

CSE4227 Digital Image Processing

Lecture 01 – Introduction of Digital Image Processing

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Today's Contents

- What is a digital image?
- What is digital image processing (DIP)?
- Why do we need to learn DIP?
- DIP Applications
- Key stages in digital image processing

• Chapter 1 from R.C. Gonzalez and R.E. Woods, Digital Image Processing (3rd Edition), Prentice Hall, 2008

What is an Image?



What we see

0	3	2	5	4	7	6	9	8
3	0	1	2	3	4	5	6	7
2	1	0	3	2	5	4	7	6
5	2	3	0	1	2	3	4	5
4	3	2	1	0	3	2	5	4
7	4	5	2	3	0	1	2	3
6	5	4	3	2	1	0	3	2
9	6	7	4	5	2	3	0	1
8	7	6	5	4	3	2	1	0

What a computer sees

What is a Digital Image?

A digital image: is a representation of a two-dimensional image as a finite number of elements, each one has a particular location and value.. These element are called picture elements, image elements or pixels.

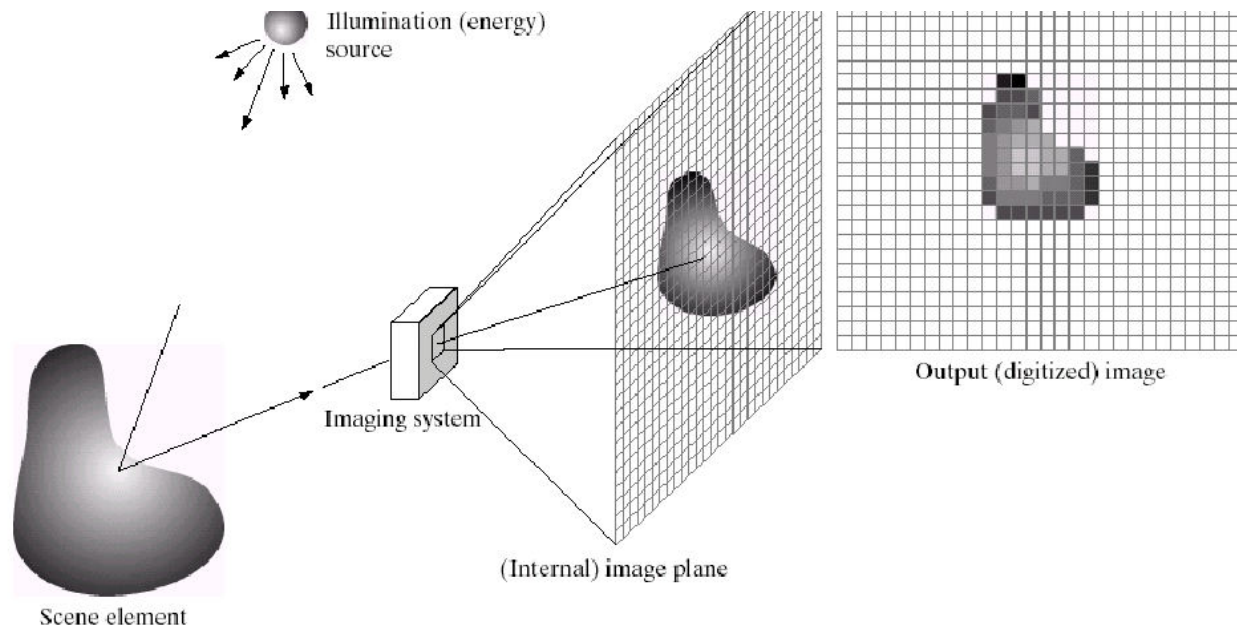
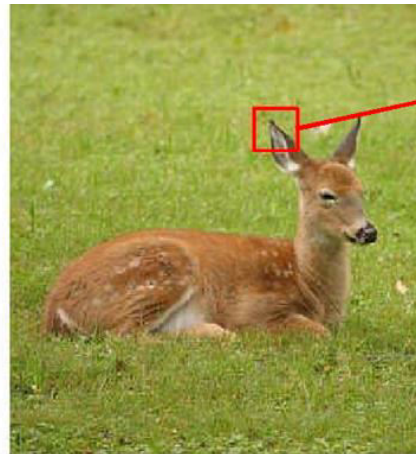
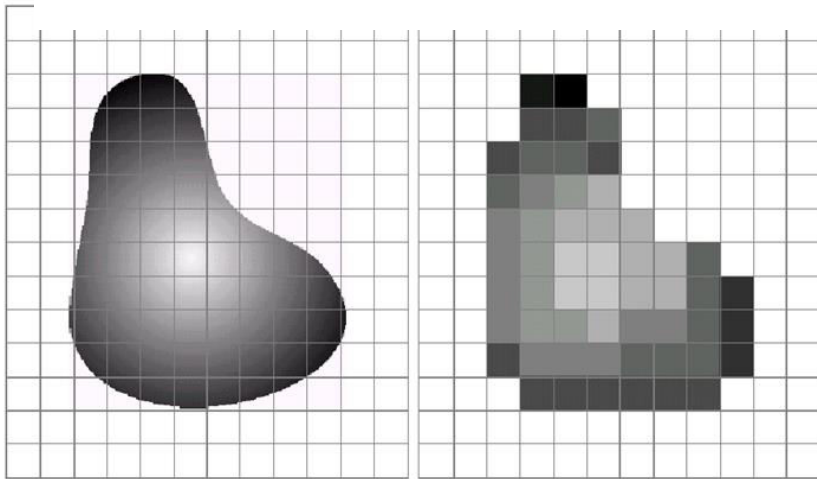


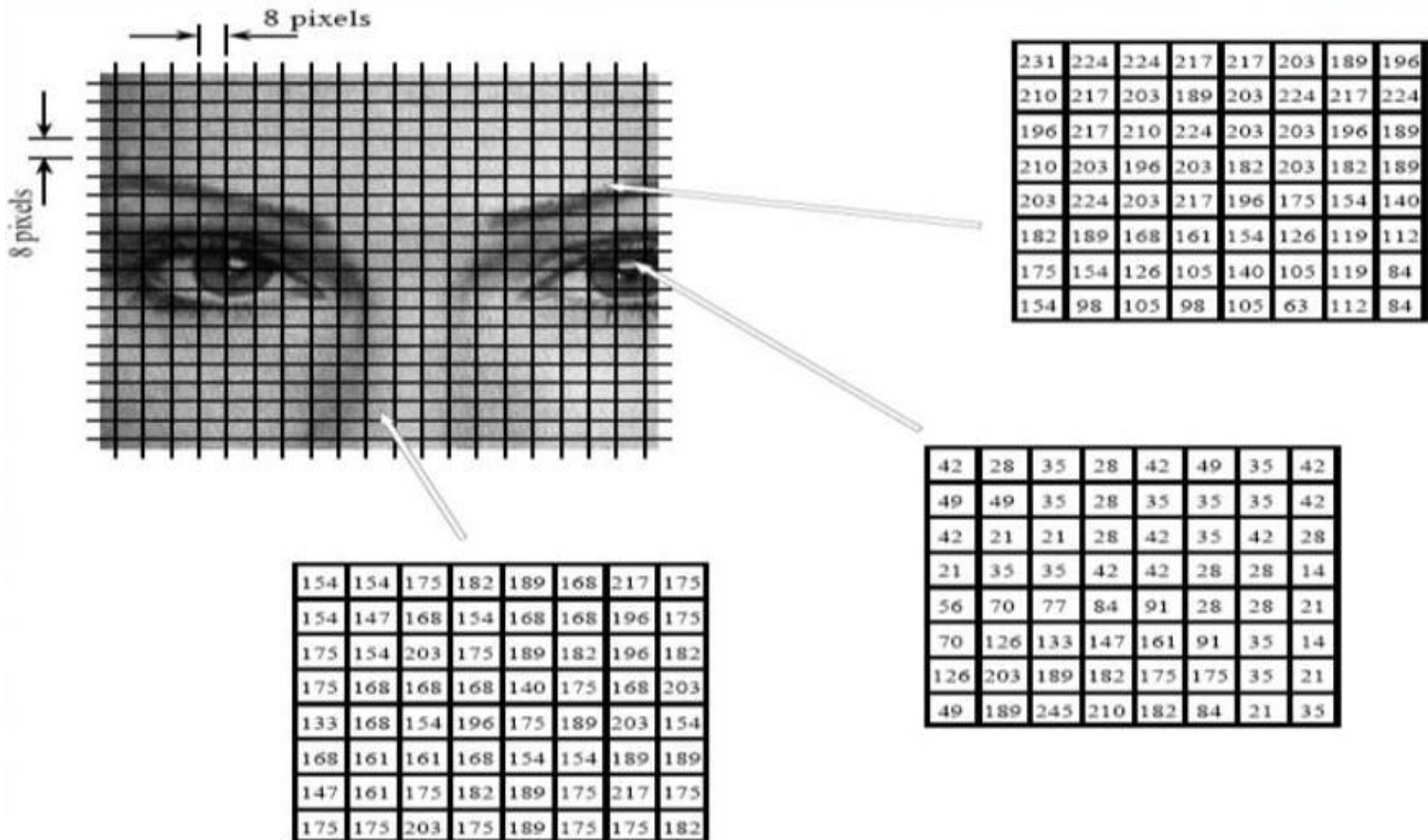
FIGURE 2.15 An example of the digital image acquisition process. (a) Energy (“illumination”) source. (b) An element of a scene. (c) Imaging system. (d) Projection of the scene onto the image plane. (e) Digitized image.

