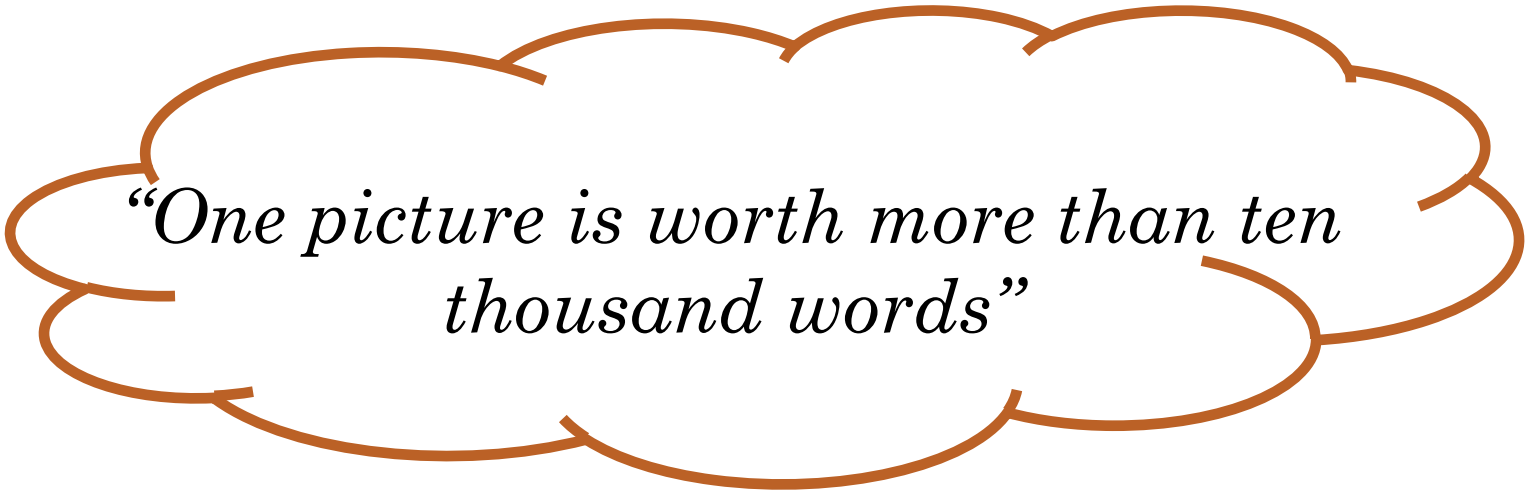
Digital Image Processing Introduction

Rajitha B, Assistant Professor, CSED,MNNIT ALLD

Introduction



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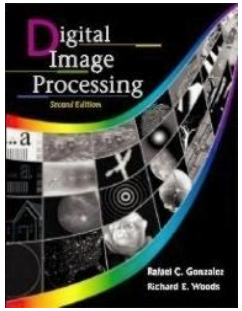
Text Book

"Digital Image Processing", Rafael C. Gonzalez & Richard E. Woods, Addison-Wesley, 2002



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Contents

Topics to be covered:

1. What is a digital image?
2. What is digital image processing?
3. History of digital image processing
4. State of the art examples of digital image processing
5. Key stages in digital image processing

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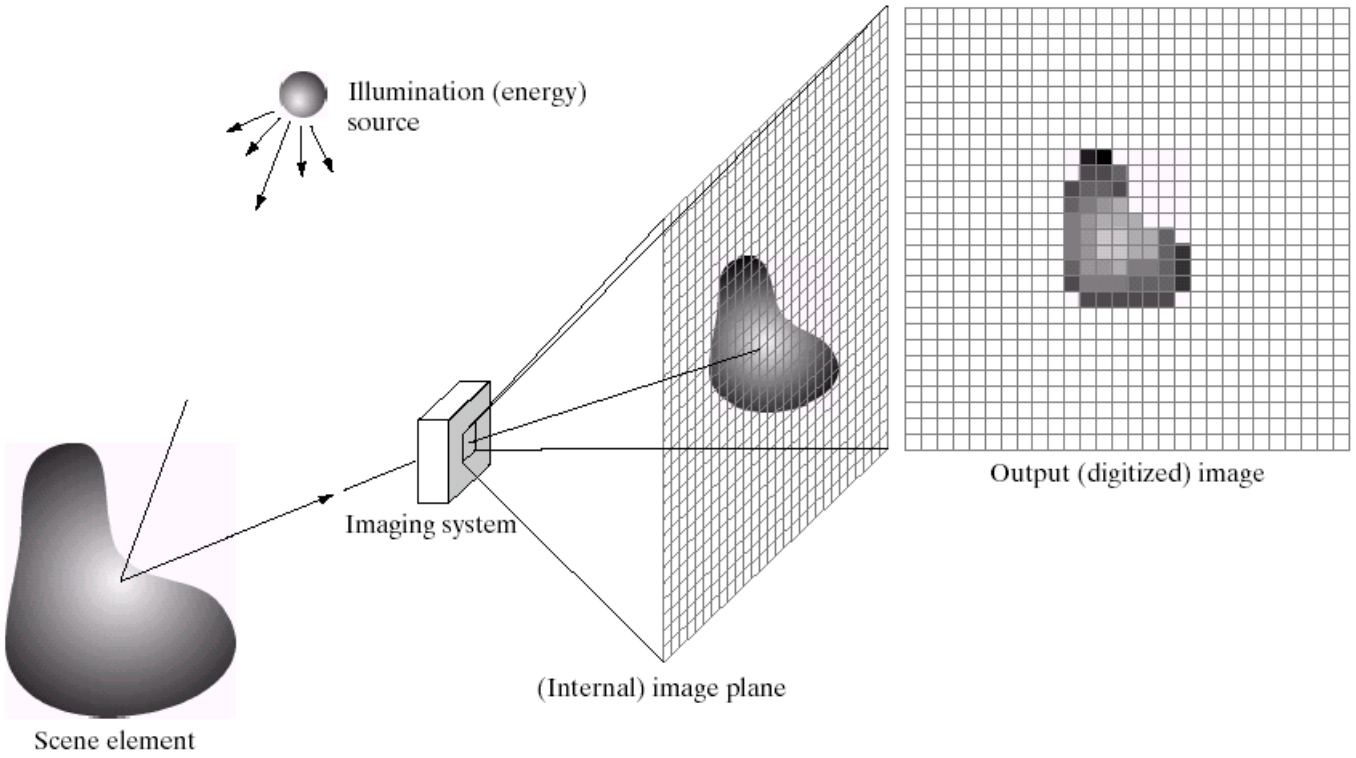
1. What is a Digital Image?

A **digital image** is a representation of a two-dimensional image as a finite set of digital values, called picture elements or pixels



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

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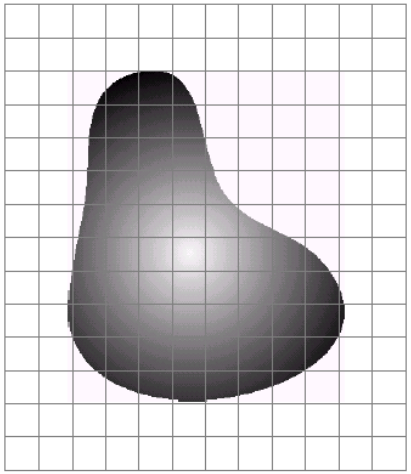
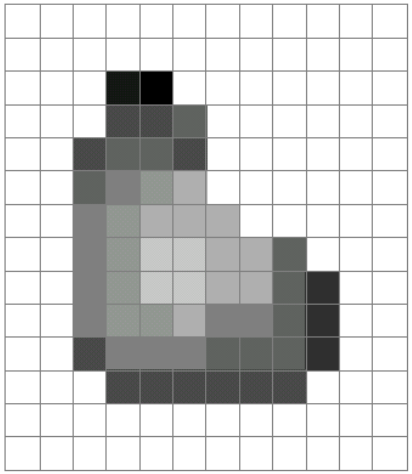
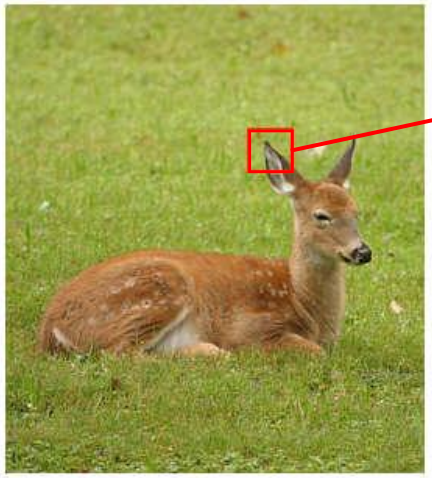
1. What is a Digital Image? (cont…)

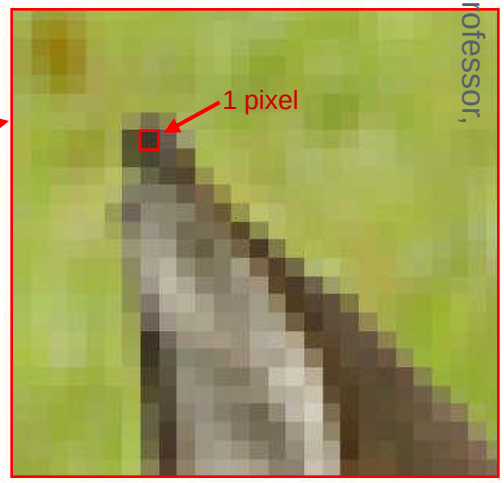
Pixel values typically represent ***gray levels, colors, heights, opacities etc***

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









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1. What is a Digital Image? (cont…)

Image formats:

- 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)

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2. What is 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 start**

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2. What is DIP? (cont…)

Low Level Process
Input: Image **Output:** Image **Examples:** Noise removal, image sharpening

Mid Level Process
Input: Image **Output:** Attributes **Examples:** Object recognition, segmentation

High Level Process
Input: Attributes **Output:** Understanding **Examples:** Scene understanding, autonomous navigation

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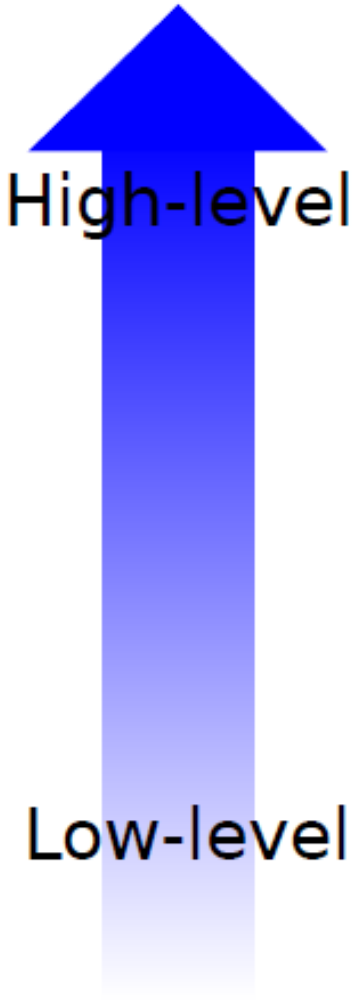

