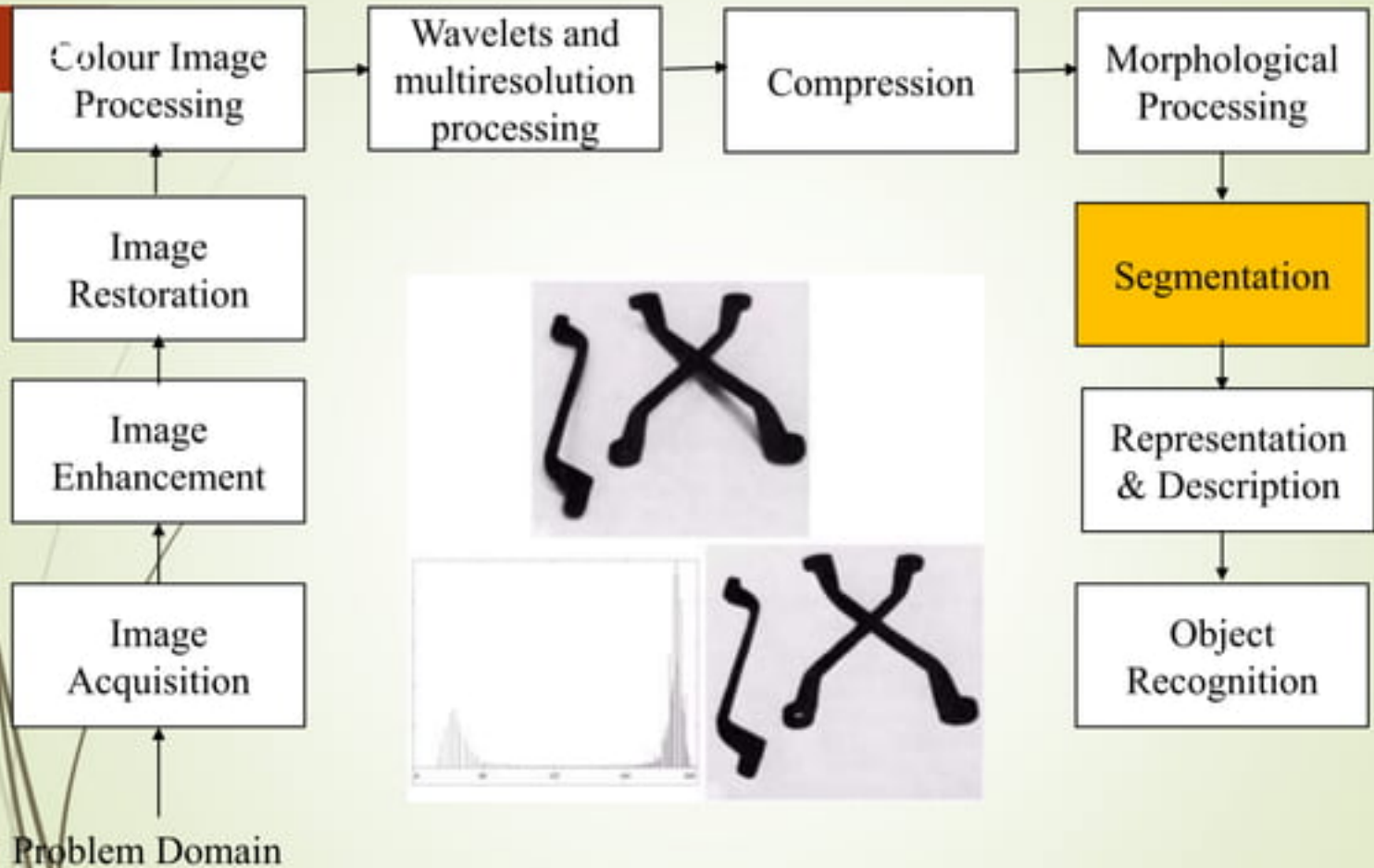
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