Introduction

Delivered by

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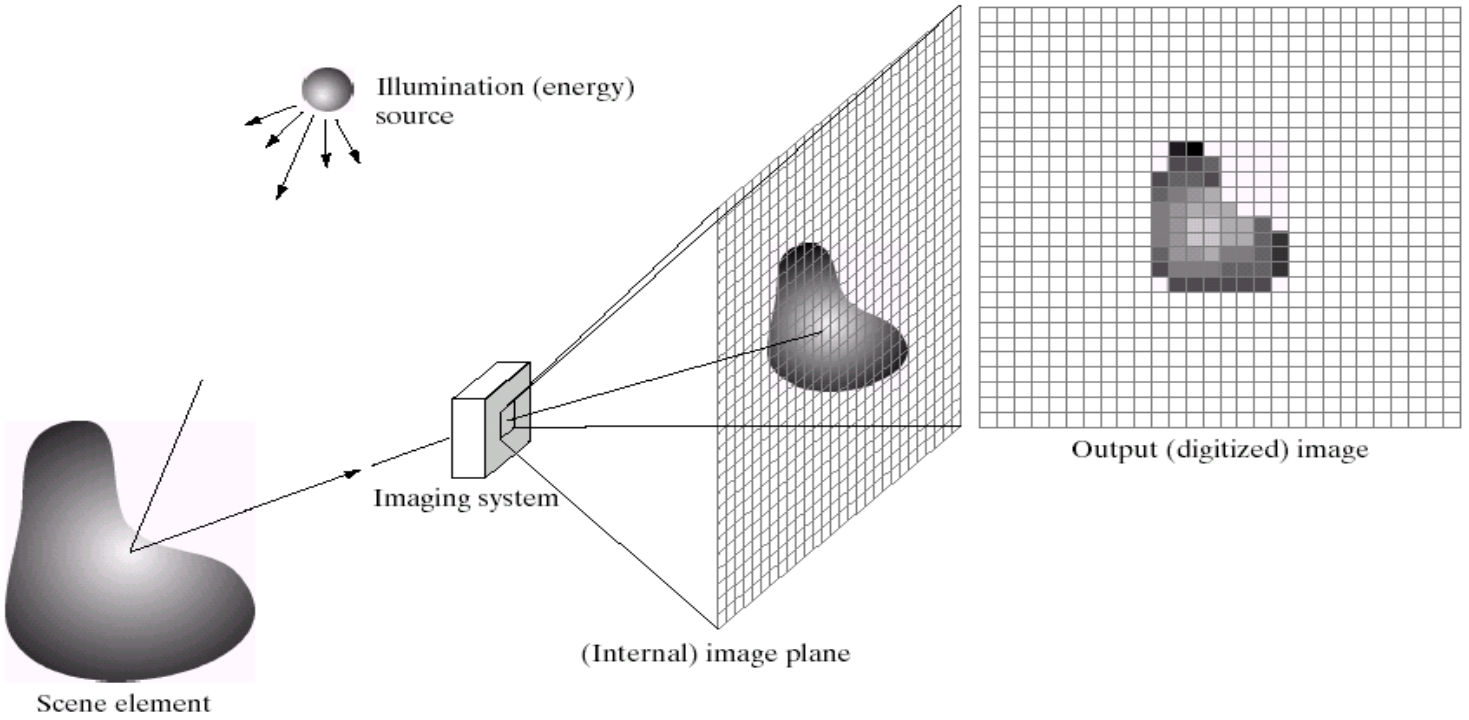
Contents

- History of Computer Vision
- Applications of Computer Vision
- Challenges in Computer Vision
- Market survey on Computer Vision
- Block diagram of Computer Vision.

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



Digital Image

- We can think of an **image** as a function, f, from R^2 to R:
  - $f(x, y)$ gives the **intensity** at position (x, y)
  - Realistically, we expect the image only to be defined over a rectangle, with a finite range:
    - f: $[a,b]$x$[c,d]$ → [0,1]

- A color image is just three functions pasted together. We can write this as a "vector-valued" function:

$$f(x,y) = \begin{bmatrix} r(x,y) \\ g(x,y) \\ b(x,y) \end{bmatrix}$$

Digital image

- We usually operate on **digital** (**discrete**) images:
  - **Sample** the 2D space on a regular grid
  - **Quantize** each sample (round to nearest integer)
- If our samples are Δ apart, we can write this as:

$$f[i, j] = \text{Quantize}\{ f(i\,\Delta, j\,\Delta) \}$$

- The image can now be represented as a matrix of integer values

$j \longrightarrow$

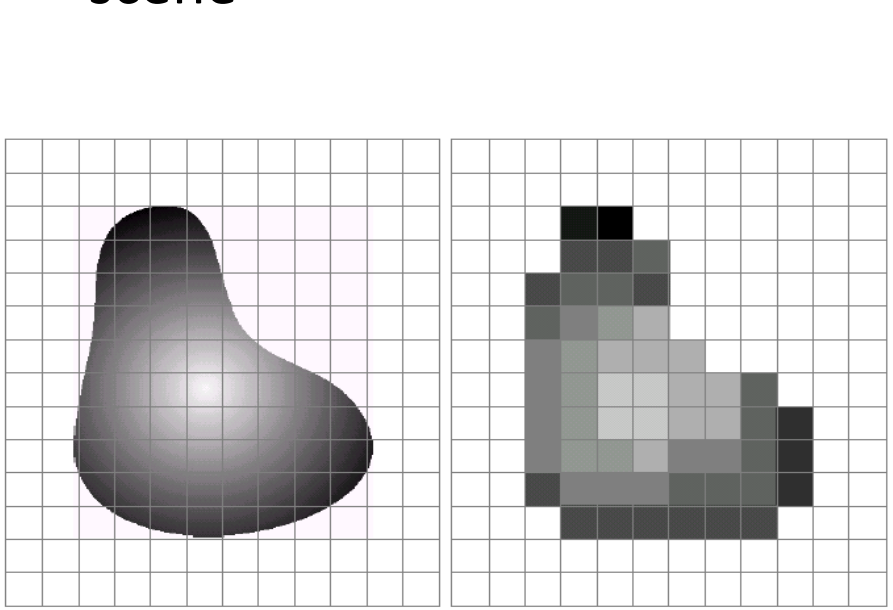
$i \downarrow$

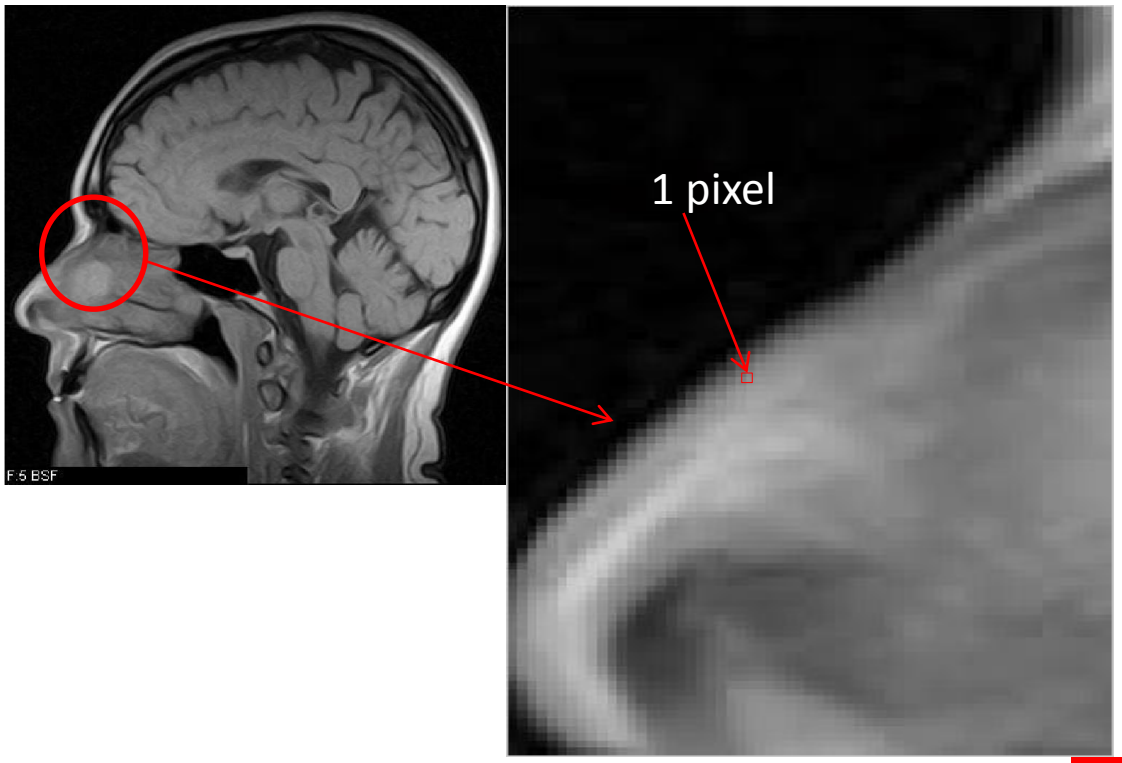
62	79	23	119	120	105	4	0
10	10	9	62	12	78	34	0
10	58	197	46	46	0	0	48
176	135	5	188	191	68	0	49
2	1	1	29	26	37	0	77
0	89	144	147	187	102	62	208
255	252	0	166	123	62	0	31
166	63	127	17	1	0	99	30

