Computer Vision and Image Processing (EC 336)

Lecture 1: Introduction

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Outline

- Syllabus
- Books
- Introduction
- Image Formation Model
- Representation of Digital Images
- Key Stages of Digital Image Processing
- Applications
- Opportunities

Syllabus

- Image representation - Gray scale and colour Images, image sampling and quantization.; Two dimensional orthogonal transforms - DFT, FFT, WT, Haar transform, DCT.

- Image enhancement - Filters in spatial and frequency domains, histogram-based processing, homomorphic filtering.; Edge detection - non parametric and model based approaches, LOG filters, localization problem.

- Image Restoration - PSF, deconvolution, restoration using inverse filtering, Wiener filtering and maximum entropy-based methods.;

Syllabus

- Mathematical morphology - binary morphology, dilation, erosion, opening and closing, duality relations, gray scale morphology, applications such as hit-and-miss transform, thinning and shape decomposition.

- Computer tomography - parallel beam projection, Radon transform, and its inverse, Back-projection operator, Fourier-slice theorem, CBP and FBP methods, ART, Fan beam projection.; Image communication - JPEG, MPEGs and H.26x standards, packet video, error concealment.

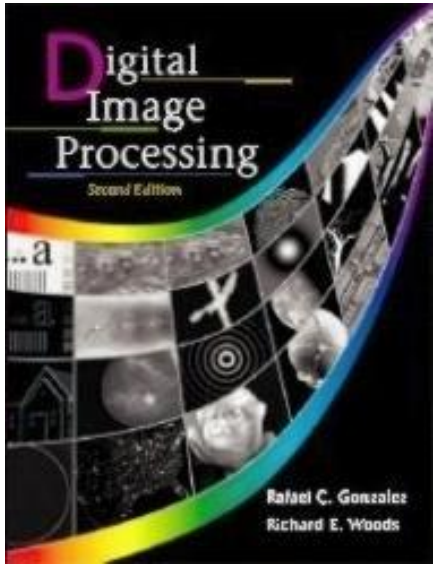
- Image texture analysis - co- occurrence matrix, measures of textures, statistical models for textures. Misc. topics such as - Hough Transform, boundary detection, chain coding, and segmentation, thresholding methods.

Books

1. A. K. Jain, Fundamentals of digital image processing, Prentice Hall, 1989.
2. W. K. Pratt, Digital image processing, Prentice Hall, 1989.
3. R.M. Haralick, and L.G. Shapiro, Computer and Robot Vision, Vol-1, Addison Wesley, 1992.
4. R. Jain, R. Kasturi and B.G. Schunck, Machine Vision, McGraw-Hill International Edition, 1995.
5. A. Rosenfold and A. C. Kak, Digital image processing, Vols. 1 and 2, Prentice Hall, 1986.
6. H. C. Andrew and B. R. Hunt, Digital image restoration, Prentice Hall, 1977.

Books

- http://www.imageprocessingplace.com/
- Gonzalez, R. C. and Woods, R. E., "Digital Image Processing", Prentice Hall, 3rd Ed.



Introduction

- **What is Digital Image Processing?**

Digital Image

— a two-dimensional function $f(x, y)$

x and *y* are spatial coordinates

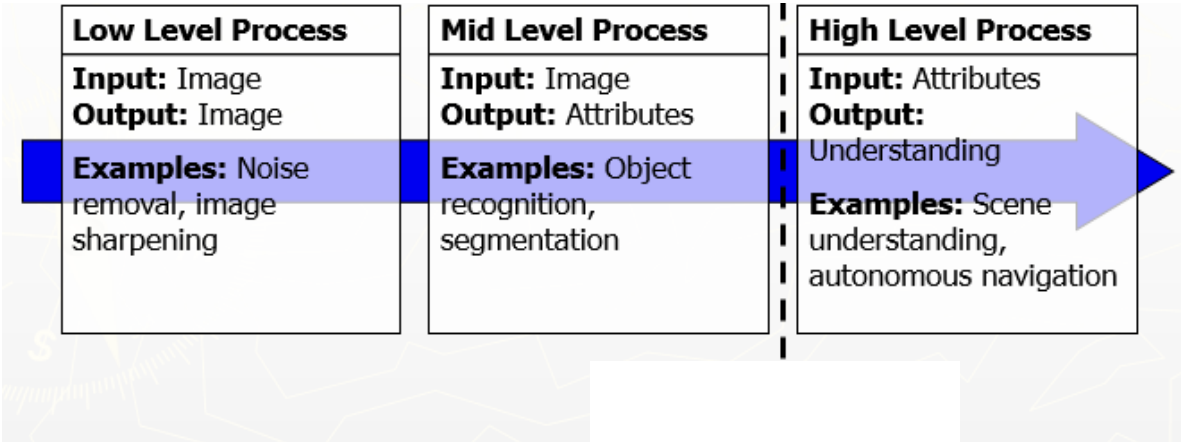
Pixel

— the elements of a digital image

The amplitude of f is called intensity or gray level at the point (x, y)

Digital Image Processing

— process digital images by means of computer, it covers low-, mid-, and high-level processes



Introduction

- **What is Digital Computer Vision?**

In Computer Vision, computers or machines are made to gain high-level understanding from the input digital images or videos with the purpose of automating tasks that the human visual system can do.

- Computer vision comes from modelling image processing using the techniques of machine learning.

- It applies machine learning to recognize patterns for interpretation of images.

- we can distinguish between objects, classify them, sort them according to their size, and so forth.

