Image and Video Processing

Lectures:

- Days: Monday, Thursday & Friday
- slot: H

Labs: Assignment based

Google group: https://groups.google.com/d/forum/ivpw18

Textbook:

"Digital Image Processing", Rafael C. Gonzalez & Richard E. Woods, 3rd ed.

Course outcomes

At the end of the course the students will be able to:

- Describe the fundamentals of image and video processing and their applications
- Develop familiarity and implement basic image and video processing techniques & algorithms.
- Select and apply appropriate techniques to real problems in image and video analysis.

Introduction

This lecture will cover:

- What is digital image and it's processing?
- Brief History of DIP
- Sample applications of DIP
- Key stages in DIP
- The human visual system
- Imaging beyond visible spectrum

What is a Digital Image?

An image is a two-dimensional function f(x,y), where x and y are the spatial (plane) coordinates, and the amplitude of f at any pair of coordinates (x,y) is called the intensity of the image at that level.

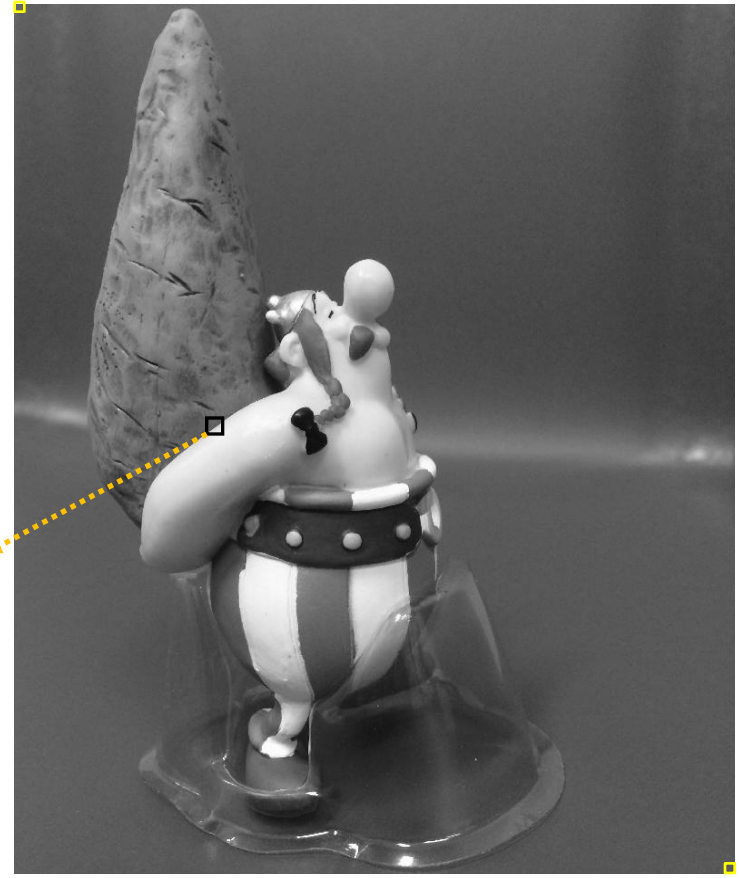
If x,y and the amplitude values of f are finite and discrete quantities, we call the image a digital image. A digital image is composed of a finite number of elements called pixels, each of which has a particular location and value.

What is a Digital Image? (contd.)

Pixel intensity value

f(1,1) = 103

Pixel location



rows columns

f(645:650,1323:1328) =

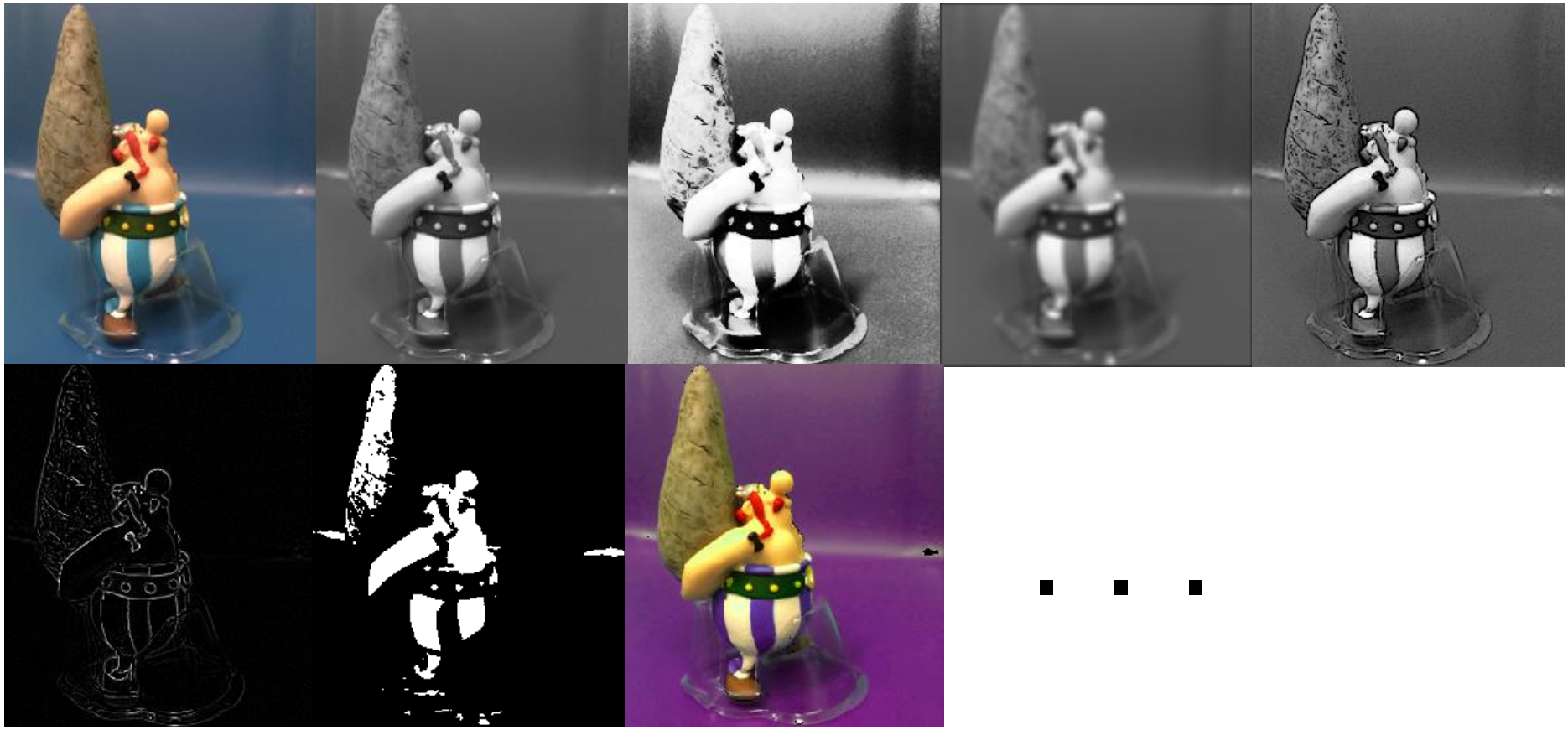
83	82	82	82	82	82
82	82	82	81	81	81
82	82	81	81	80	80
82	82	81	80	80	79
80	79	78	77	77	77
80	79	78	78	77	77

f(2724,2336) = 88

Consider the following image (2724x2336 pixels) to be 2D function or a **matrix** with **rows** and **columns**

In 8-bit representation Pixel intensity values range between 0 (Black) and 255 (White)

Digital Image Processing



Digital Image Processing

Motivated by following principal objectives:

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

History of DIP

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

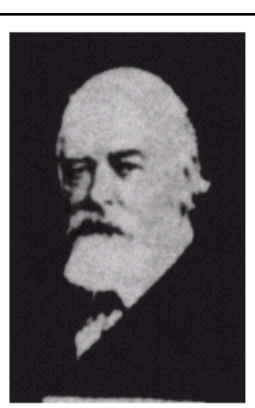
Early digital image

- The Bartlane cable picture transmission service
- Photographs were transmitted by cable between London and New York
- Pictures were coded for cable transfer and reconstructed at the receiving end on a telegraph printer using specially designed printing blocks.

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

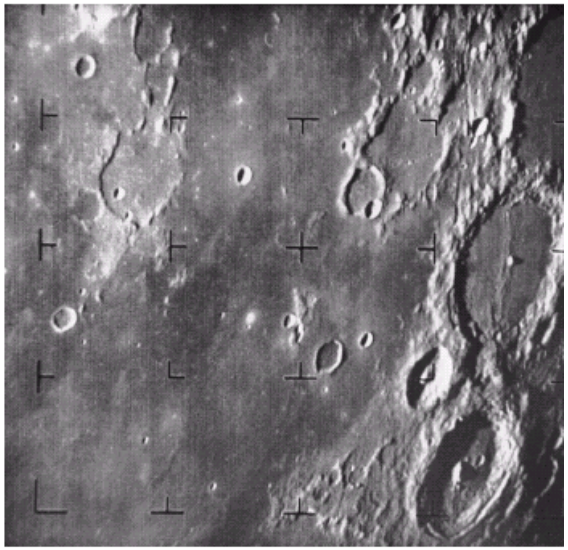
Early 15 tone digital image

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

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

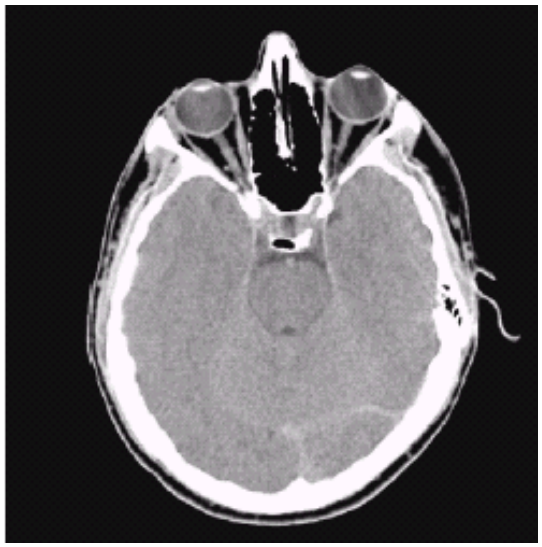


A picture of the moon taken by the Ranger 7 probe minutes before landing

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

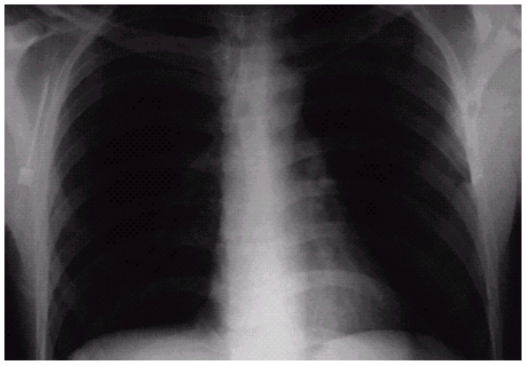
History of DIP (cont…)

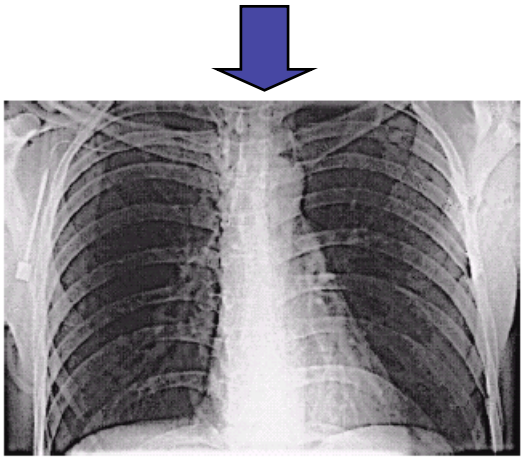
1980s - Today: The use of digital image processing techniques has exploded and they are now used for all kinds of tasks in all kinds of areas

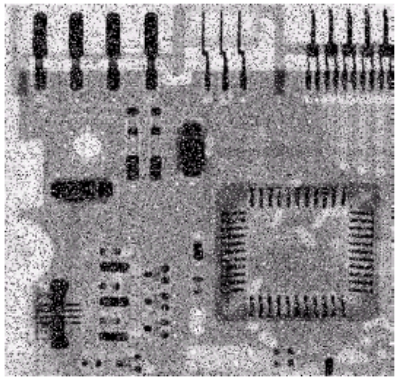
- Image enhancement/restoration
- Medical visualisation
- Remote sensing & GIS
- Industrial inspection
- Law enforcement
- Human computer interfaces
- Special effects in movies