Digital Image - Pixels

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

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

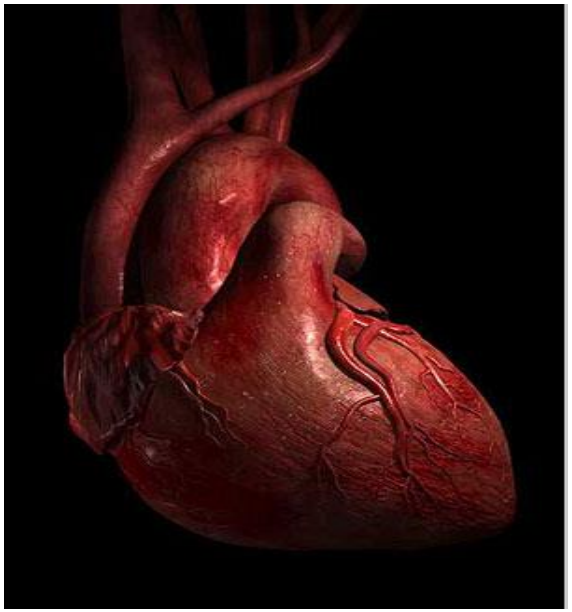


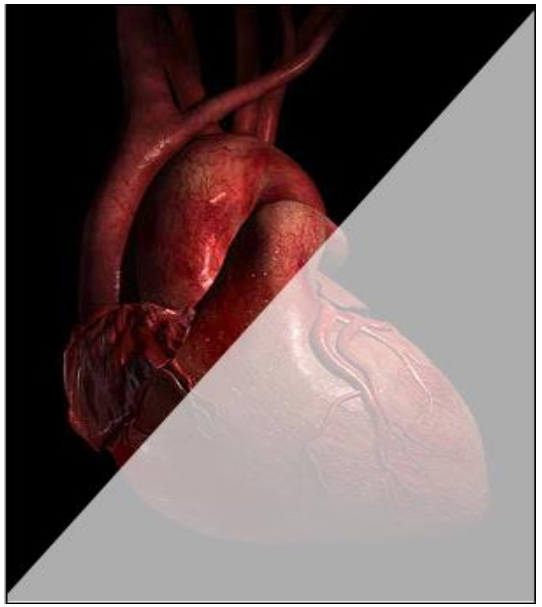


Digital Image

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)



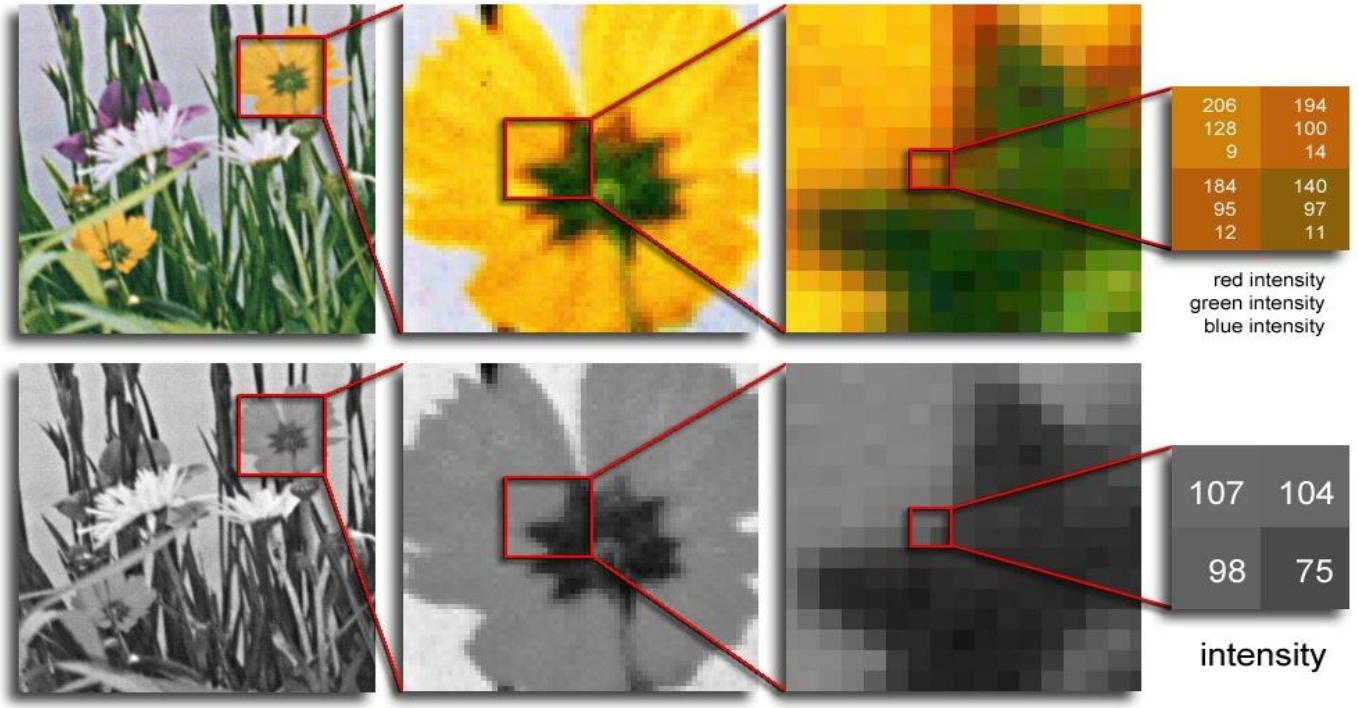


Cont..

Color images have 3 values per pixel; monochrome images have 1 value per pixel.

a grid of squares, each of which contains a single color

each square is called a pixel (for *picture element*)



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 starts

Digital Image processing

- An **image processing** operation typically defines a new image *g* in terms of an existing image *f.*
- We can transform either the range of *f*.

$$g(x, y) = t(f(x, y))$$

- Or the domain of *f*:

$$g(x, y) = f(t_x(x, y), t_y(x, y))$$

History of Digital Image Processing

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

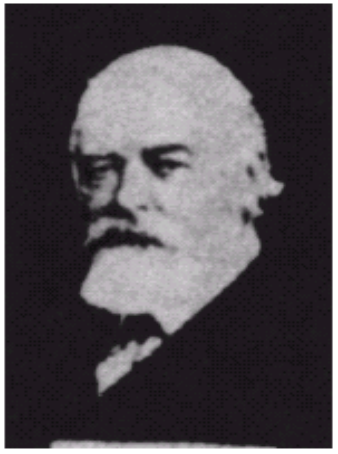
- The Bartlane cable picture transmission service
- Images were transferred by submarine cable between London and New York
- Pictures were coded for cable transfer and reconstructed at the receiving end on a telegraph printer

Early digital image

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



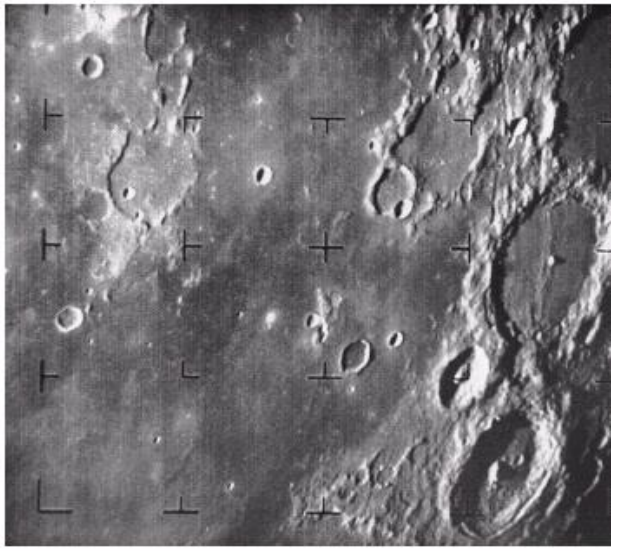
Improved digital image

Early 15 tone digital image

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 including the Apollo landings



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

Sources for Images

- Electromagnetic (EM) energy spectrum
- Acoustic
- Ultrasonic
- Electronic
- Synthetic images produced by computer

Electromagnetic (EM) energy spectrum

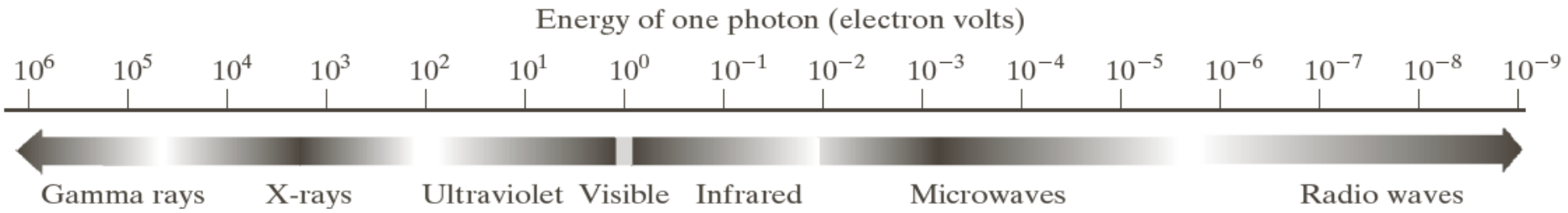


FIGURE 1.5 The electromagnetic spectrum arranged according to energy per photon.

Major uses

Gamma-ray imaging: nuclear medicine and astronomical observations

X-rays: medical diagnostics, industry, and astronomy, etc.