Computer Vision

Object detection, recognition, shape analysis, tracking
Use of Artificial Intelligence and Machine Learning

Image Analysis

Segmentation, image registration, matching

Image Processing

Image enhancement, noise removal, restoration,
feature detection, compression

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3. 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

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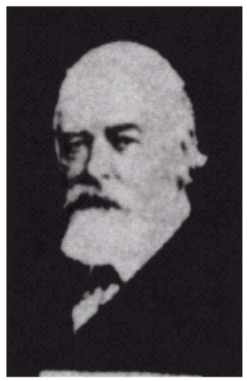
3. History of DIP (cont…)

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)

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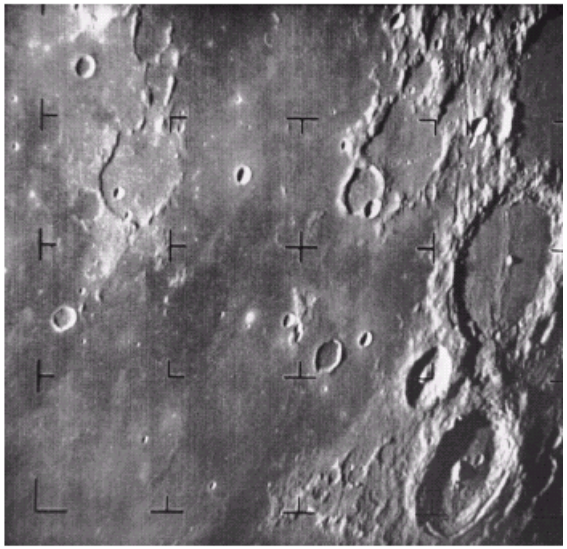
3. History of DIP (cont…)

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 including the Apollo landings



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

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

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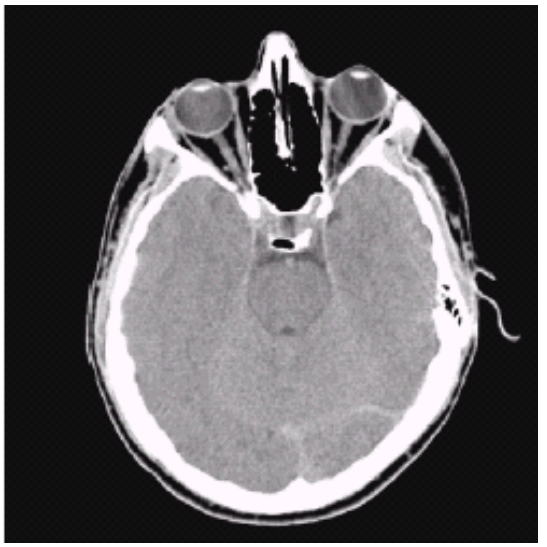
3. History of DIP (cont…)

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

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3. 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

- 3.1 Image enhancement/restoration
- 3.2 Artistic effects
- 3.3 Medical visualisation
- 3.4 Industrial inspection
- 3.5 Law Enforcement
- 3.6 Human computer interfaces

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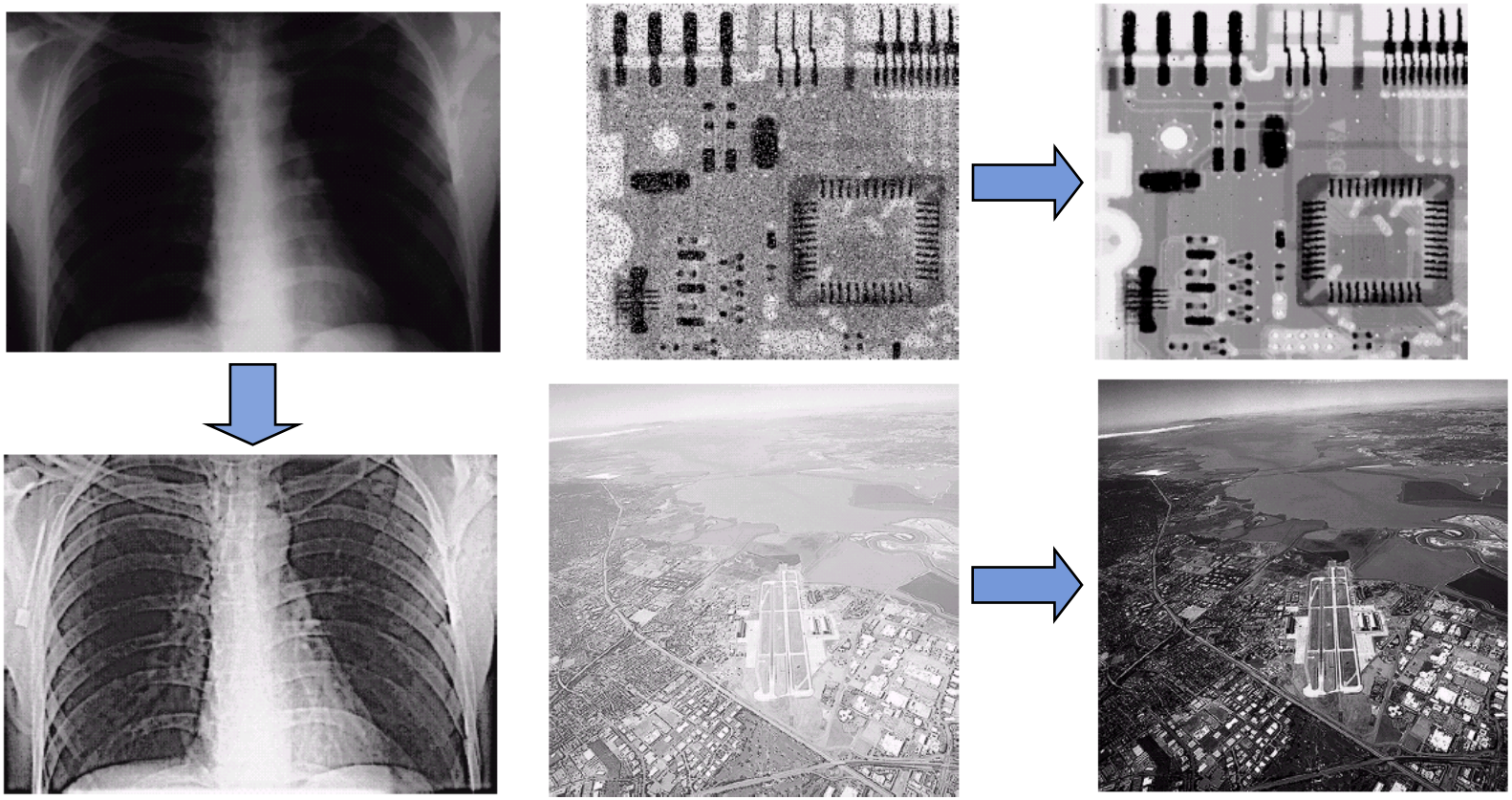
3.1 Examples: Image Enhancement

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



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

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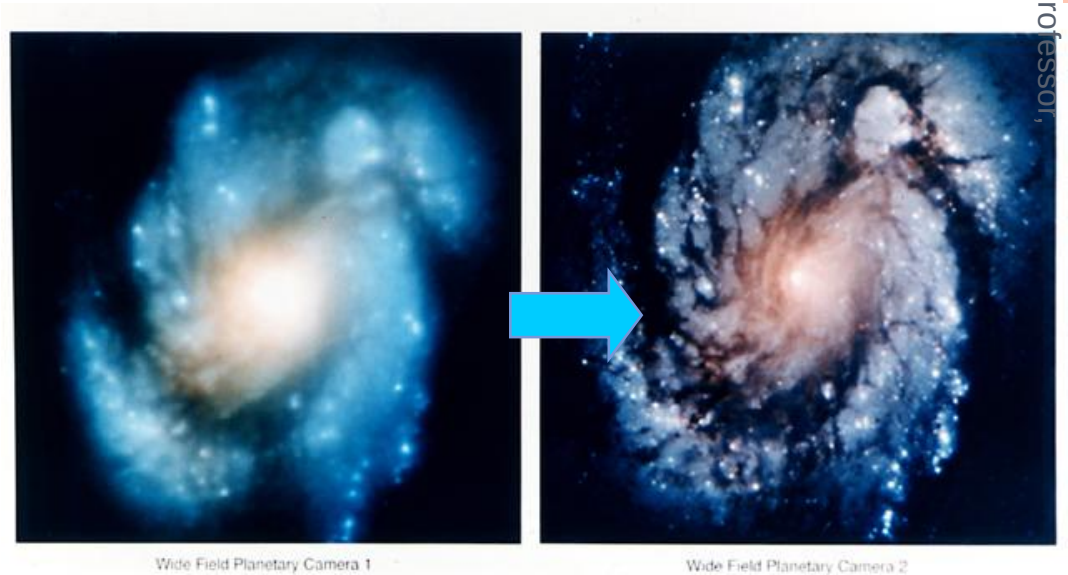
3.1 Examples: The Hubble Telescope

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



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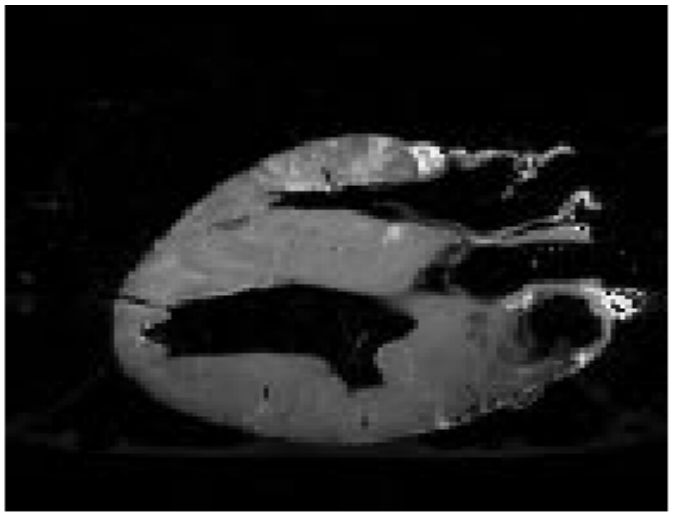
3.2 Examples: Artistic Effects

