Digital Image Processing
Session 1 – Introduction

Books

- "*Digital Image Processing*", Rafael C. Gonzalez & Richard E. Woods, 3rd Edition, Addison-Wesley, 2007
- "*Digital Image Processing*", S.Sridhar, Oxford University press, 2012.
- "*Digital Image Processing*", William K. Pratt, John Wiley, 4th Edition, 2007.
- "*Computer Vision: a Modern Approach*", Forsyth and Ponce, 2nd edition, 2011.

Introduction

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

- Anonymous

Contents

- This lecture will cover:
  - History of digital image processing
  - What is a digital image?
  - What is digital image processing?
  - Why is digital image processing needed?
  - State of the art examples of digital image processing
  - Key stages in digital image processing

What is Digital Image Processing?

Processing of images which are digital in nature by a digital computer

- Digital image processing focuses on **three major tasks**
  - Improvement of pictorial information for human interpretation
  - Image processing for autonomous machine perception
  - Efficient storage and transmission

Human Perception

Focus: To enhance the pictorial information in a digital image for human interpretation and analysis

Typical applications:

- Noise Filtering
- Content Enhancement
  - Contrast enhancement
  - De-blurring *(Reasons for Blurring – camera settings – improper, lens – improper focusing, moving platform, scene – object moving)*
- Remote Sensing

Noise Filtering

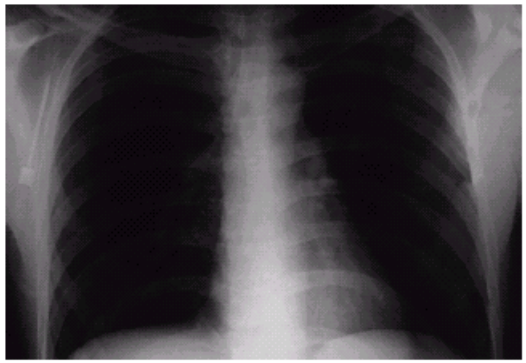
Noise Filtering

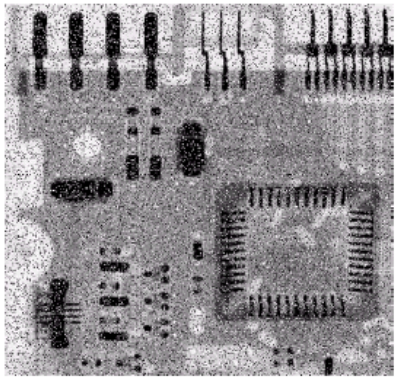
Original

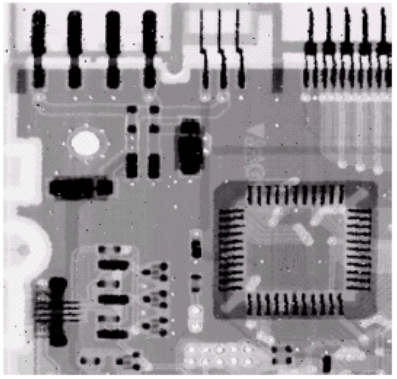
Filtered

Image Enhancement

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







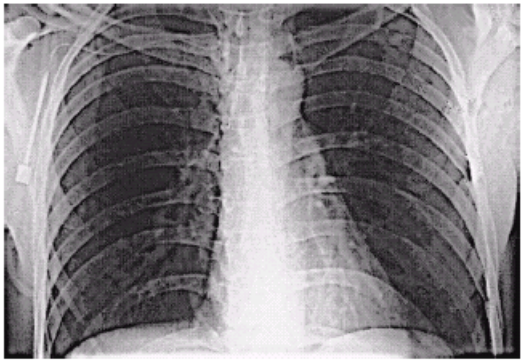
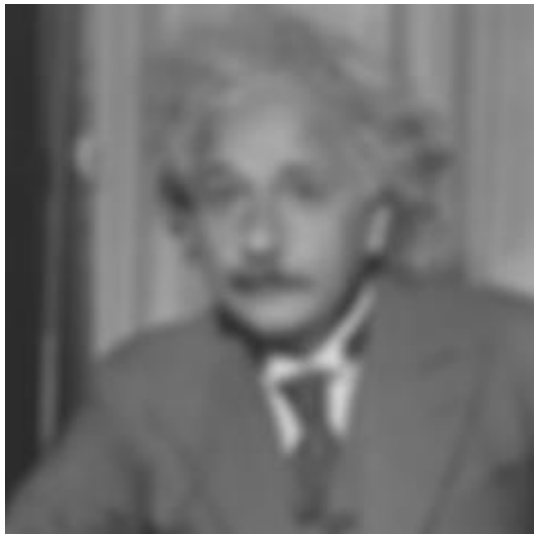


Image Enhancement

Image Enhancement

Image Deblurring



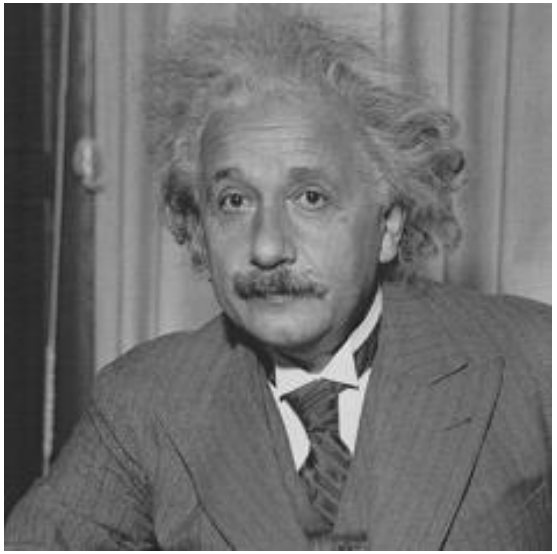
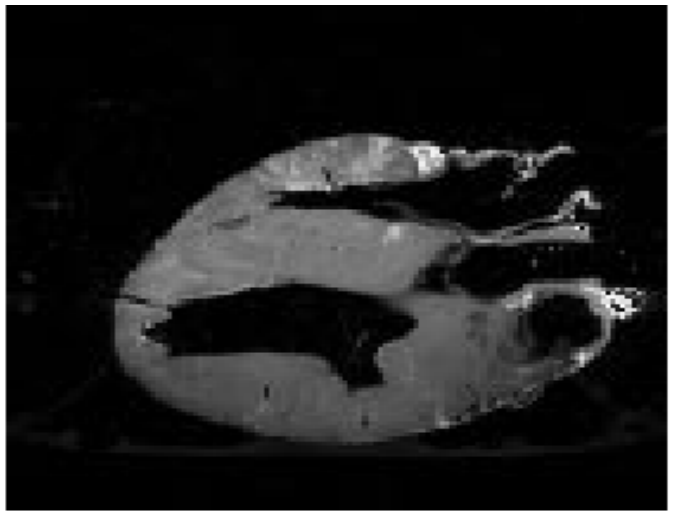