Ultraviolet: lithography, industrial inspection, microscopy, lasers, biological imaging, and astronomical observations

Visible and infrared bands: light microscopy, astronomy, remote sensing, industry, and law enforcement

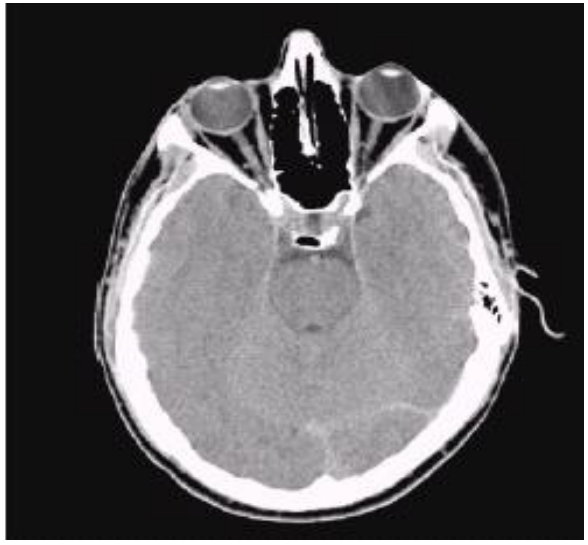
Microwave band: radar

Radio band: medicine (such as MRI) and astronomy

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

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
- Artistic effects
- Medical visualisation
- Industrial inspection
- Law enforcement
- Human computer interfaces

Applications of Image Processing

- Today digital image processing finds its applications in large number of diverse areas:

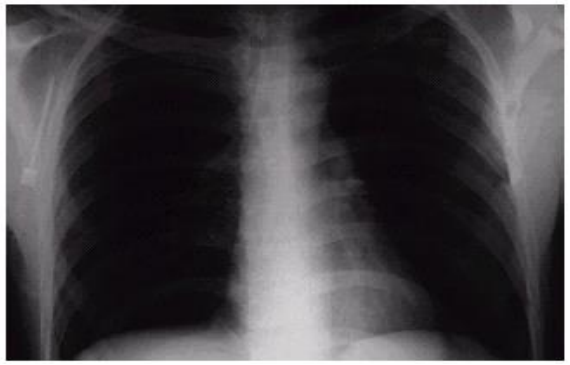
- Office automation
  - Character recognition
  - Logo and icon identification
  - Address identification
- Industrial automation
  - PCB checking
  - Robotics
  - Process Control Application
- Bio-medical:
  - ECG, EEG, EMG analysis
  - Pathology, X-ray image analysis

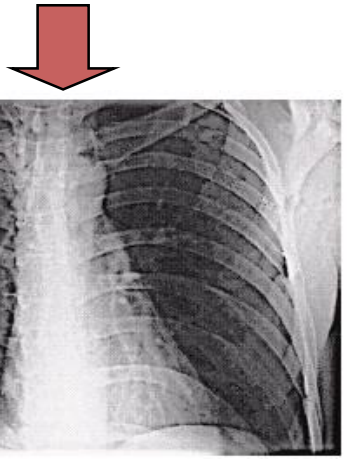
Cont..

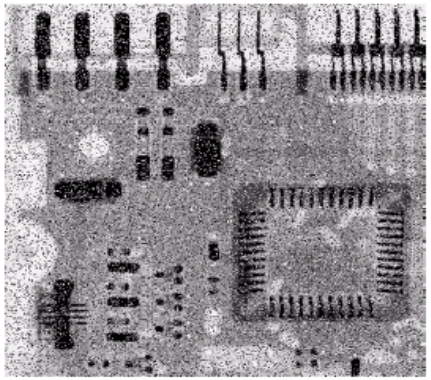
- Remote Sensing:
  - Natural resources survey and management
  - Agriculture
  - Urban planning
  - Satellite image registration and classification
- Forensic Investigation
  - Figure print identification
  - Human face detection and recognition
- Astronomy and Space Application
- Consumer Electronics
- Military Applications

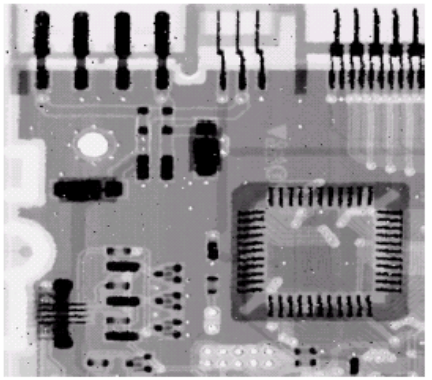
Examples: Image Enhancement

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







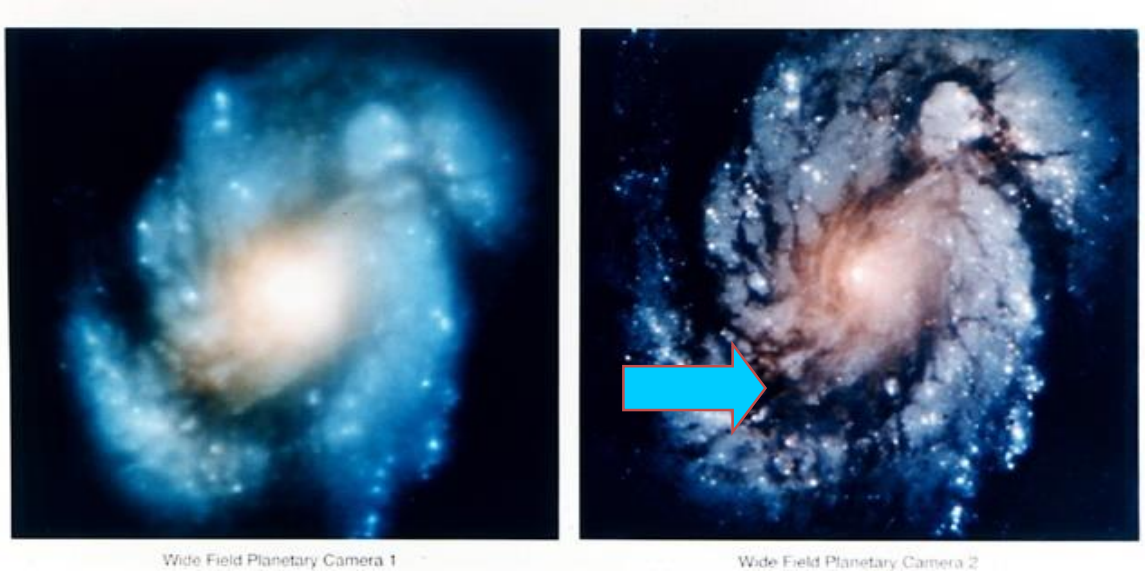


Examples: The Hubble Telescope

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.



