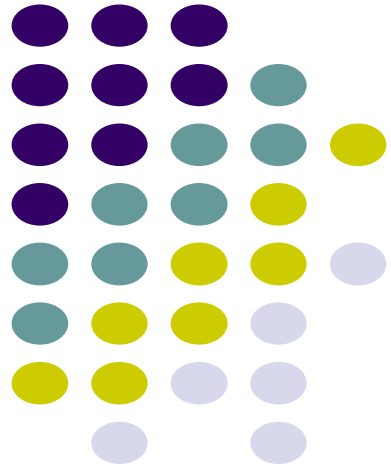
Introduction

Dr. Navjot Singh

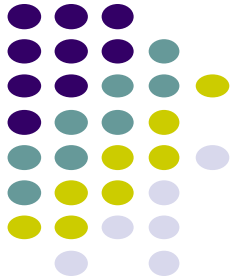
Image and Video Processing



Acknowledgements

- Gonzalez, Rafael C. Digital image processing. Pearson, 4th edition, 2018.
- Jain, Anil K. Fundamentals of digital image processing. Prentice-Hall, Inc., 1989.
- Digital Image Processing course by Brian Mac Namee, Dublin Institute of Technology
- Digital Image Processing course by Christophoros Nikou, University of Ioannina

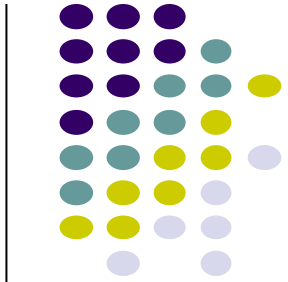
Introduction



“One picture is worth more than ten thousand words”

Anonymous

Contents

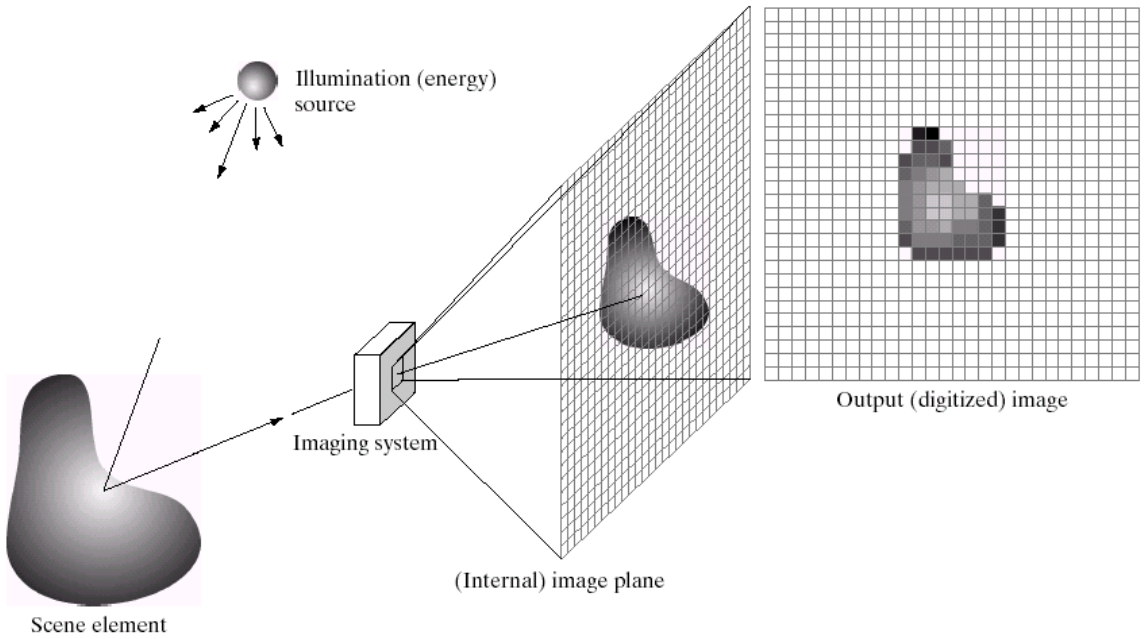


This lecture will cover:

- 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

What is a Digital Image?

A **digital image** is a representation of a two-dimensional image as a finite set of digital values, called picture elements or pixels

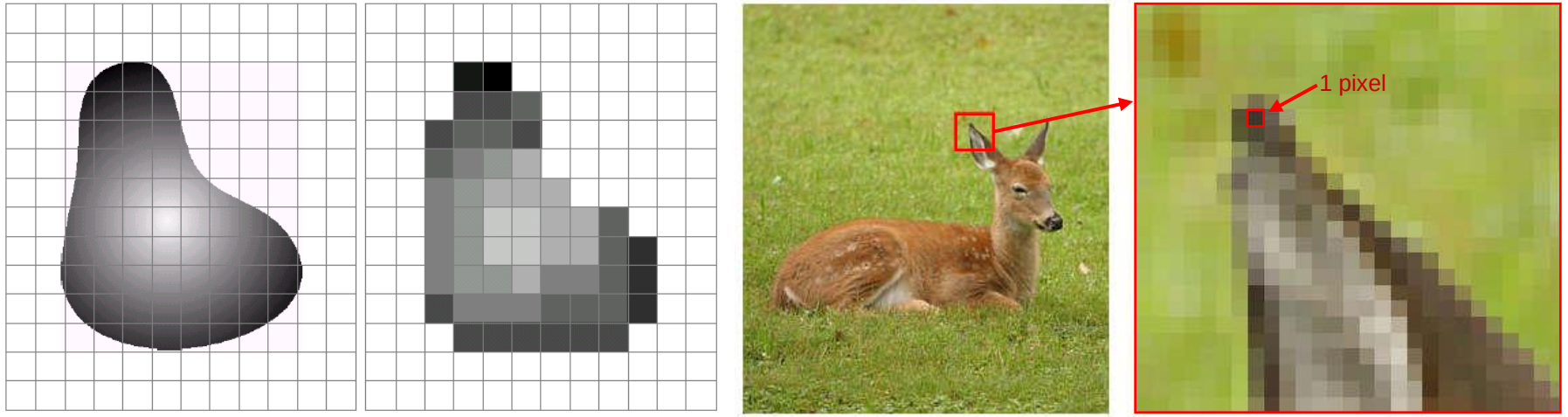


Adapted from Gonzalez, Rafael C. Digital image processing. Pearson education India, 2009.

What is a Digital Image? (cont…)

Pixel values typically represent gray levels, colours, heights, opacities etc

Remember *digitization* implies that a digital image is an *approximation* of a real scene



Adapted from Gonzalez, Rafael C. Digital image processing. Pearson education India, 2009.

What is a Digital Image? (cont…)

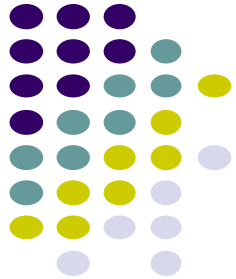
Common image formats include:

- 1 sample per point (B&W or Grayscale)
- 3 samples per point (Red, Green, and Blue)
- 4 samples per point (Red, Green, Blue, and “Alpha”, a.k.a. Opacity)

For most of this course we will focus on gray-scale images

Adapted from Gonzalez, Rafael C. Digital image processing. Pearson education India, 2009.

What is Digital Image Processing?



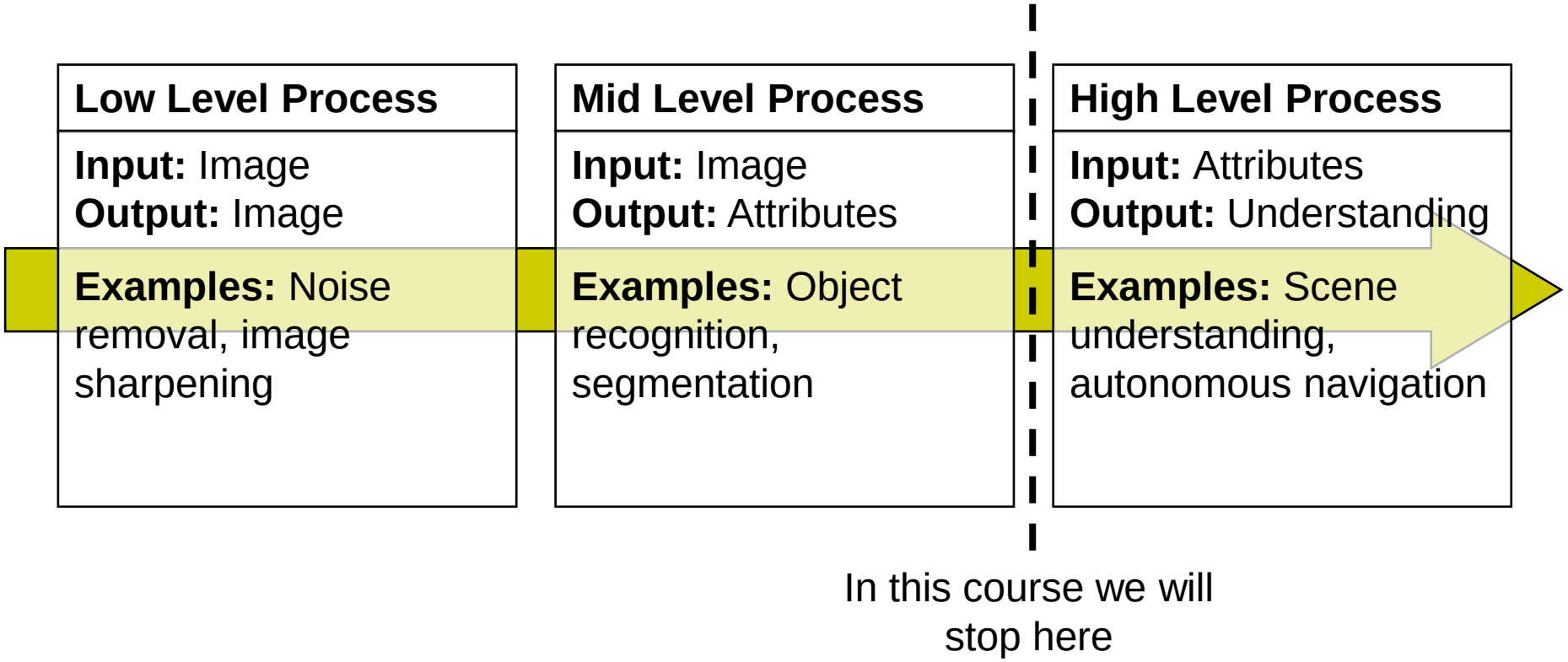
Digital image processing focuses on two major tasks

- Improvement of pictorial information for human interpretation
- Processing of image data for storage, transmission and representation for autonomous machine perception

Some argument about where image processing ends and fields such as image analysis and computer vision start

What is DIP? (cont…)

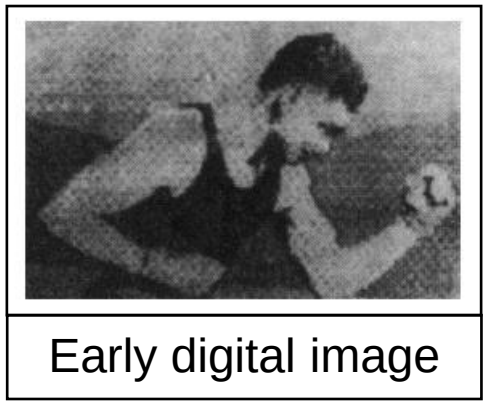
The continuum from image processing to computer vision can be broken up into low-, mid- and high-level processes



History of Digital Image Processing

Early 1920s: One of the first applications of digital imaging was in the newspaper industry

- The Bartlane cable picture transmission service
- Images were transferred by submarine cable between London and New York
- Pictures were coded for cable transfer and reconstructed at the receiving end on a telegraph printer



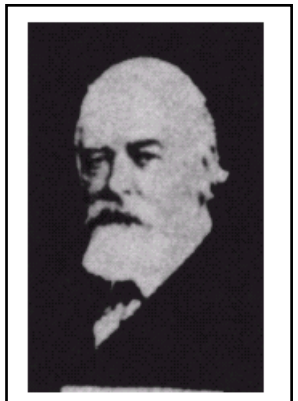
Early digital image

Adapted from Gonzalez, Rafael C. Digital image processing. Pearson education India, 2009.