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

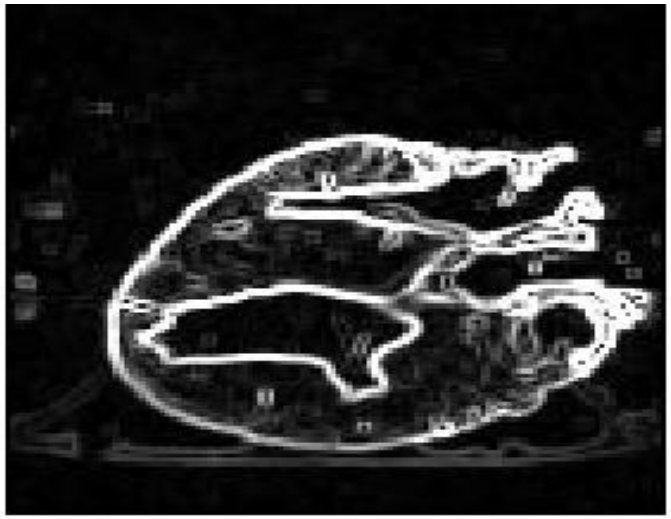
3.3 Examples: Medicine

Take slice from MRI scan of 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

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

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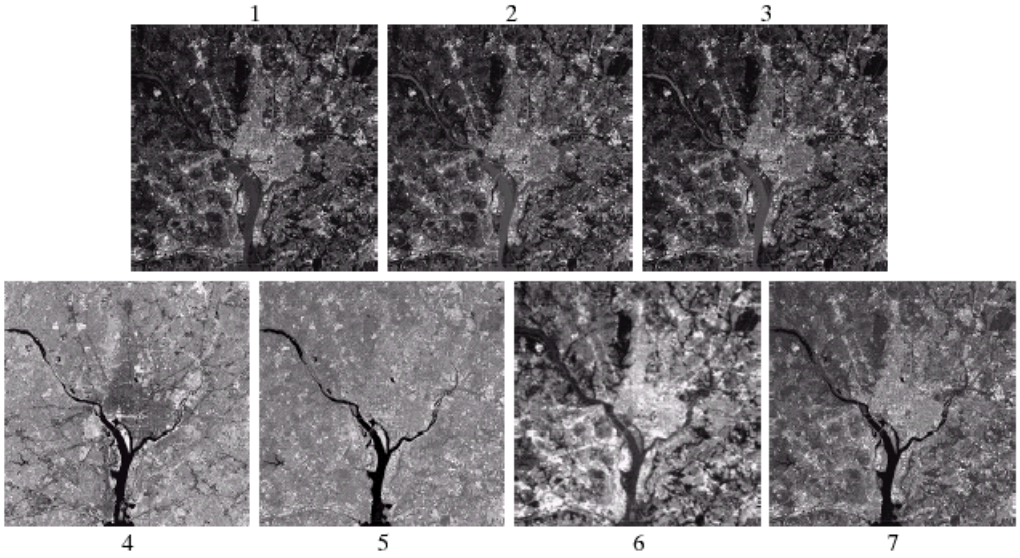
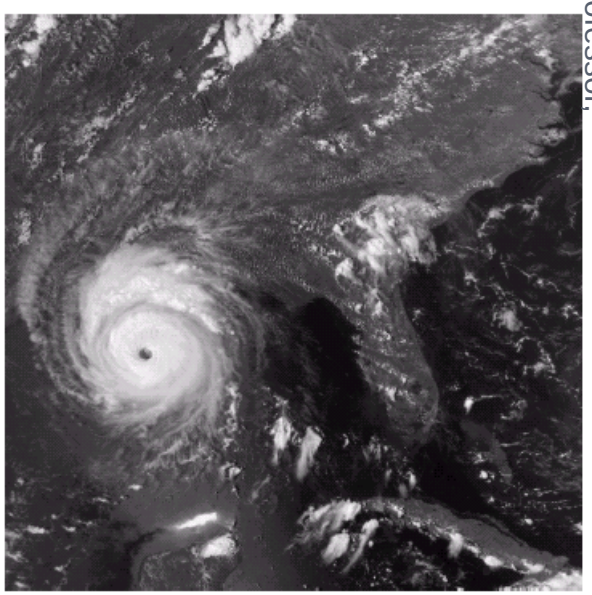
3.3 Examples: GIS

Geographic Information Systems

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





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

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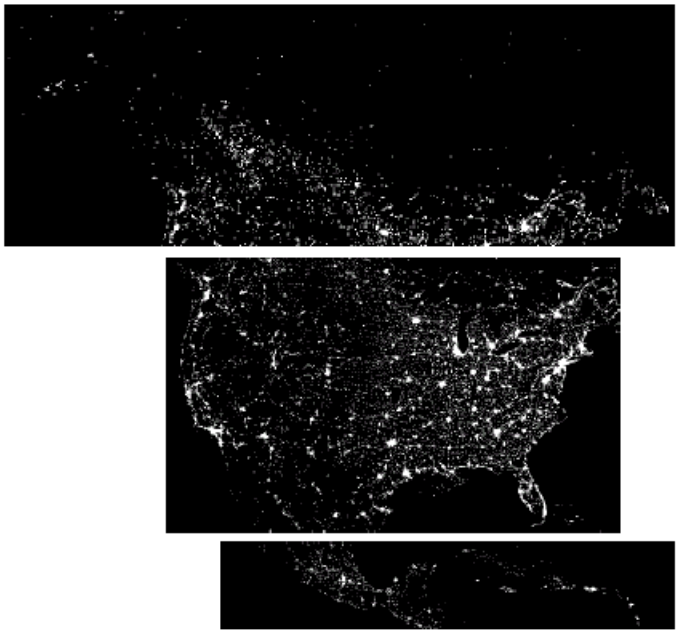
3.3 Examples: GIS (cont…)

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



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

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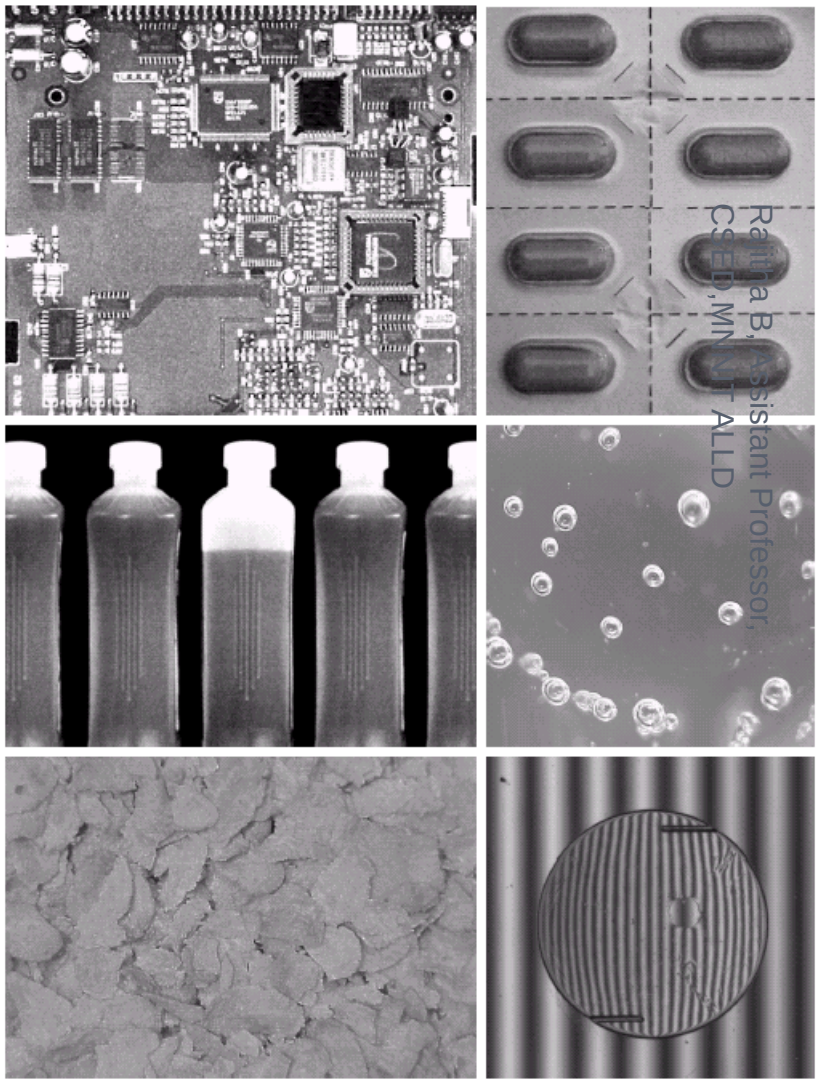
3.4 Examples: Industrial Inspection

Human operators are expensive, slow and unreliable.

Make machines do the job instead.

Industrial vision systems are used in all kinds of industries

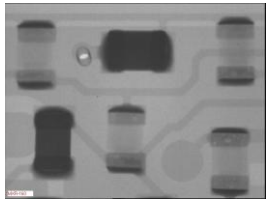
Can we trust them?