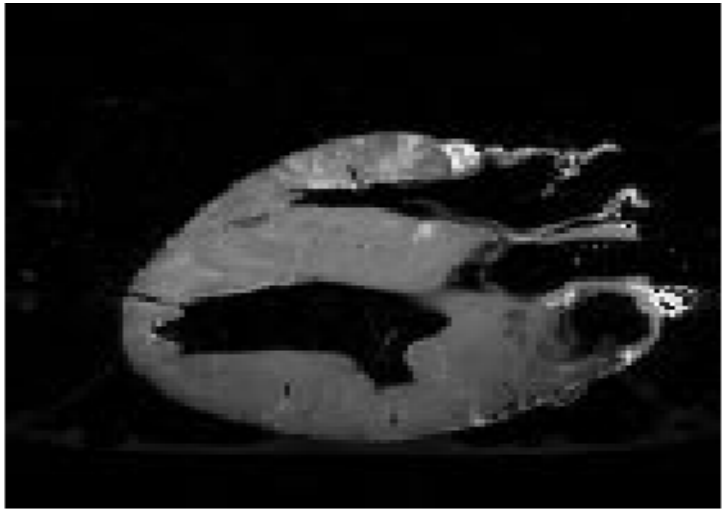
Examples: Artistic Effects

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

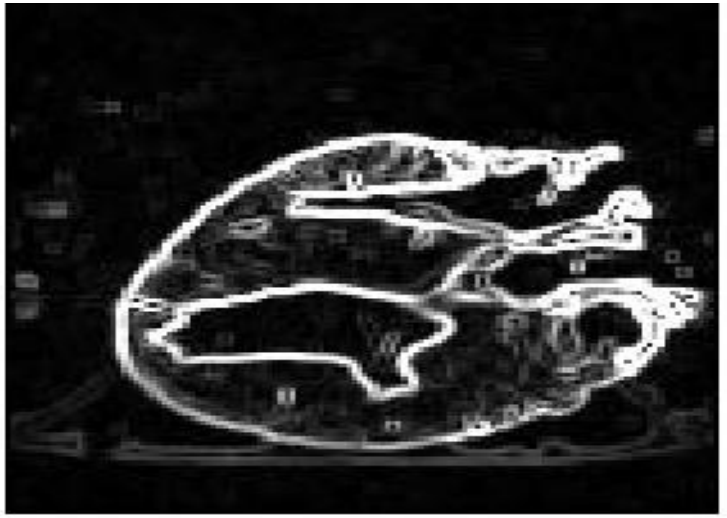
Examples: Medicine

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

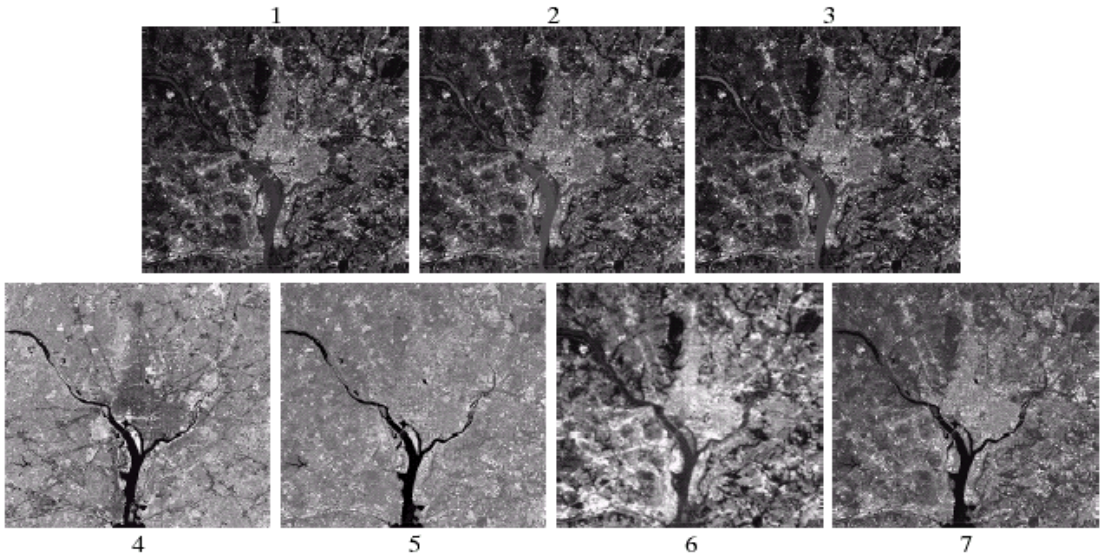


Edge Detection Image

Examples: GIS

Geographic Information Systems

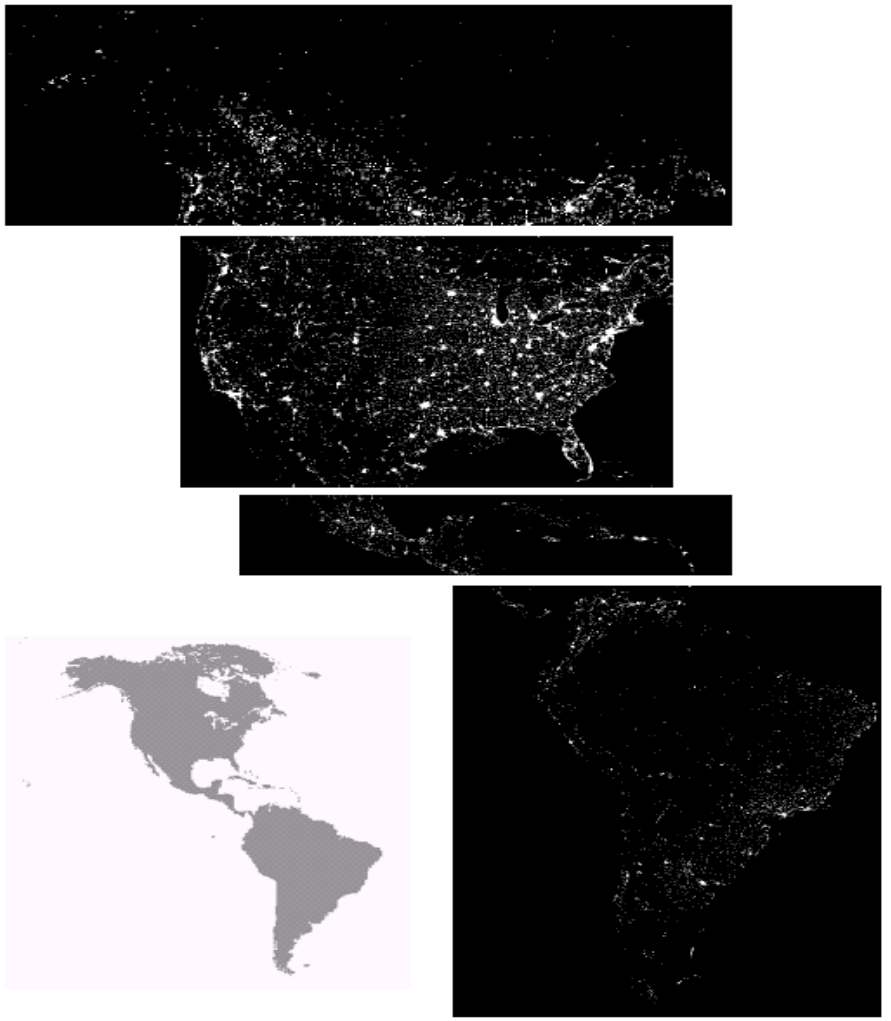
- Digital image processing techniques are used extensively to manipulate satellite imagery
- Terrain classification
- Meteorology



Examples: GIS

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



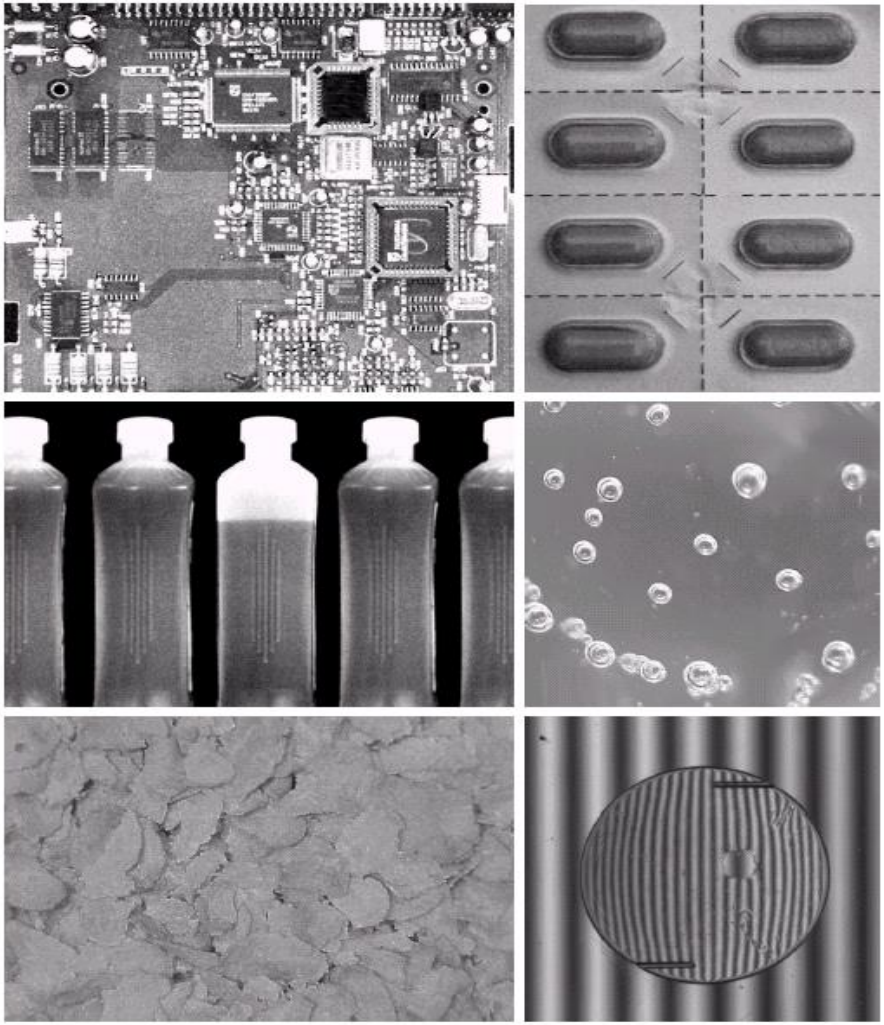
Examples: Industrial Inspection

Human operators are expensive, slow and unreliable.

Make machines do the job instead.

Industrial vision systems are used in all kinds of industries.

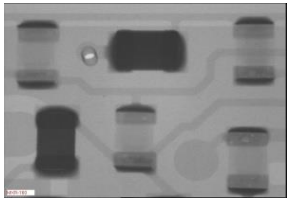
How accurate can we make these systems?

