INTRODUCTION (DIGITAL IMAGE PROCESSING)

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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

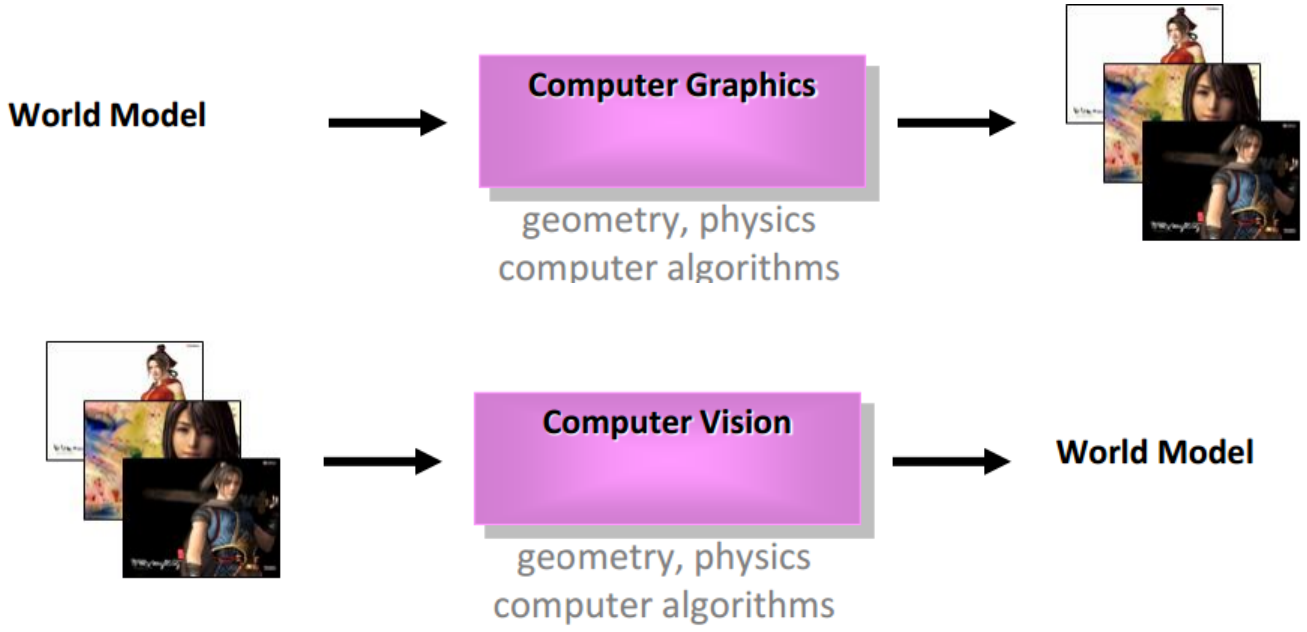
Some argument about where image processing ends and fields such as image analysis and computer vision start

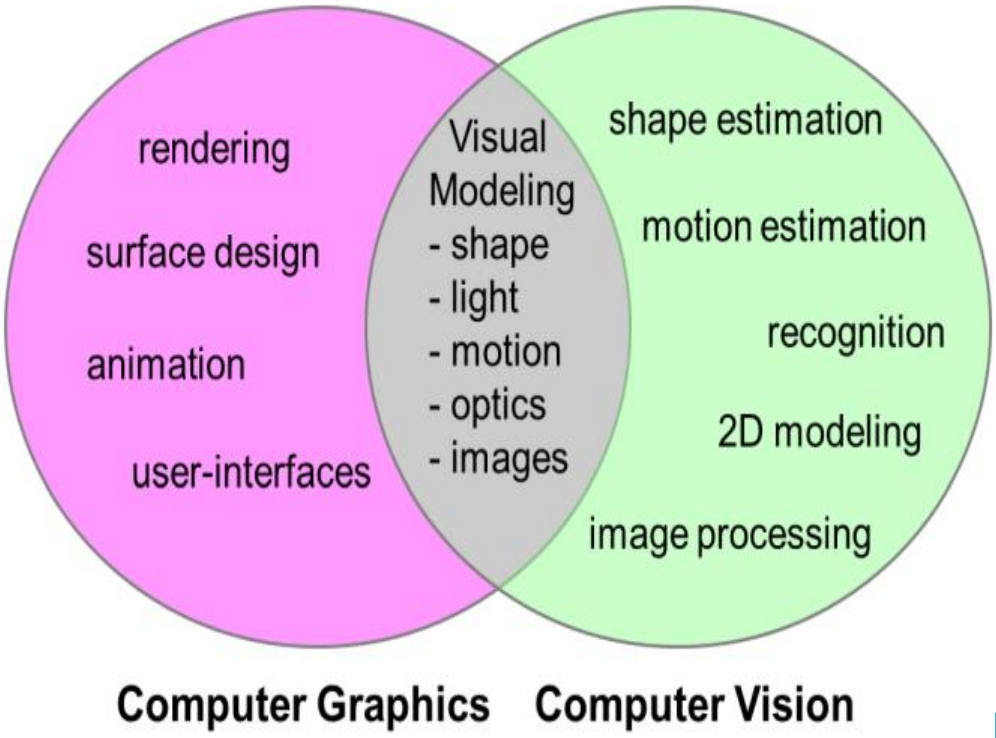
COMPARE

Digital image processing

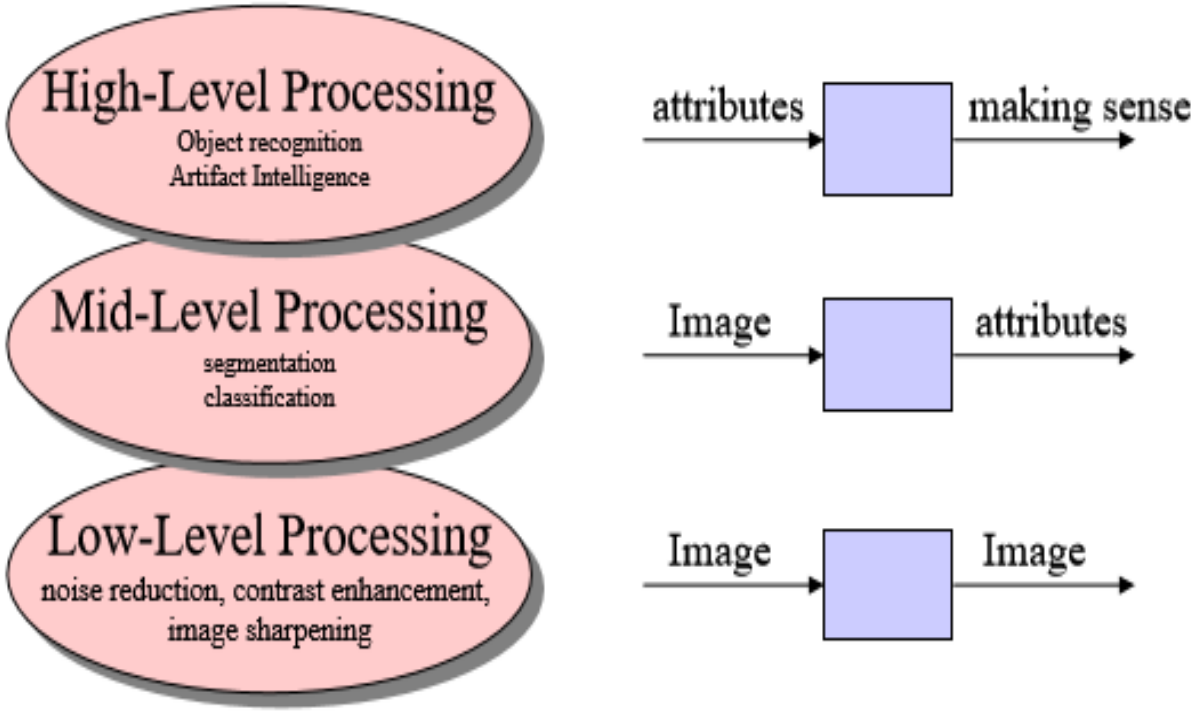
Computer graphics

Computer Vision


World Model
Computer Graphics
geometry, physics
computer algorithms
Computer Vision
geometry, physics
computer algorithms
World Model


rendering
surface design
animation
user-interfaces
Visual Modeling
- shape
- light
- motion
- optics
- images
shape estimation
motion estimation
recognition
2D modeling
image processing
Computer Graphics
Computer Vision