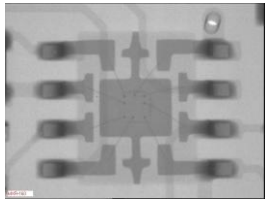


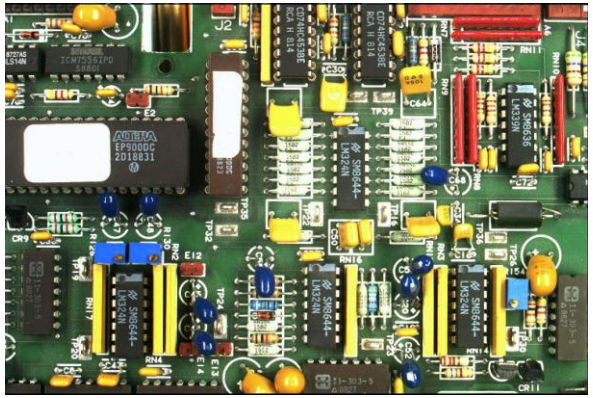
3.4 Examples: PCB Inspection

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



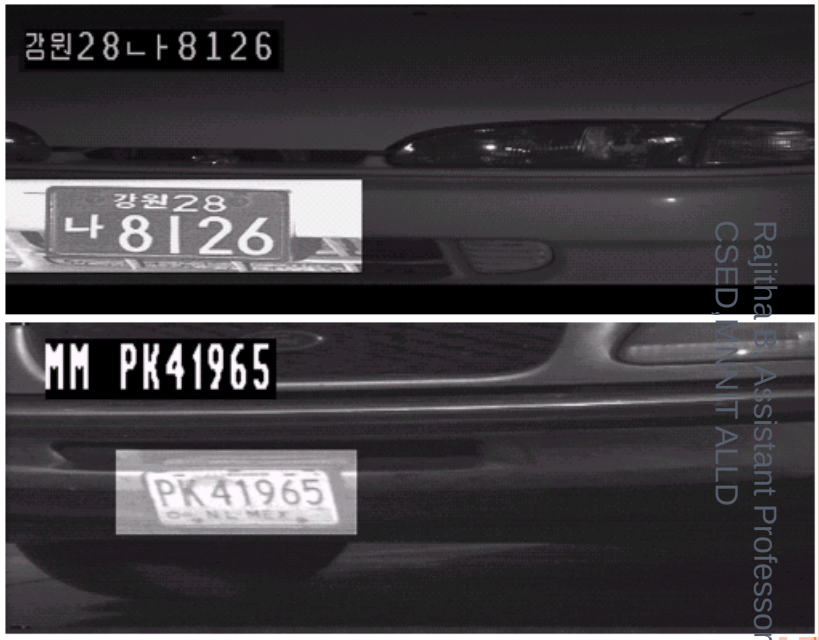


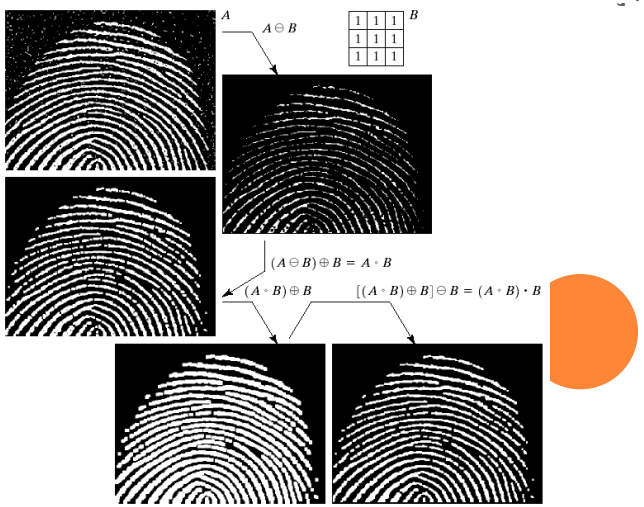


3.5 Examples: Law Enforcement

Image processing techniques are used extensively by law enforcers

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





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

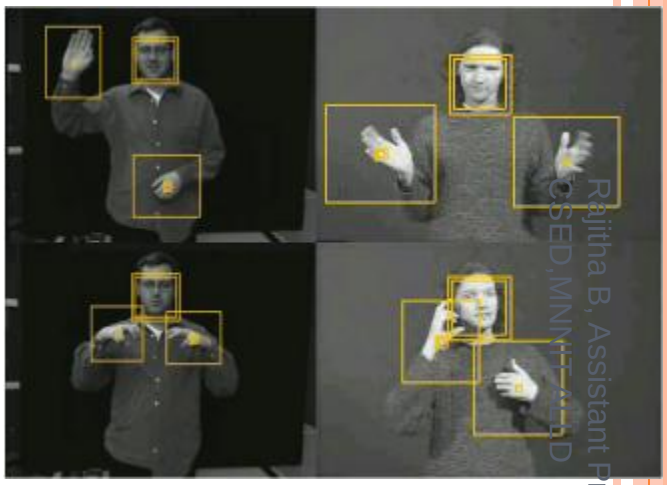
3.6 Examples: HCI

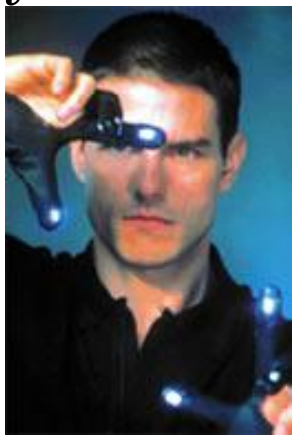
Try to make human computer interfaces more natural

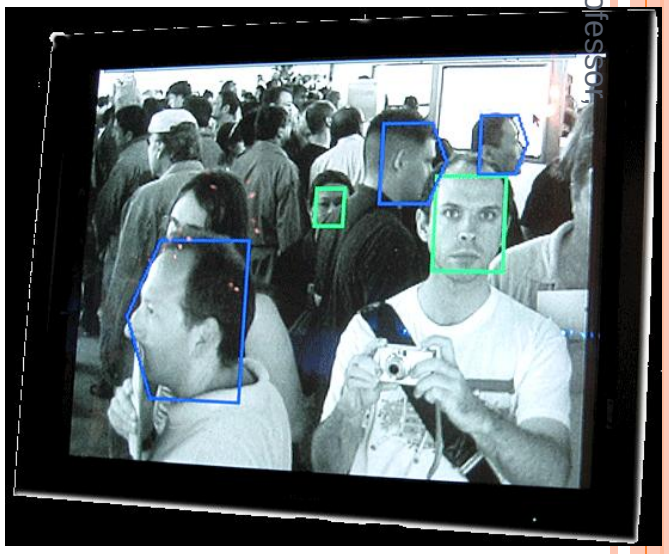
- Face recognition
- Gesture recognition

Does anyone remember the user interface from "Minority Report"?