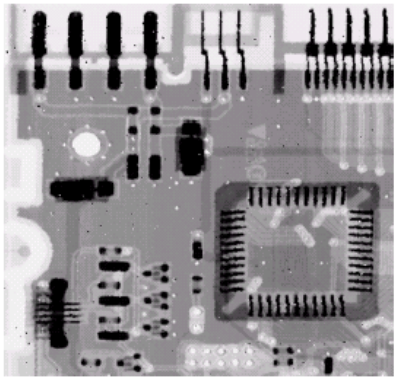
Applications: Image Enhancement

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









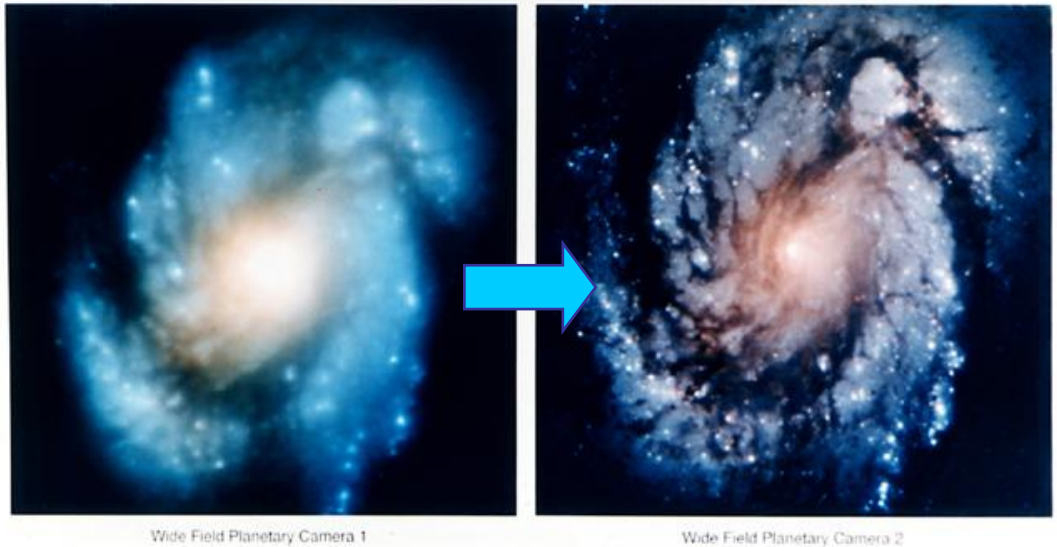
Images taken from Gonzalez & Woods, Digital Image Processing (2002)

Applications : The Hubble Telescope

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

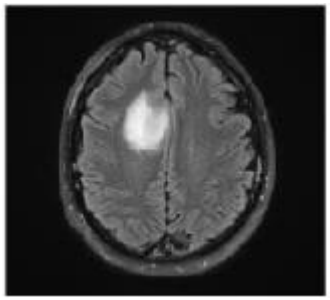
However, an incorrect mirror made many of Hubble's images useless

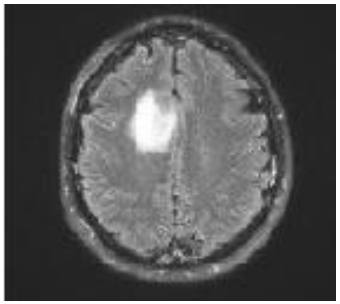
Image processing techniques were used to fix this

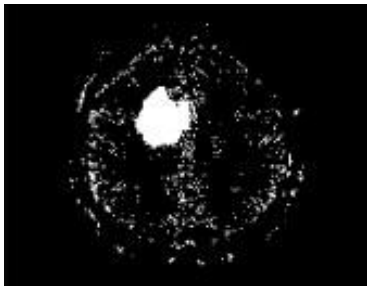


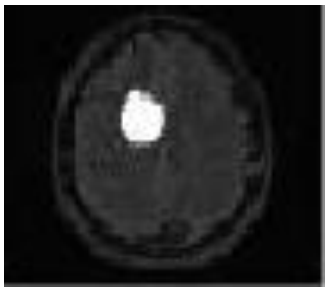
Applications : Medicine

Detection of brain tumor







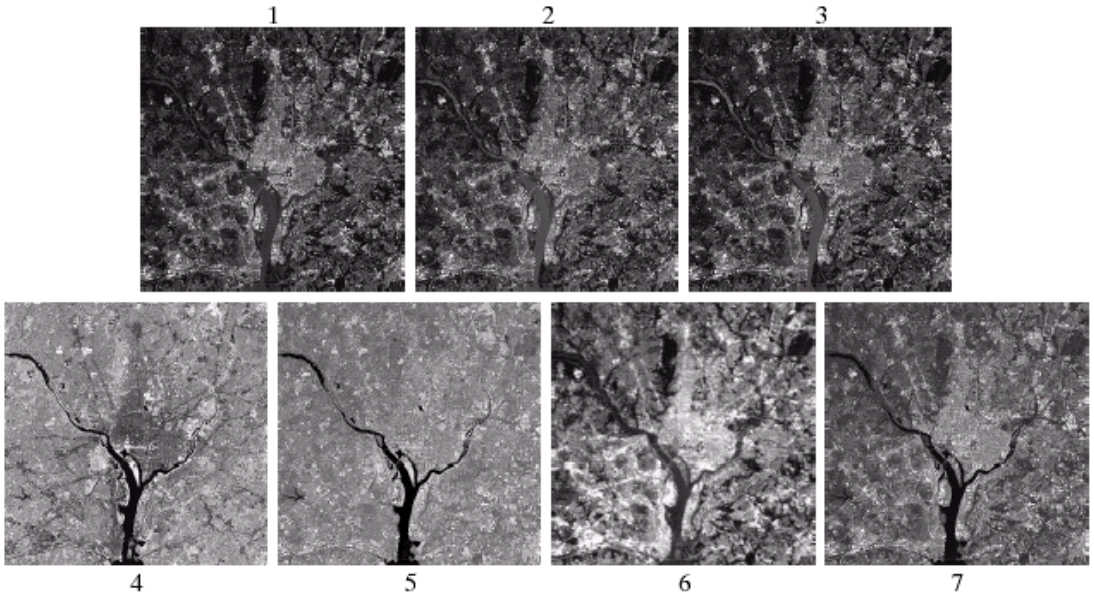


Images taken from Gonzalez & Woods, Digital Image Processing (2002)

Applications : GIS

Geographic Information Systems

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

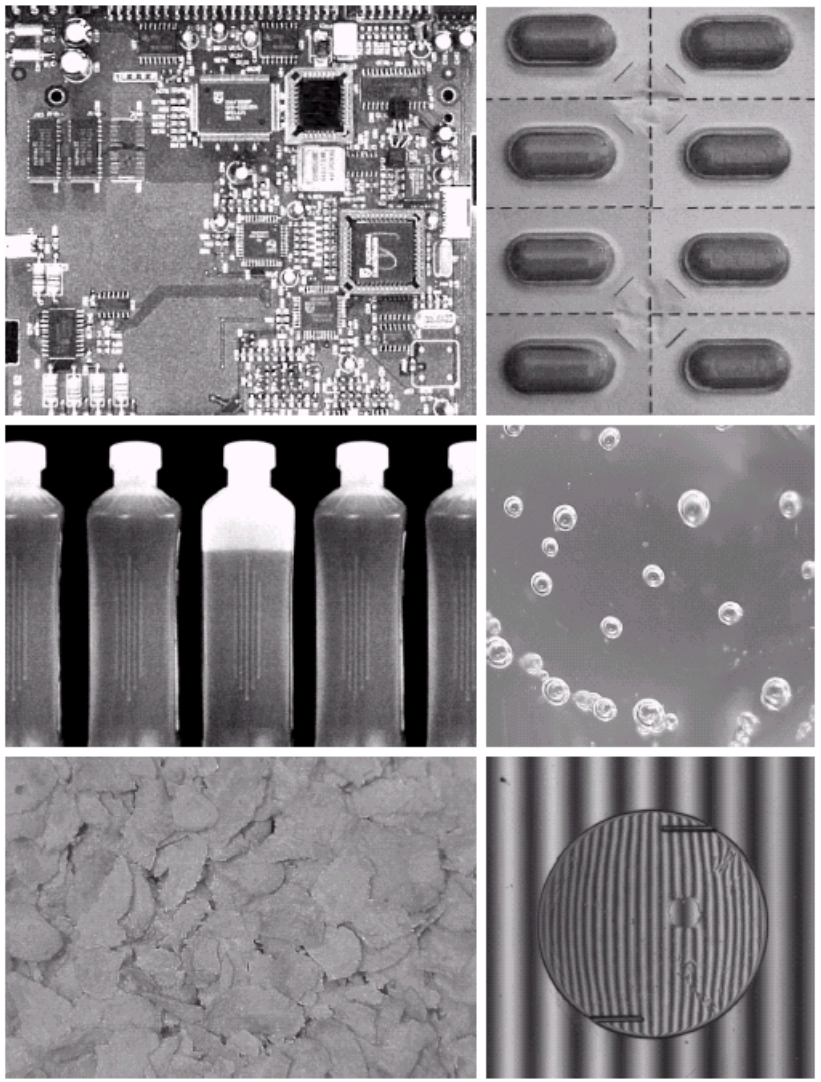


Images taken from Gonzalez & Woods, Digital Image Processing (2002)

Applications : Industrial Inspection

Human operators are expensive, slow and at times unreliable.

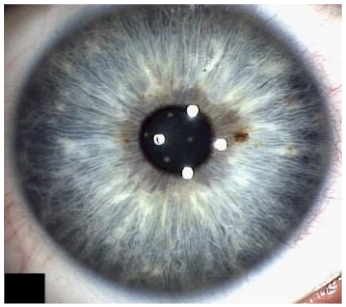
Industrial vision systems are used in all kinds of industries



Applications : Law Enforcement

Image processing techniques are used extensively by law enforcers

- Number plate recognition for speed cameras/ automated toll systems
- Biometrics and forensics.

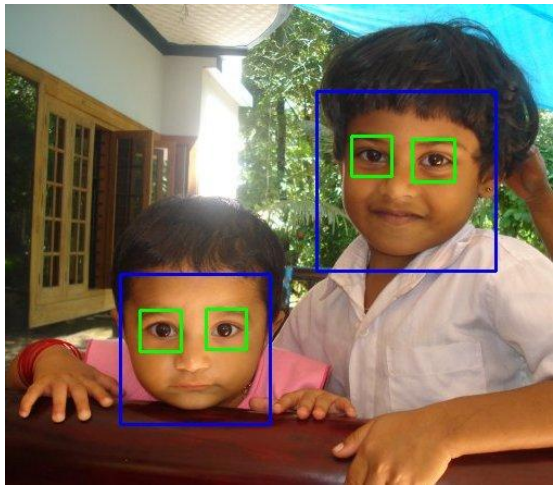


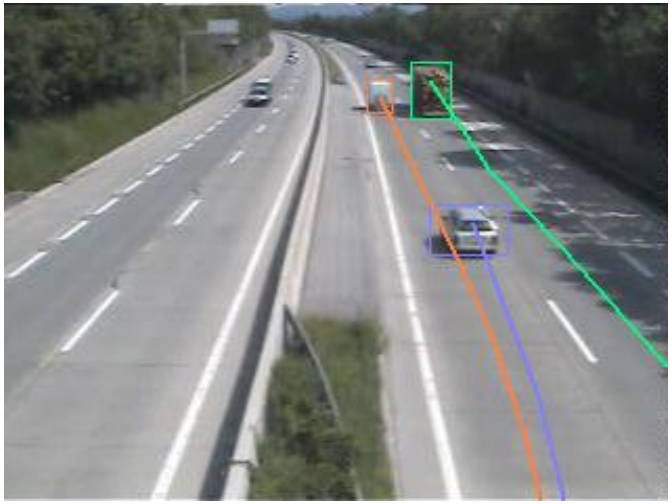
Applications : Special Effects in movies

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

Image classification and tagging

Object Detection, Recognition and Tracking





Applications : Law Enforcement

Video surveillance using CCTV camera

- Pedestrian and vehicle detection and tracking

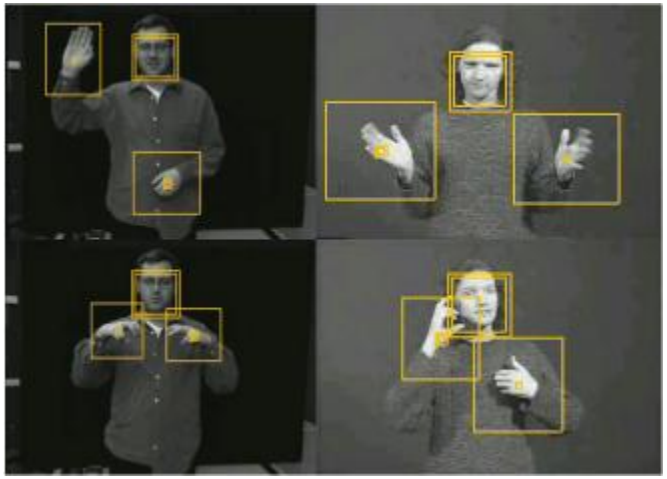
Homeland security for human lives and property in banks, shopping malls, smart homes, buildings etc.

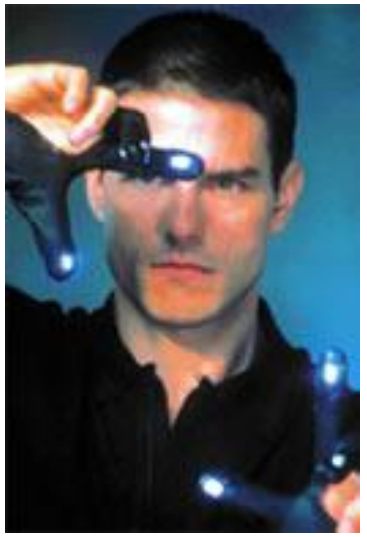
Traffic and safety in highways, metro stations, Airport, railways etc.

