

# Digital Image Processing: Introduction

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*“One picture is worth more than ten  
thousand words”*

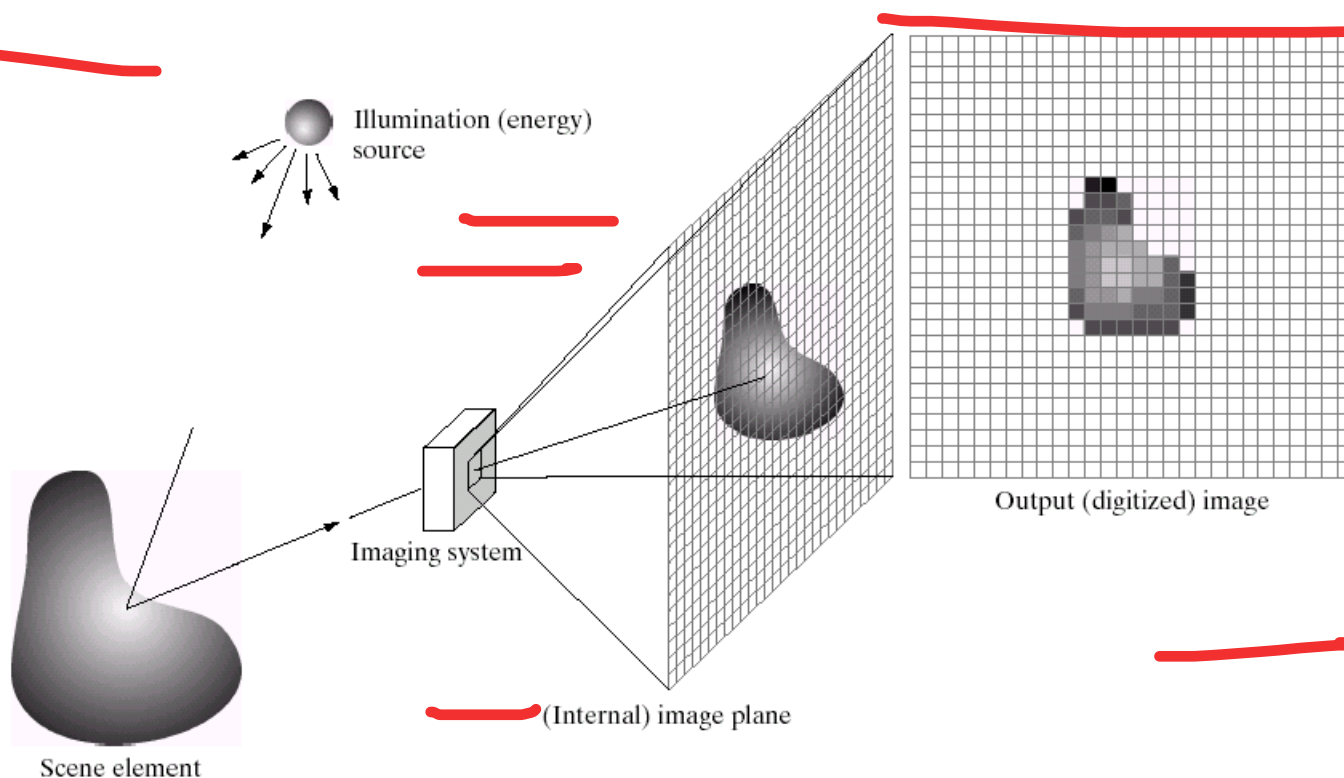
Anonymous

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?

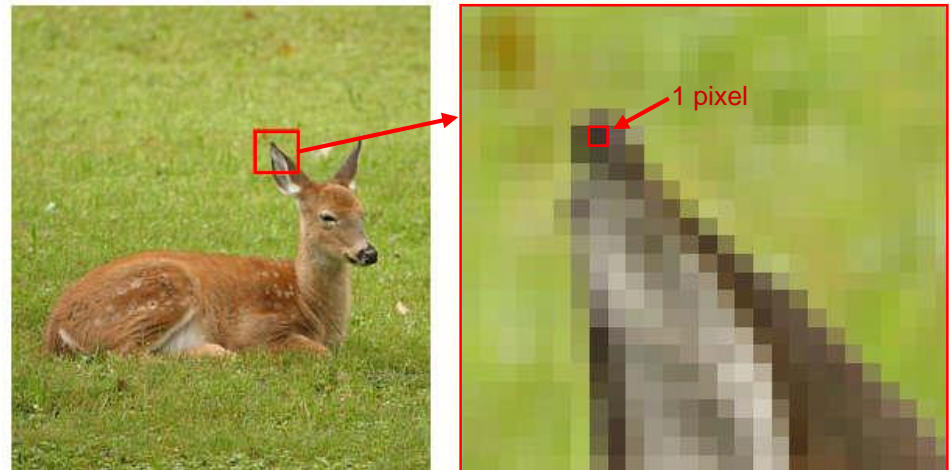
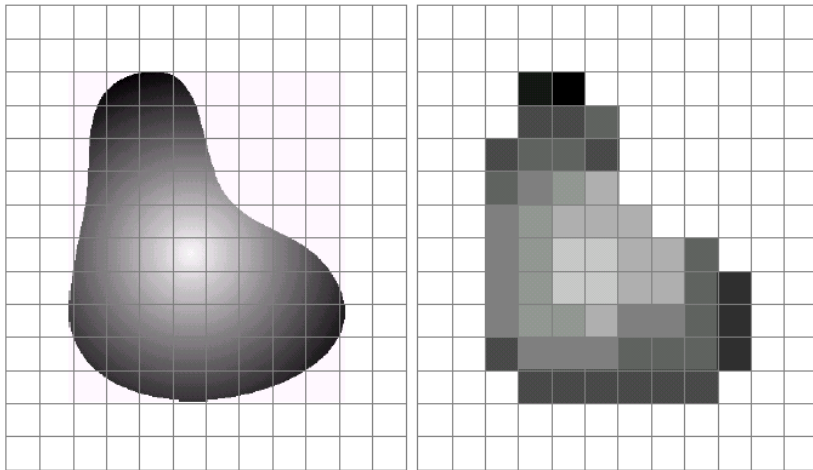
A **digital image** is a representation of a two-dimensional image as a finite set of digital values, called picture elements or pixels



# What is a Digital Image? (cont...)

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

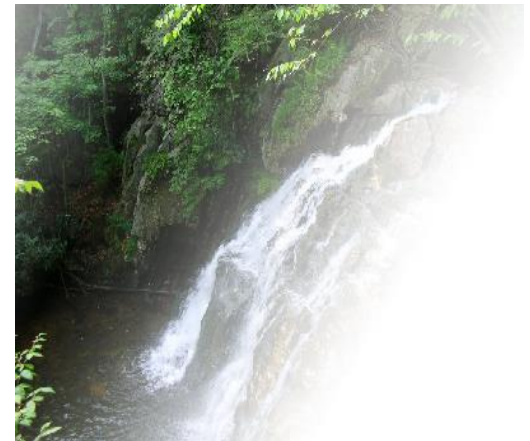
**Remember** digitization implies that a digital image is an approximation of a real scene



# 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

# 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

Low Level Process	Mid Level Process	High Level Process
<b>Input:</b> Image <b>Output:</b> Image	<b>Input:</b> Image <b>Output:</b> Attributes	<b>Input:</b> Attributes <b>Output:</b> Understanding
<b>Examples:</b> Noise removal, image sharpening	<b>Examples:</b> Object recognition, segmentation	<b>Examples:</b> Scene understanding, autonomous navigation

In this course we will  
stop here



# History of Digital Image Processing

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

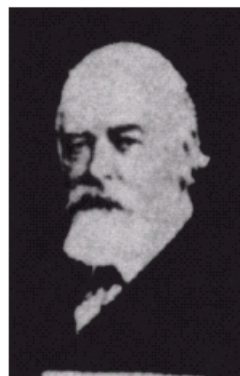
- The Bartlane cable picture transmission service
- Images were transferred by submarine cable between London and New York
- Pictures were coded for cable transfer and reconstructed at the receiving end on a telegraph printer



