



IMAGE PROCESSING



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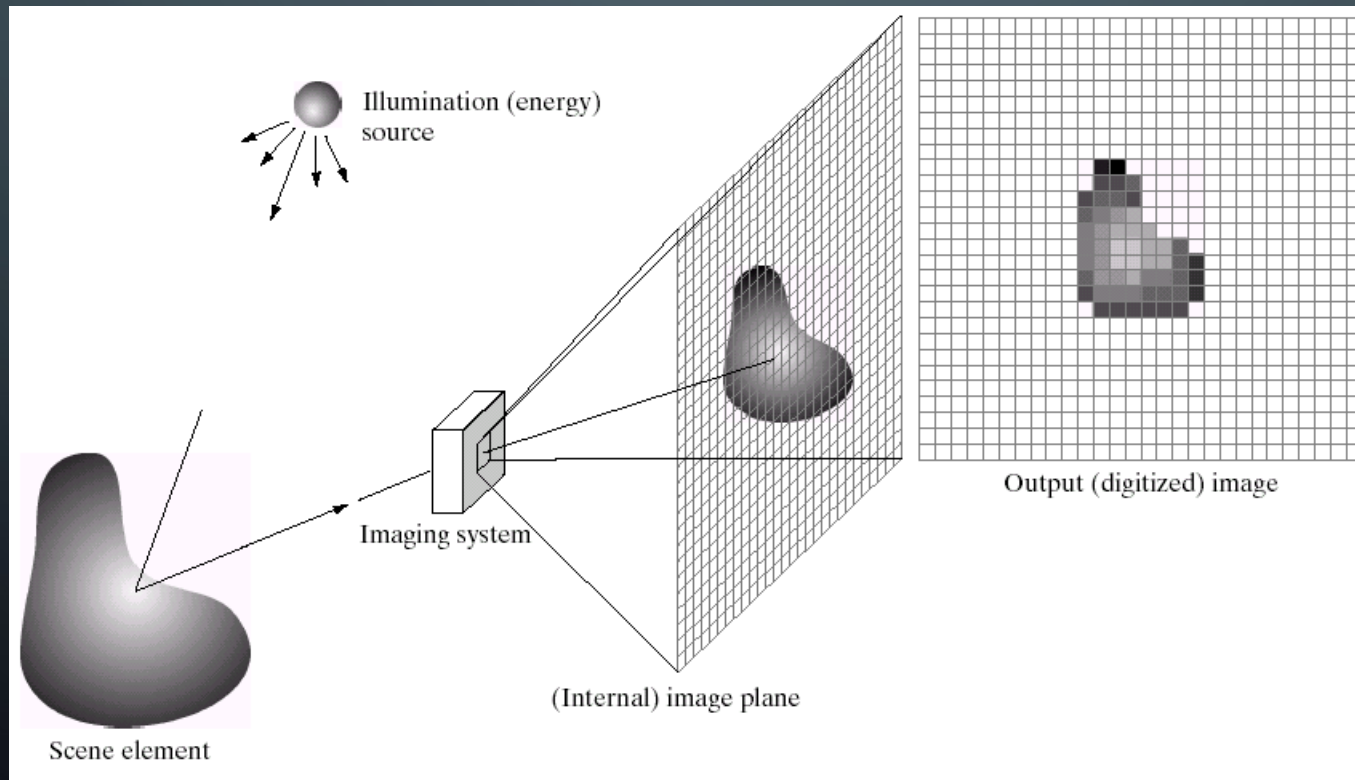
CONTENTS

- This presentation covers:

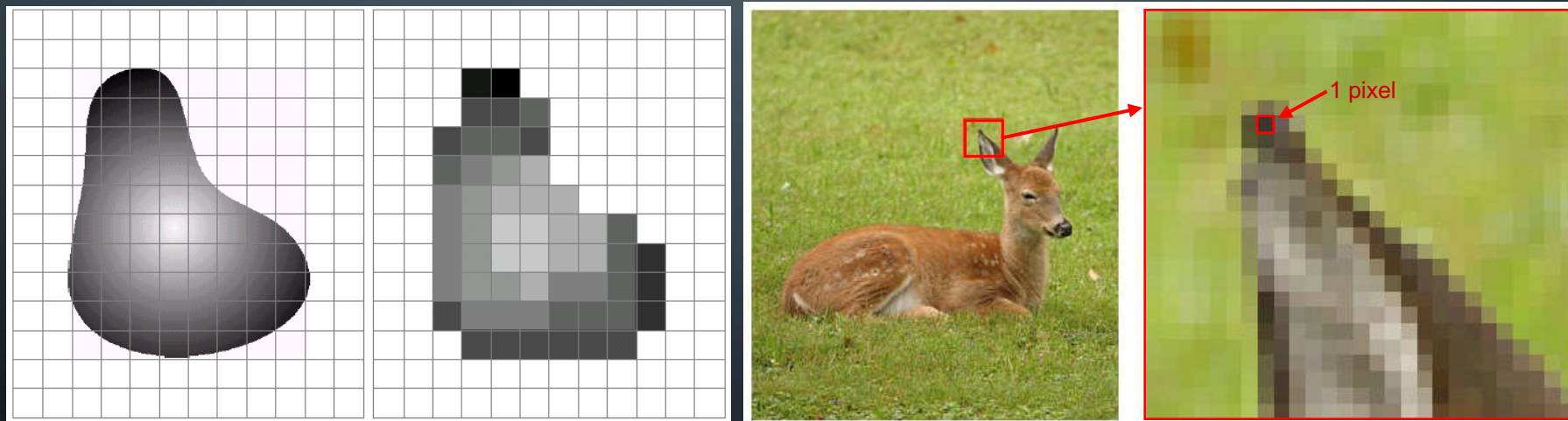
- What is a digital image?
- What is digital image processing?
- History of digital image processing
- State of the art examples of digital image processing
- Key stages in digital image processing
- Basic applications

WHAT IS A DIGITAL IMAGE?

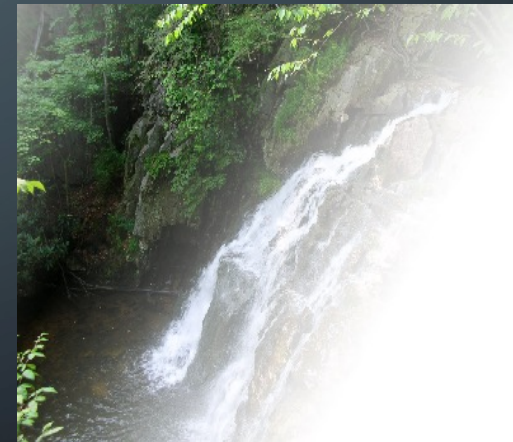
- A digital image is a representation of a two-dimensional image as a finite set of digital values, called picture elements or pixels



- Pixel values typically represent gray levels, colours, heights, opacities etc
- Remember *digitization* implies that a digital image is an *approximation* of a real scene



- **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 presentation we will focus on greyscale images.