History of DIP (cont…)

Mid to late 1920s: Improvements to the Bartlane system resulted in higher quality images

- New reproduction processes based on photographic techniques
- Increased number of tones in reproduced images



Improved digital image

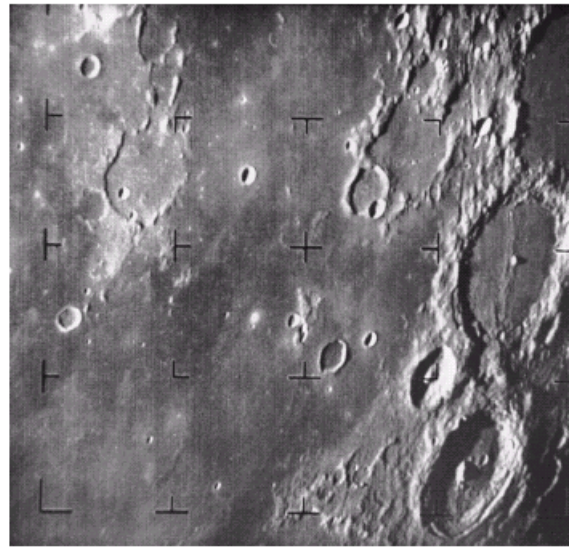
Early 15 tone digital image

Adapted from Gonzalez, Rafael C. Digital image processing. Pearson education India, 2009.

History of DIP (cont…)

1960s: Improvements in computing technology and the onset of the space race led to a surge of work in digital image processing

- **1964:** Computers used to improve the quality of images of the moon taken by the *Ranger 7* probe
- Such techniques were used in other space missions including the Apollo landings



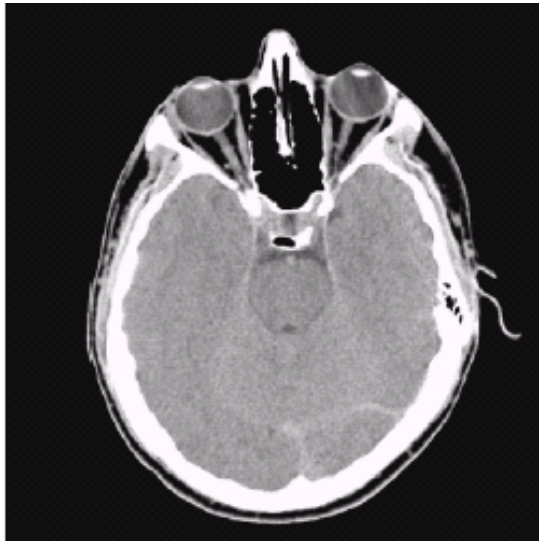
A picture of the moon taken by the Ranger 7 probe minutes before landing

Adapted from Gonzalez, Rafael C. Digital image processing. Pearson education India, 2009.

History of DIP (cont…)

1970s: Digital image processing begins to be used in medical applications

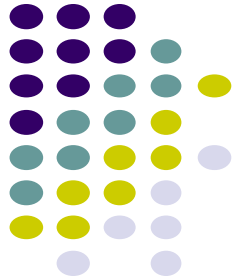
- **1979:** Sir Godfrey N. Hounsfield & Prof. Allan M. Cormack share the Nobel Prize in medicine for the invention of tomography, the technology behind Computerised Axial Tomography (CAT) scans



Typical head slice CAT image

Adapted from Gonzalez, Rafael C. Digital image processing. Pearson education India, 2009.

History of DIP (cont…)



1980s - 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

Applications – Imaging modalities

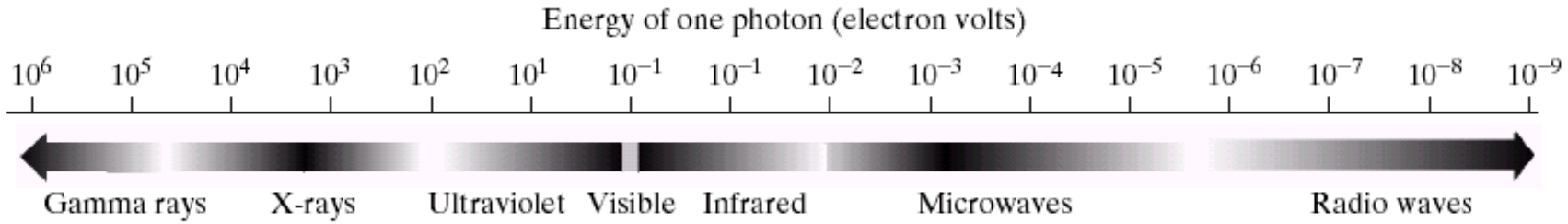
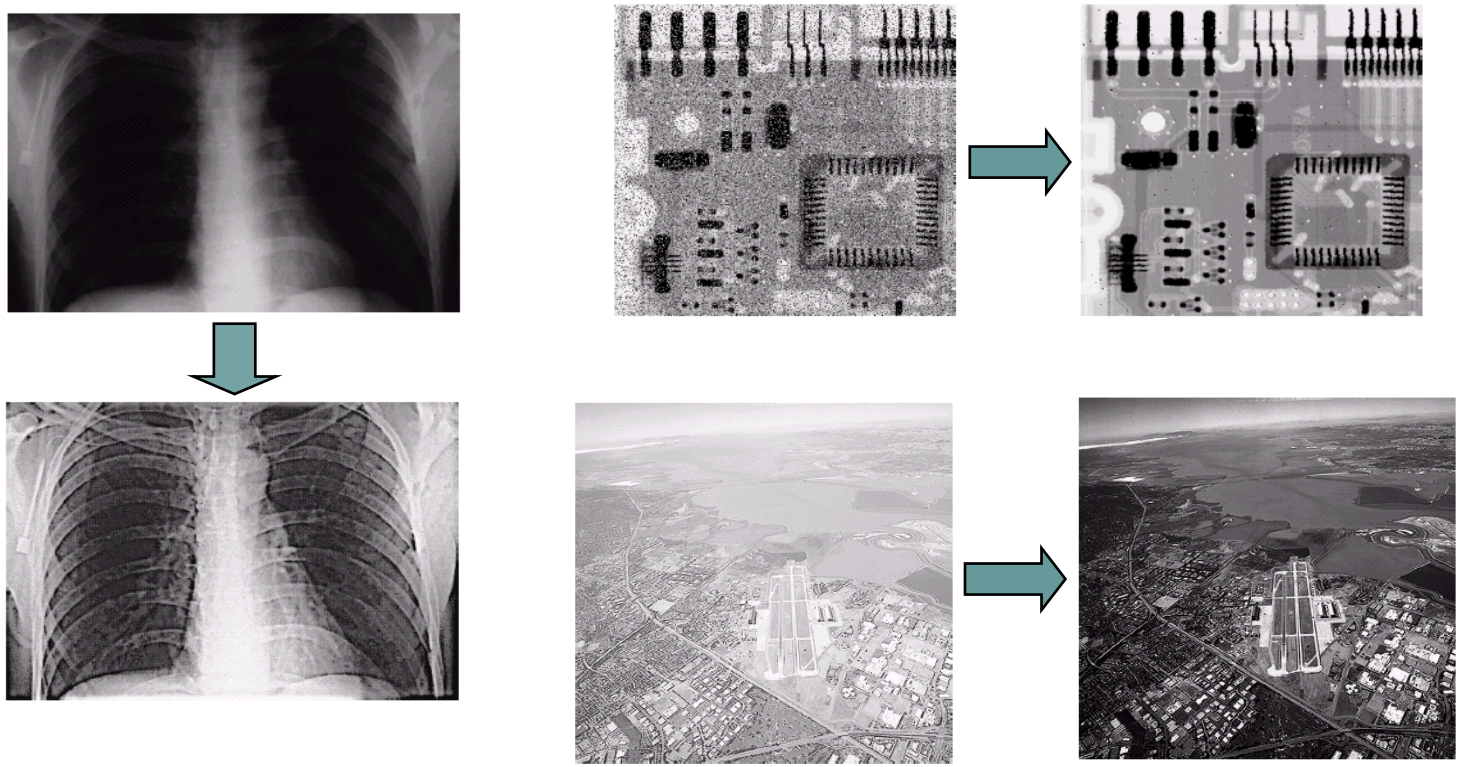


FIGURE 1.5 The electromagnetic spectrum arranged according to energy per photon.

Adapted from Gonzalez, Rafael C. Digital image processing. Pearson education India, 2009.

Applications: Image Enhancement

One of the most common uses of DIP techniques: improve quality, remove noise etc



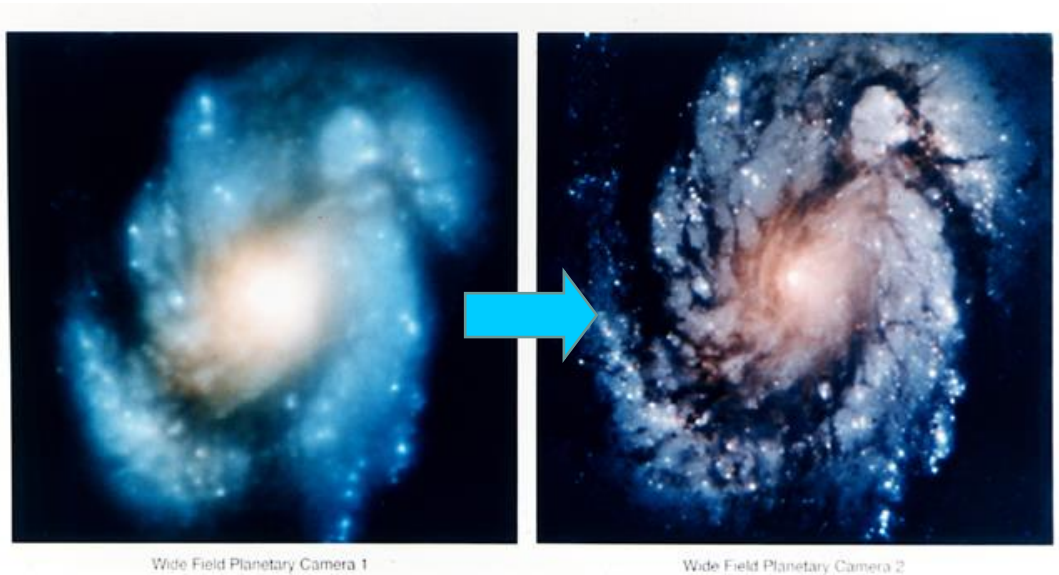
Adapted from Gonzalez, Rafael C. Digital image processing. Pearson education India, 2009.

Applications: The Hubble Telescope

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



Adapted from Gonzalez, Rafael C. Digital image processing. Pearson education India, 2009.