Applications : HCI

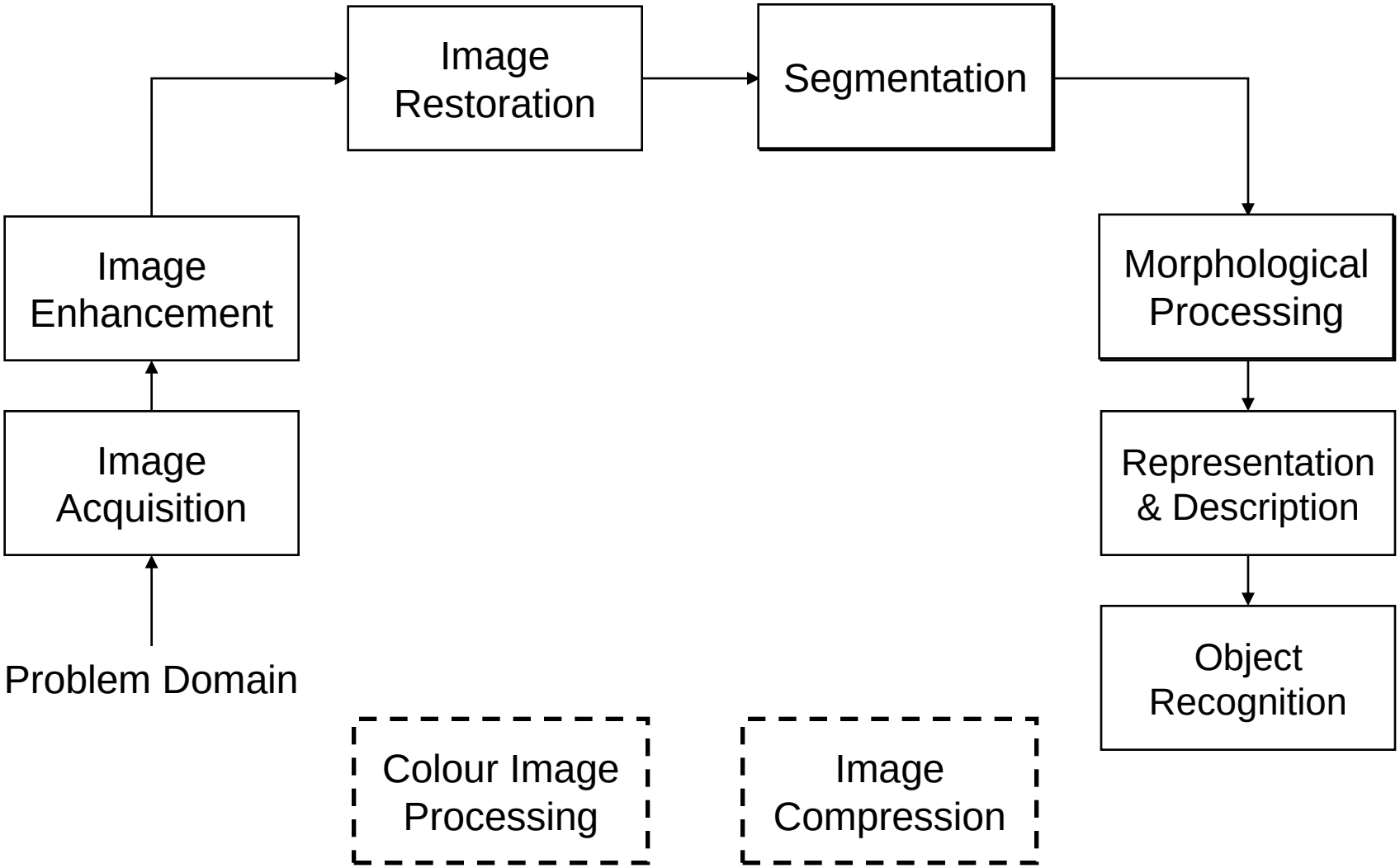
Try to make human computer interfaces more natural

- Face recognition
- Gesture recognition

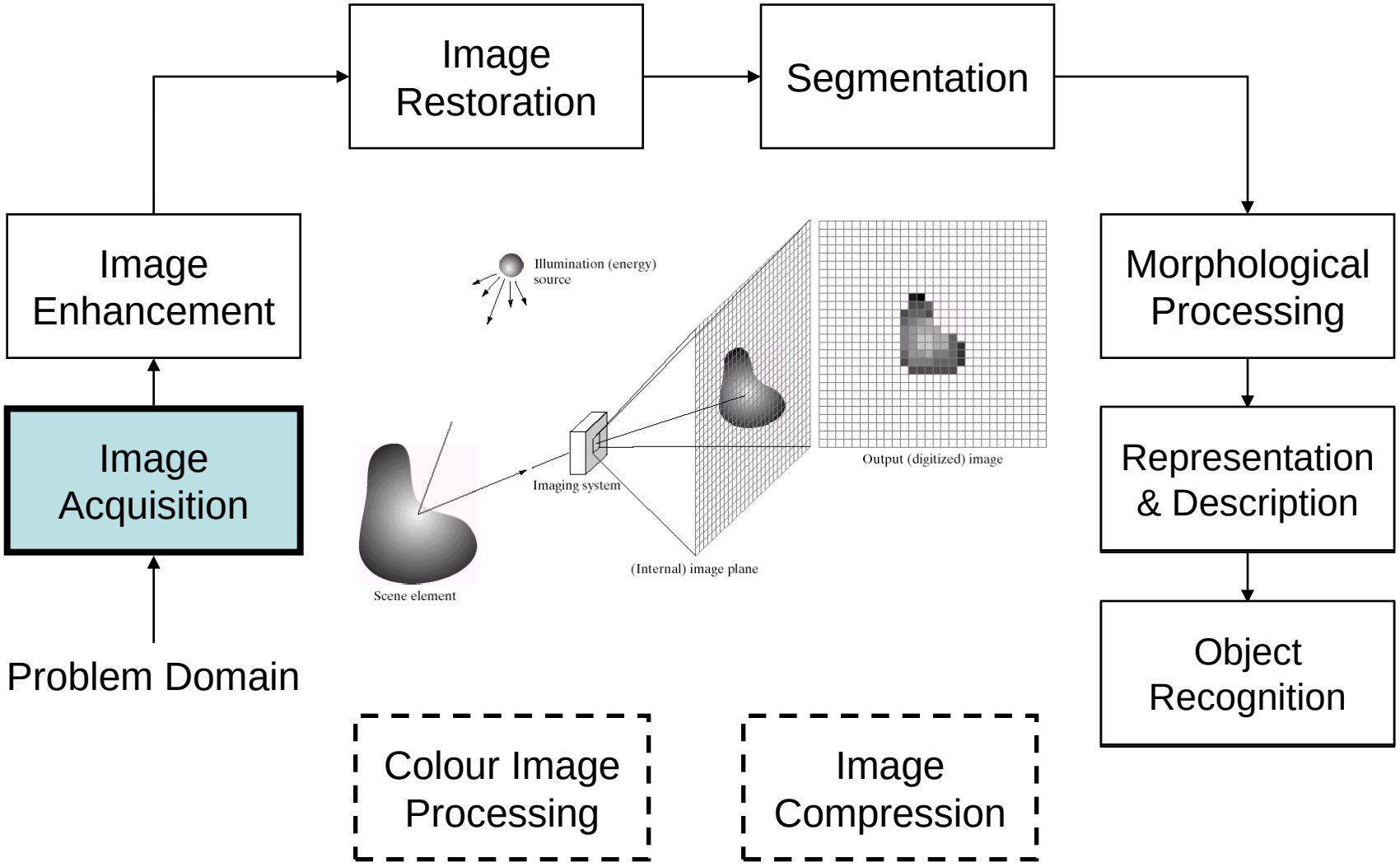




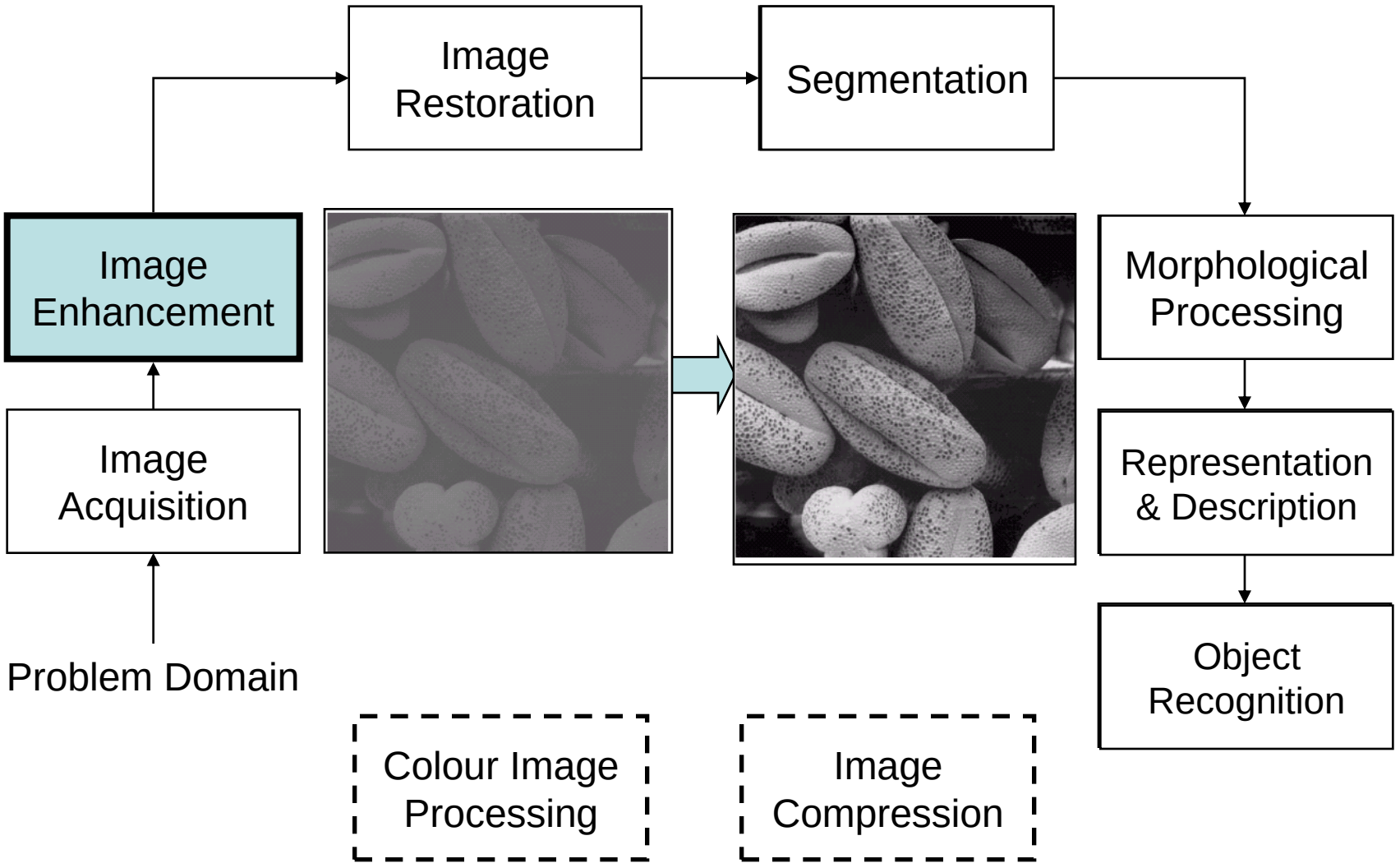
Key Stages in Digital Image Processing



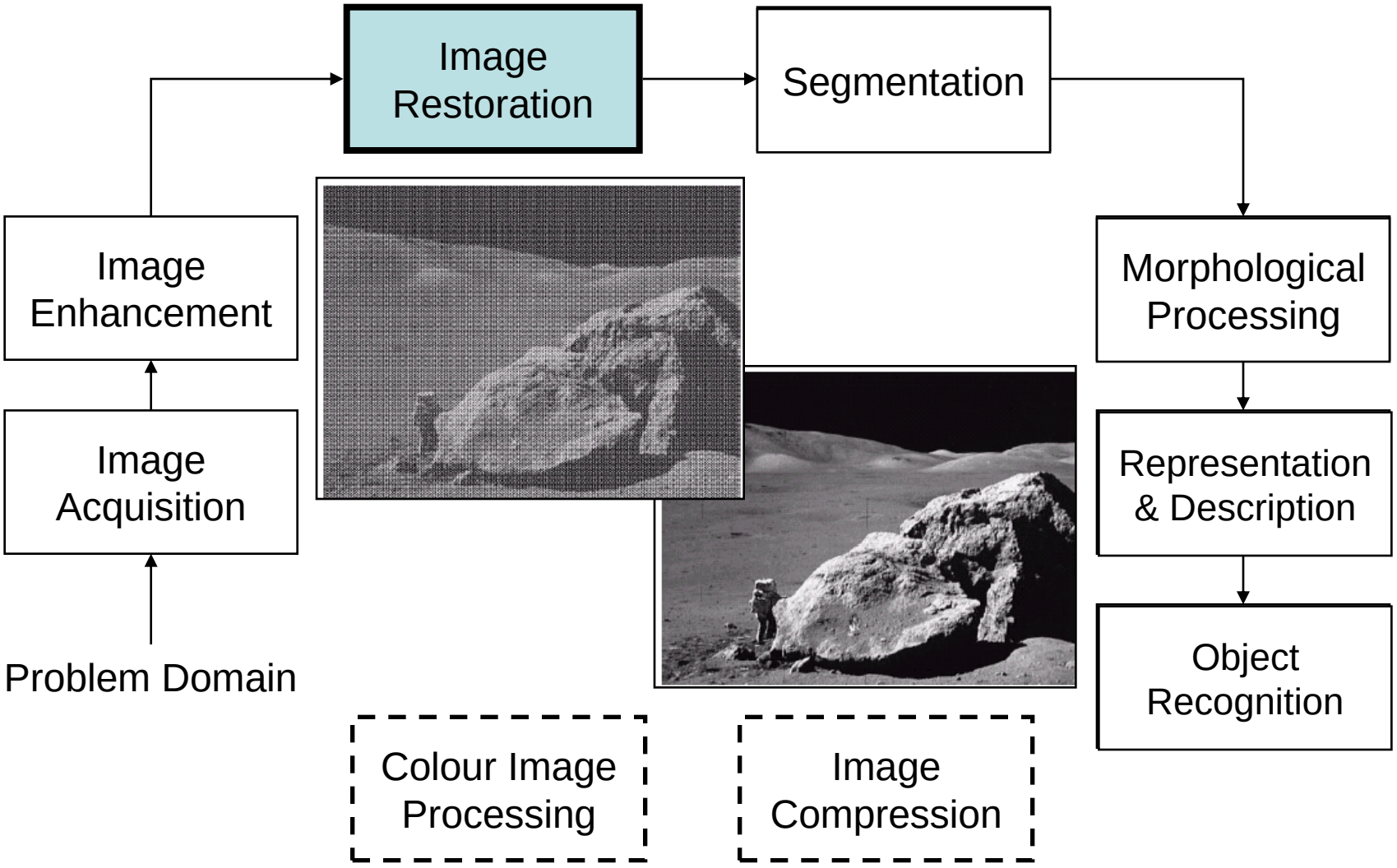
Key Stages in Digital Image Processing: Image Aquisition