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

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

| 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 |

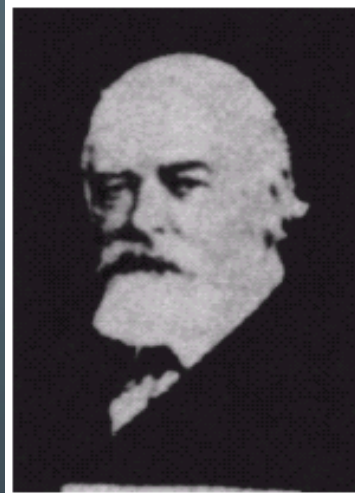
HISTORY OF DIGITAL IMAGE PROCESSING

- 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



•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



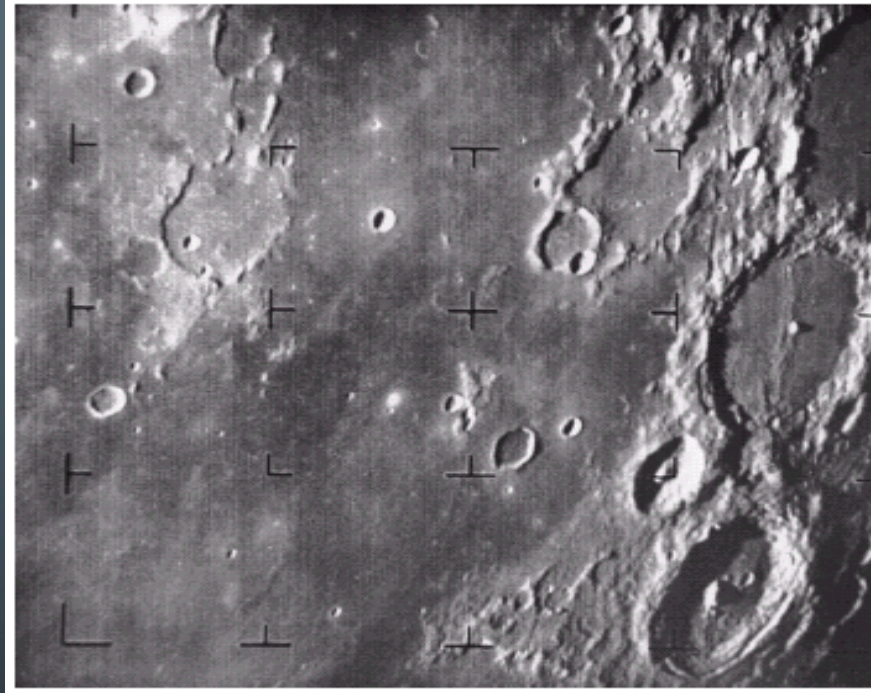
Improved digital image



Early 15 tone digital image

- **1960s:** Improvements in computing technology and the onset of the space race led to a surge of work in digital image processing

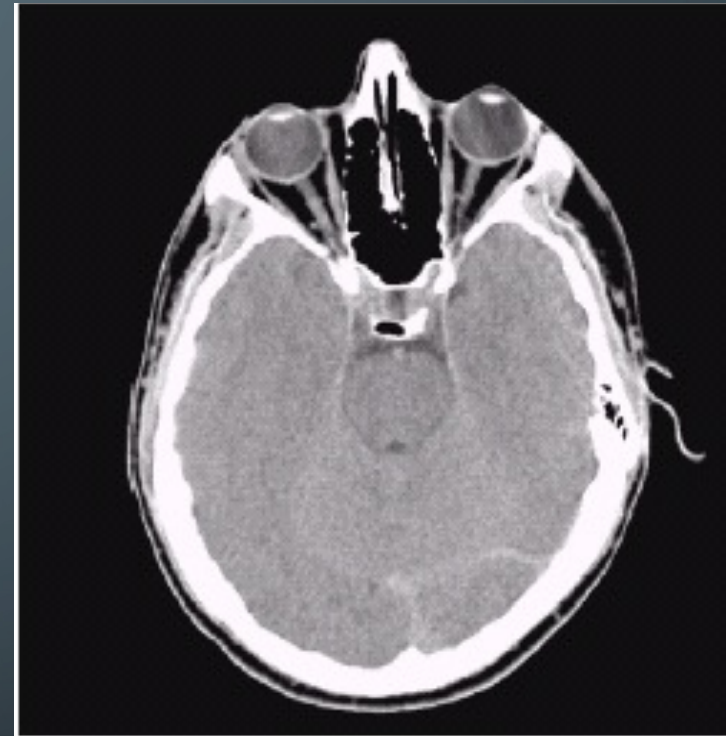
- **1964:** Computers used to improve the quality of images of the moon taken by the *Ranger 7* probe
- Such techniques were used in other space missions including the Apollo landings





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

- 1970s: Digital image processing begins to be used in medical applications


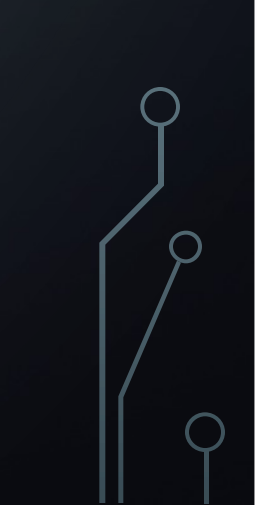
- **1979:** Sir Godfrey N. Hounsfield & Prof. Allan M. Cormack share the Nobel Prize in medicine for the invention of tomography, the technology behind Computerised Axial Tomography (CAT) scans



Typical head slice CAT image

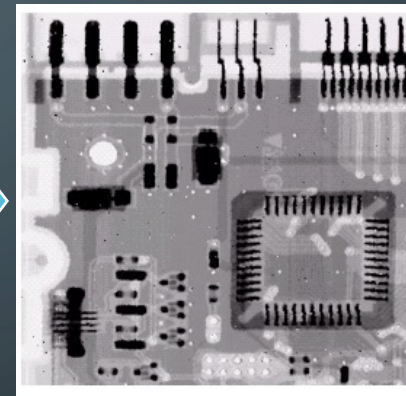
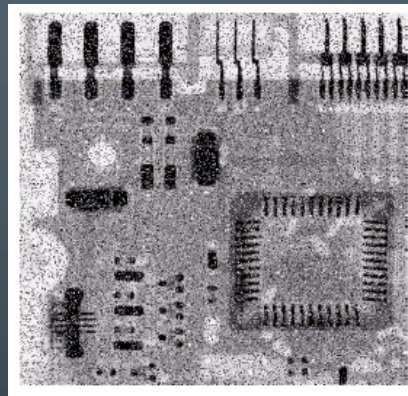
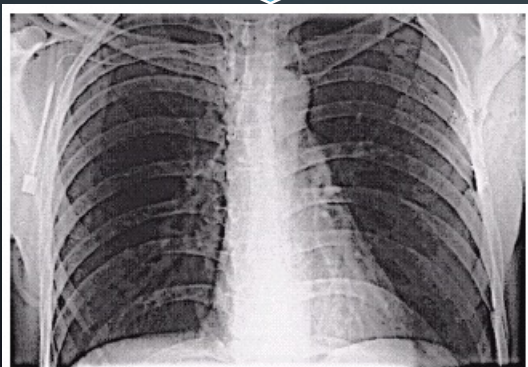
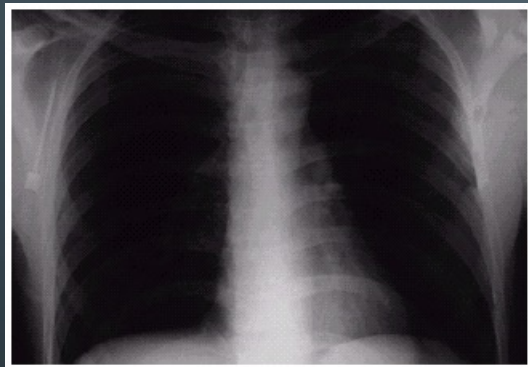


•1980s - Today: The use of digital image processing techniques has exploded and they are now used for all kinds of tasks in all kinds of areas