- ***Image processing to computer vision***



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

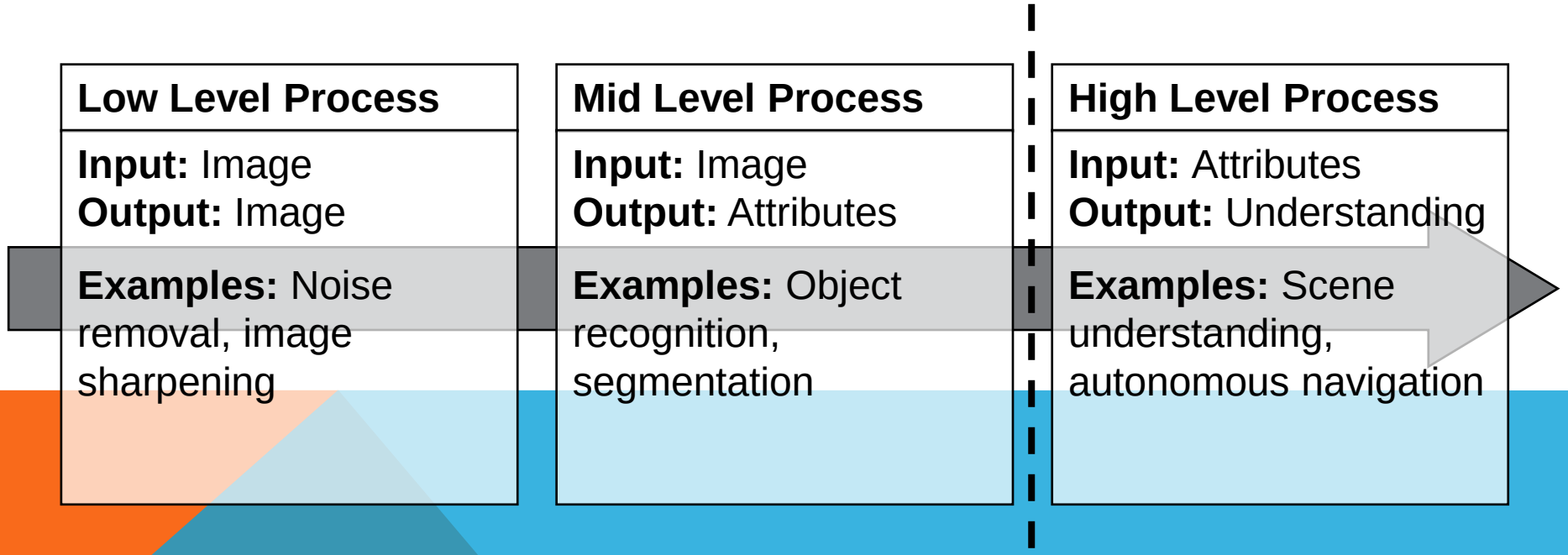


IMAGE FORMATION

What the computer “sees” is just a grid of numbers.

this grid of numbers is all the computer “sees”.

Our task then becomes to turn this noisy grid of numbers into the perception: “side mirror”.

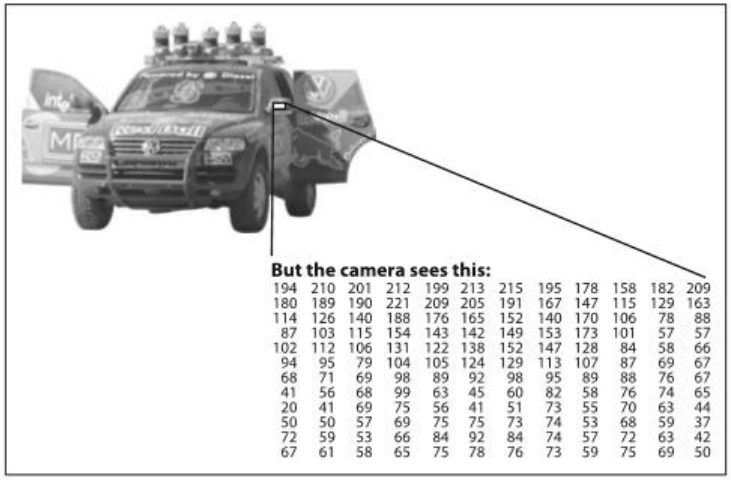
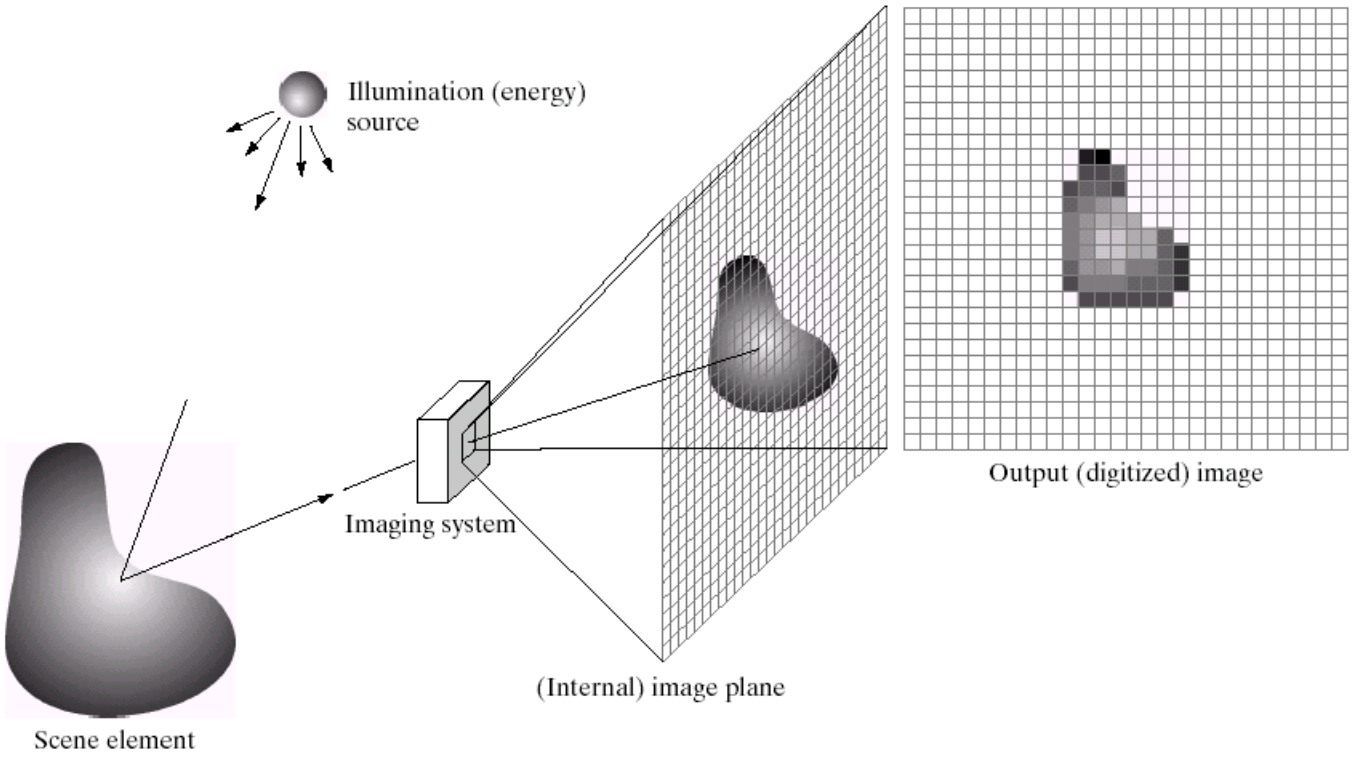


Figure 1-1. To a computer, the car's side mirror is just a grid of numbers

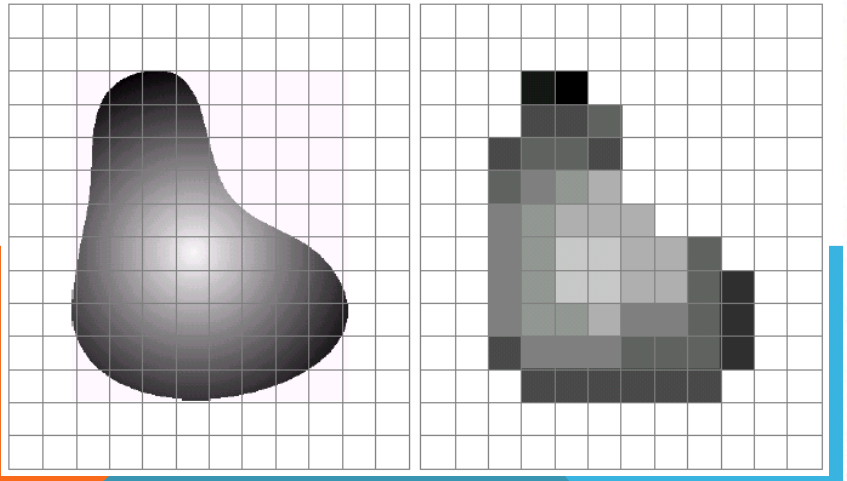
WHAT IS A DIGITAL IMAGE?

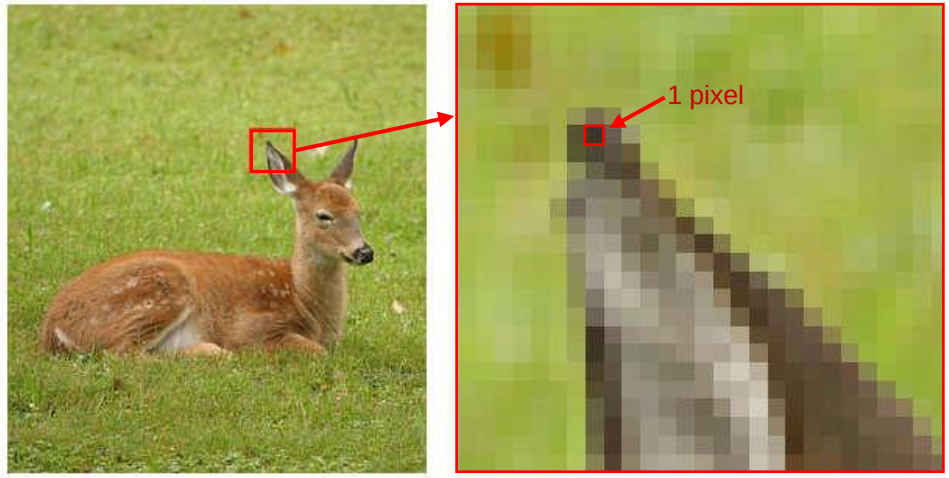
A digital image is a representation of a two-dimensional image as a finite set of digital values, called picture elements or pixels



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

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

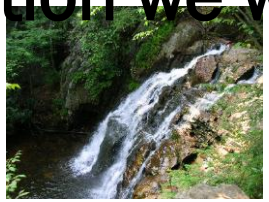




Common image formats include:

- 1 sample per point (B&W or Grayscale)
- 3 samples per point (**R**ed, **G**reen, and **B**lue) - RGB
- 4 samples per point (Red, Green, Blue, and “Alpha”, a.k.a. Opacity)

For most of this presentation we will focus on greyscale images.