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

- ❑ **Pixels:** Smallest elements of the digital image, each has intensity.
- ❑ **Intensity** of pixel: the amplitude of *gray level* (in *gray scale images*)



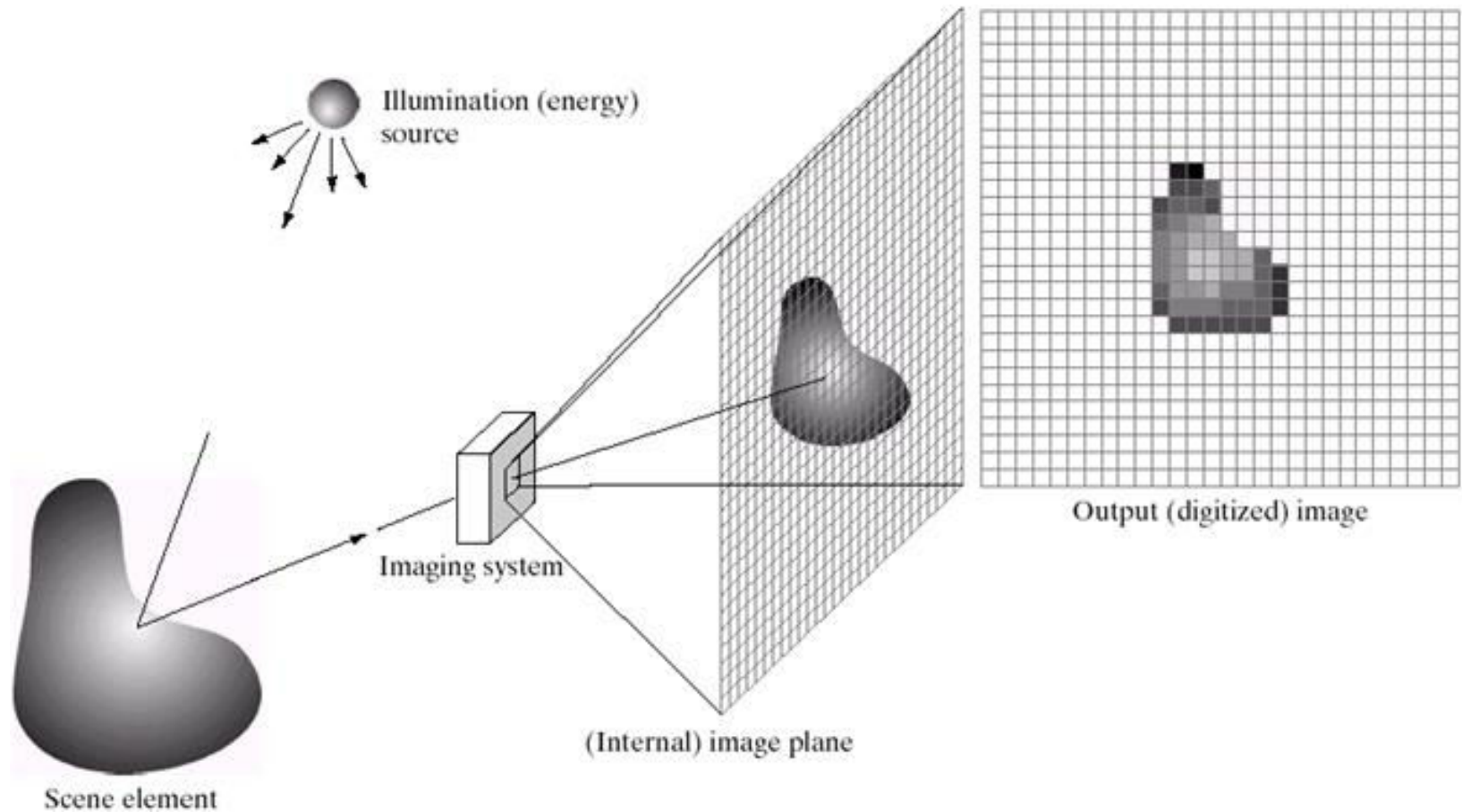
What is digital Image?



What is digital Image?

- ▣ An image can be defined as function of 2 variables , $f(x,y)$, where **x** and **y** are **spatial** coordinates, and the amplitude of **f** at any pair of coordinates (x , y) is called the **intensity** of the image at that point

Image Acquisition using Sensor Array



□ Images are typically generated by *illuminating a scene* and absorbing the energy reflected by the objects in that scene.

A Simple Image Formation Model

$$f(x, y) = i(x, y)r(x, y)$$

$f(x, y)$: intensity at the point (x, y)

$i(x, y)$: illumination at the point (x, y)

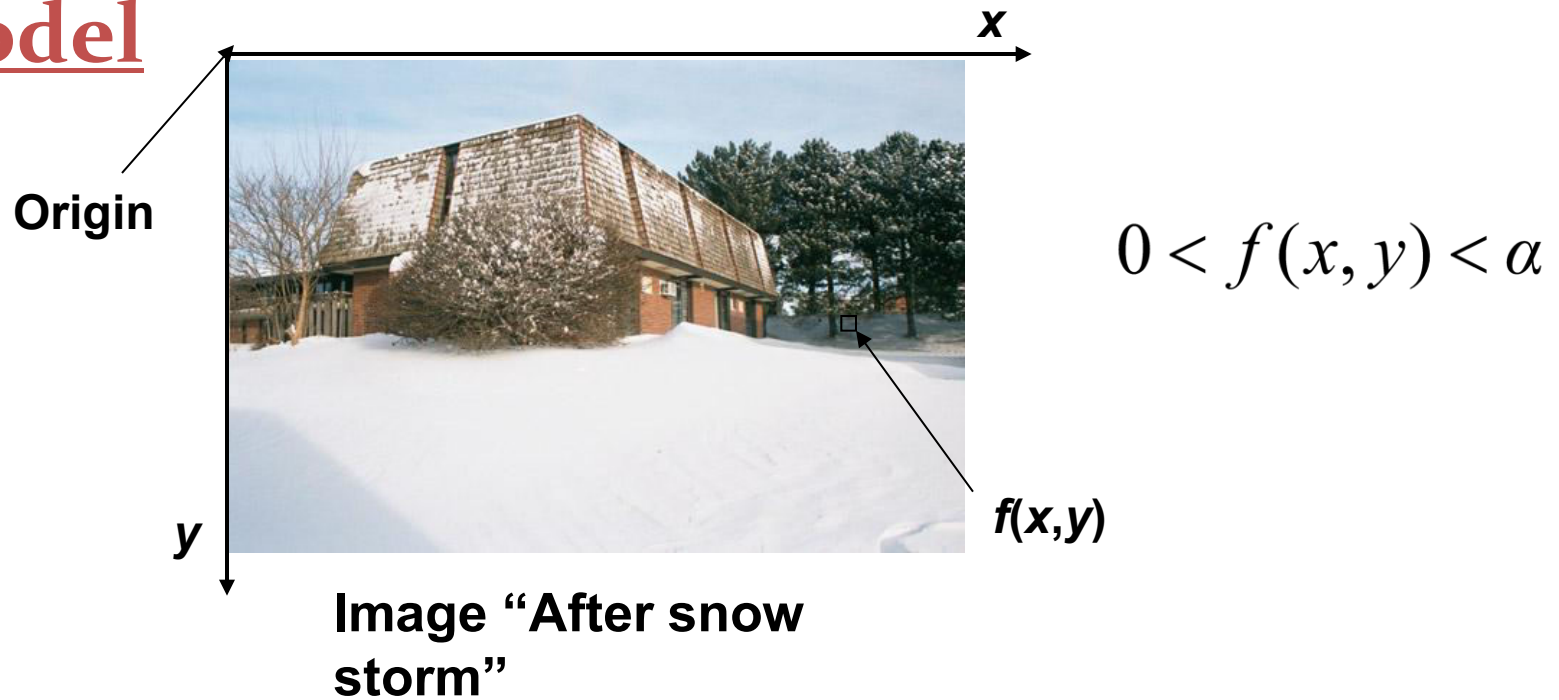
(the amount of source illumination incident on the scene)

$r(x, y)$: reflectance/transmissivity at the point (x, y)

(the amount of illumination reflected/transmitted by the object)

where $0 < i(x, y) < \infty$ and $0 < r(x, y) < 1$

Image Formation Model



- ✓ An image: **a multidimensional function of spatial coordinates.**
- ✓ Spatial coordinate: (x,y) for 2D case such as photograph,
 (x,y,z) for 3D case such as CT scan images
 (x,y,t) for movies
- ✓ The **function f** may represent intensity (for monochrome images) or color (for color images) or other associated values.

Some Typical Ranges of illumination

► Illumination

Lumen — A unit of light flow or luminous flux

Lumen per square meter (lm/m^2) — The metric unit of measure for illuminance of a surface

- On a clear day, the sun may produce in excess of $90,000 \text{ lm}/\text{m}^2$ of illumination on the surface of the Earth
- On a cloudy day, the sun may produce less than $10,000 \text{ lm}/\text{m}^2$ of illumination on the surface of the Earth
- On a clear evening, the moon yields about $0.1 \text{ lm}/\text{m}^2$ of illumination
- The typical illumination level in a commercial office is about $1000 \text{ lm}/\text{m}^2$

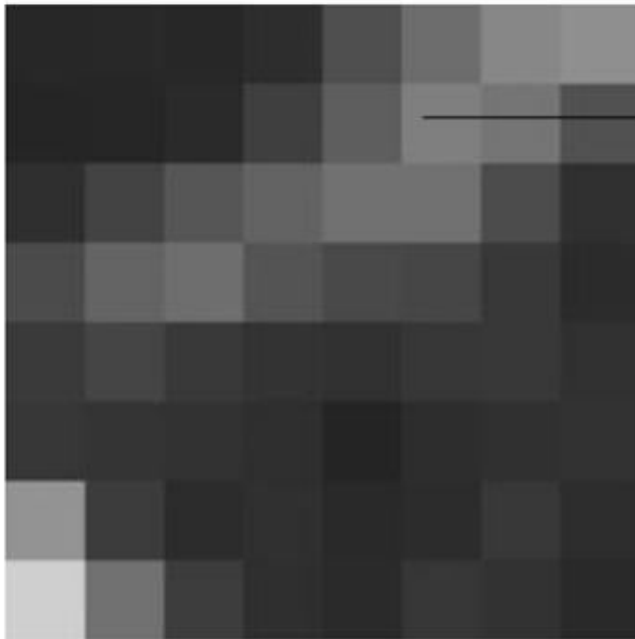
Some Typical Ranges of Reflectance

► Reflectance

- 0.01 for black velvet
- 0.65 for stainless steel
- 0.80 for flat-white wall paint
- 0.90 for silver-plated metal
- 0.93 for snow

What is digital image?

- The image consists of finite number of pixels ($f(x,y)$)
- Every pixel Is an intersection between a row and a column.
- Every pixel has intensity



pixel

Ex:

$$f(2,6) = 123$$

Refers to a pixel existing on the intersection between row 2 with column 6, and its intensity is 123.

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

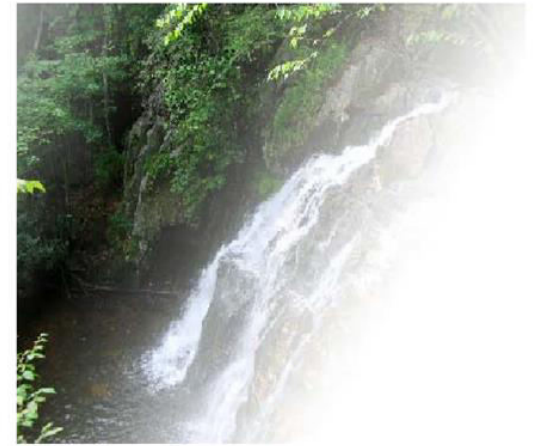


What is a Digital Image? (cont...)