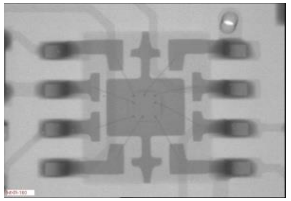


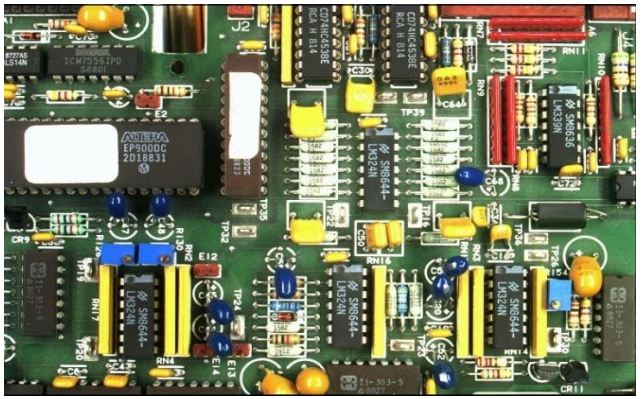
Examples: PCB Inspection

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



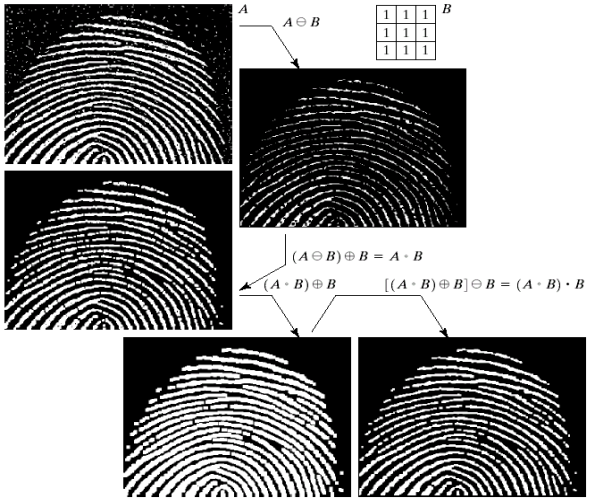




Examples: Law Enforcement

Image processing techniques are used extensively by law enforcers

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



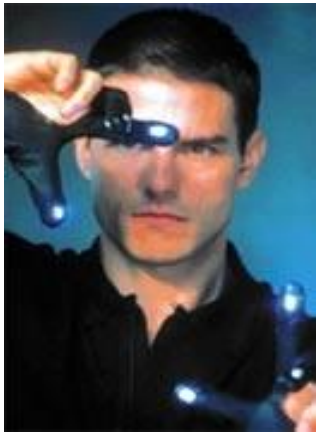
–Fingerprint recognition