HISTORY OF DIGITAL IMAGE PROCESSING

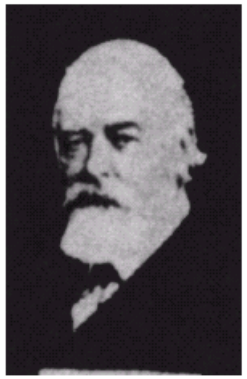
Early 1920s: One of the first applications of digital imaging was in the news-paper industry

- 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

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

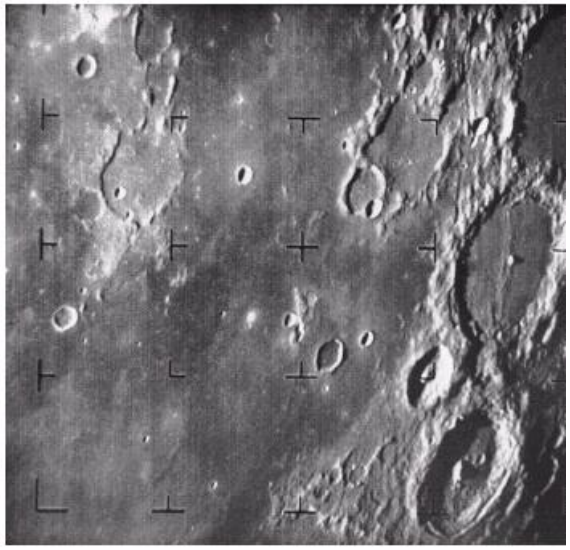


Improved digital image

Early 15 tone digital image

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

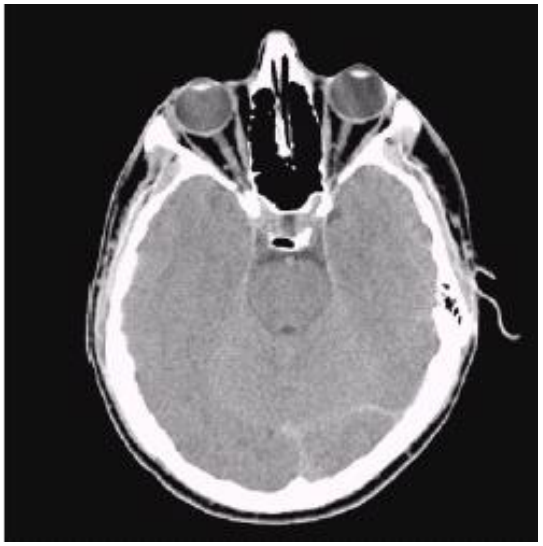
- **1964:** Computers used to improve the quality of images of the moon taken by the *Ranger 7* probe
- Such techniques were used in other space missions including the Apollo landings



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

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



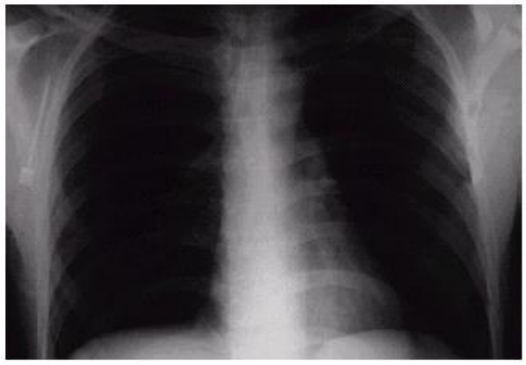
Typical head slice CAT image

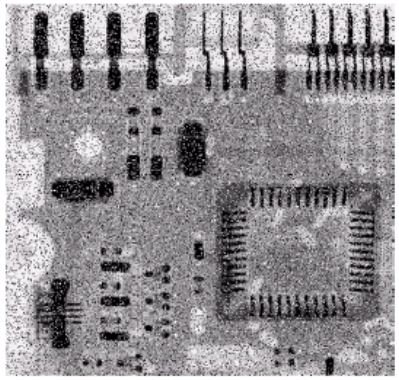
1980s - Today: The use of digital image processing techniques has exploded and they are now used for all kinds of tasks in all kinds of areas

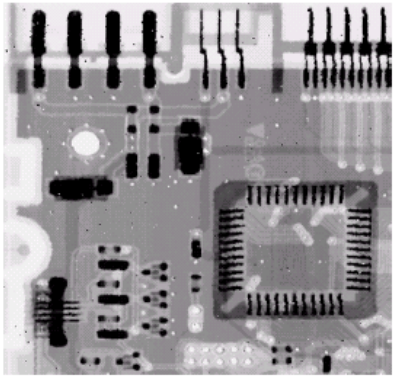
- Image enhancement/restoration
- Artistic effects
- Medical visualisation
- Industrial inspection
- Law enforcement
- Human computer interfaces

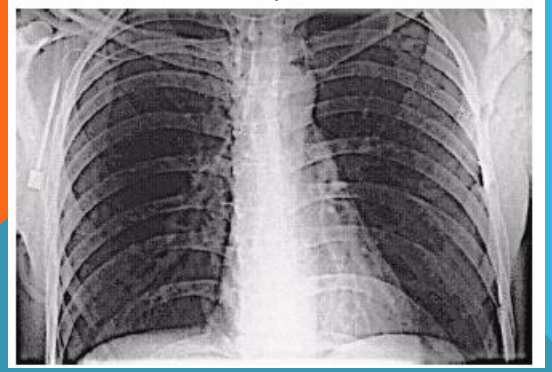
EXAMPLES: IMAGE ENHANCEMENT

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







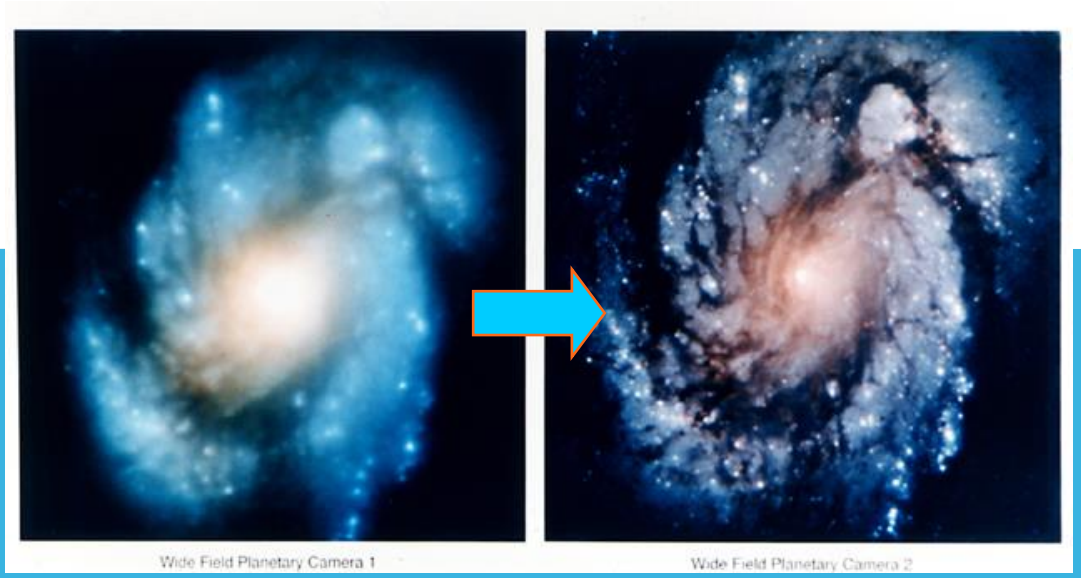


EXAMPLES: THE HUBBLE TELESCOPE

Launched in 1990 the Hubble telescope can take images of very distant objects

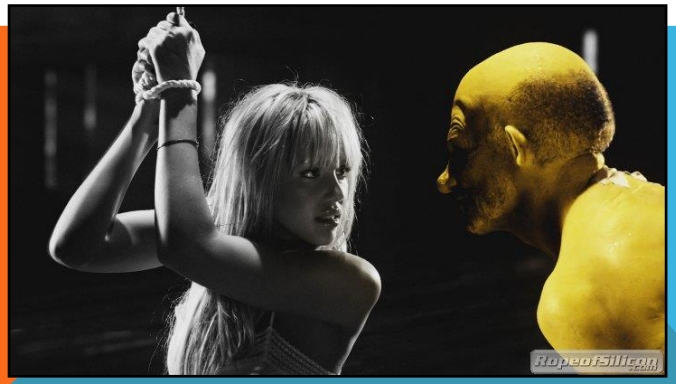
However, an incorrect mirror made many of Hubble's images useless

Image processing techniques were used to fix this



EXAMPLES: ARTISTIC EFFECTS

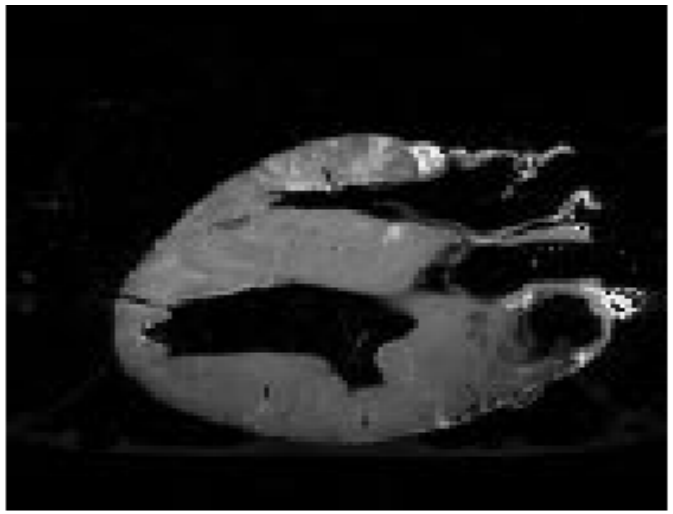
Artistic effects are used to make images more visually appealing, to add special effects and to make composite images