- 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 Planetary Camera 1

Wide Field Planetary 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

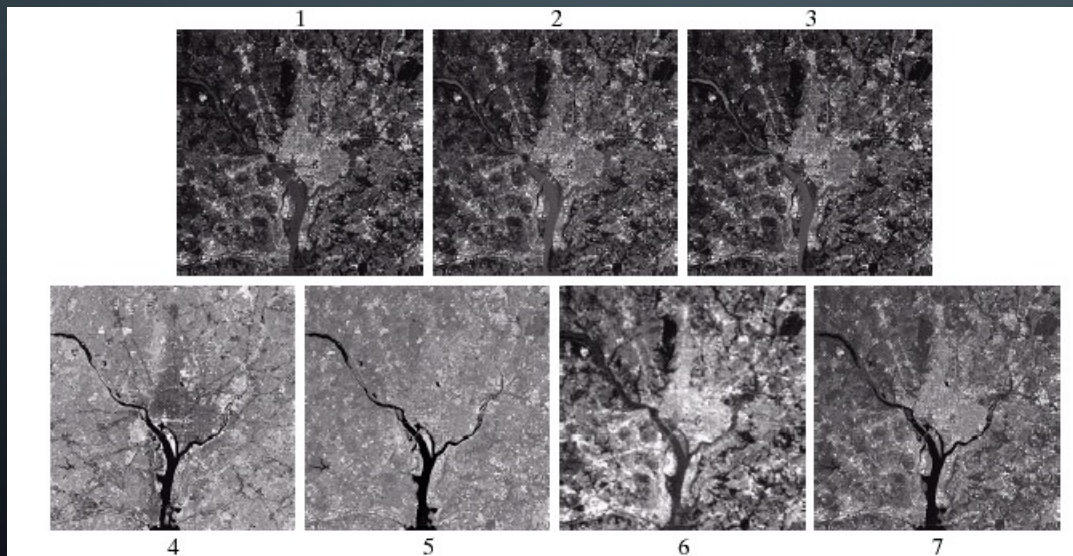


Edge Detection Image

EXAMPLES: GIS

- Geographic Information Systems

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



EXAMPLES: GIS (CONT...)

- *Night-Time Lights of the World*

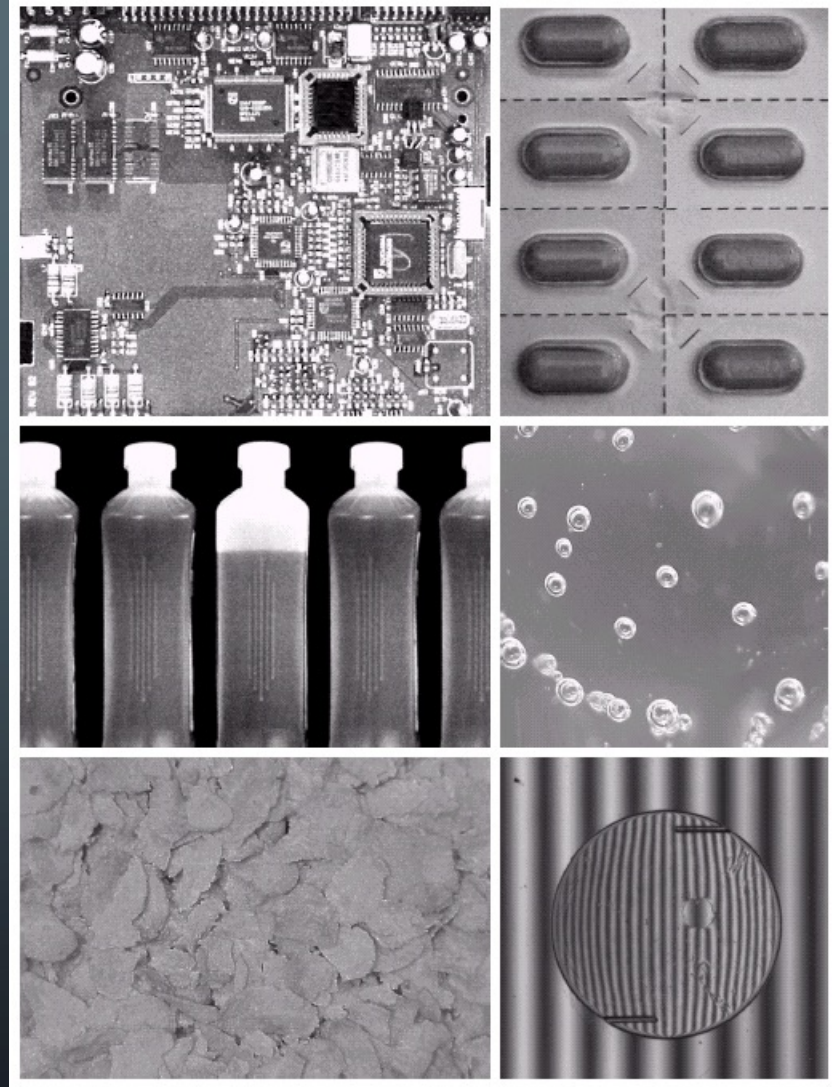
data set

- Global inventory of human settlement
- Not hard to imagine the kind of analysis that might be done using this data