Early digital image

## 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



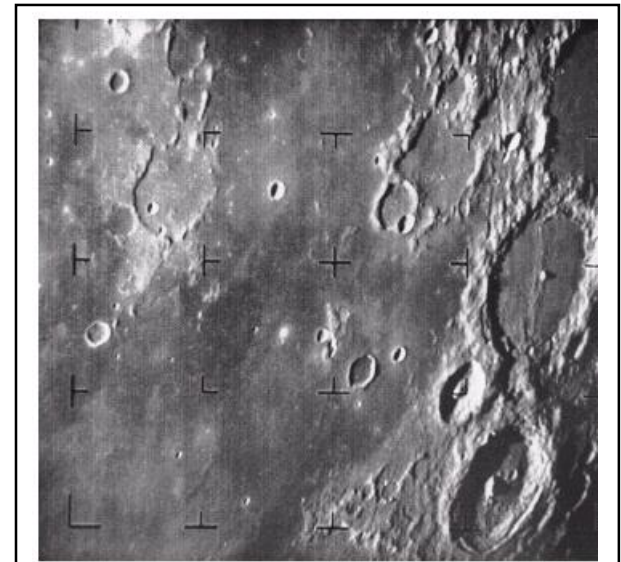
Improved  
digital image



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

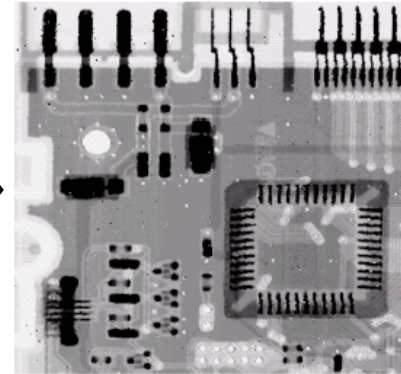
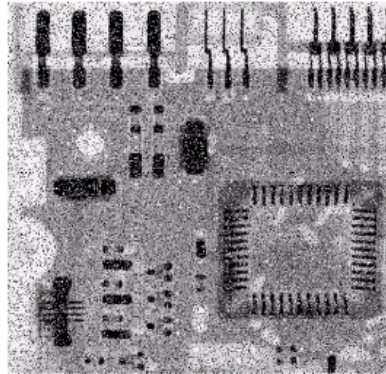
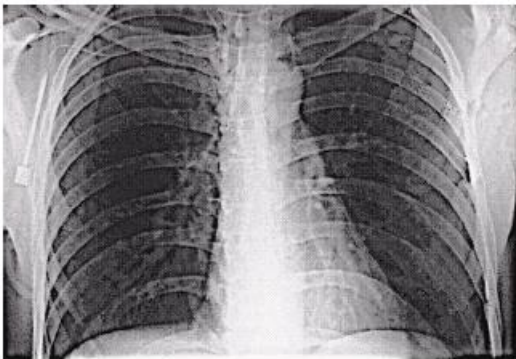
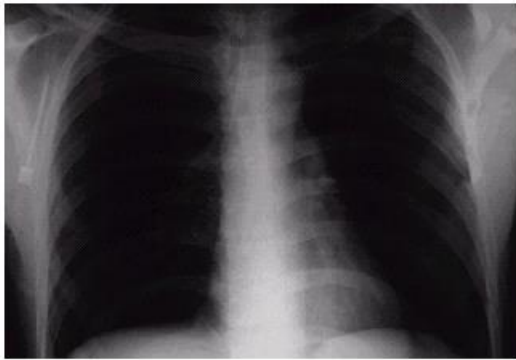
– Law enforcement

– Human computer interfaces



# Examples: Image Enhancement

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

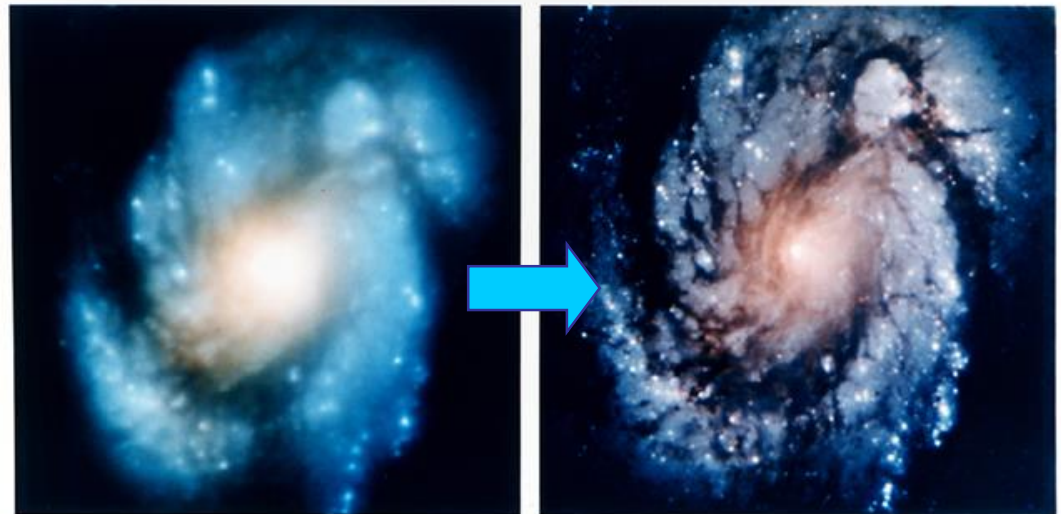


# Examples: The Hubble Telescope

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



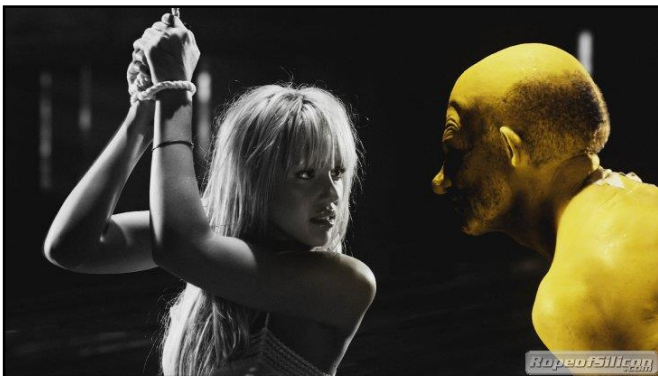
Wide Field Planetary Camera 1

Wide Field Planetary Camera 2



# Examples: Artistic Effects

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



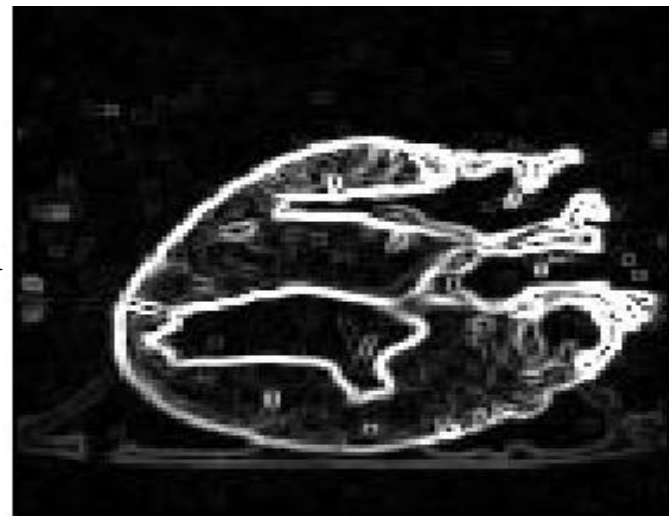


Take slice from MRI scan of canine heart,  
and find boundaries between types of tissue