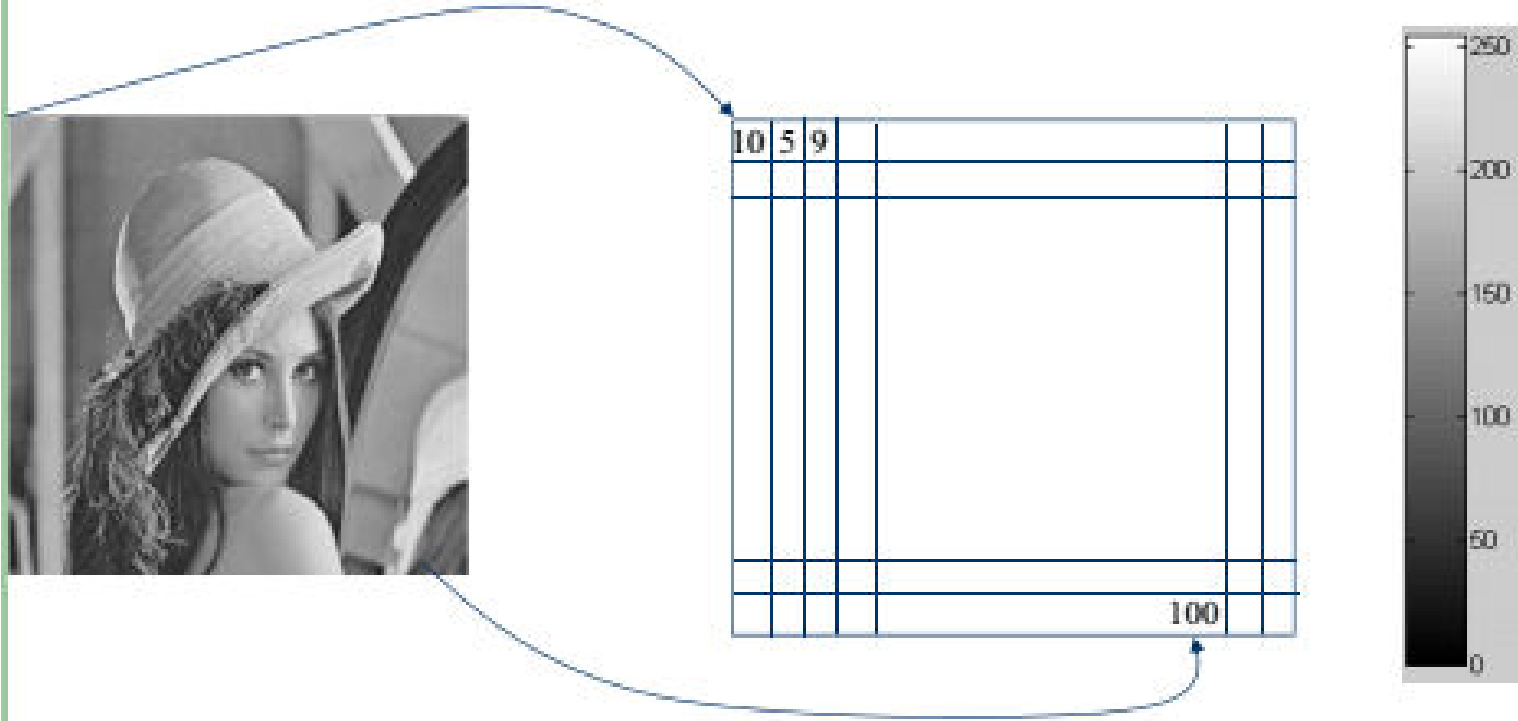
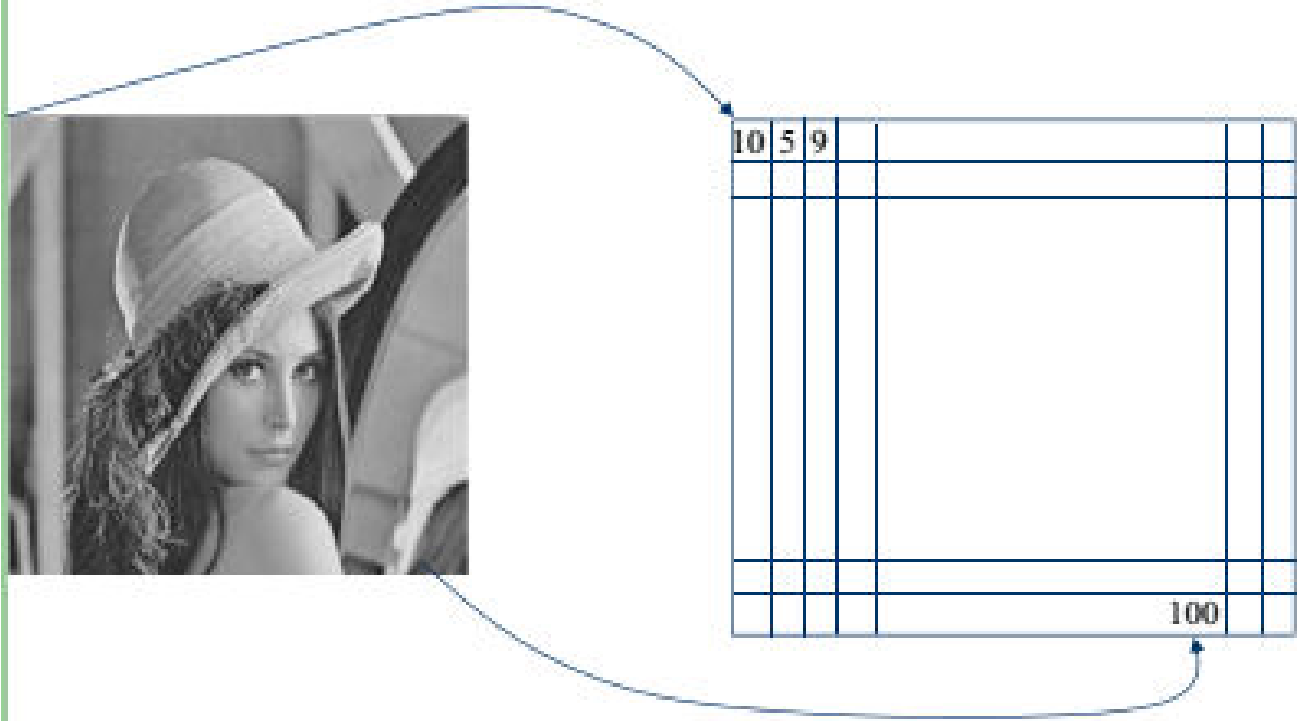
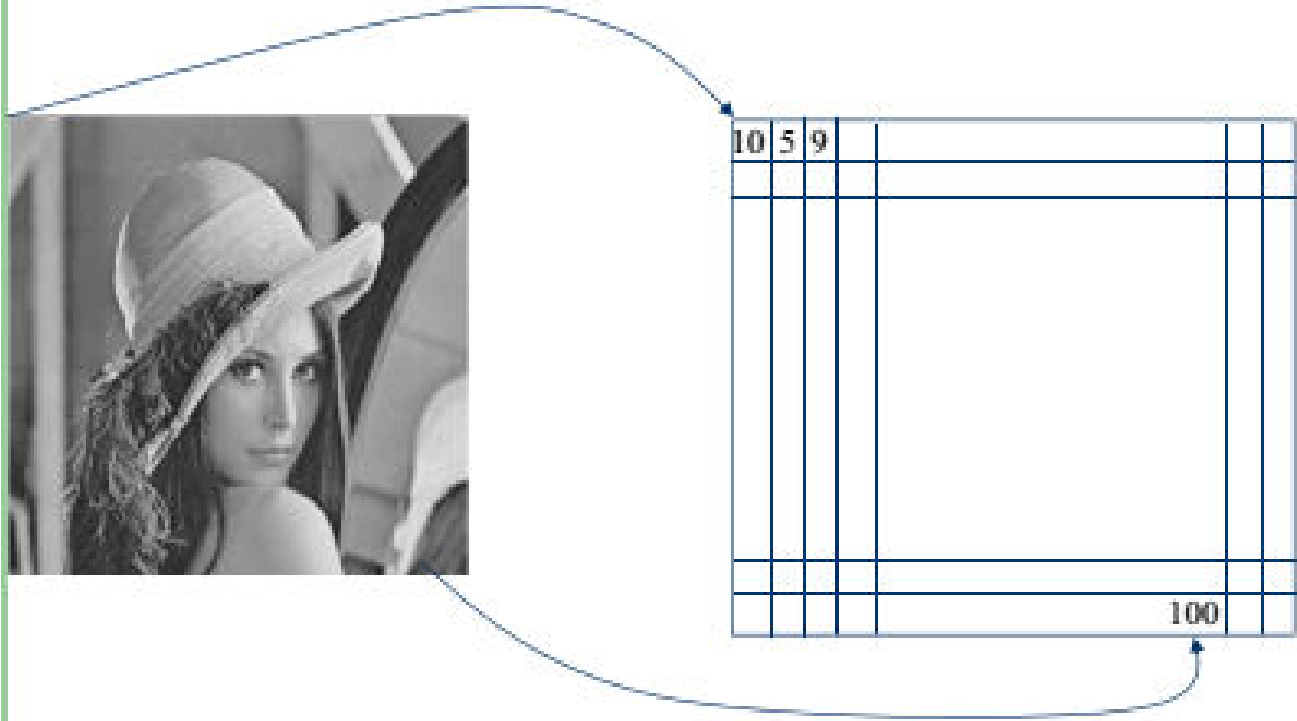
Common image formats include:

- 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

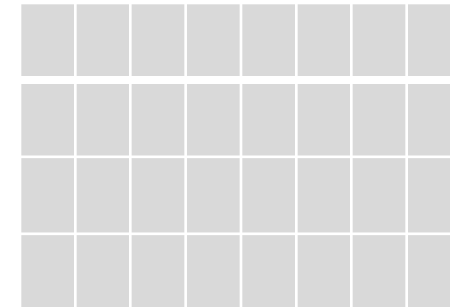
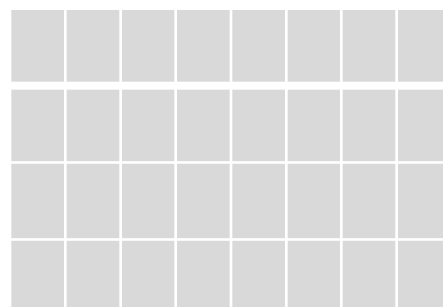
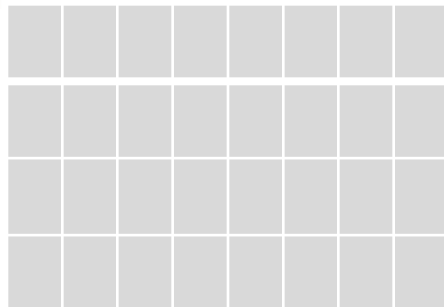
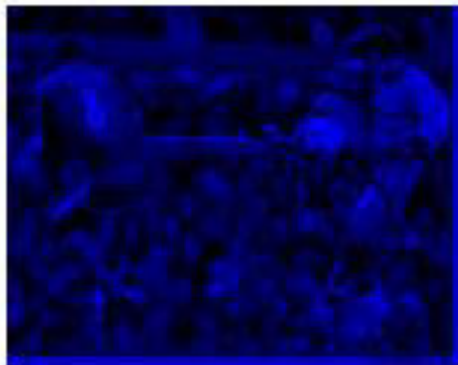


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Color Image

Red, Green, Blue Channels



What is digital image processing (DIP)?