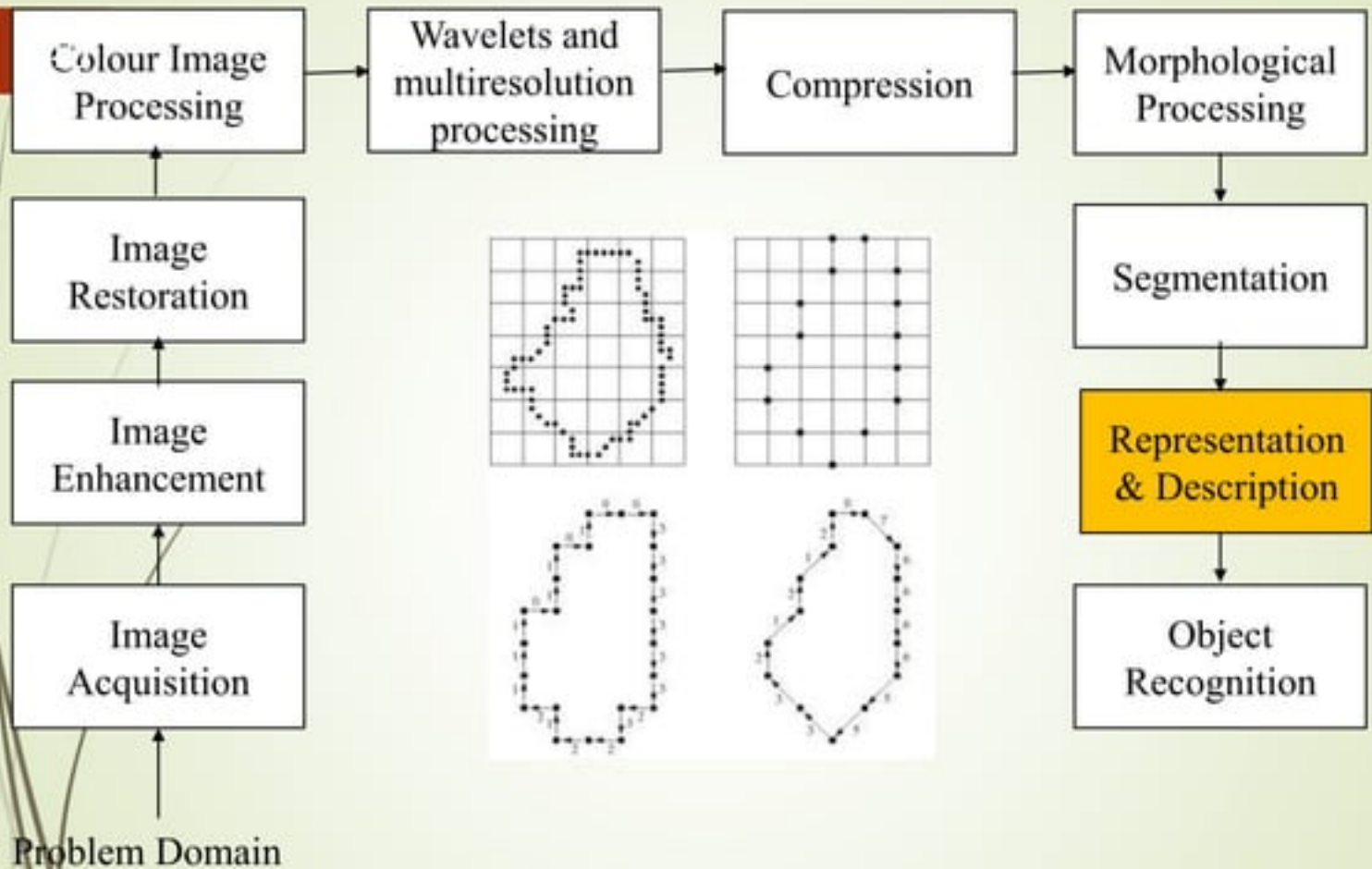
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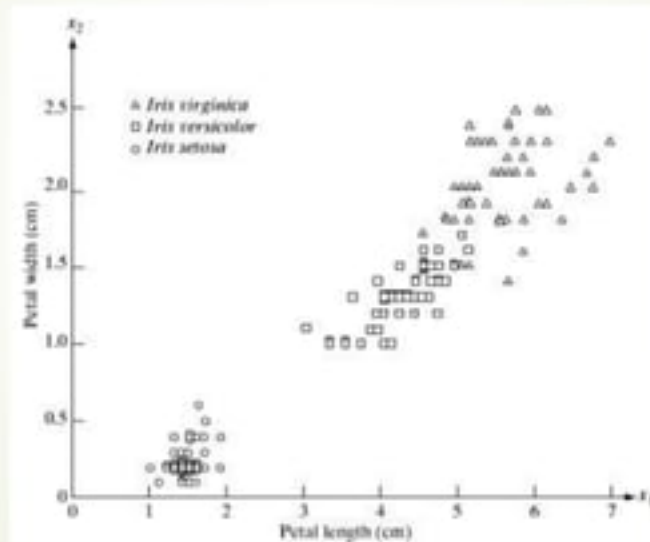