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



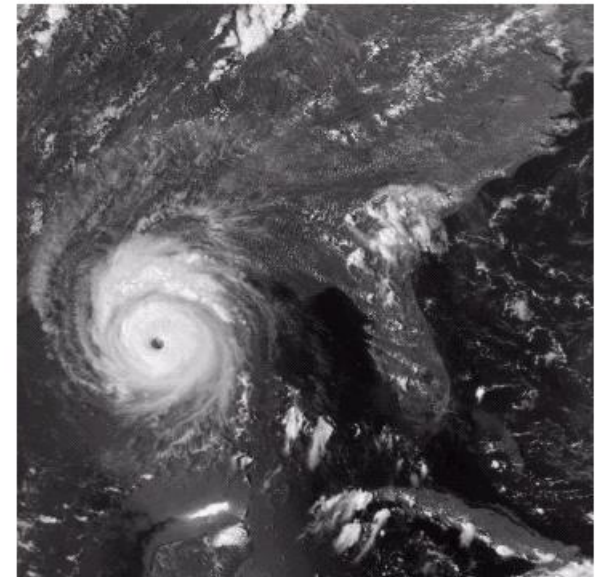
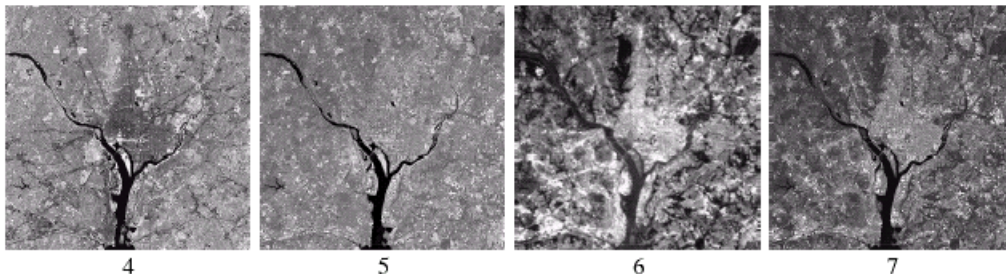
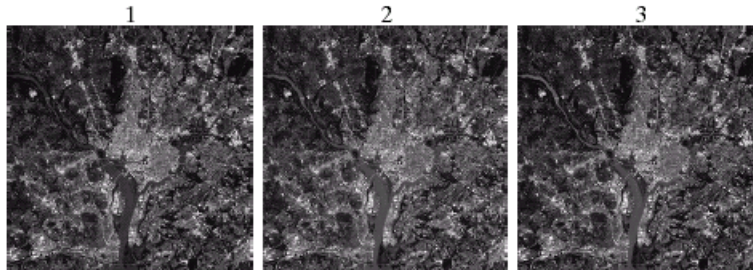
Original MRI Image of a Dog Heart



Edge Detection Image

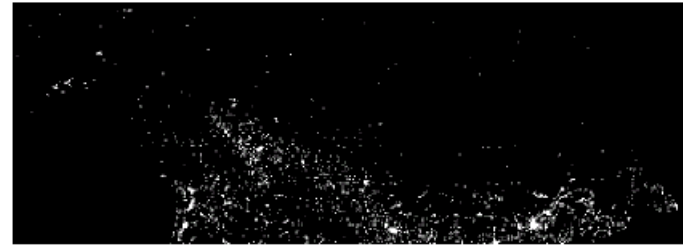
## Geographic Information Systems

- 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



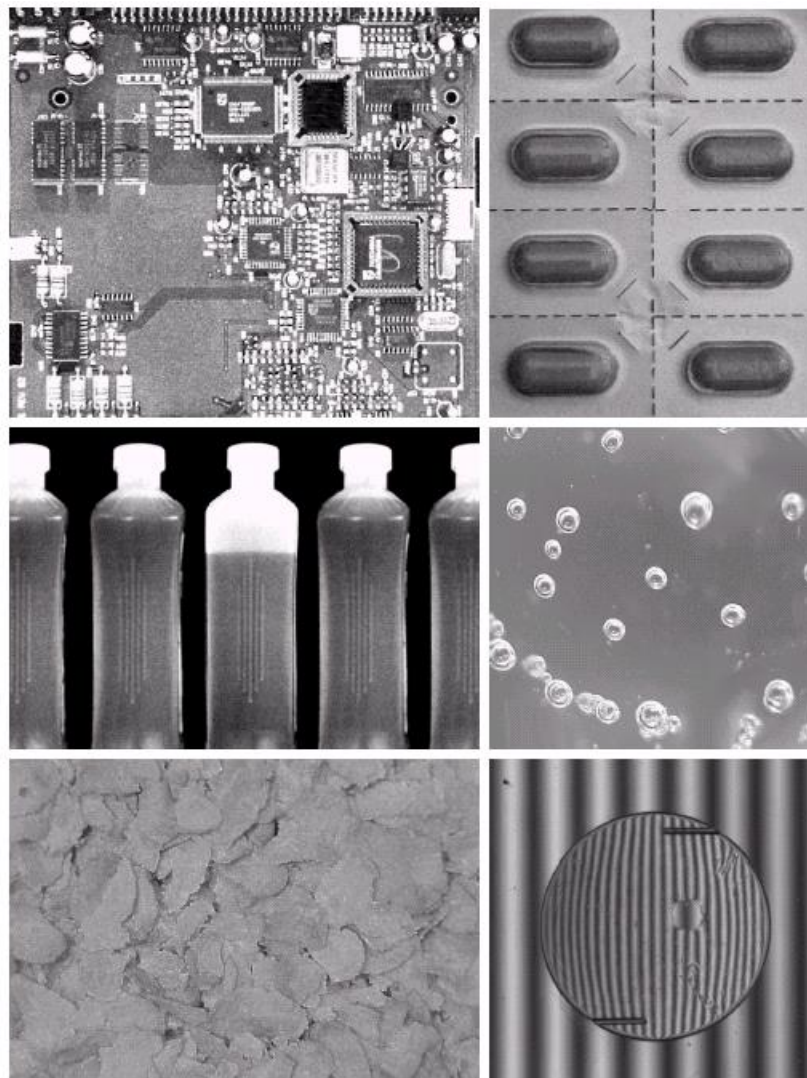
# Examples: Industrial Inspection

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?

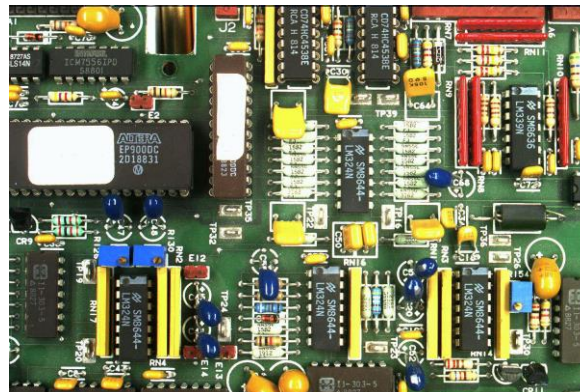
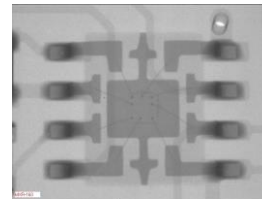
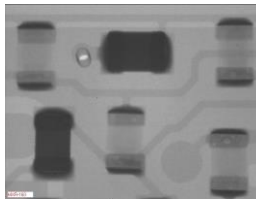




# Examples: PCB Inspection

## Printed Circuit Board (PCB) inspection

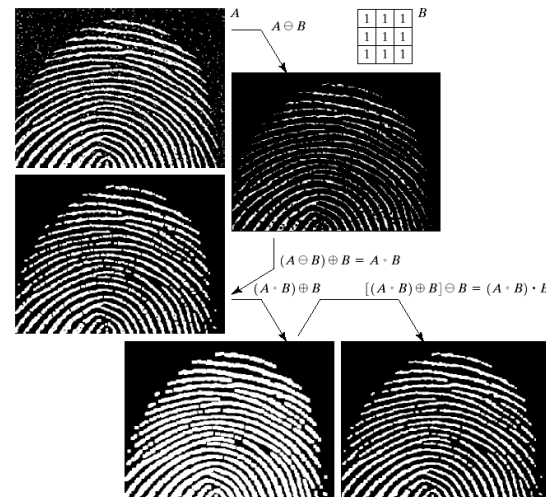
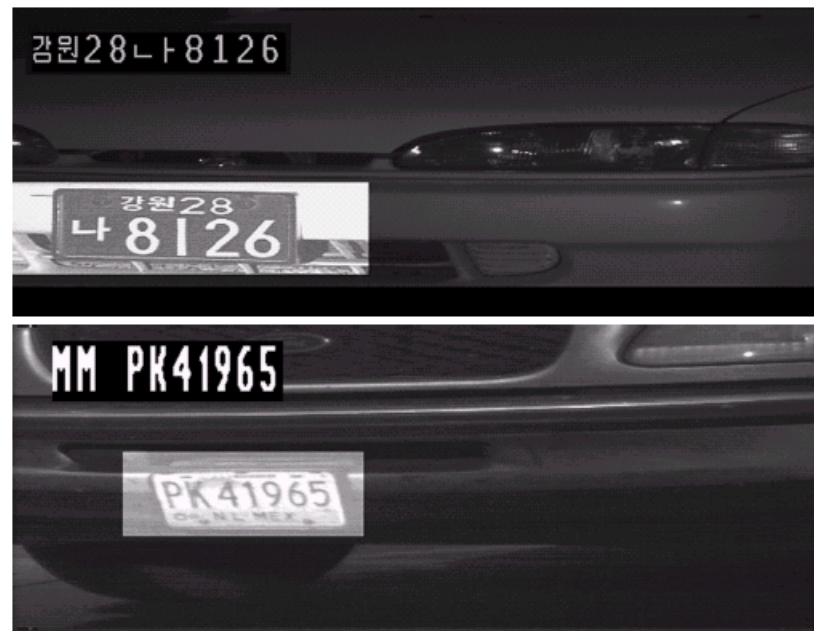
- Machine inspection is used to determine that all components are present and that all solder joints are acceptable
- Both conventional imaging and x-ray imaging