❑ DIP:

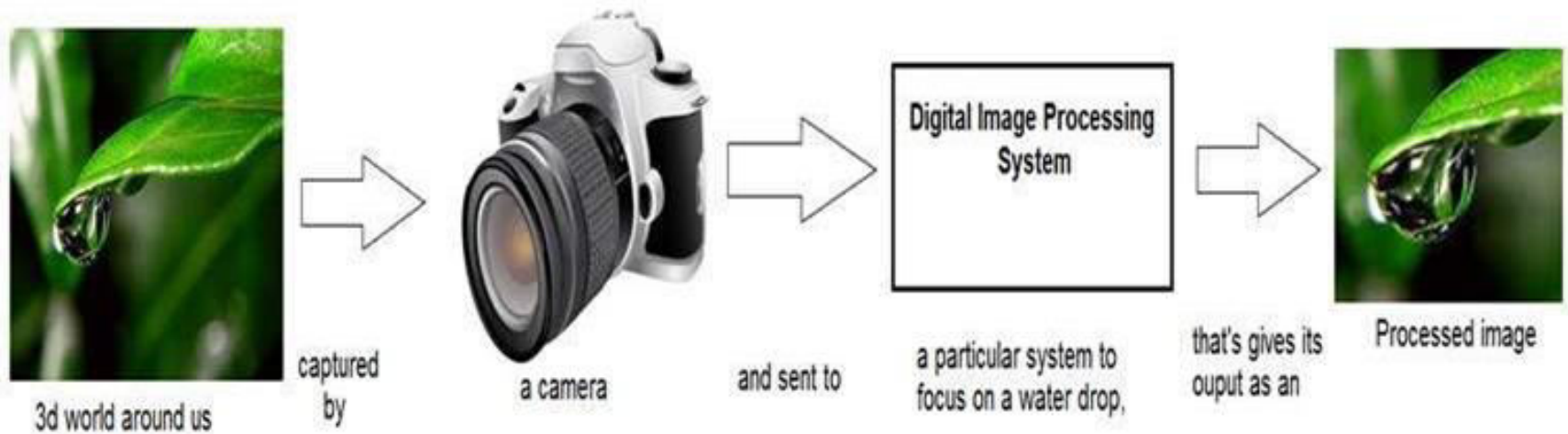
- Processing of image which are digital in nature by a digital computer.

❑ DIP focuses on two major tasks

–Improvement of pictorial information for human perception and interpretation.

–Processing of image data for storage, transmission and representation for autonomous machine perception.

How DIP works?



Levels of digital image processing (DIP)

- Image Processing
 - image in → image out
- Image Analysis
 - image in → measurements out
- Image Understanding
 - image in → high-level description out

What are digital image processing levels?

□ low level processes:

- **Input** and **output** are images
- **Tasks:** Primitive operations, such as, image processing to reduce noise, contrast enhancement and image sharpening

What are digital image processing levels?

□ Mid-Level Processes:

- **Inputs**, generally, are images. **Outputs** are attributes extracted from those images (edges, contours, identity of individual objects)
- **Tasks:**
 - Segmentation (partitioning an image into regions or objects)
 - Description of those objects to reduce them to a form suitable for computer processing
 - Classifications (recognition) of objects

What are digital image processing levels?

- **High-Level Processes**
- **Input:** Attributes **Output:** Understanding
- **Tasks:** recognizing objects
 - Image analysis and computer vision (Analysis of the image content)
- **Examples:** Scene understanding

Comparisons of DIP

- **DIP vs Computer Graphics:**
 - DIP deals with raster data or bitmaps, whereas computer graphics primarily deals with vector data.
- **DIP vs Signal Processing:**
 - Digital Signal Processing deals with a one dimension signal while DIP deals with visual information that is often in two or more dimensions.
- **DIP vs Machine/Computer Vision:**
 - The main goal of machine vision is to interpret the image and to extract its physical, geometric, or topological properties.

Why do we need to learn DIP?

- ❑ Image is better than any other information form for our human being to perceive.
- ❑ Vision allows humans to perceive and understand the world surrounding us.
- ❑ Has many potential applications

DIP Applications

❑ Almost all of the technical fields are impacted by DIP.

- Image enhancement/restoration
- Medical visualization
- Remote sensing
- Transmission and encoding
- Machine/Robot vision
- Satellite Imaging
- Law enforcement
- Human computer interfaces

Others

- Color processing
- Pattern recognition
- Video processing

Examples: Image Enhancement

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

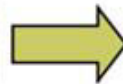
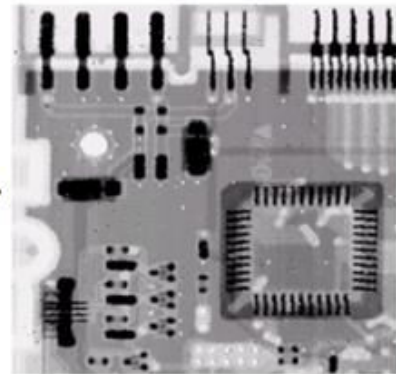
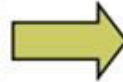
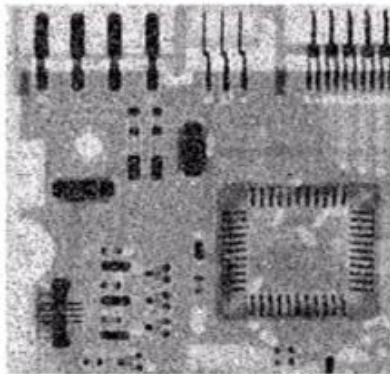
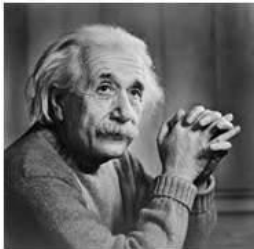


Image sharpening and restoration

- ❑ to make them a better image
- ❑ to manipulate images in way to achieve desired result.
 - Zooming, blurring , sharpening , gray scale to color conversion, detecting edges and vice versa ,
 - Image retrieval and Image recognition.
- ❑ The common examples are:



Original
Image
Image

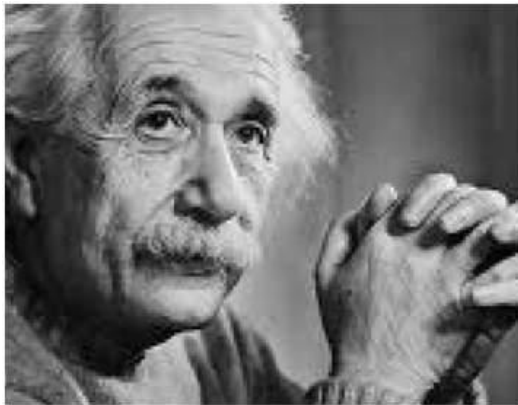
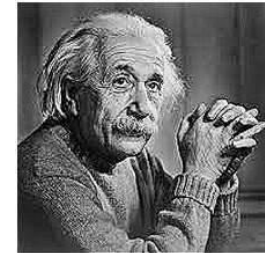
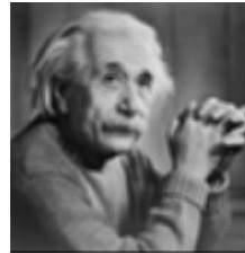


Image Image
Zoomed Image



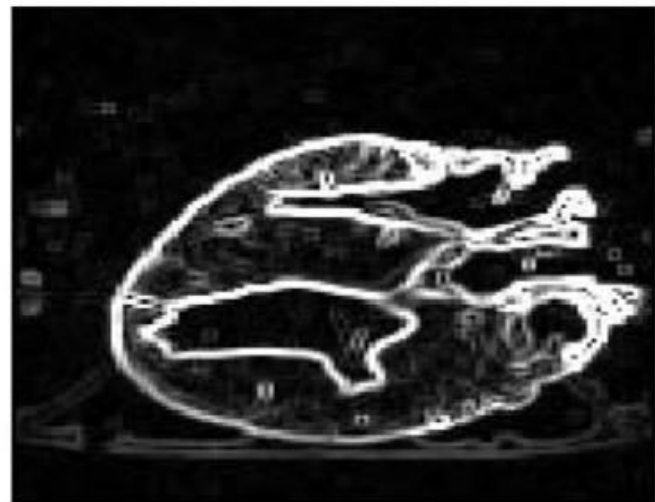
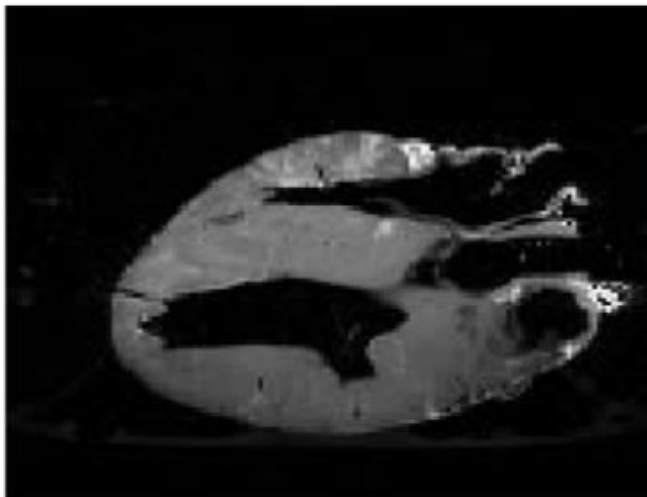
Medical field

- ❑ The common applications of DIP in the field of medical is
 - Gamma ray in nuclear medicine and astronomical observation
 - PET scan
 - X Ray Imaging
 - Medical CT
 - Remote Sensing

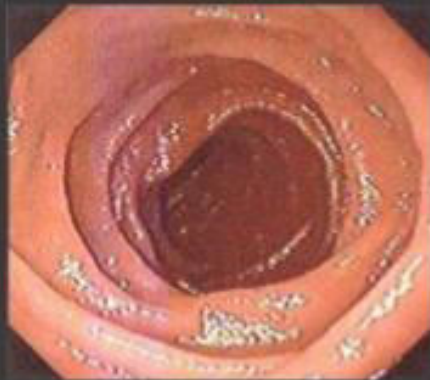
Examples: Medicine

Take slice from MRI (Magnetic Resonance Imaging) scan of a heart, and find boundaries between types of tissue

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



Medical Applications of Remote Sensing



Transmission and encoding

- ❑ The very first image that has been transmitted over the wire was from London to New York via a submarine cable. The picture that was sent is shown below.



- ❑ The picture that was sent took three hours to reach from one place to another.