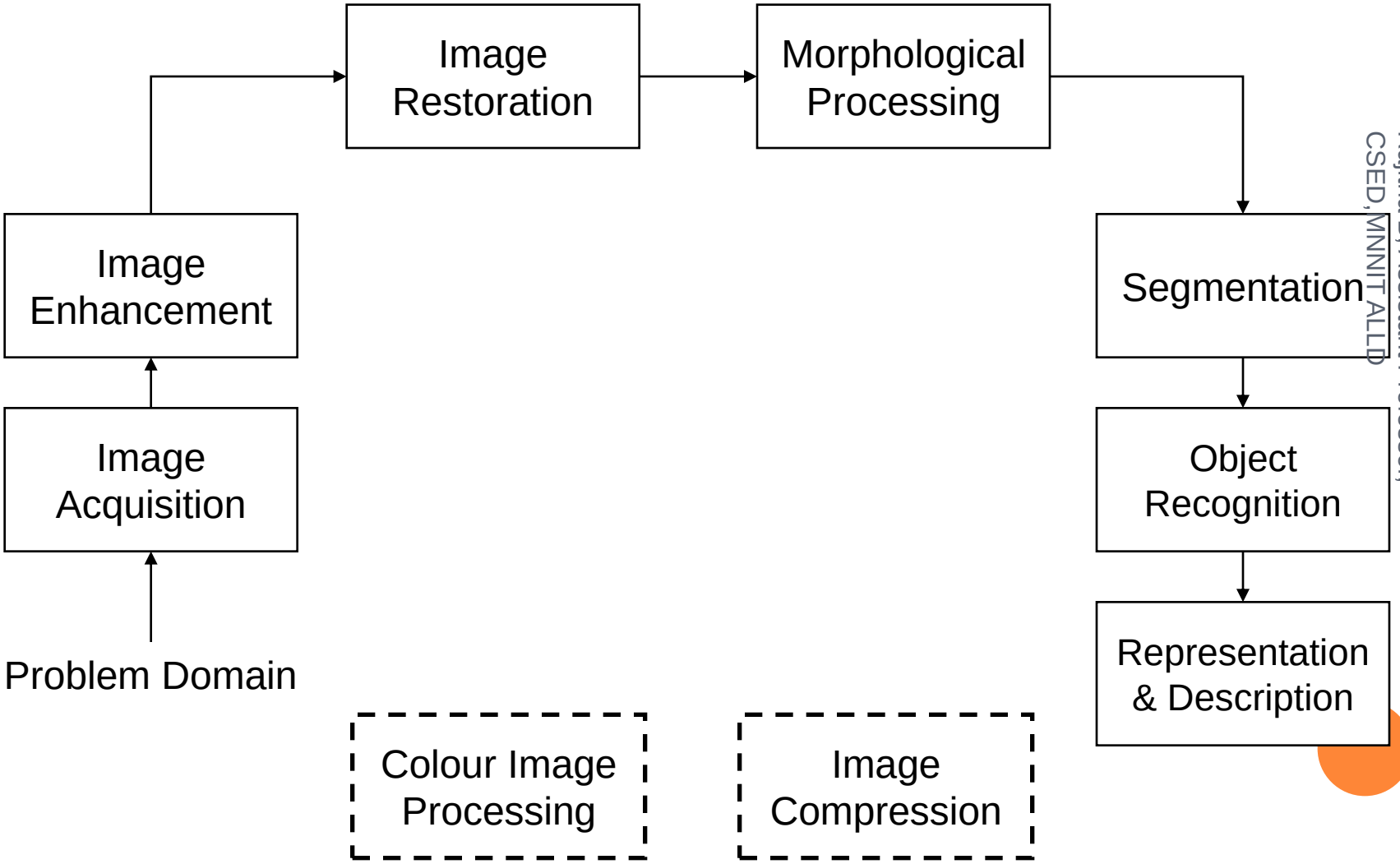
These tasks can be extremely difficult



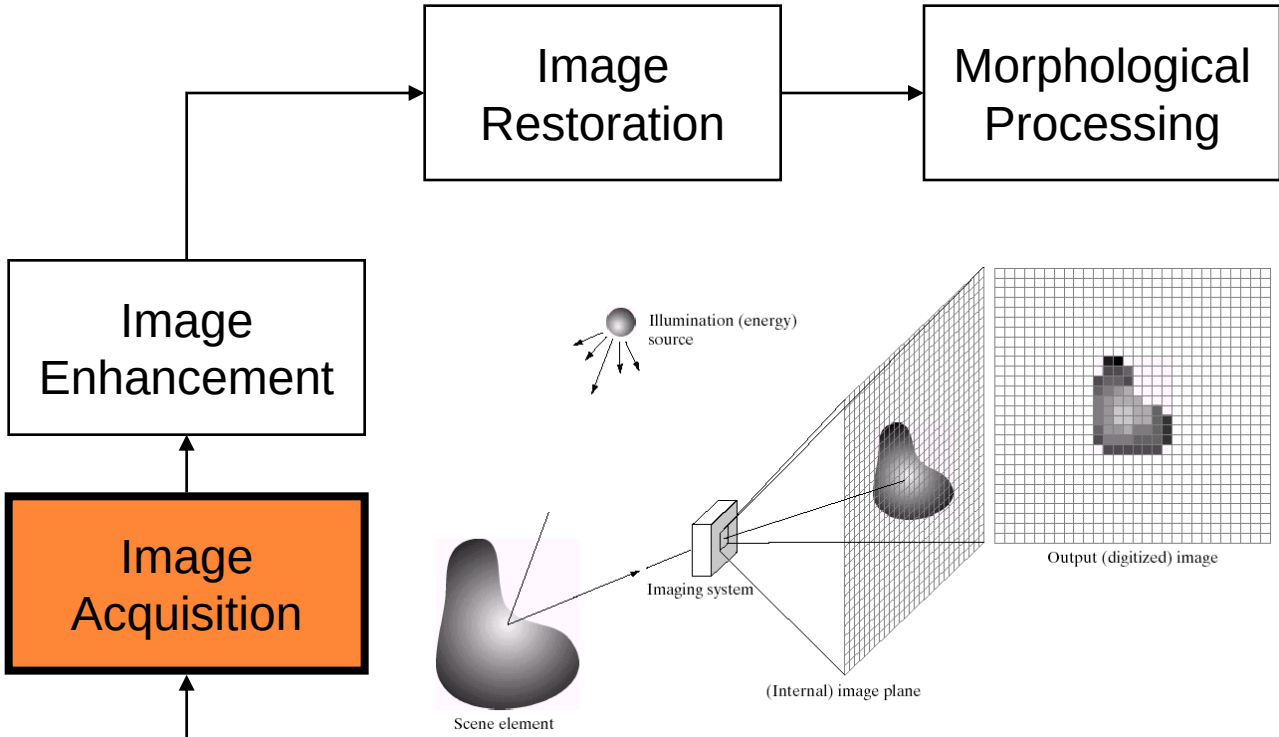




Key Stages in Digital Image Processing



Key Stages in Digital Image Processing: Image Acquisition



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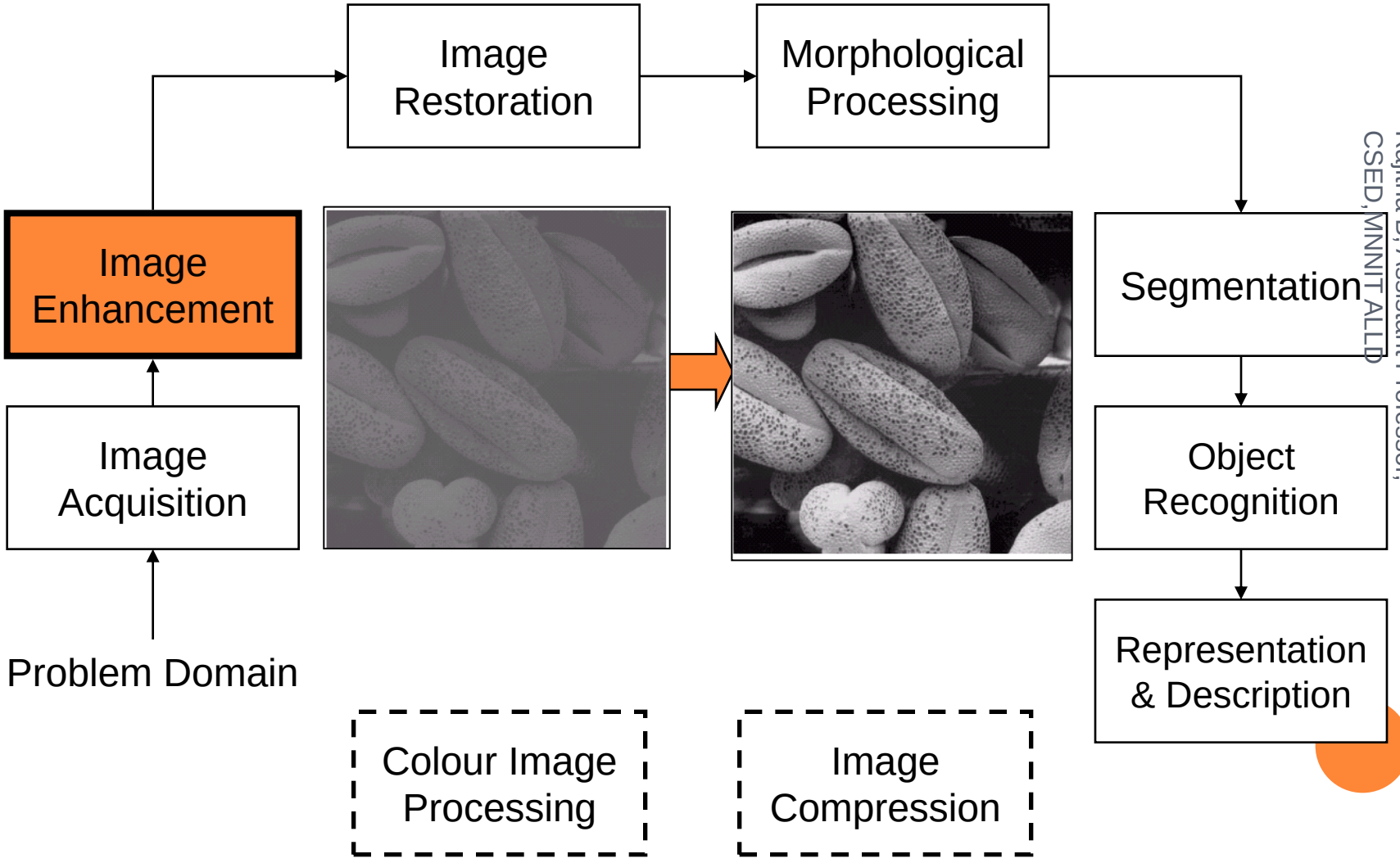
Key Stages in Digital Image Processing: Image Enhancement



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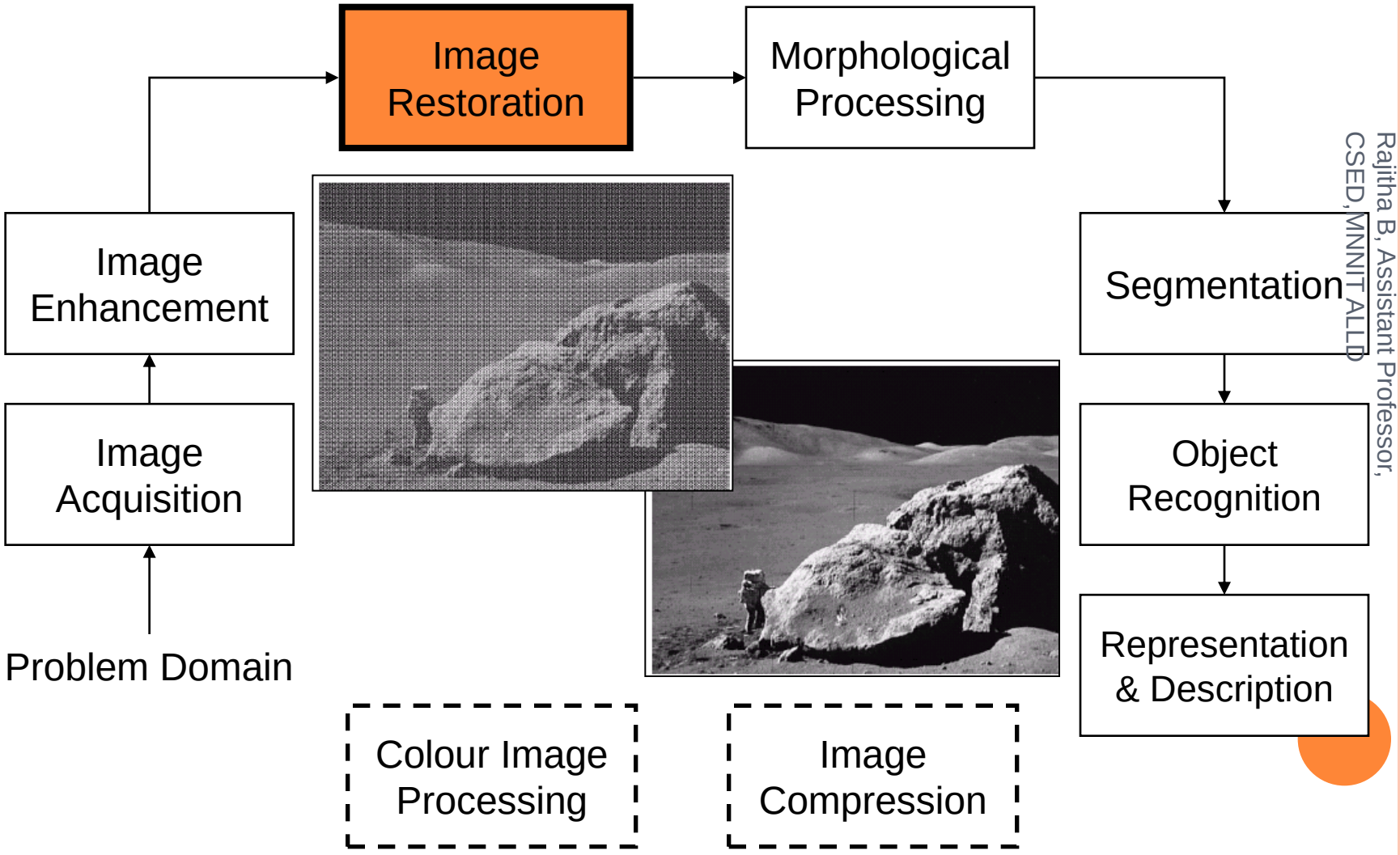
Key Stages in Digital Image Processing: Image Restoration