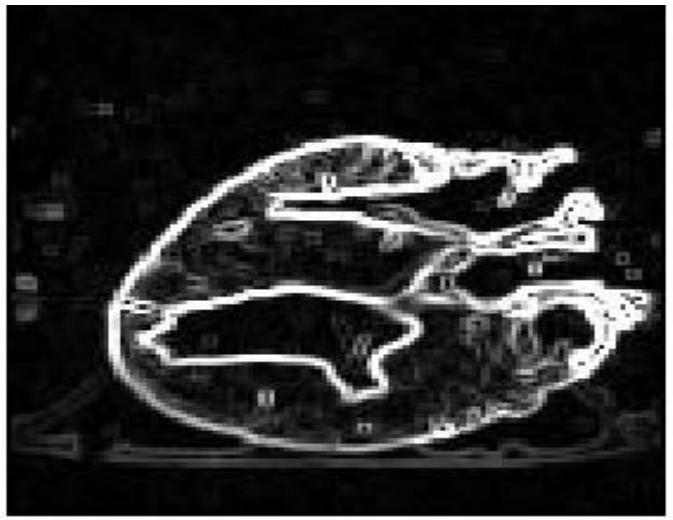
Image Defocussing

Medical Images

- 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

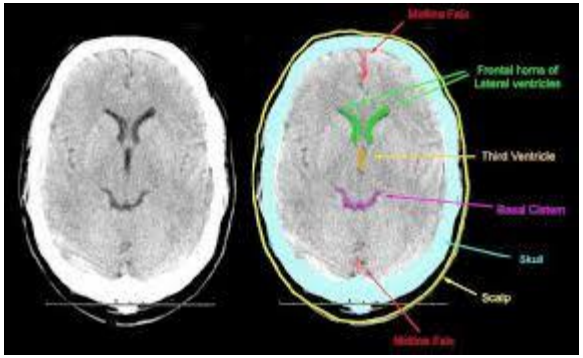


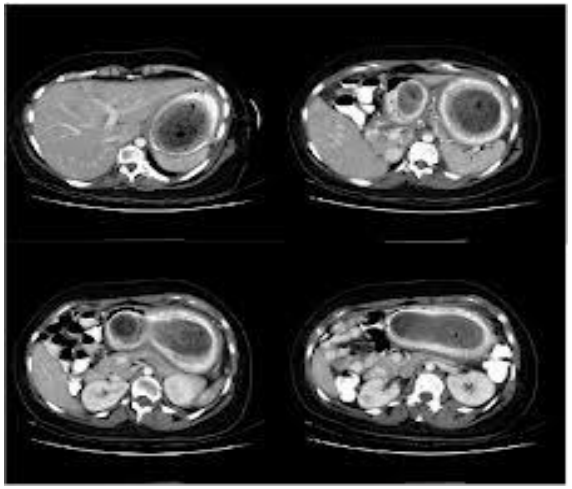
Original MRI Image of a Dog Heart



Edge Detection Image

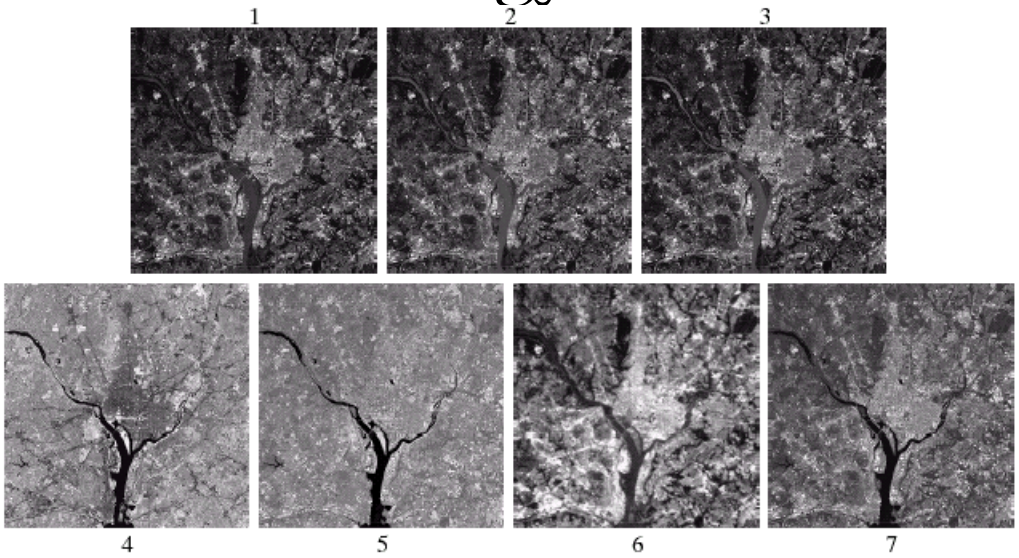
Medical Images

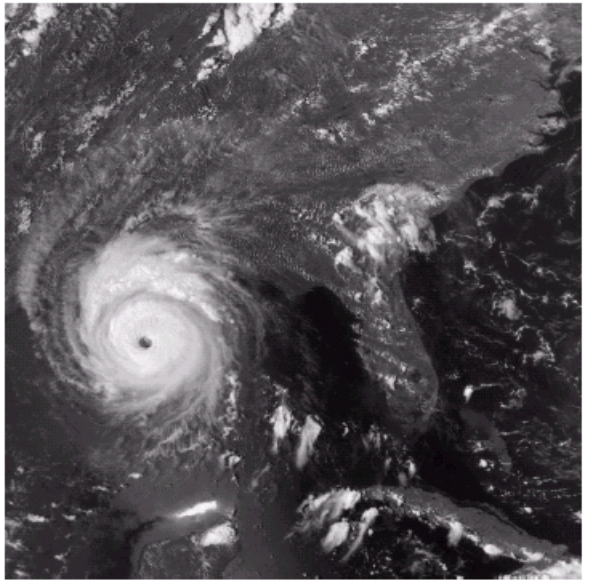




Remote Sensing Images GIS

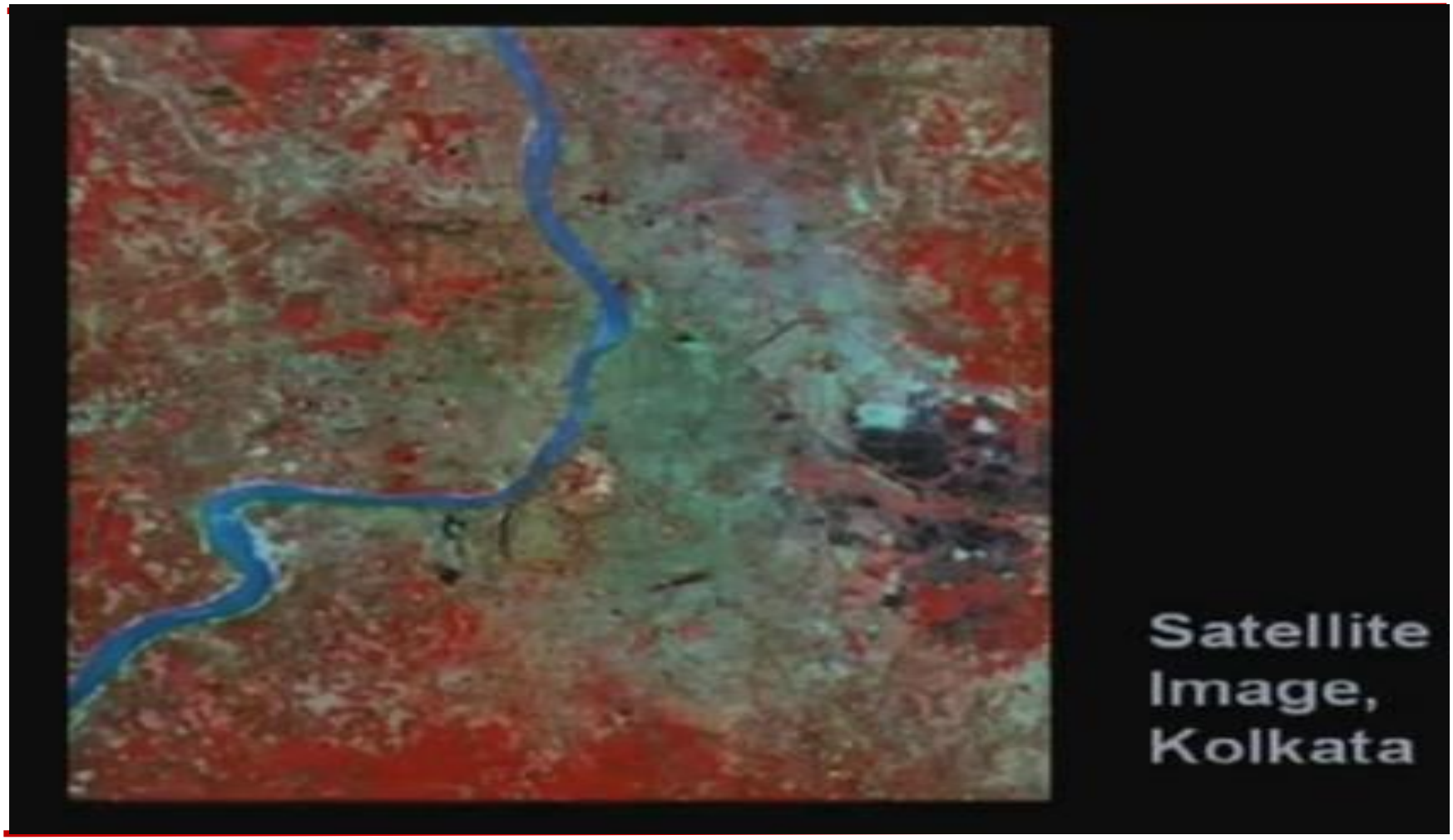
- Geographic Information Systems
  - Digital image processing techniques are used extensively to manipulate satellite imagery
  - Terrain classification
  - Meteorology



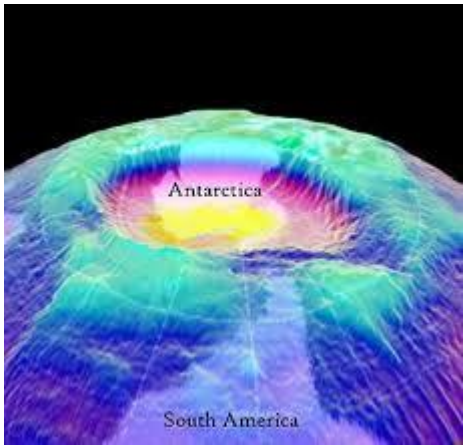


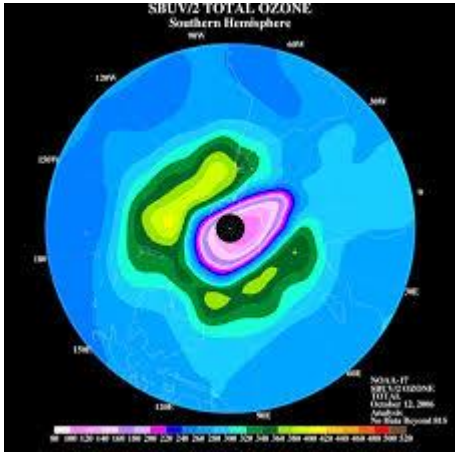
Images taken from Gonzalez & Woods, Digital Image Processing (2002)

Remote Sensing Images GIS



Atmosphere Study
Ozone Hole Formation





Astronomical Studies
Star Formation; Galaxy





Machine Vision Applications

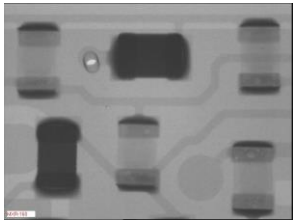
Focus: To extract the image information suitable for computer processing

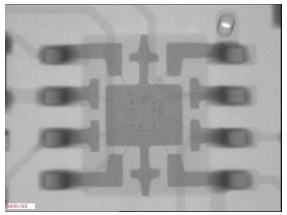
Typical applications:

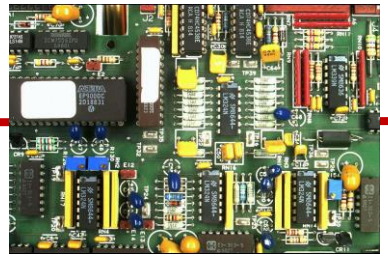
- Industrial machine vision for product assembly and inspection
- Automated target detection and tracking
- Fingerprint recognition
- Machine processing of aerial and satellite imagery for weather prediction and crop assessment etc.,

