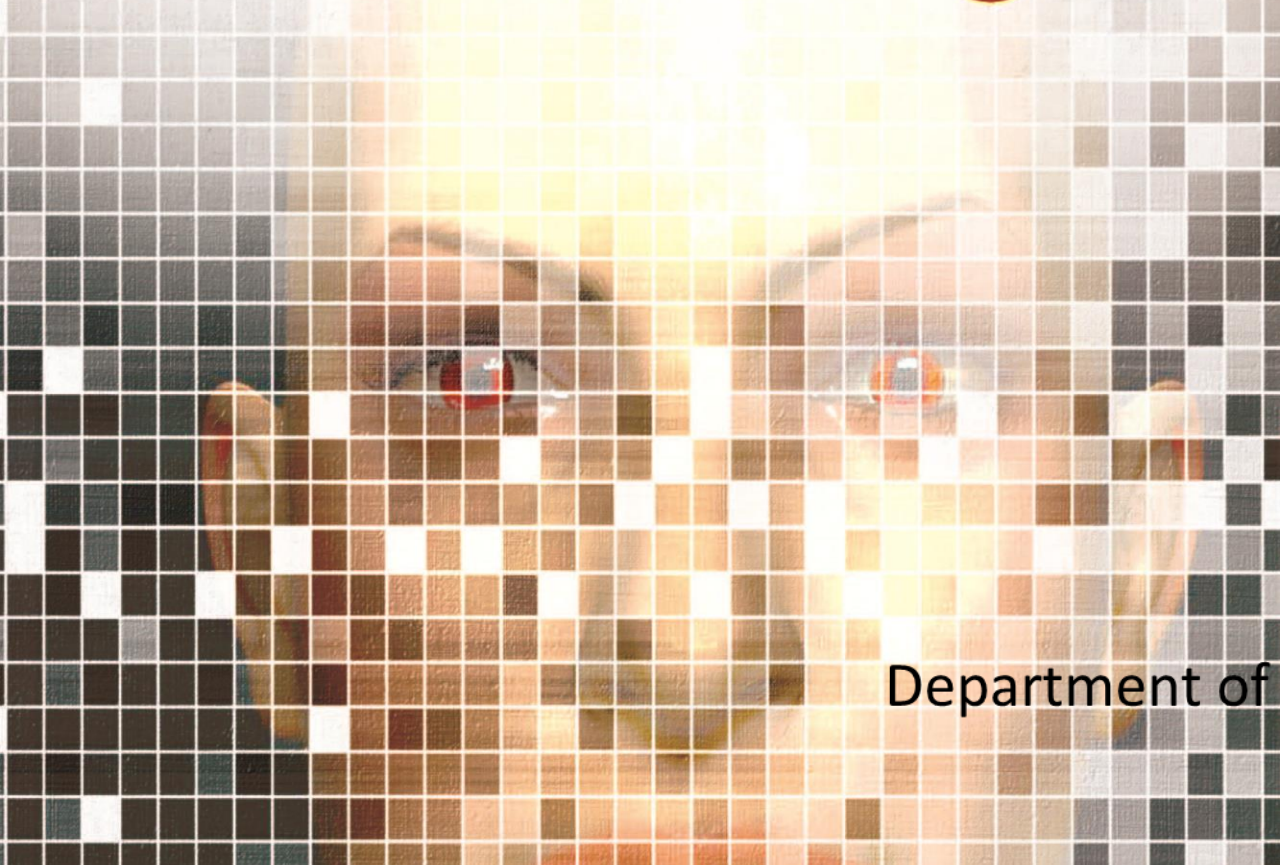


Digital Image Processing

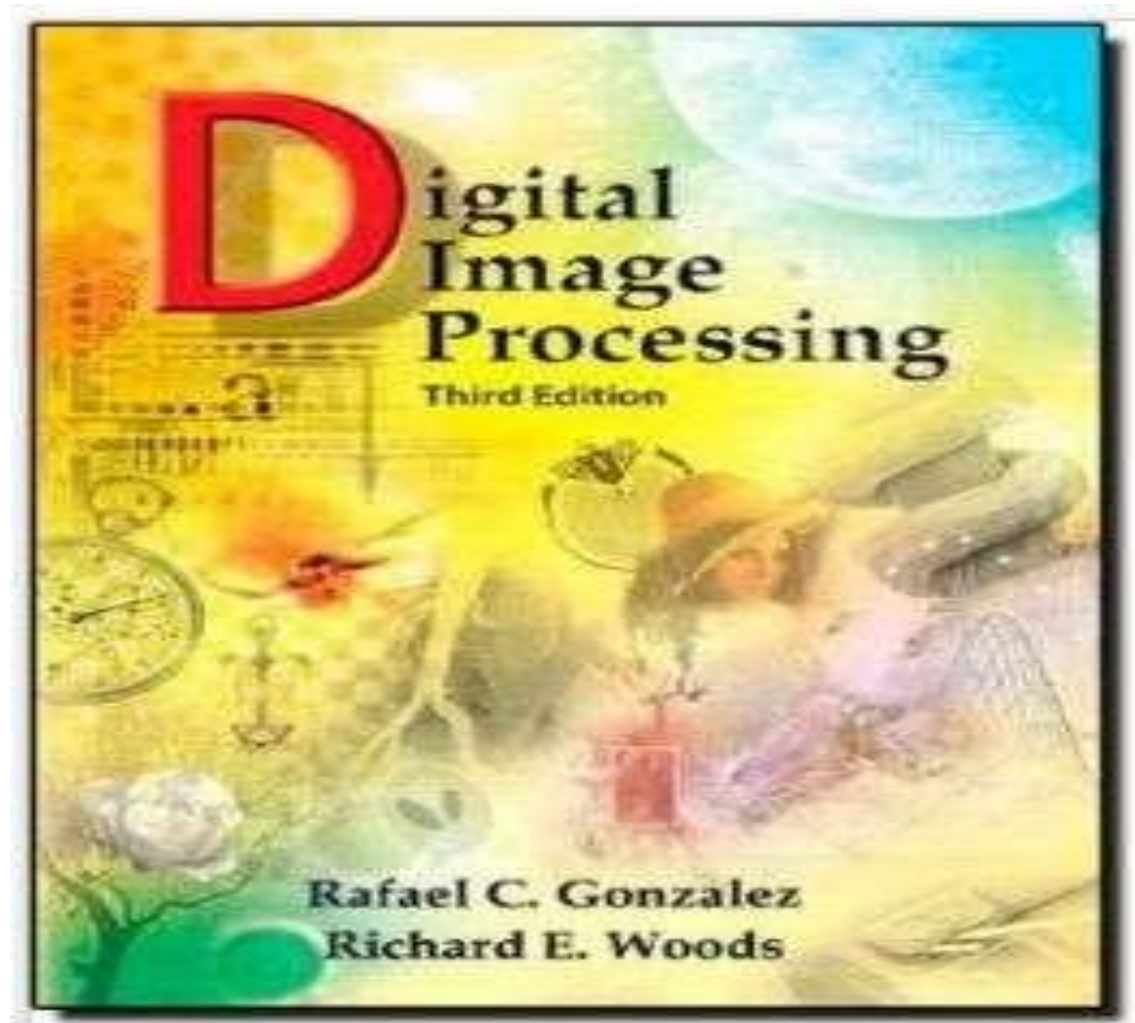


Introduction to Digital Image Processing

Prof. Sheli Sinha Chaudhuri

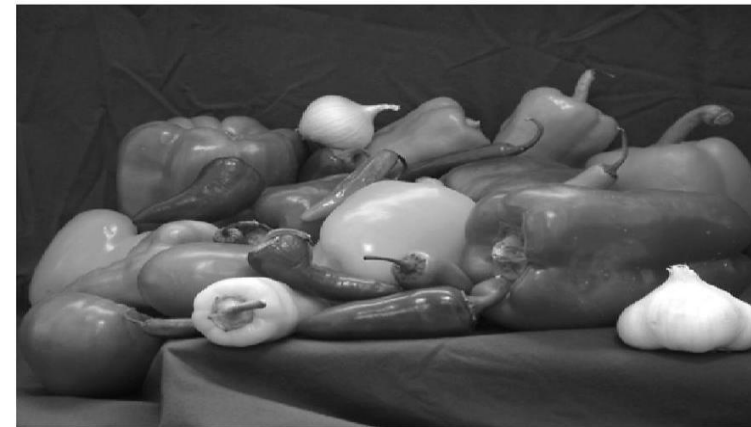
Department of Electronics and Telecommunication Engineering
Jadavpur University

