



# Digital Image Processing

Lecture No: 02



# What is Digital Image Processing?

- An image may be defined as a two-dimensional function  $f(x,y)$  where  $x$  and  $y$  are spatial (plane) coordinates.
- Amplitude of  $f$  at any pair of coordinates is called “ **Intensity or gray level of the image**” at that point.
- $x,y$ , and the amplitude values of  $f$  are all finite, discrete quantities, the image is called as “**Digital Image**”
- Image is composed of a finite number of elements with particular location and value.



## What is DIP (Cont'd...)

- These elements are referred to as *picture elements, image elements, pels, and pixels.*
- Image processing can be defined as a discipline in which both the input and output of a process are *images*.
- On the other hand, **computer vision** – whose ultimate goal is to use computers to emulate human vision, including learning and being able to make inferences and take actions based on visual inputs.



## What is DIP (Cont'd...)

Digital image processing focuses on three major tasks

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

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



## What is DIP (Cont'd...)

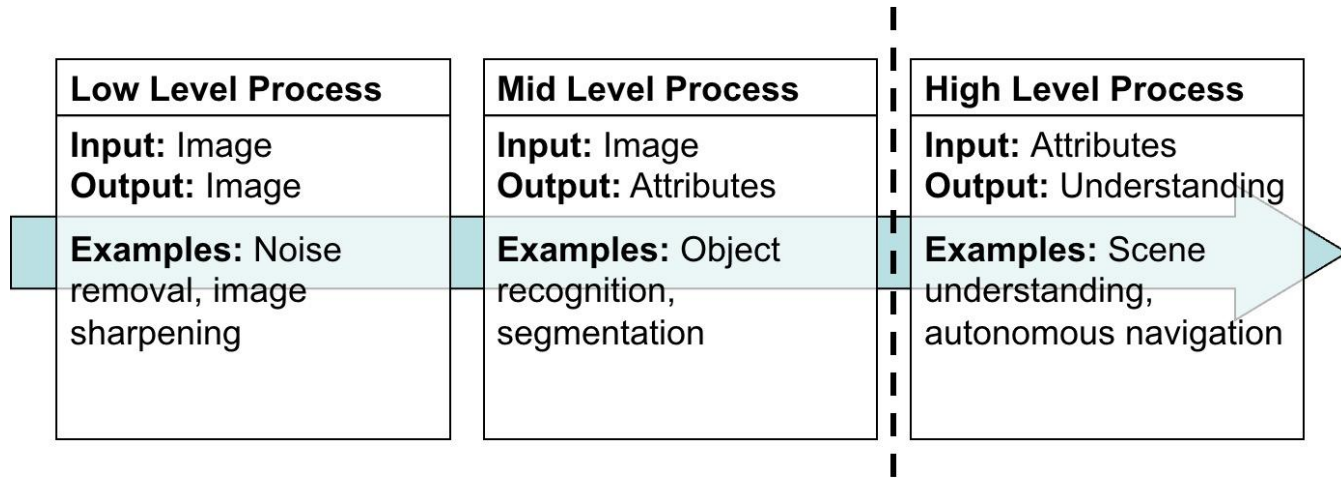
### **Human Perception**

Employ methods able to enhance pictorial information for human interpretation and analysis such as:

- Noise filtering
- Content enhancement
- Contrast enhancement
- Deblurring
- Remote sensing

# What is DIP (Cont'd...)

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



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

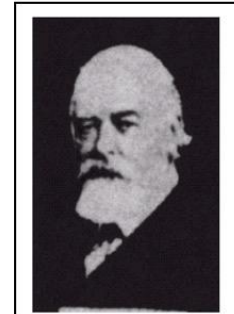


Early digital image

## History of DIP (Cont'd...)

**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



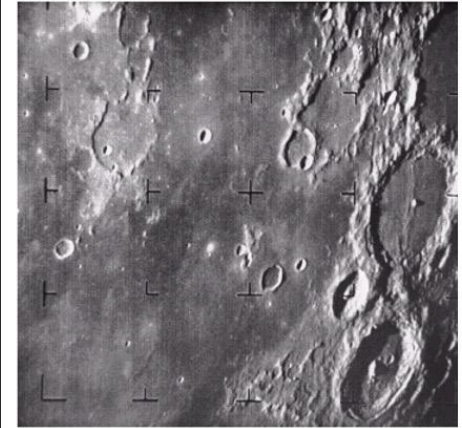
Early 15 tone digital  
image



## History of DIP (Cont'd...)

**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

## History of DIP (Cont'd...)

**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



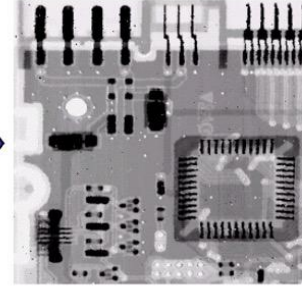
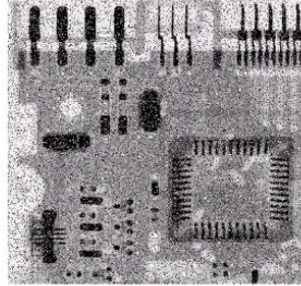
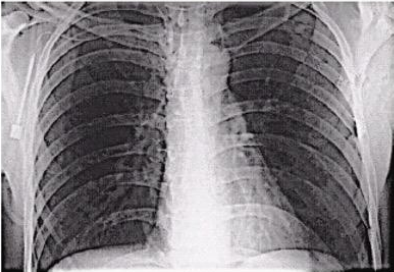
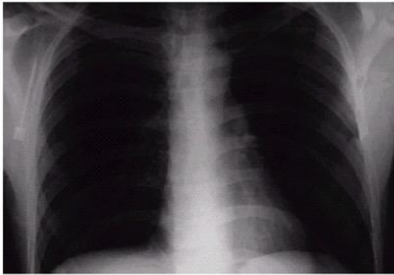
## History of DIP (Cont'd...)