A Simple Image Formation Model

$$f(x,y) = i(x,y) \bullet r(x,y)$$

$f(x,y)$: intensity at the point (x,y)

$i(x,y)$: illumination at the point (x,y)

(the amount of source illumination incident on the scene)

$r(x,y)$: reflectance/transmissivity at the point (x,y)

(the amount of illumination reflected/transmitted by the object)

where $0 < i(x,y) < \infty$ and $0 < r(x,y) < 1$

Example of Reflectance values

0.01 for black velvet
0.80 for flat-white wall paint
0.93 for snow
0.65 for stainless steel
0.90 for silver-plated metal

Representation of Digital Images

- The representation of an M×N numerical array as

$$f(x,y)=\begin{bmatrix} f(0,0) & f(0,1) & \dots & f(0,N-1) \\ f(1,0) & f(1,1) & \dots & f(1,N-1) \\ \dots & \dots & \dots & \dots \\ f(M-1,0) & f(M-1,1) & \dots & f(M-1,N-1) \end{bmatrix}$$

- Discrete intensity interval [0, L-1], $L=2^k$

  The number *b* of bits required to store a M × N digitized image

  b = M × N × k

- The representation of an M×N numerical array in MATLAB $f(x,y)=\begin{bmatrix} f(1,1) & f(1,2) & \dots & f(1,N) \\ f(2,1) & f(2,2) & \dots & f(2,N) \\ \dots & \dots & \dots & \dots \\ f(M,1) & f(M,2) & \dots & f(M,N) \end{bmatrix}$

Digital Image (cont…)

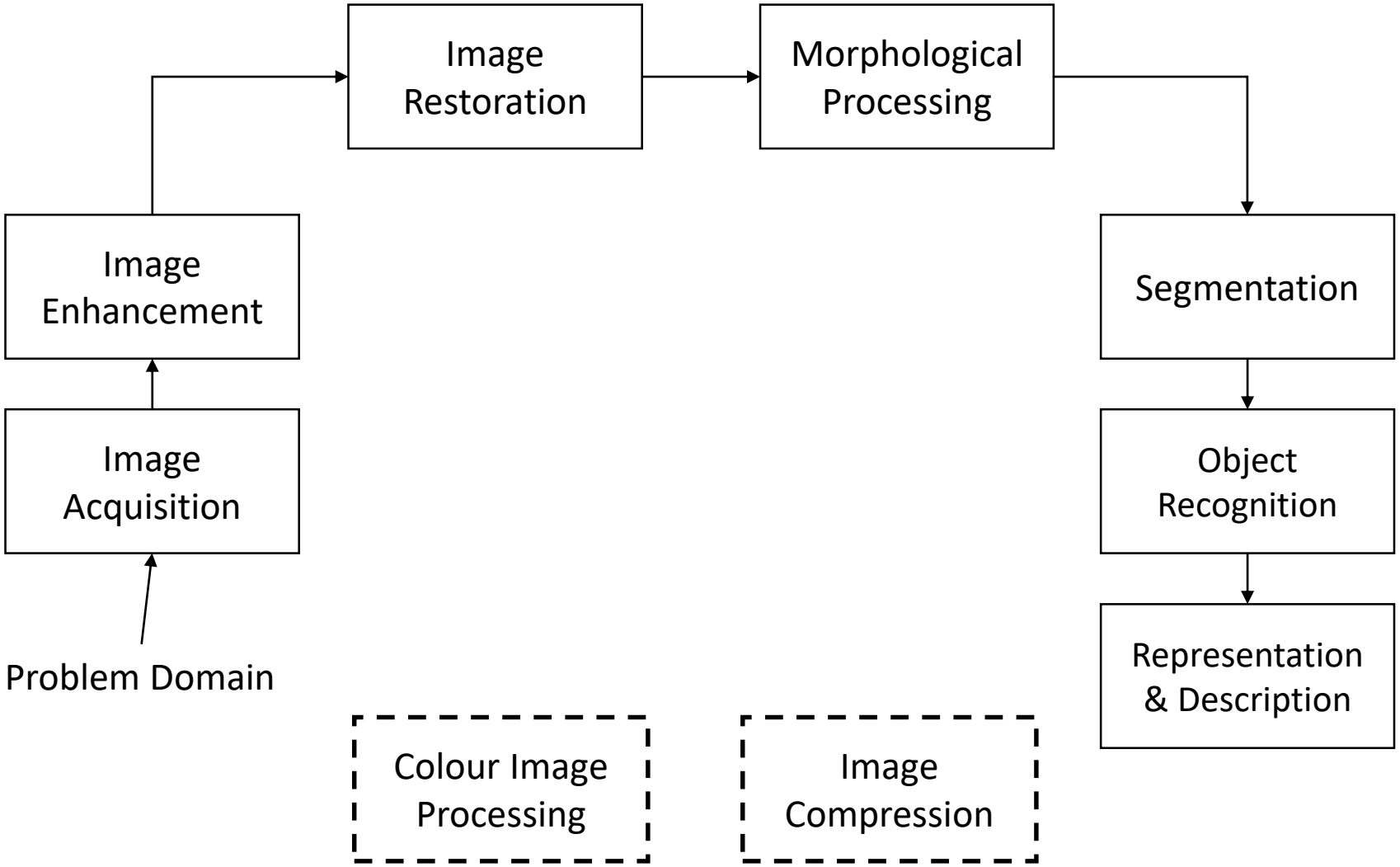
•Common image formats include:

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

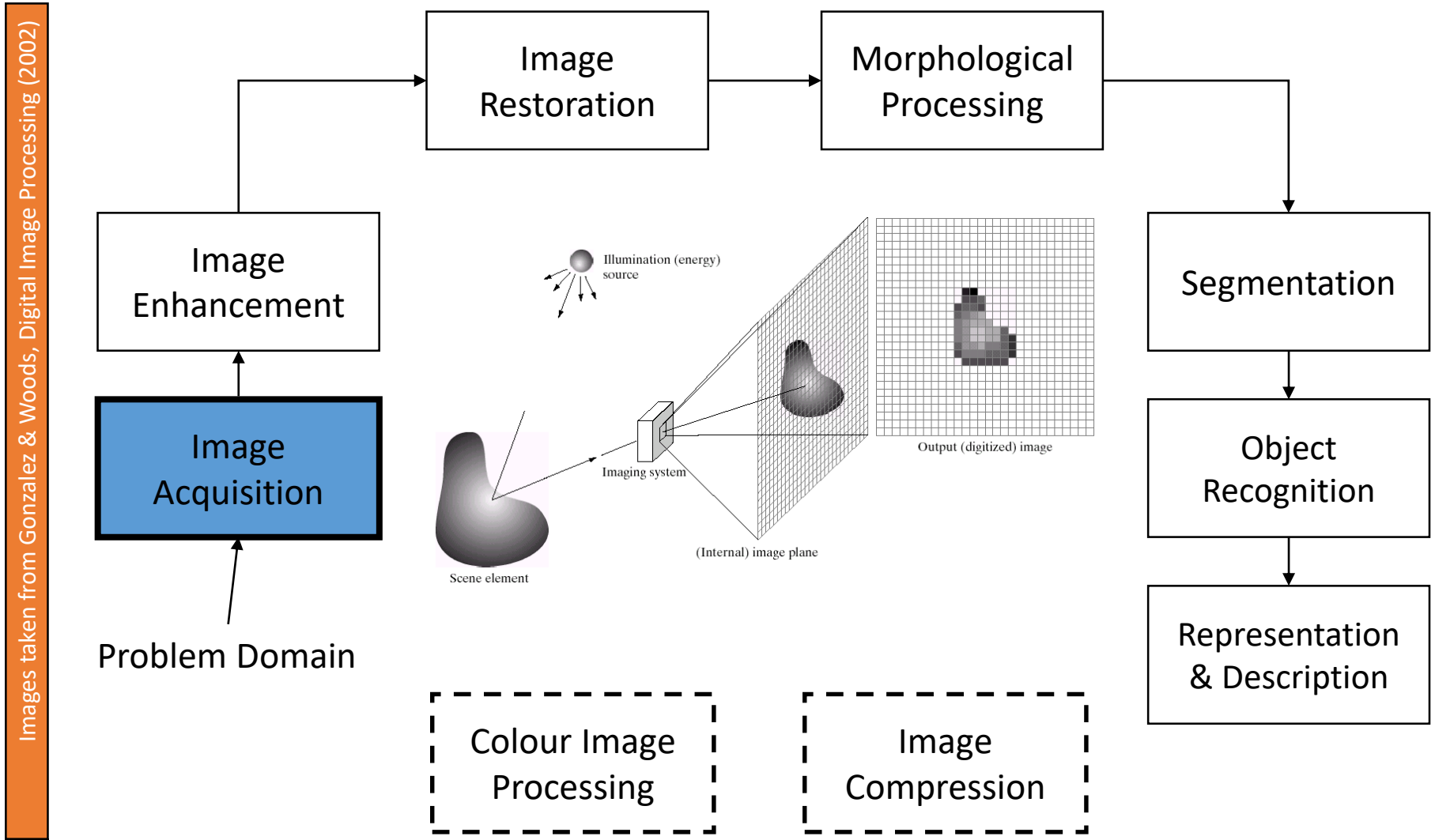
•For most of this course we will focus on B&W,

