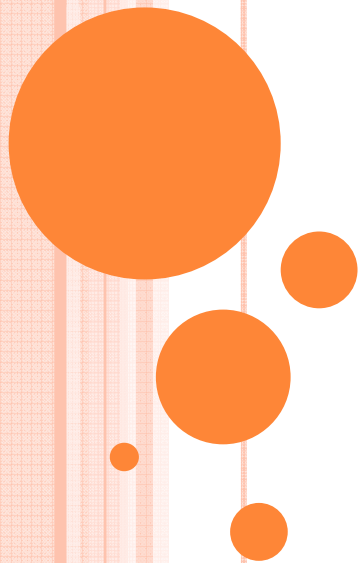


DIGITAL IMAGE FUNDAMENTALS



OUTLINE

- What is an image?
- What is Digital Image?
- What is Digital Image Processing?
- Origin of DIP
- Steps in DIP
- Components of an Image Processing System



WHAT IS AN IMAGE?

- Image is an array of integers:
 - $f(x,y) \in \{0,1,\dots, I_{\max}-1\}$,
where $x,y \in \{0,1,\dots,N-1\}$
- N is the resolution of the image and I_{\max} is the level of discretized brightness value
- Larger the value of N , more is the clarity of the picture (larger resolution), but more data to be analyzed in the image
- If the image is a gray-level (8-bit per pixel - termed raw, gray) image, then it requires $N*N$ Bytes for storage
- If the image is color - RGB, each pixel requires $3*N*N$ Bytes of storage space.
- Eg: $64*64$ 4K (gray) 12K(color)



WHAT IS AN DIGITAL IMAGE?

- A digital image is a two-dimensional function $f(x, y)$,
 - Where X and Y are spatial coordinates
 - Amplitude of f – intensity level or gray-level at the point (x, y)
- The coordinates as well as the amplitudes to be digitized.
- Digitizing the coordinate values is called **sampling** and the amplitude values is **quantization**
- x, y and the amplitude values of ' f ' are all finite, discrete quantities, then the image is a **digital image**.
- The elements of digital image are called pixels (picture elements).
- An image is represented as matrix form of real numbers.
- The integer represents the brightness or darkness at that point.
- N - number of rows; M - number of columns; Q - number of gray-levels



DIGITAL IMAGE?



135 137 138 137 134 133 134 136 143 136
136 137 138 137 135 133 134 136 143 136
137 138 138 137 135 134 135 136 142 136
137 137 137 137 136 135 135 135 141 135
137 136 136 135 135 135 134 134 140 135
136 135 134 134 135 134 133 132 137 134
136 134 132 132 134 134 132 130 135 133
135 133 131 131 133 133 131 129 134 132
128 130 133 135 135 134 132 131 139 134
129 130 132 133 133 131 128 127 134 130



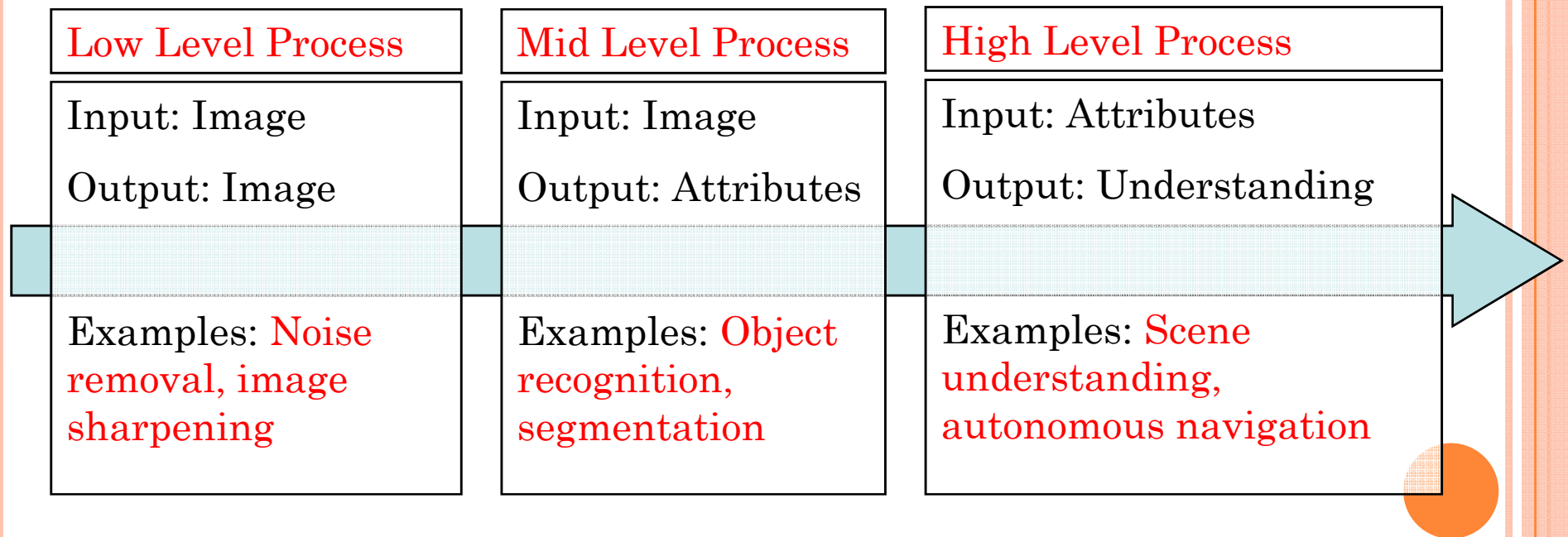
WHAT IS DIGITAL IMAGE PROCESSING (DIP)?

- The field of digital image processing refers to processing digital images by means of digital computer.
- DIP motivated for two major applications:
 - Improvement of Pictorial Information for human interpretation
 - improve the contrast of the image
 - remove noise
 - remove blurring caused by movement of the camera
 - it may correct for geometrical distortions caused by the lens.
 - Processing of image data for intelligent interpretation for autonomous machine perception (termed Computer Vision, Pattern Recognition or Visual Perception)



TYPES OF COMPUTERIZED PROCESSES

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



TYPES OF COMPUTERIZED PROCESSES

- **Low-level processing** - both inputs as well as outputs are images
 - Pre-processing to reduce noise
 - Contrast enhancement
 - Image sharpening
- **Mid-level processing** - inputs are images, outputs are attributes extracted from the images
 - Segmentation
 - Recognition
- **High-level processing** - Image analysis, performing cognitive functions associated with vision to emulate human intelligence



ORIGIN 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 system
- 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



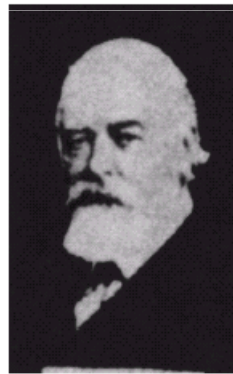
Early digital image



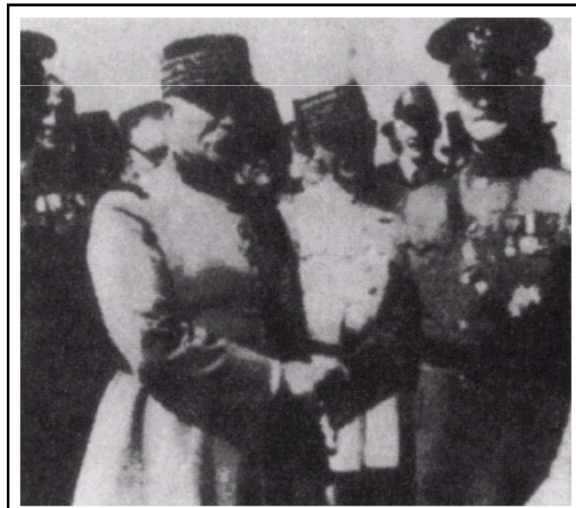
ORIGIN OF DIP (CONT...)