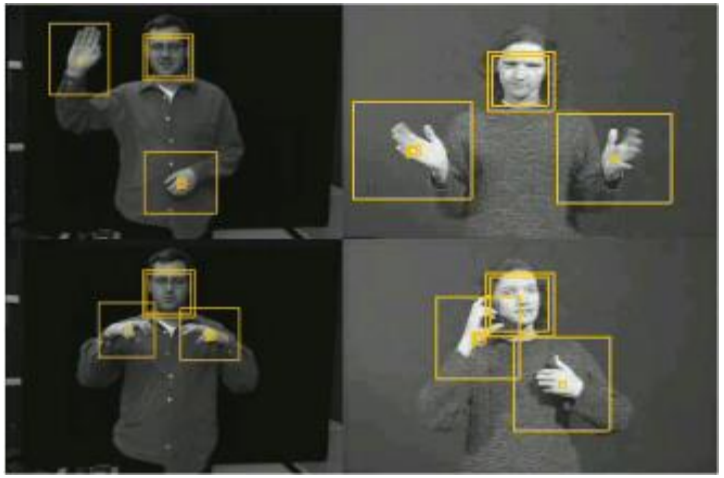
Examples: HCI

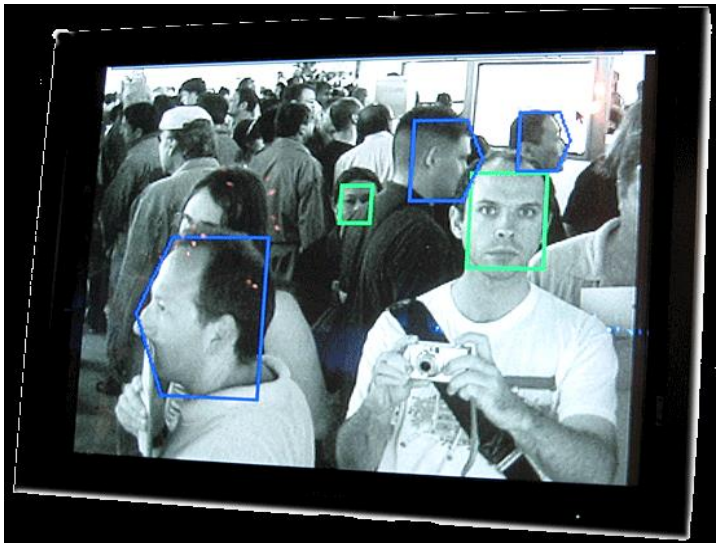
Try to make human computer interfaces more natural

- Face recognition
- Gesture recognition

These tasks can be extremely difficult







Key Stages in Digital Image Processing

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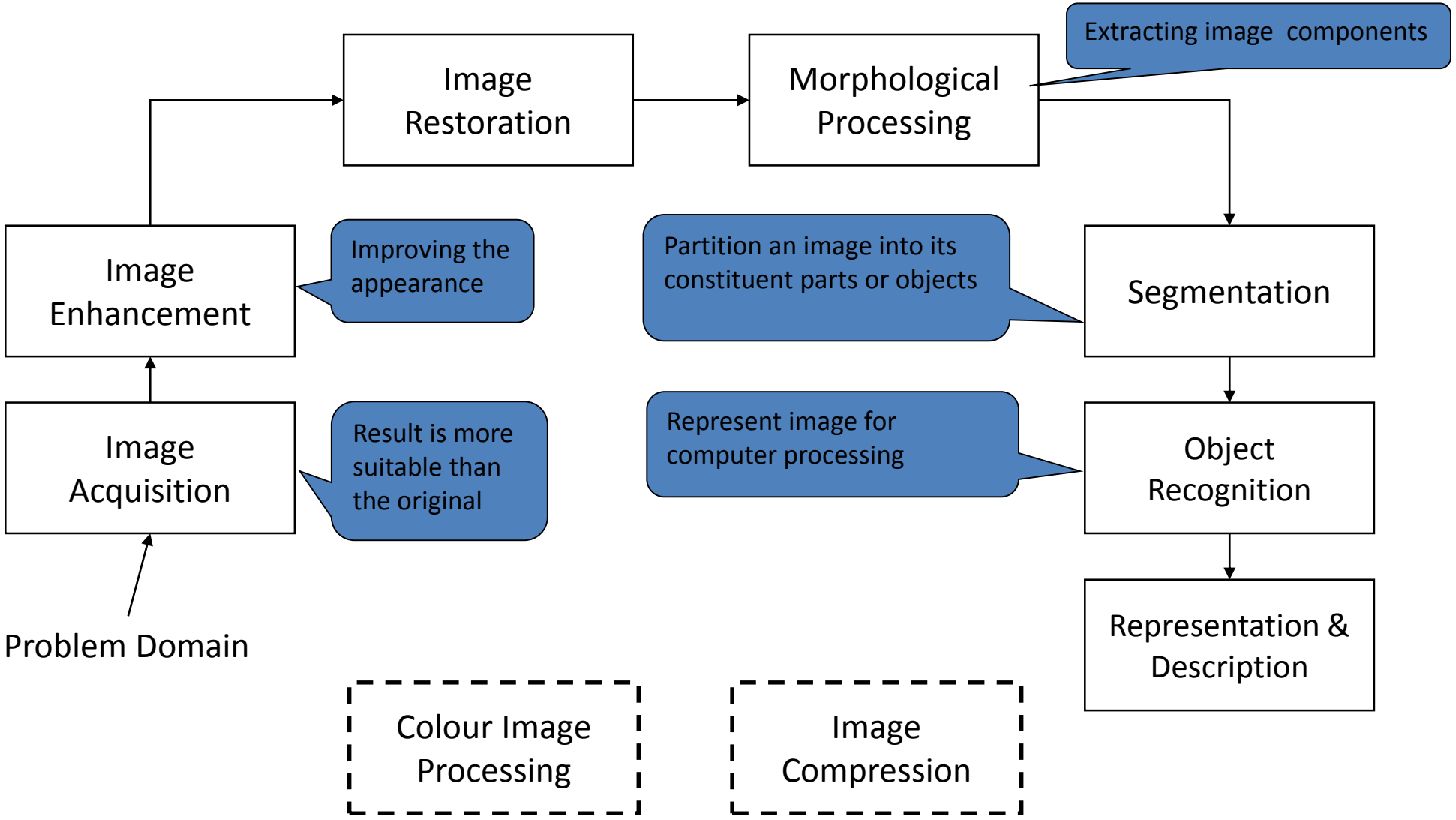
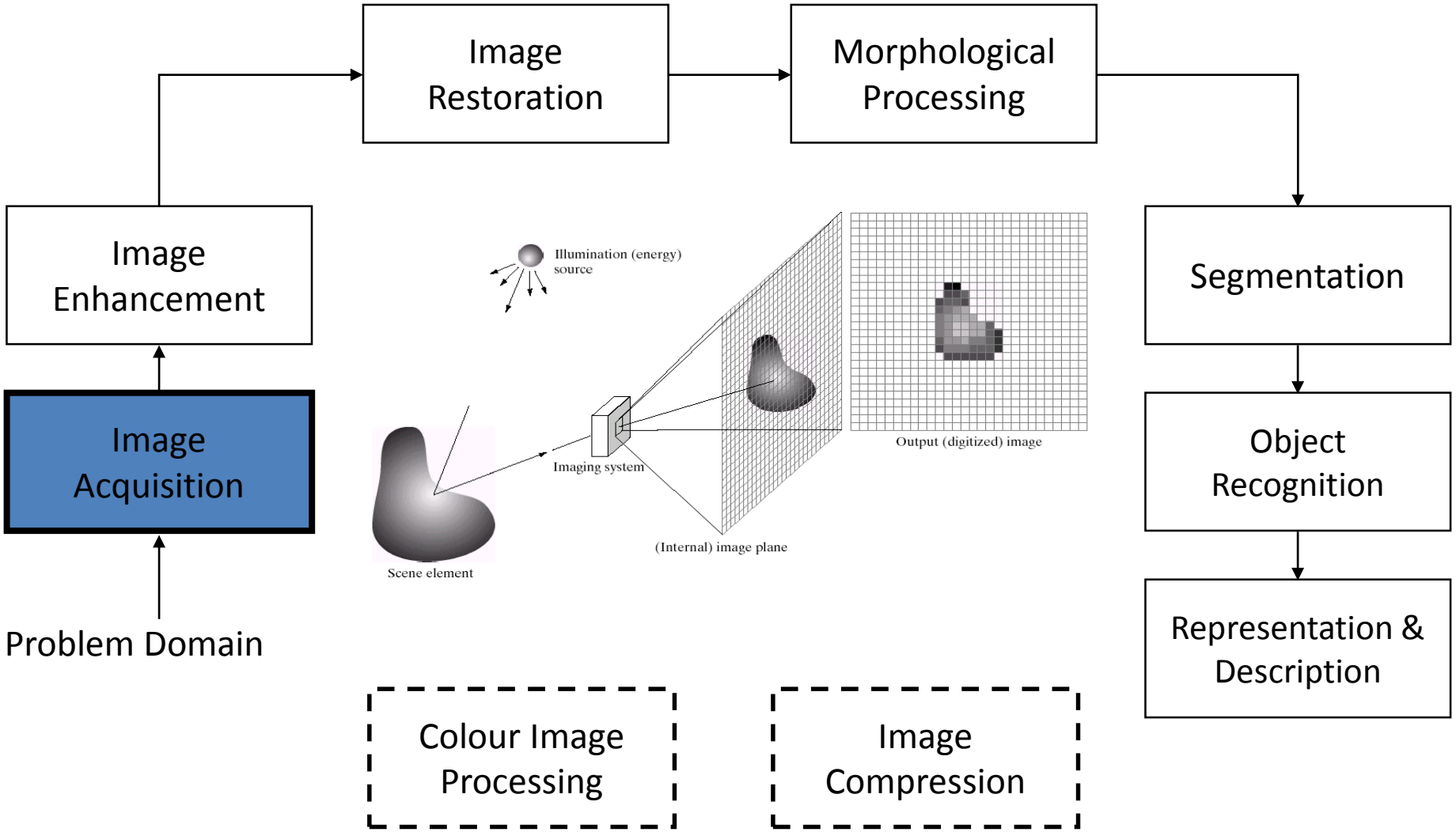
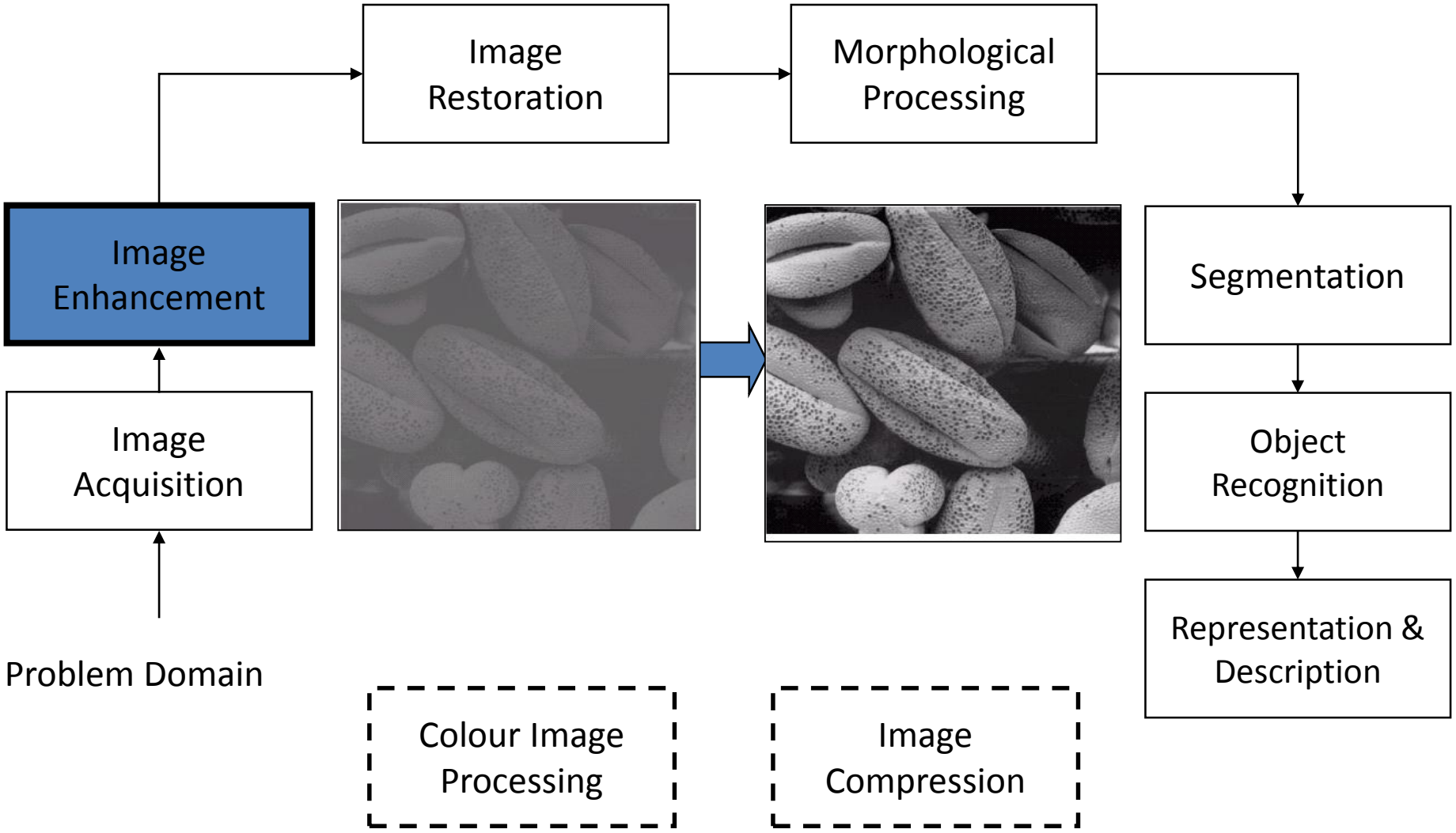