Grayscale and color image

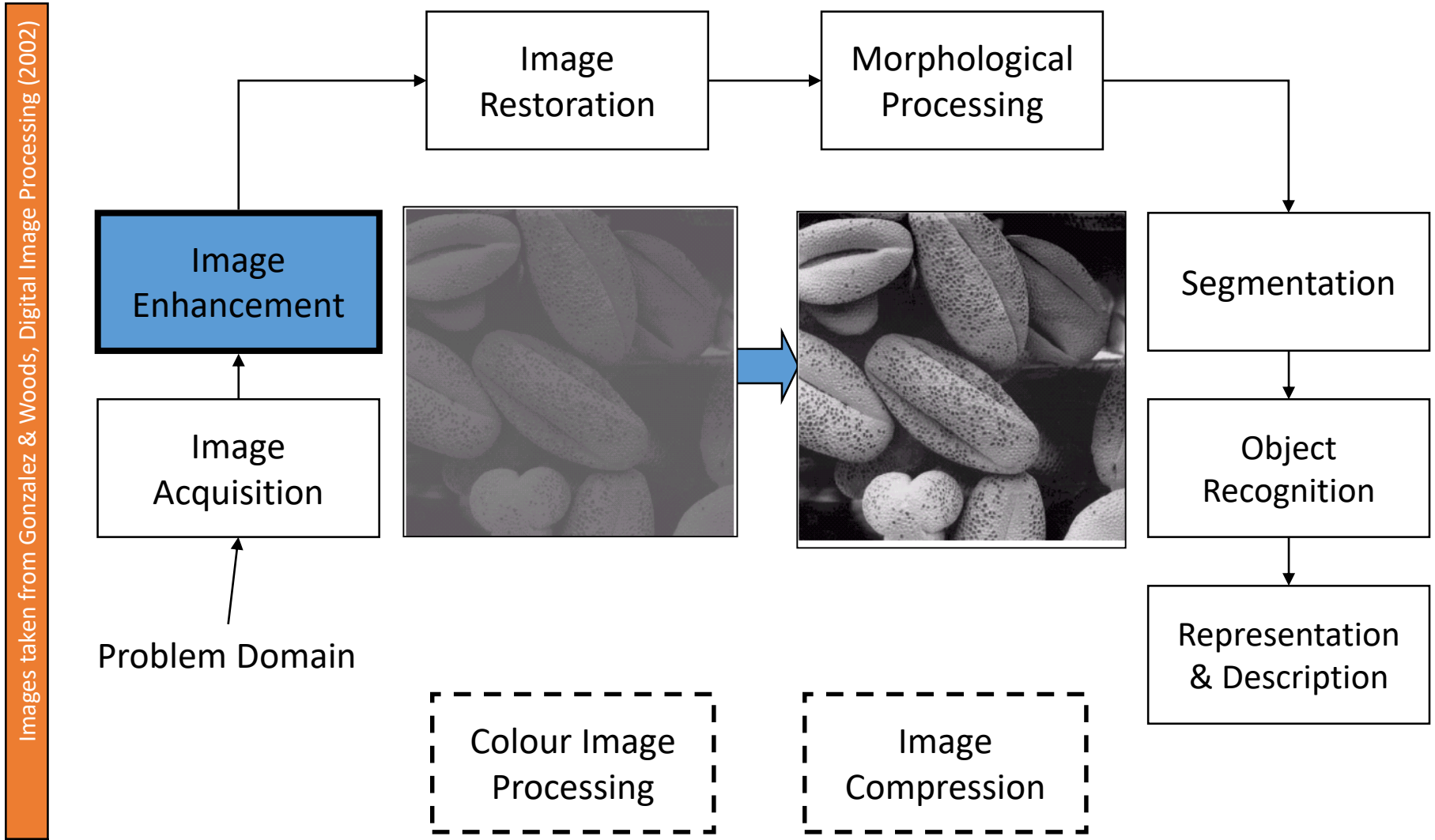
Key Stages in Digital Image Processing



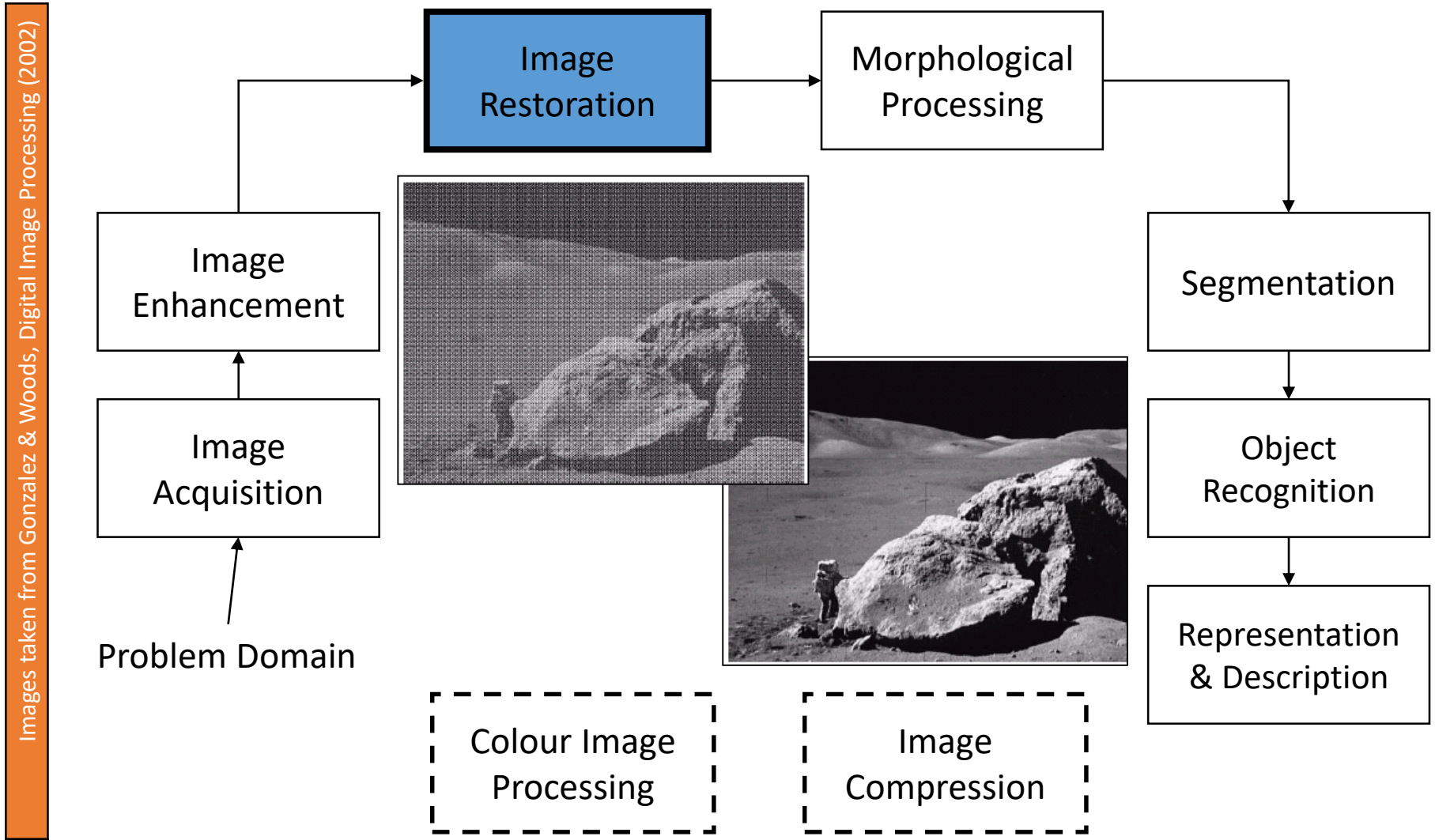
Key Stages in Digital Image Processing: Image Aquisition