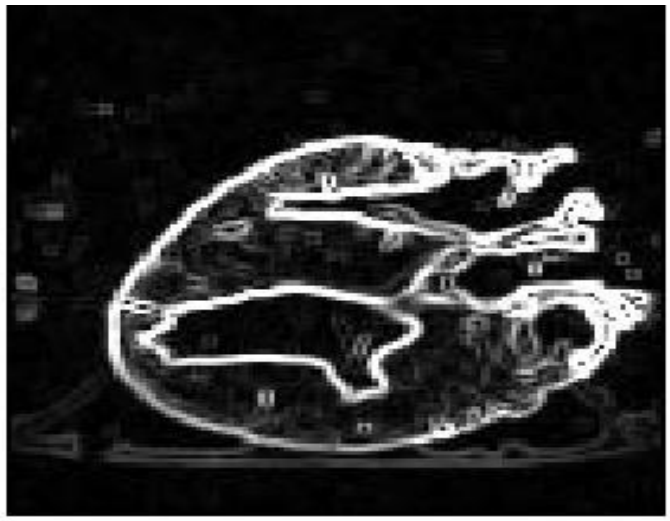
EXAMPLES: MEDICINE

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

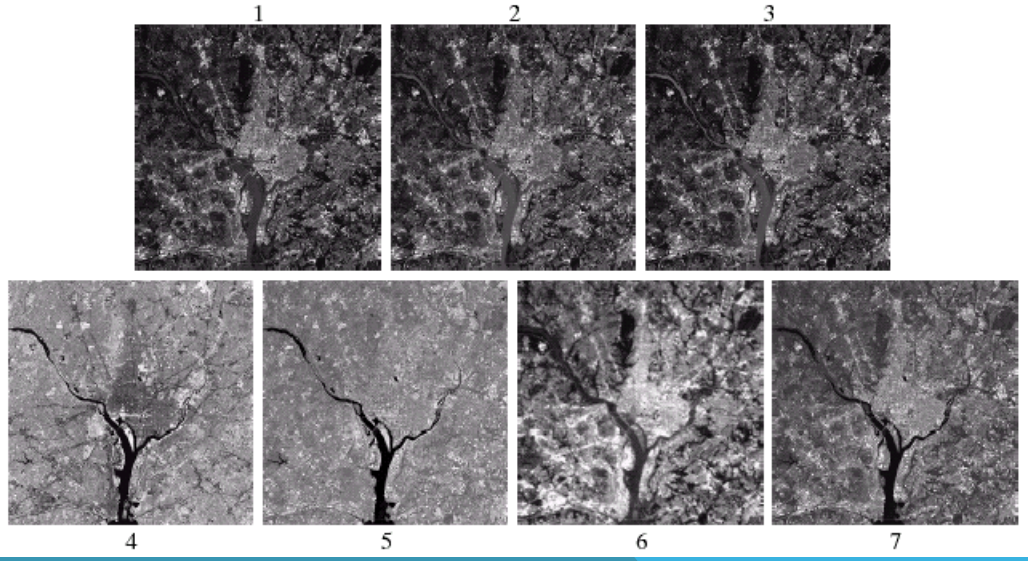


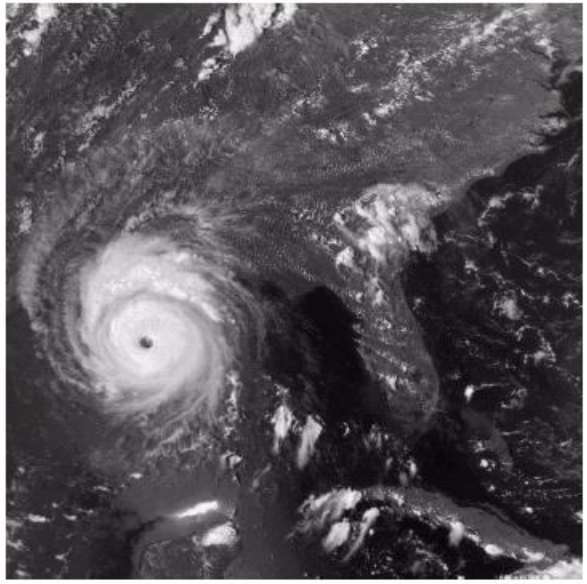
Edge Detection Image

EXAMPLES: GIS

Geographic Information Systems

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





EXAMPLES: GIS (CONT…)

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

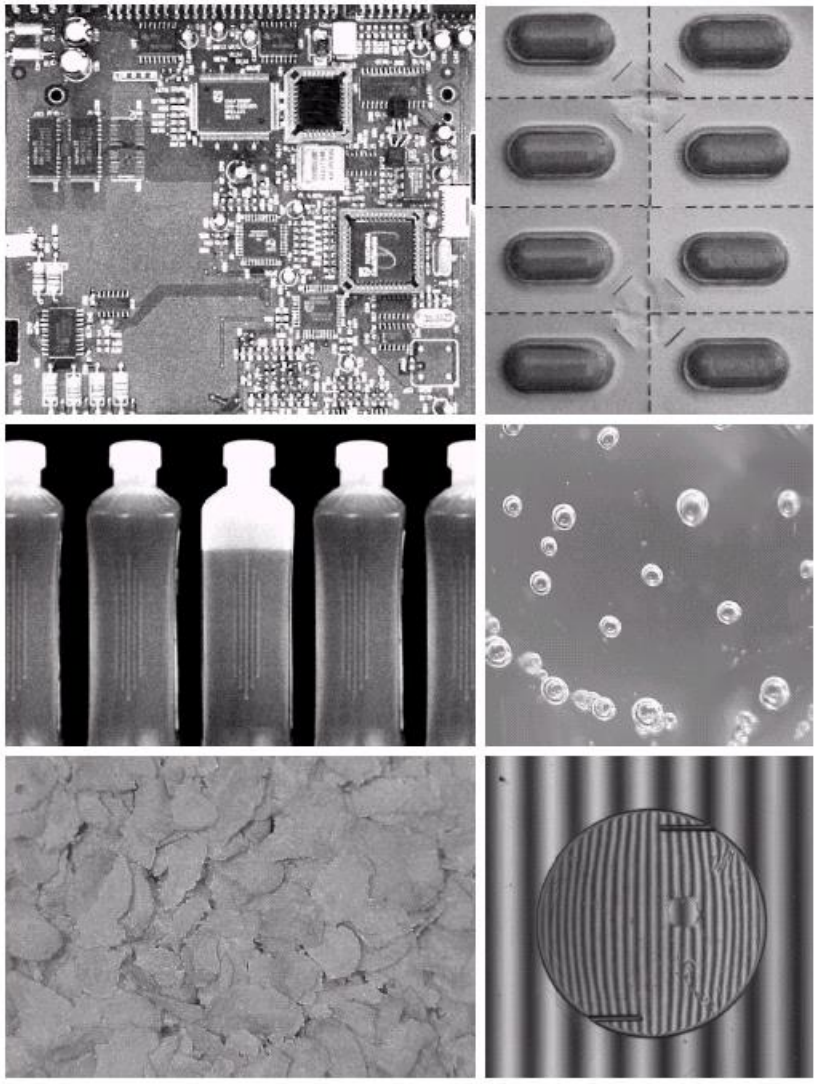
EXAMPLES: INDUSTRIAL INSPECTION

Human operators are expensive, slow and unreliable

Make machines do the job instead

Industrial vision systems are used in all kinds of industries

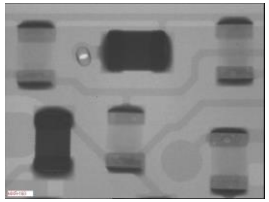
Can we trust them?