**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



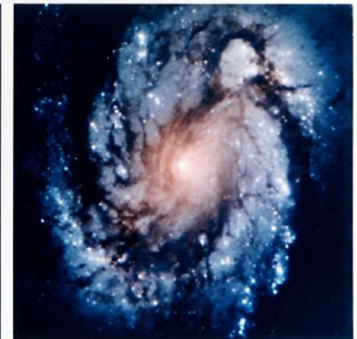
## Examples: The Hubble Telescope

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 and Pricella Camera 1



Wide Field and Pricella Camera 2

## Examples: Artistic Effects

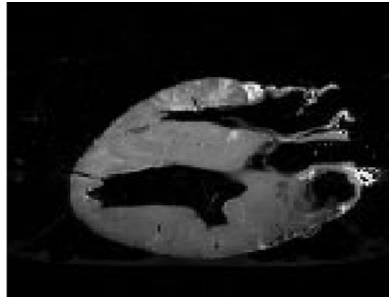
Artistic effects are used to make images more visually appealing, to add special effects and to make composite images



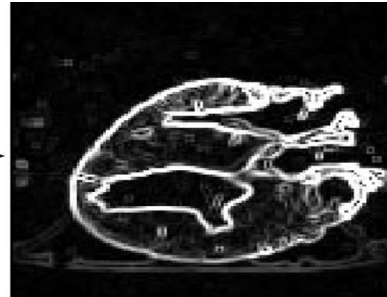
## Examples: Medicine

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



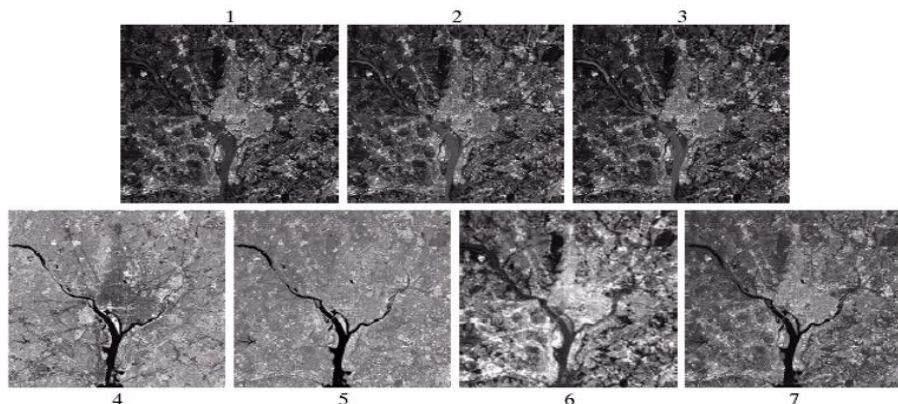
Edge Detection Image



# Examples: GIS

## Geographic Information Systems

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



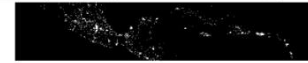
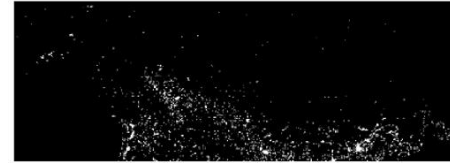