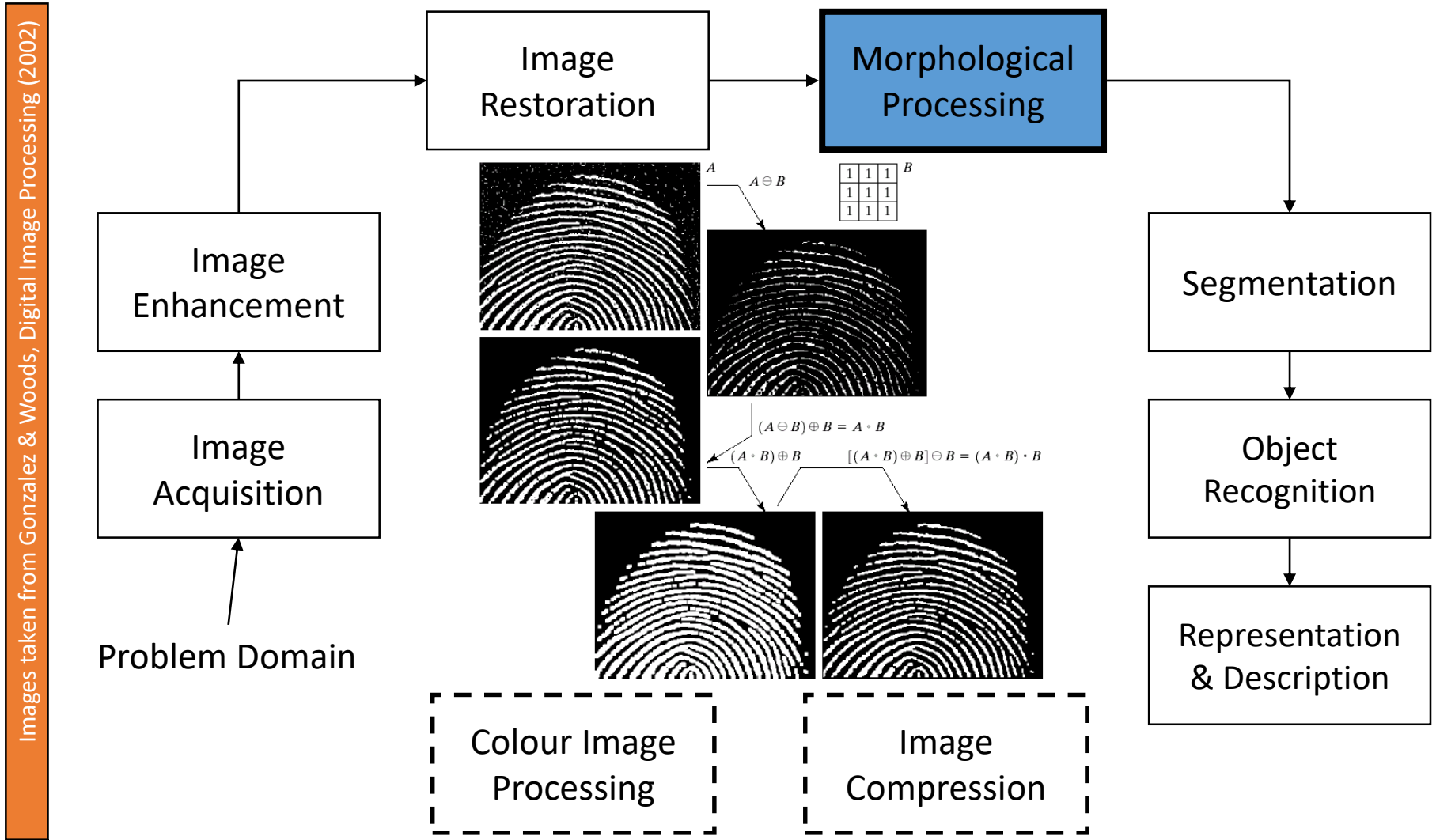
Key Stages in Digital Image Processing: Image Enhancement



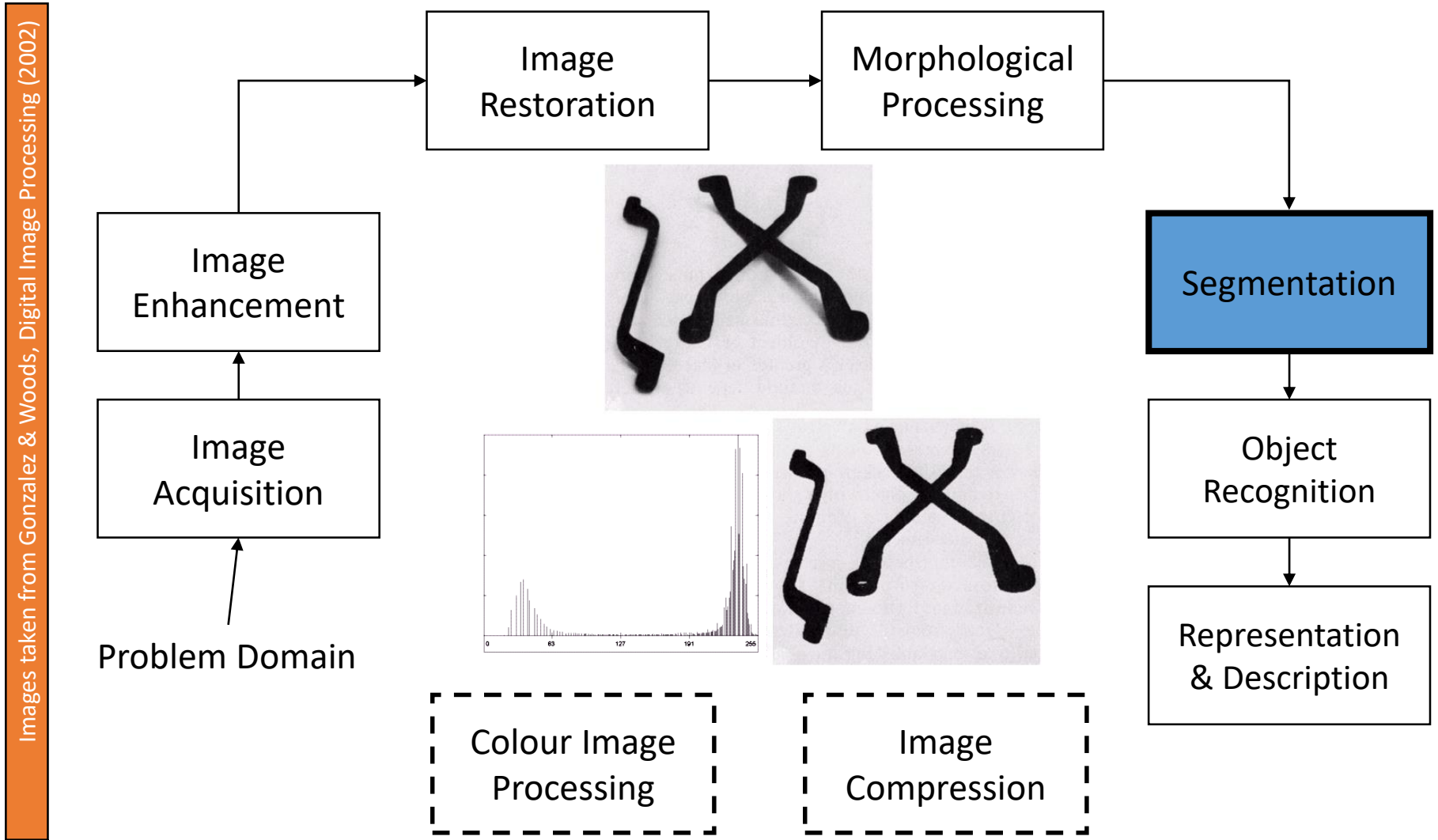
Key Stages in Digital Image Processing: Image Restoration