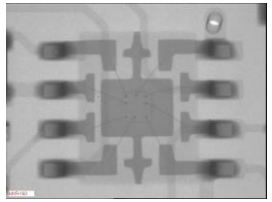


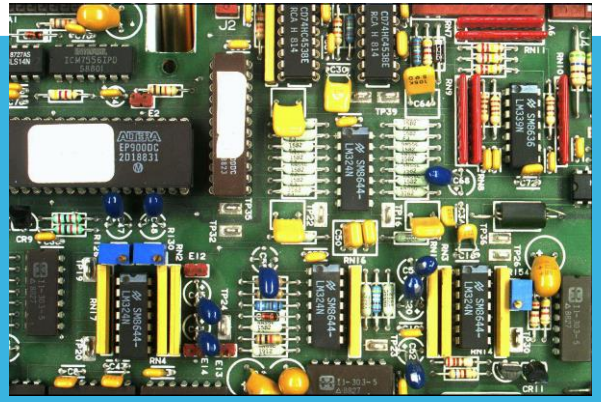
EXAMPLES: PCB INSPECTION

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



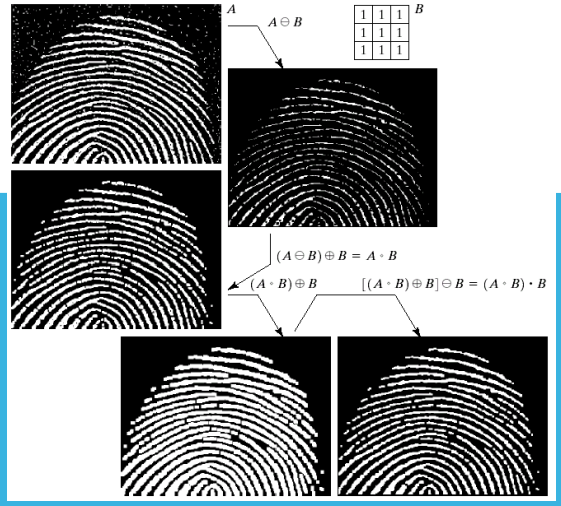




EXAMPLES: LAW ENFORCEMENT

Image processing techniques are used extensively by law enforcers

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



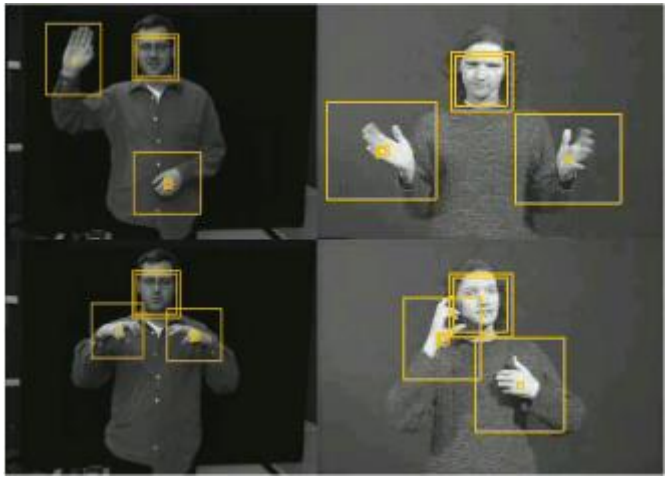
EXAMPLES: HCI

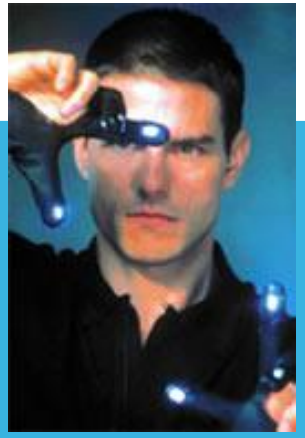
Try to make human computer interfaces more natural

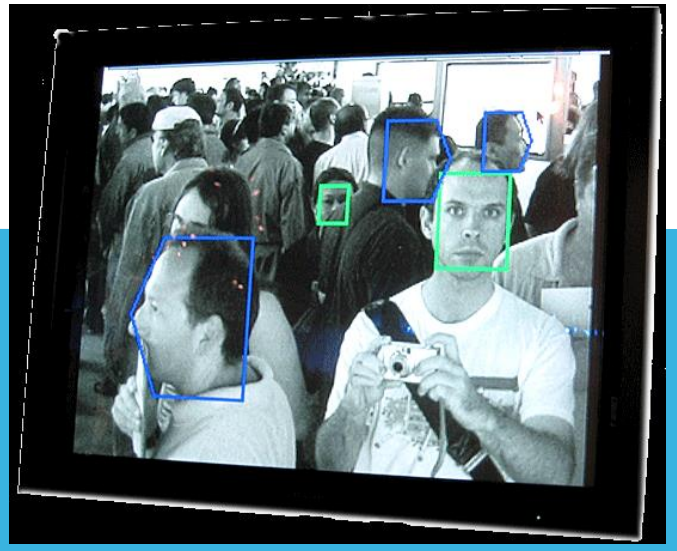
- Face recognition
- Gesture recognition