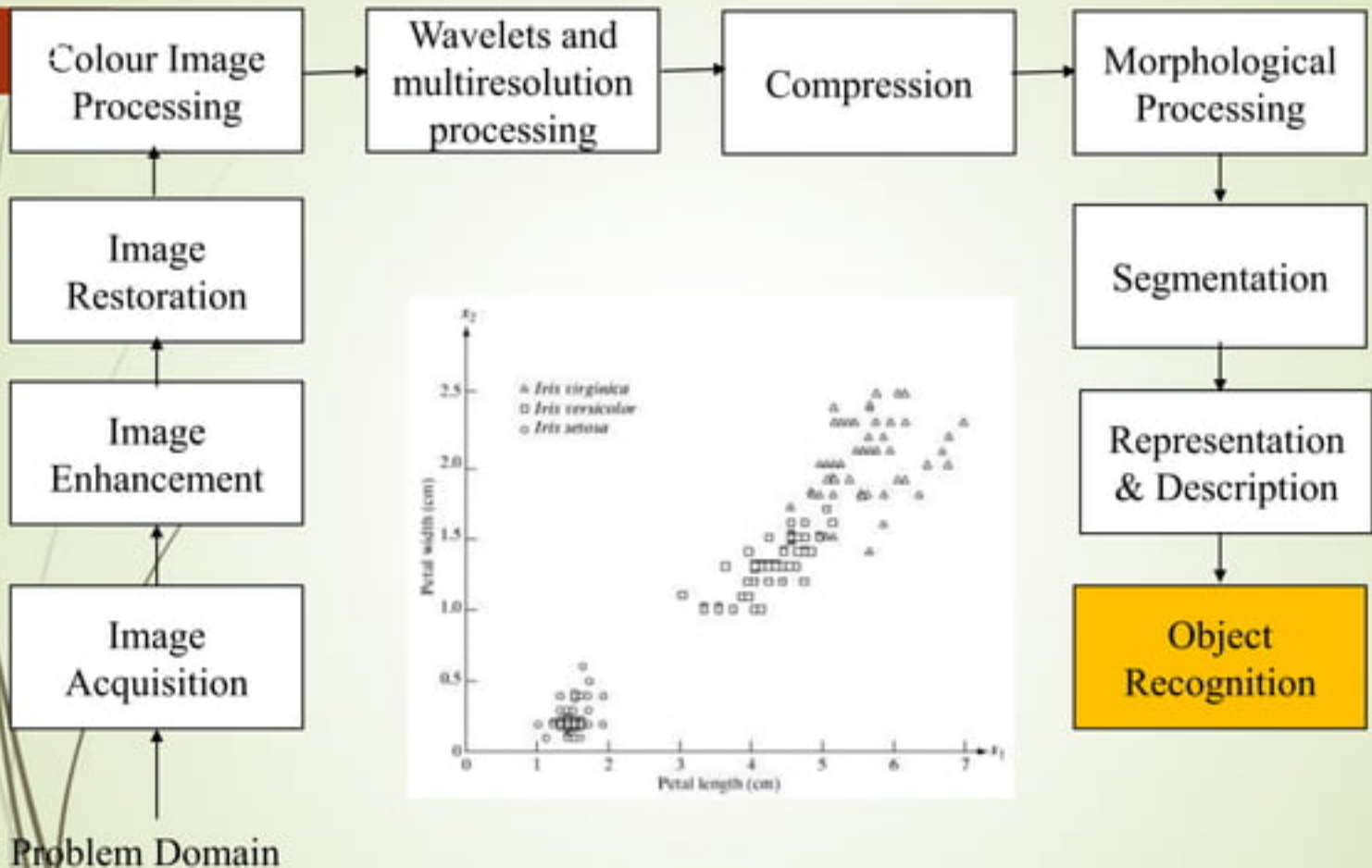
Fundamental Steps in Digital Image Processing