## Examples: GIS (Cont'd...)

### *Night-Time Lights of the World* data set

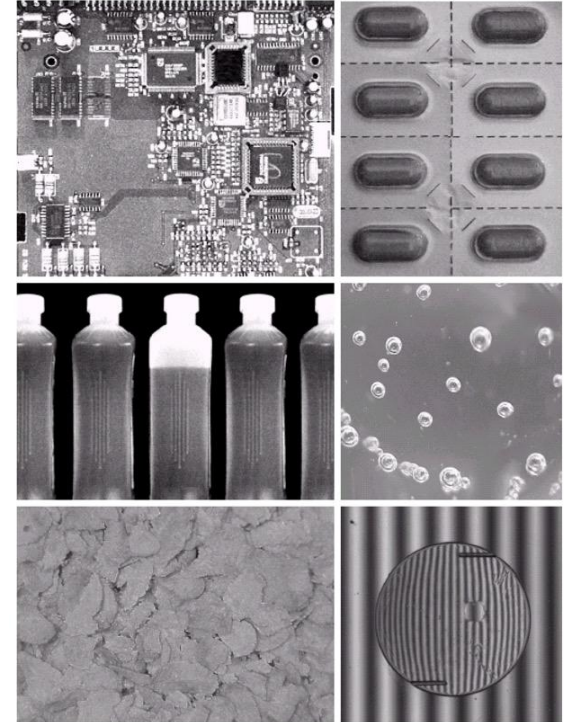
Global inventory of human  
settlement

Not hard to imagine the  
kind of analysis that might  
be done using this data



## Examples: Industrial Inspection

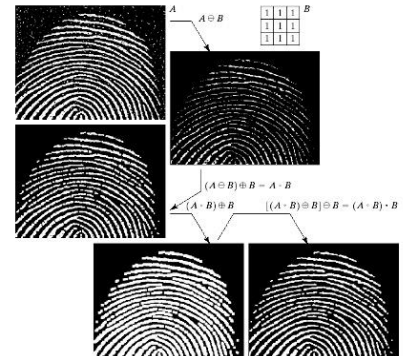
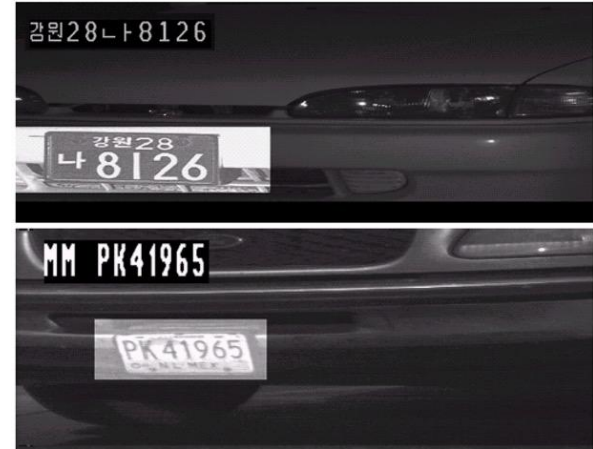
- Human operators are expensive, slow and unreliable
- Make machines do the job instead
- Industrial vision systems are used in all kinds of industries