Text book: Digital Image Processing, 3rd edition by
R.C. Gonzalez and R. E. Woods



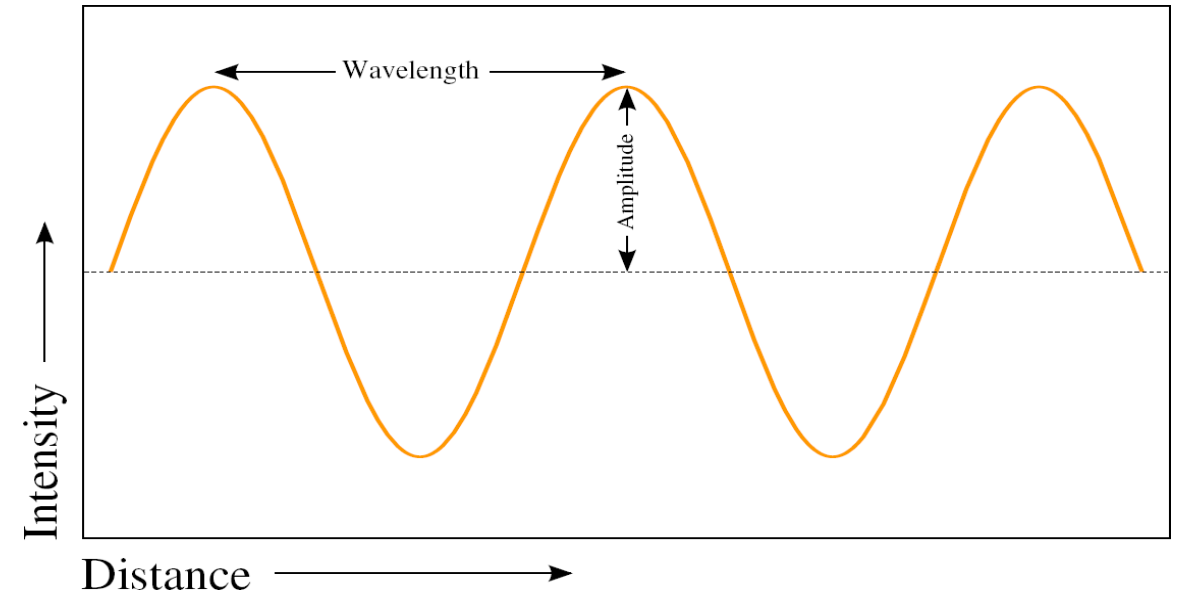
INTRODUCTION

1. What is a Digital Image
2. What is Digital Image Processing
3. The origins of Digital Image Processing
4. Applications of Digital Image Processing
5. Fundamental steps in Digital Image Processing
6. Components of an Image Processing System

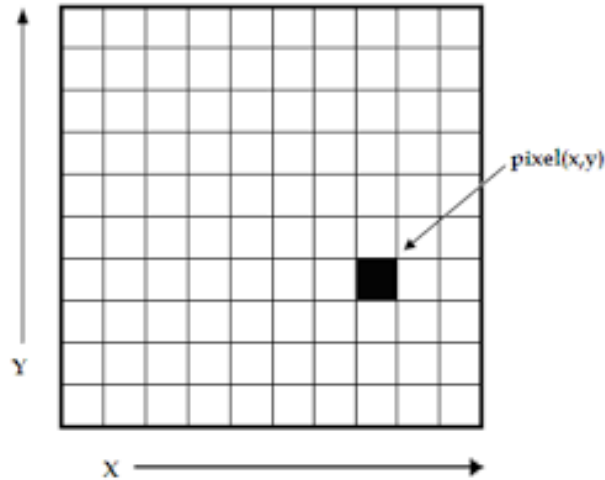


INTRODUCTION to Digital Image

- An **image** is nothing more than a digital representation of light intensity in two dimensions at a particular time.
- In other words, an **image** conveys information about the structure, shape or position of an object by representing the variation of light intensity reflecting from the particular object.
- Thus, an **image** is a two dimensional signal.