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

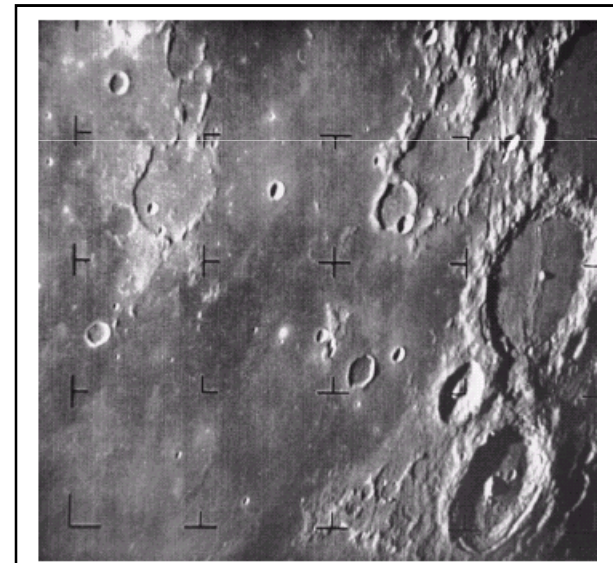


Early 15 tone digital
image

ORIGIN OF DIP (CONT...)

1960s: Improvements in computing technology and the onset of the space program led to a surge of work 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

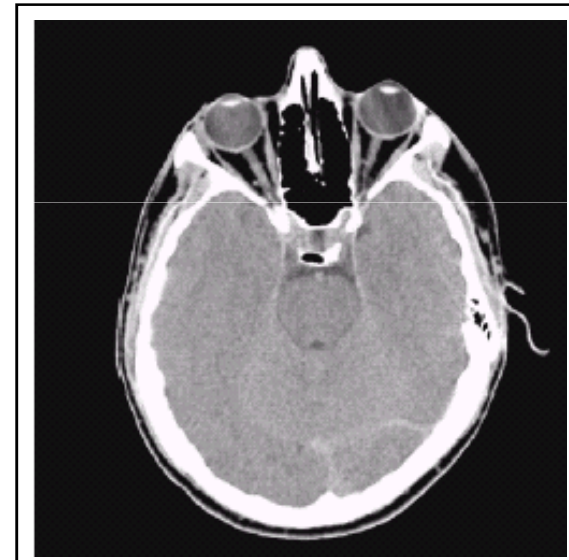


A picture of the moon taken by the Ranger 7 probe minutes before landing

ORGIN 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

ORGIN OF DIP (CONT...)

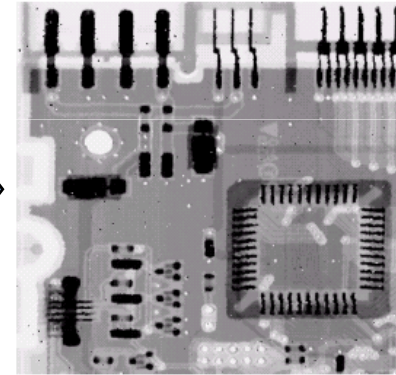
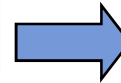
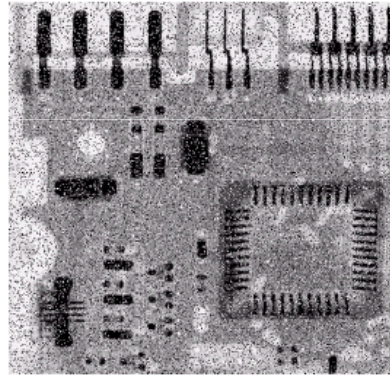
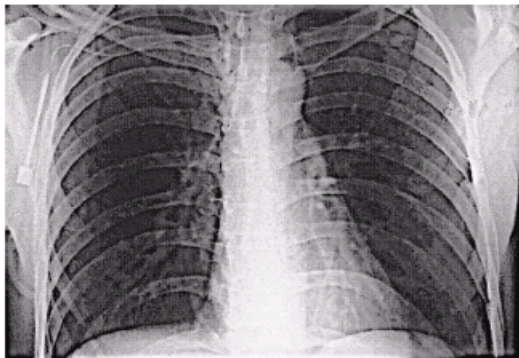
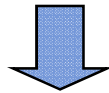
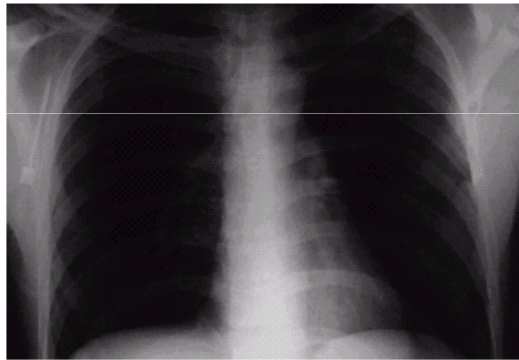
1980s - Today: The use of digital image processing techniques has exploded and they are now used for all kinds of tasks in all kinds of areas

- Image enhancement/restoration
- 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: ARTISTIC EFFECTS

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



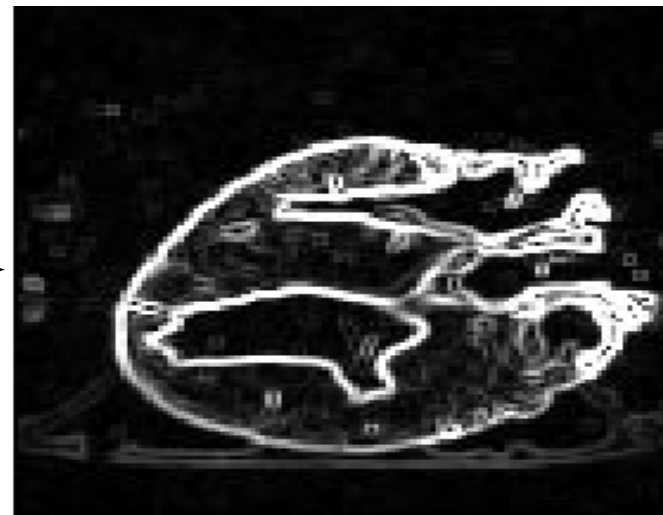
EXAMPLES: MEDICINE

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



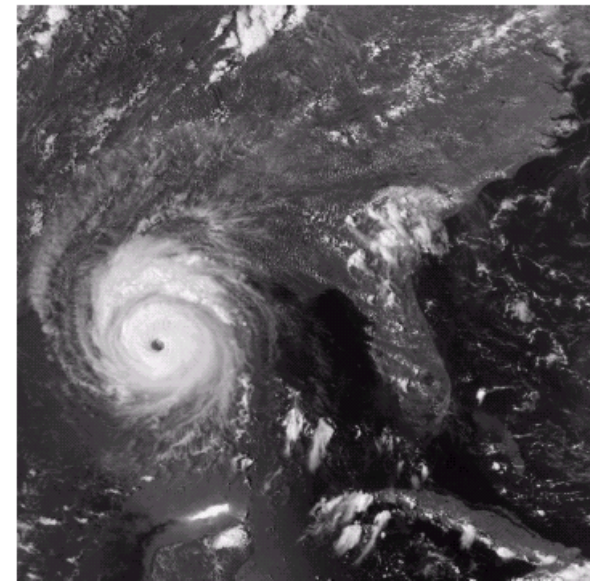
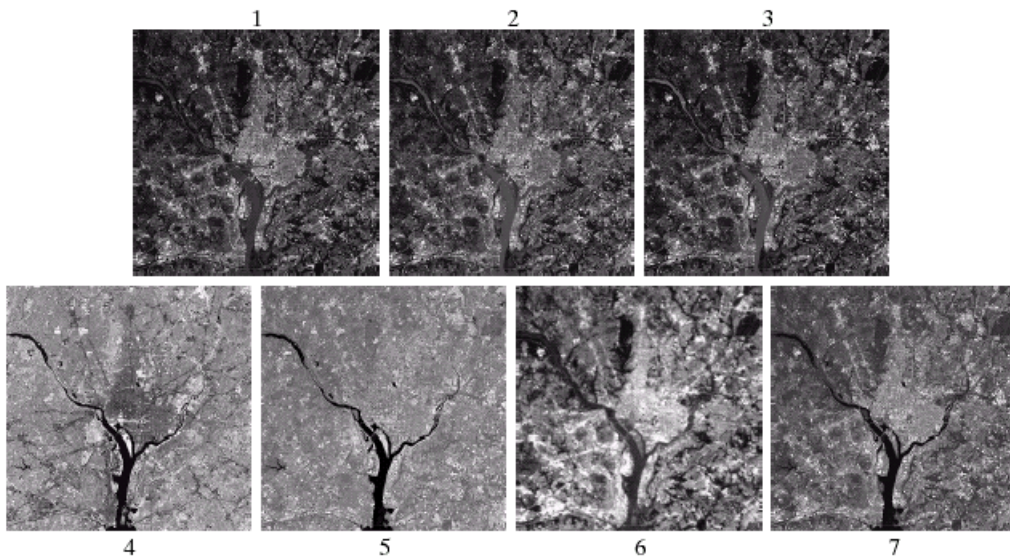
Edge Detection Image