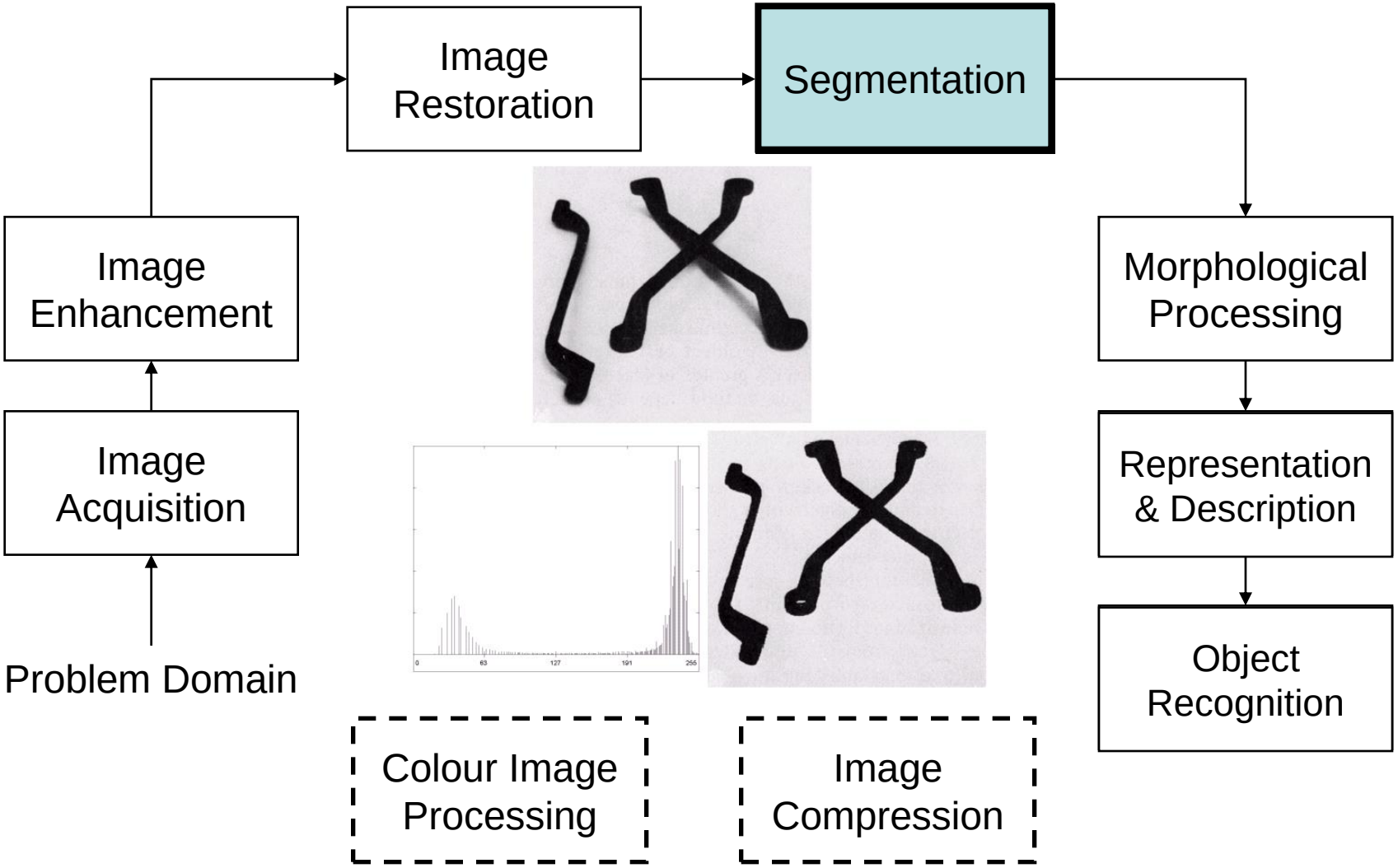
Key Stages in Digital Image Processing: Image Enhancement



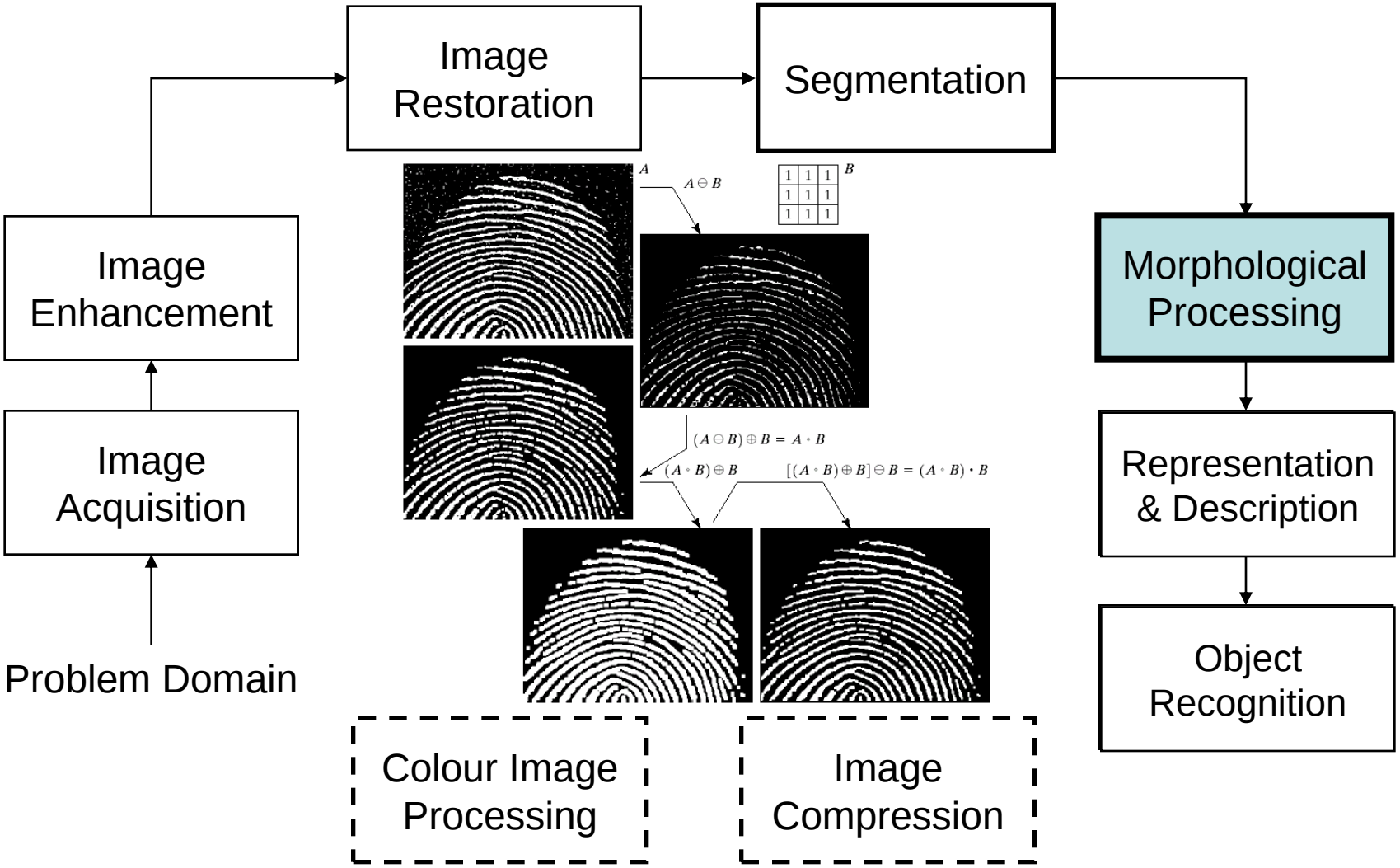
Key Stages in Digital Image Processing: Image Restoration



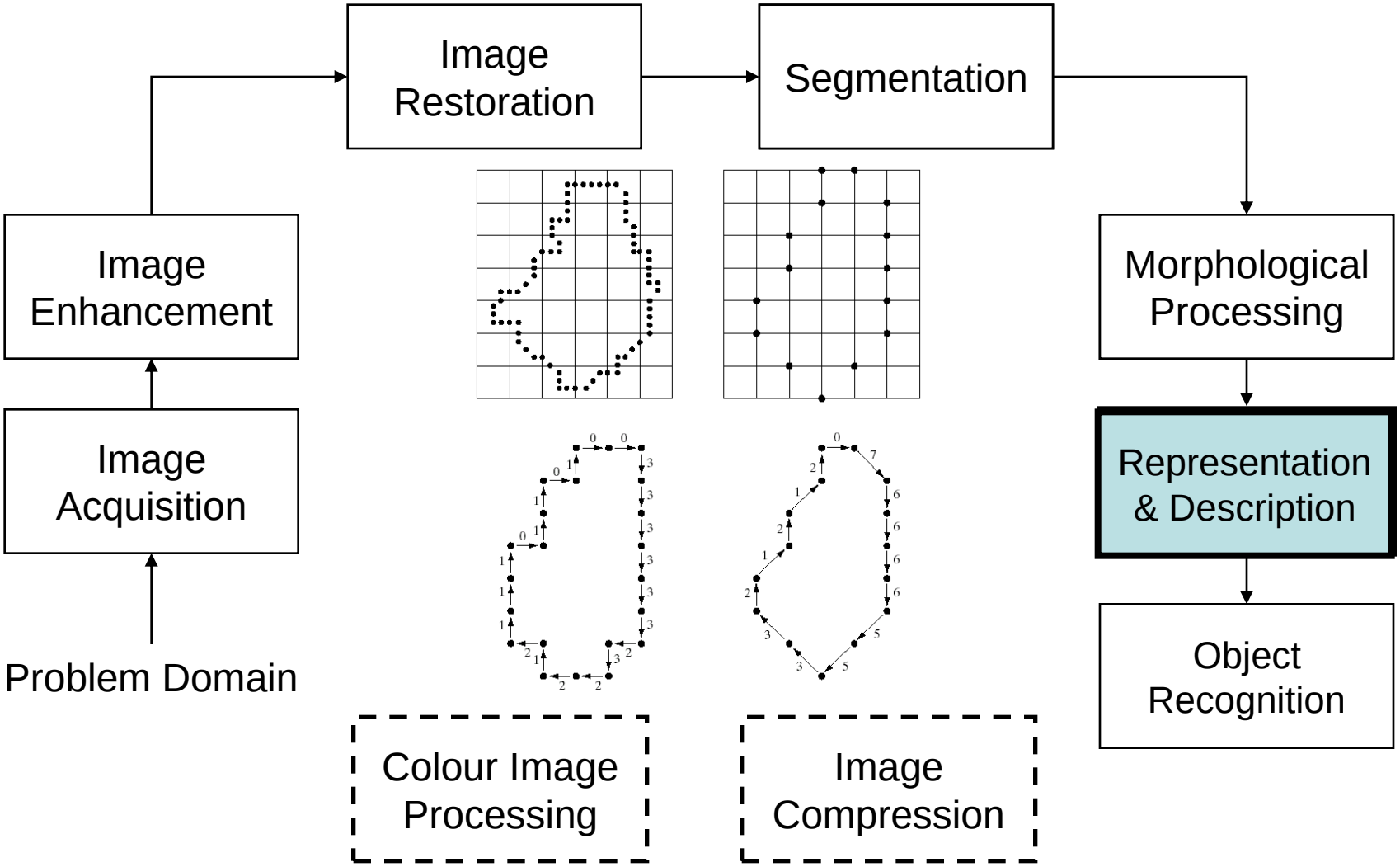
Key Stages in Digital Image Processing: Segmentation