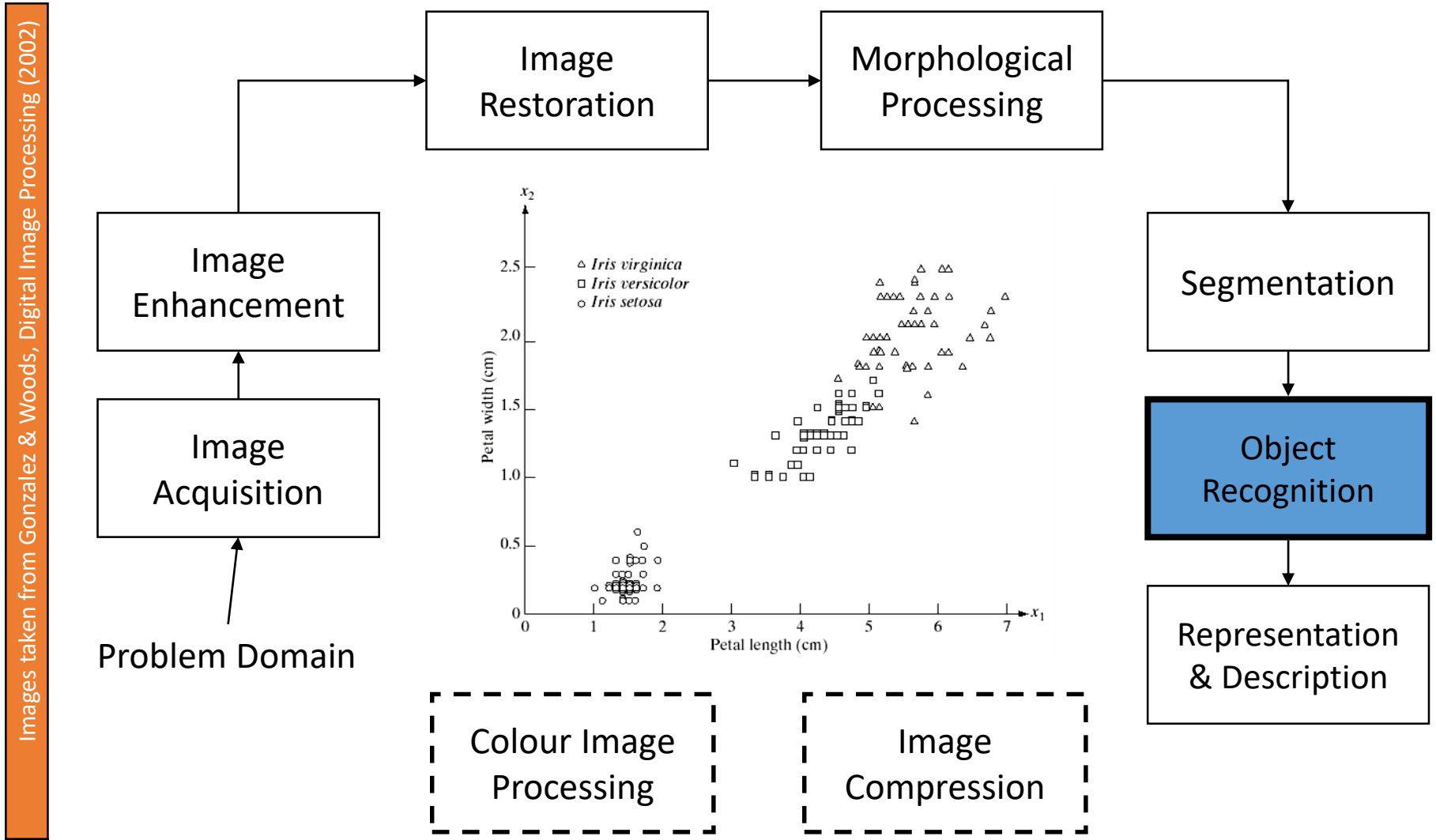
Key Stages in Digital Image Processing: Morphological Processing