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

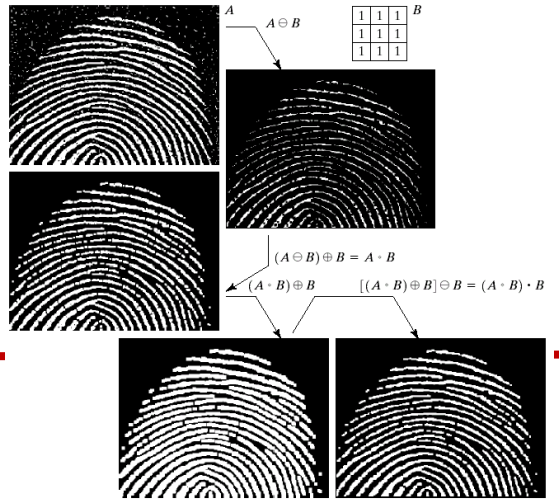






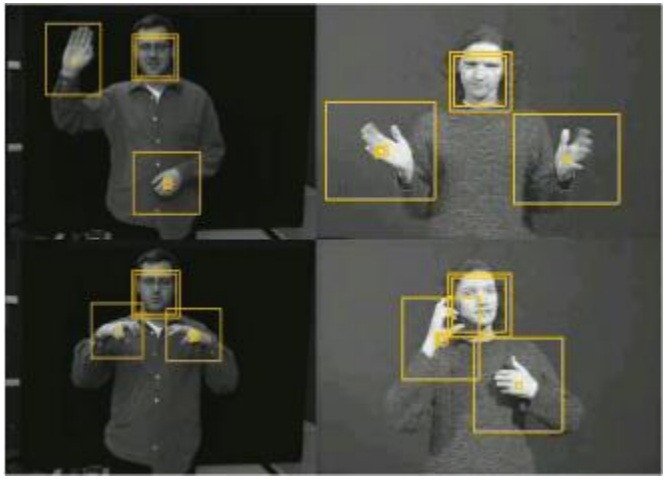
Law Enforcement

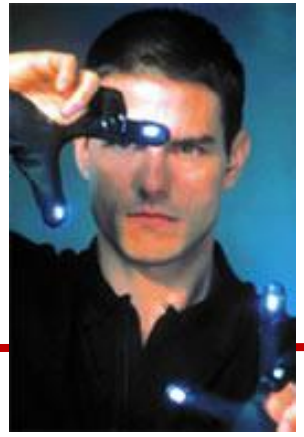
- Image processing techniques are used extensively by law enforcers
  - Number plate recognition for speed cameras/automated toll systems
  - Fingerprint recognition
  - Enhancement of CCTV images

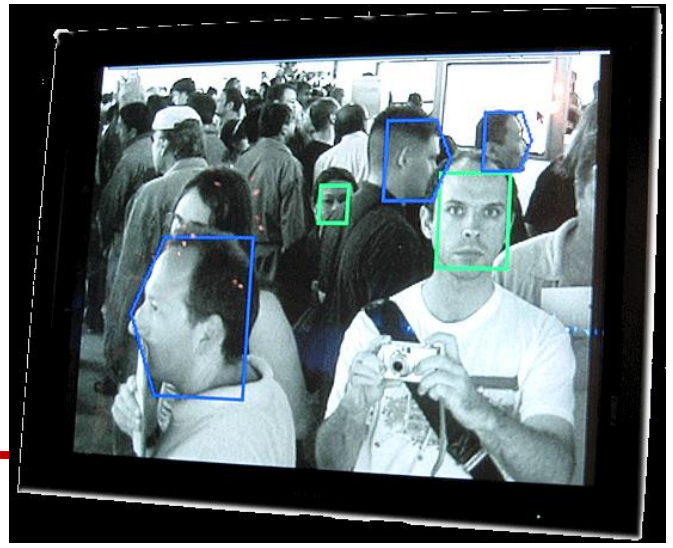


HCI

- Try to make human computer interfaces more natural
  - Face recognition
  - Gesture recognition
- These tasks can be extremely difficult







Video Sequence Processing

- Detection and Tracking of moving targets for security surveillance purpose

Image Compression

Focus :

To reduce the storage space on a disk and bandwidth requirement during transmission

Image :

Information Content

Redundancy

- Pixel redundancy
- Coding redundancy
- Psycho visual redundancy

Aim:

Remove redundancy and retain only the information content

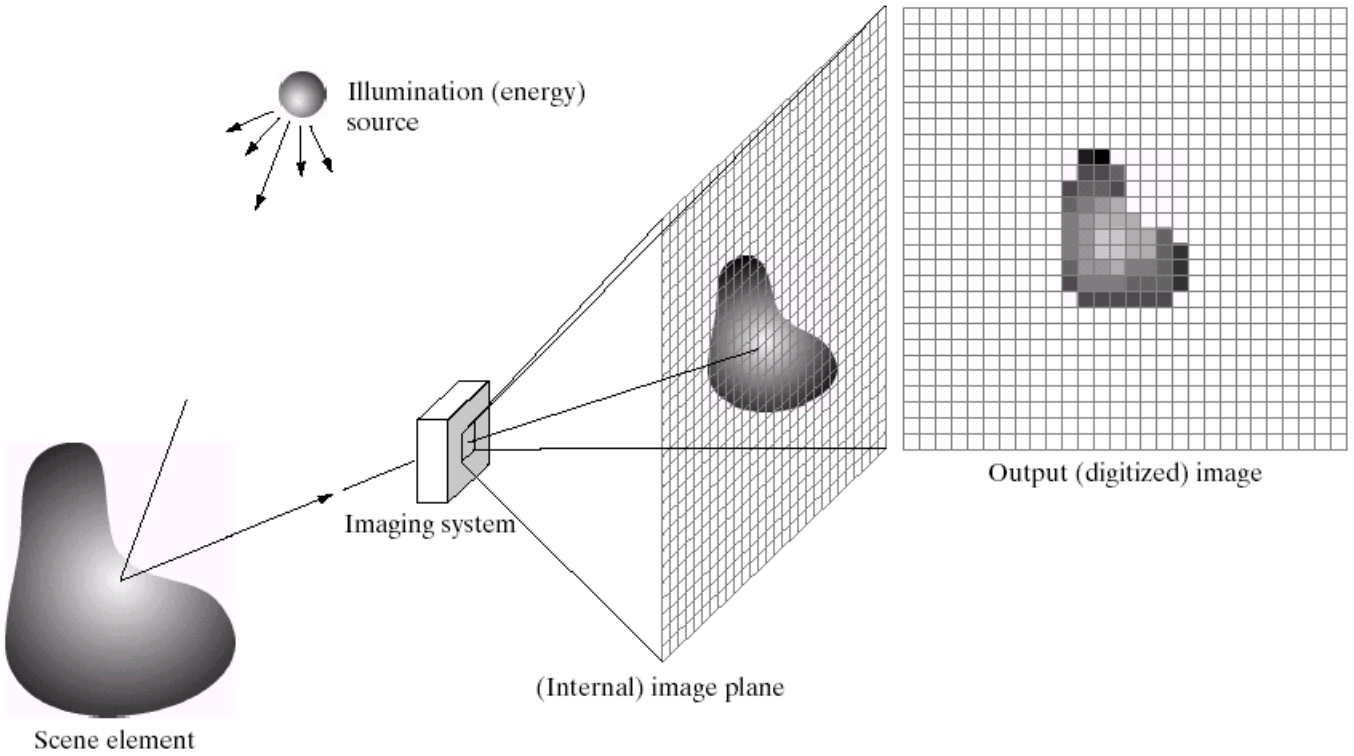
Types:

Lossy compression (information content is also removed – low quality)

Lossless compression (redundancy alone is removed – high quality)

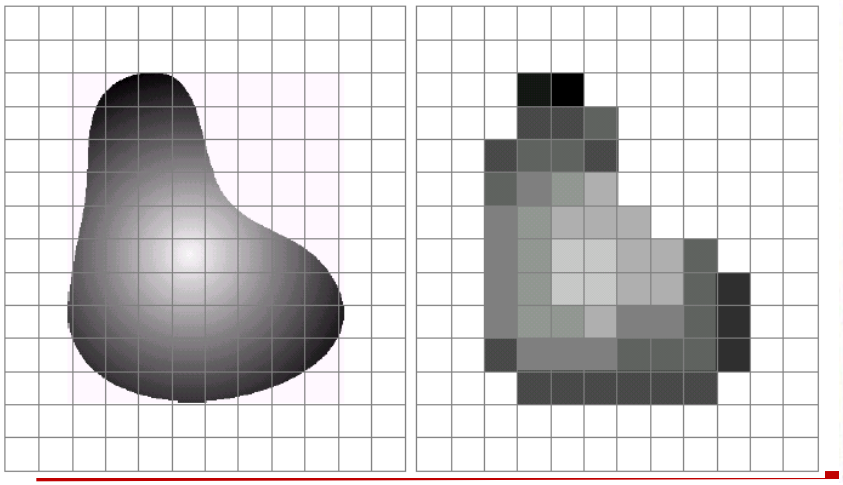
What is a Digital Image?