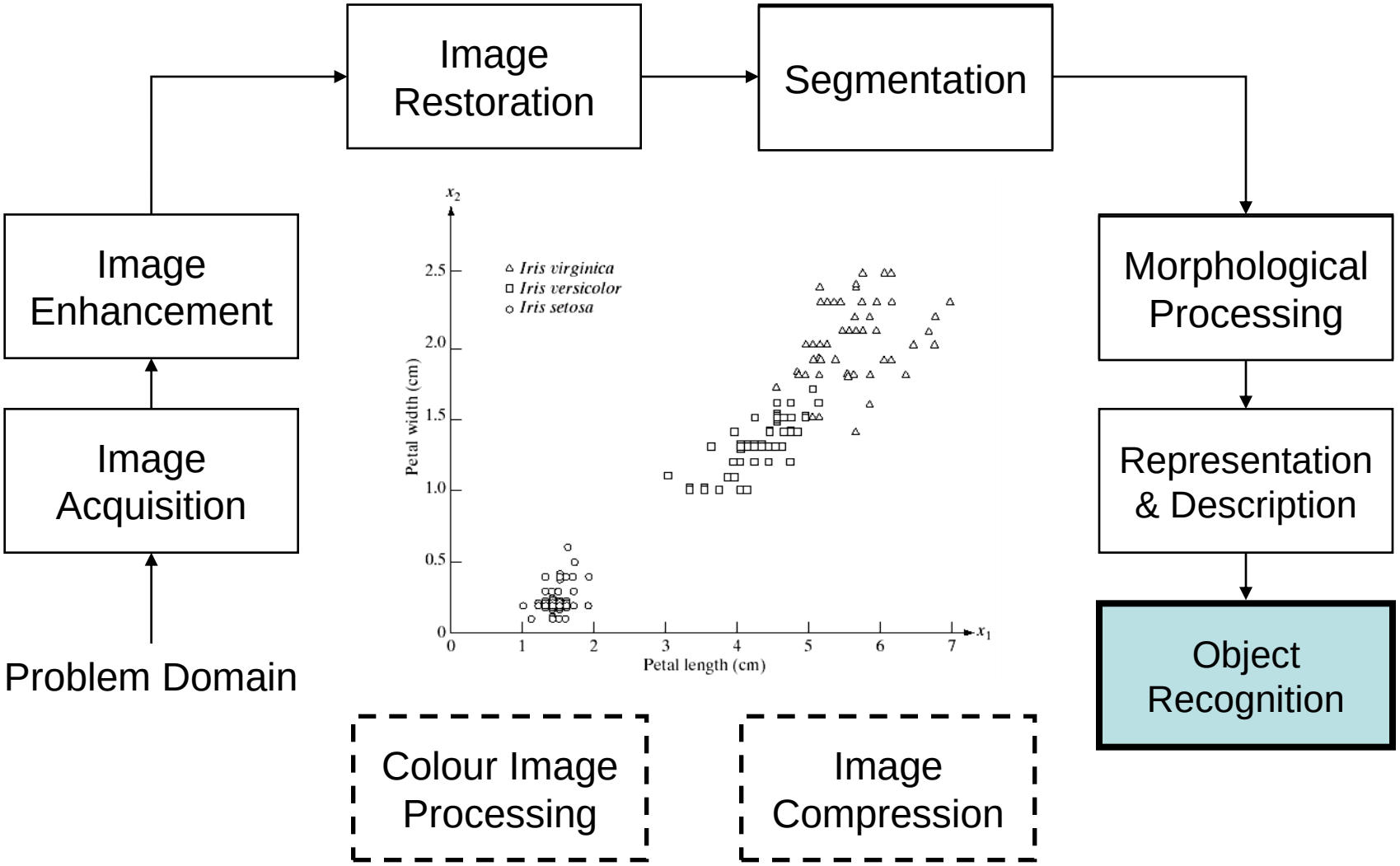
Key Stages in Digital Image Processing: Morphological Processing



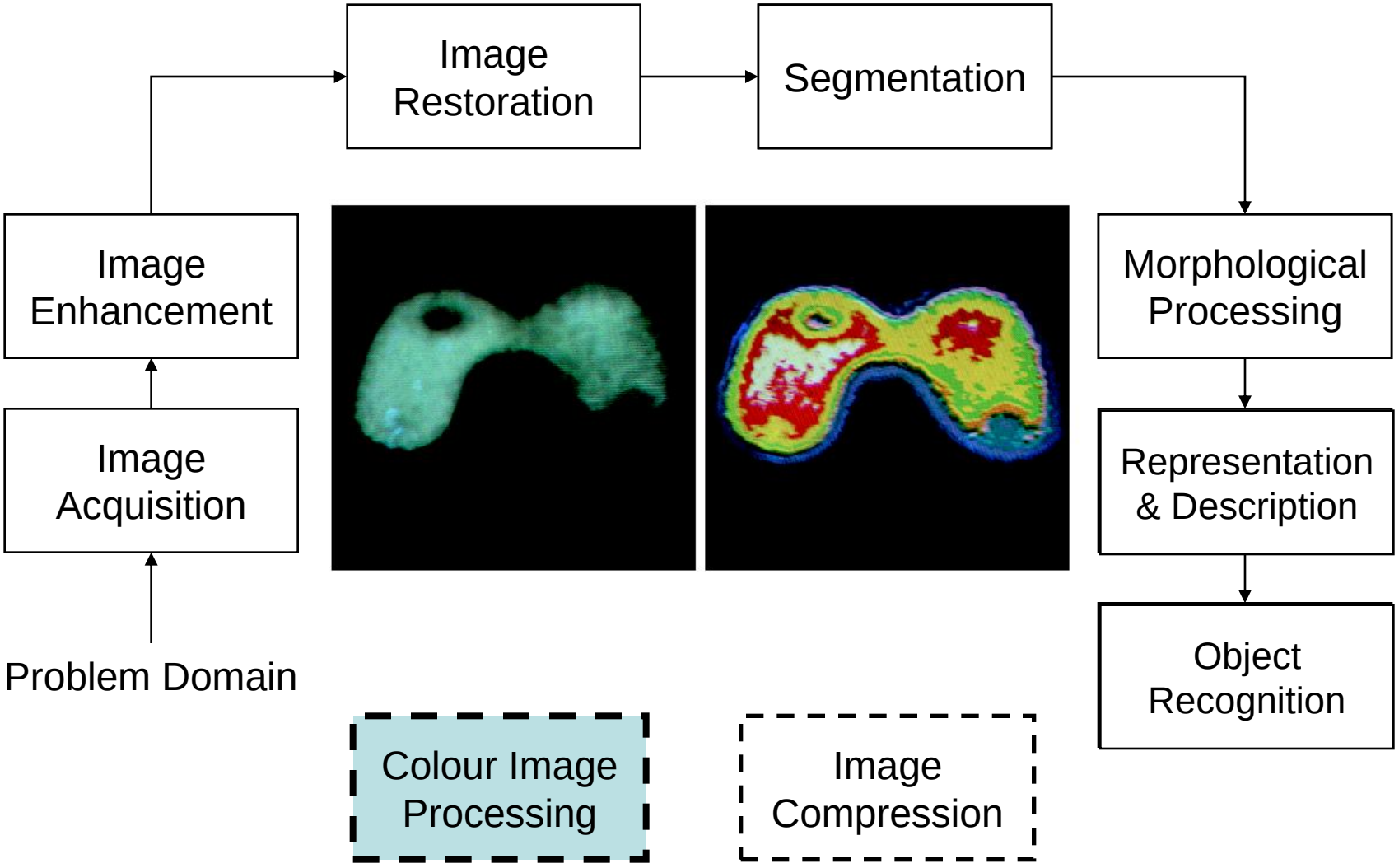
Key Stages in Digital Image Processing: Representation & Description



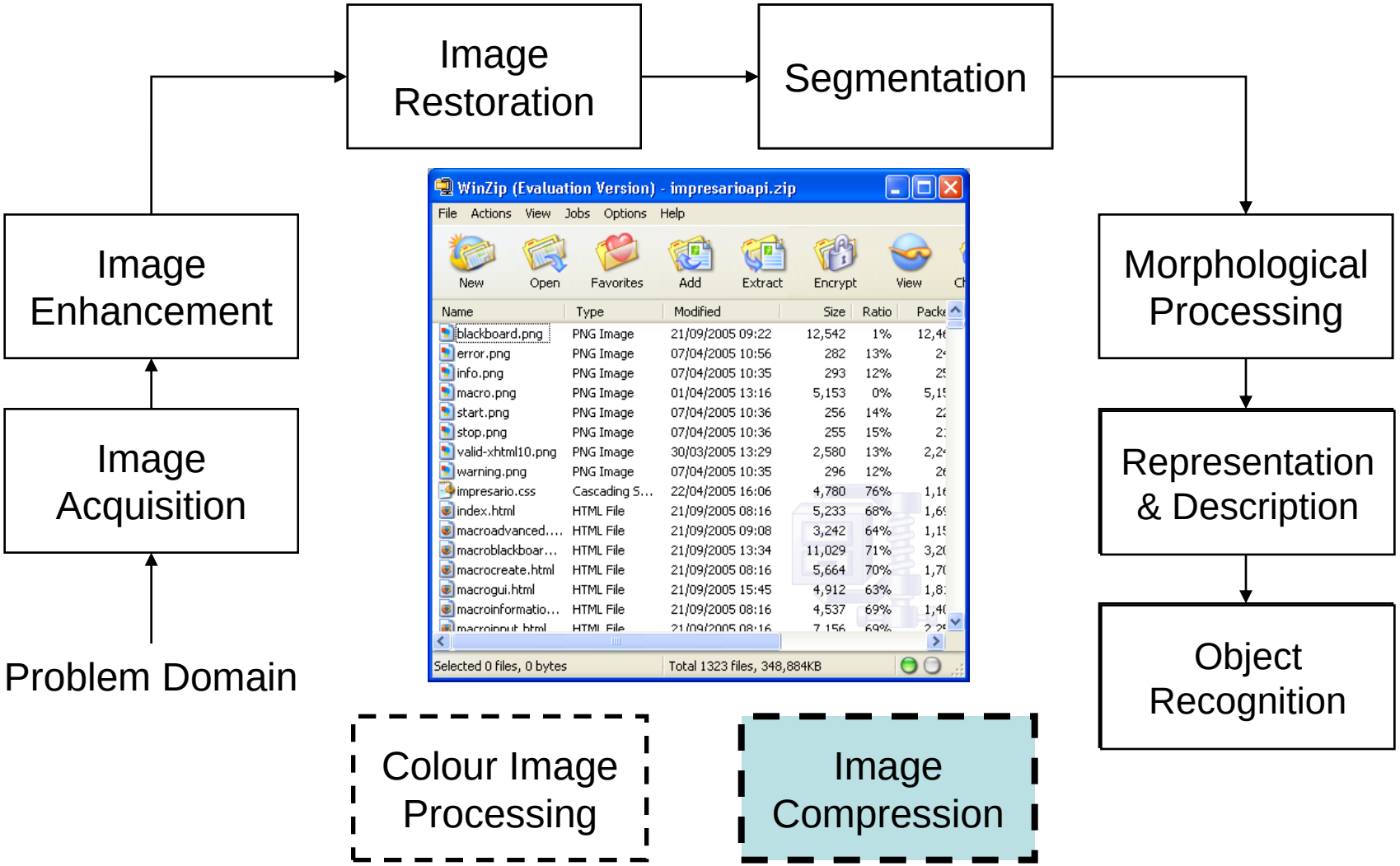
Key Stages in Digital Image Processing: Object Recognition