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

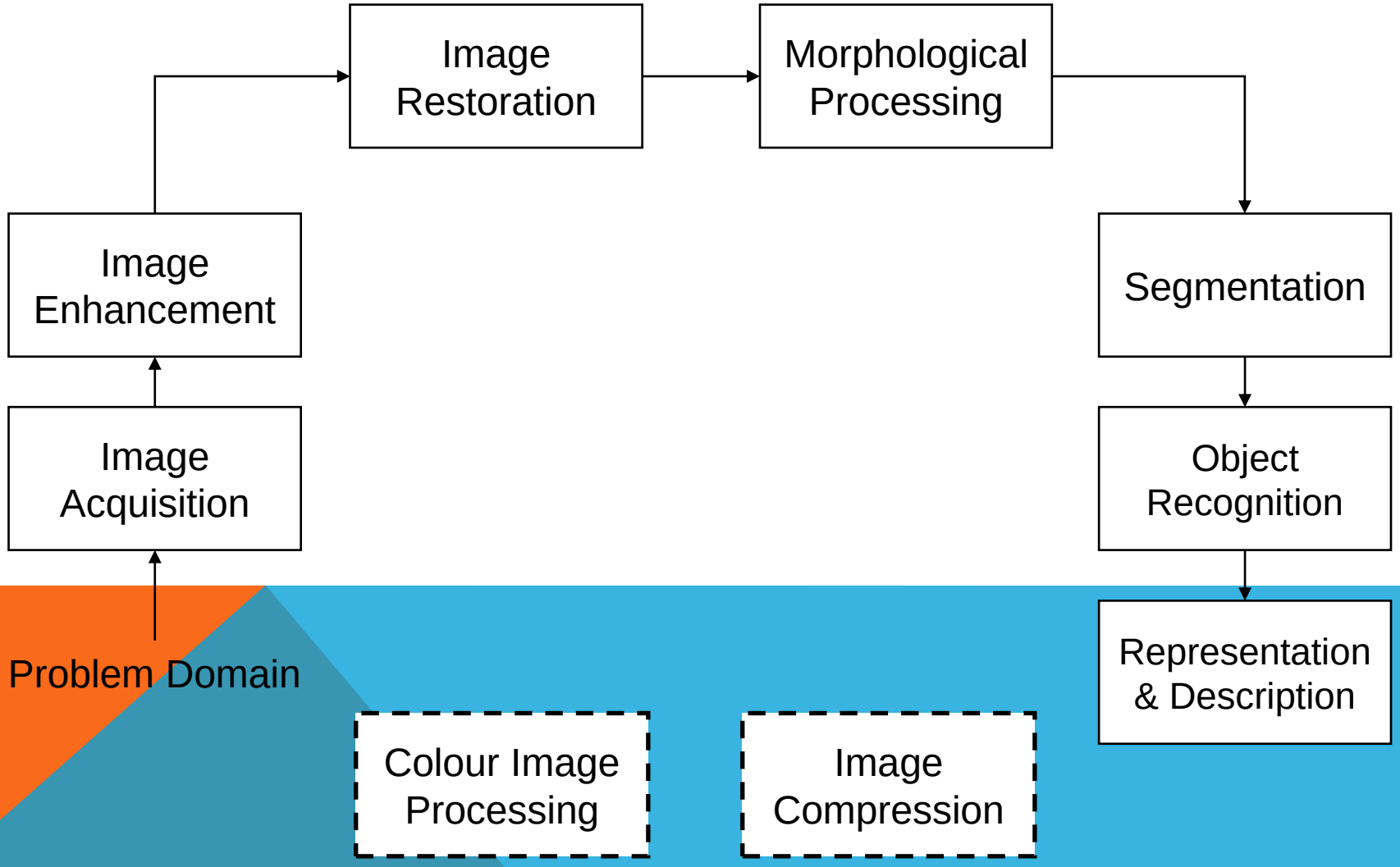
These tasks can be extremely difficult



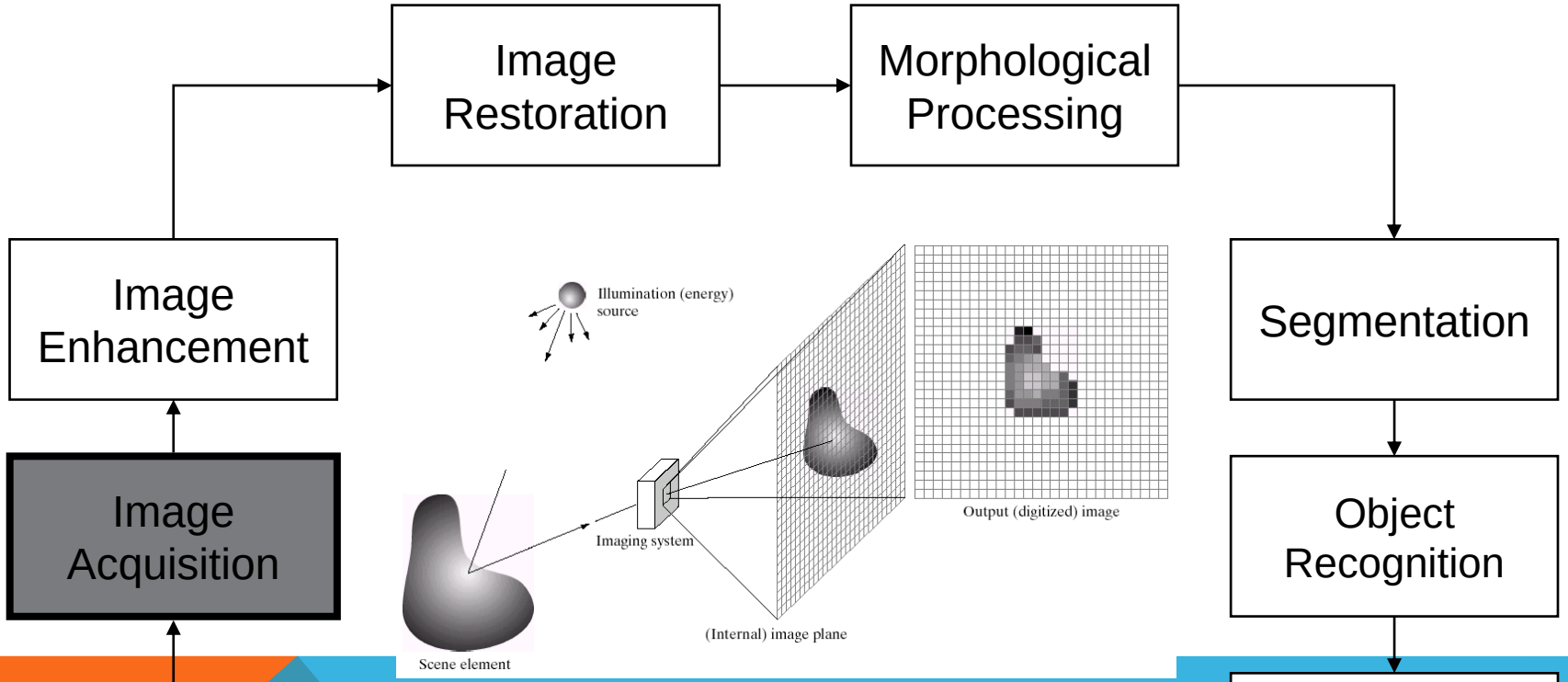




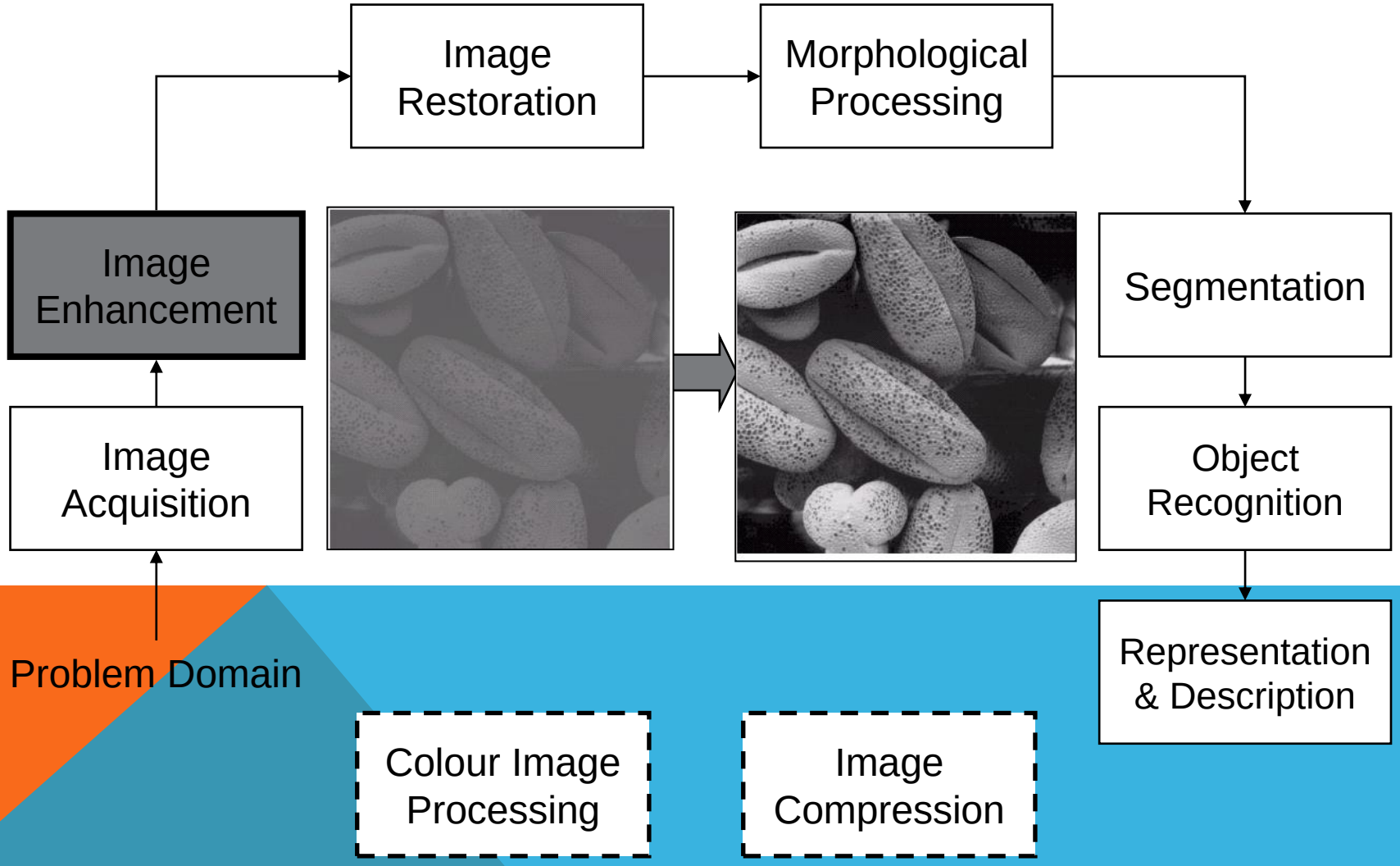
KEY STAGES IN DIGITAL IMAGE PROCESSING



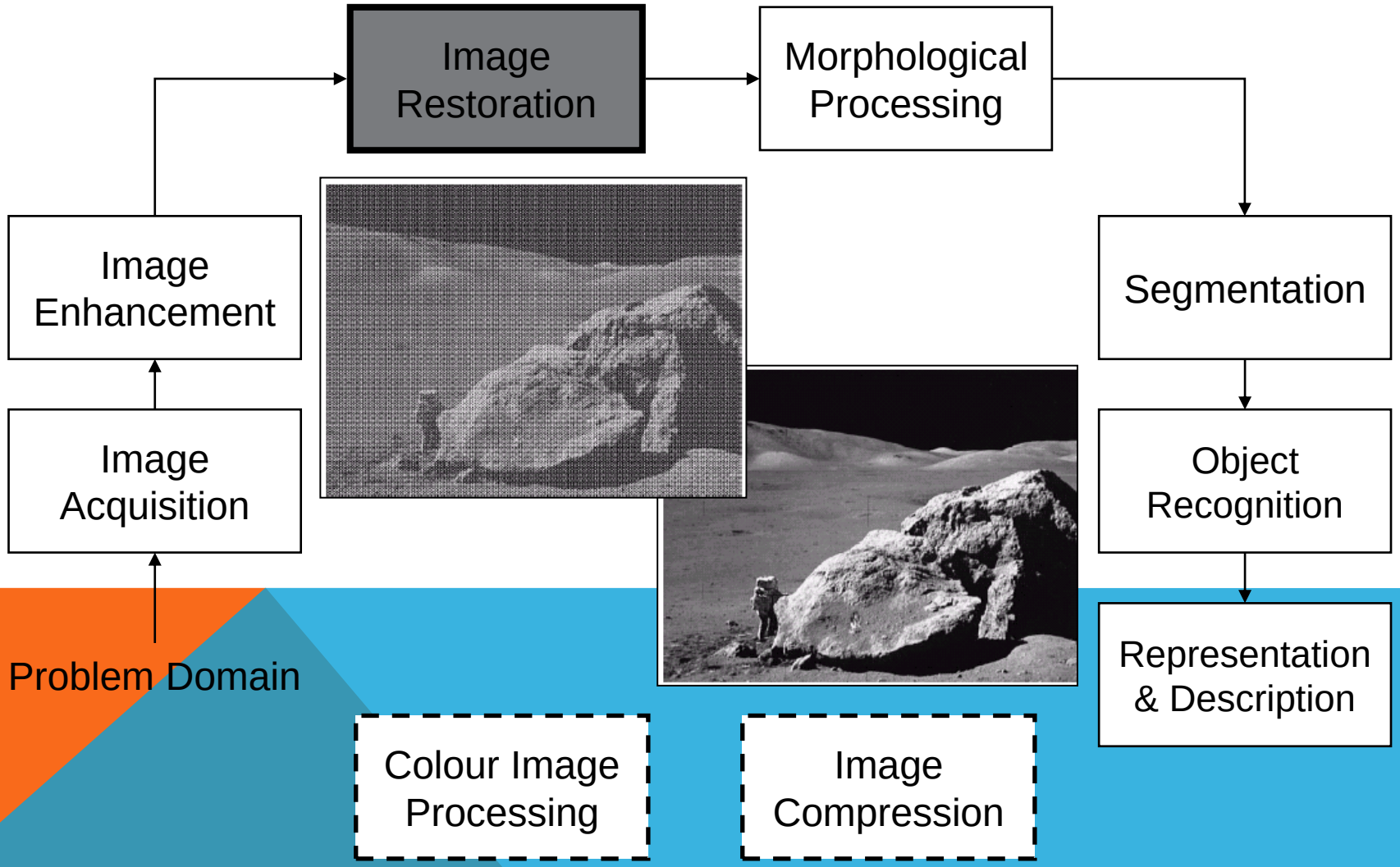