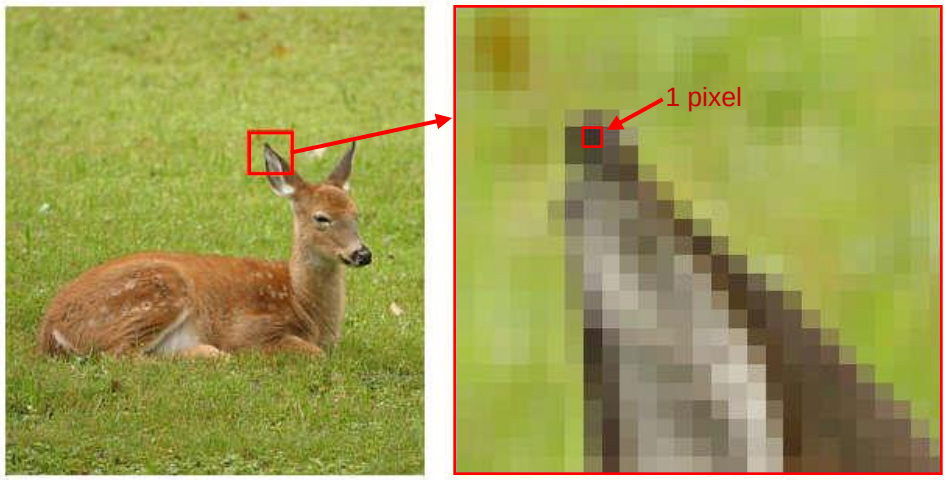
- A **digital image** is a representation of a two-dimensional image as a finite set of digital values, called picture elements or pixels



What is a Digital Image? (cont…)

- Pixel values typically represent gray levels, colours, opacities etc
- **Remember** *digitization* implies that a digital image is an *approximation* of a real scene





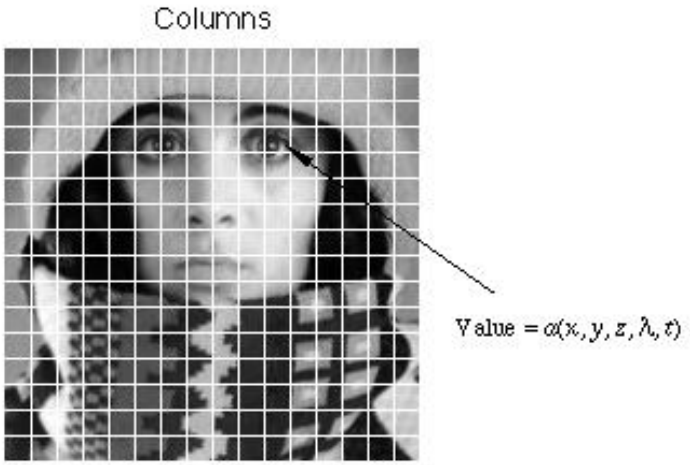
What is a Digital Image? (cont…)

- 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 grey-scale images

Digital Image



$$f(x,y) \cong \begin{bmatrix} f(0,0) & f(0,1) & f(0,N-1) \\ . & . & . \\ . & . & . \\ f(N-1,0) & .... & f(N-1,N-1) \end{bmatrix}_{N \times N}$$

- f(x,y)=r(x,y) * i(x,y)
- Spatial discretization by grids (sampling)
- Intensity discretization by quantization.
- Sampling+quantization = Digitization.
- picture element or pixel or pel
- Typical image size:
  - 64 X 64, 128 X 128
  - 256 X 256, 640 X 480 1024 X 1024

Digital Image

- The value of the function $f(x, y)$ at every point indexed by a row and a column is called *grey value* or *intensity* of the image.

- Resolution is an important characteristic of an imaging system. It is the ability of the imaging system to produce the smallest discernible details, i.e., the smallest sized object clearly, and differentiate it from the neighboring small objects that are present in the image.

Useful definitions

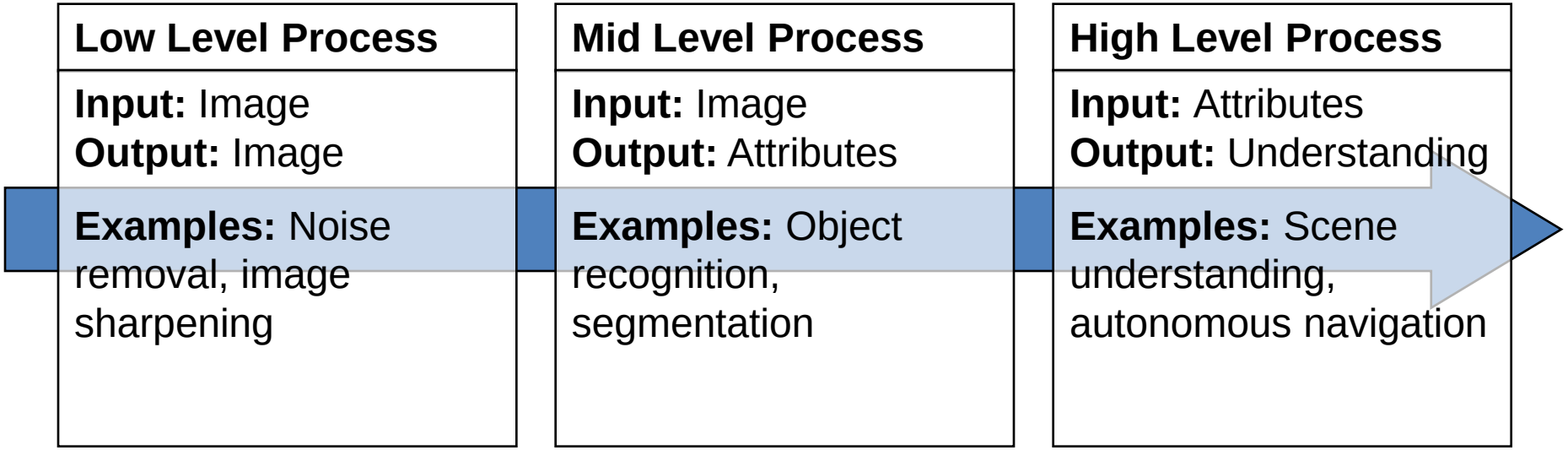
- Spatial resolution depends on two parameters—the number of pixels of the image and the number of bits necessary for adequate intensity resolution, referred to as the bit depth.

Useful definitions

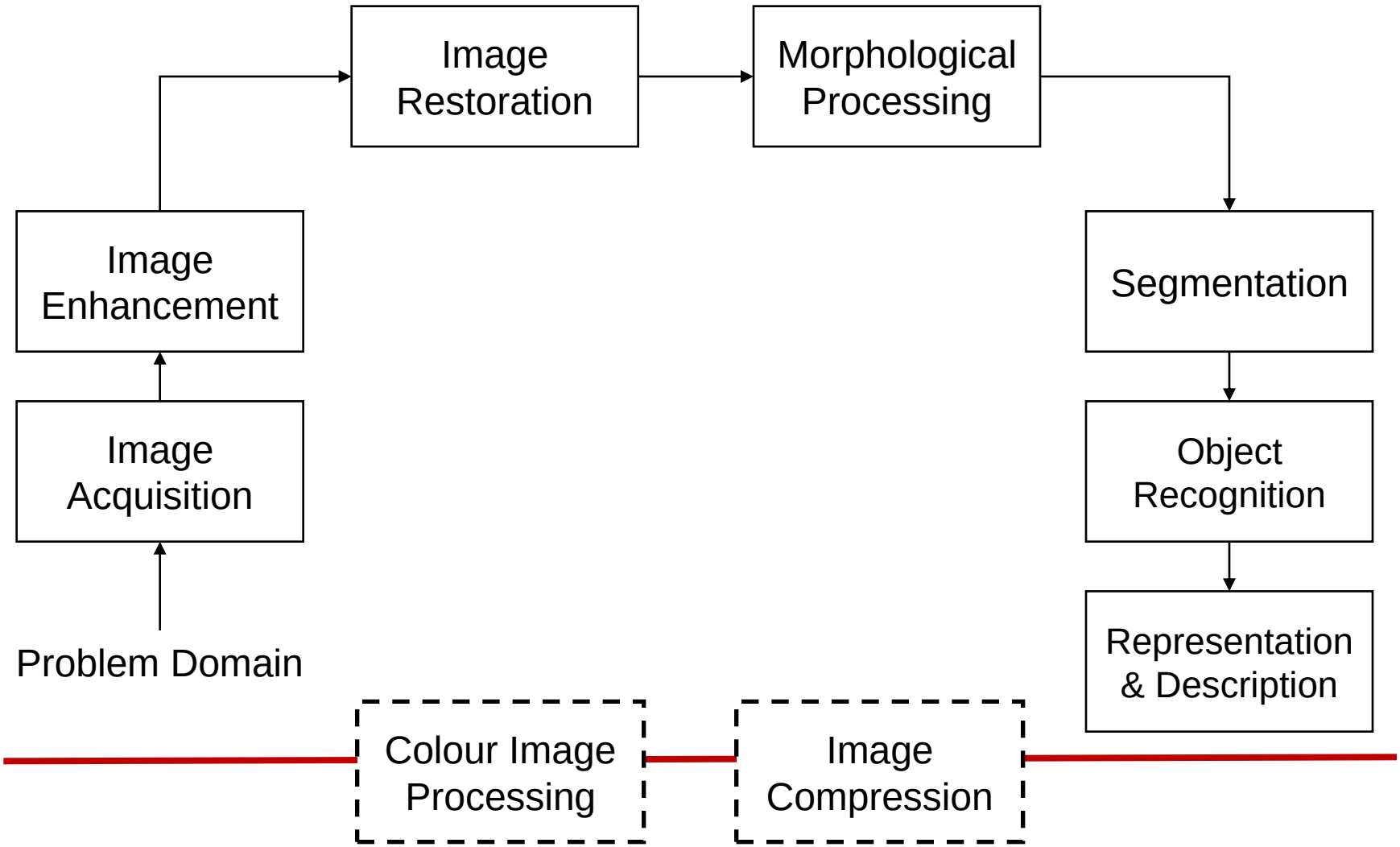
- The number of bits necessary to encode the pixel value is called *bit depth*. It can be written as powers of 2.
- So the total number of bits necessary to represent the image is
- Number of rows *Number of columns * Bit depth