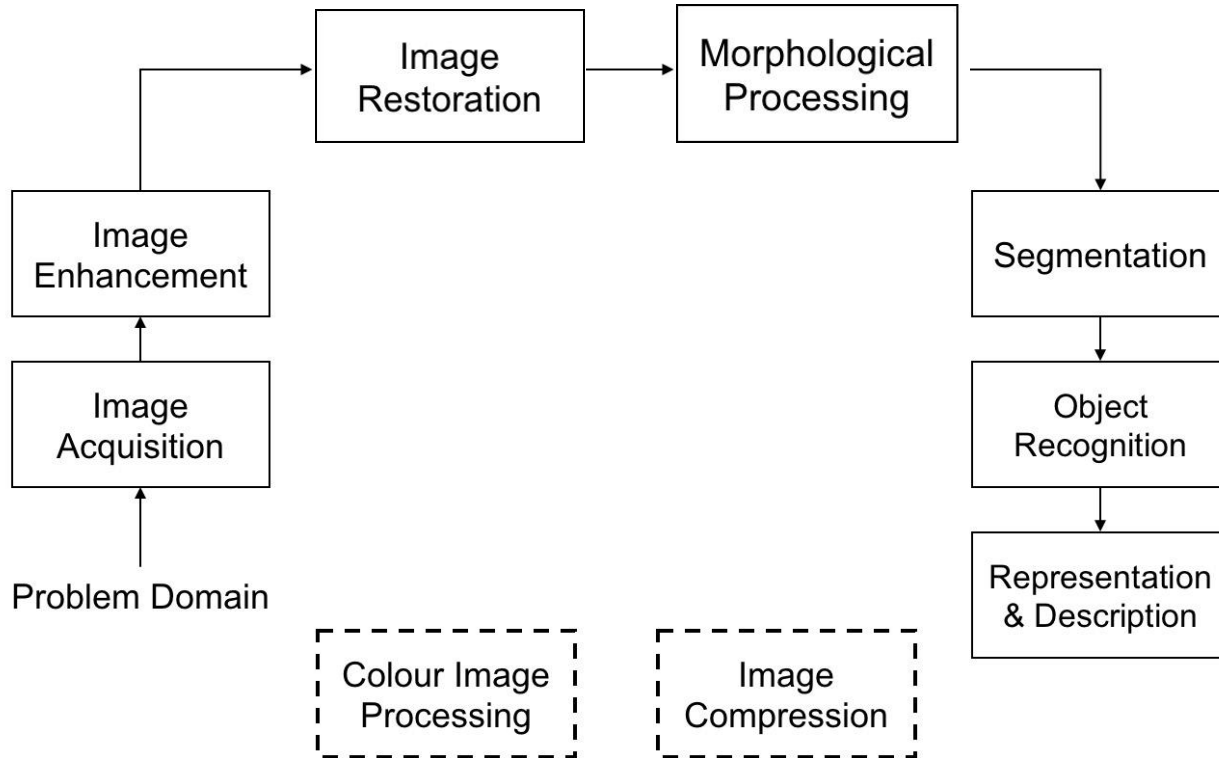
## Examples: Law Enforcement

Image processing techniques are used extensively by law enforcers

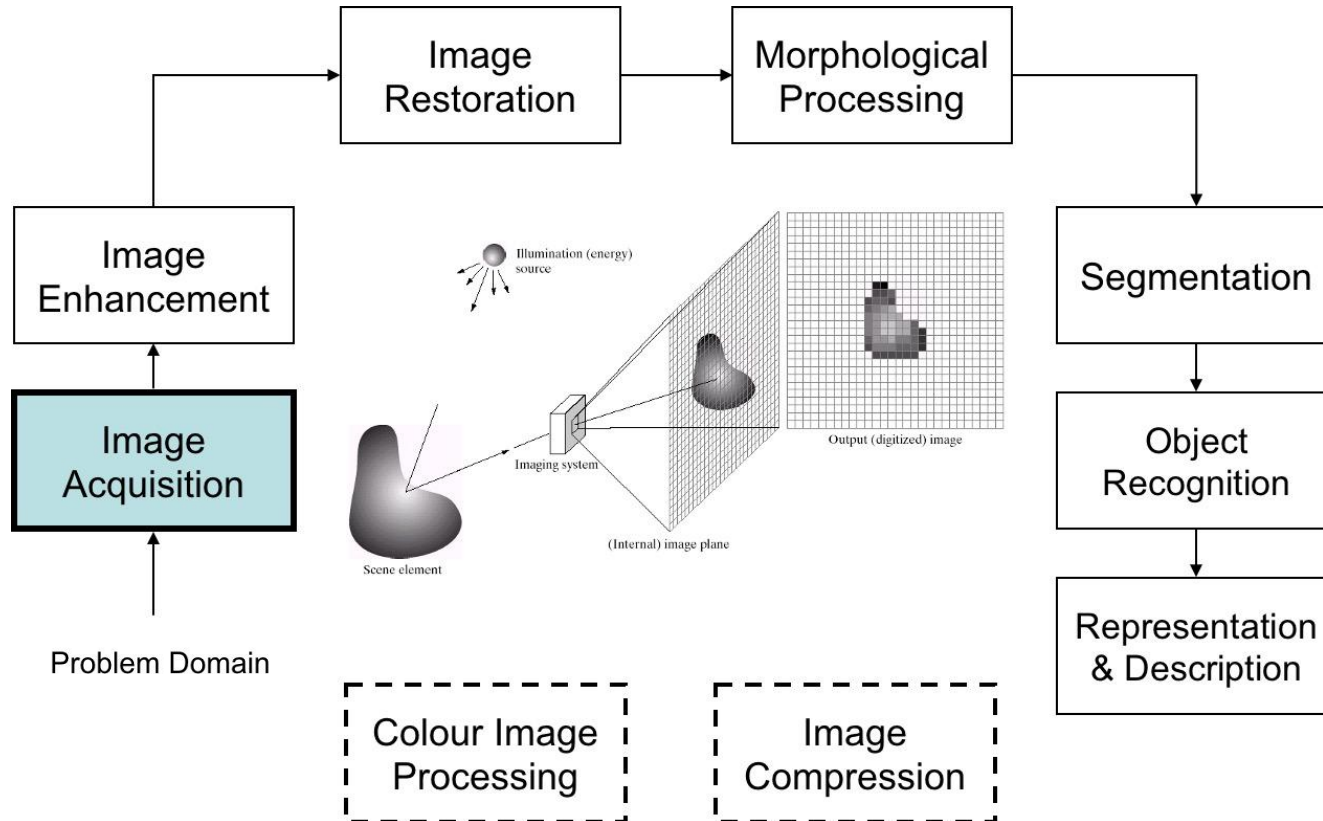
- Number plate recognition for speed cameras/automated toll systems
- Fingerprint recognition
- Enhancement of CCTV images



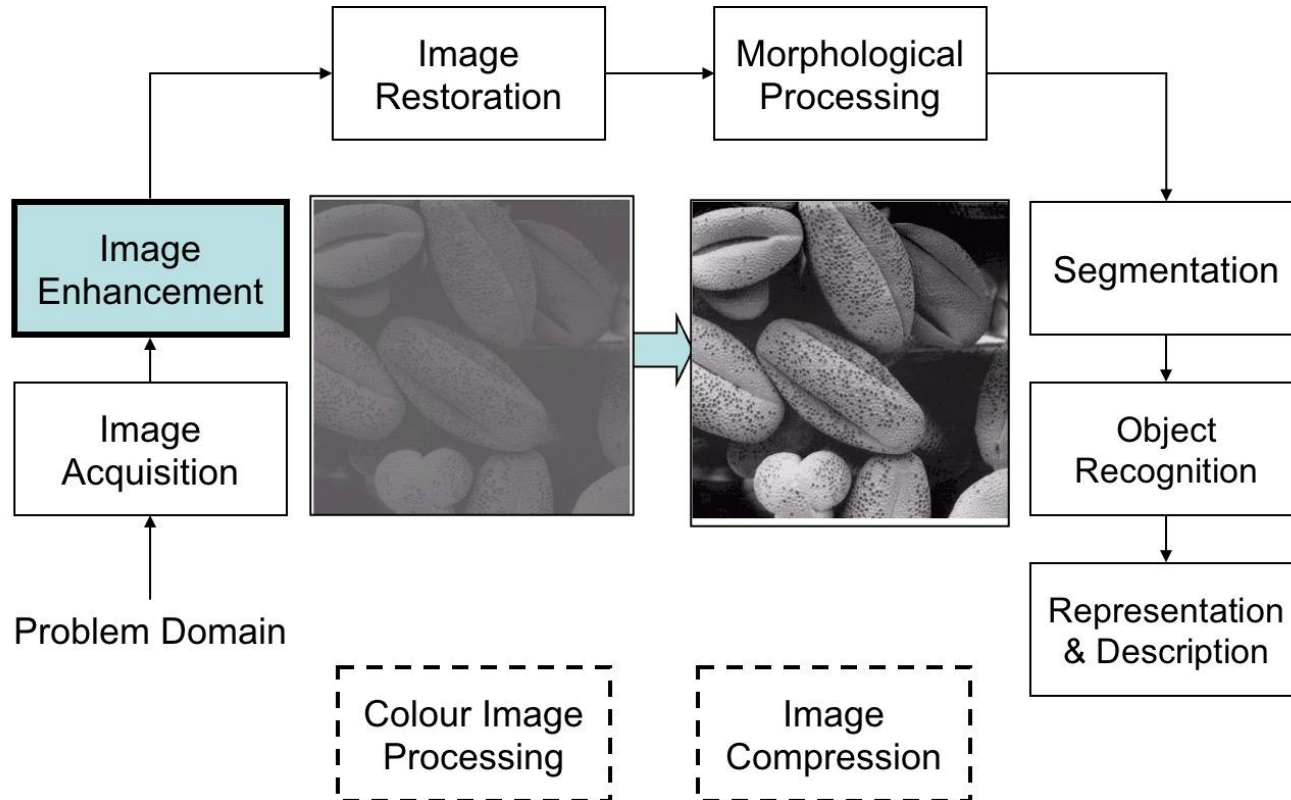
# Key Stages in Digital Image Processing