# Examples: Law Enforcement

Image processing techniques are used extensively by law enforcers

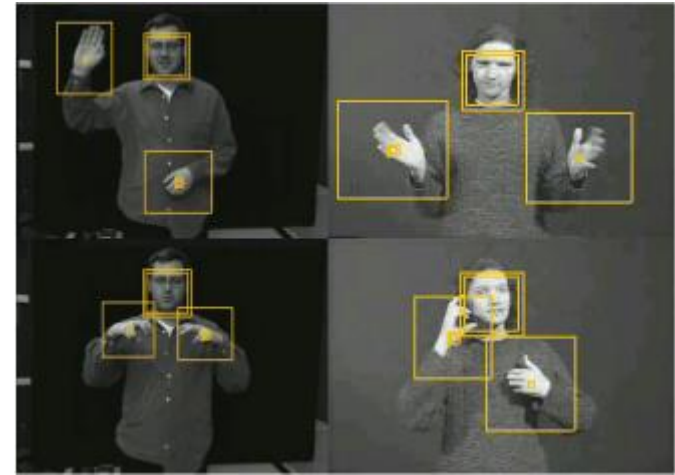
- Number plate recognition for speed cameras/automated toll systems
- Fingerprint recognition
- Enhancement of CCTV images



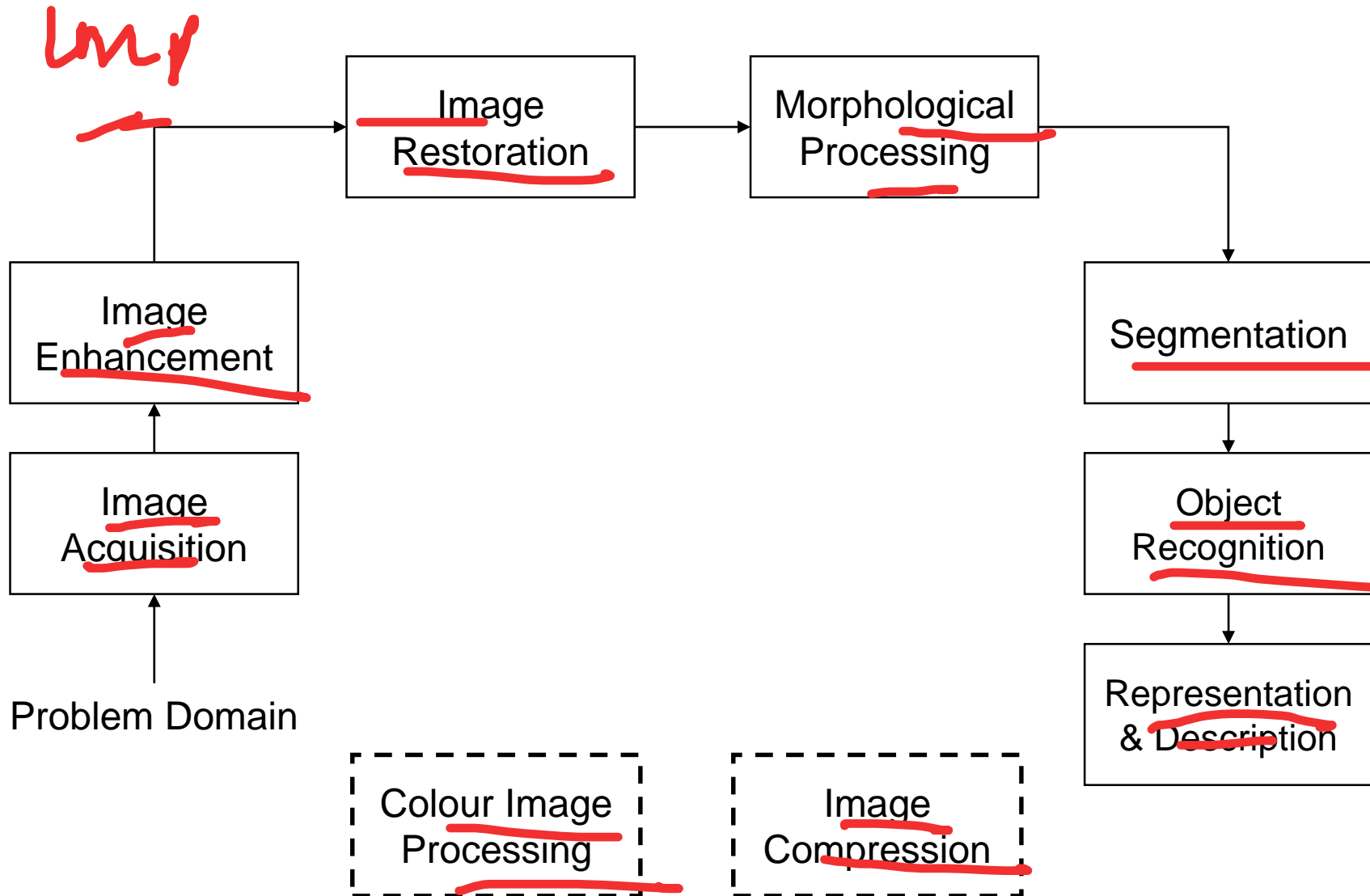
Try to make human computer interfaces more natural