EXAMPLES: GIS

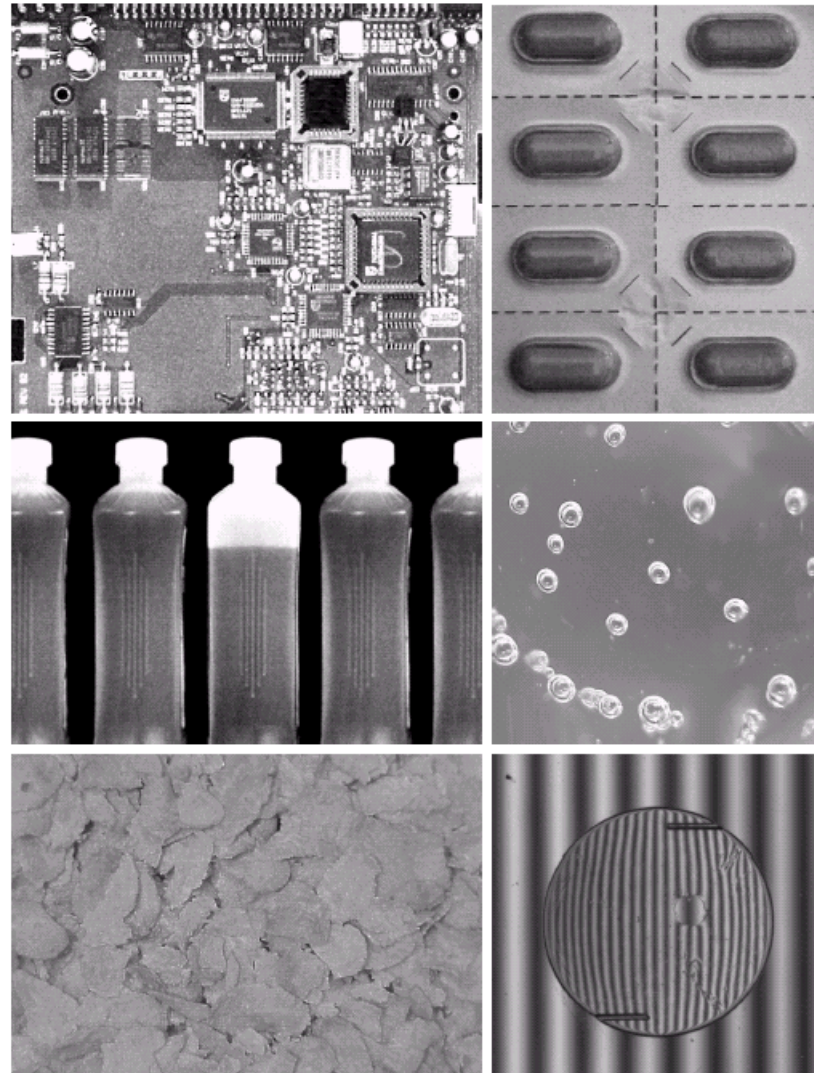
Geographic Information Systems

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



EXAMPLES: INDUSTRIAL INSPECTION

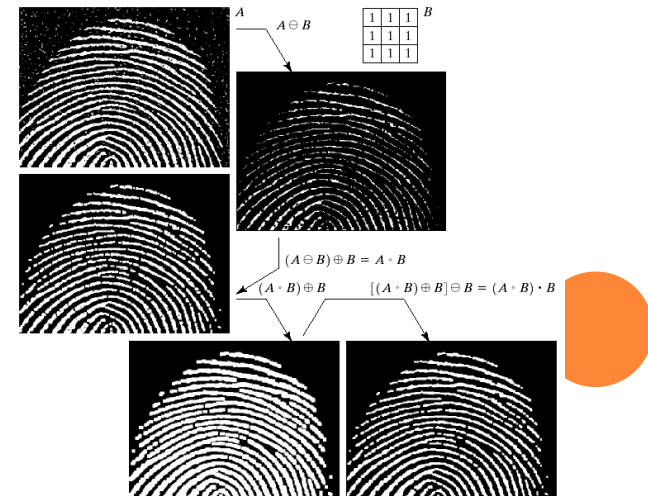
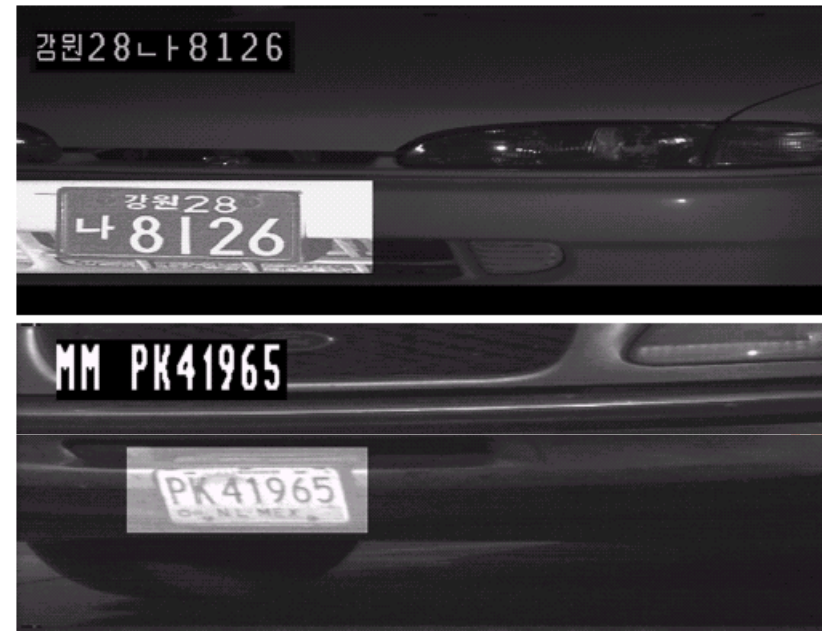
- Human operators are expensive, slow and unreliable in visual inspections of manufactured goods
- Industrial vision systems are used in all kinds of industries



EXAMPLES: LAW ENFORCEMENT

Image processing techniques are used extensively by law enforcers

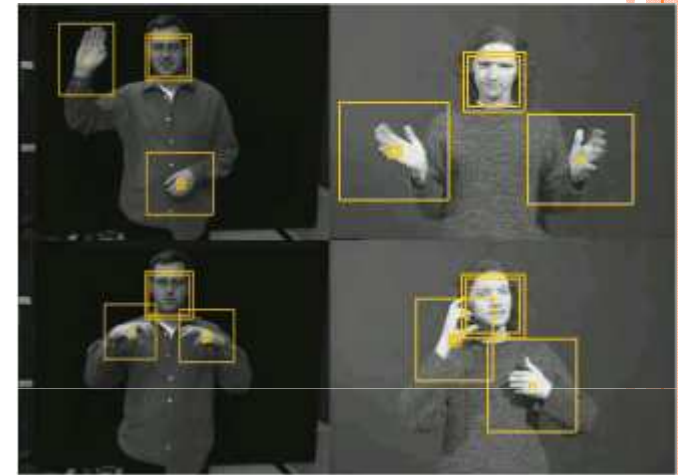
- Number plate recognition for automated toll systems
- Fingerprint recognition
- Enhancement of CCTV images



EXAMPLES: HCI

Try to make human computer interfaces more natural

- Face recognition
- Gesture recognition



IMAGING TYPES

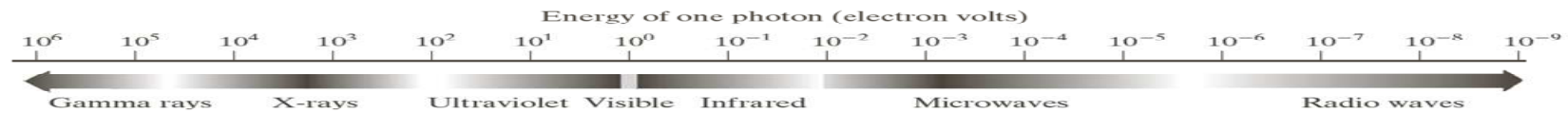


FIGURE 1.5 The electromagnetic spectrum arranged according to energy per photon.