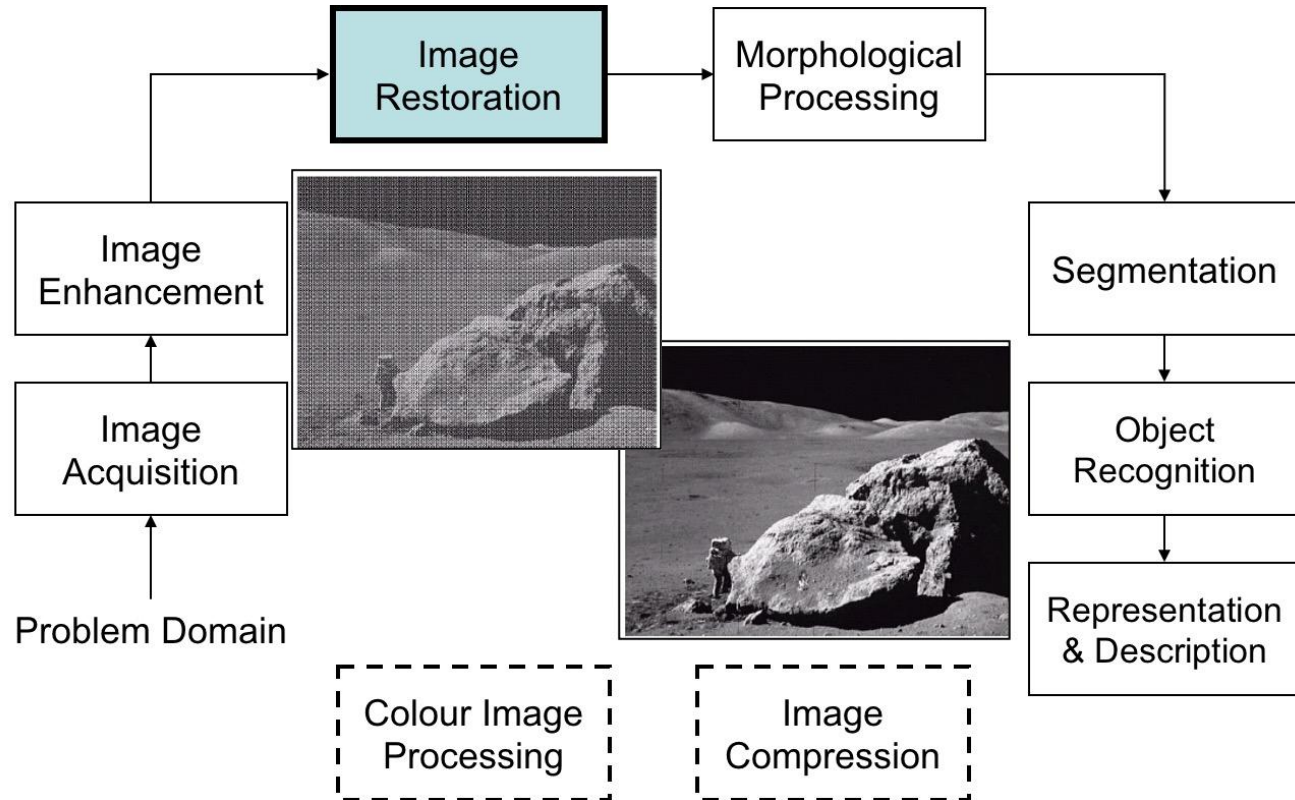
# Key Stages in Digital Image Processing: Image Aquisition