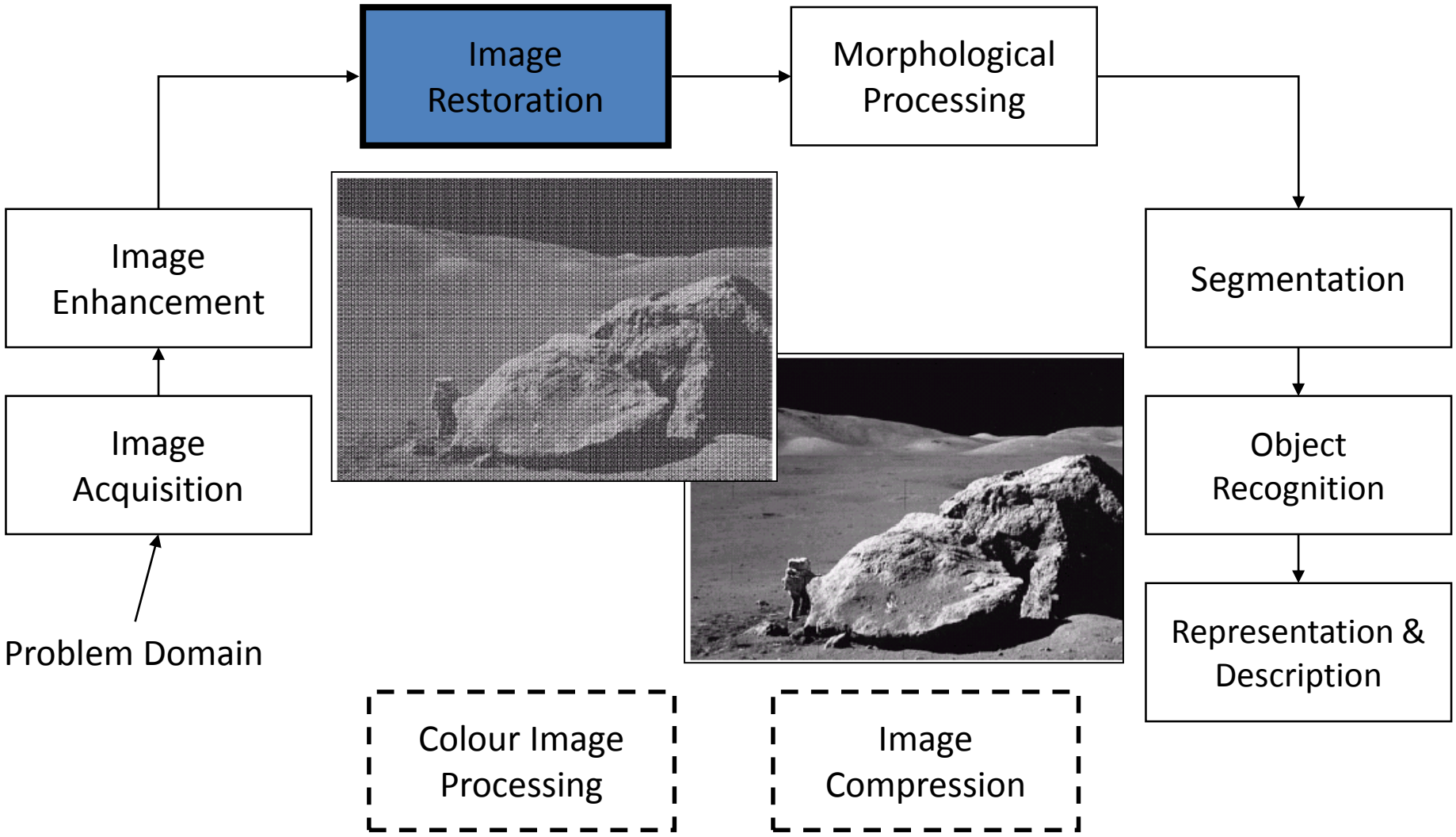
Key Stages in DIP: Image Acquisition



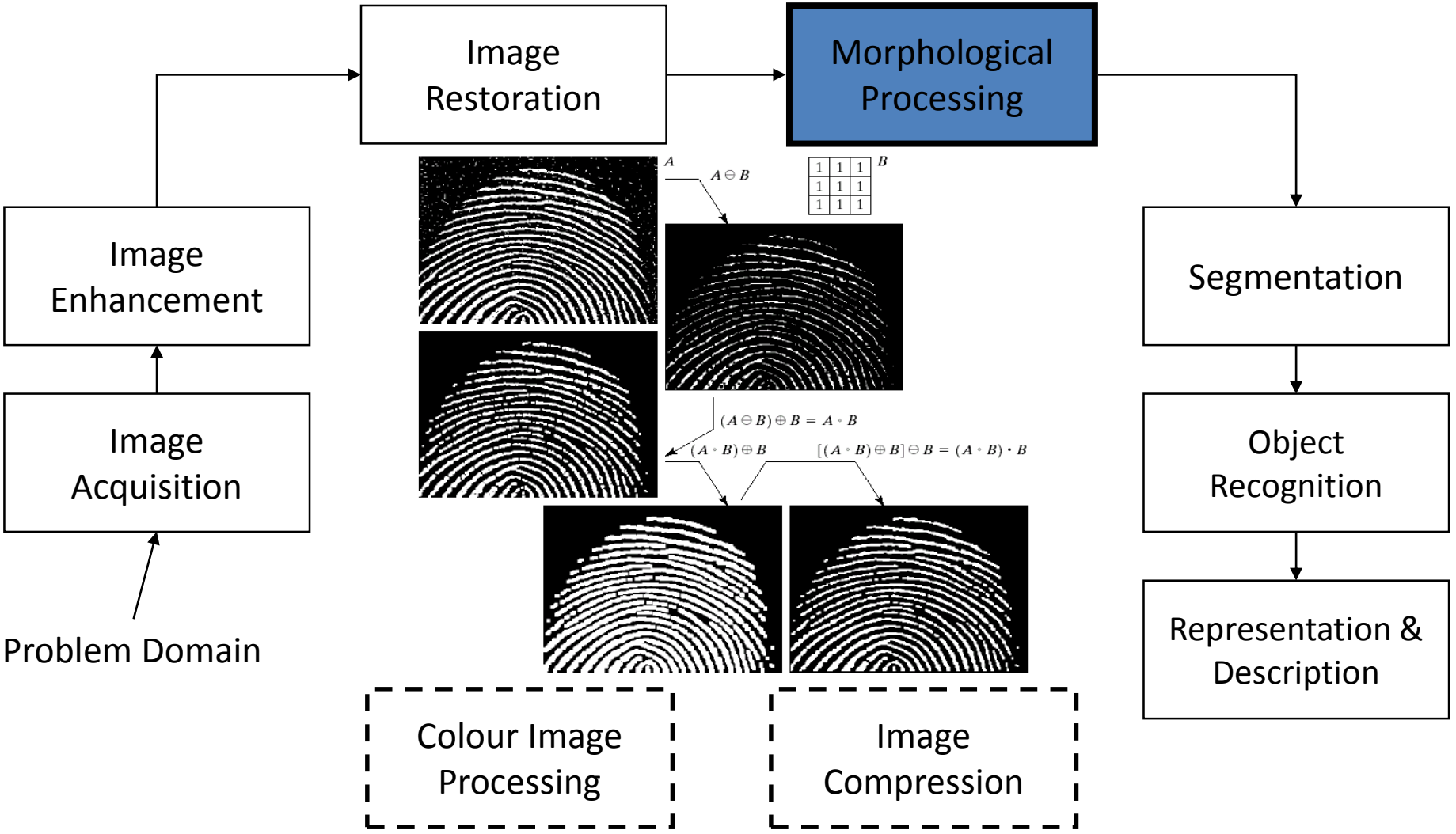
Key Stages in DIP: Image Enhancement



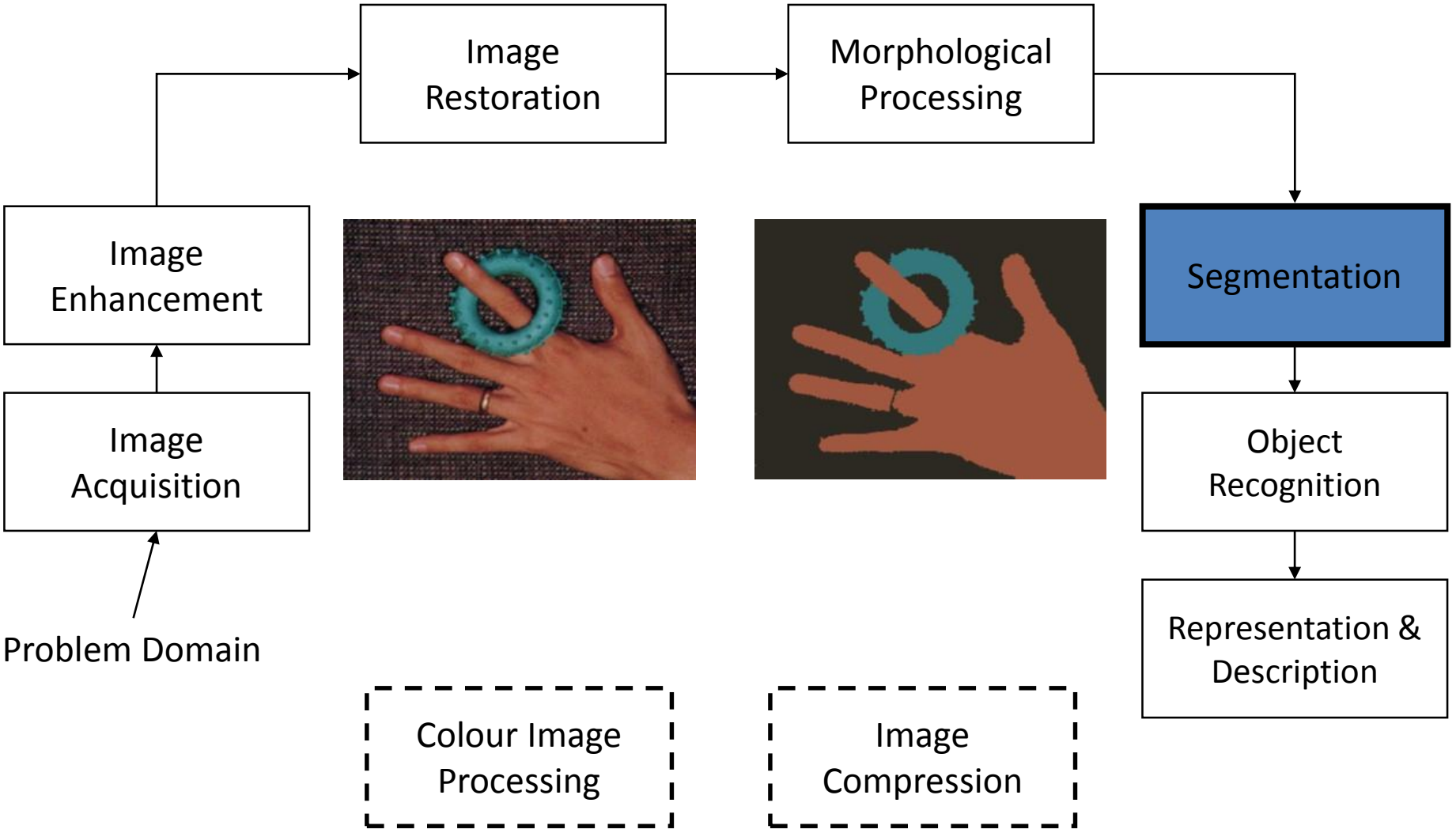
Key Stages in DIP: Image Restoration



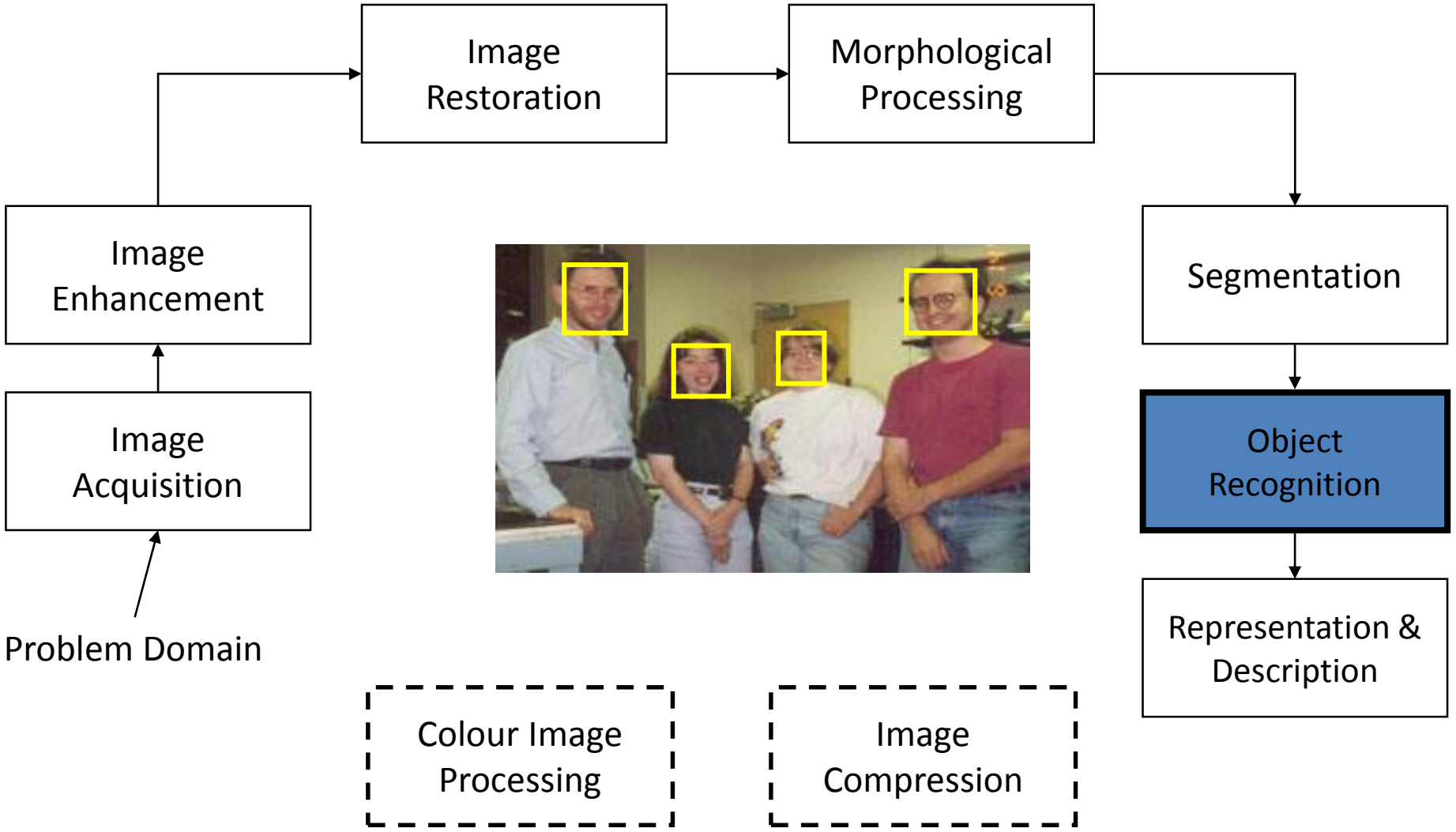
Key Stages in DIP: Morphological Processing