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

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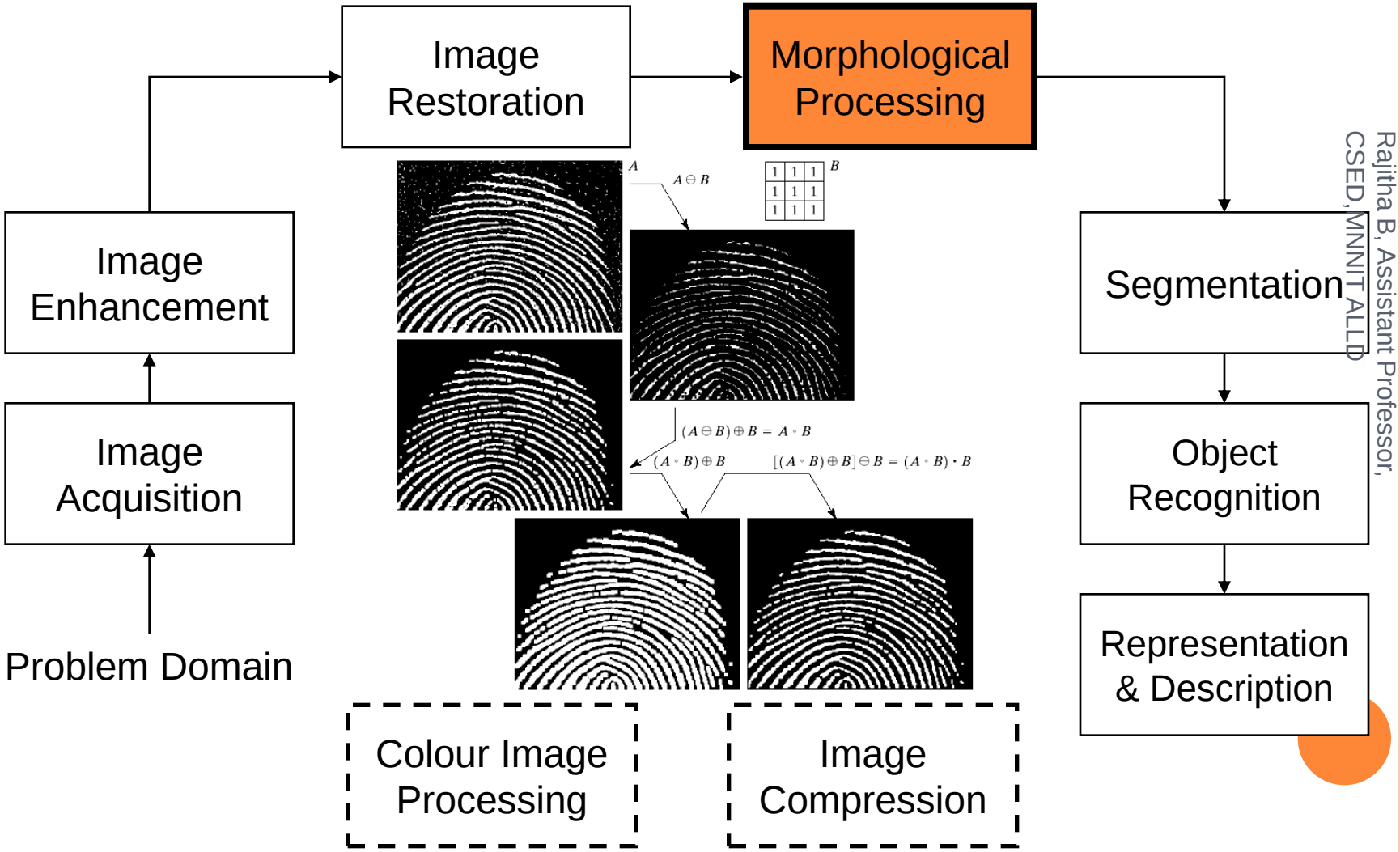
Key Stages in Digital Image Processing: Morphological Processing



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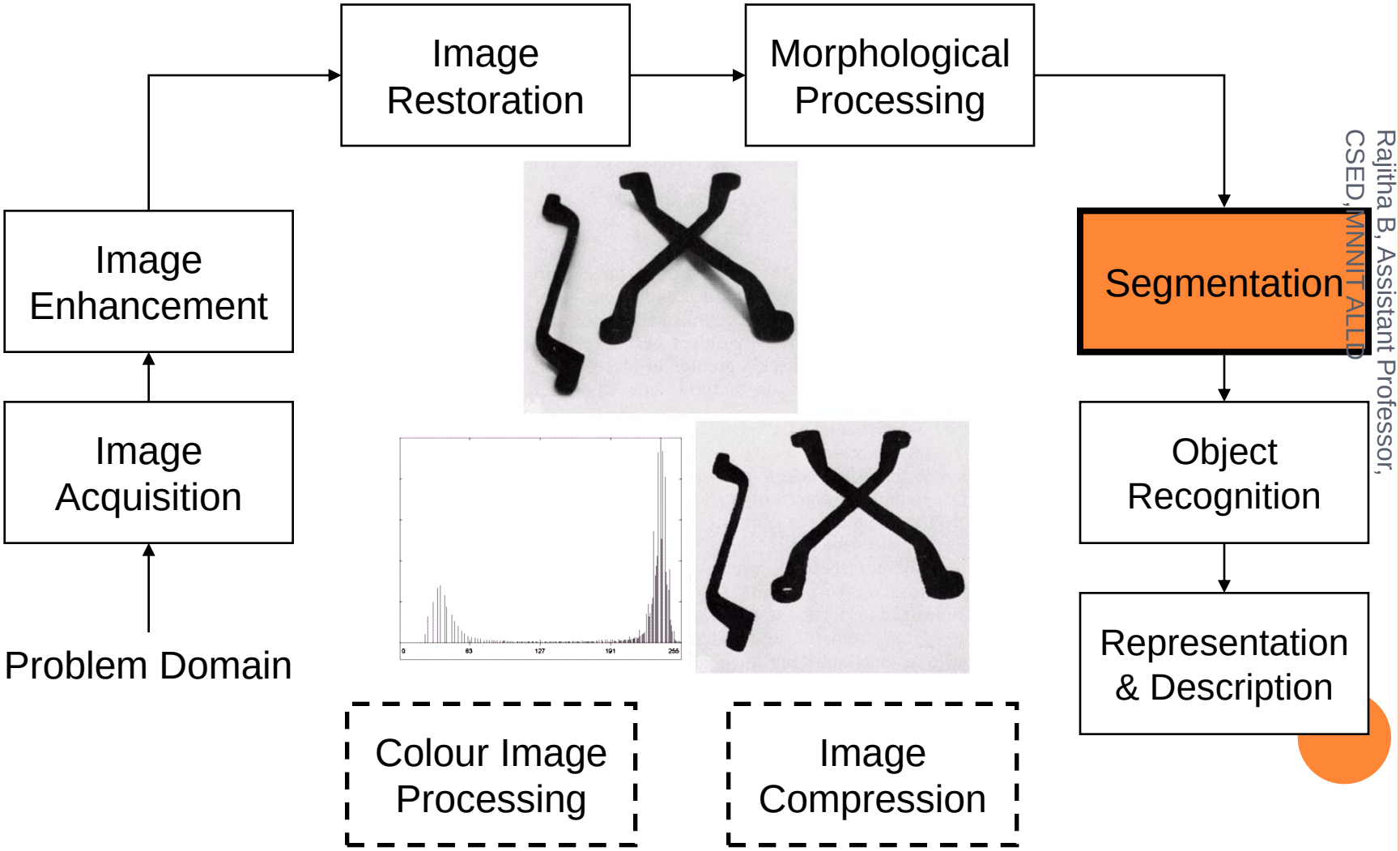
Key Stages in Digital Image Processing: Segmentation



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

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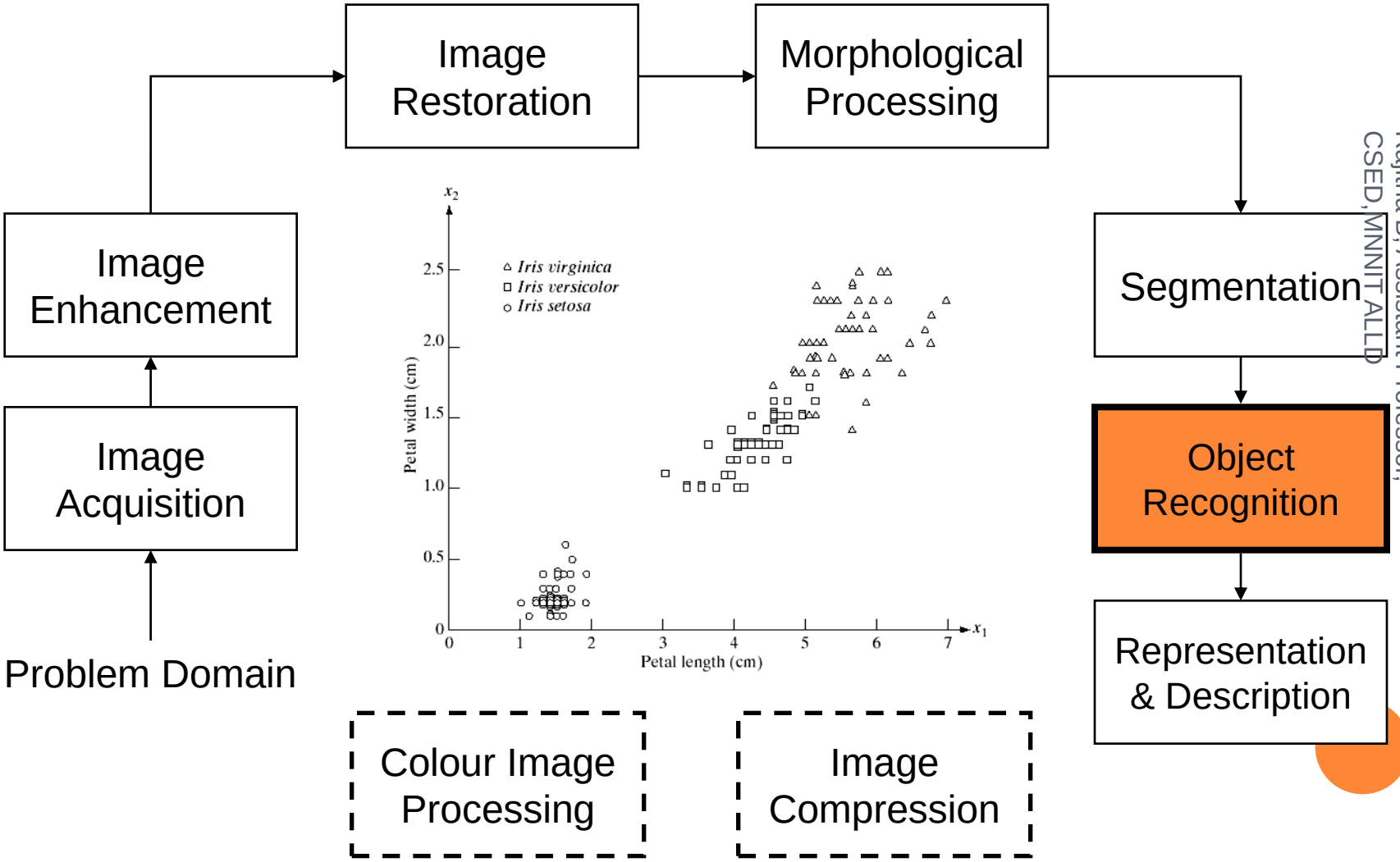
Key Stages in Digital Image Processing: Object Recognition