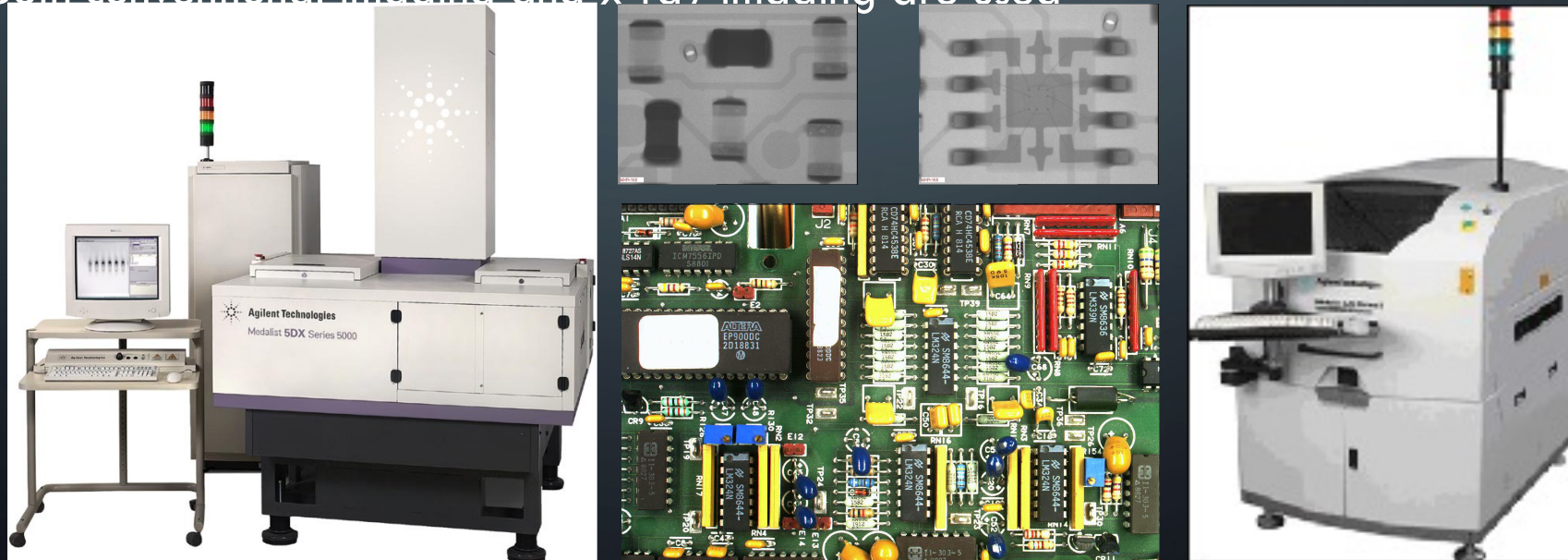
EXAMPLES: INDUSTRIAL INSPECTION

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



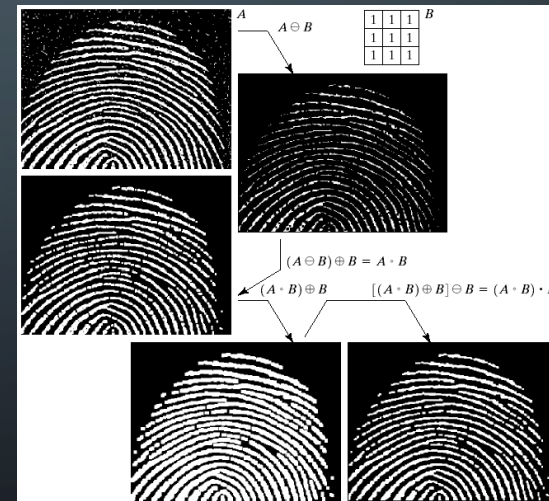
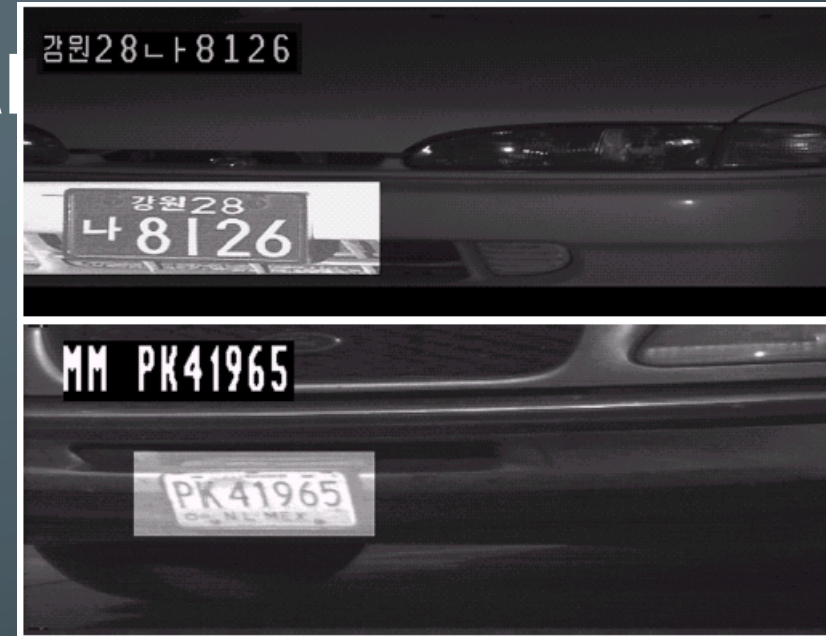
EXAMPLES: PCB INSPECTION

- 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
 - Fingerprint recognition
 - Enhancement of CCTV images



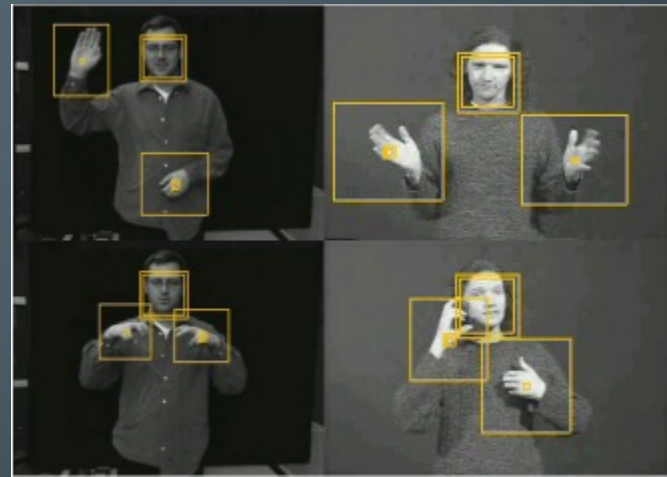
EXAMPLES: HCI

- Try to make human computer interfaces more natural

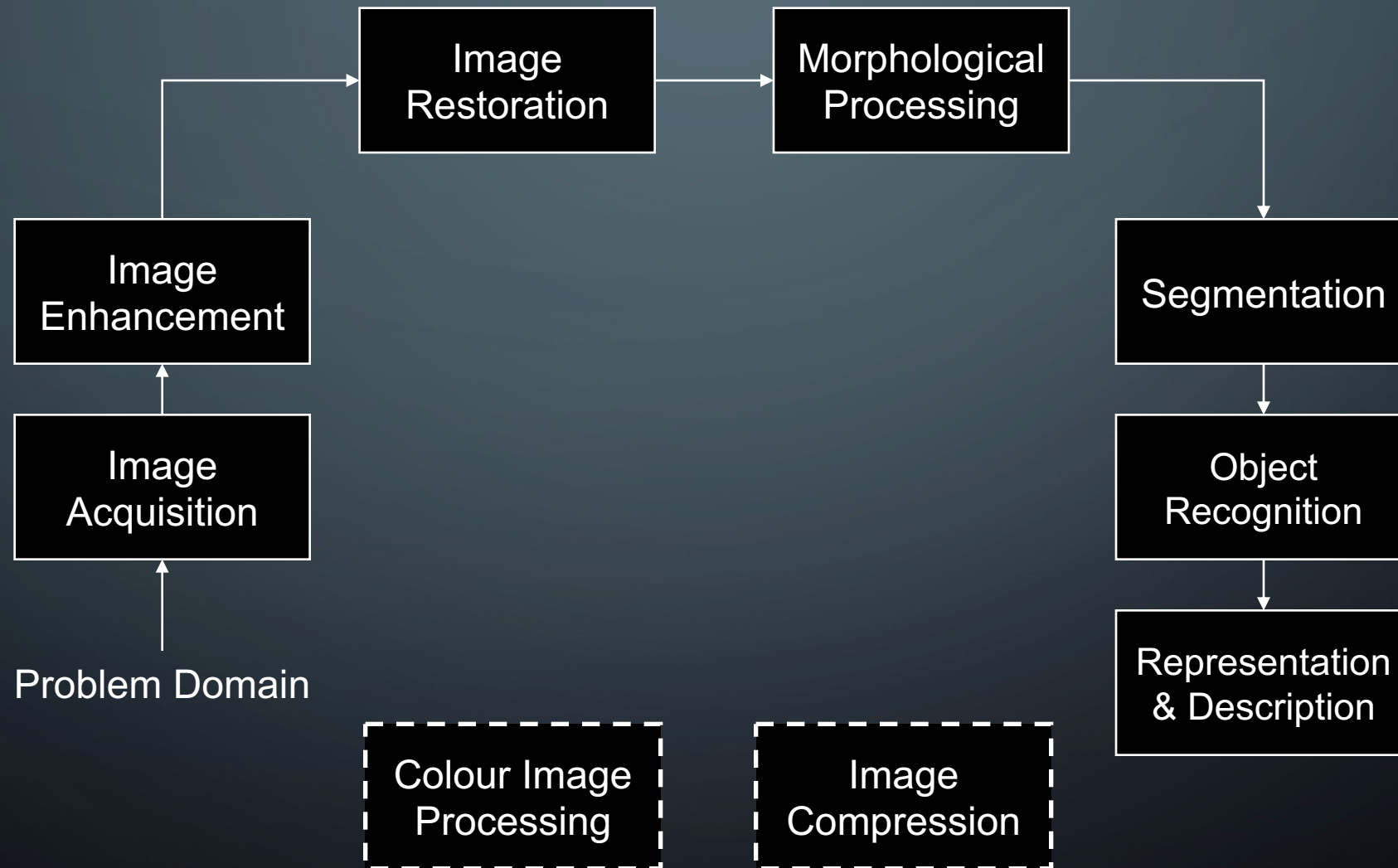
- Face recognition
- Gesture recognition

- Does anyone remember the user interface from “Minority Report”?