Machine/Robot vision



Hurdle detection



Line follower robot

Examples: Artistic Effects

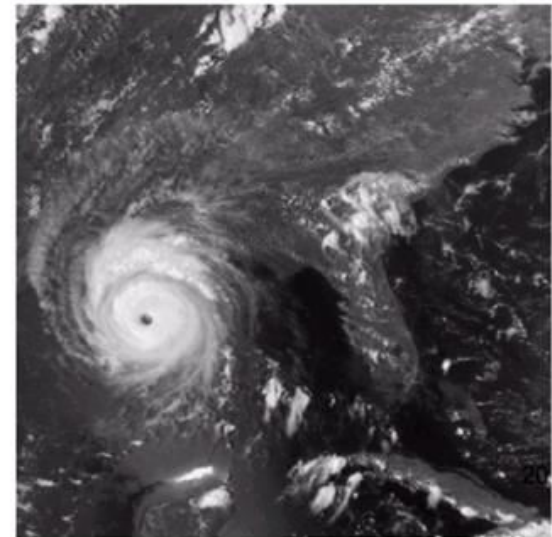
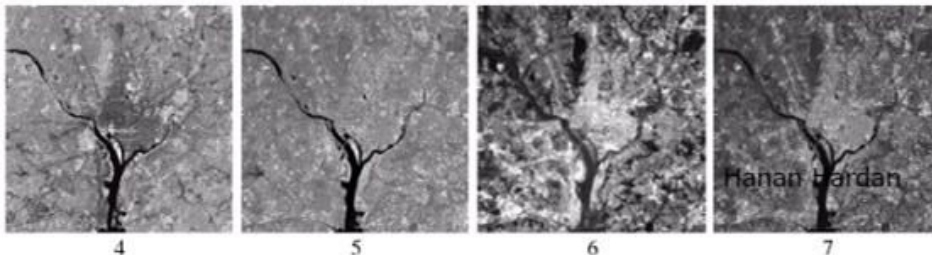
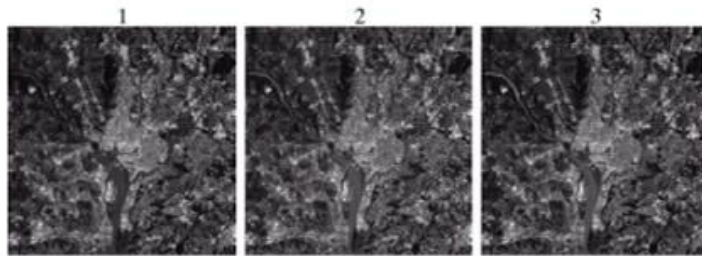
- Artistic effects are used to make images more visually appealing, to add special effects and to make composite images



Examples: GIS

■ Geographic Information Systems

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



Remote Sensing Satellite Image

❖ Urbanization & Transportation

- ❖ Updating road maps
- ❖ Asphalt conditions
- ❖ Wetland delineation
- ❖ Urban Planning



❖ Agriculture

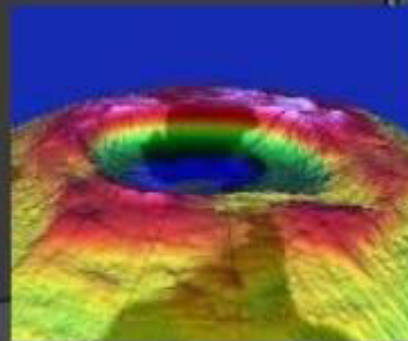
- ❖ Crop health analysis
- ❖ Precision agriculture
- ❖ Compliance mapping
- ❖ Yield estimation
- ❖ Forest application



Remote Sensing Satellite Image

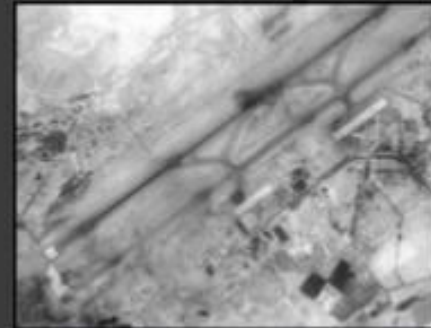
□ Natural Resource Management

- Habitat analysis
- Environmental assessment
- Pest/disease outbreaks
- Impervious surface mapping
- Lake monitoring
- Hydrology
- Landuse-Landcover monitoring
- Mineral province
- Geomorphology
- Geology



Remote Sensing Satellite Image

- National Security
 - Targeting
 - Disaster mapping and monitoring
 - Damage assessment
 - Weapons monitoring
 - Homeland security
 - Navigation
 - Policy
 - Telecommunication planning
 - Coastal mapping



Examples: Law Enforcement

- Image processing techniques are used extensively by law enforcers
 - Number plate recognition for speed cameras
 - Fingerprint recognition



Hanan Hardan



Examples: HCI

- Try to make human computer interfaces more natural
 - Face recognition



❑ Color processing

- ❑ includes processing of colored images and different color spaces that are used. For example RGB color model , YCbCr, HSV. It also involves studying transmission , storage , and encoding of these color images.

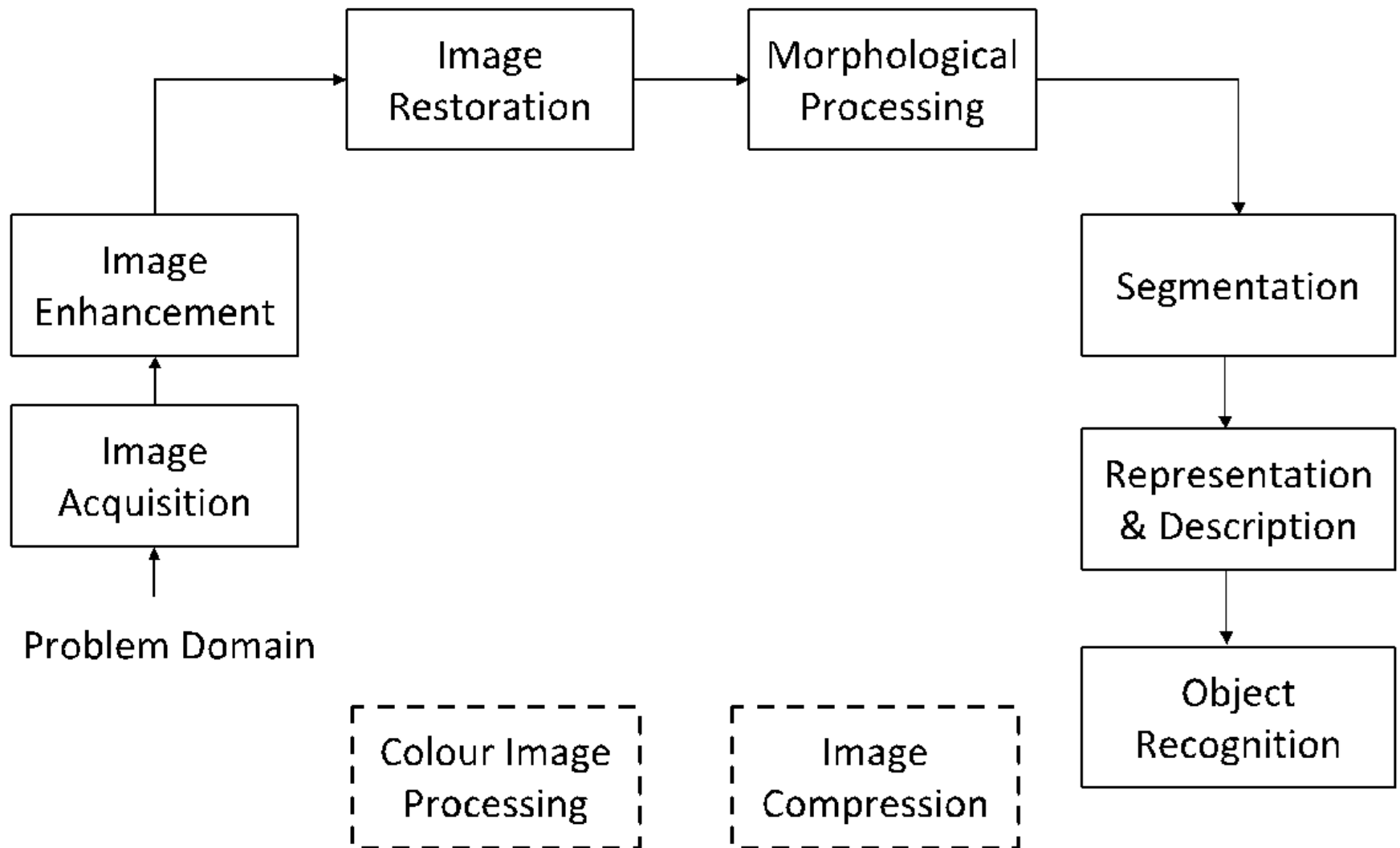
❑ Pattern recognition

- ❑ image processing is used for identifying the objects in an images and then machine learning is used to train the system for the change in pattern. Pattern recognition is used in computer aided diagnosis , recognition of handwriting , recognition of images e.t.c.

❑ Video processing

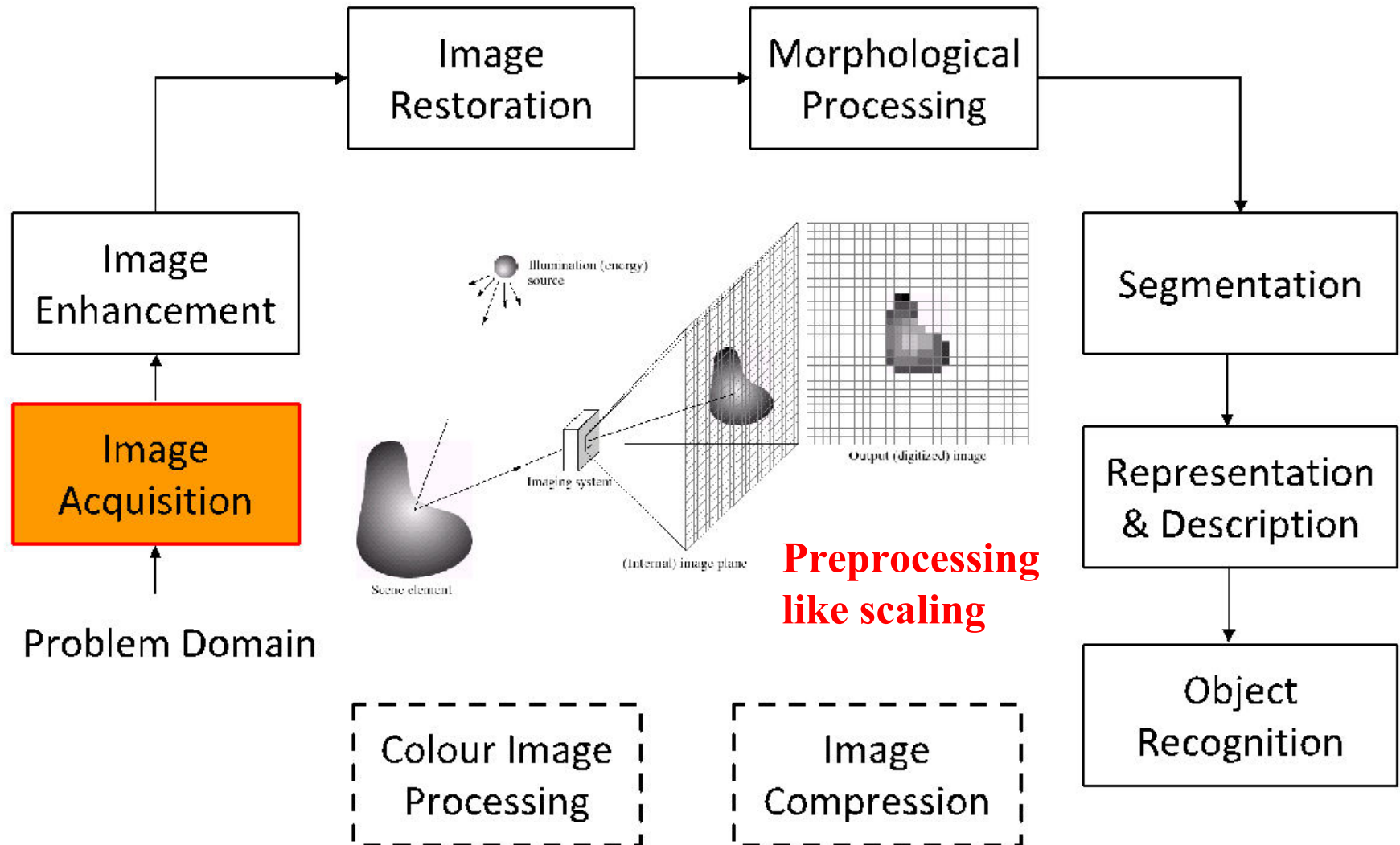
- ❑ A video is nothing but just the very fast movement of pictures. The quality of the video depends on the number of frames/pictures per minute and the quality of each frame being used. Video processing involves noise reduction , detail enhancement , motion detection , frame rate conversion , aspect ratio conversion , color space conversion e.t.c