# Key Stages in Digital Image Processing: Image Enhancement

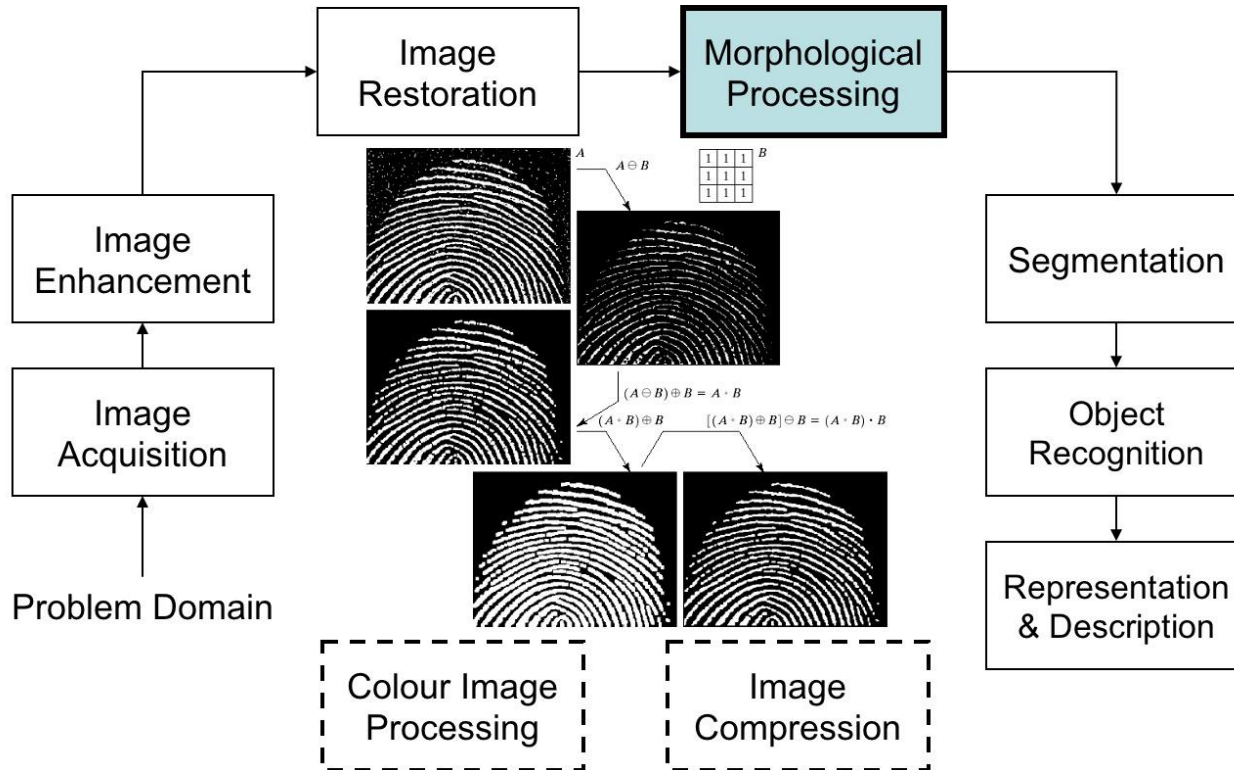


# Key Stages in Digital Image Processing: Image Restoration



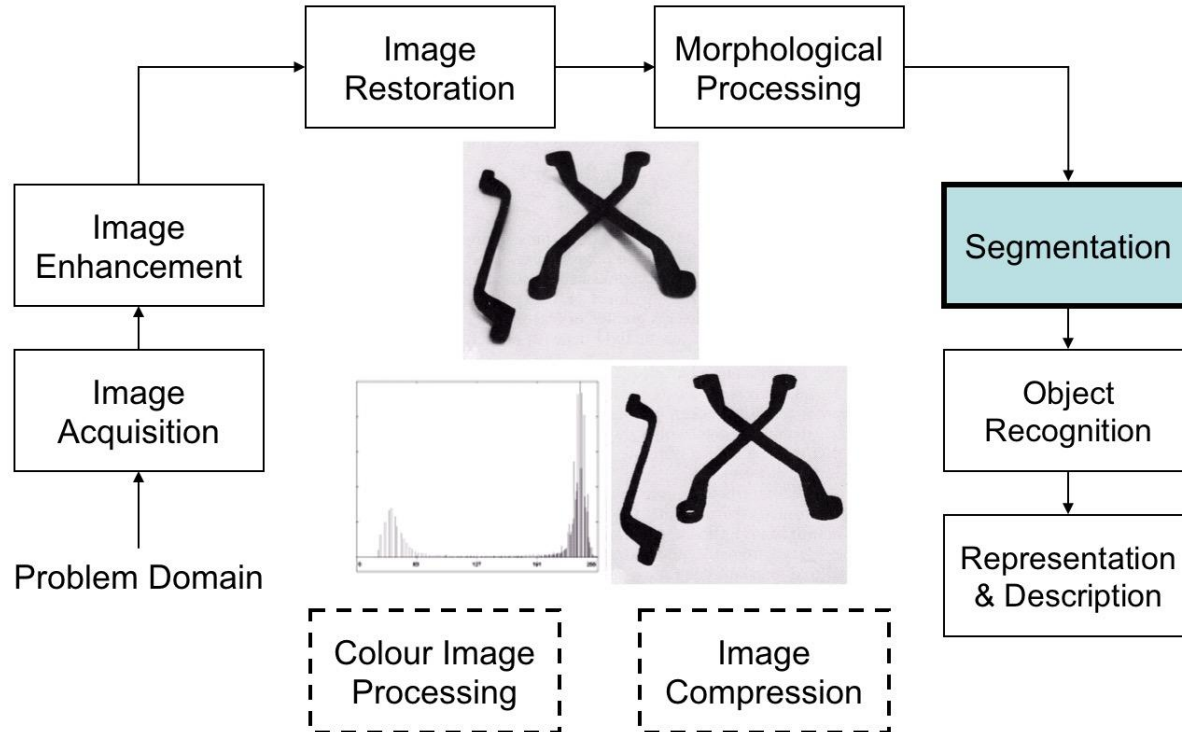
# Key Stages in Digital Image Processing:

## Morphological Processing

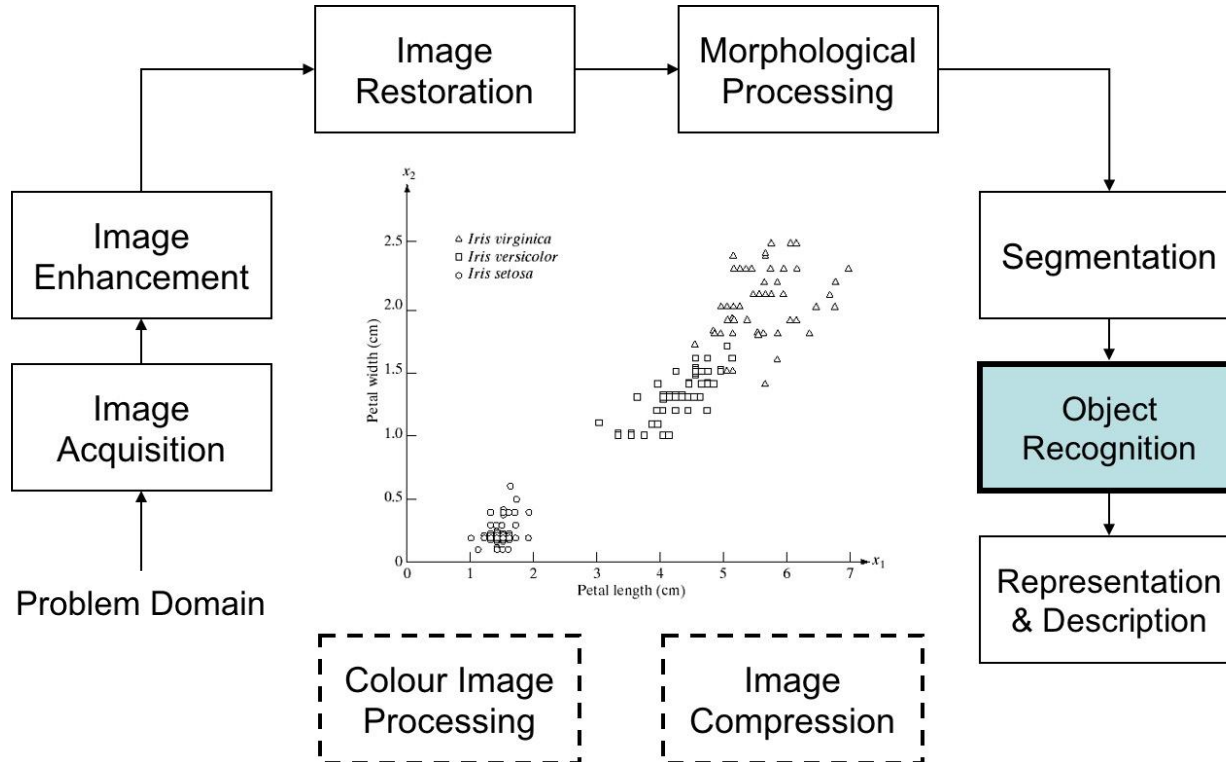




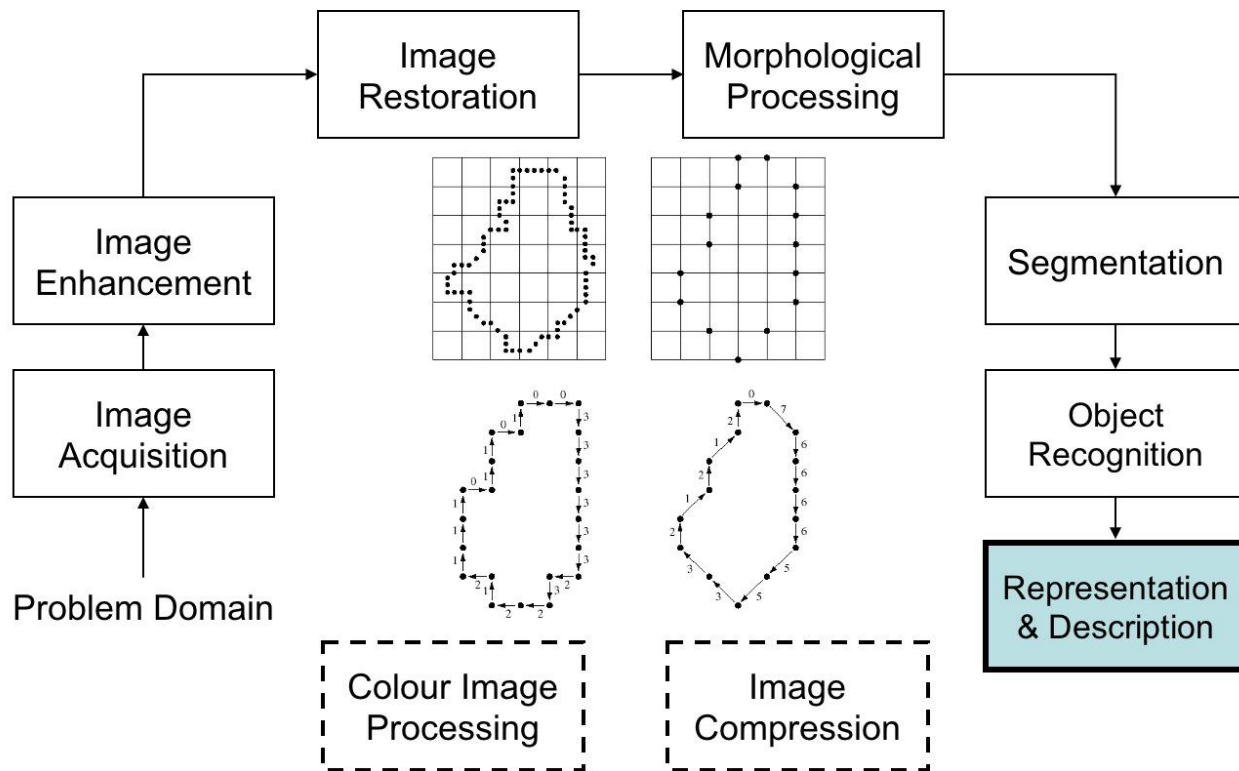
# Key Stages in Digital Image Processing: Image Segmentation