What is DIP? (cont…)

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



Key Stages in Digital Image Processing



Key Stages in Digital Image Processing: Image Aquisition

Problem Domain

Image Acquisition

Image Enhancement

Image Restoration

Morphological Processing

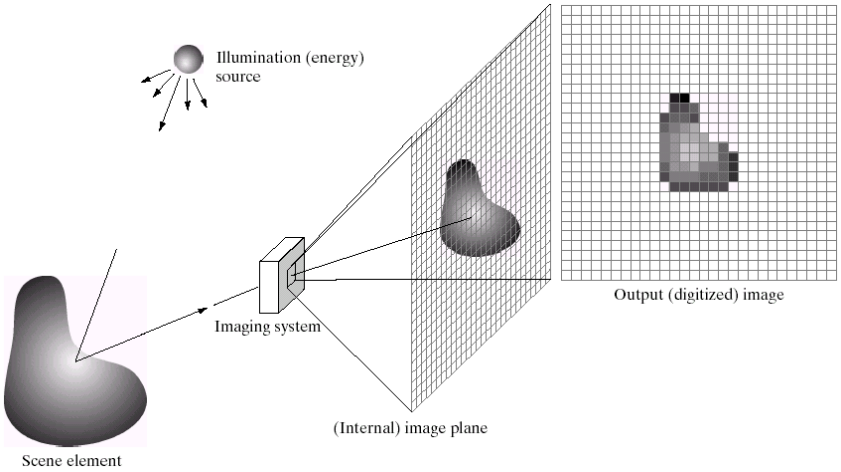
Segmentation

Object Recognition

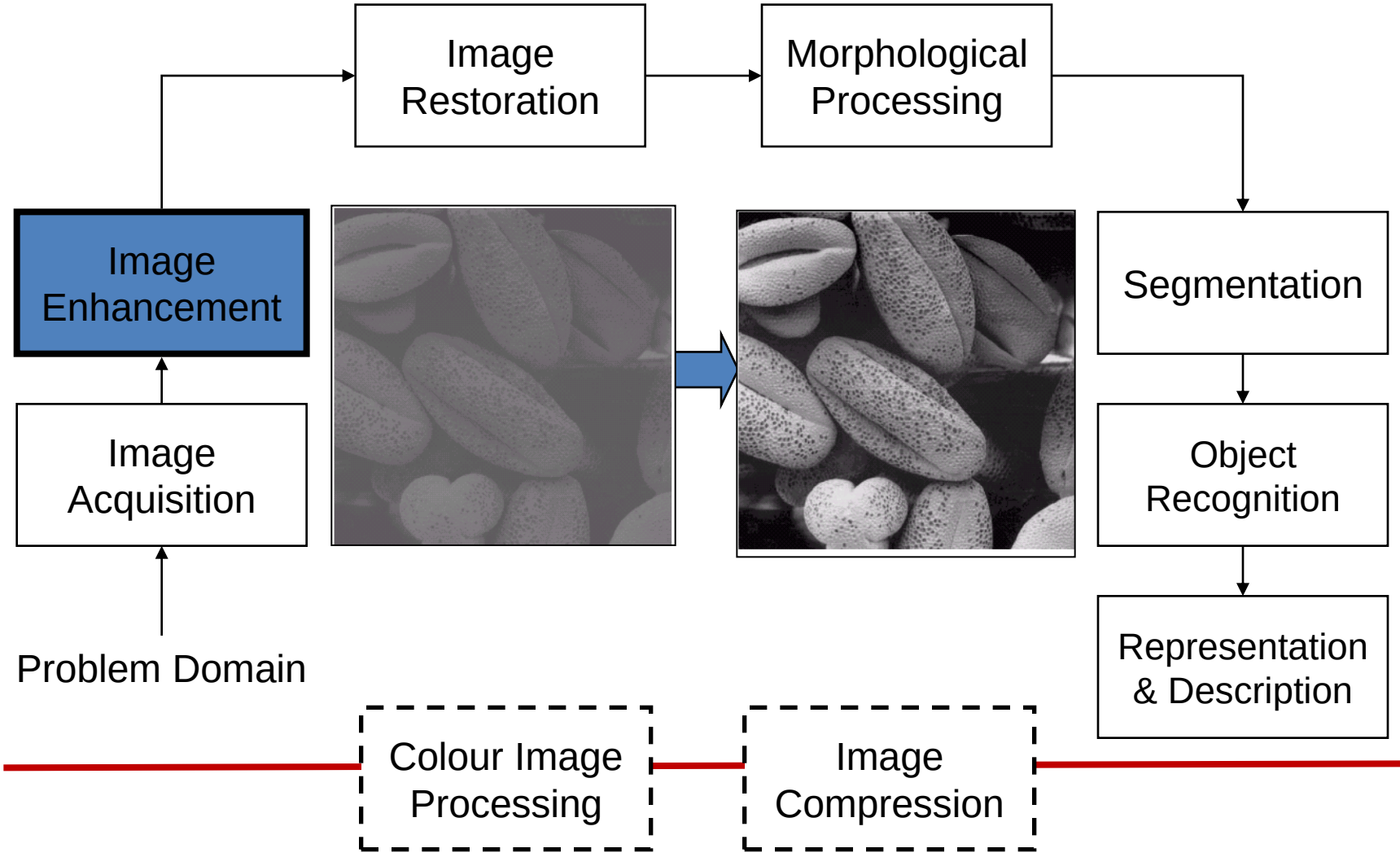