Key Stages in Digital Image Processing



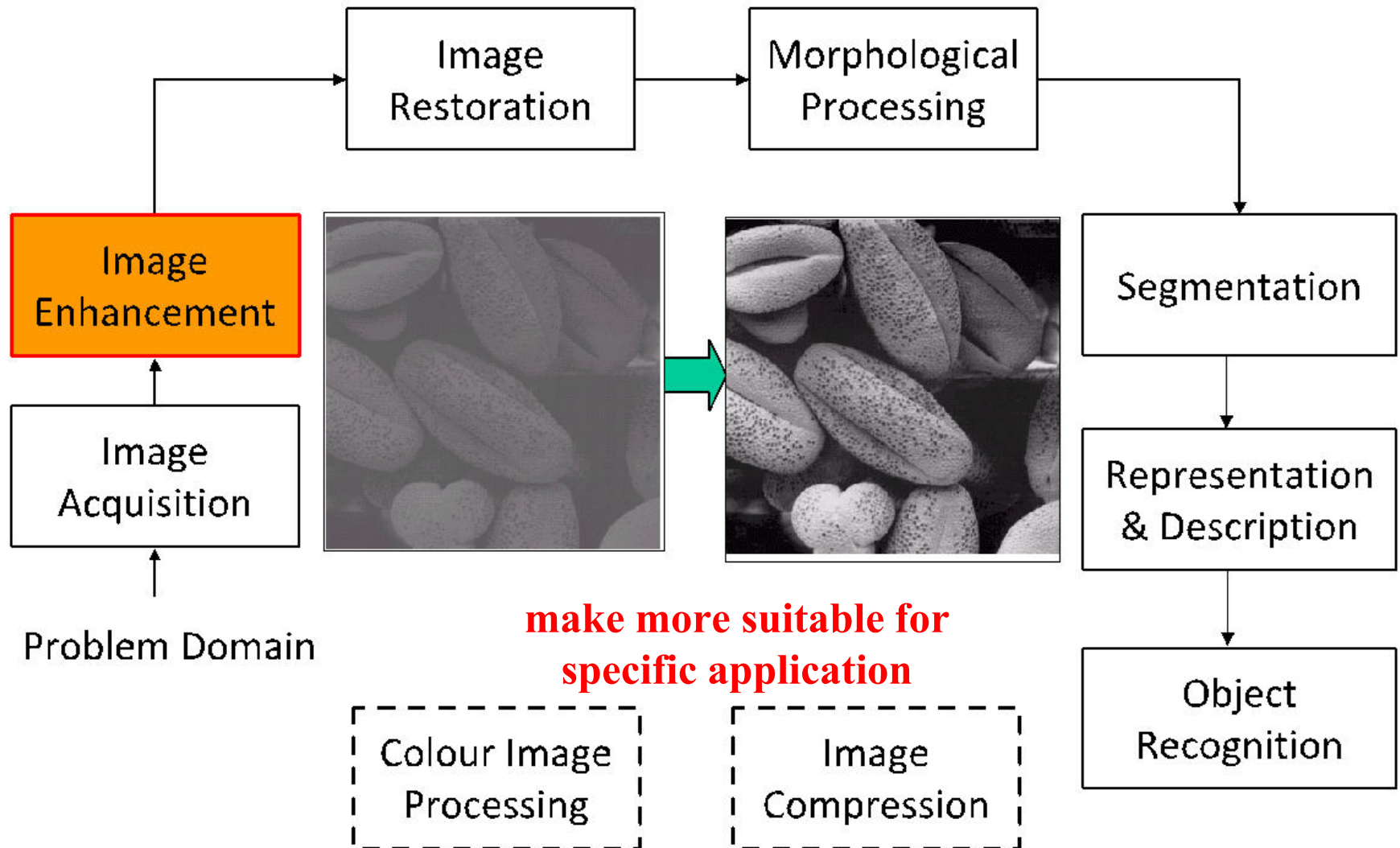


Key Stages in DIP: Image Acquisition



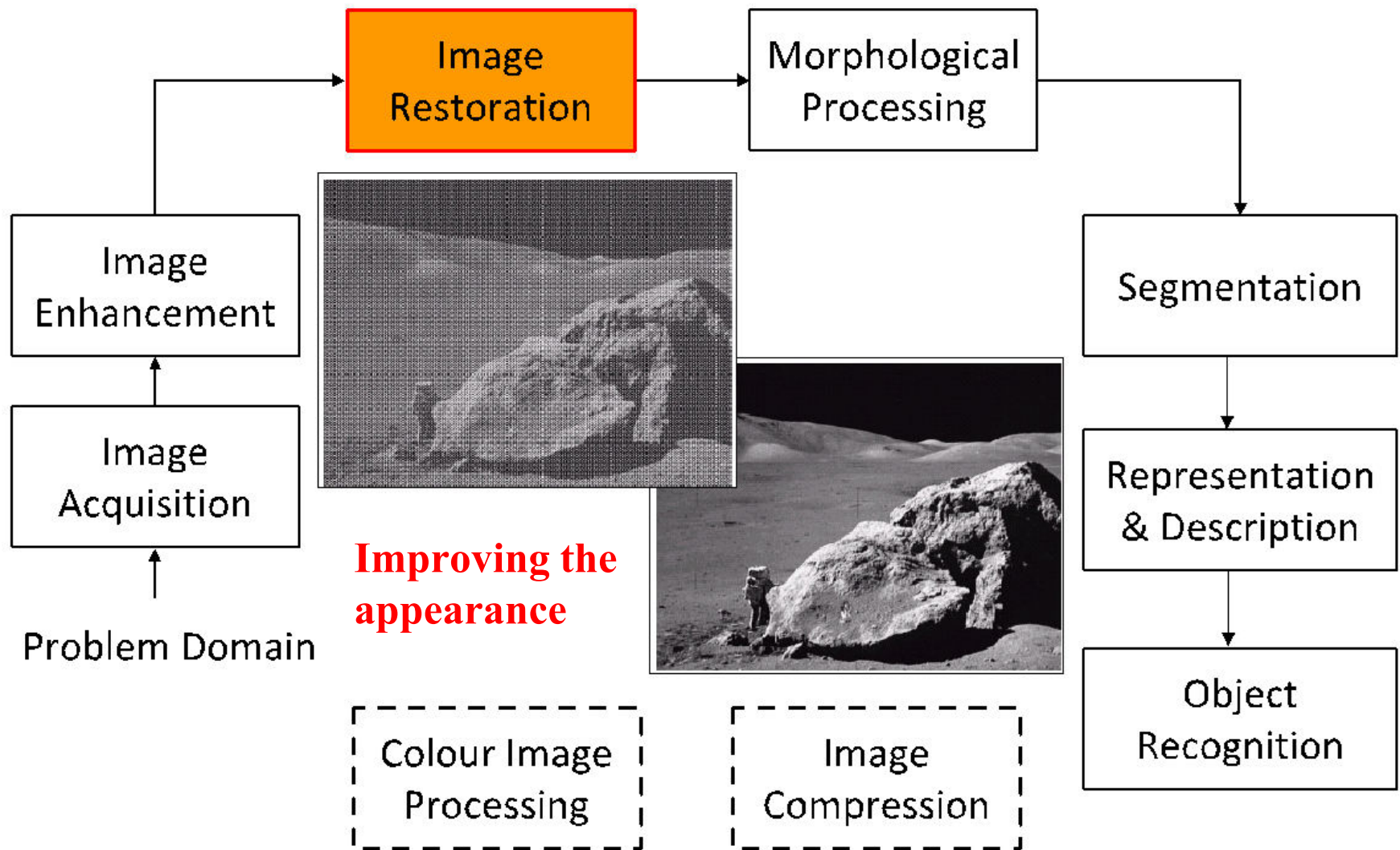


Key Stages in DIP: Image Enhancement



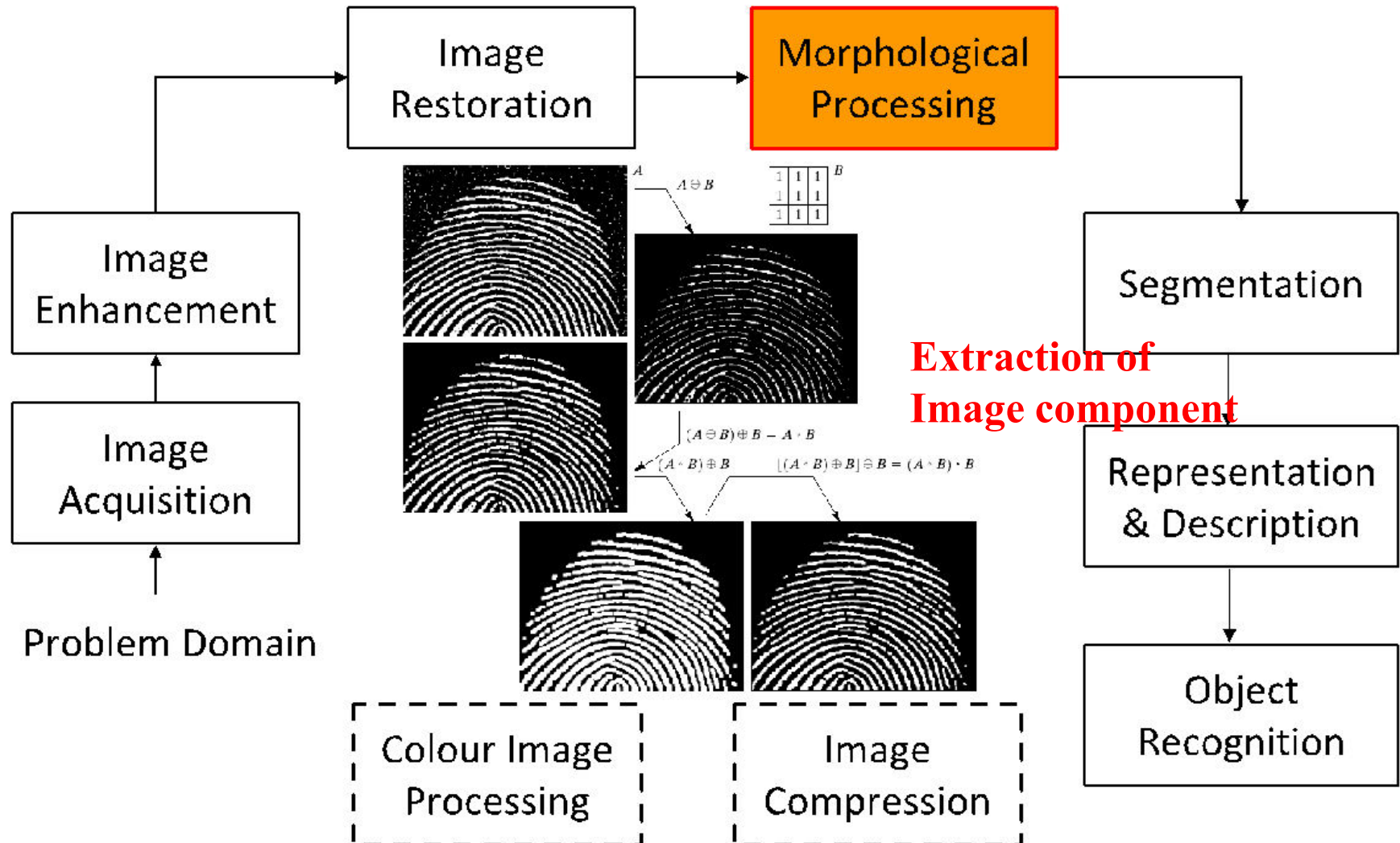


Key Stages in DIP: Image Restoration