KEY STAGES IN DIGITAL IMAGE PROCESSING: IMAGE AQUISITION



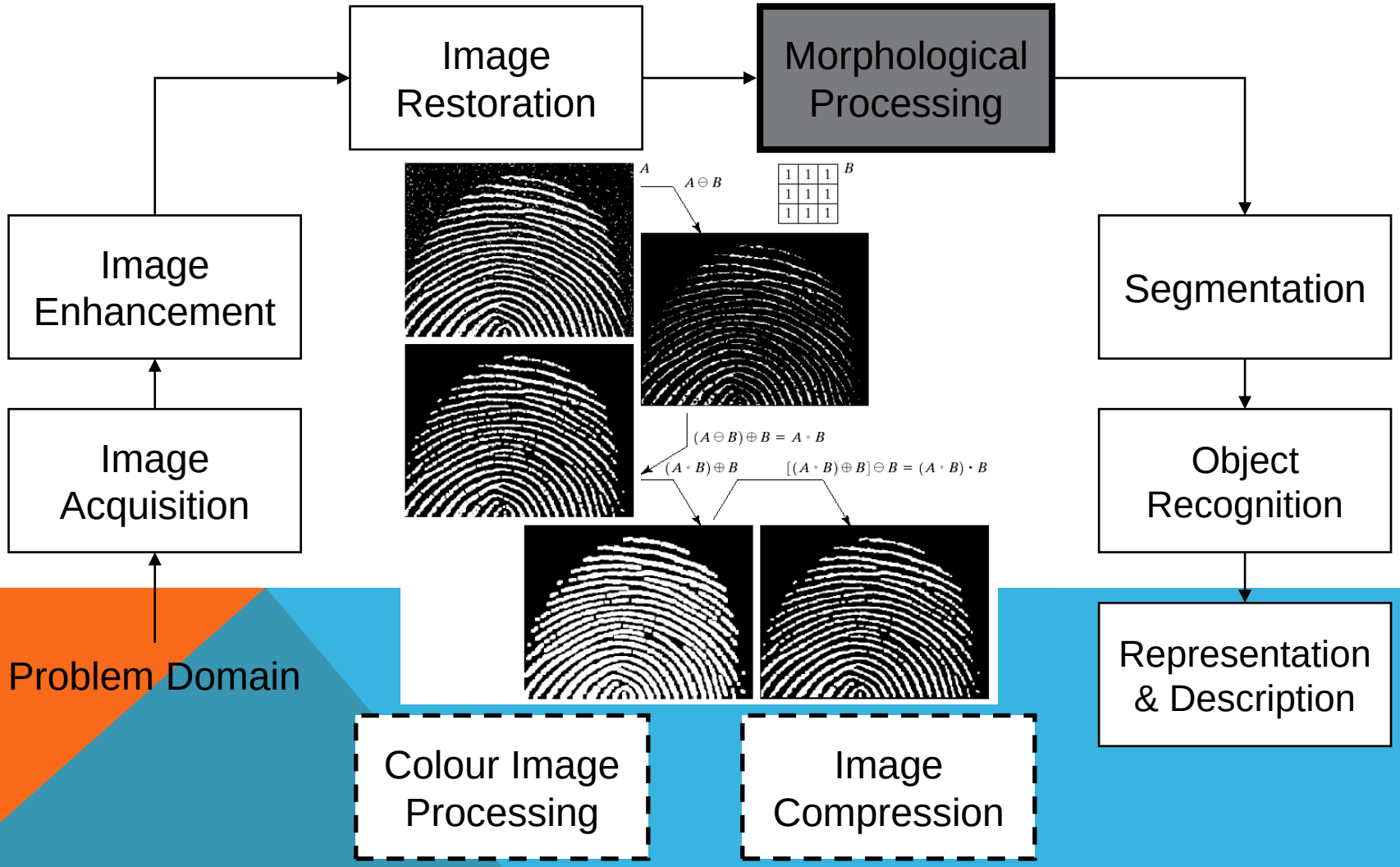
KEY STAGES IN DIGITAL IMAGE PROCESSING: IMAGE ENHANCEMENT



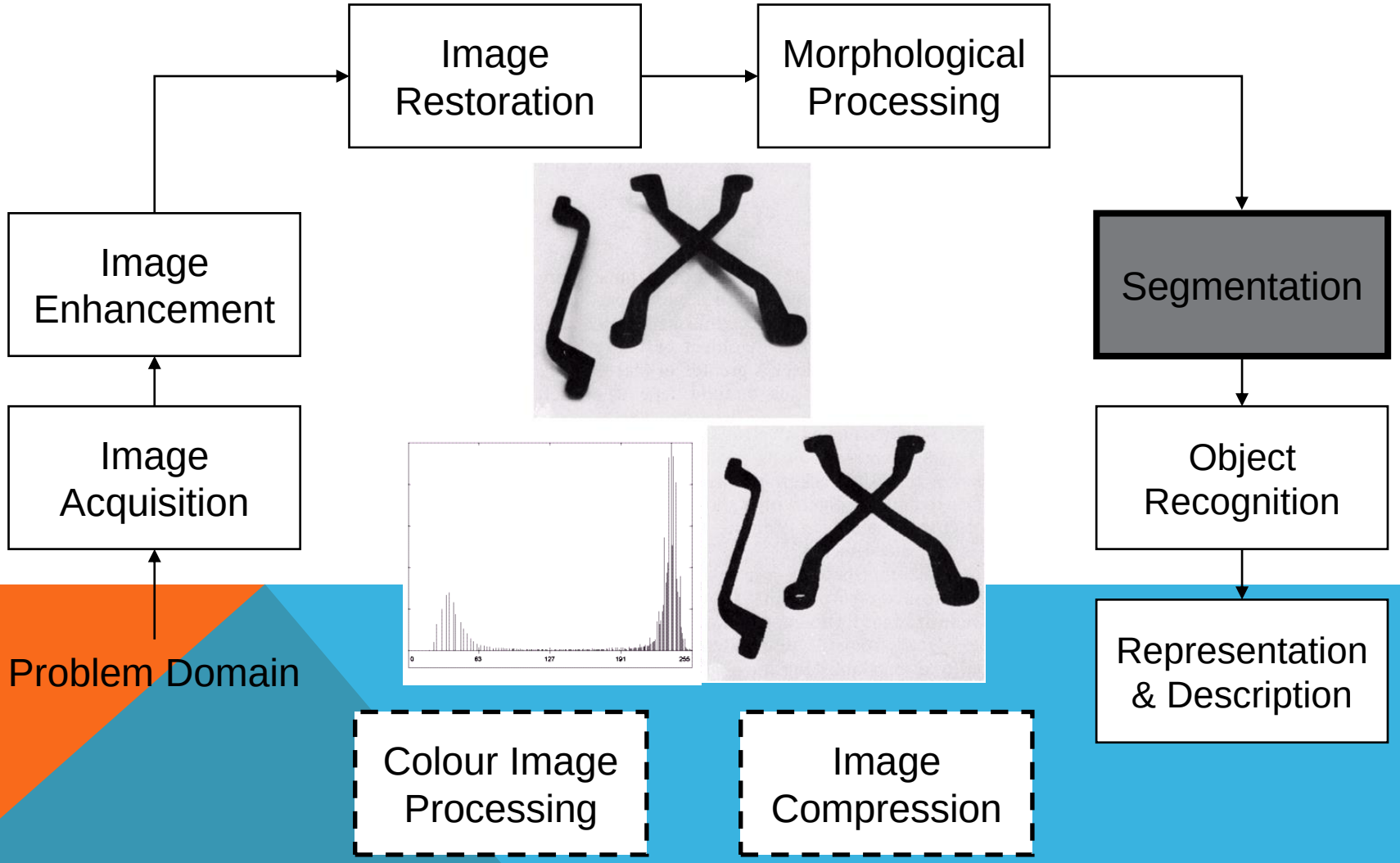
KEY STAGES IN DIGITAL IMAGE PROCESSING: IMAGE RESTORATION



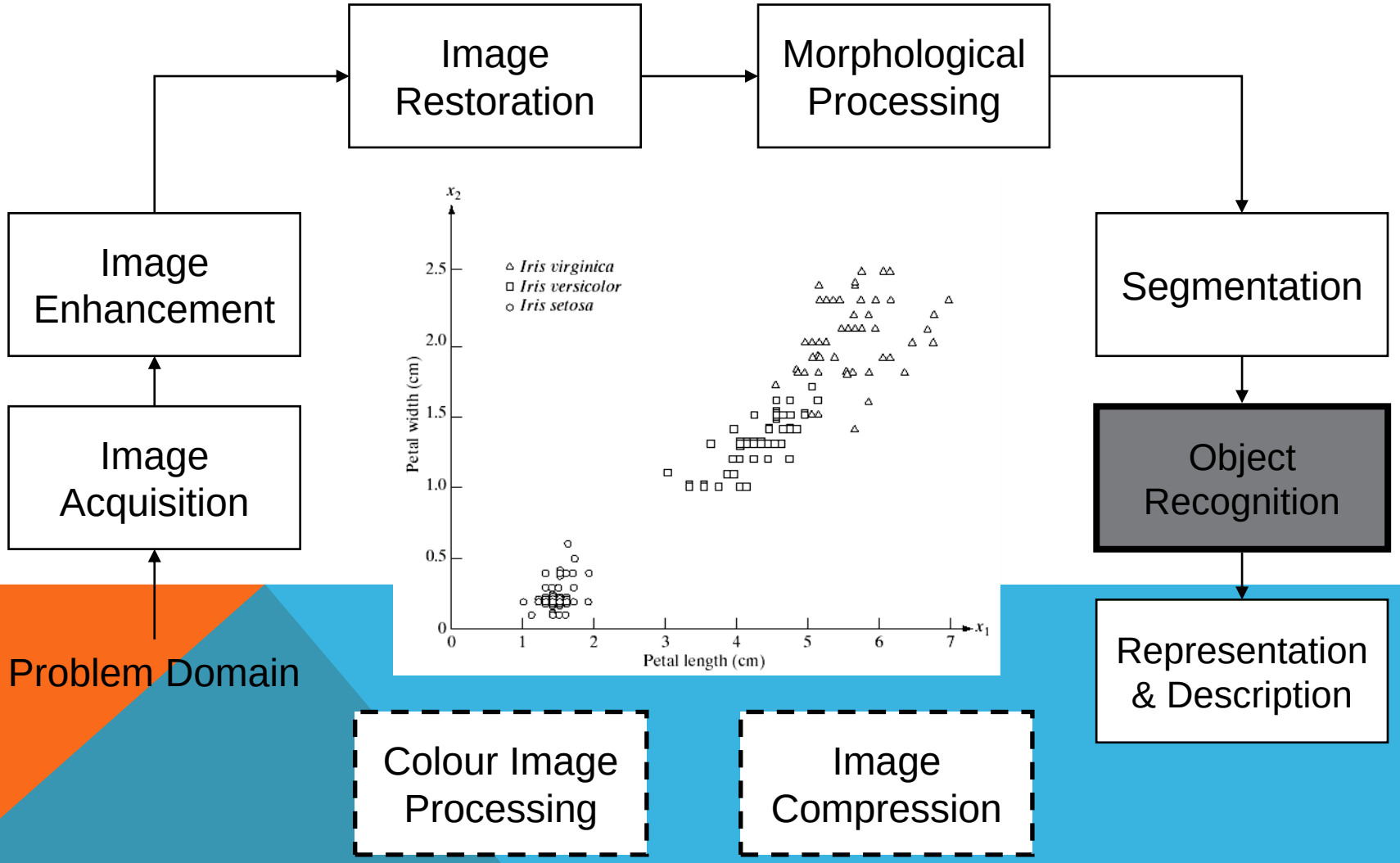