- Face recognition
- Gesture recognition

These tasks can be extremely difficult

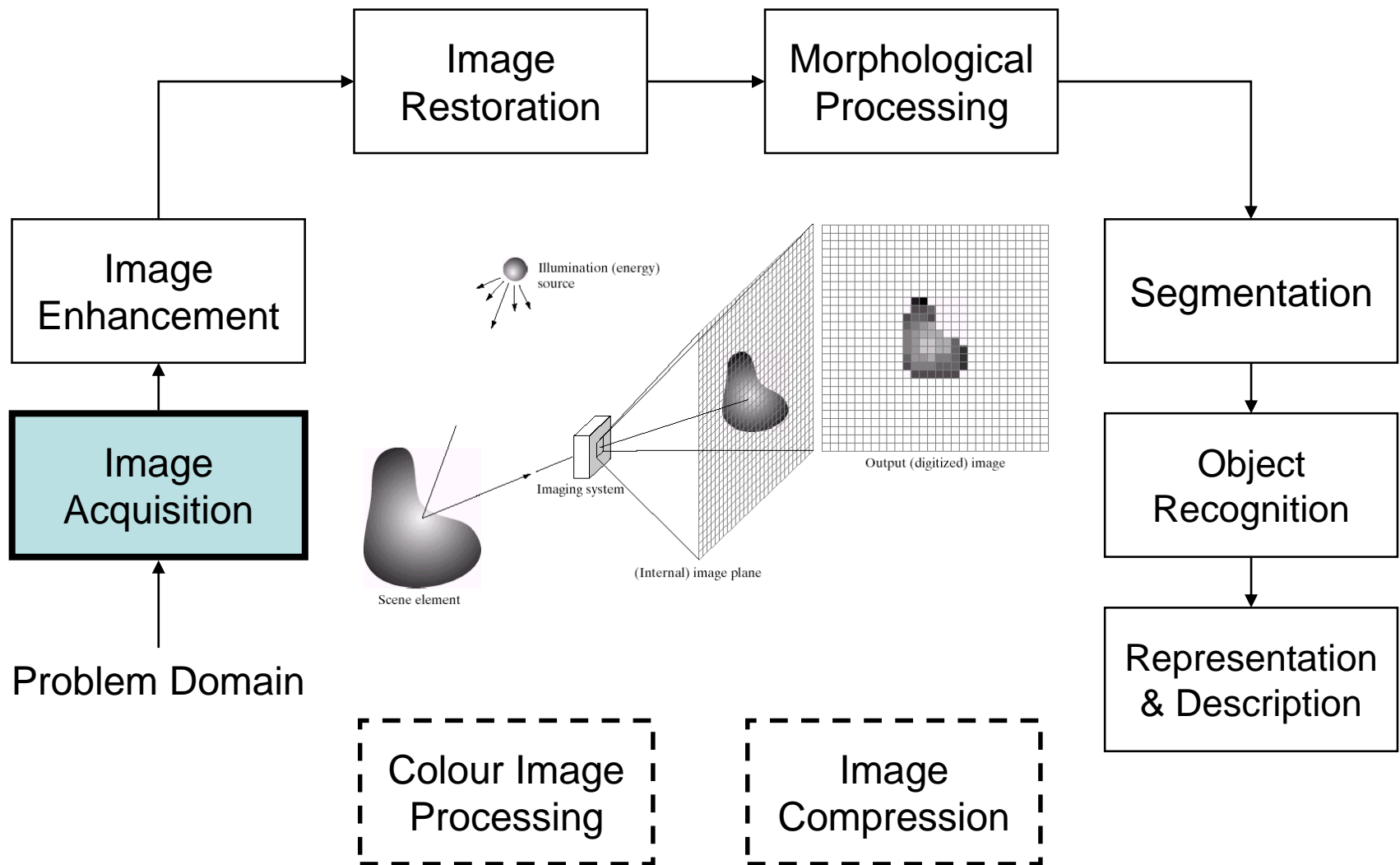


# Key Stages in Digital Image Processing

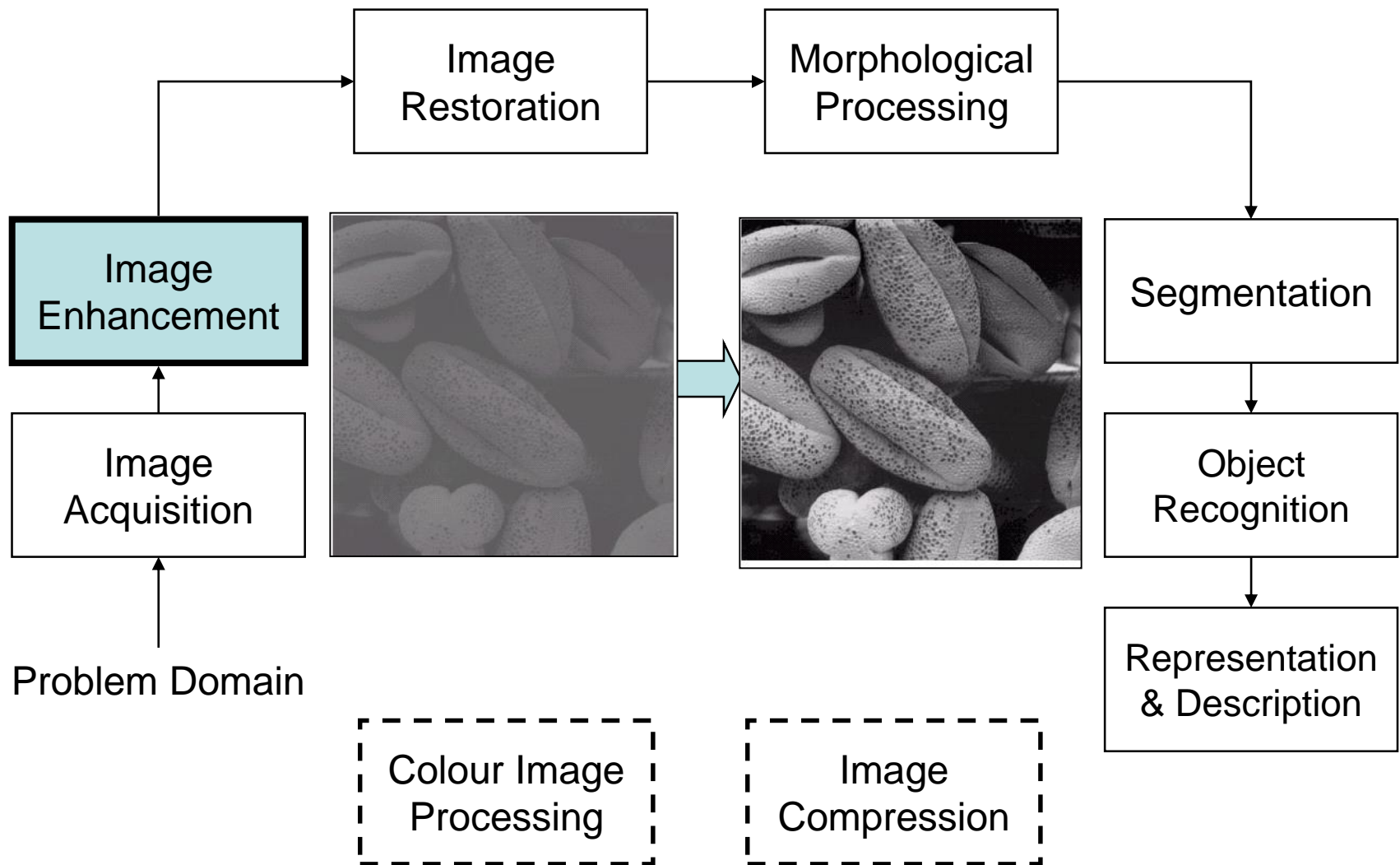




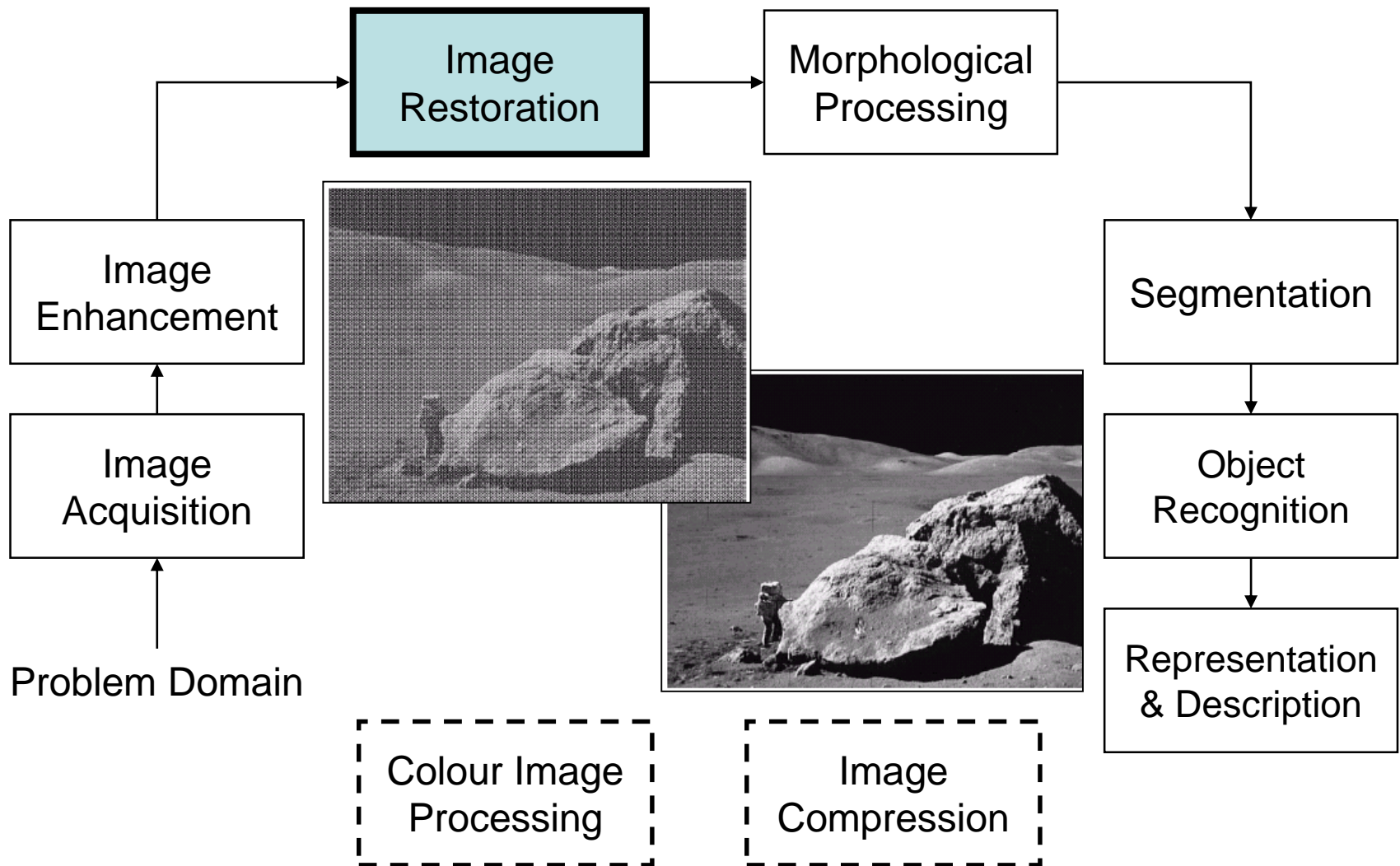
# Key Stages in Digital Image Processing: Image Aquisition