- .Images are based on the radiation from Electromagnetic spectrum
 - oGamma ray Imaging(Nuclear Medicine and astronomical observation)
 - oX-ray imaging(Diagnosis,Industrial inspection)
 - oImaging in Ultraviolet band(industrial inspection, astronomical observation,biological imaging and lasers)
 - oImaging in visible & Infra Red band (light microscopy,astronomy,remote sensing industry and law enforcement)

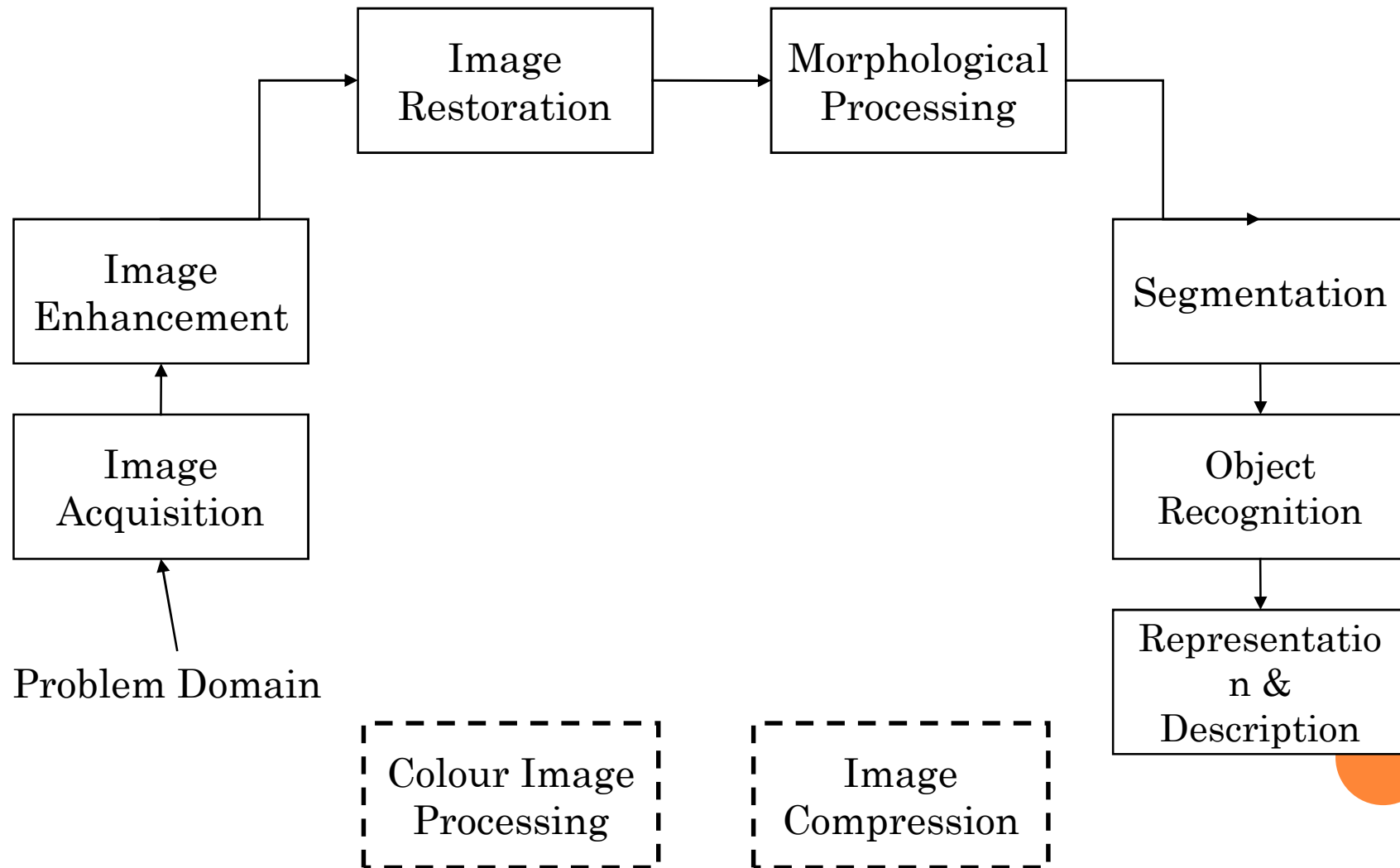


IMAGING TYPES

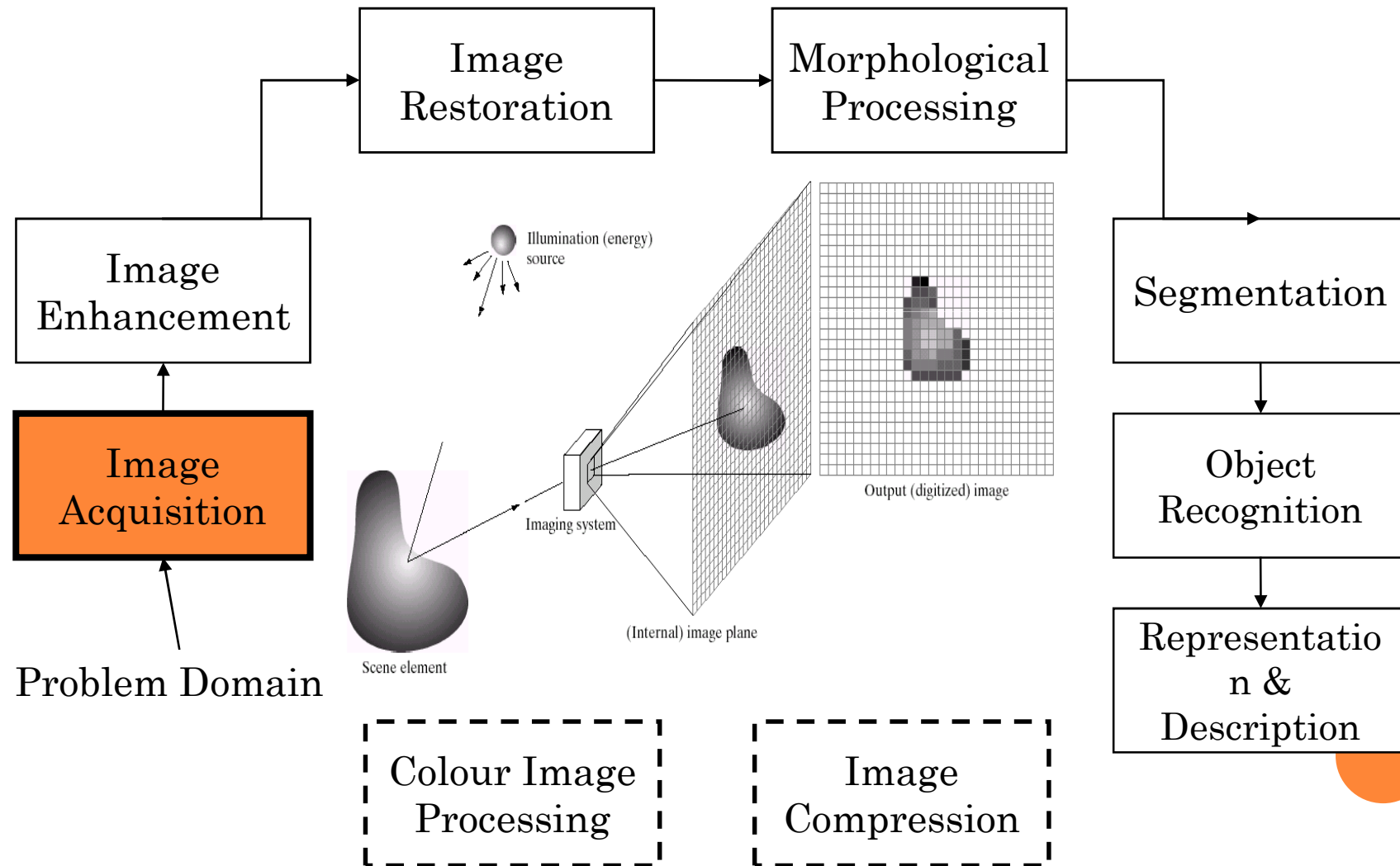
- Imaging in MicroWave band
 - Radar imaging belong to this category
 - Can penetrate the inaccessible regions of earth's surface
 - Ability to collect data over virtually any region at anytime, regardless of weather or ambient lighting condition
- Imaging in Radio band
 - Used in Magnetic Resonance Imaging
- Imaging Modeleties using non EM Spectrum band (Acoustic imaging)
 - Uses sound energy
 - Used in geological exploration, industry and medicine,mineral and oil exploration