Representation & Description

Colour Image Processing

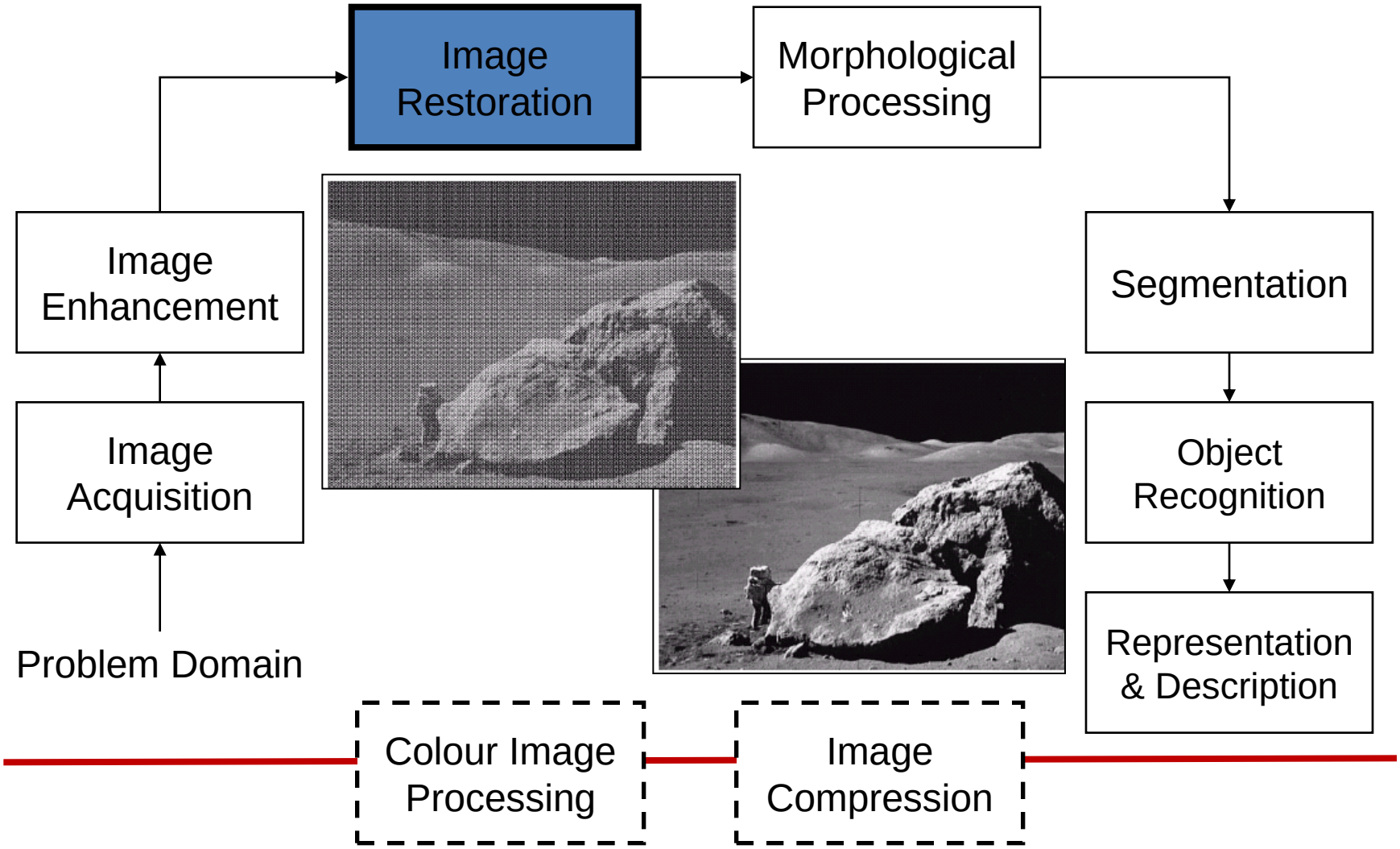
Image Compression



Key Stages in Digital Image Processing: Image Enhancement

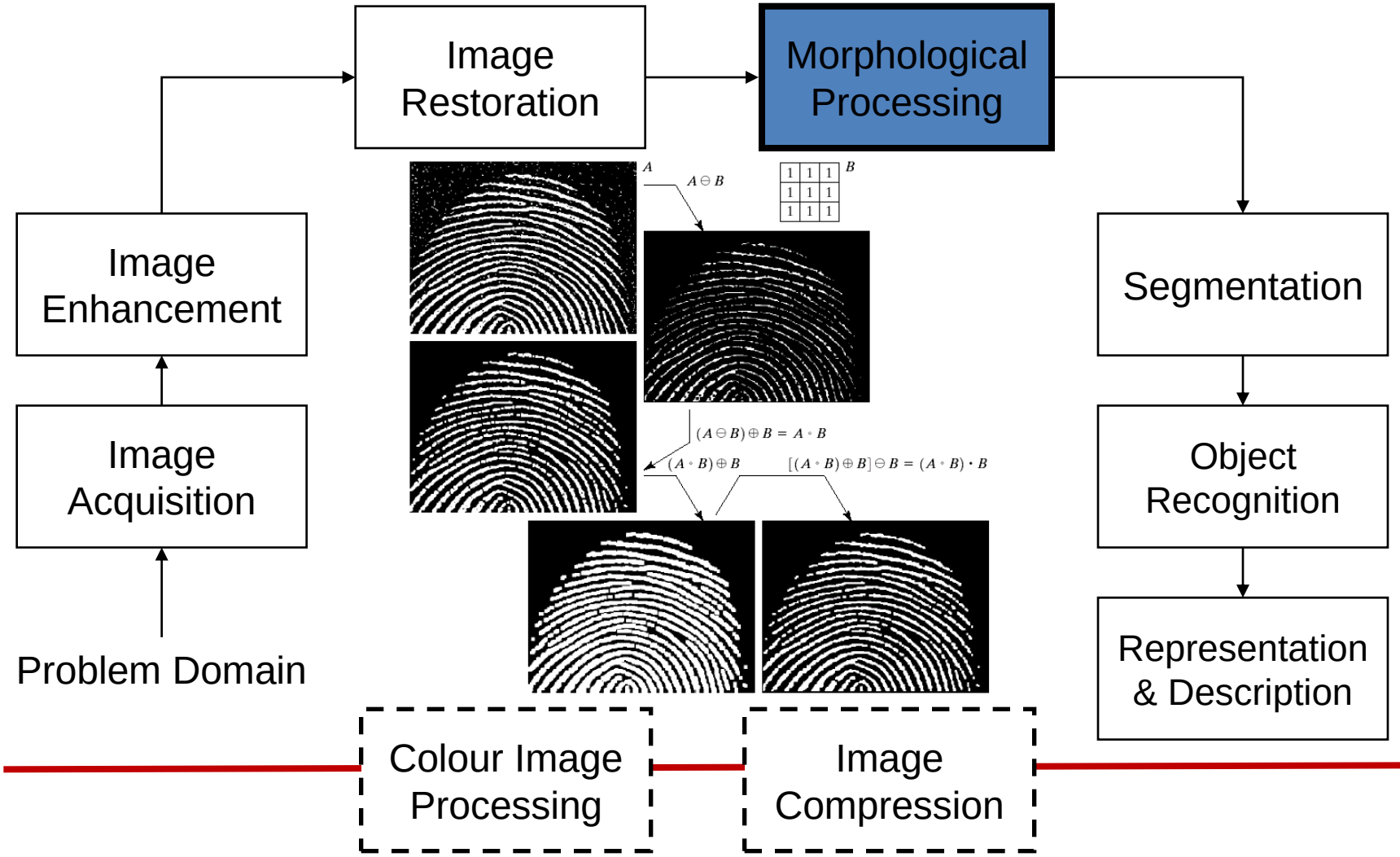


Key Stages in Digital Image Processing: Image Restoration



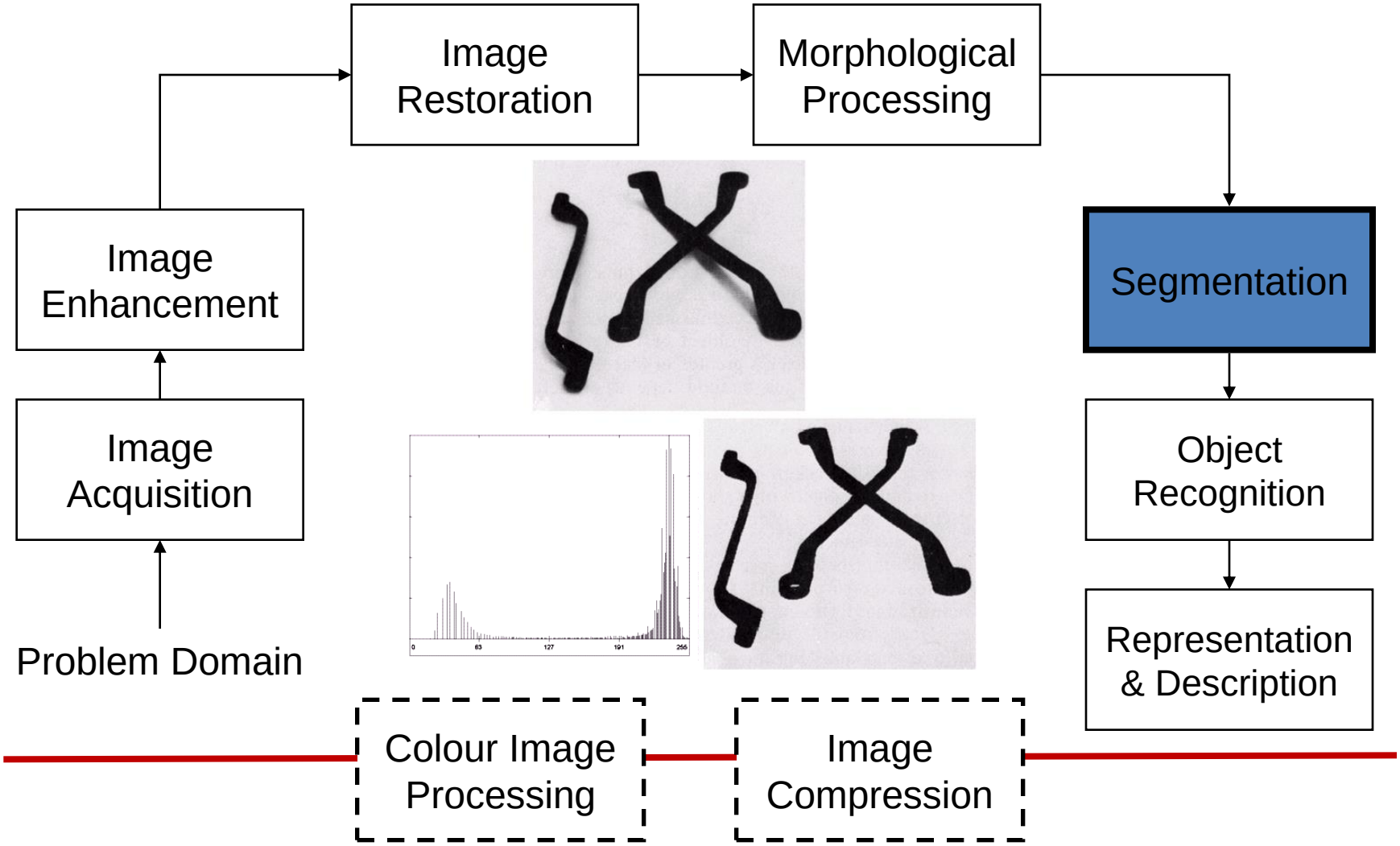
Images taken from Gonzalez & Woods, Digital Image Processing (2002)