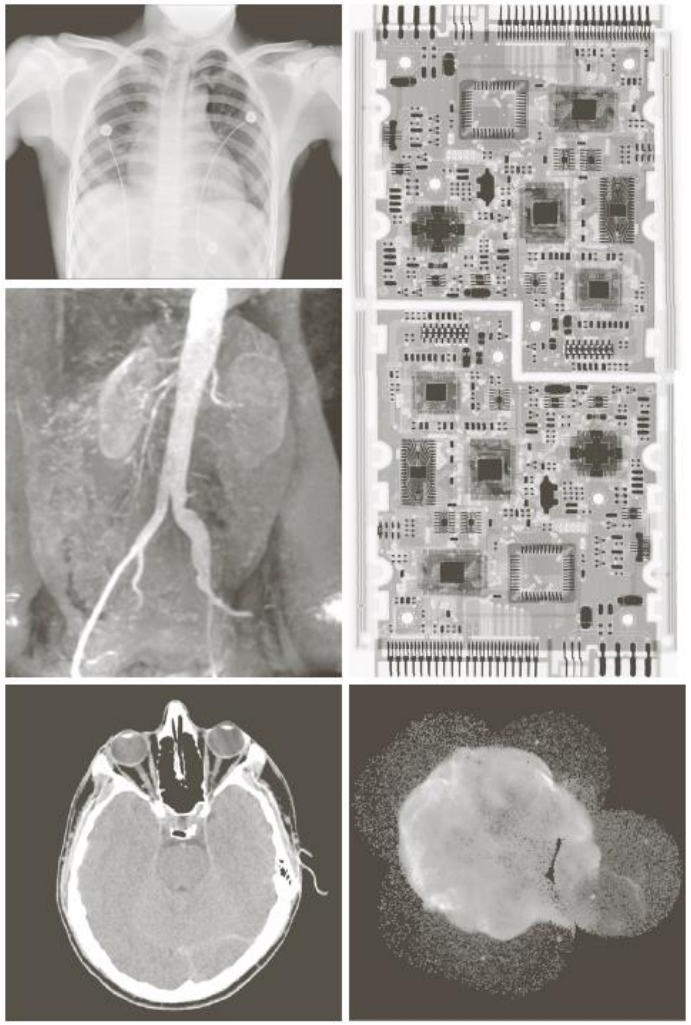
Applications: Artistic Effects

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

Adapted from Gonzalez, Rafael C. Digital image processing. Pearson education India, 2009.

Applications: Medicine

X-ray imaging



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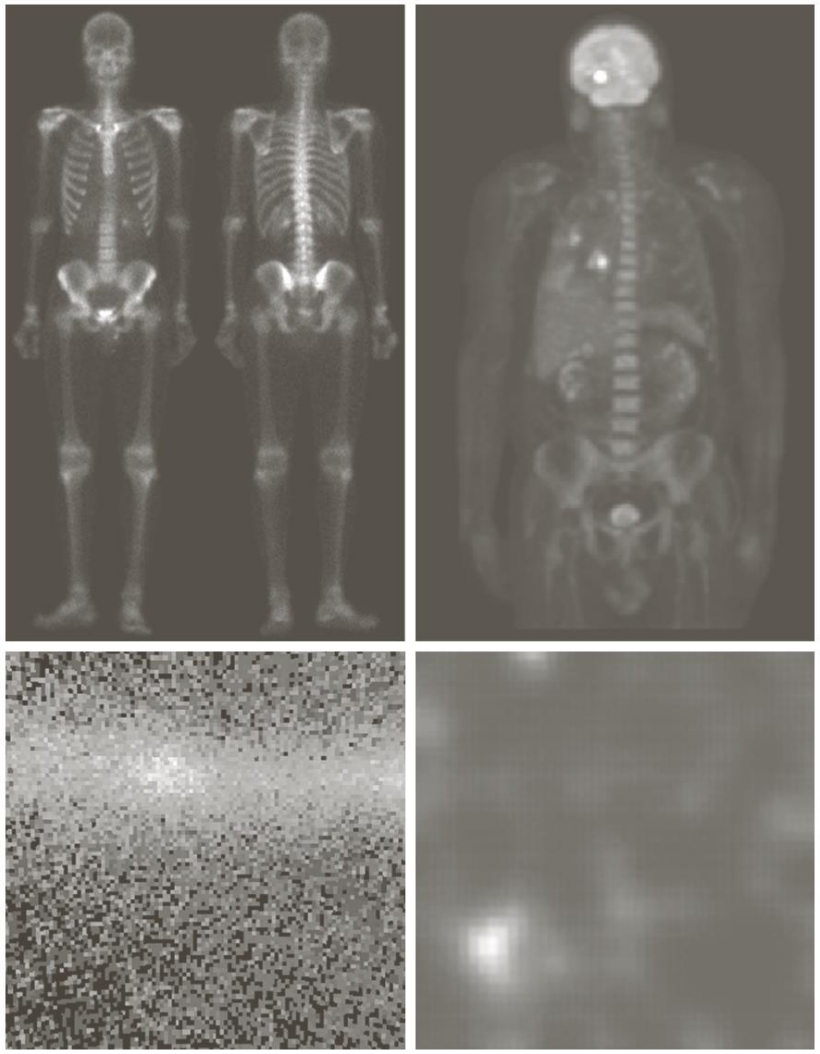
Applications: Medicine (cont...)

Gamma-ray imaging



Adapted from Gonzalez, Rafael C. Digital image processing. Pearson education India, 2009.

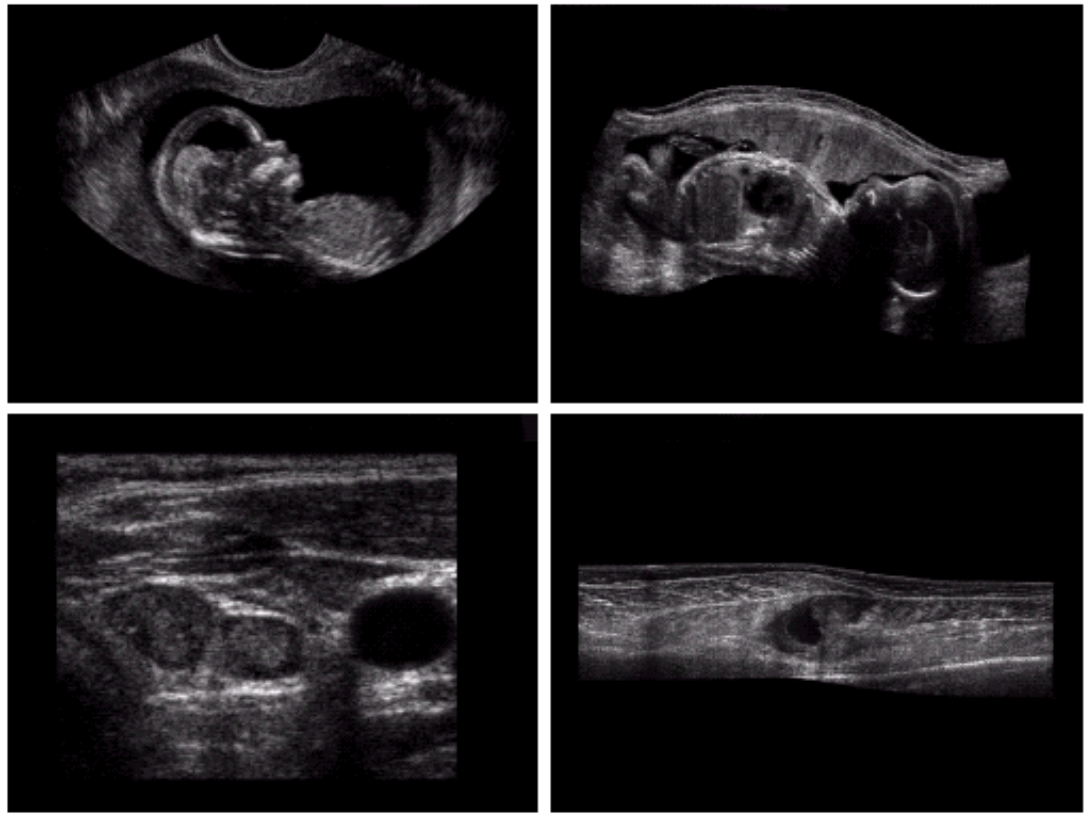
Applications: Medicine (cont...)

- Radio frequencies
- Magnetic Resonance Imaging (MRI)

Adapted from Gonzalez, Rafael C. Digital image processing. Pearson education India, 2009.

Applications: Medicine (cont...)

Ultrasound



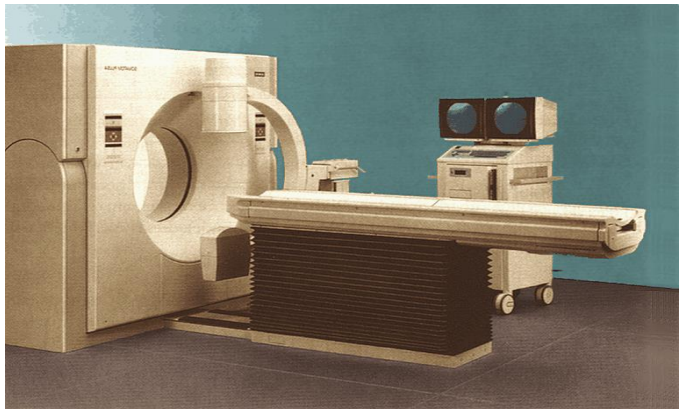
a b
c d

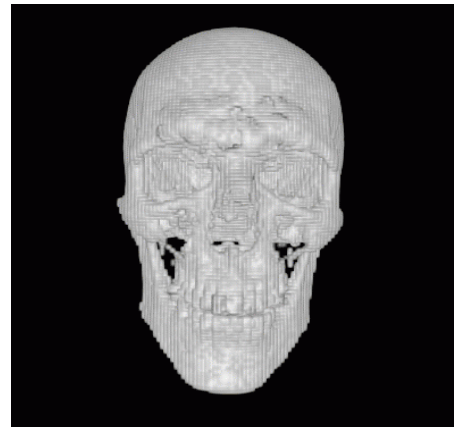
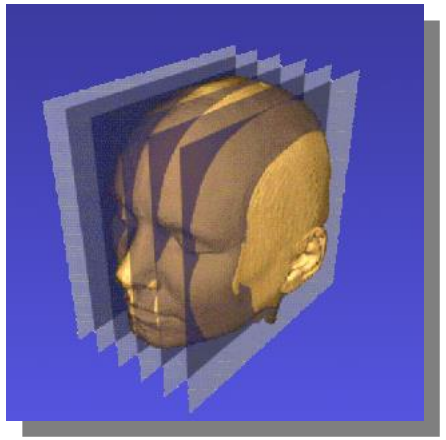
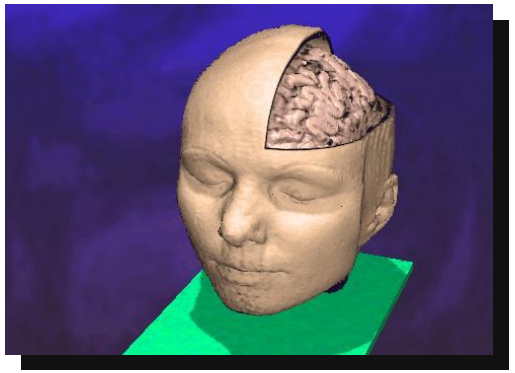
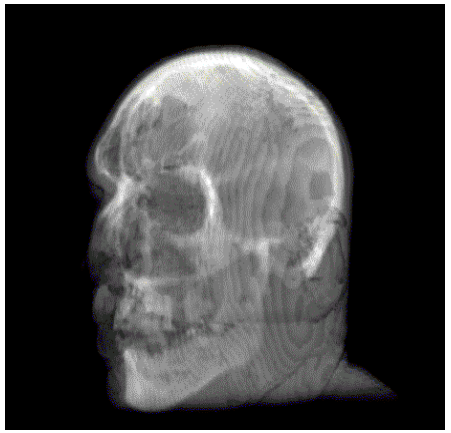
FIGURE 1.20 Examples of ultrasound imaging. (a) Baby. (2) Another view of baby. (c) Thyroids. (d) Muscle layers showing lesion. (Courtesy of Siemens Medical Systems, Inc., Ultrasound Group.)