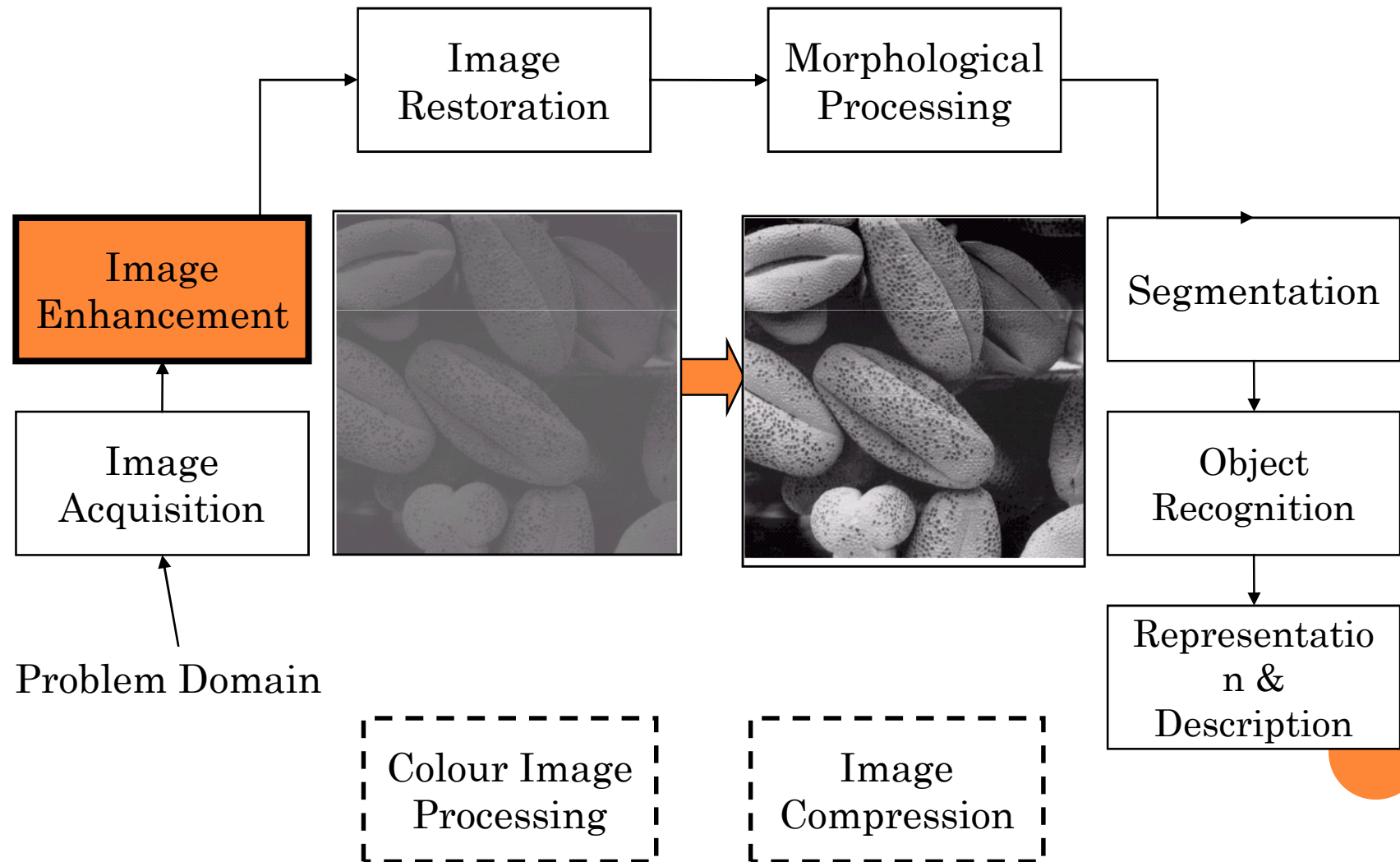
KEY STAGES IN DIGITAL IMAGE PROCESSING



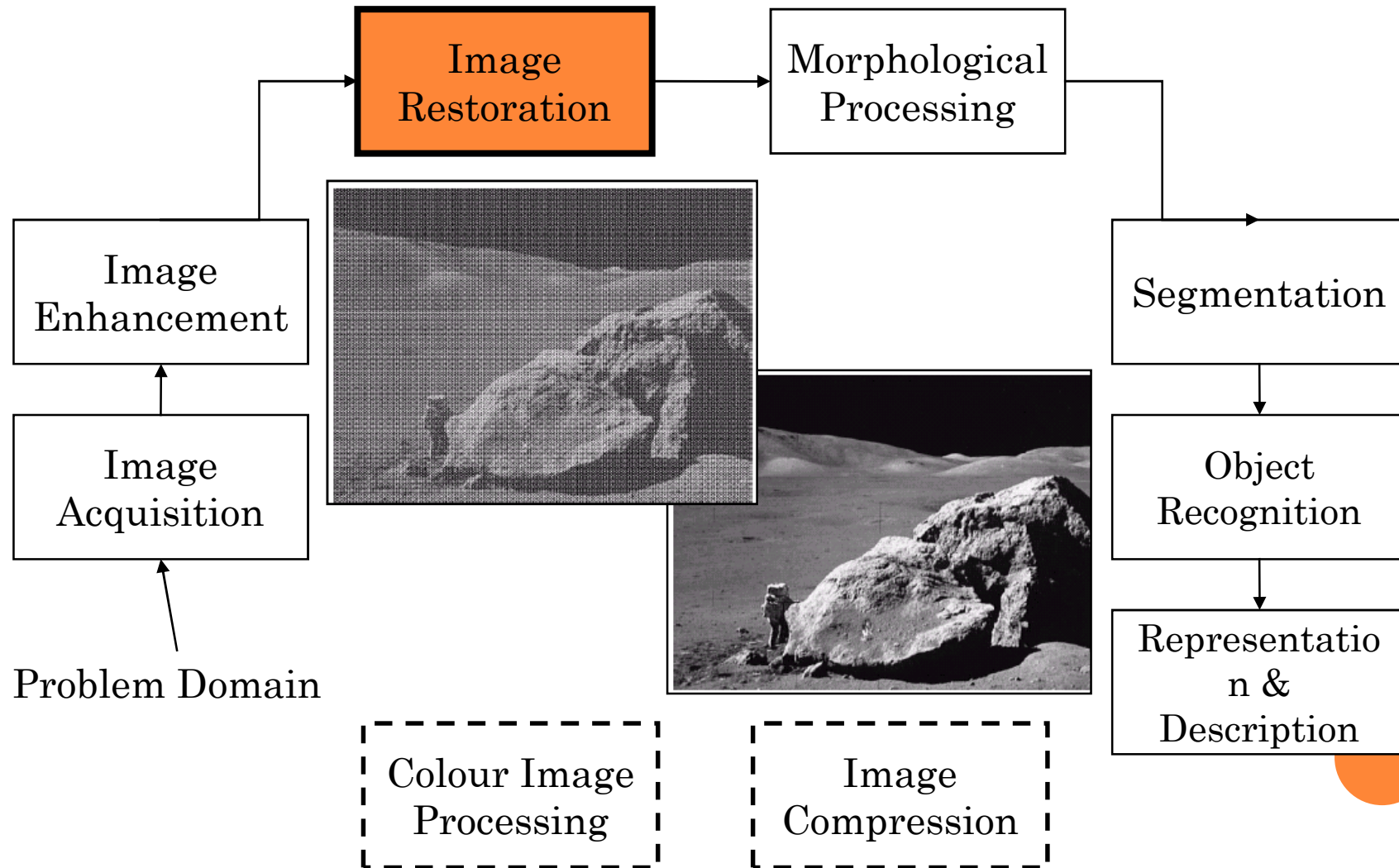
KEY STAGES IN DIGITAL IMAGE PROCESSING: IMAGE ACQUISITION



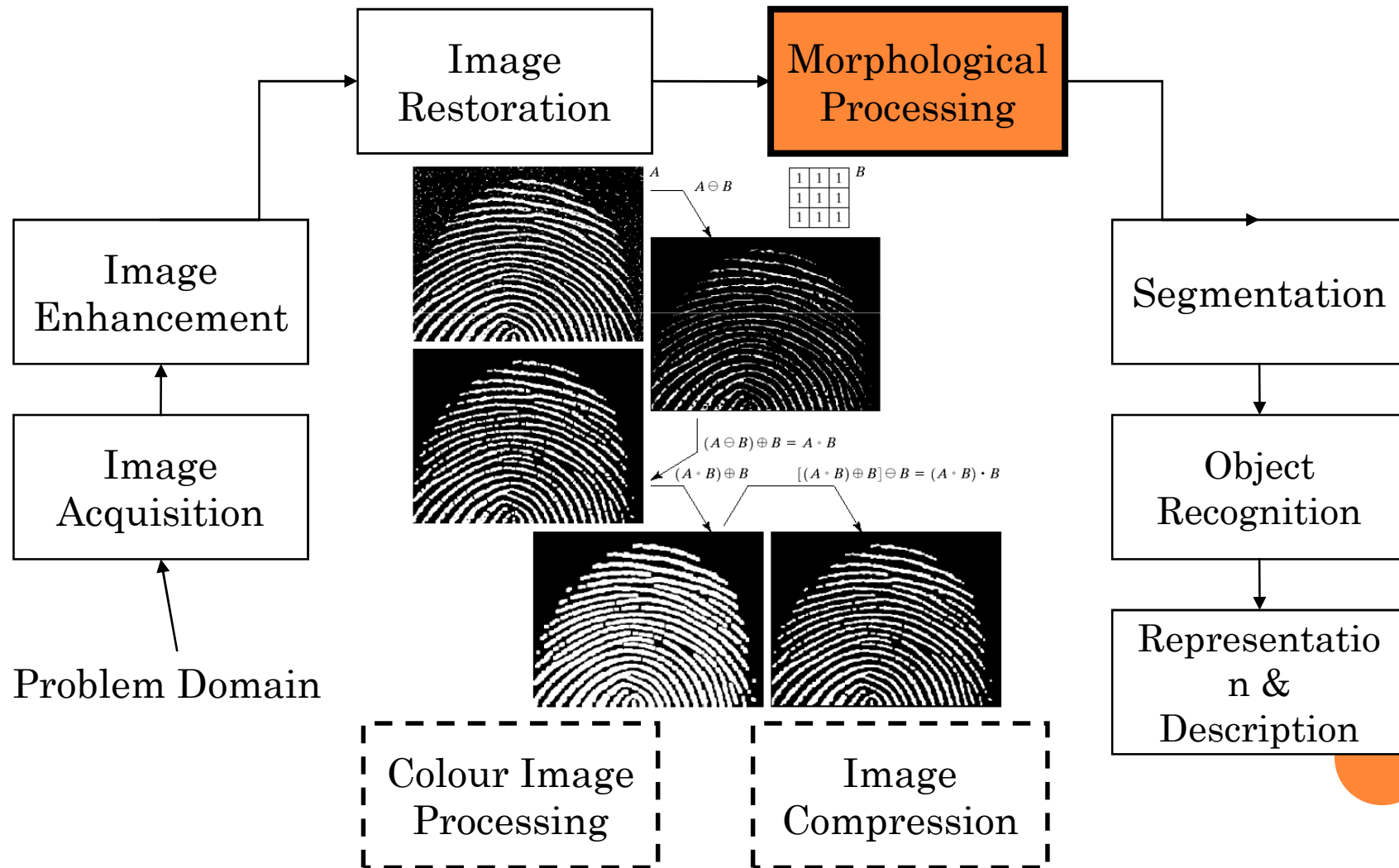