Key Stages in Digital Image Processing: Morphological Processing



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

Key Stages in Digital Image Processing: Segmentation



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

Key Stages in Digital Image Processing: Object Recognition

Problem Domain

Image Acquisition

Image Enhancement

Image Restoration

Morphological Processing

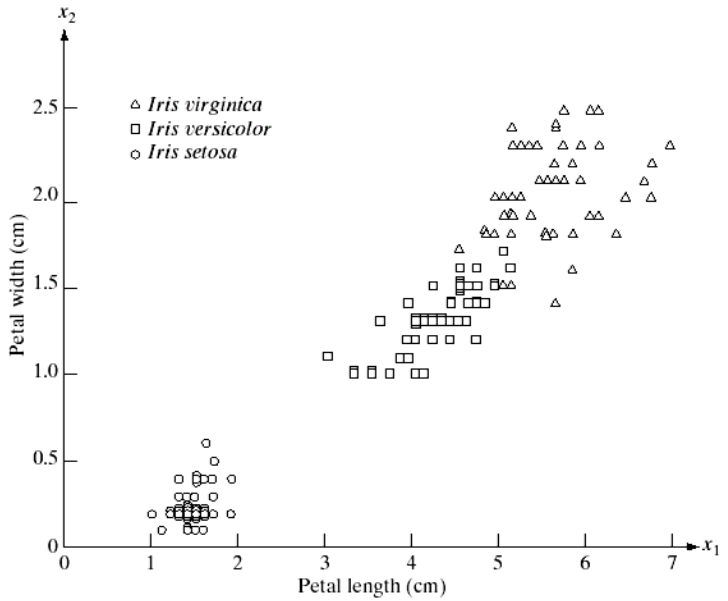
Segmentation

Object Recognition

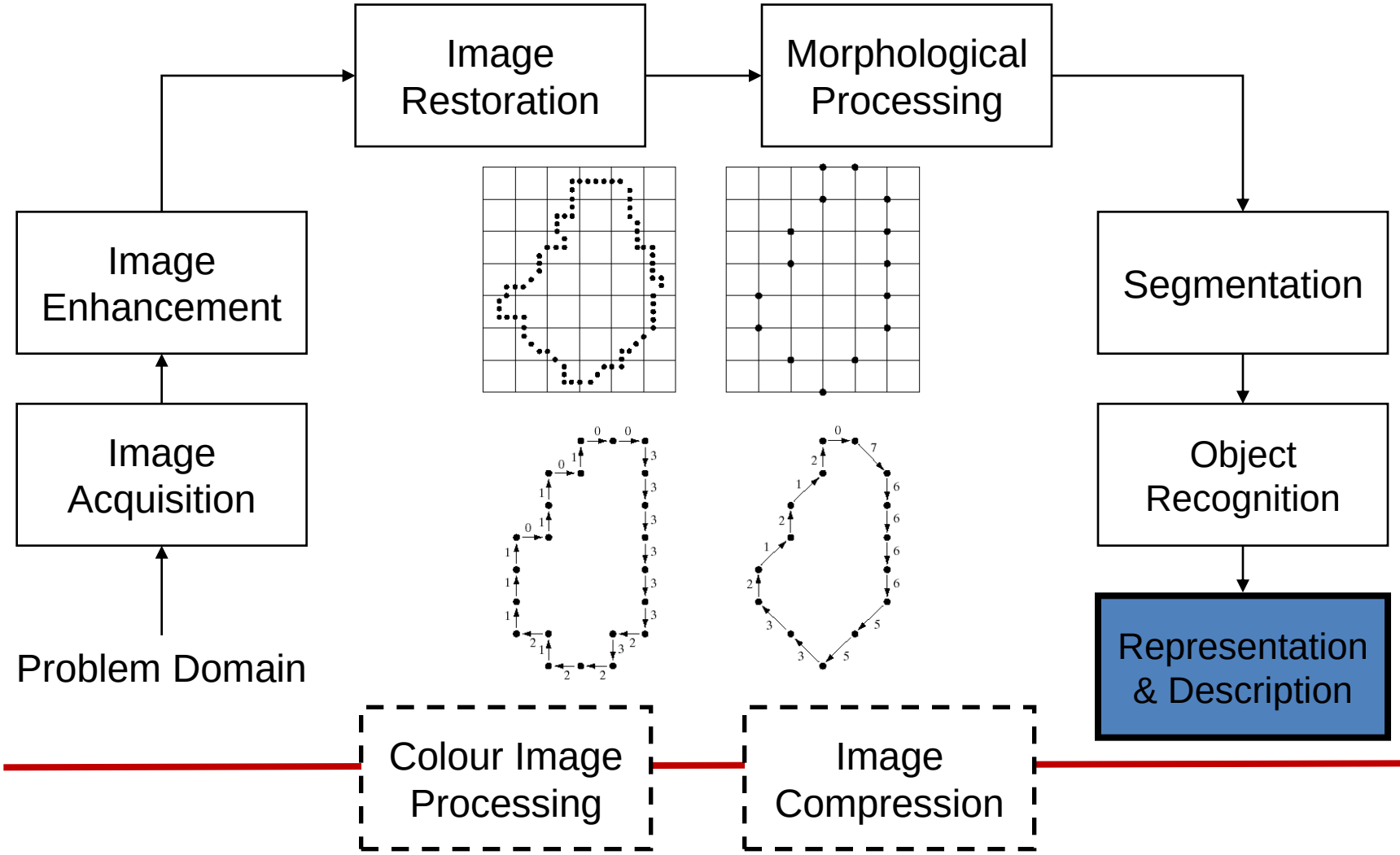
Representation & Description

Image Compression

Colour Image Processing

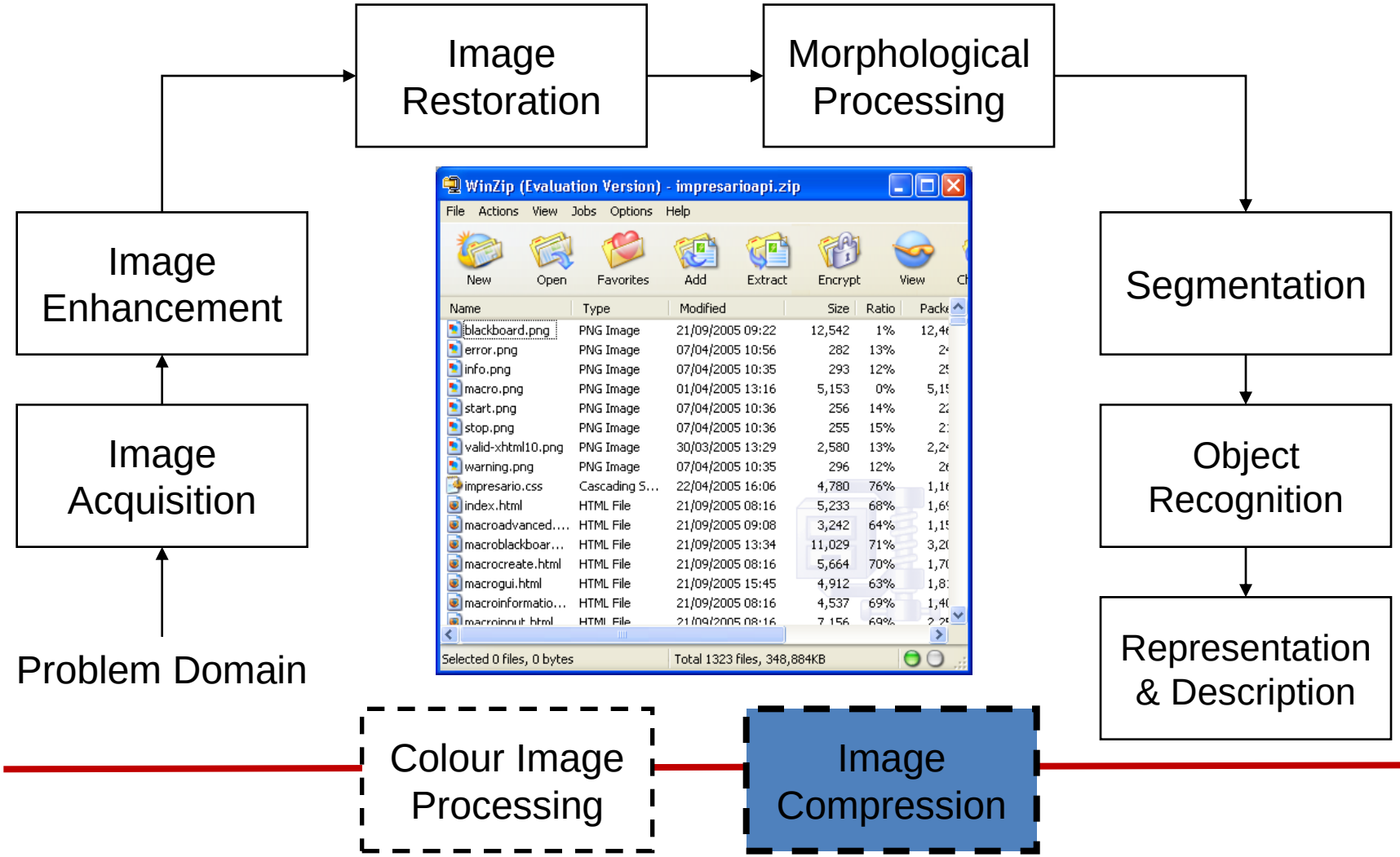


Key Stages in Digital Image Processing: Representation & Description

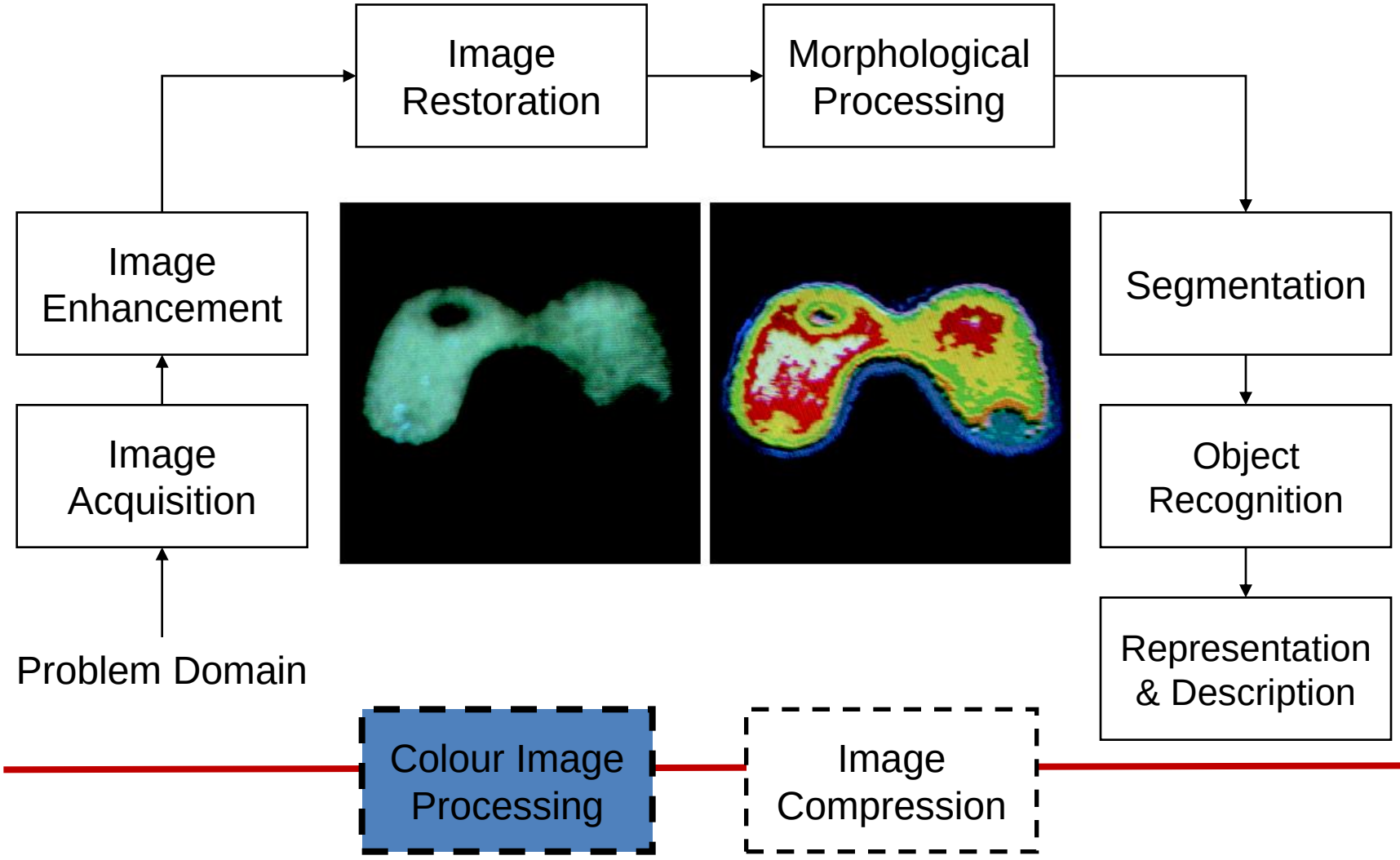


Images taken from Gonzalez & Woods, Digital Image Processing (2002)

Key Stages in Digital Image Processing: Image Compression



Key Stages in Digital Image Processing: Colour Image Processing



Reasons for Popularity of DIP

1. It is easy to post-process the image. Small corrections can be made in the captured image using software.
2. It is easy to store the image in the digital memory.
3. It is possible to transmit the image over networks. So sharing an image is quite easy.
4. A digital image does not require any chemical process. So it is very environment friendly, as harmful film chemicals are not required or used.
5. It is easy to operate a digital camera.

IMAGE PROCESSING AND RELATED FIELDS

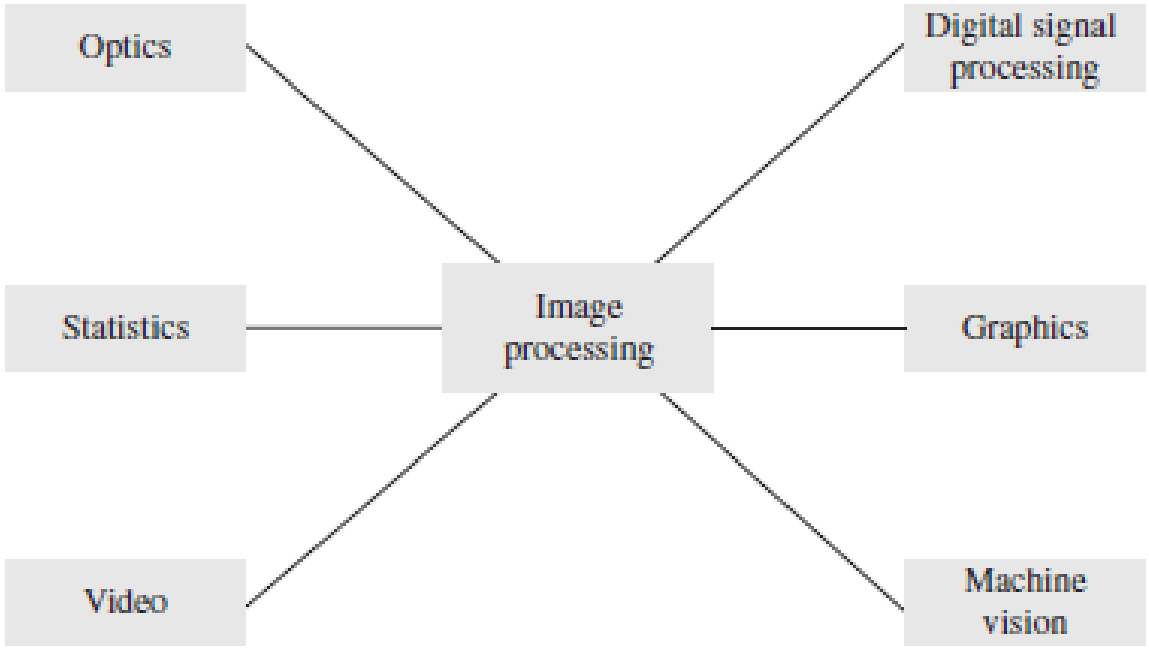


Fig. 1.2 Image processing and other closely related fields