Adapted from Gonzalez, Rafael C. Digital image processing. Pearson education India, 2009.

Applications: Medicine (cont...)

3D tomography and rendering with transparencies



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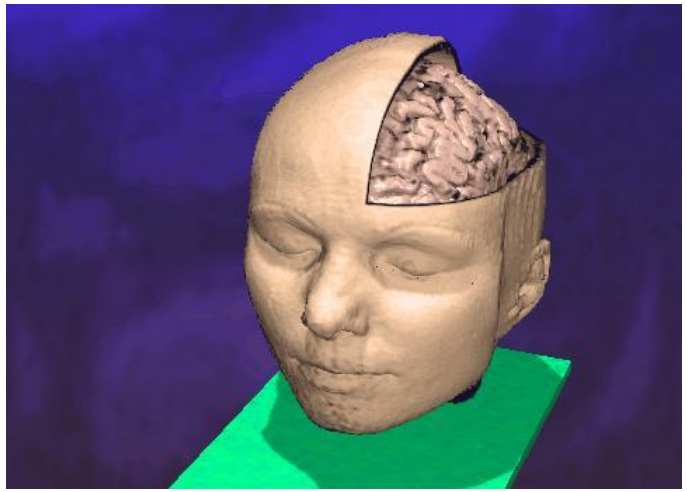
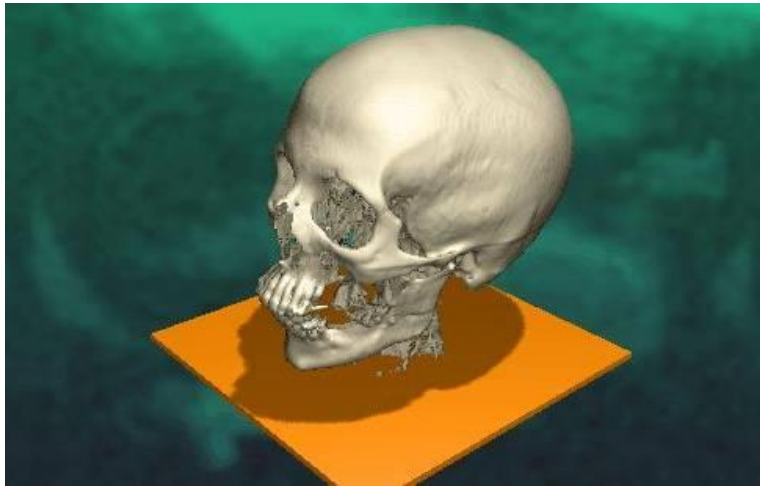
Applications: Medicine (cont...)

3D tomography and rendering with transparencies





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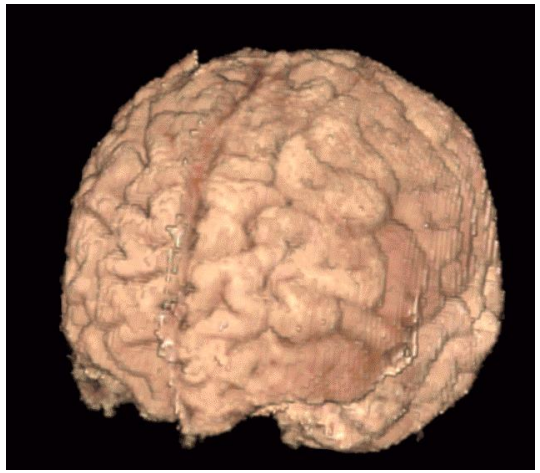
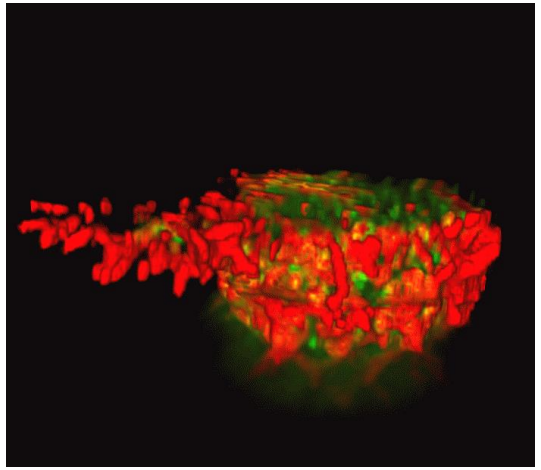
Applications: Medicine (cont...)

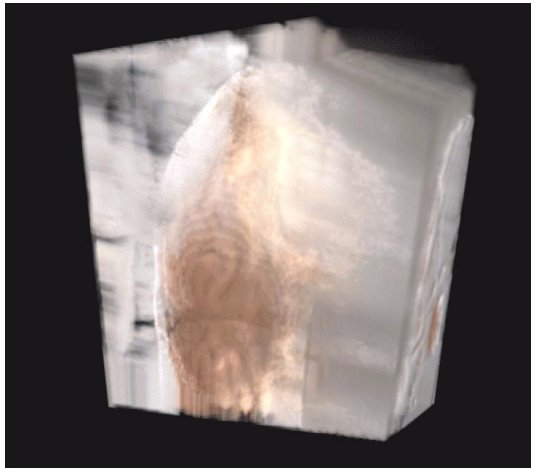
3D tomography and rendering with transparencies



Human brain
(128 cross-sections)



Cancer cell
(256 cross-sections)



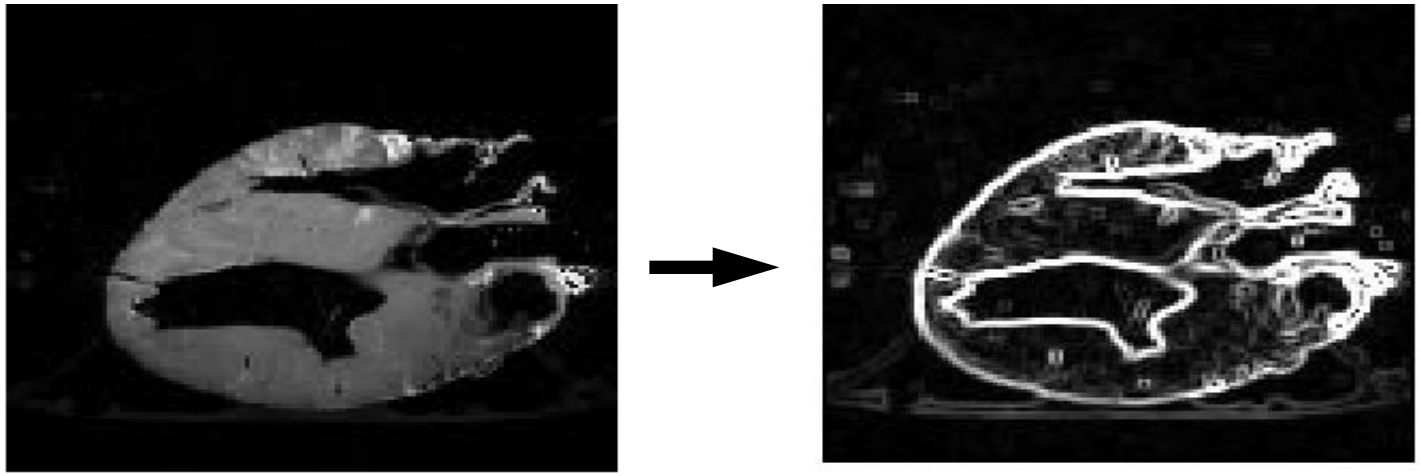
Ice Block
(Human brain)
(128 cryo-sections)

Adapted from Gonzalez, Rafael C. Digital image processing. Pearson education India, 2009.

Applications: Medicine (cont...)

Take slice from MRI scan of canine heart, and find boundaries between types of tissue

- Image with gray levels representing tissue density
- Use a suitable filter to highlight edges



Original MRI Image of a Dog Heart

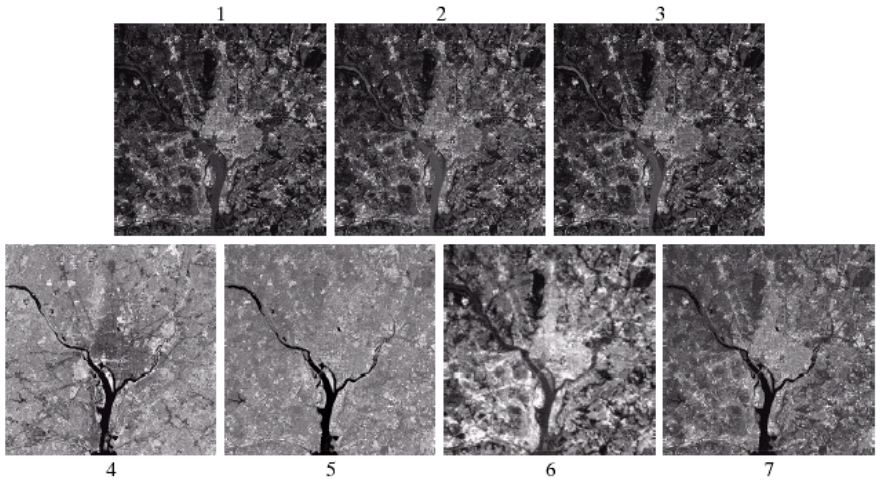
Edge Detection Image

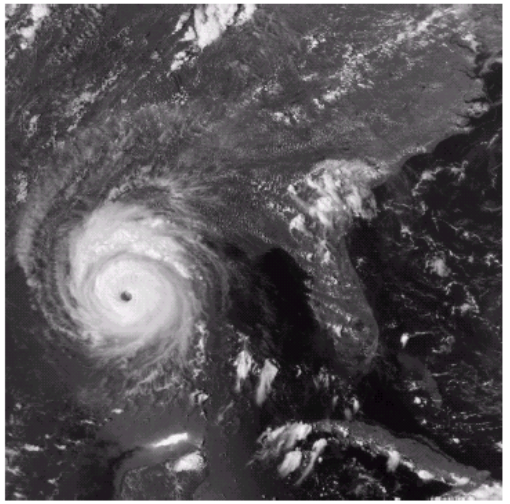
Adapted from Gonzalez, Rafael C. Digital image processing. Pearson education India, 2009.