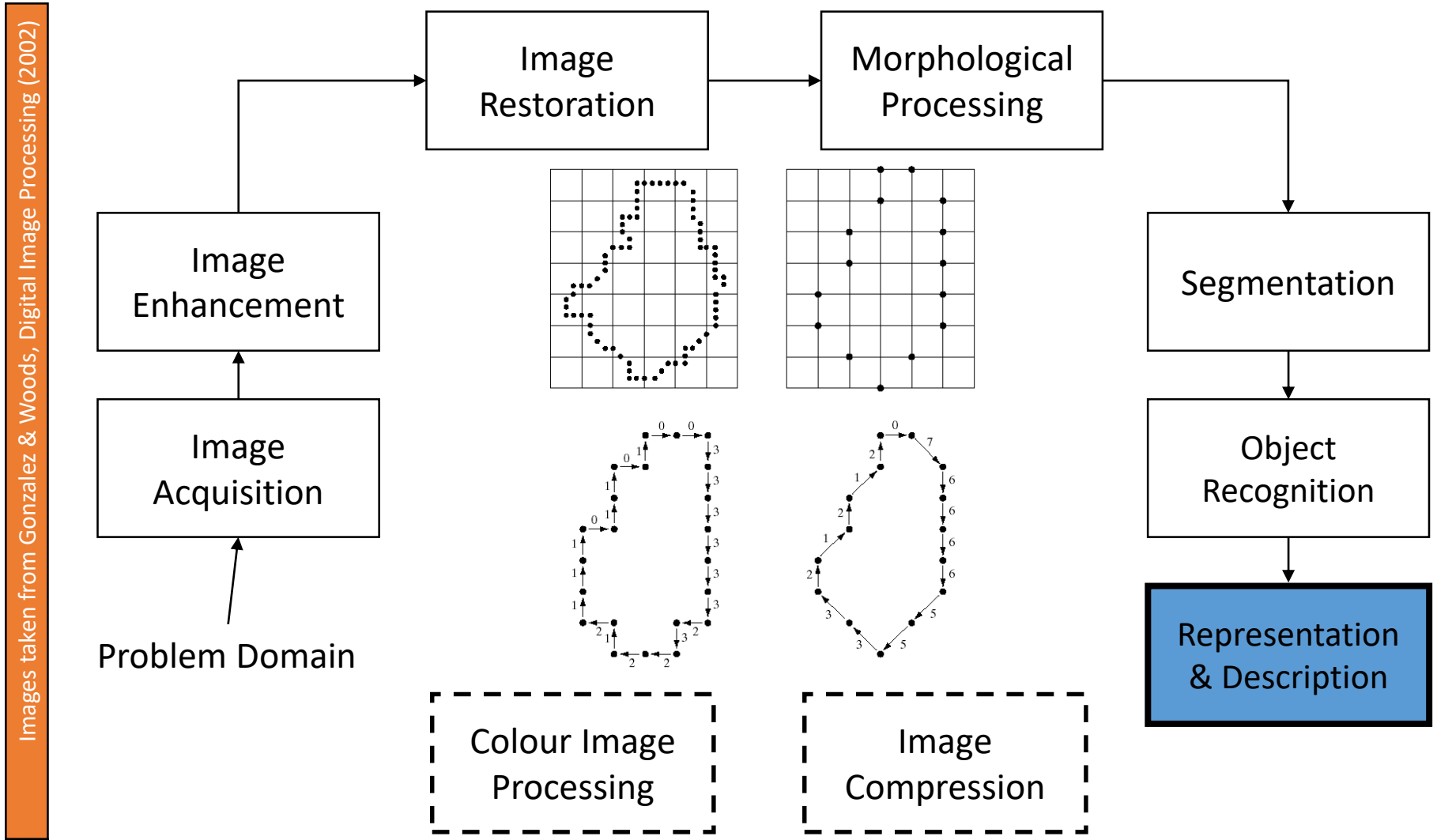
Key Stages in Digital Image Processing: Segmentation



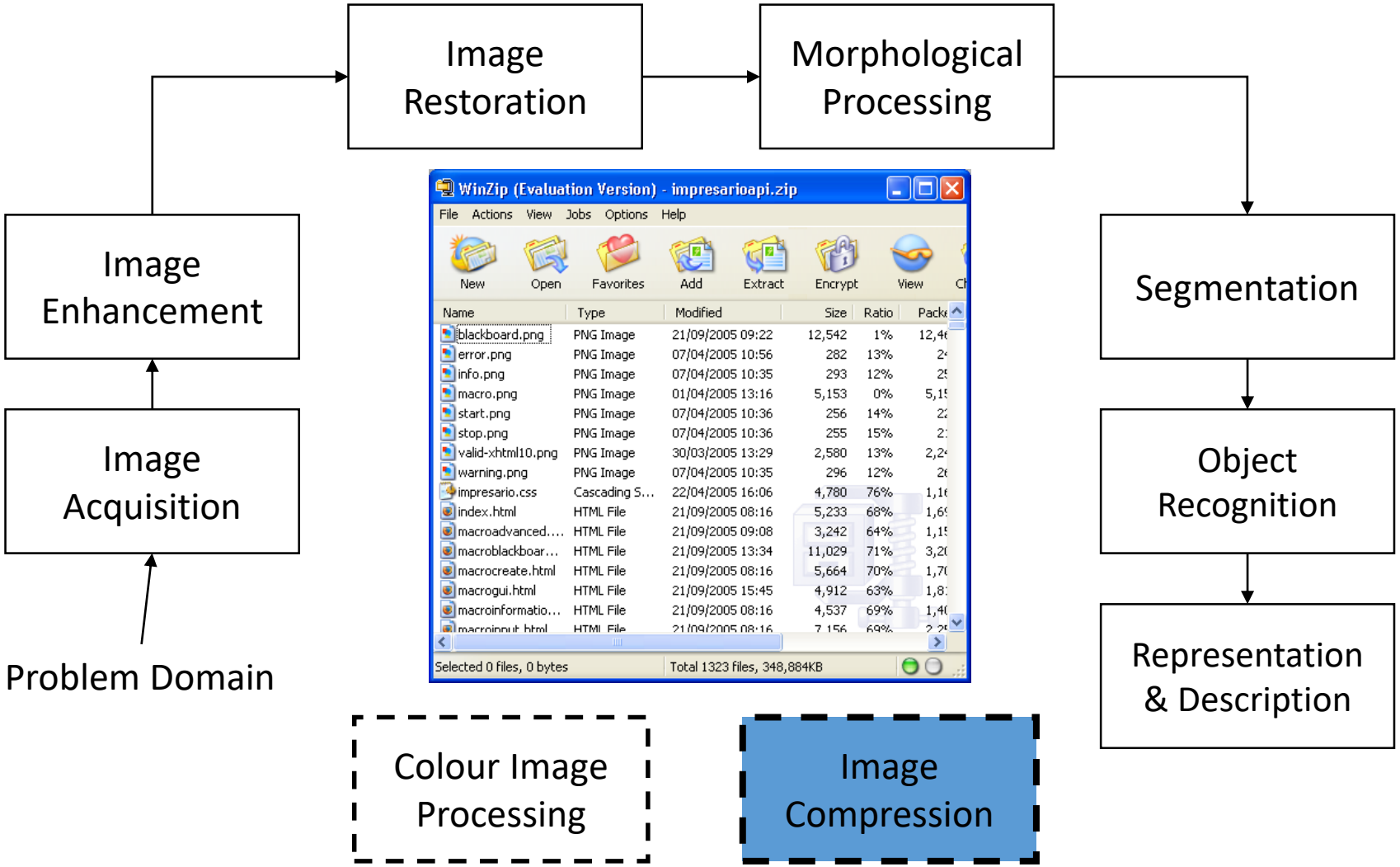
Key Stages in Digital Image Processing: Object Recognition