TYPES OF IMAGES

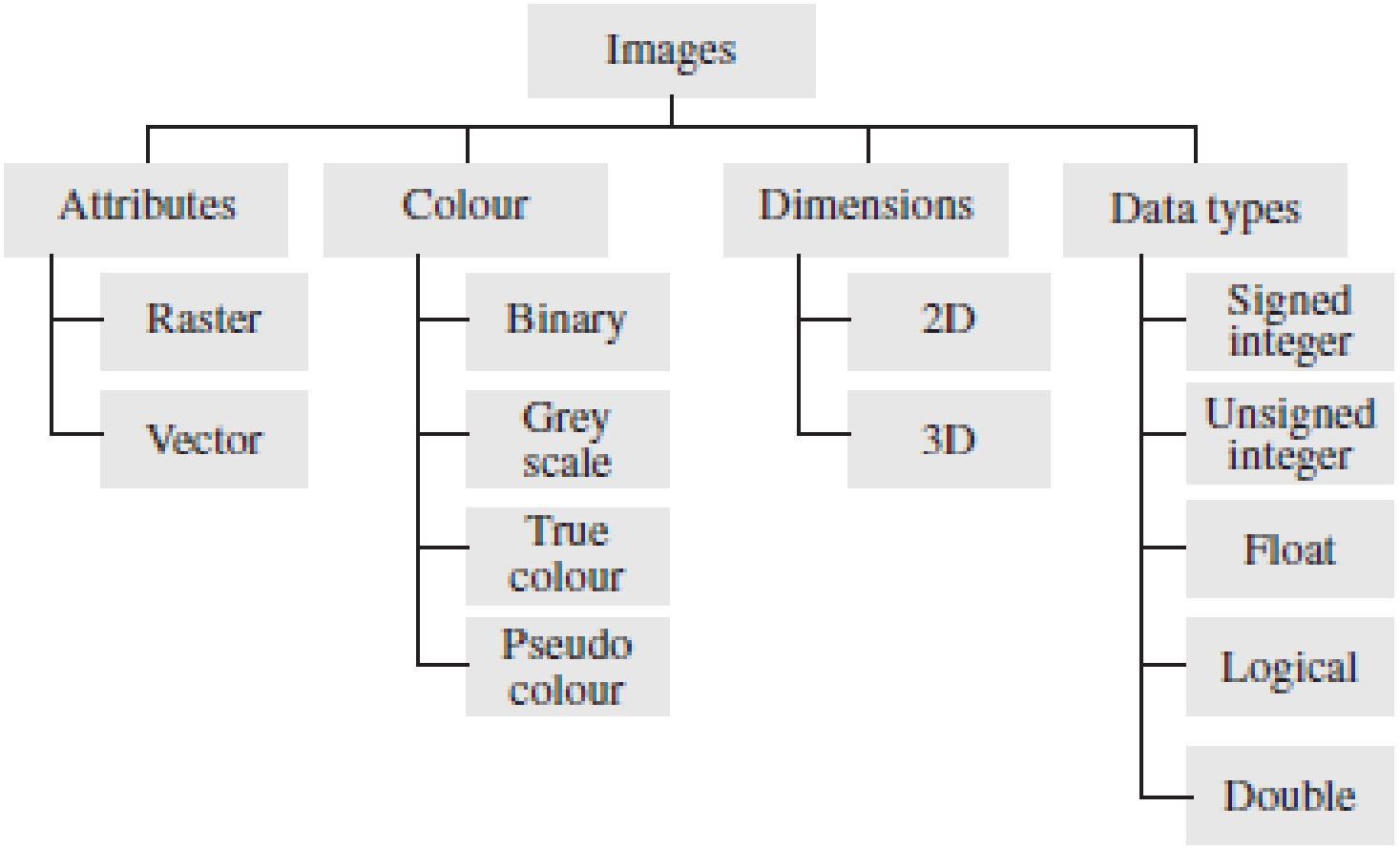


Fig. 1.4 Classification of images

Types of Images

- In binary images, the pixels assume a value of 0 or 1. So one bit is sufficient to represent the pixel value. Binary images are also called bi-level images.

- Grey scale images are different from binary images as they have many shades of grey between black and white. These images are also called monochromatic as there is no colour component in the image, like in binary images. *Grey scale* is the term that refers to the range of shades between white and black or vice versa.

Types of Images

- In true colour images, the pixel has a colour that is obtained by mixing the primary colours red, green, and blue. Each colour component is represented like a grey scale image using eight bits. Mostly, true colour images use 24 bits to represent all the colours.

Pseudocolour Image

- Like true colour images, Pseudocolour images are also used widely in image processing. True colour images are called three-band images. However, in remote sensing applications, multi-band images or multi-spectral images are generally used. These images, which are captured by satellites, contain many bands.

Types of Images based on Dimensions

- **Types of Images Based on Dimensions**

  2D and 3D
- **Types of Images Based on Data Types**
- Single, double, Signed or unsigned.

Summary

- We have looked at:
  - What is a digital image?
  - What is digital image processing?
  - Why we need 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…