KEY STAGES IN DIGITAL IMAGE PROCESSING: IMAGE ENHANCEMENT



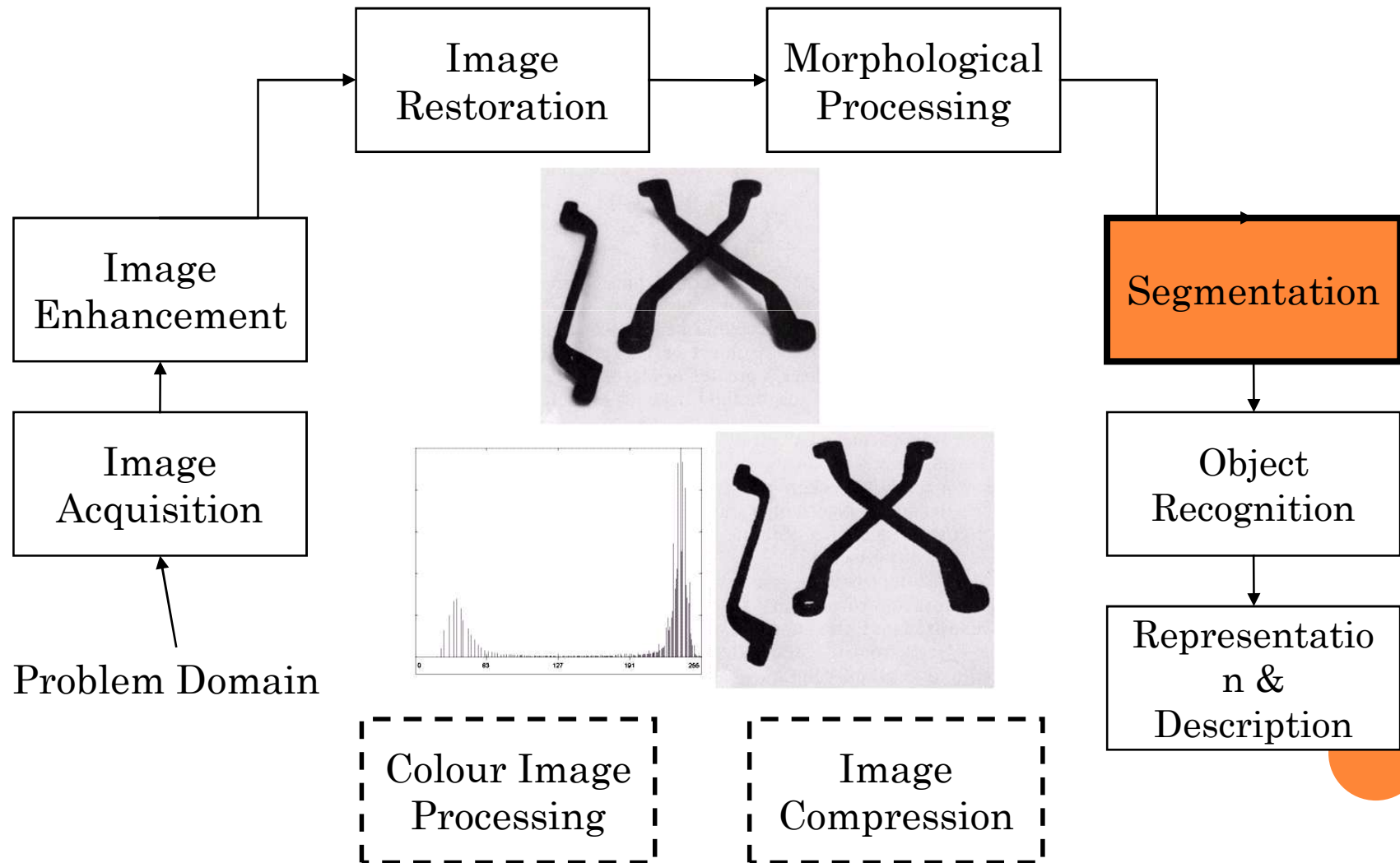
KEY STAGES IN DIGITAL IMAGE PROCESSING: IMAGE RESTORATION



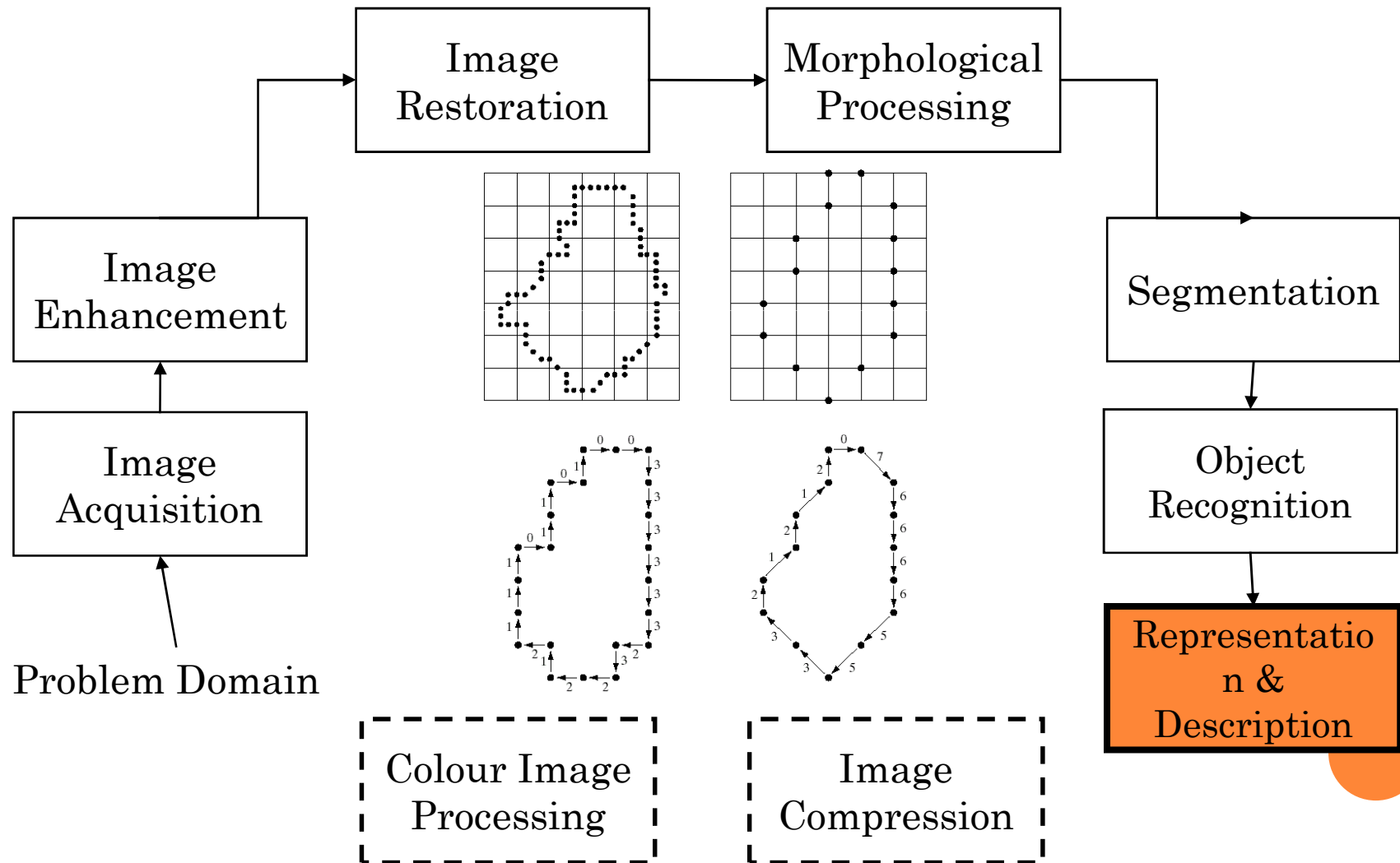
KEY STAGES IN DIGITAL IMAGE PROCESSING: MORPHOLOGICAL PROCESSING