Applications: GIS

Geographic Information Systems

- Satellite imagery
- Terrain classification (LANDSAT)
- Meteorology (NOAA)





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Applications: GIS (cont…)

Night-Time Lights of the World data set

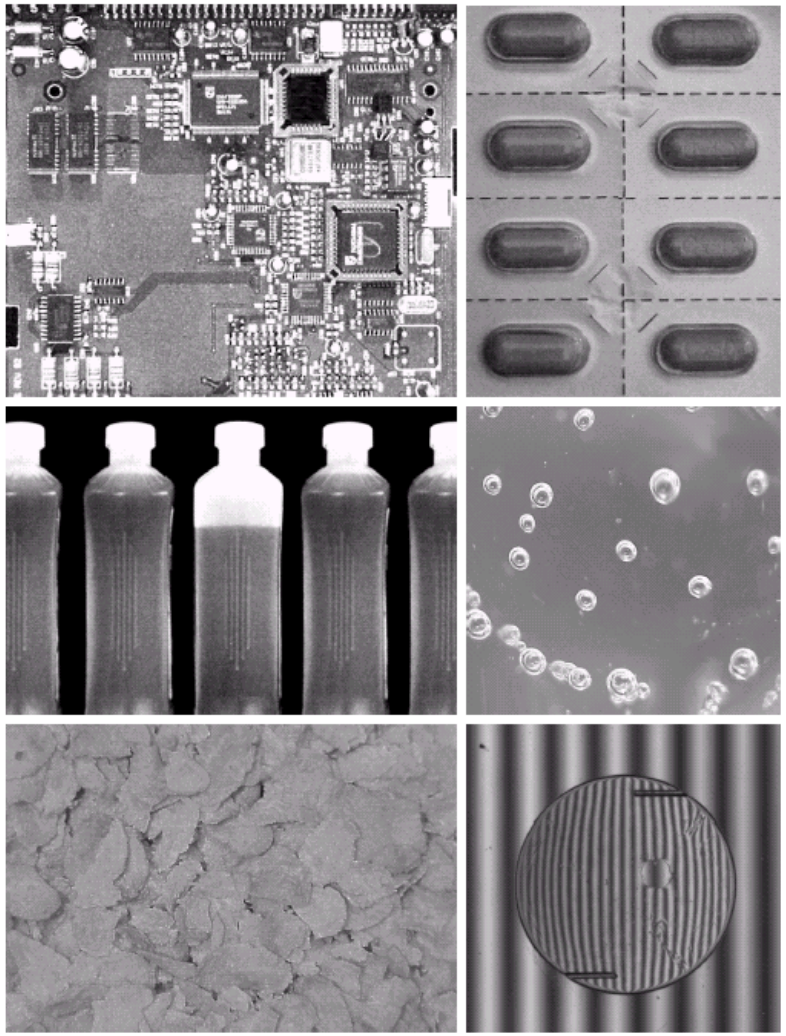
(infra red)

- Global inventory of human settlement
- Not hard to imagine the kind of analysis that might be done using this data

Adapted from Gonzalez, Rafael C. Digital image processing. Pearson education India, 2009.

Applications: 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?



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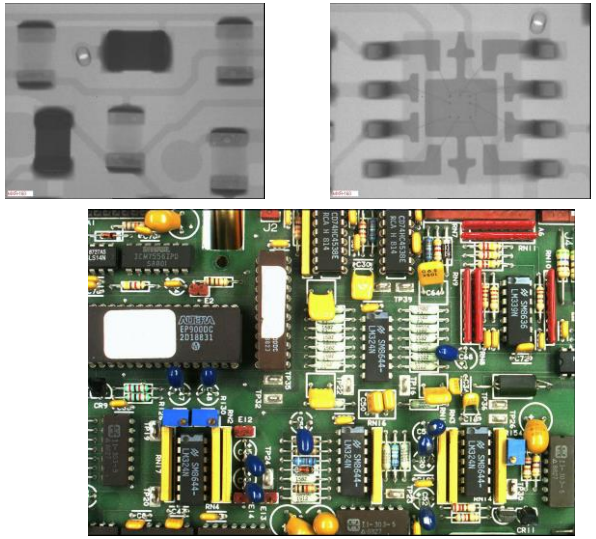
Applications: PCB Inspection

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



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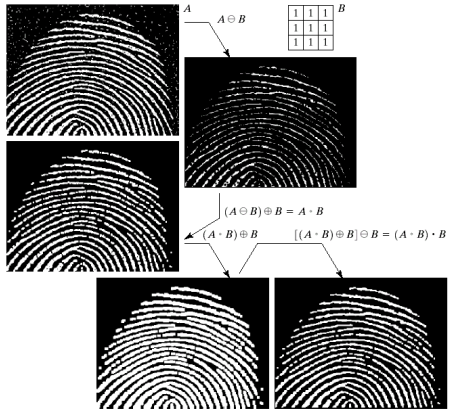
Applications: Law Enforcement

Image processing techniques are used extensively by law enforcers

- Number plate recognition for speed cameras/automated toll systems
- Fingerprint recognition
- Enhancement of CCTV images



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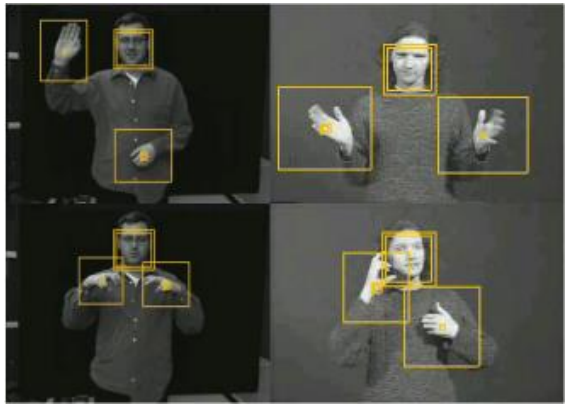
Applications: HCI

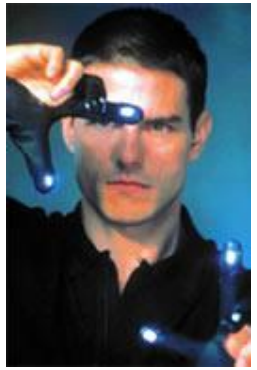
Try to make human computer interfaces more natural

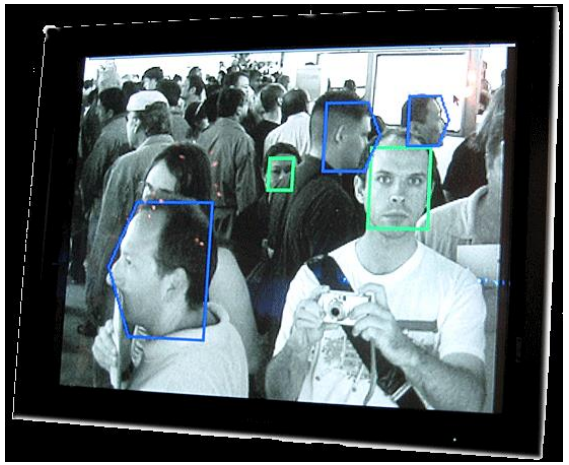
- Face recognition
- Gesture recognition

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

These tasks can be extremely difficult







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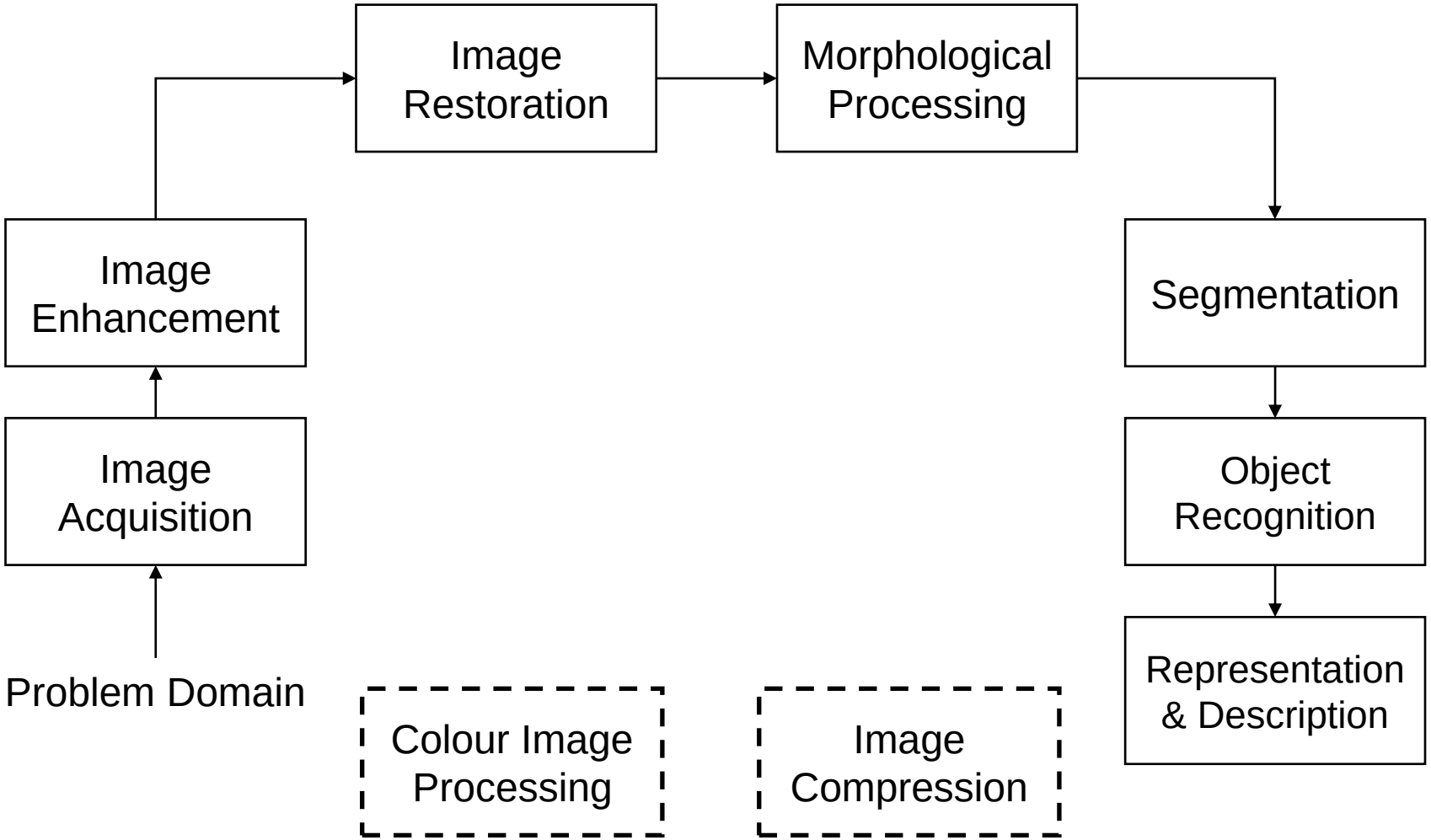
Key Stages in Digital Image Processing