Fundamental Steps in Digital Image Processing

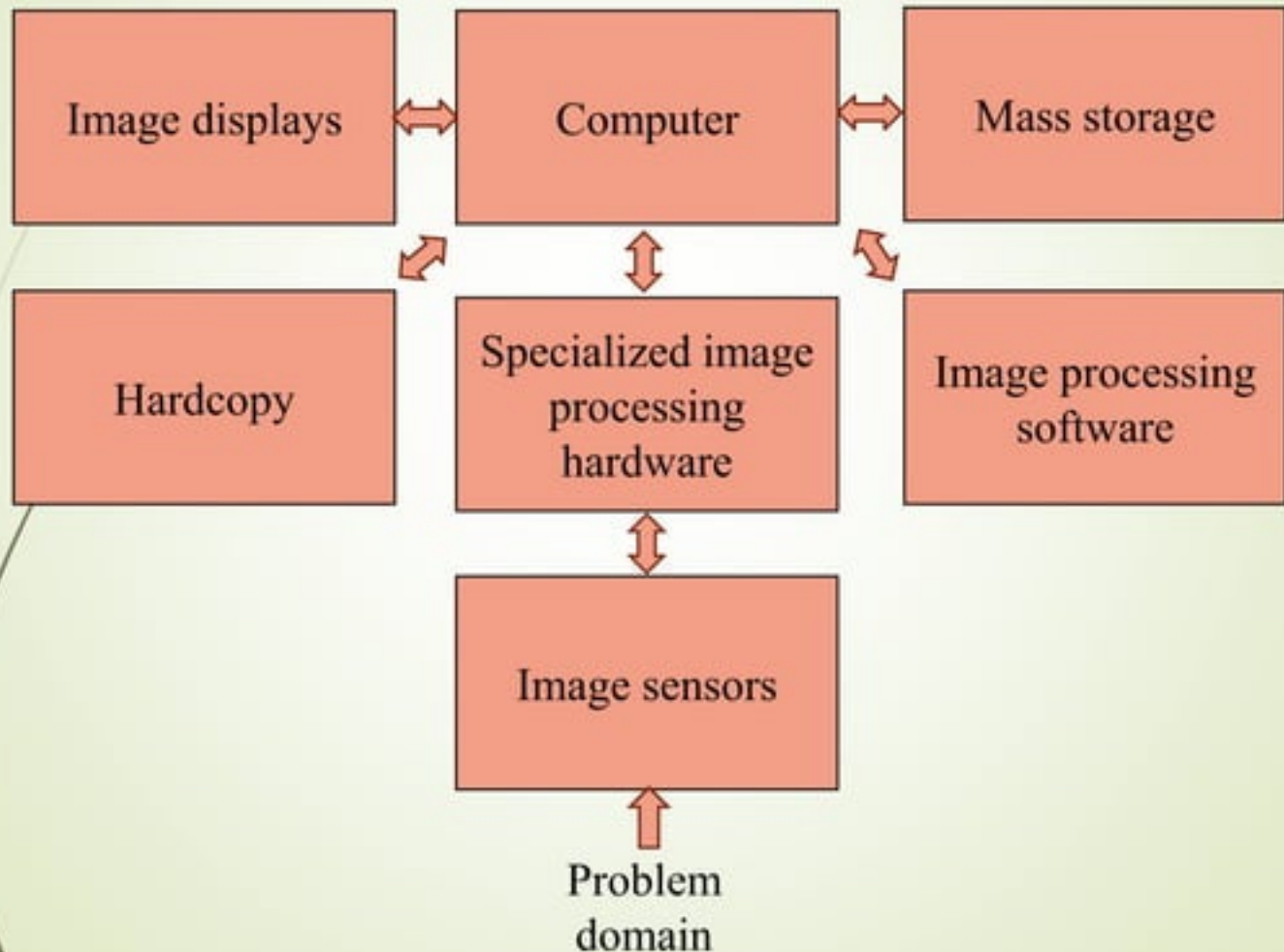


Fundamental Steps in Digital Image Processing



Components of an Image Processing System

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Summary

- We have looked at:
 - What is a digital image?
 - What is digital image processing?
 - History of digital image processing
 - State of the art examples of digital image processing
 - Key stages in digital image processing
- Next time we will start to see how it all works...

References

- “Digital Image Processing”, 2/ E, Rafael C. Gonzalez & Richard E. Woods, www.prenhall.com/gonzalezwoods.