Key Stages in Digital Image Processing: Colour Image Processing

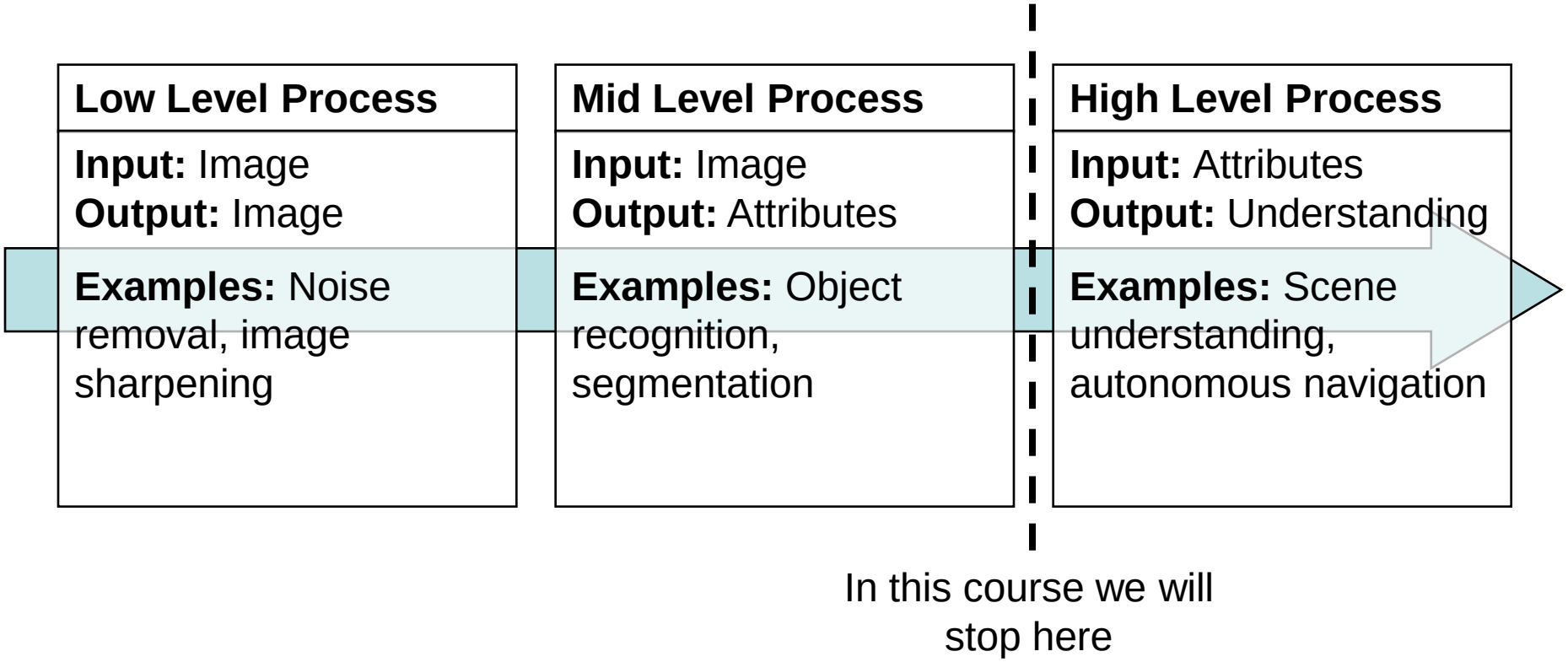


Key Stages in Digital Image Processing: Image Compression



Scope of this course

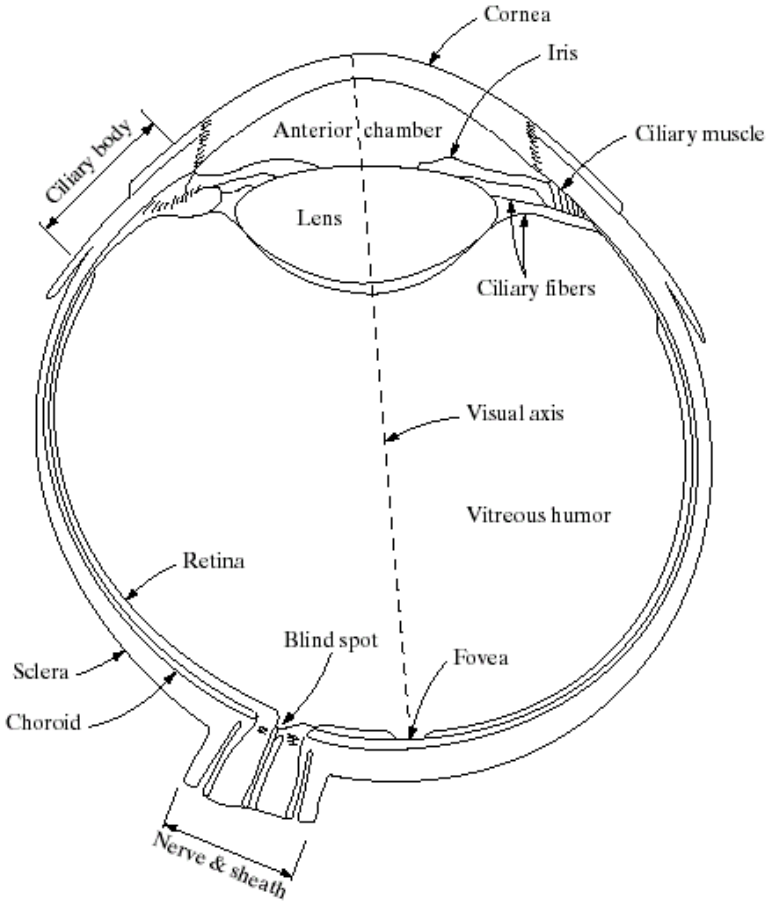
The continuum from image processing to computer vision can be broken up into low-, mid- and high-level processes

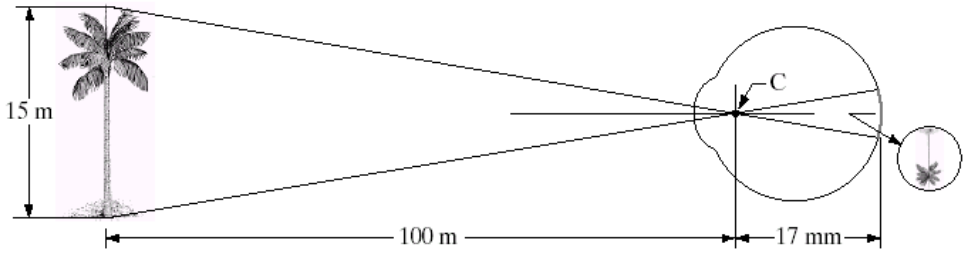


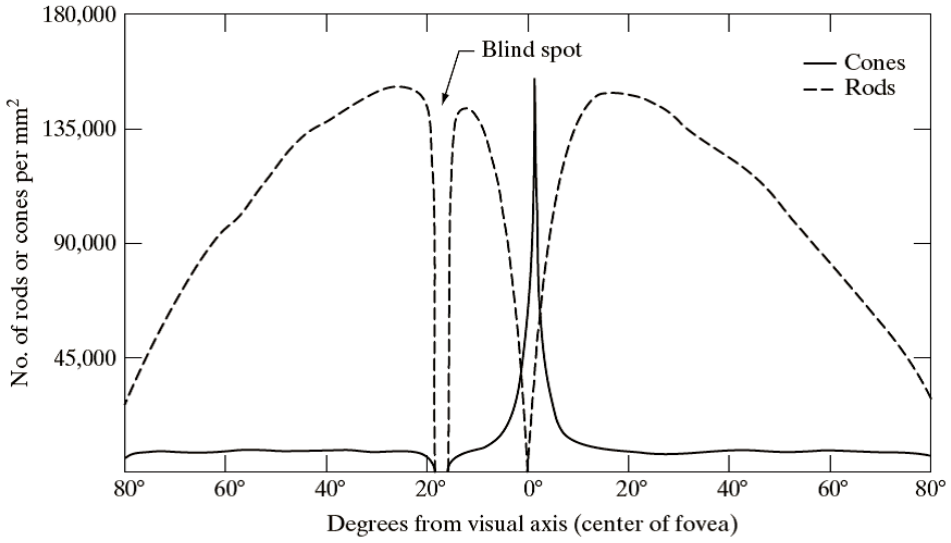
The Human Visual System

- Understanding of the human visual system can help in appreciating how computer vision systems might be designed.
- Human intuition and analysis based on visual judgement can play a significant role in choice of one technique over other.
- Given the complexity of vision model we will just look at a rudimentary aspects of the human visual system

Structure Of The Human Eye







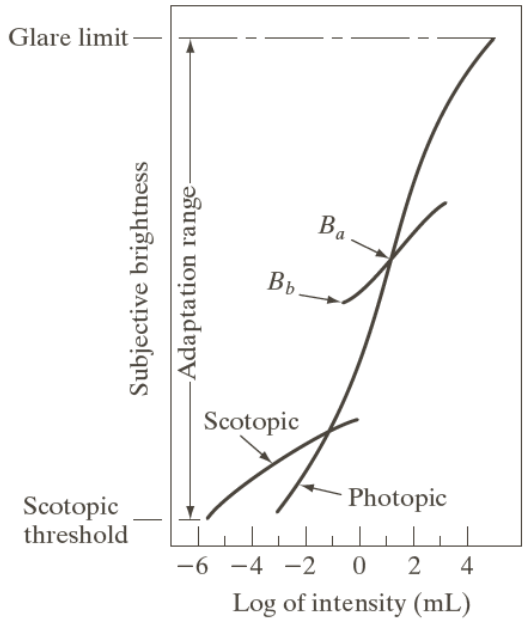
Blind-Spot Experiment

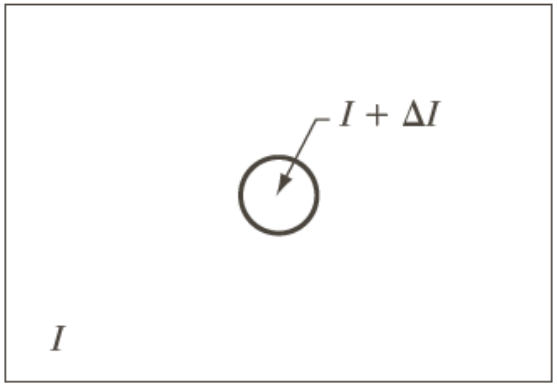
- Draw an image similar to that below on a piece of paper (the dot and cross are about 6 inches apart)

- Close your right eye and focus on the cross with your left eye
- Hold the image about 20 inches away from your face and move it slowly towards you
- The dot should disappear!

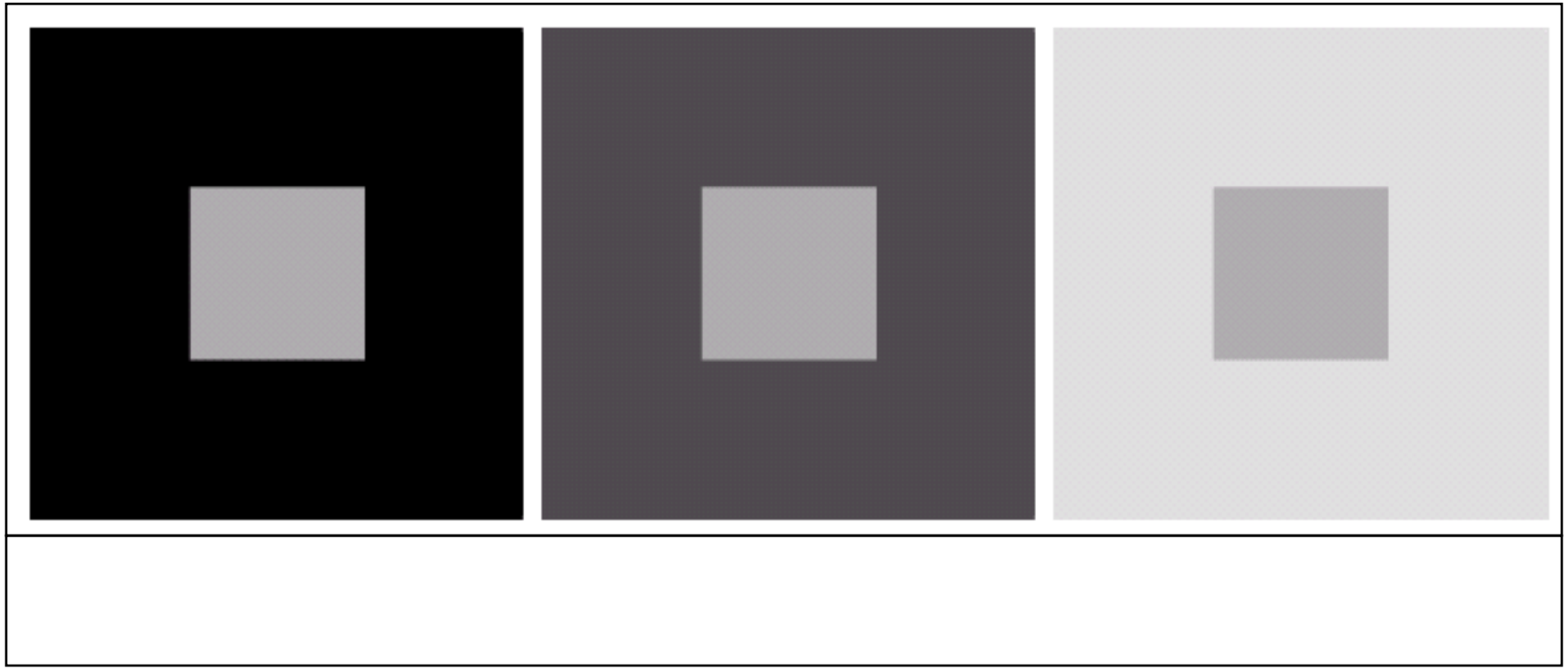
Brightness Adaptation & Discrimination

- The human visual system can perceive approximately 10^{10} different light intensity levels
- However, at any one time we can only discriminate between a much smaller number – *brightness adaptation*
- Similarly, the *perceived intensity* of a region is related to the light intensities of the regions surrounding it