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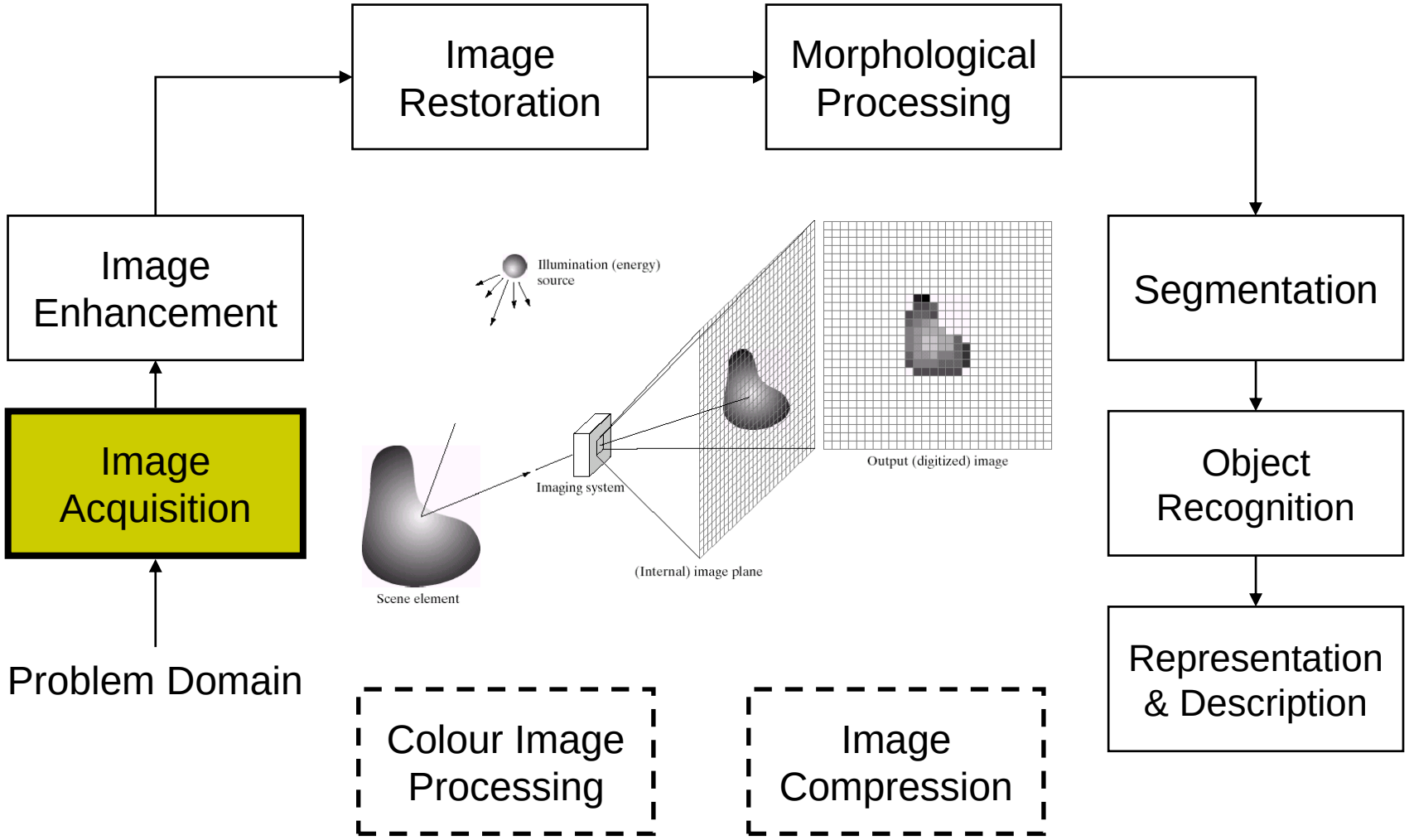
Key Stages in Digital Image Processing: Image Aquisition



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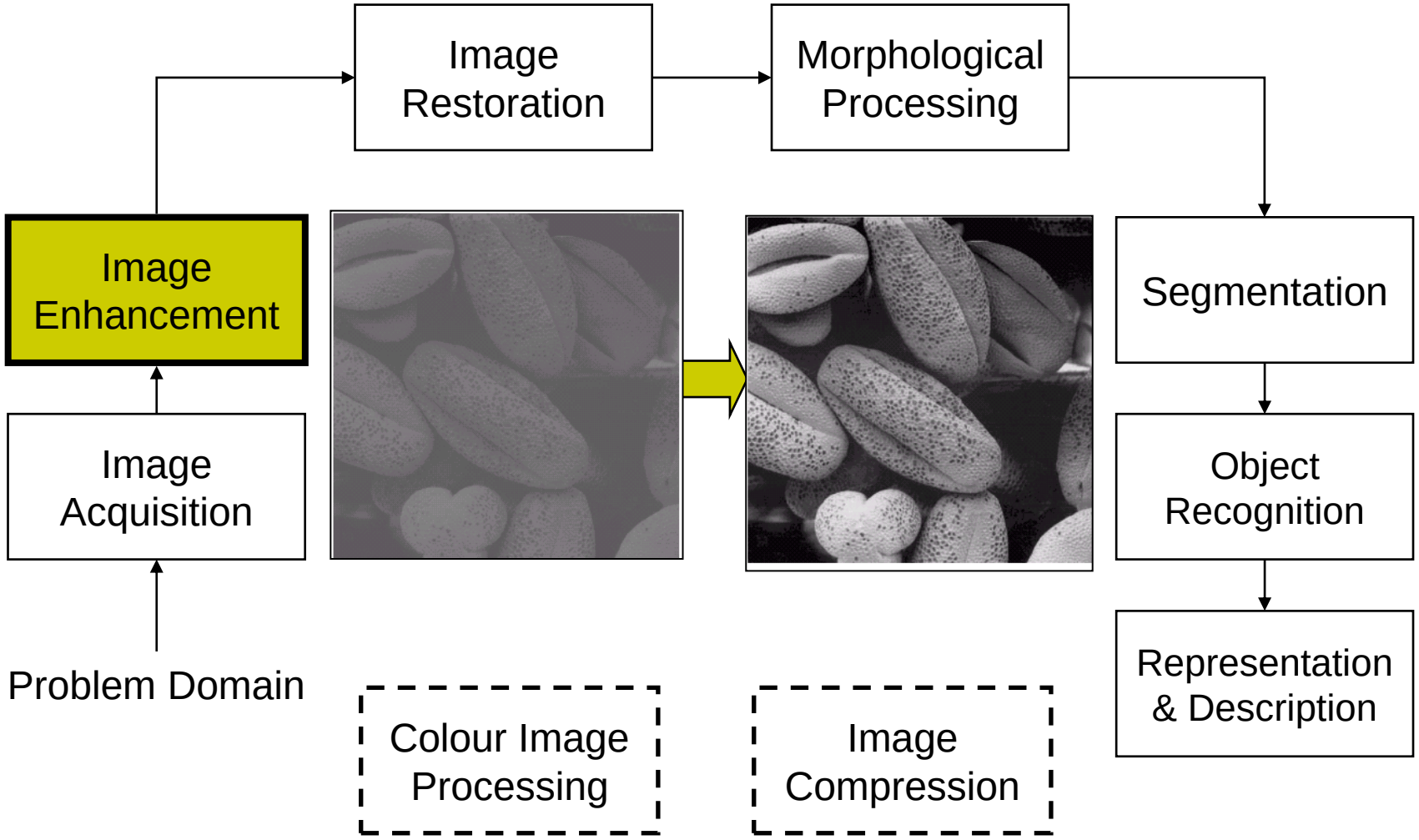
Key Stages in Digital Image Processing: Image Enhancement



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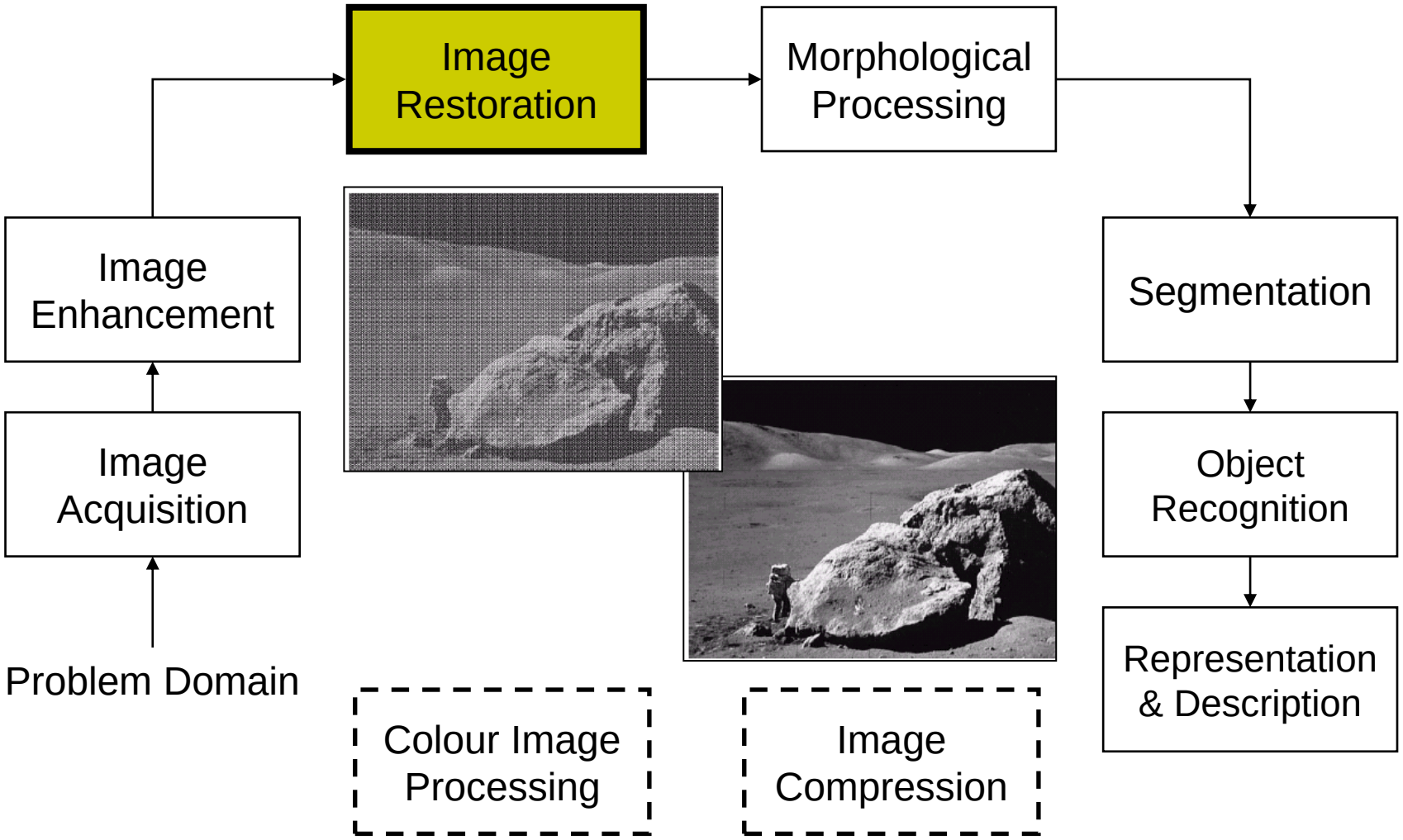
Key Stages in Digital Image Processing: Image Restoration