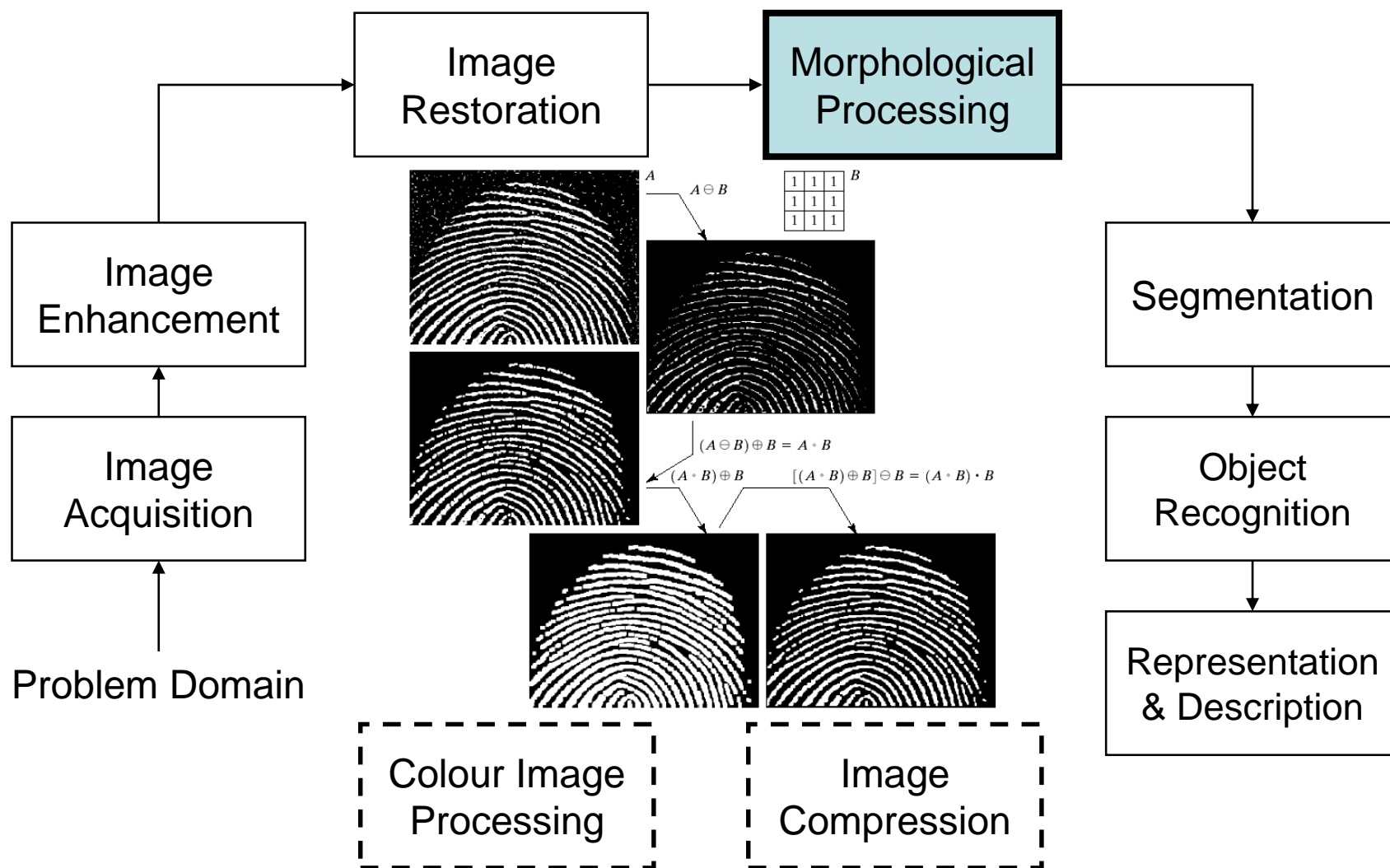
# Key Stages in Digital Image Processing: Image Enhancement



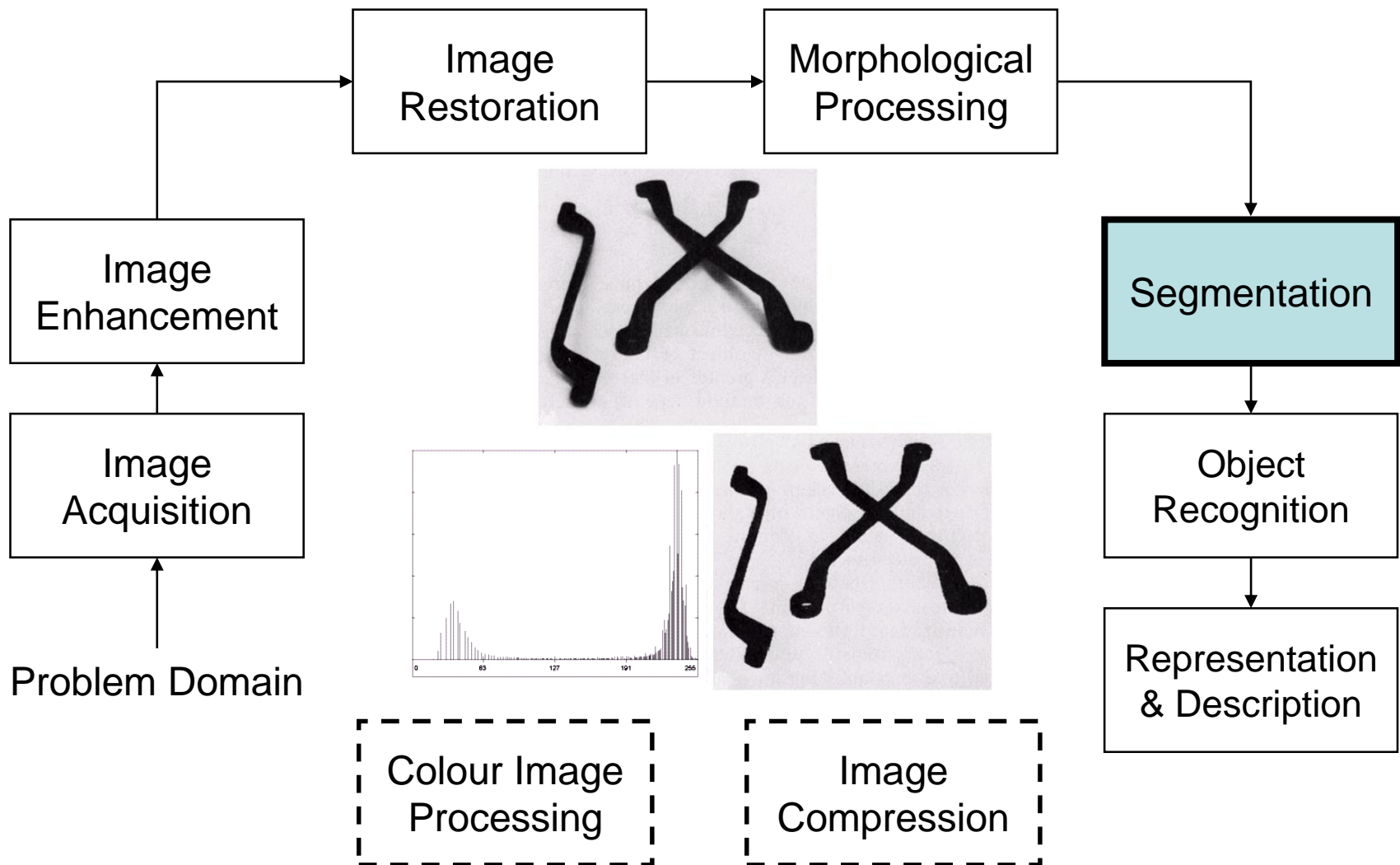
# Key Stages in Digital Image Processing: Image Restoration