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

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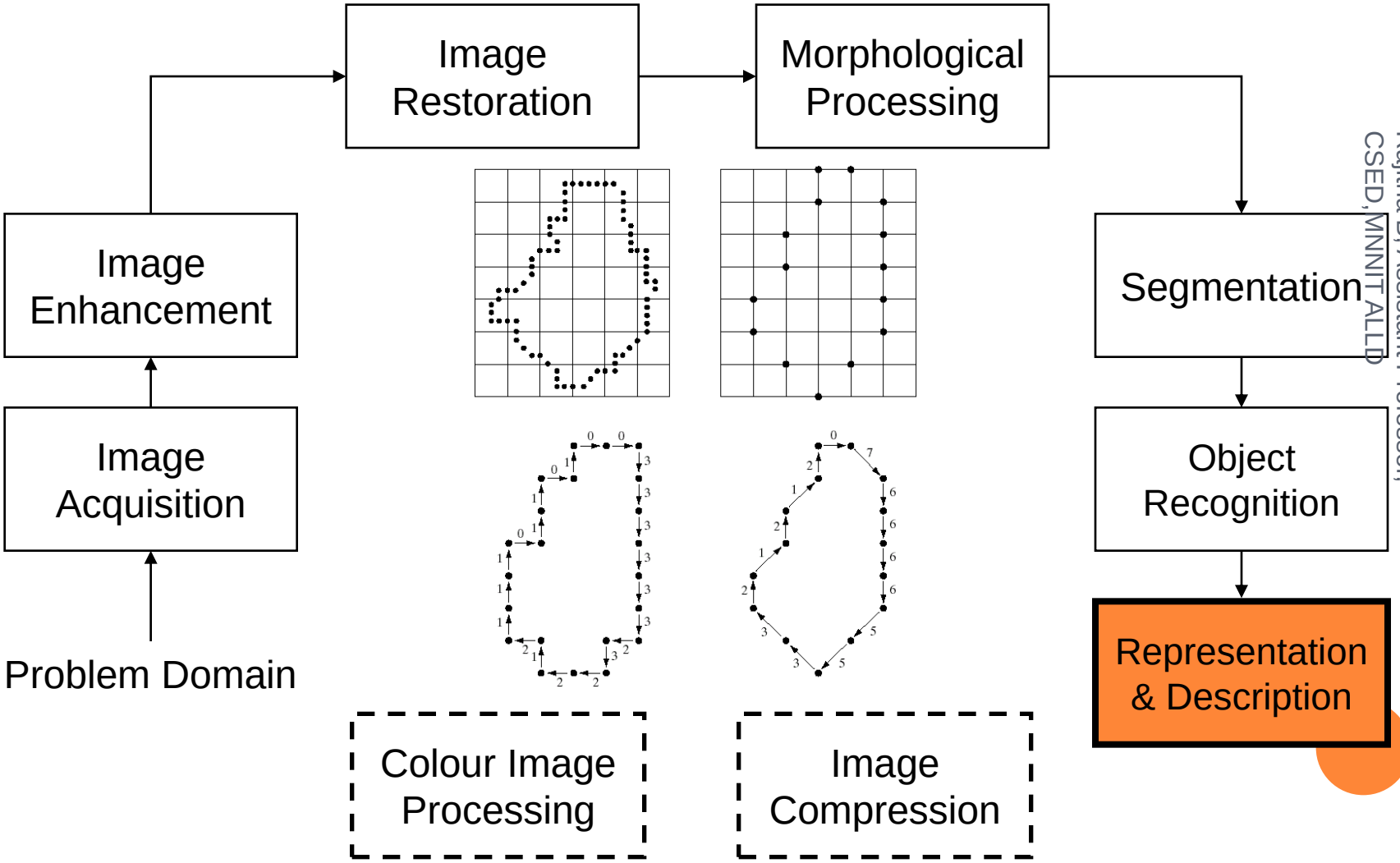
Key Stages in Digital Image Processing: Representation & Description



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

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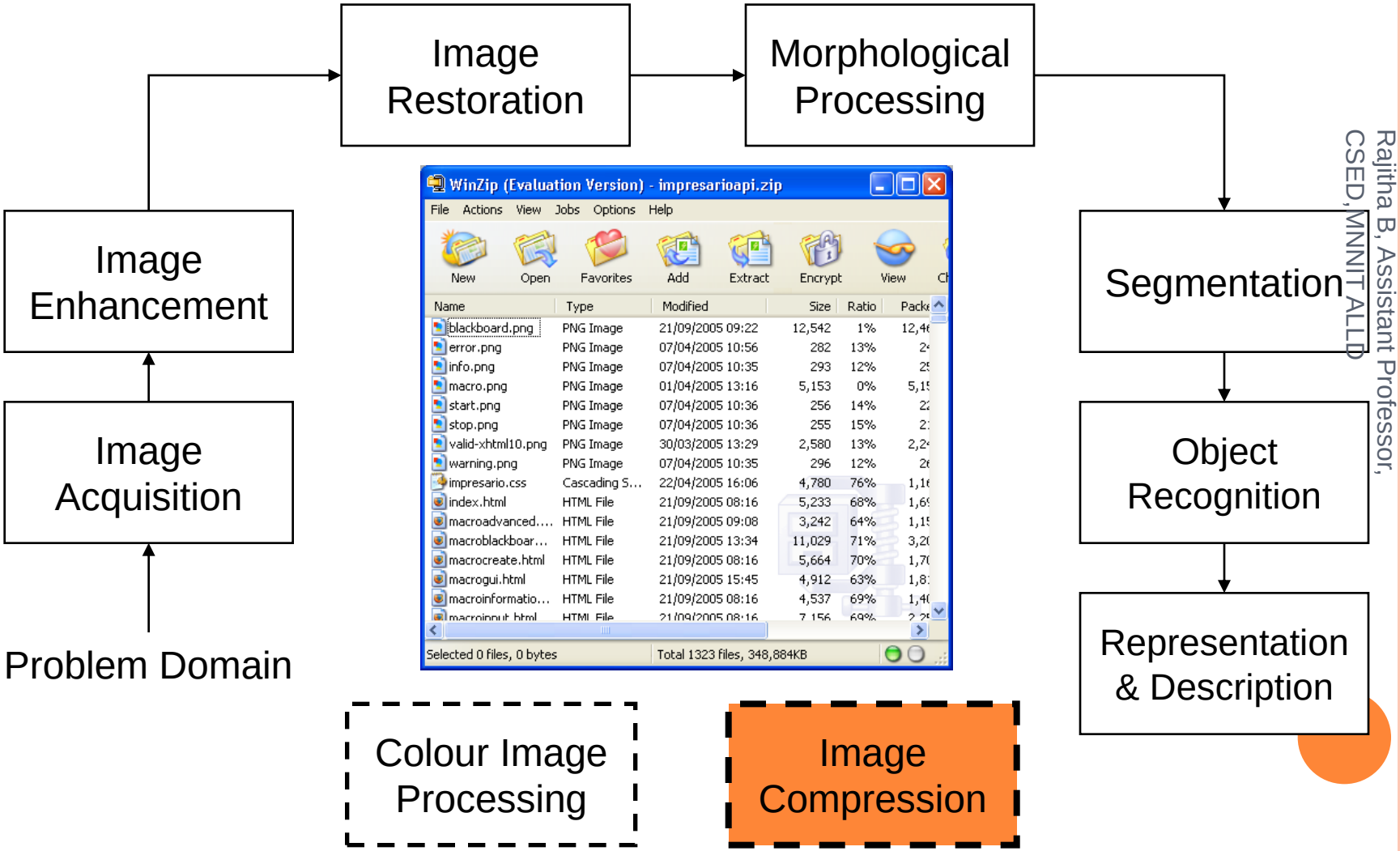
Key Stages in Digital Image Processing: Image Compression



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Key Stages in Digital Image Processing: Colour Image Processing

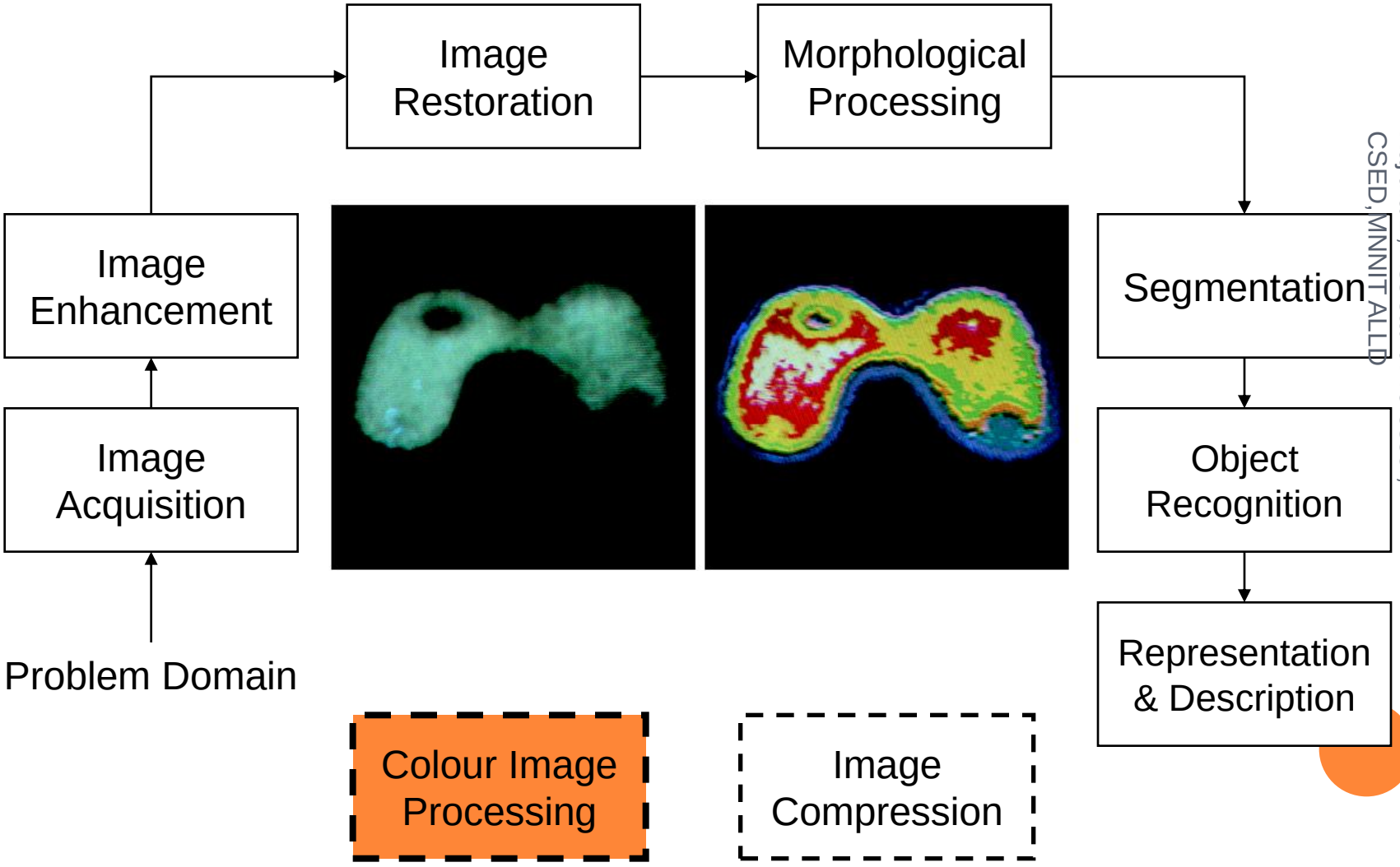

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Image Processing: Definition