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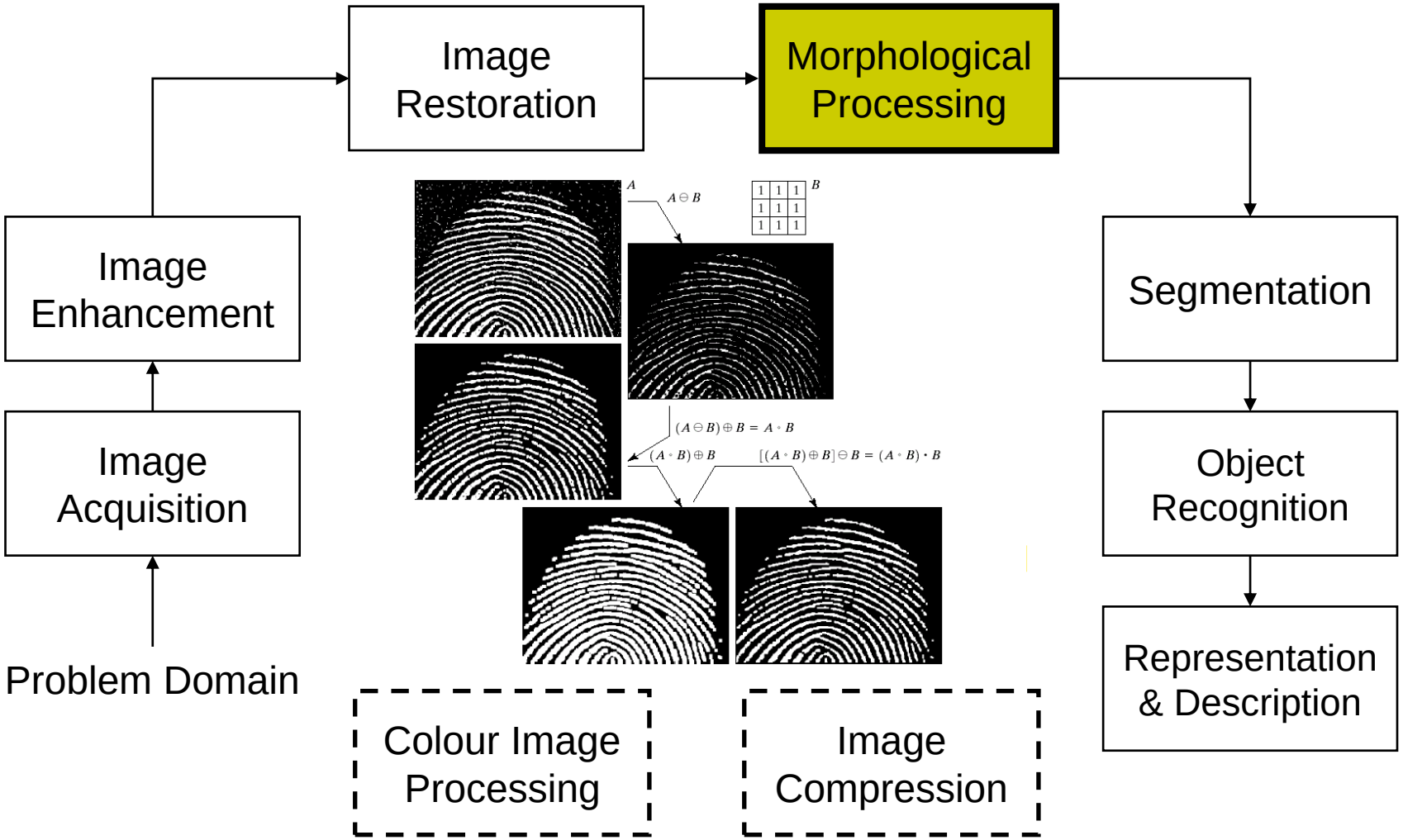
Key Stages in Digital Image Processing: Morphological Processing



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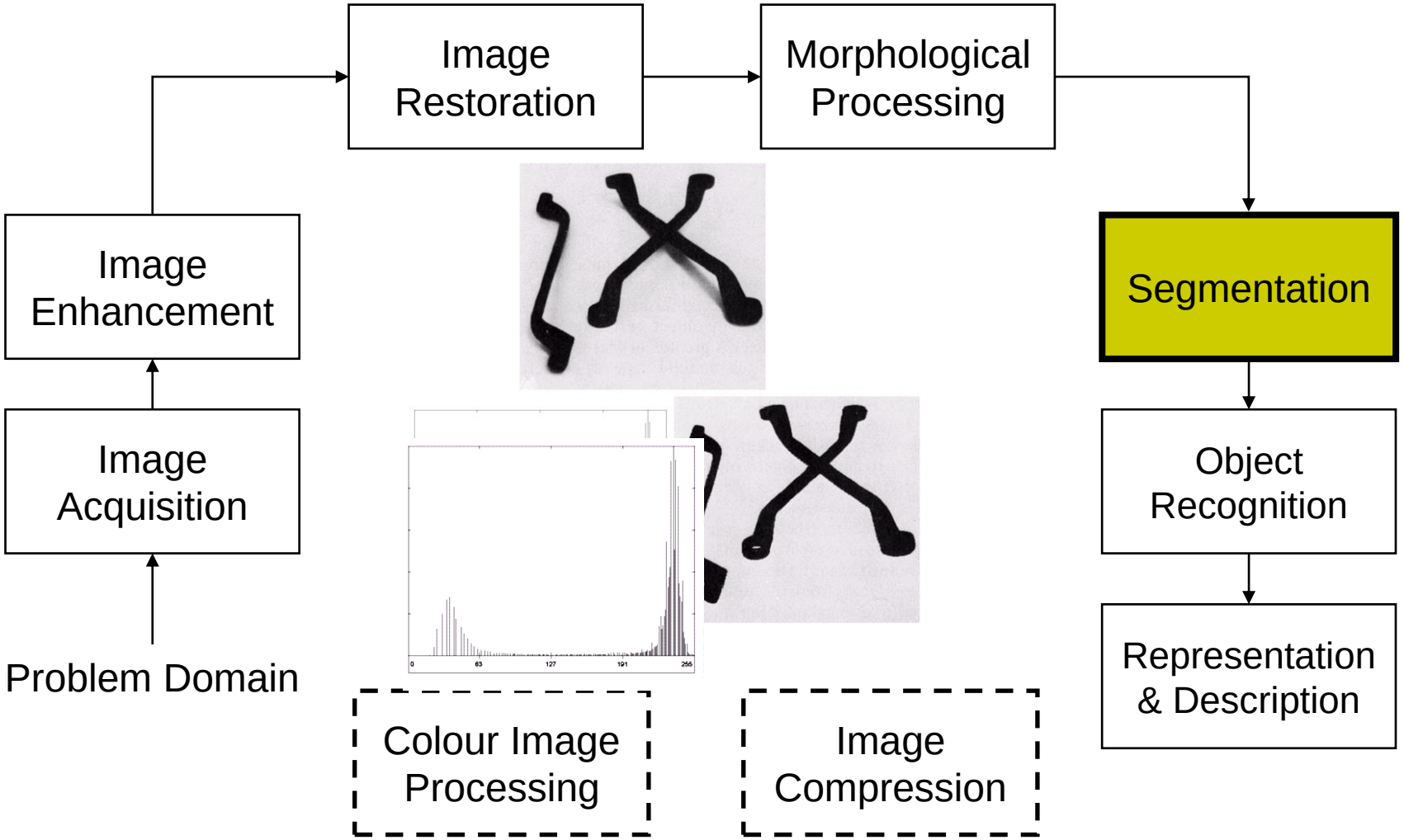
Key Stages in Digital Image Processing: Segmentation



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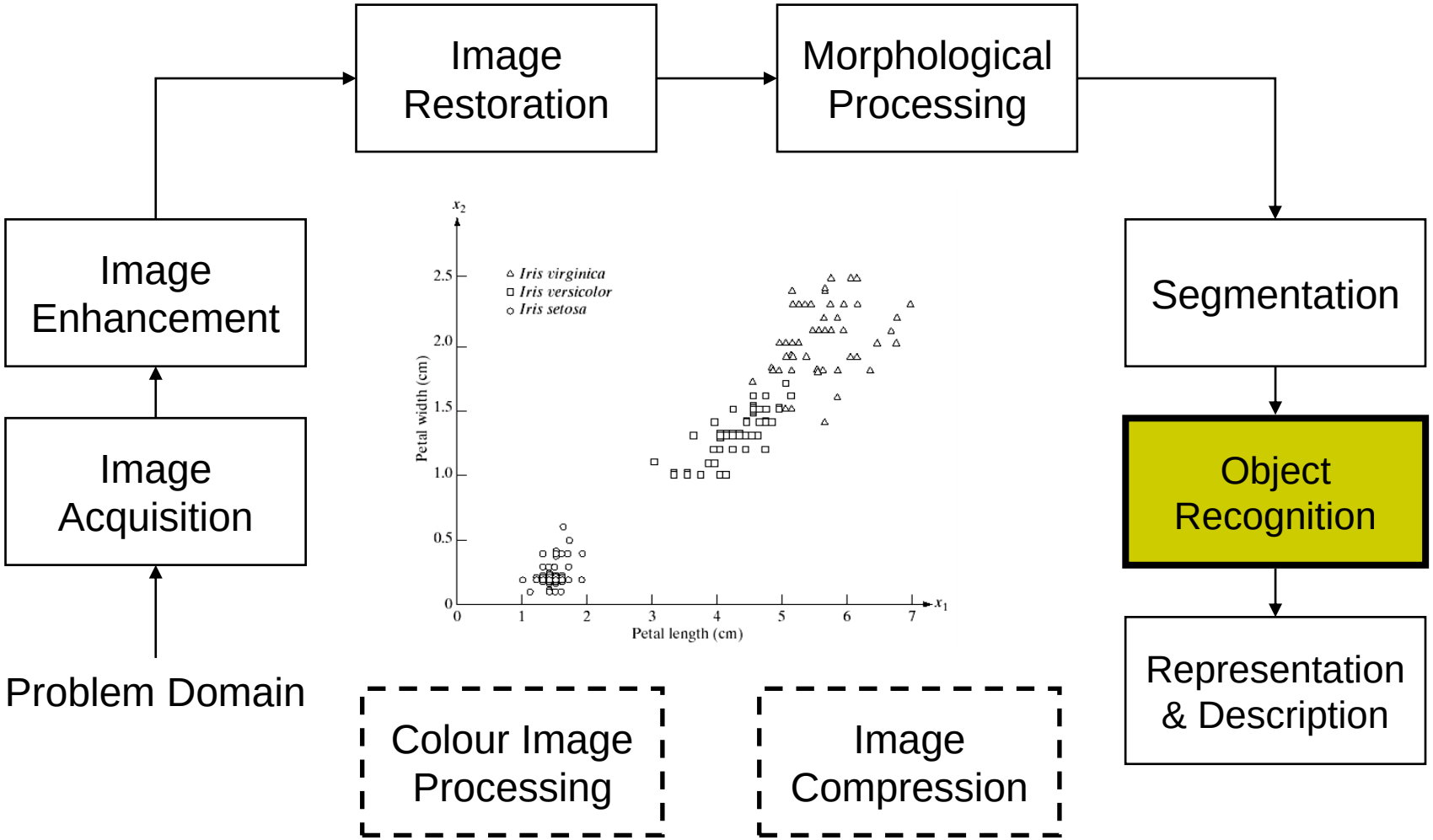
Key Stages in Digital Image Processing: Object Recognition