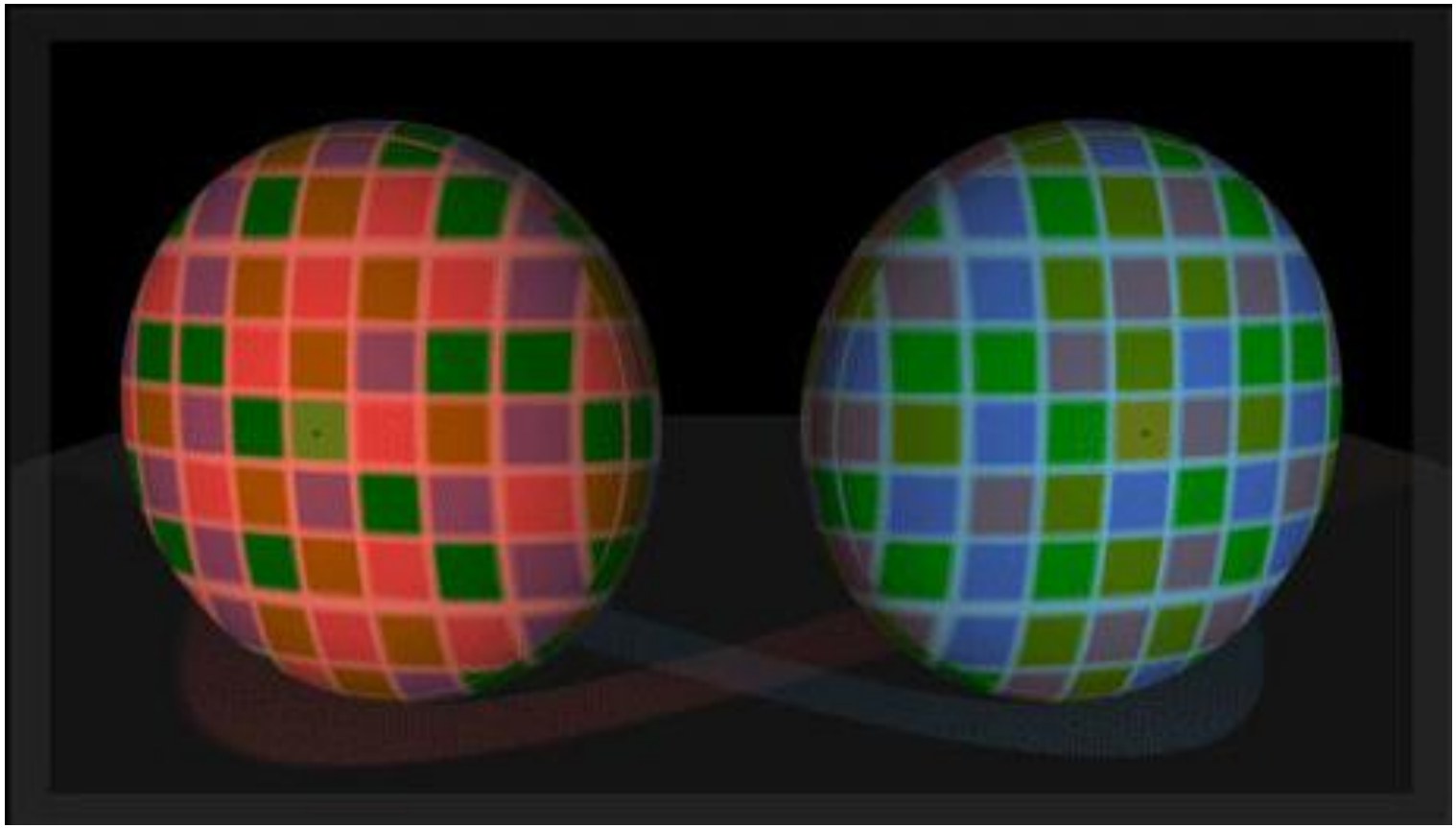


Brightness Adaptation & Discrimination (cont…)



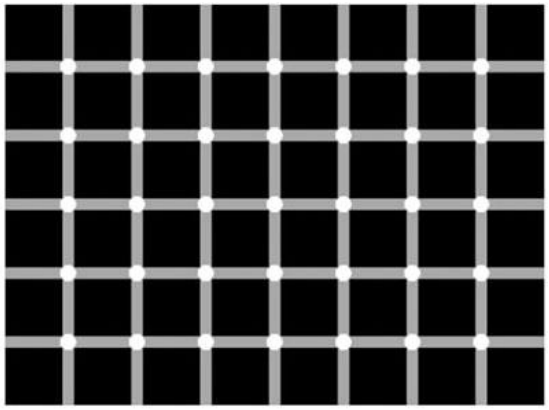
Images taken from Gonzalez & Woods, Digital Image Processing (2002)

Color Adaptation

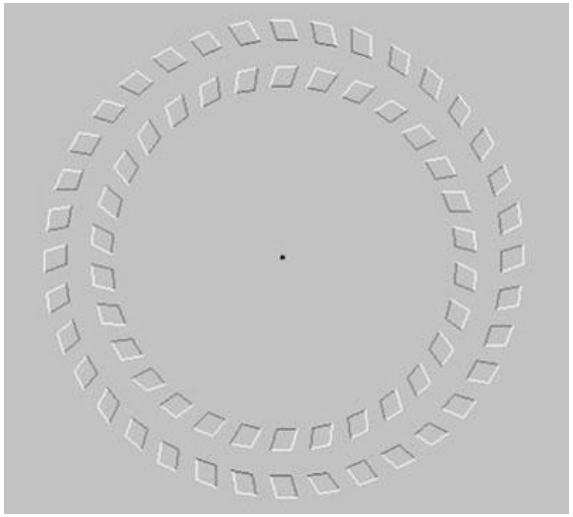


Available here: http://www.lottolab.org/Visual%20Demos/Demo%2015.html

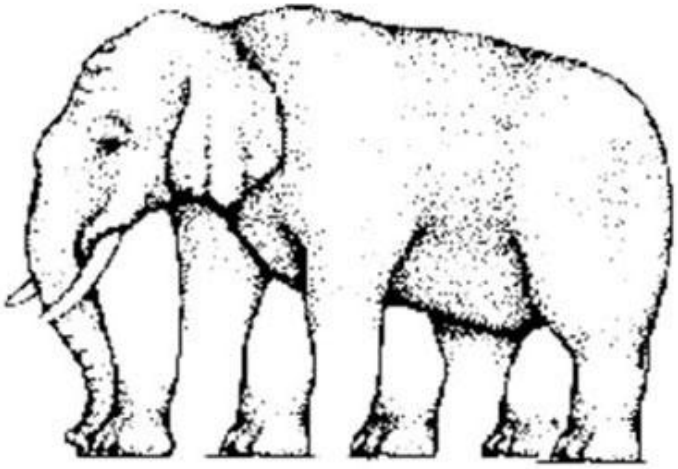
Optical Illusions



Are the dots in between the squares white, black or grey?



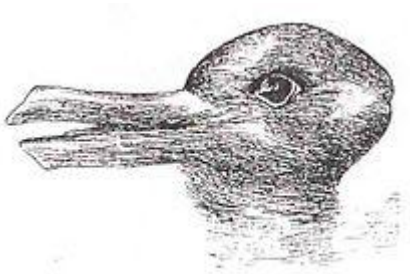
Focus on the dot in the middle and then move your head backwards and forwards.

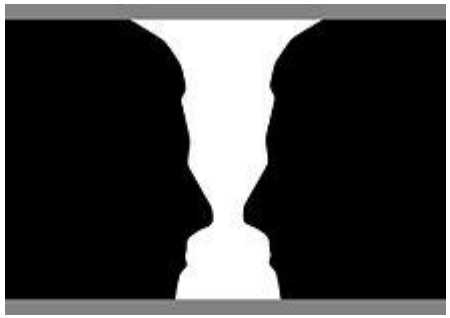


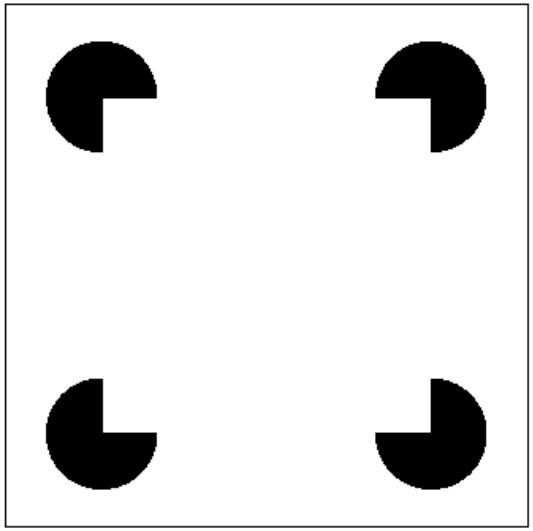
How many legs does this elephant have?

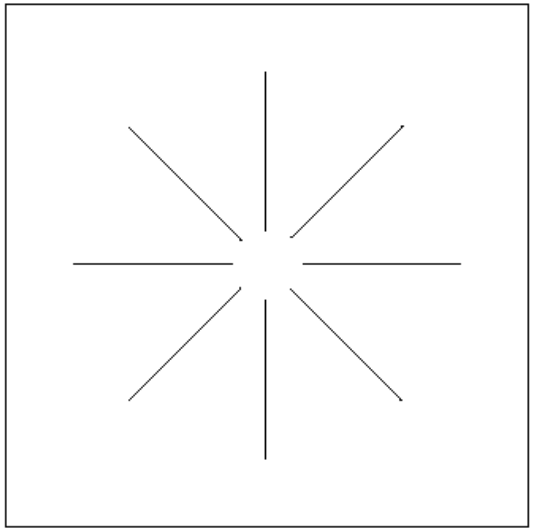
Is this the face of a lady or a word?