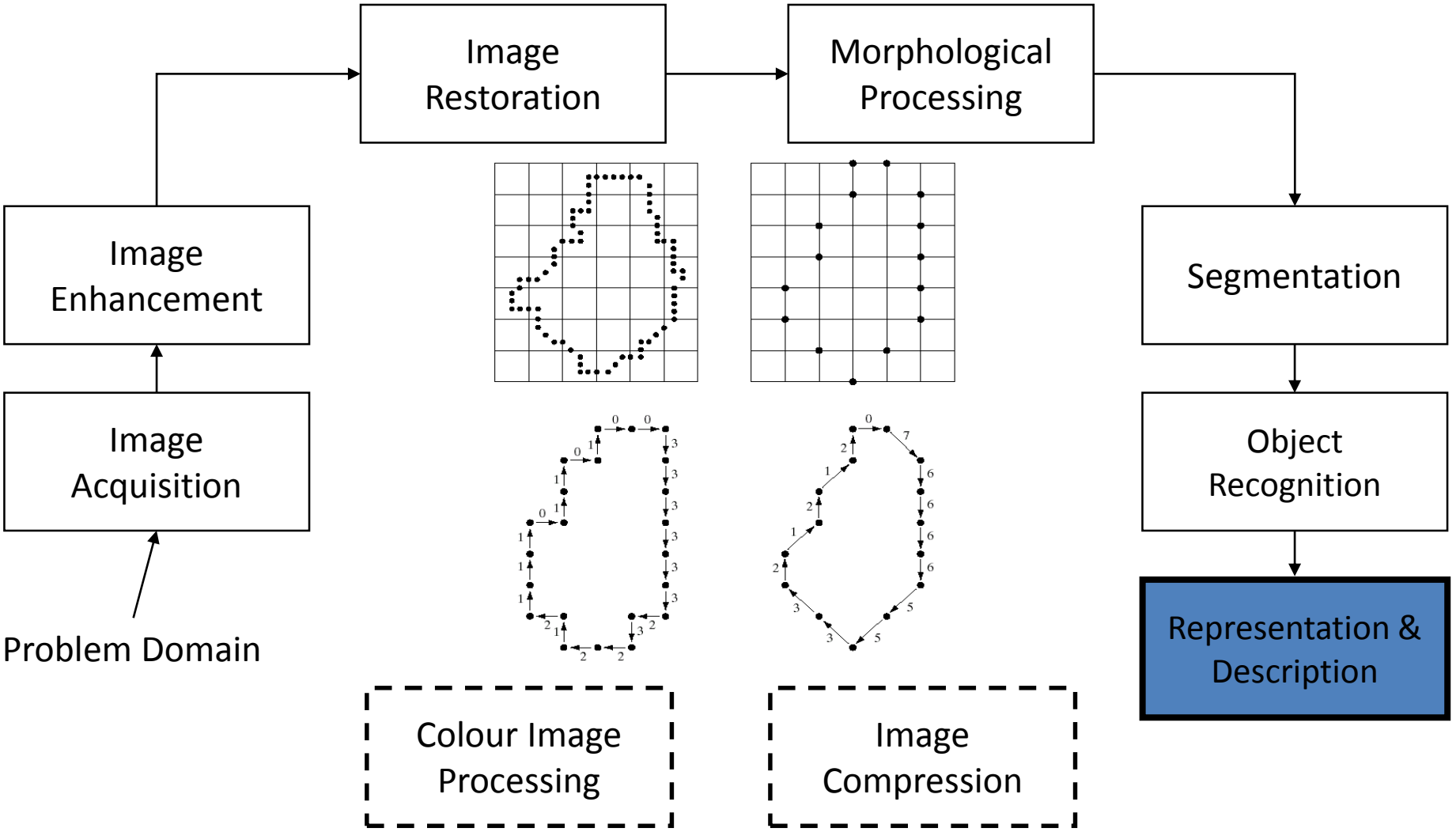
Key Stages in DIP: Segmentation



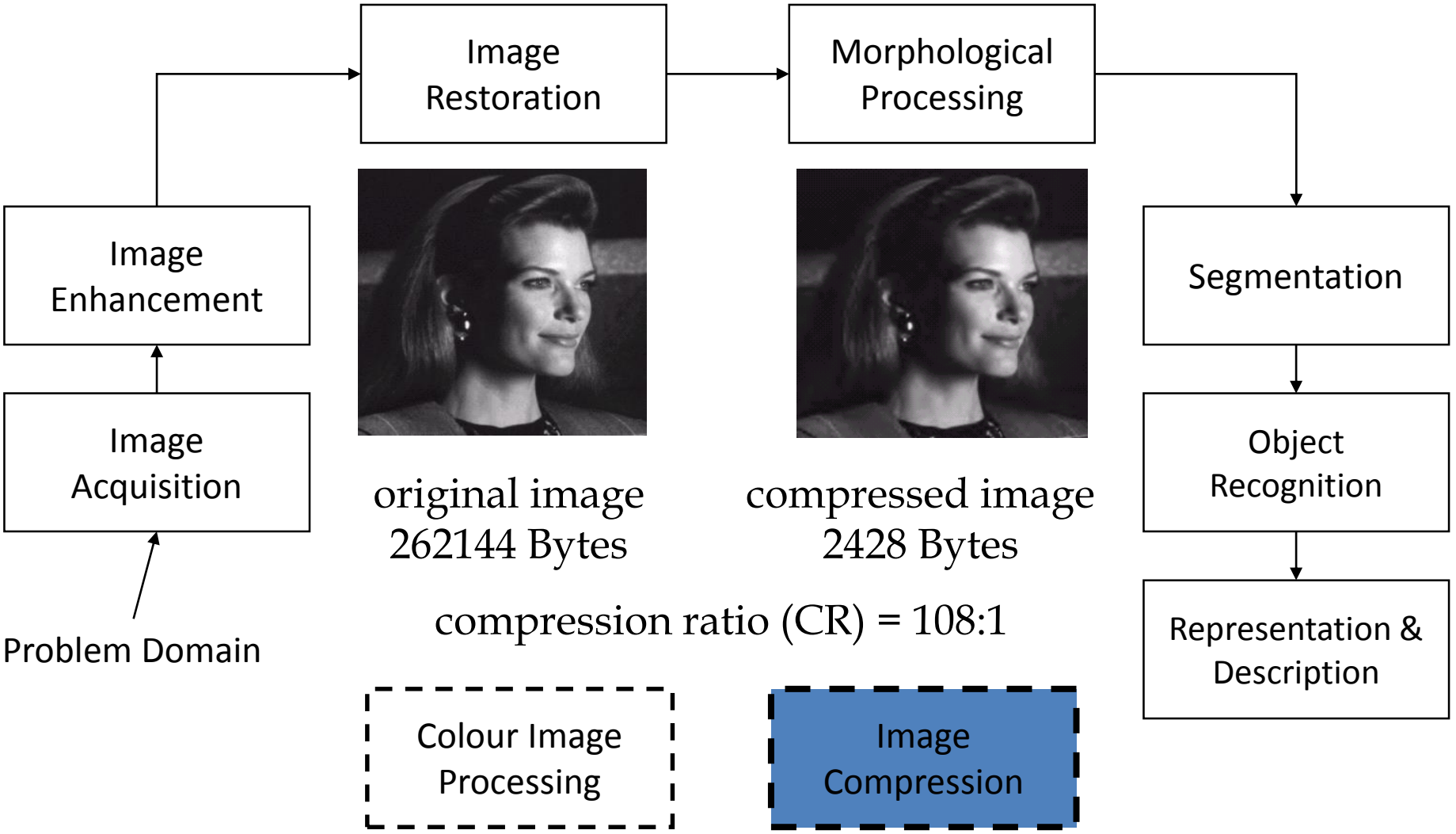
Key Stages in DIP: Object Recognition



Key Stages in DIP: Representation & Description



Key Stages in DIP: Image Compression



Key Stages in DIP: Colour Image Processing