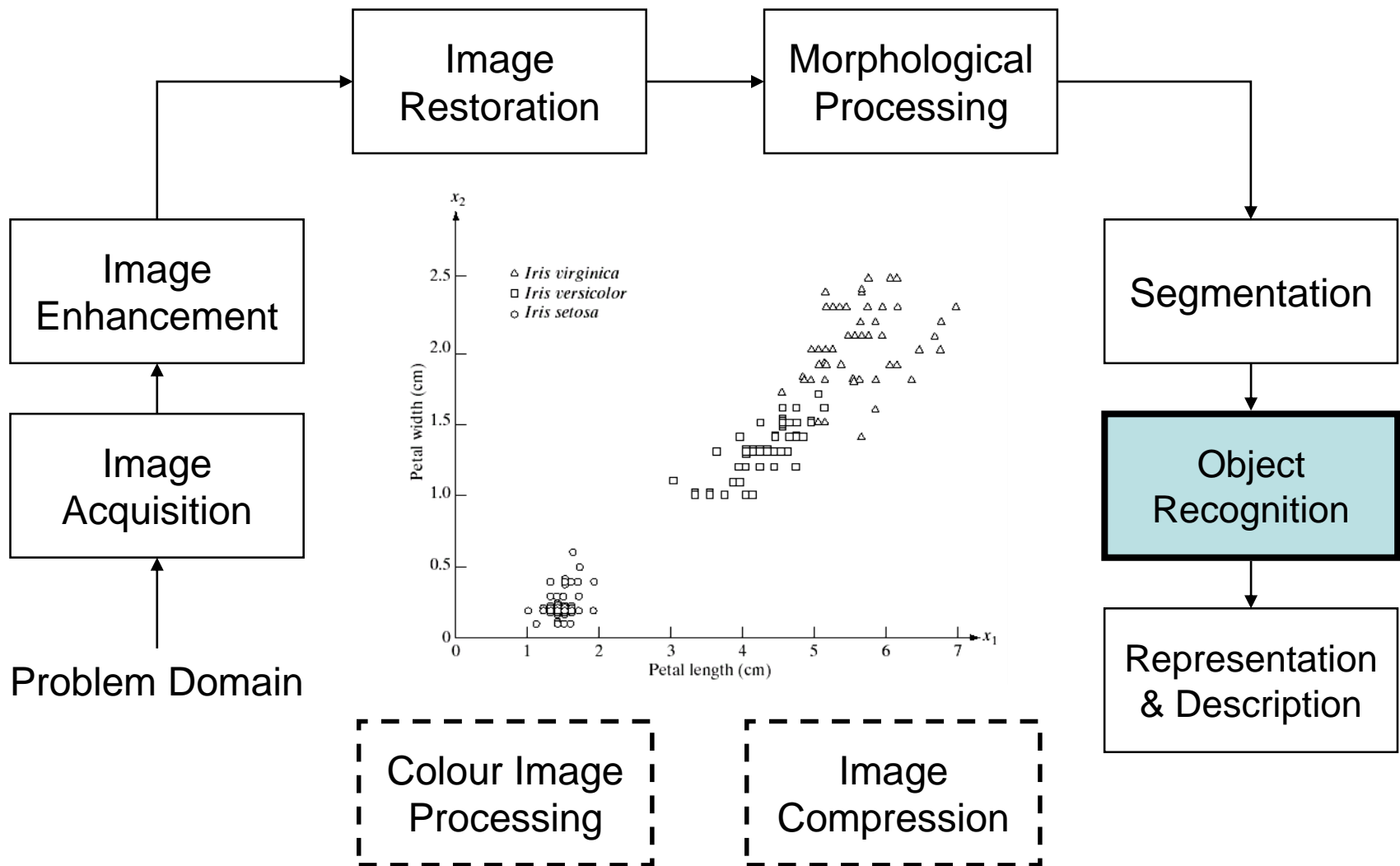
# Key Stages in Digital Image Processing: Morphological Processing



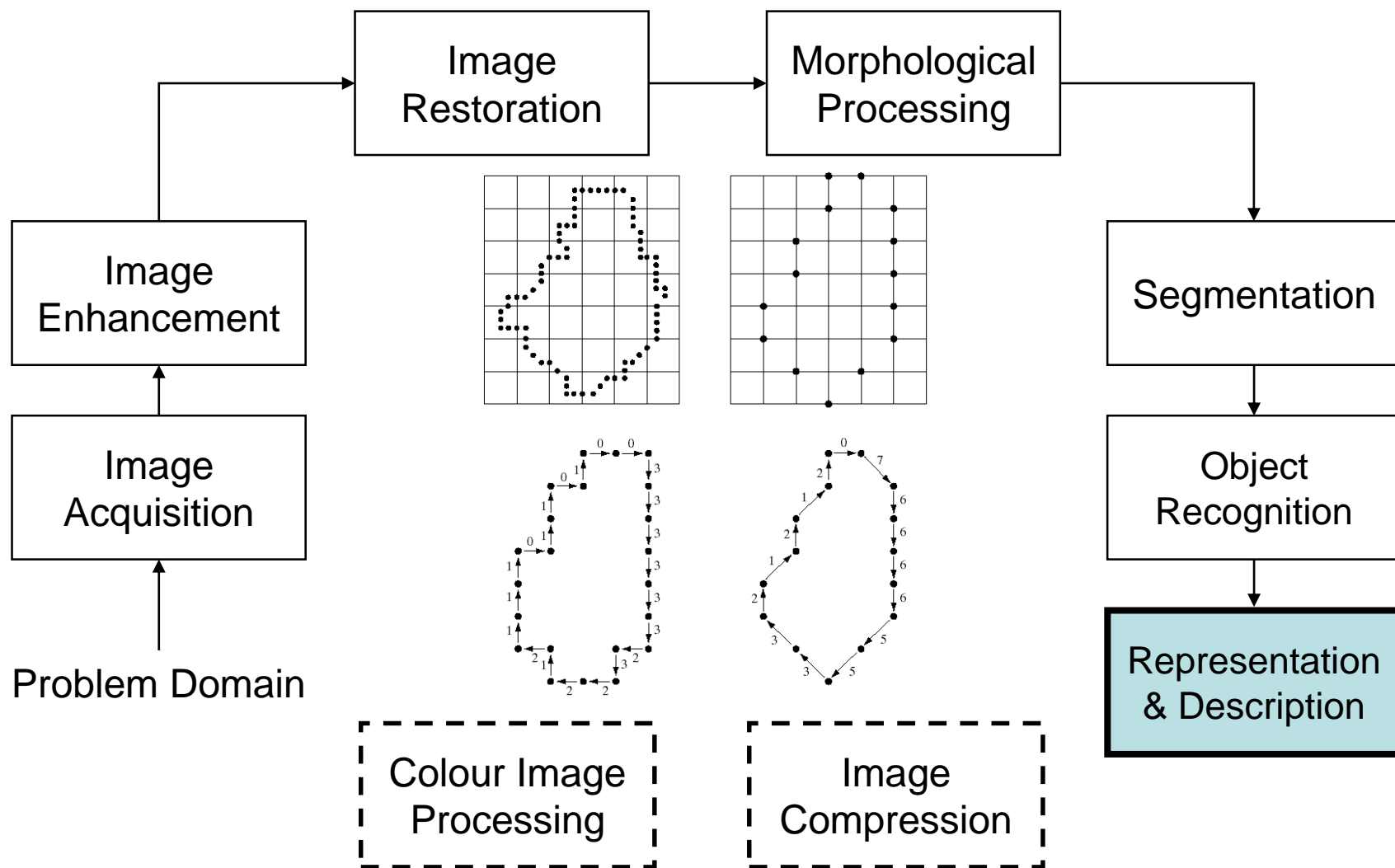
# Key Stages in Digital Image Processing: Segmentation