Image processing is the study of any algorithm that takes an image as input and returns an image as output

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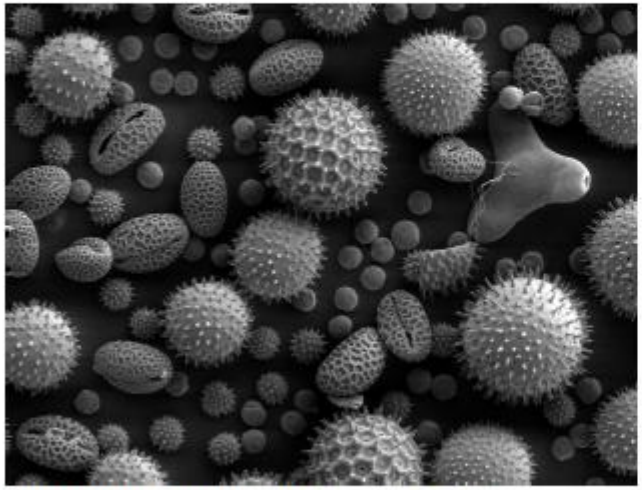
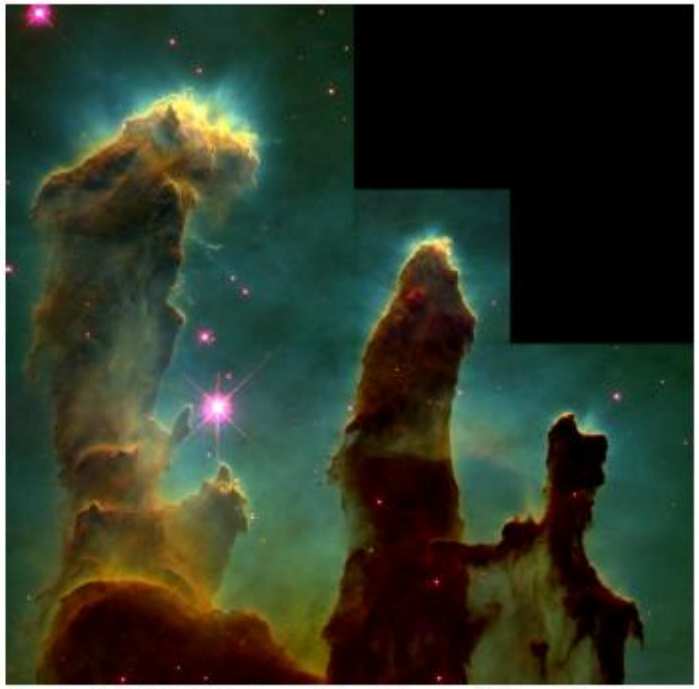
Applications of IP:

Biology



Credit: Dartmouth Electron Microscopy Facility

Astronomy



Credit: NASA, Jeff Hester, and Paul Scowen (Arizona State)
More info here

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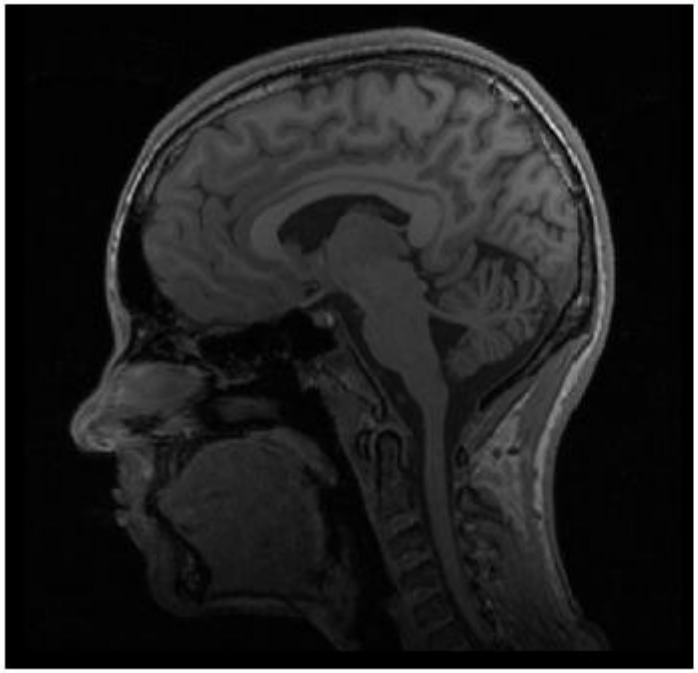
Applications

Medicine



Credit: Dr. Janet Lainhart, UofU Psychiatry

Security, Biometrics

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Applications

Satellite Imagery

Credit: NASA

Personal Photos

Credit: Tom Fletcher

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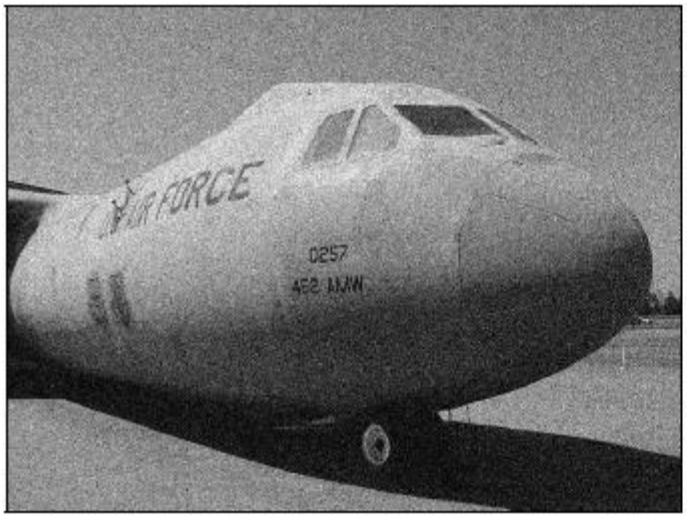
Applications

Noisy Image



Denoised Image

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Applications: Contrast Adjustment

Low Contrast

Original Contrast

High Contrast

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Applications: edge detection

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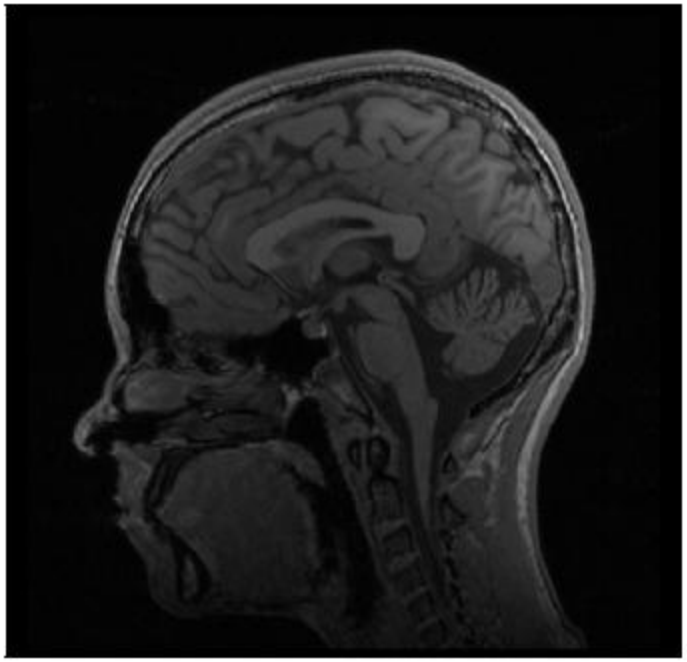
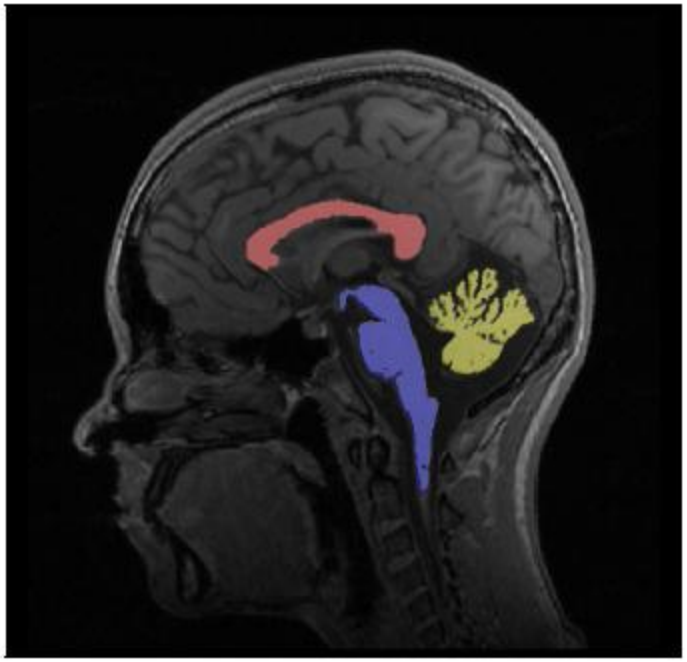
Applications: region detection, segmentation





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Applications: Compression

Original, 2.1MB

JPEG Compression, 308KB (15%)

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Applications: Digital in-painting

Damaged Image

Restored Image

Rajitha B, Assistant Professor, CSED,MNNIT ALLD

Key differences

- **Image Analysis** involves extracting meaningful information from an image
  - Image segmentation
  - Image matching and comparison
  - Medical diagnosis from an image
- **Computer Vision** strives to emulate the human visual system and interpret our 3D world from 2D images or video
  - Object recognition
  - Motion tracking
  - 3D shape from multiple 2D images

Rajitha B, Assistant Professor, CSED,MNNIT ALLD

Common image file formats

GIF	(Graphic Interchange Format)
PNG	(Portable Network Graphics)
JPEG	(Joint Photographic Experts Group)
TIFF	(Tagged Image File Format)
PGM	(Portable Gray Map)
FITS	(Flexible Image Transport System)

Rajitha B, Assistant Professor, CSED,MNNIT ALLD