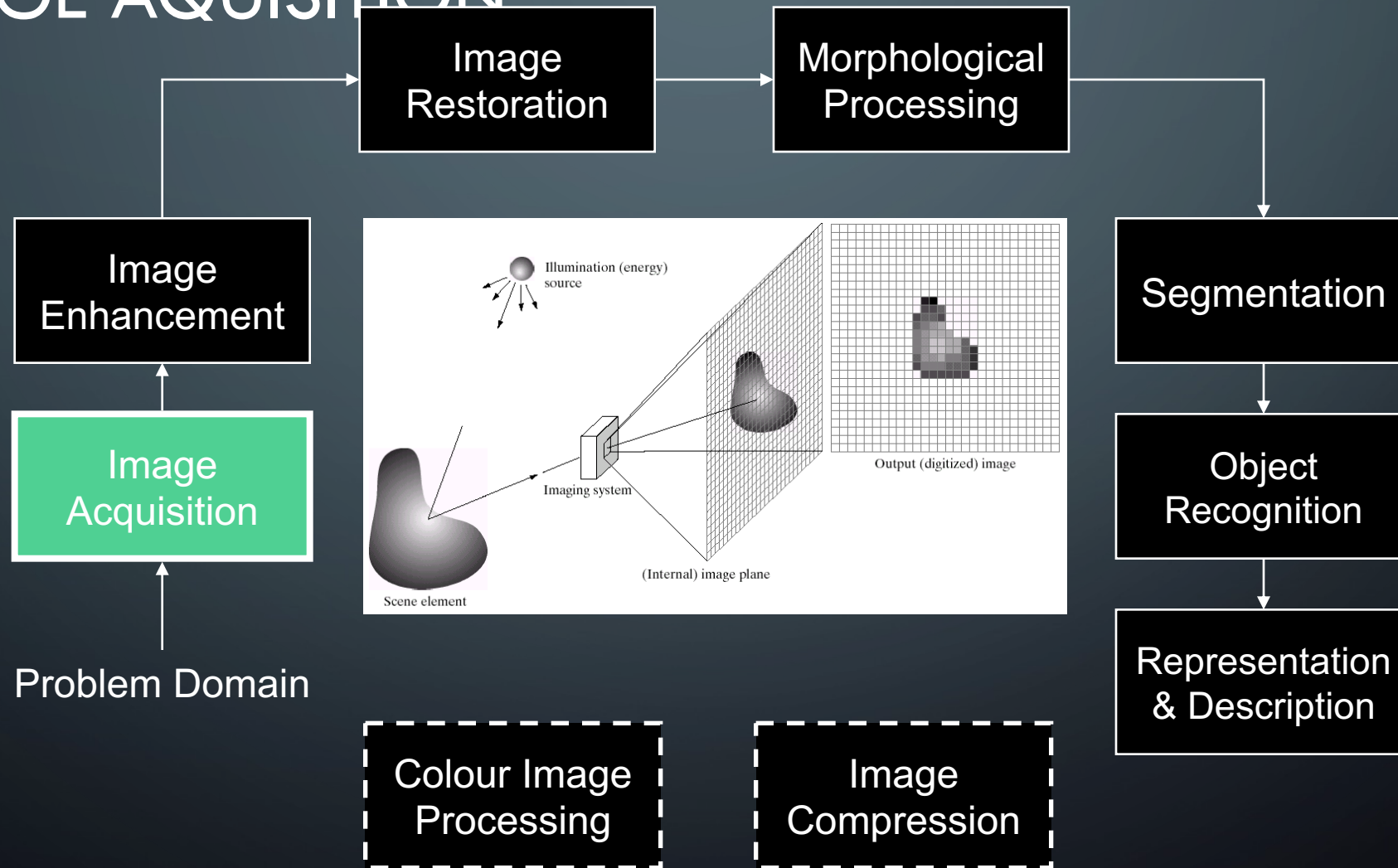
- These tasks can be extremely difficult