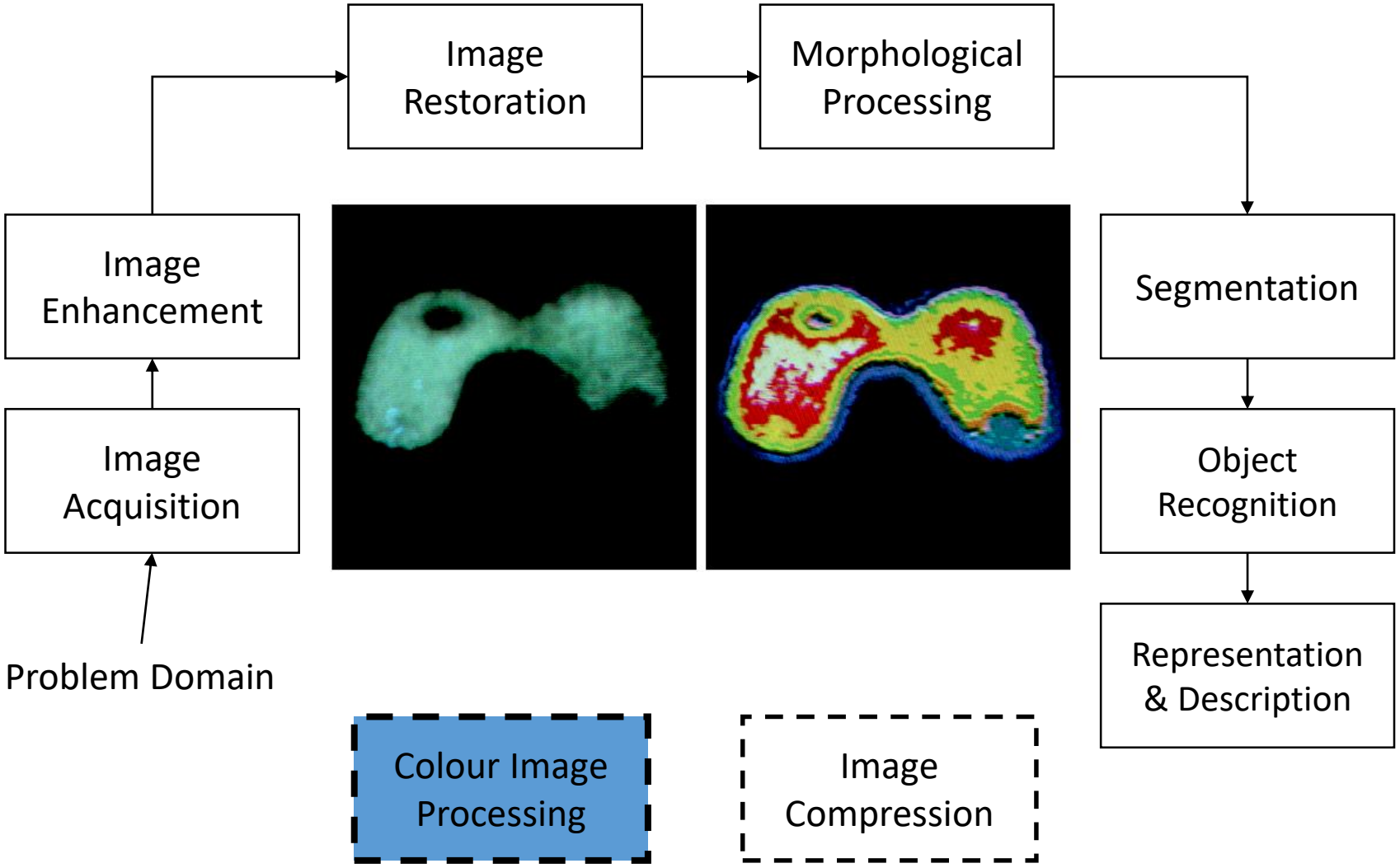
Key Stages in Digital Image Processing: Representation & Description



Key Stages in Digital Image Processing: Image Compression



Key Stages in Digital Image Processing: Colour Image Processing



Applications

- Document Handling
- Signature Verification
- Biometrics
  - Fingerprint Verification / Identification
- Object Recognition
- Indexing into Databases
- Target Recognition
  - Department of Defense (Army, Airforce, Navy)
- Interpretation of Aerial Photography
- Autonomous Vehicles (Land, Underwater, Space)
- Traffic Monitoring
- Face Detection/Recognition
- Facial Expression Recognition
- Hand Gesture Recognition (Smart Human-Computer User Interfaces, Sign Language Recognition)
- Human Activity Recognition
- Medical Applications
- Morphing
- Inserting Artificial Objects into a Scene

Opportunities

- nVidia Graphics, Pune
- Microsoft research
- DRDO labs
- ISRO labs
- GE Laboratories
- Sarnoff Corporation
- National Instruments
- Interra Systems, Noida
- Yahoo India (Multimedia Searching)
- …

Thank you !