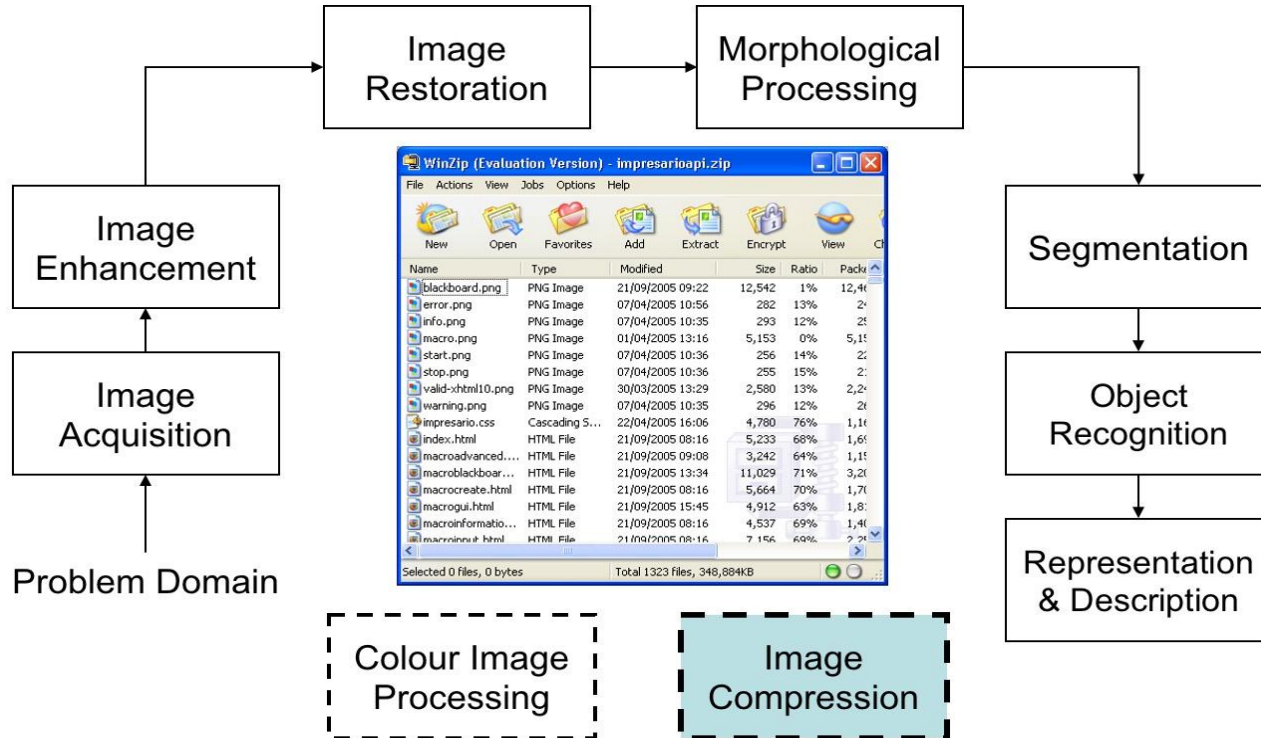
# Key Stages in Digital Image Processing: Object Recognition



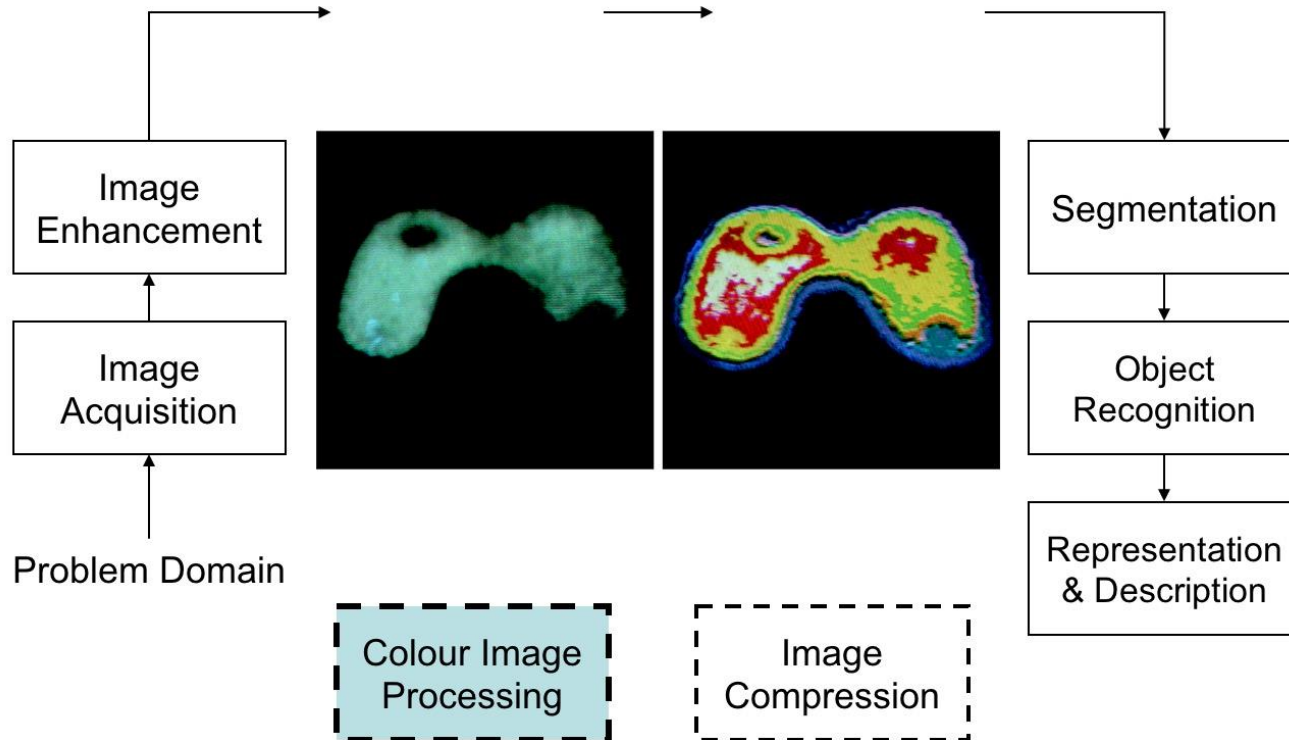
# Key Stages in Digital Image Processing: Representation & Description



# Key Stages in Digital Image Processing: Image Compression



# Key Stages in Digital Image Processing: Color Image Processing





## Summary

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...