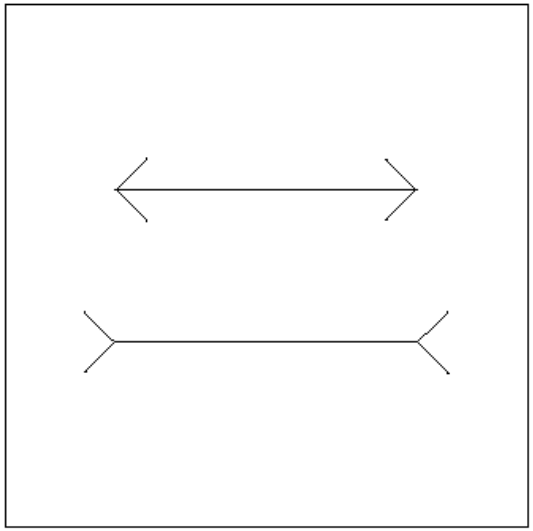
Optical Illusions

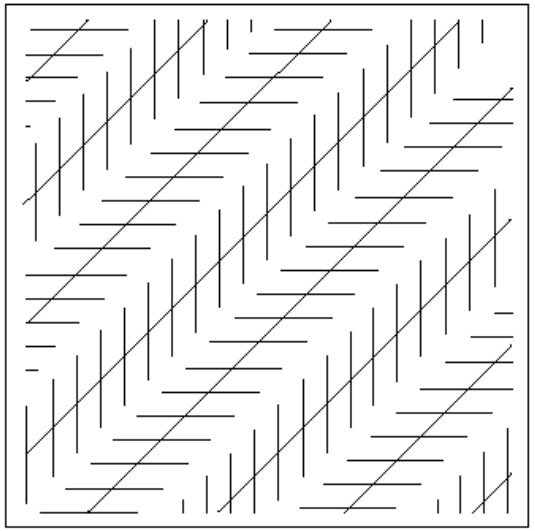




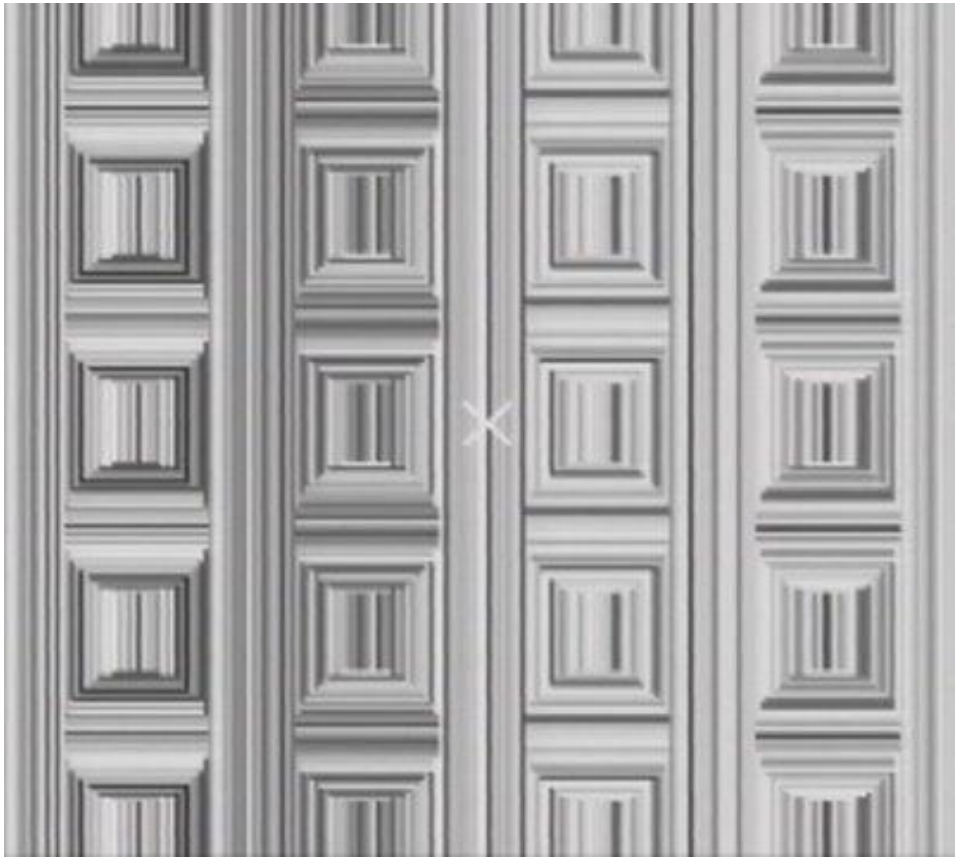




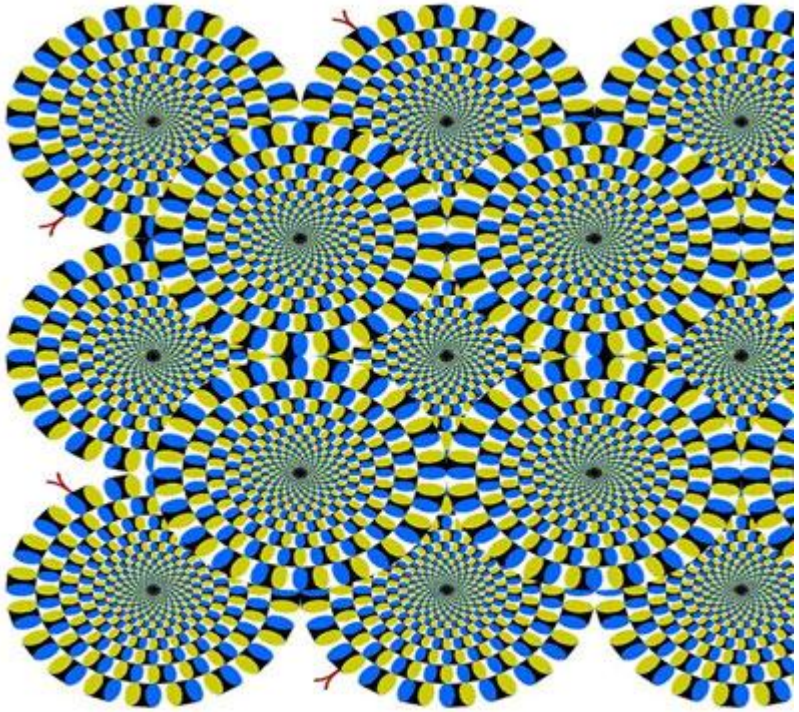




Optical Illusions



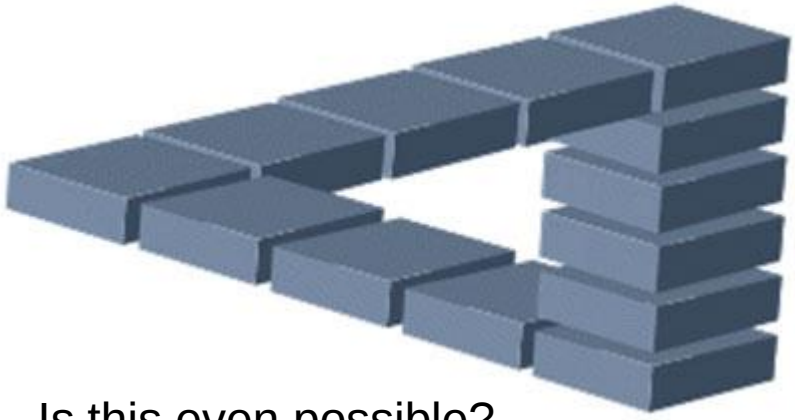
Stare at the cross in the middle of the image and think circles



Is this picture still or moving?

Optical Illusions

Is the ladder going up or down?

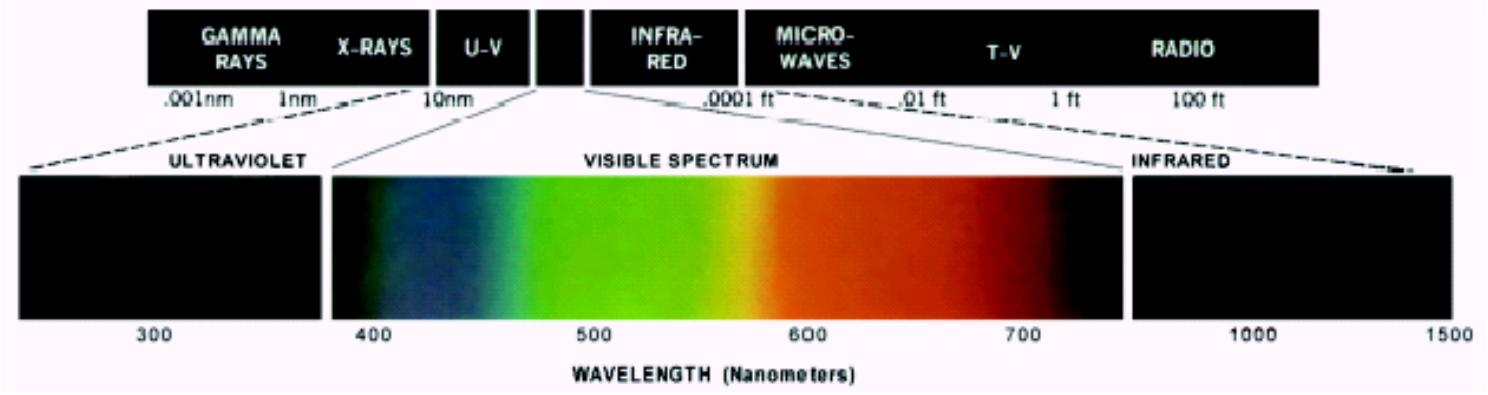


Is this even possible?

Focus on the 4 dots in the middle of the picture for 30 seconds. Then look at a blank wall - who do you see? Maybe blink your eyes a few times to find out.

Sources of Digital Images

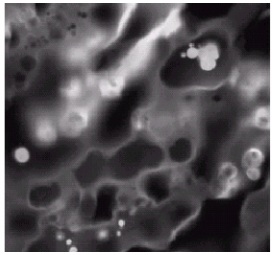
- The principal source for the images is the electromagnetic (EM) energy spectrum.
- The electromagnetic spectrum is split up according to the wavelengths of different forms of energy



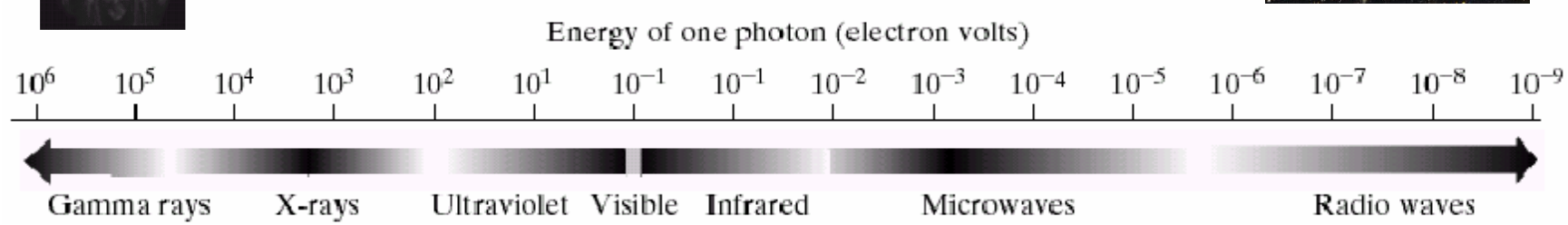
Imaging in EM spectrum

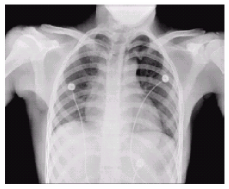
Positron Emission Tomography

Fluorescence image of corn

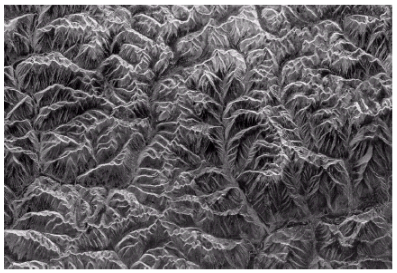


infrared Imaging





Chest X-ray

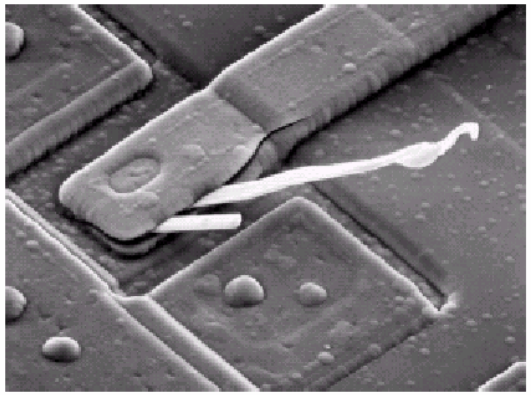


Radar Image

Other Non-Electro-Magnetic Imaging Modalities

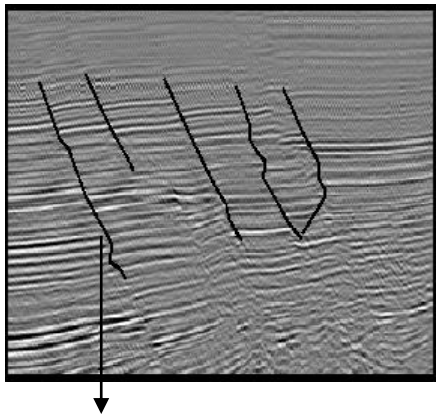
Ultrasound imaging

Electron microscopy



visible

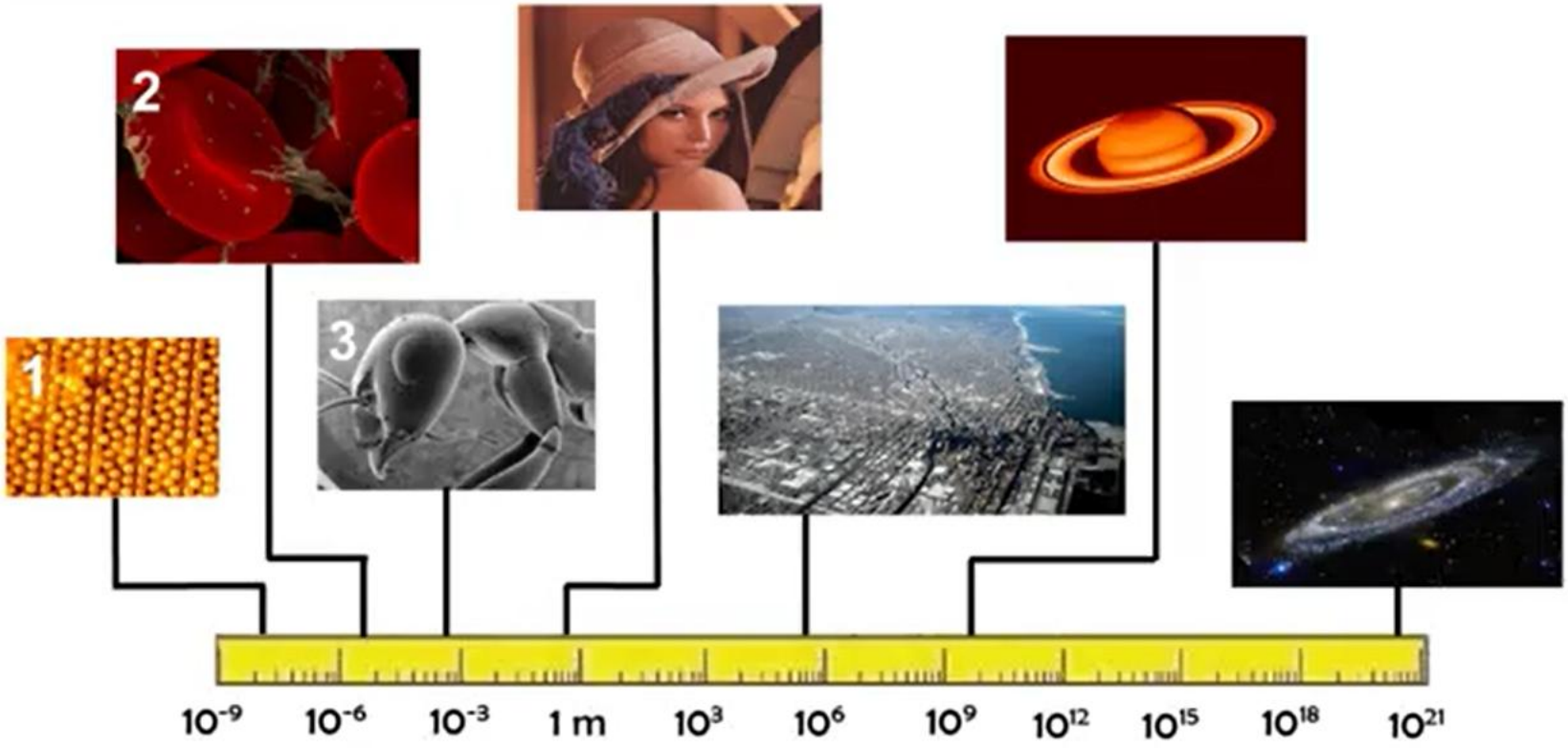
seismic



potential locations of oil/gas

Computer generated

Range/scale of imaged objects



Summary

We have looked at:

- What is digital image and video processing?
- History of DIP
- Some important applications of DIP
- Key stages in DIP
- The human visual system
- Imaging beyond visible spectrum

Next we will begin to delve in details of the stages in DIP…