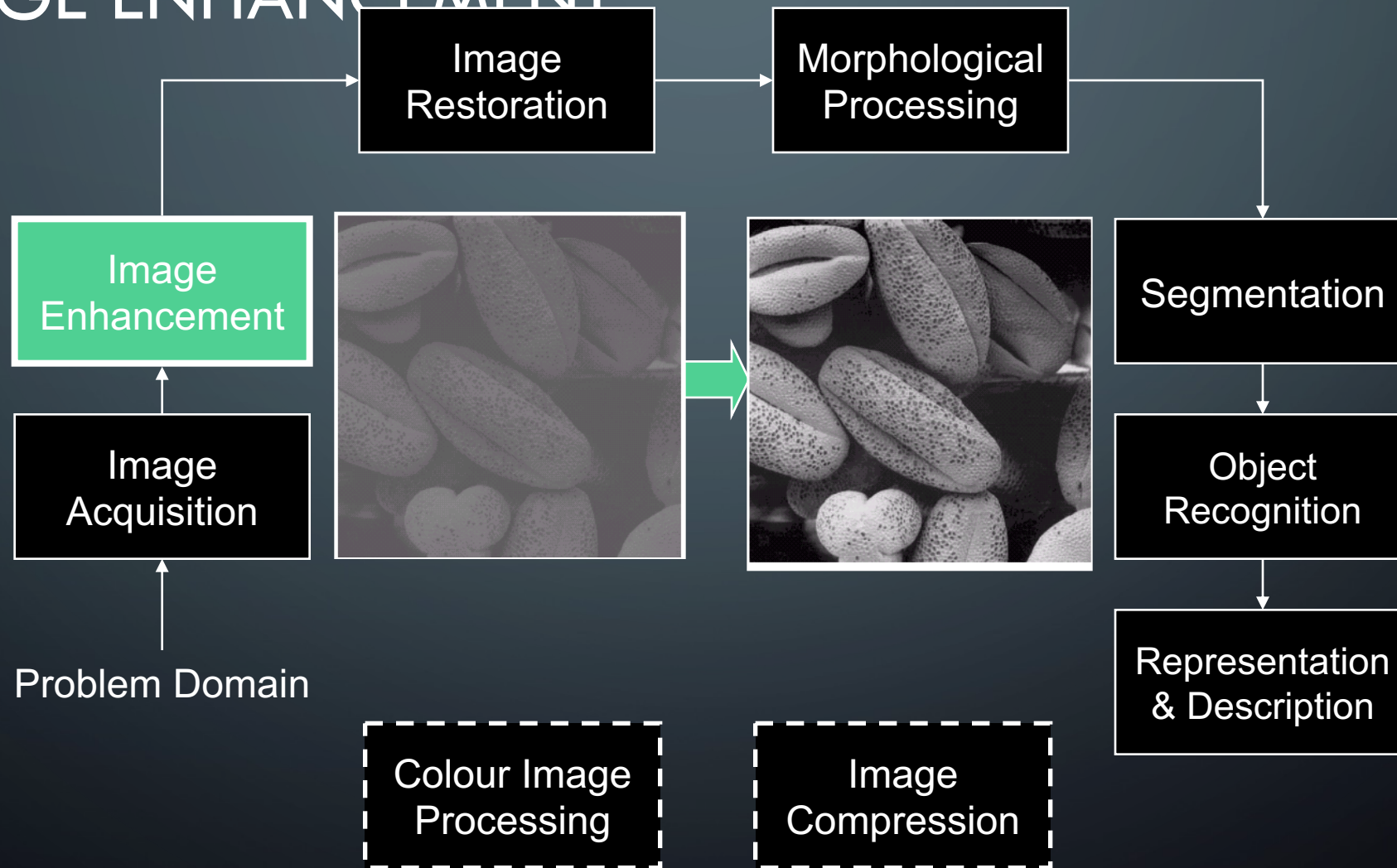
KEY STAGES IN DIGITAL IMAGE PROCESSING



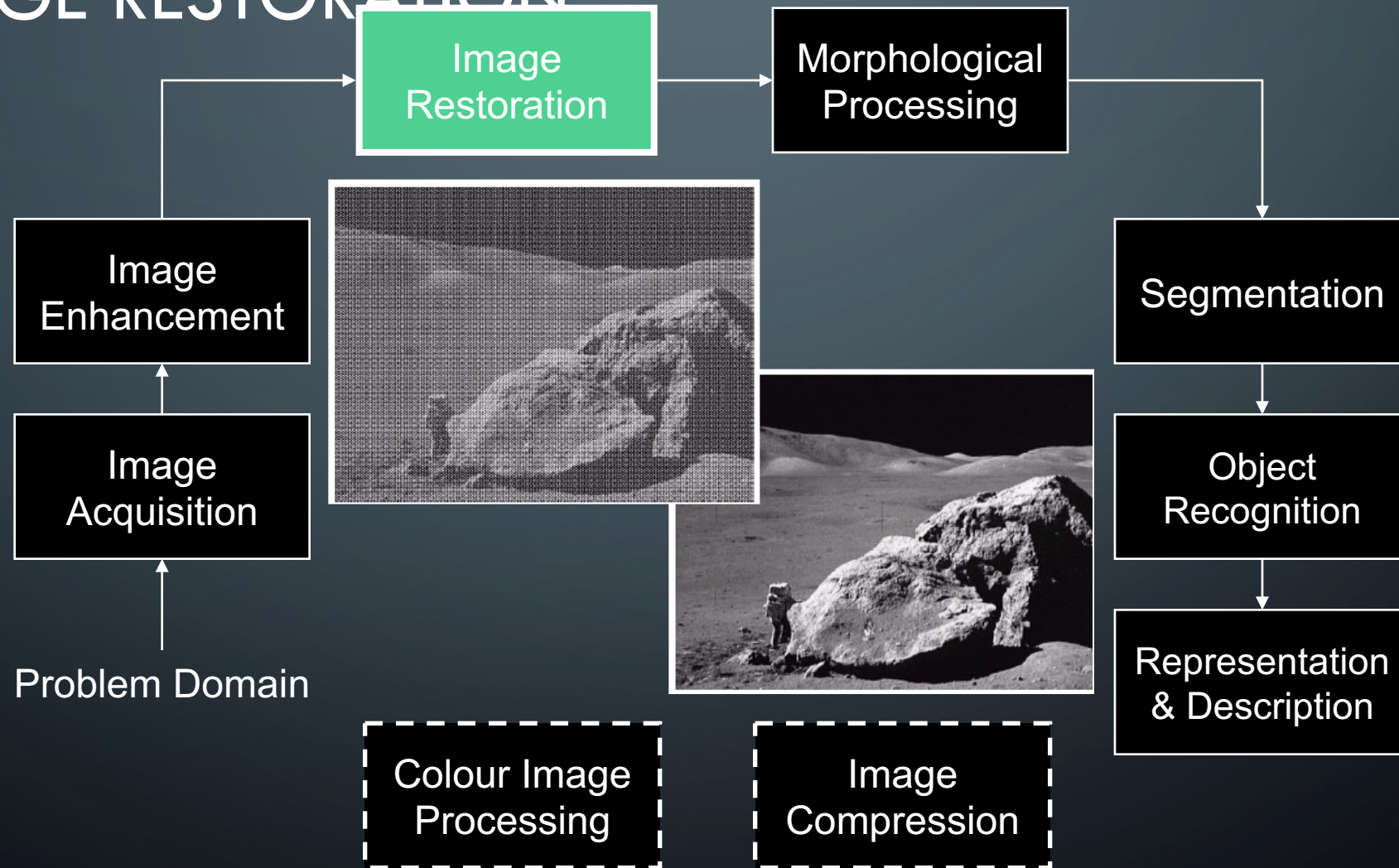
KEY STAGES IN DIGITAL IMAGE PROCESSING: IMAGE AQUISITION



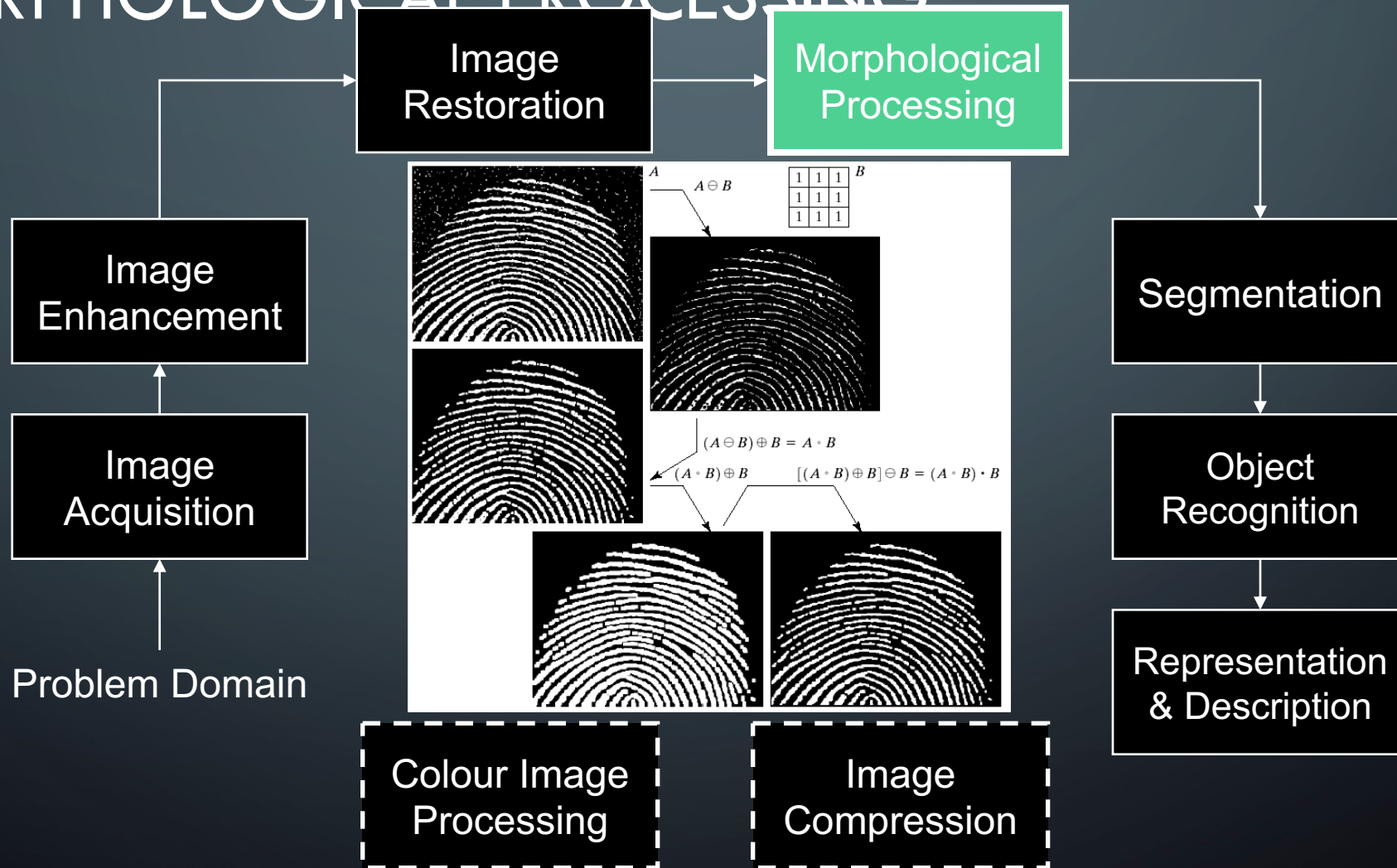
KEY STAGES IN DIGITAL IMAGE PROCESSING: IMAGE ENHANCEMENT



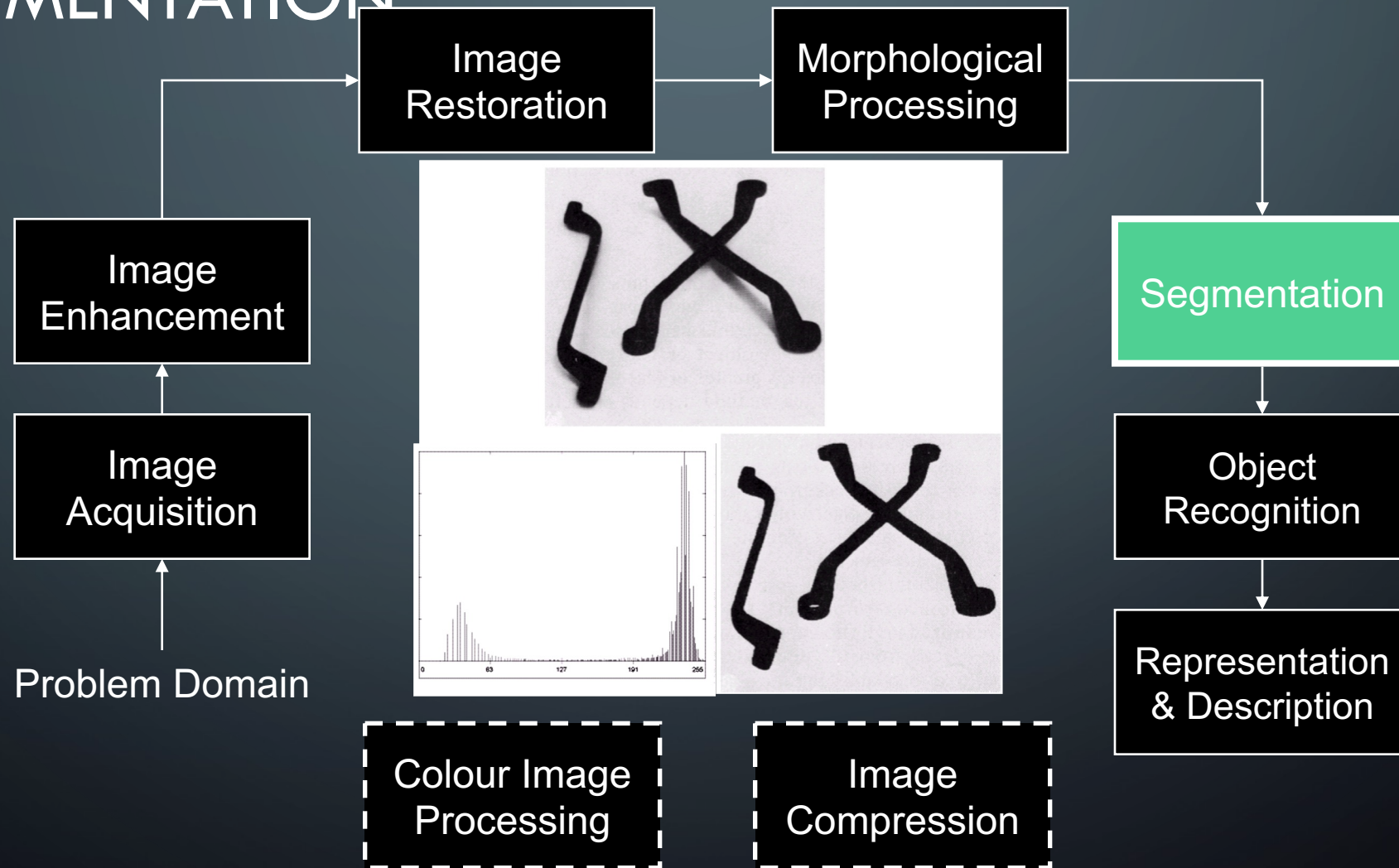
KEY STAGES IN DIGITAL IMAGE PROCESSING: IMAGE RESTORATION