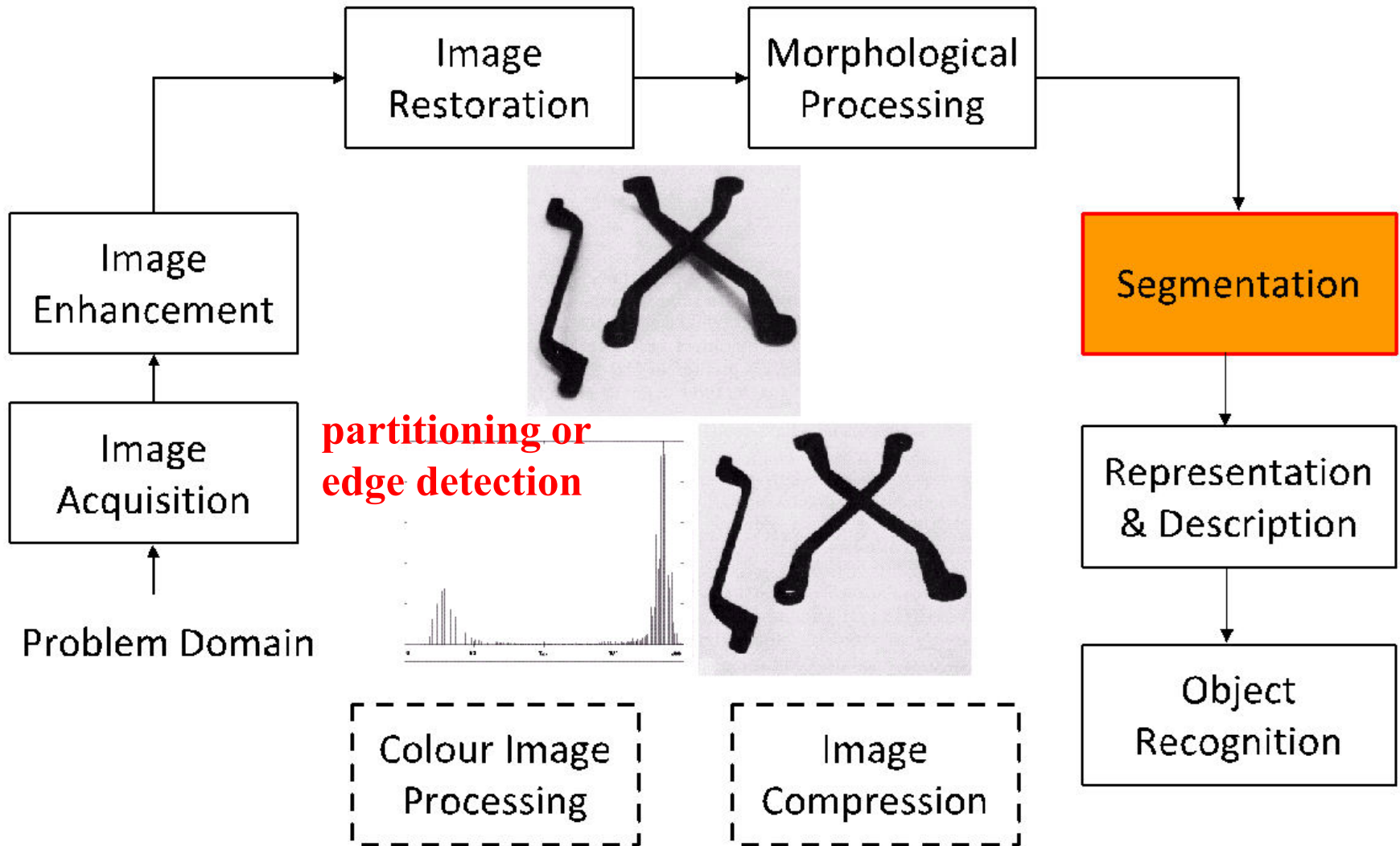


Key Stages in DIP: Morphological Processing



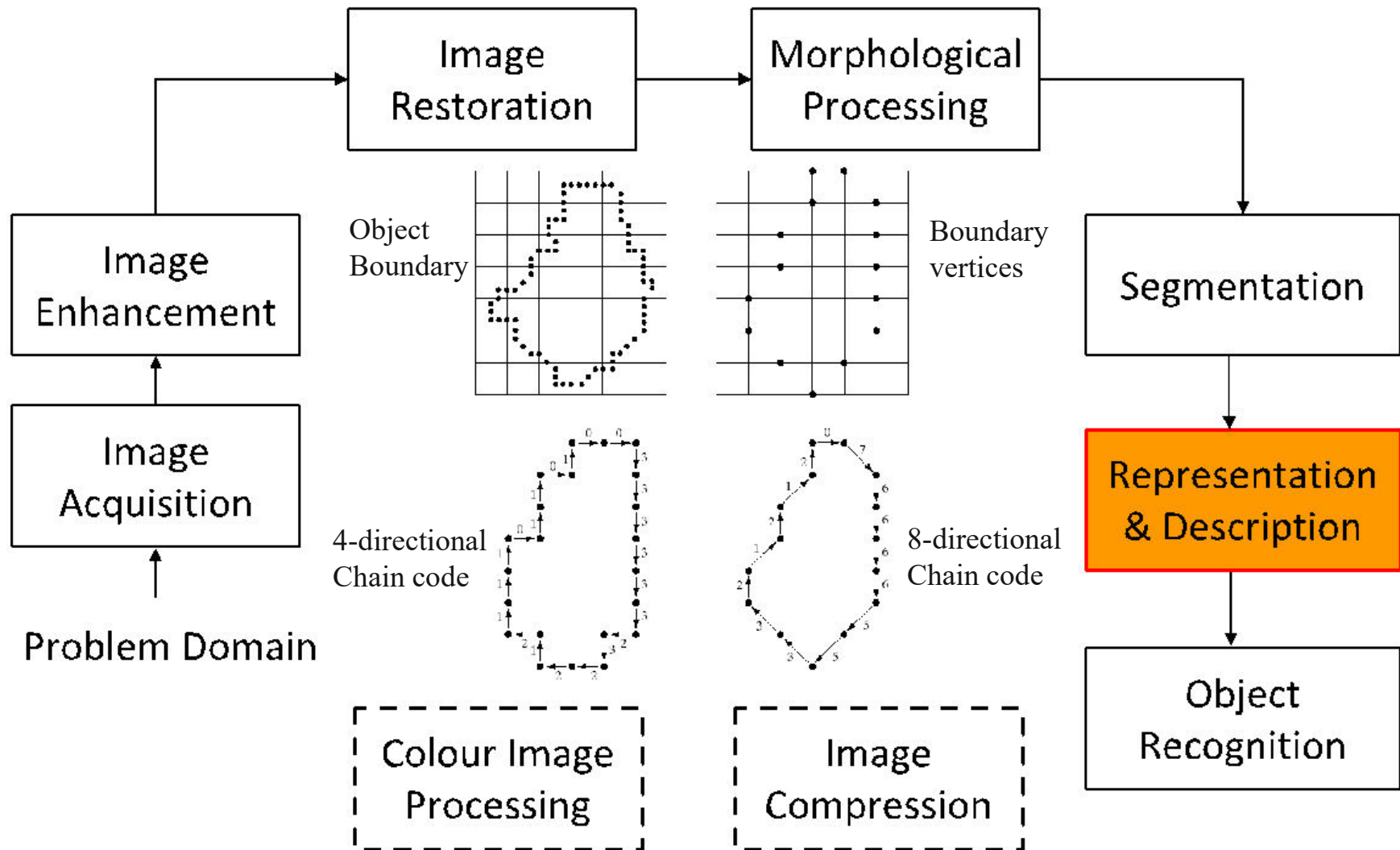


Key Stages in DIP: Segmentation



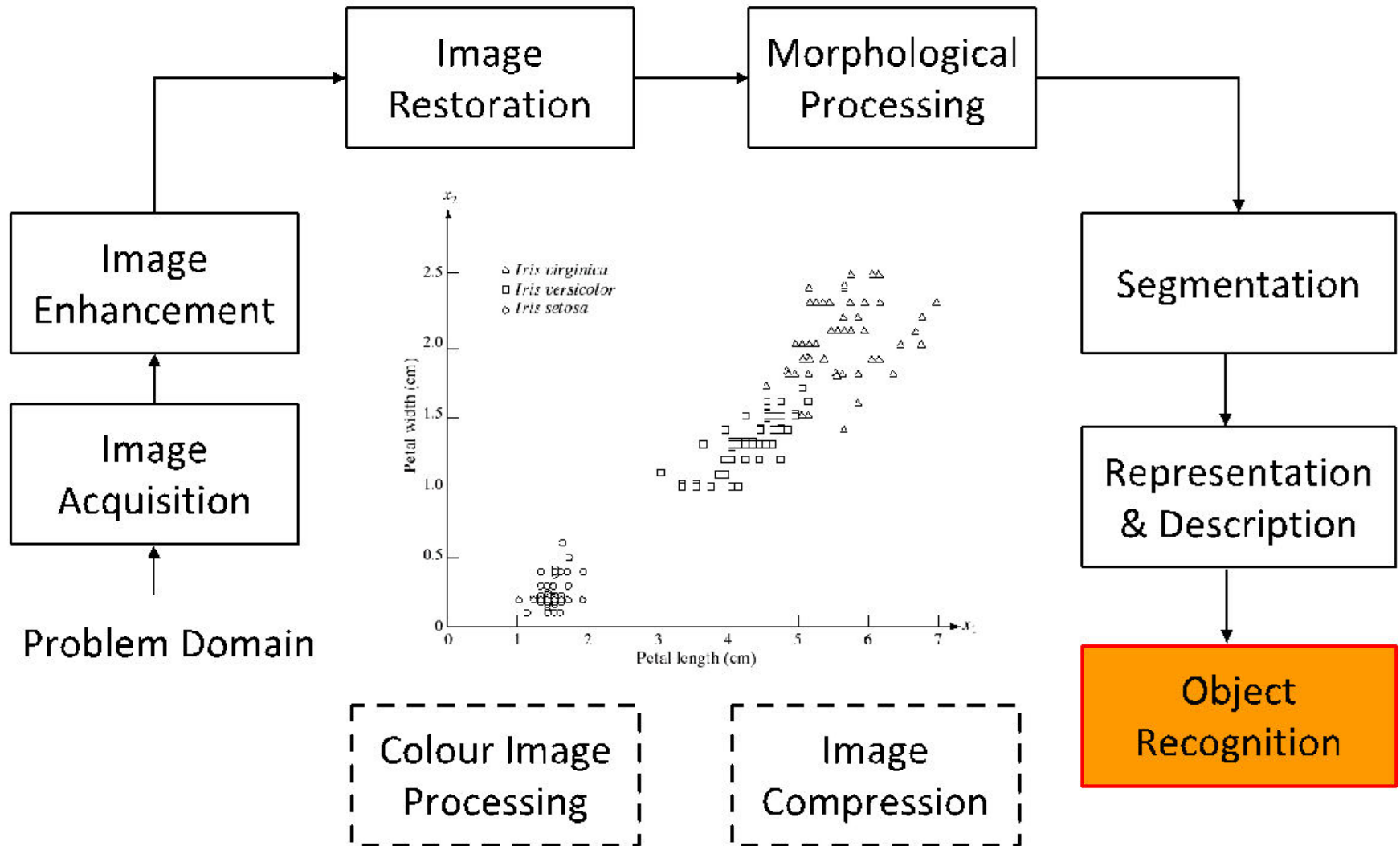


Key Stages in DIP: Representation & Description