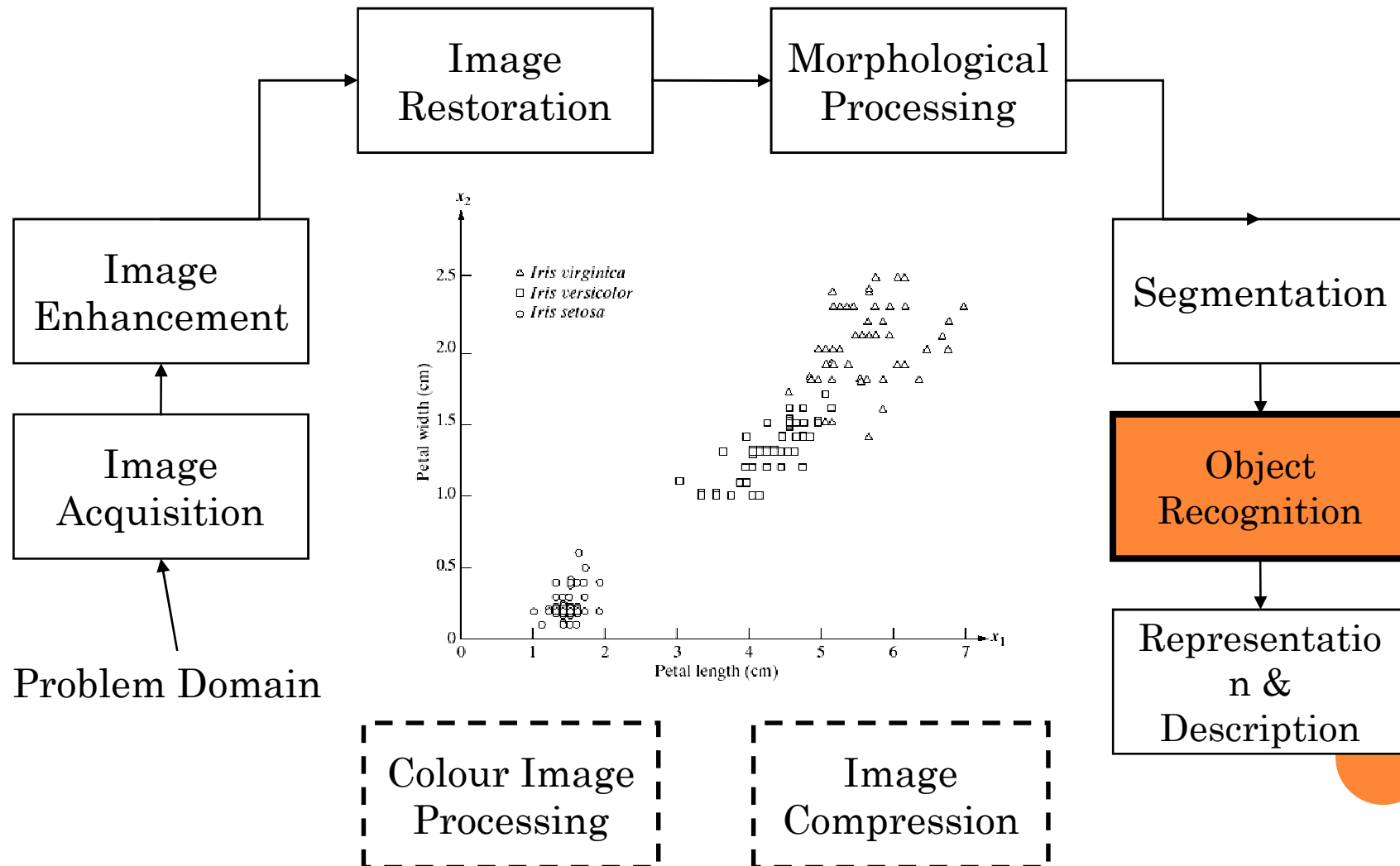
KEY STAGES IN DIGITAL IMAGE PROCESSING: SEGMENTATION



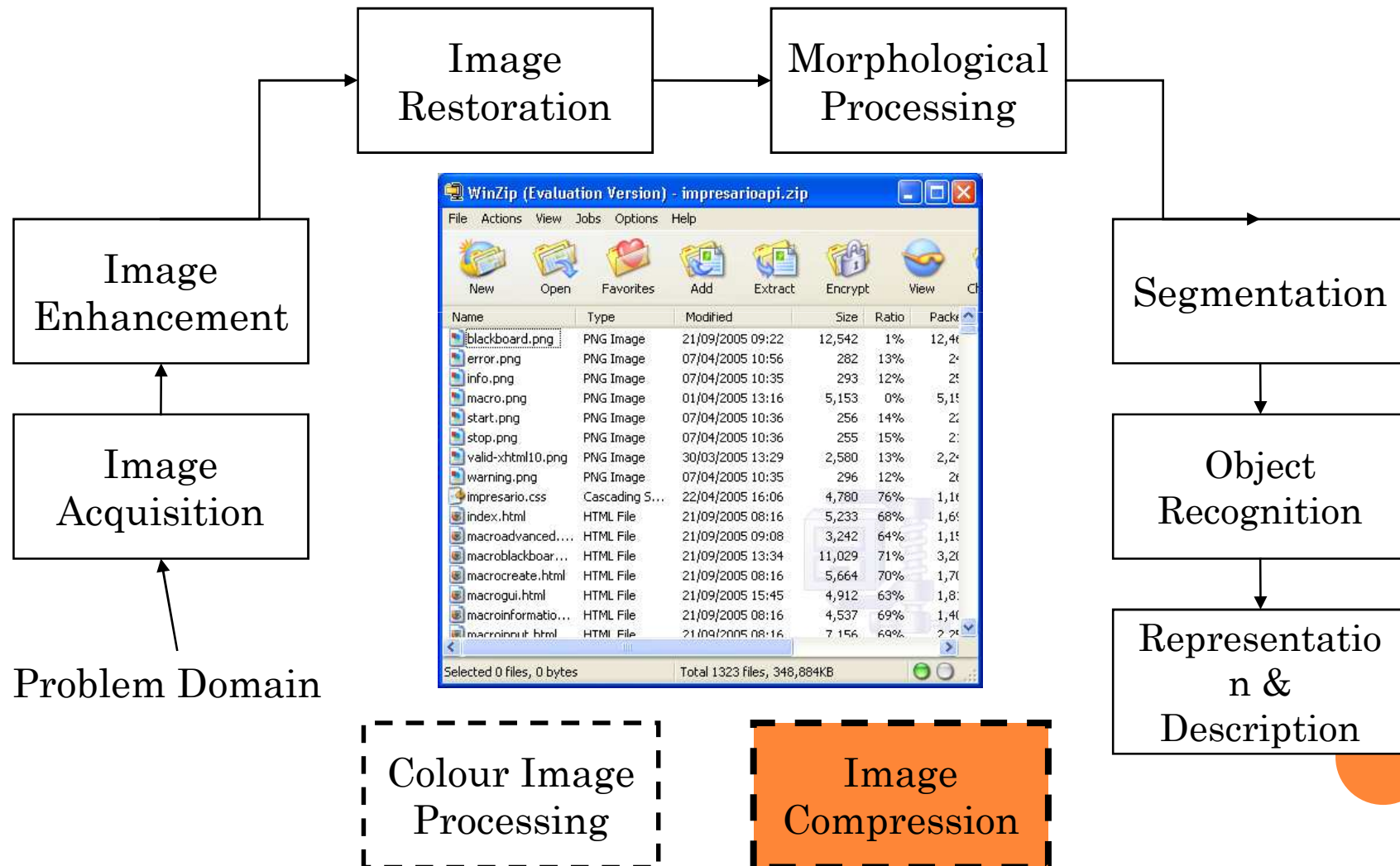
KEY STAGES IN DIGITAL IMAGE PROCESSING: REPRESENTATION & DESCRIPTION