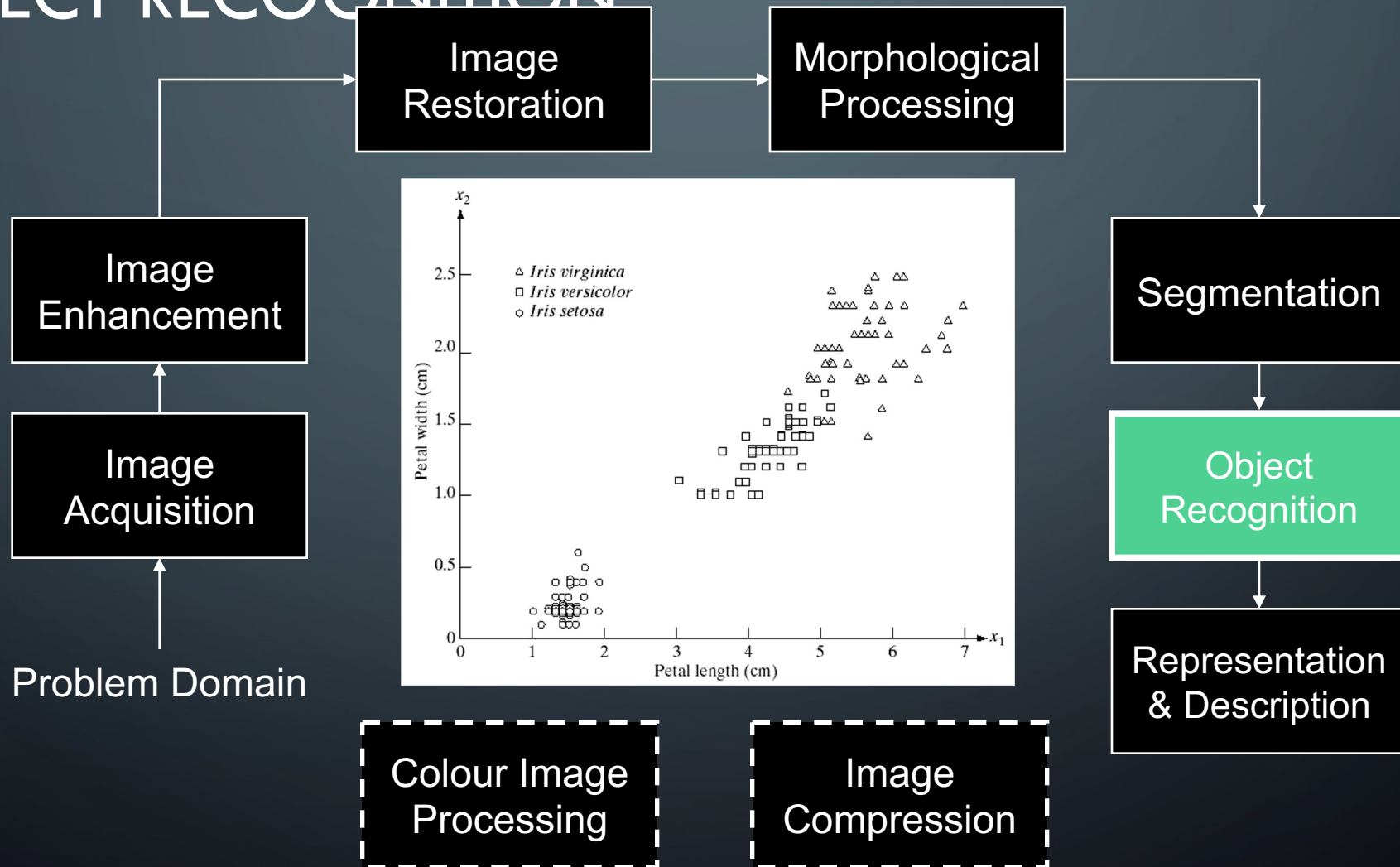
KEY STAGES IN DIGITAL IMAGE PROCESSING: MORPHOLOGICAL PROCESSING



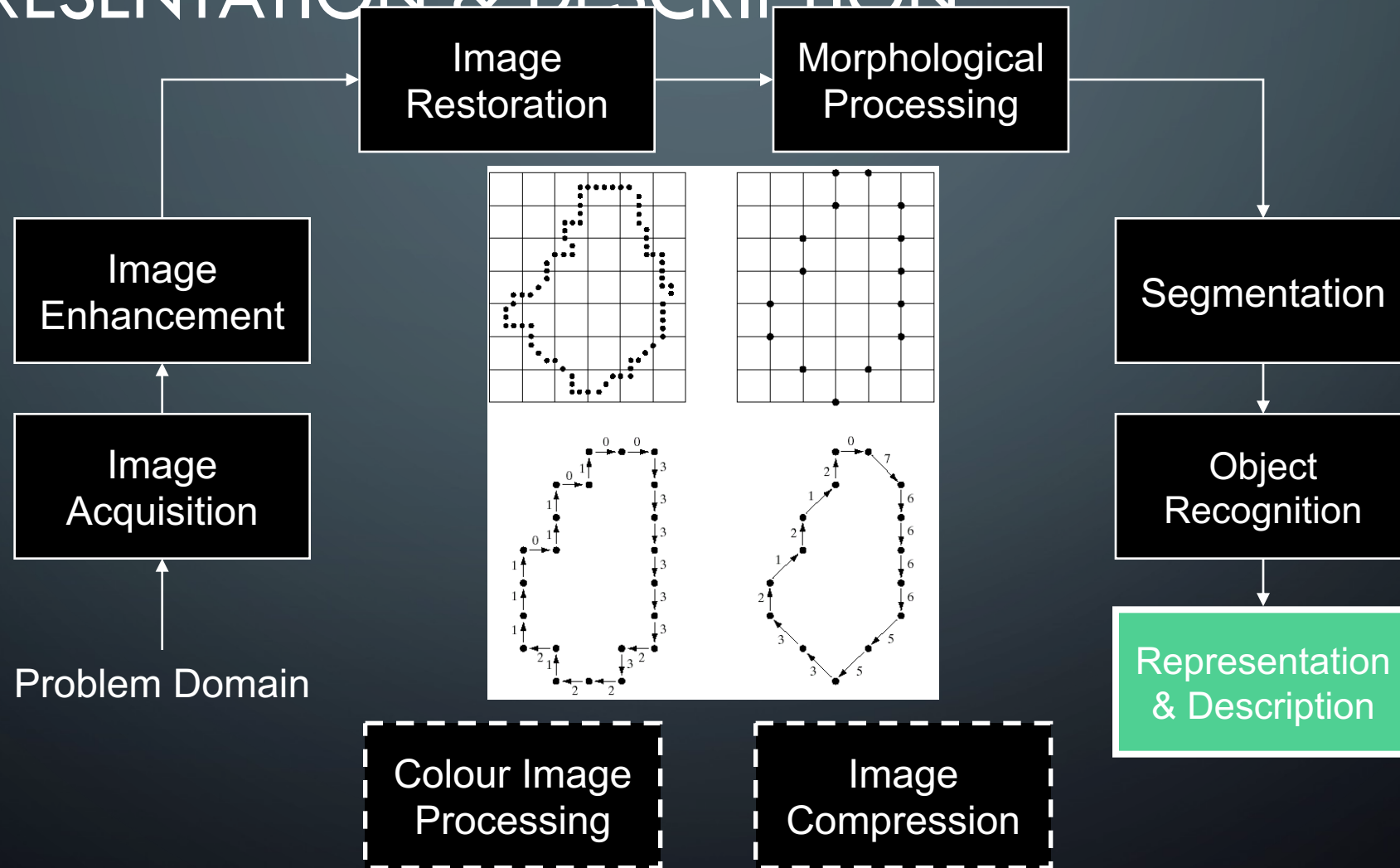
KEY STAGES IN DIGITAL IMAGE PROCESSING: SEGMENTATION



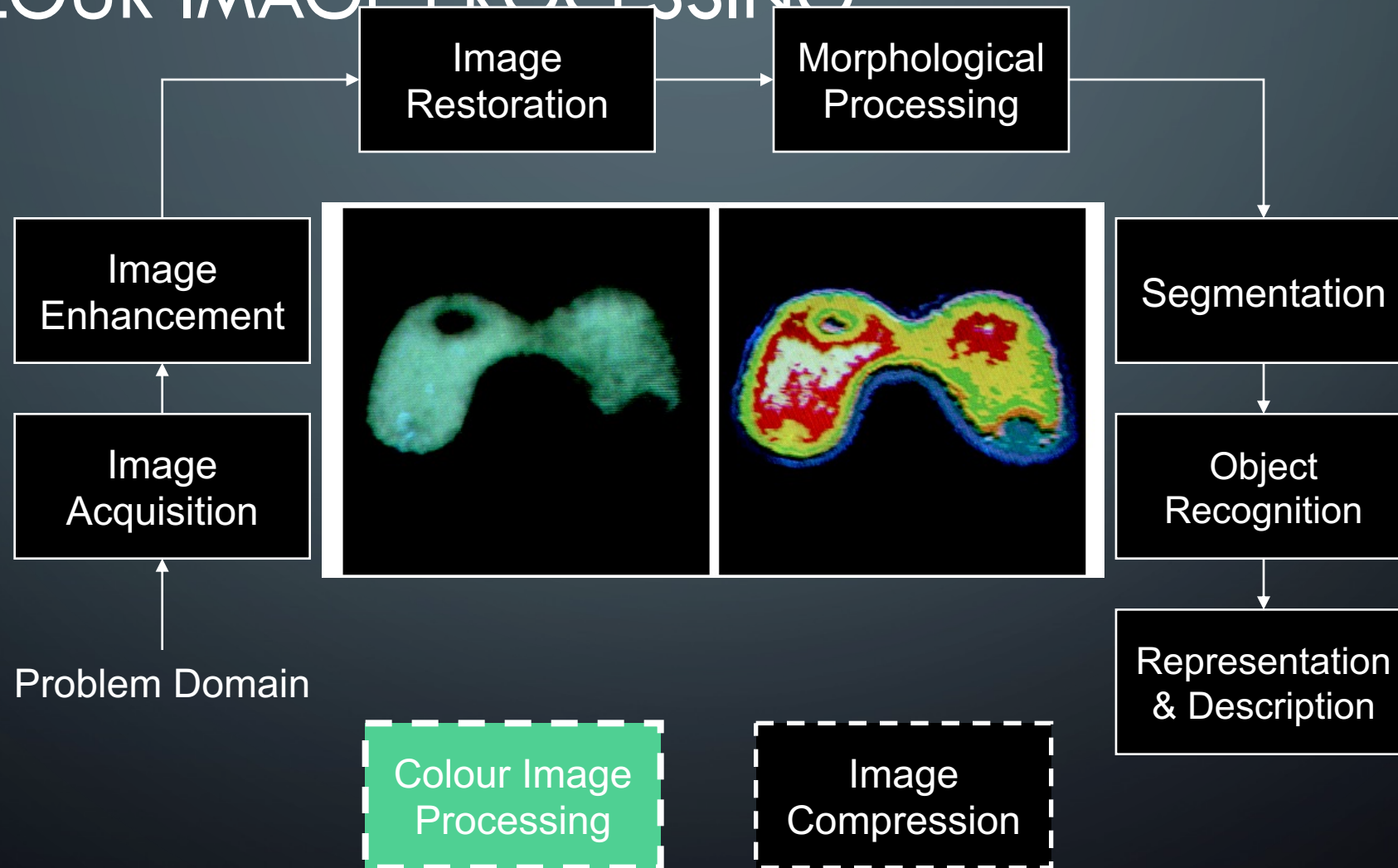
KEY STAGES IN DIGITAL IMAGE PROCESSING: OBJECT RECOGNITION



KEY STAGES IN DIGITAL IMAGE PROCESSING: REPRESENTATION & DESCRIPTION



KEY STAGES IN DIGITAL IMAGE PROCESSING: COLOUR IMAGE PROCESSING



The background is a dark blue gradient. In the four corners, there are white, stylized circuit board traces. These traces consist of straight lines of varying lengths and angles, ending in small white circles, resembling a network or data flow diagram.

THANKS FOR JOINING

Q&A