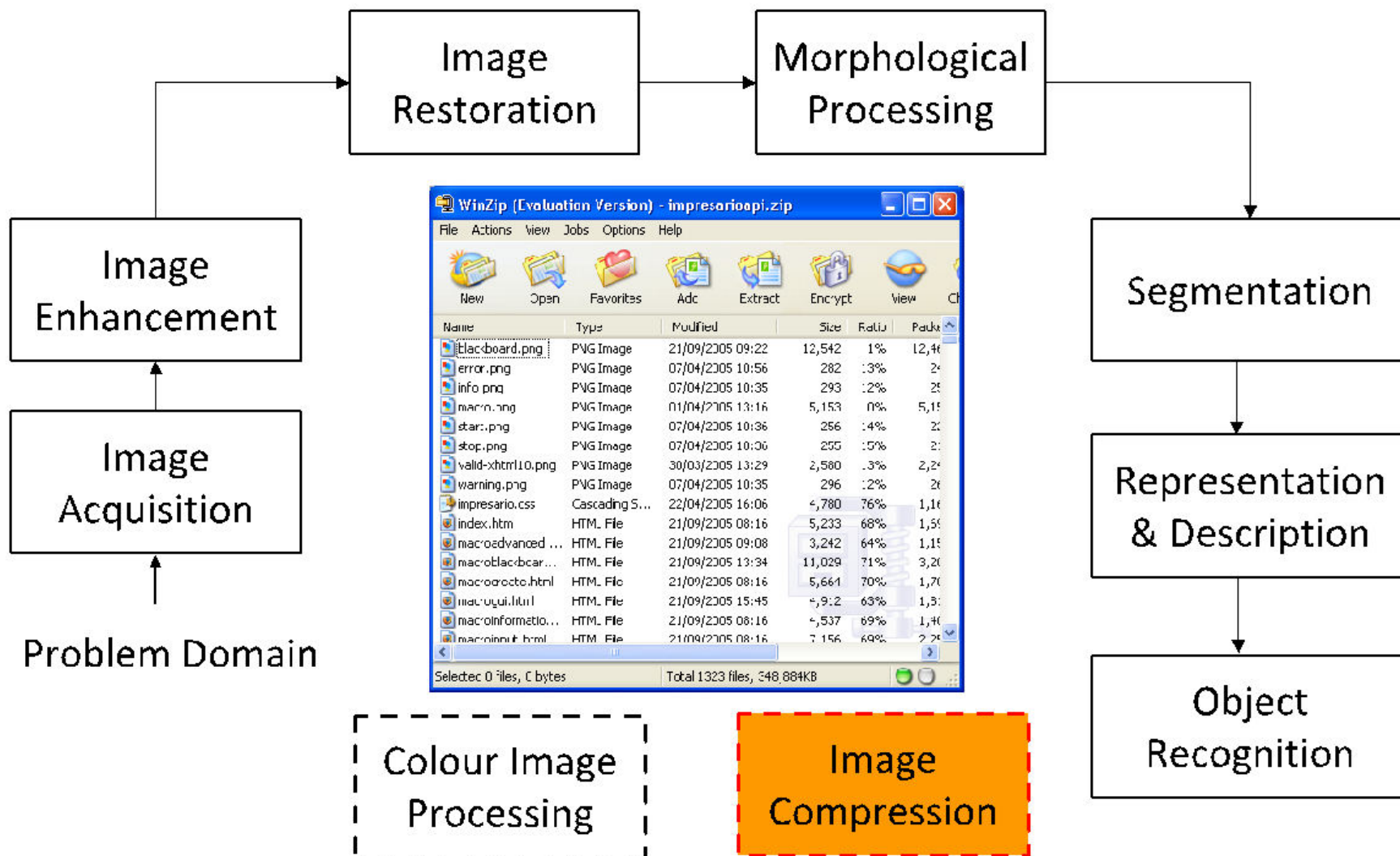


Key Stages in DIP: Object Recognition

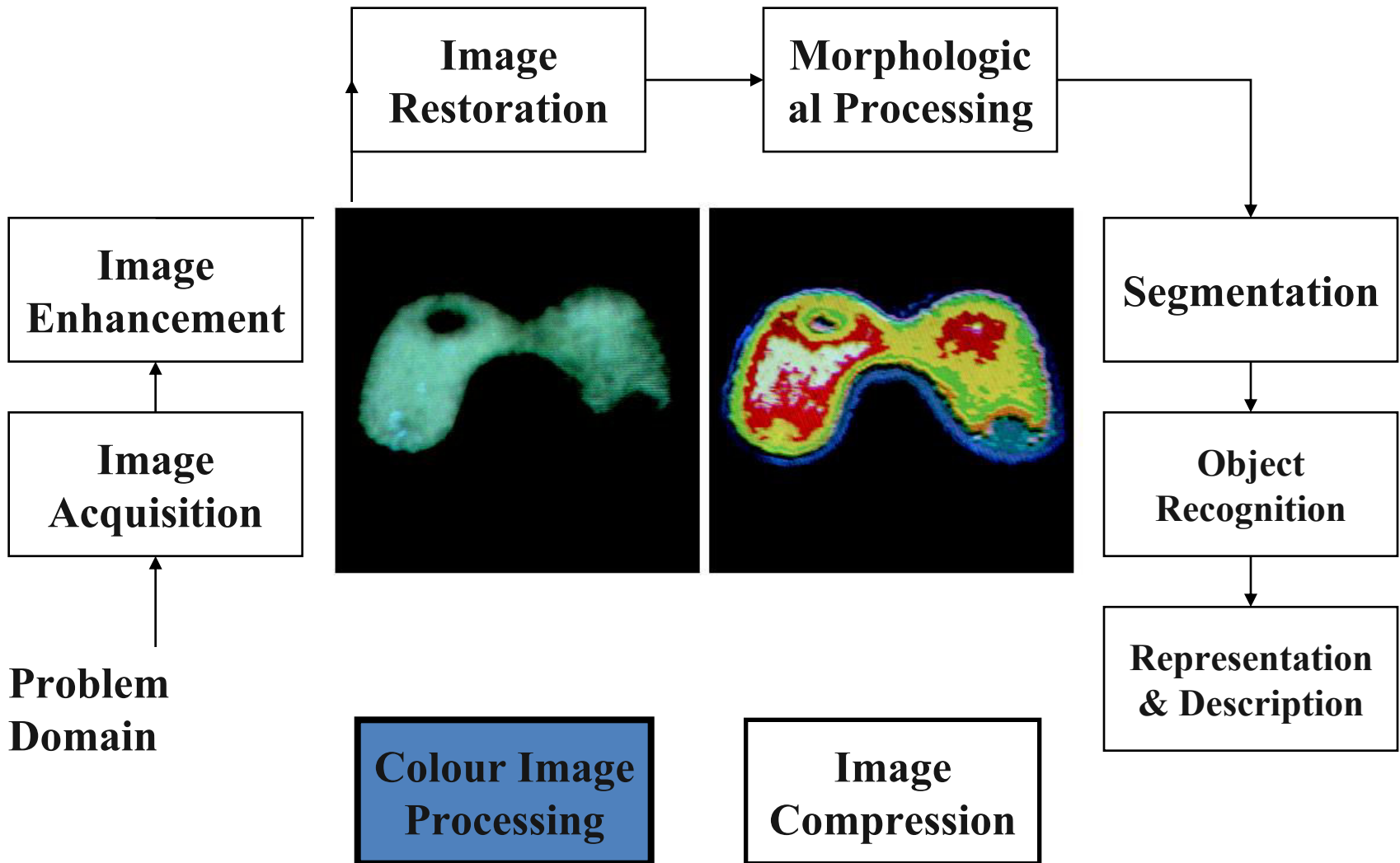




Key Stages in DIP: Image Compression



Key Stages in DIP: Colour Image Processing



**Next classes we will see how it
all works.....**