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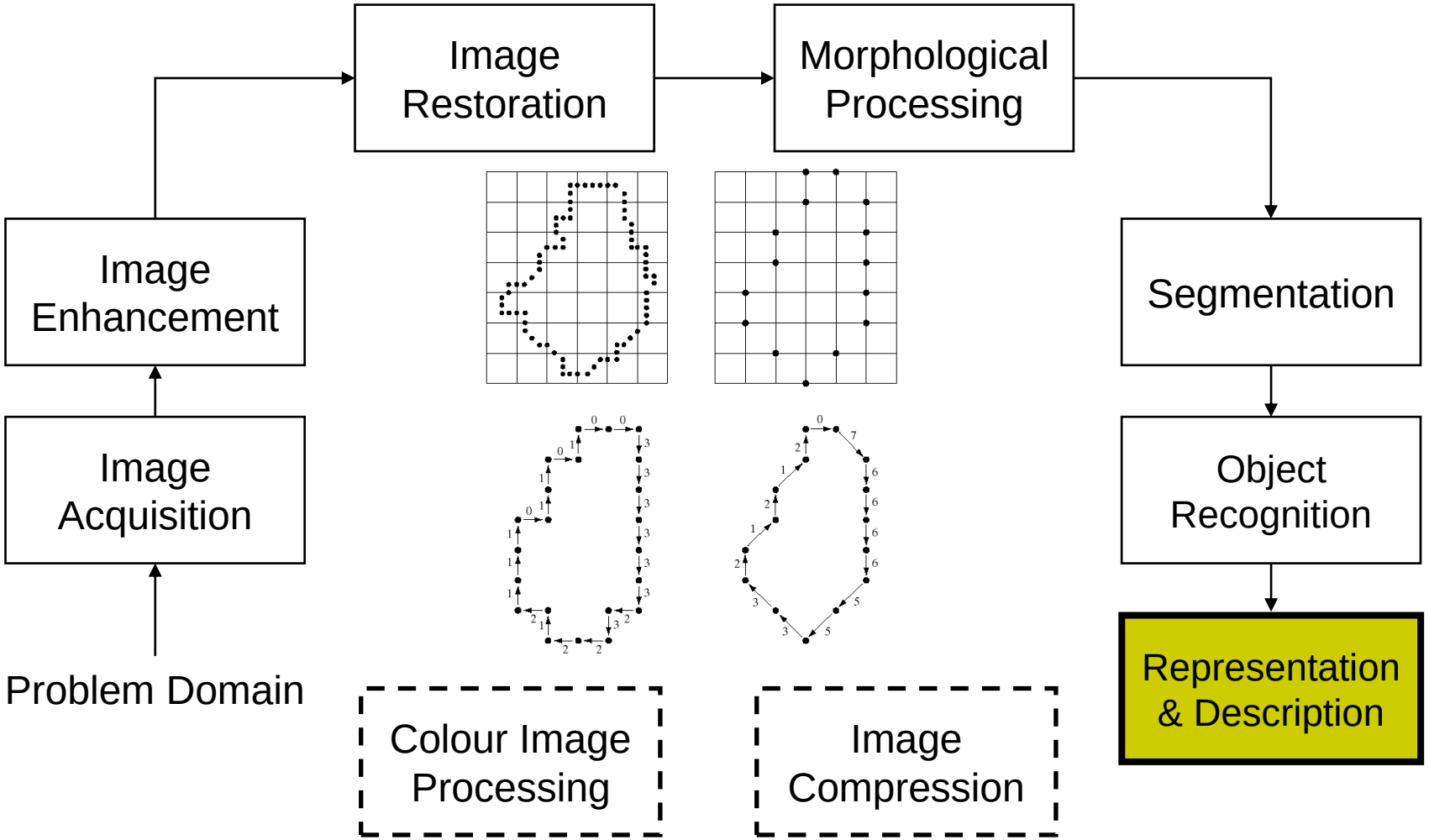
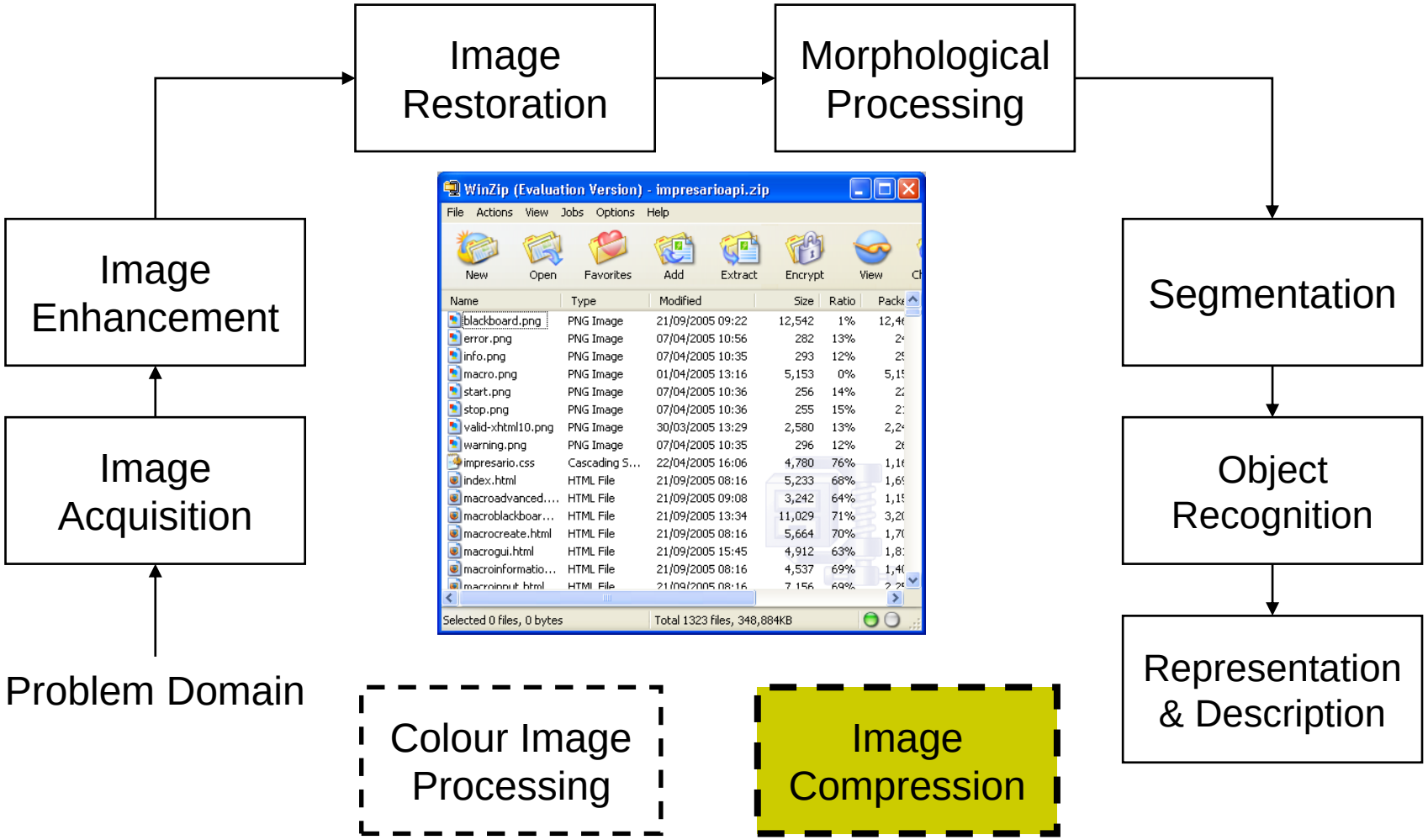
Key Stages in Digital Image Processing: Representation & Description



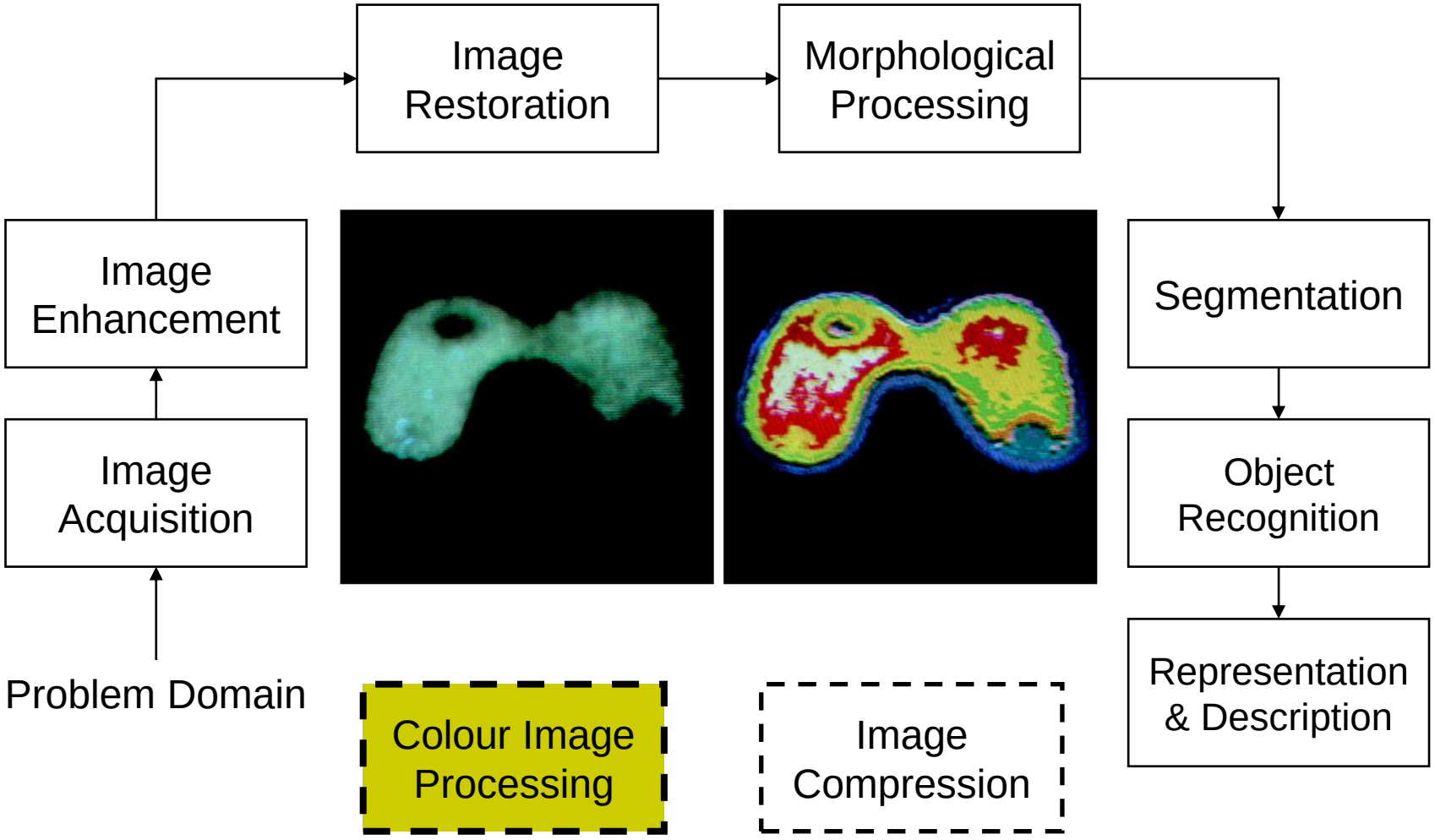
Adapted from Gonzalez, Rafael C. Digital image processing. Pearson education India, 2009.

Key Stages in Digital Image Processing: Image Compression



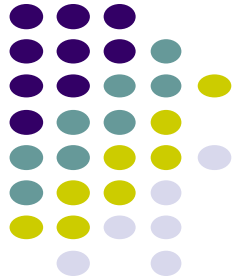
Adapted from Gonzalez, Rafael C. Digital image processing. Pearson education India, 2009.

Key Stages in Digital Image Processing: Colour Image Processing



Adapted from Gonzalez, Rafael C. Digital image processing. Pearson education India, 2009.

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

Important: Acquire some experience with Matlab/Python.