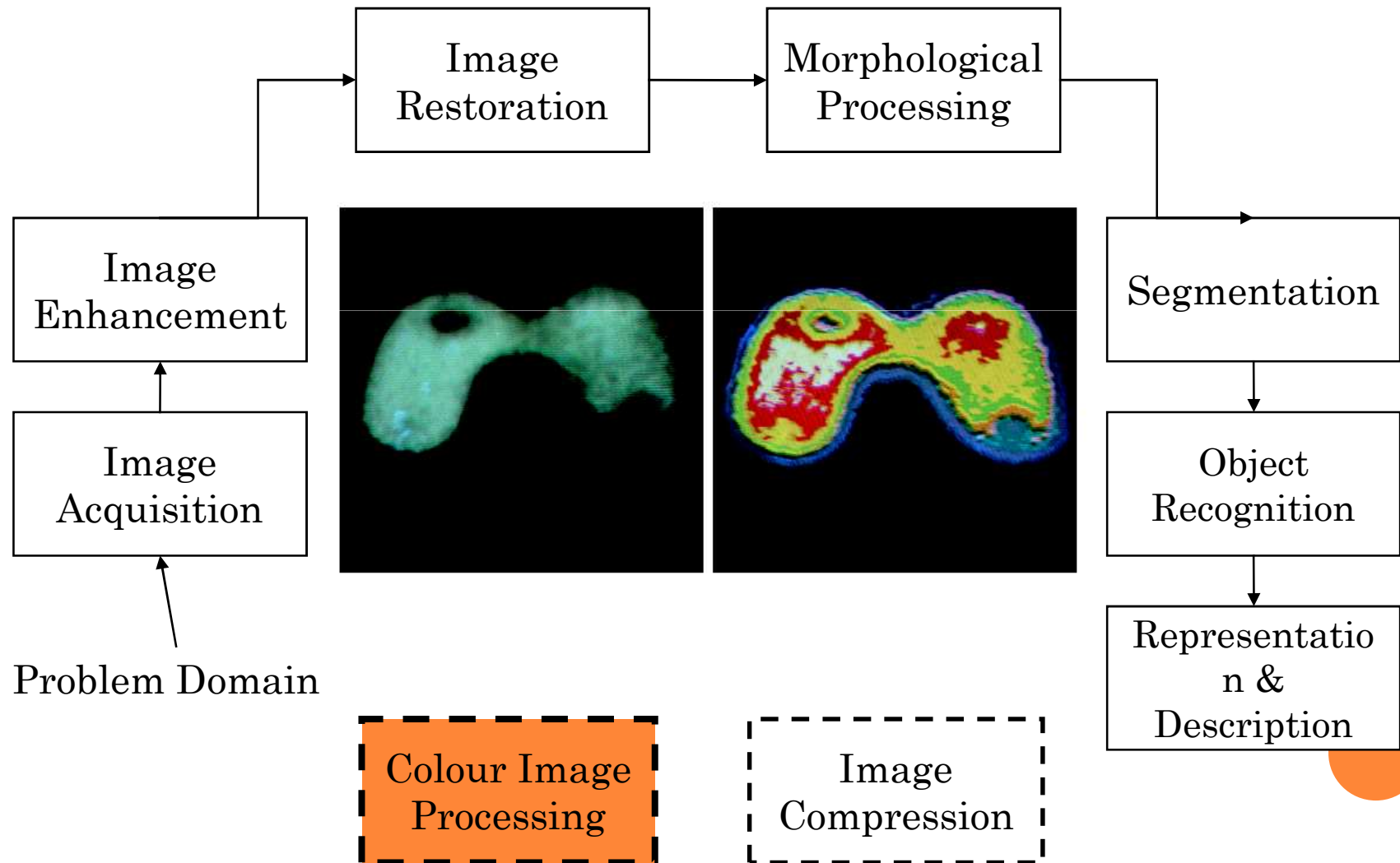
KEY STAGES IN DIGITAL IMAGE PROCESSING: OBJECT RECOGNITION



KEY STAGES IN DIGITAL IMAGE PROCESSING: IMAGE COMPRESSION



KEY STAGES IN DIGITAL IMAGE PROCESSING: COLOUR IMAGE PROCESSING



COMPONENTS OF IMAGE PROCESSING