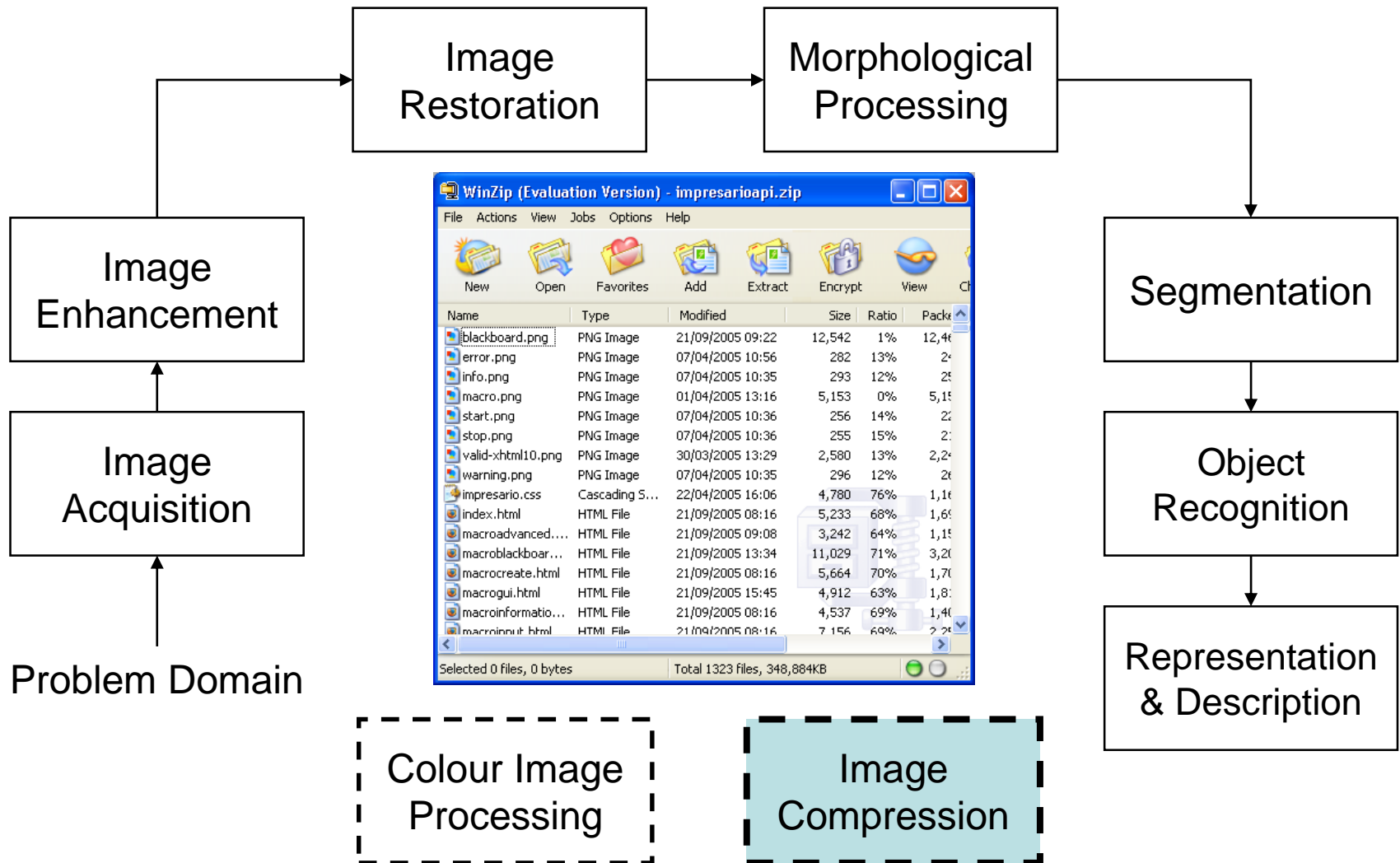
# Key Stages in Digital Image Processing: Object Recognition



# Key Stages in Digital Image Processing: Representation & Description

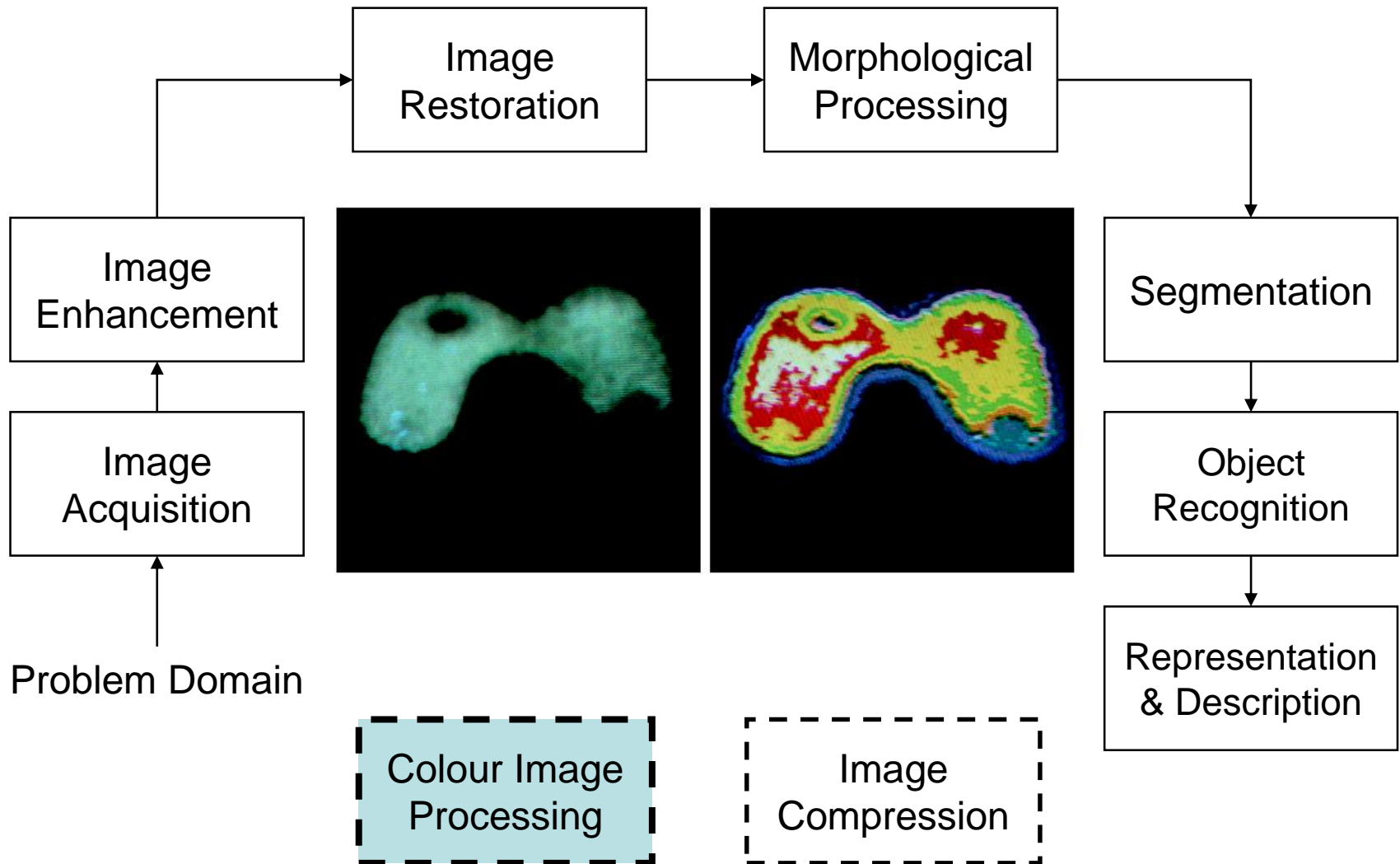


# Key Stages in Digital Image Processing: Image Compression





# Key Stages in Digital Image Processing: Colour Image Processing



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...