KEY STAGES IN DIGITAL IMAGE PROCESSING: MORPHOLOGICAL PROCESSING



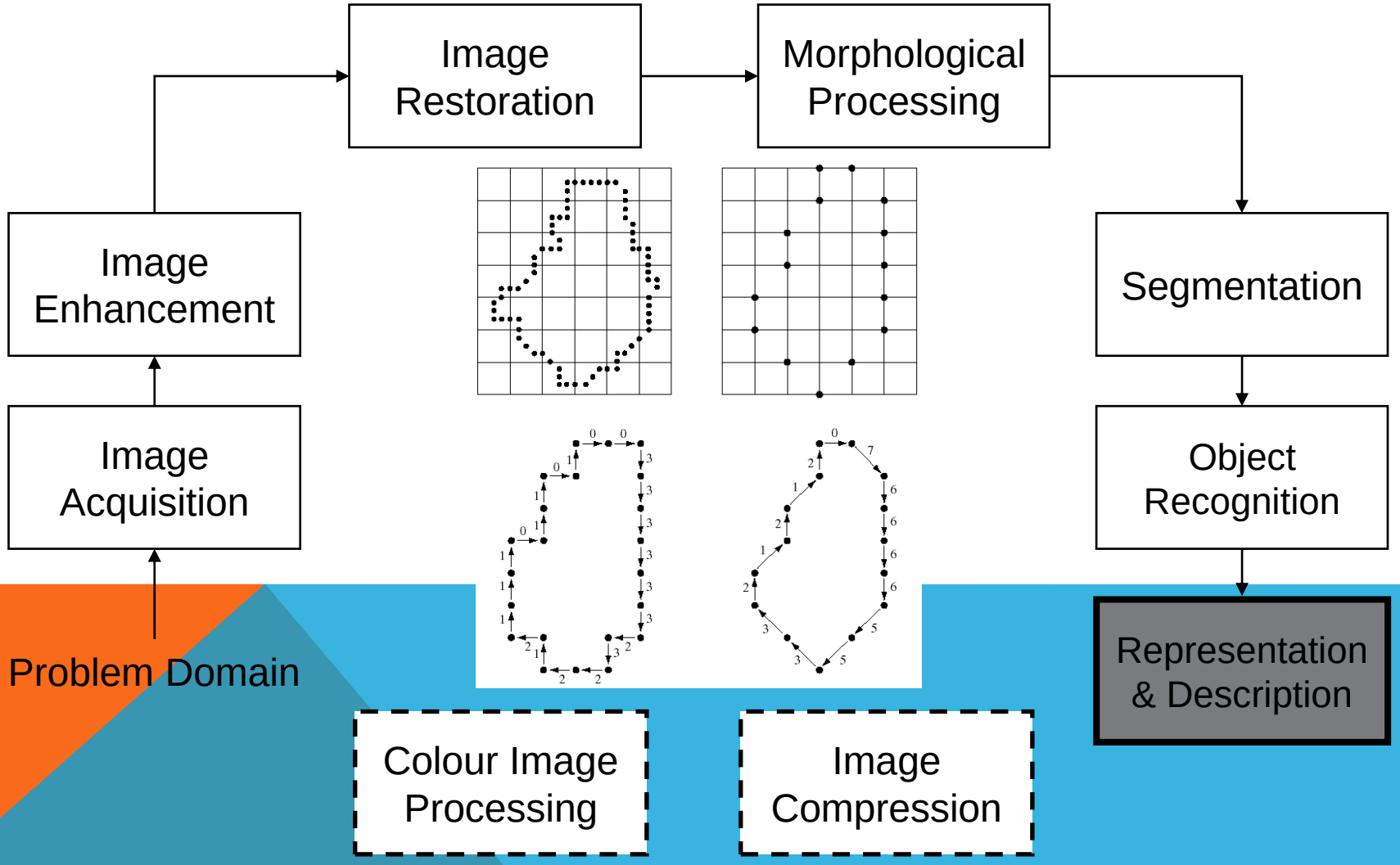
KEY STAGES IN DIGITAL IMAGE PROCESSING: SEGMENTATION



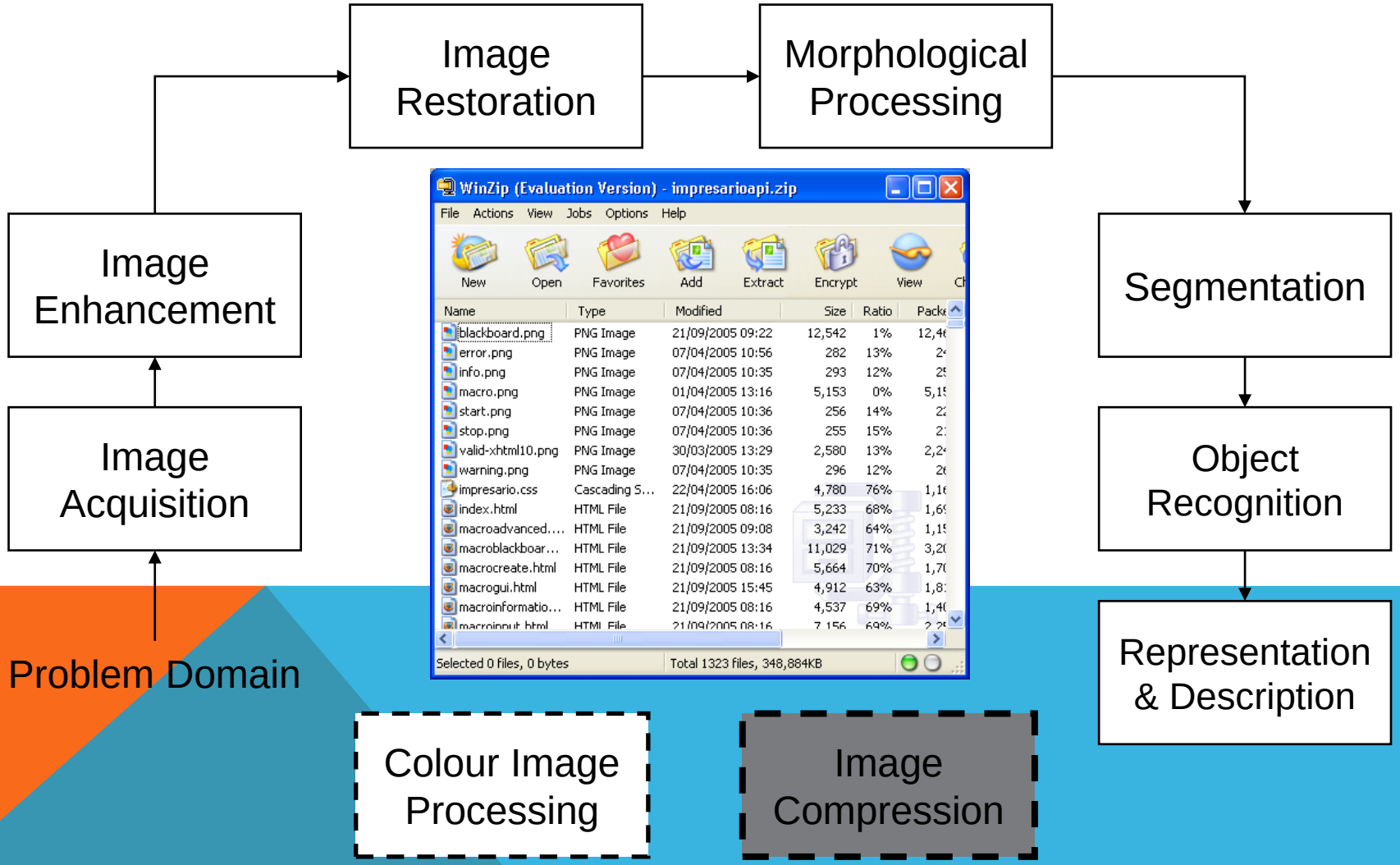
KEY STAGES IN DIGITAL IMAGE PROCESSING: OBJECT RECOGNITION



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