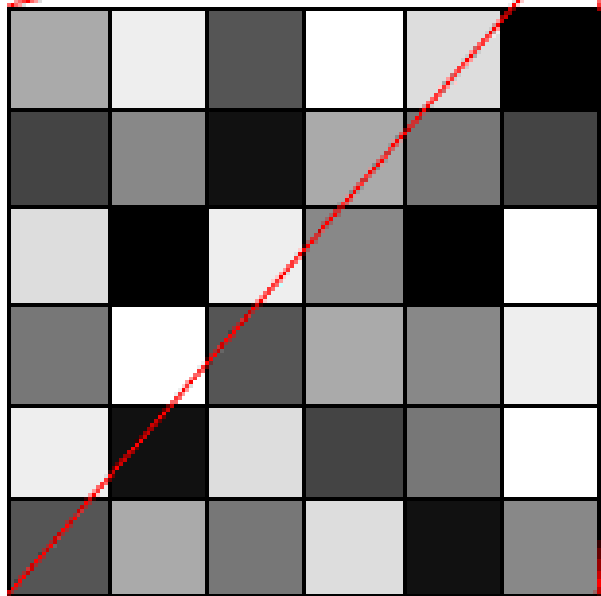
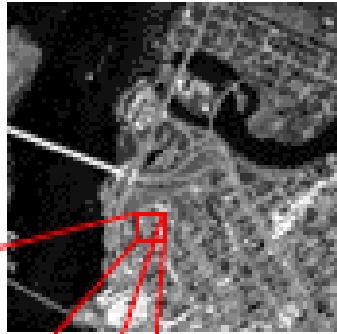
What is a Digital Image



	0	1	2	3	...	N-1
0	$f(0,0)$	$f(0,1)$	$f(0,2)$	$f(0,3)$		$f(0,N-1)$
1	$f(1,0)$	$f(1,1)$	$f(1,2)$	$f(1,3)$		$f(1,N-1)$
2	$f(2,0)$	$f(2,1)$	$f(2,2)$	$f(2,3)$		$f(2,N-1)$
3	$f(3,0)$	$f(3,1)$	$f(3,2)$	$f(3,3)$...	$f(3,N-1)$
...	⋮	⋮	⋮	⋮		⋮
M-1	$f(M-1,0)$	$f(M-1,1)$	$f(M-1,2)$	$f(M-1,3)$		$f(M-1,N-1)$

A digital image is therefore a 2D array of intensity values and each such value is called a pel or pixel. The size of the array represents the image size. So $f(x,y)$ represents a pixel intensity at the position (x,y) . And the amplitude of the 2D signal f represents the intensity or gray level.

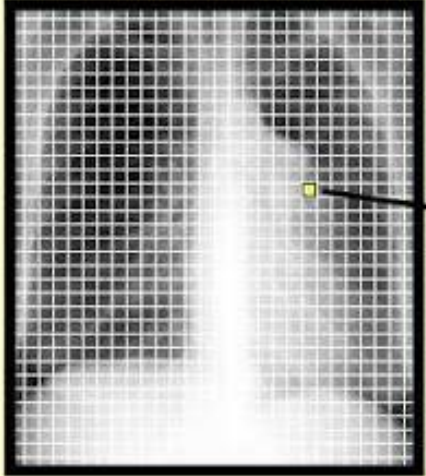
Digital Image Array



170	238	85	255	221	0
68	136	17	170	119	68
221	0	238	136	0	255
119	255	85	170	136	238
238	17	221	68	119	255
85	170	119	221	17	136

Digital Image

A Matrix of Pixels



Picture Element (Pixel)

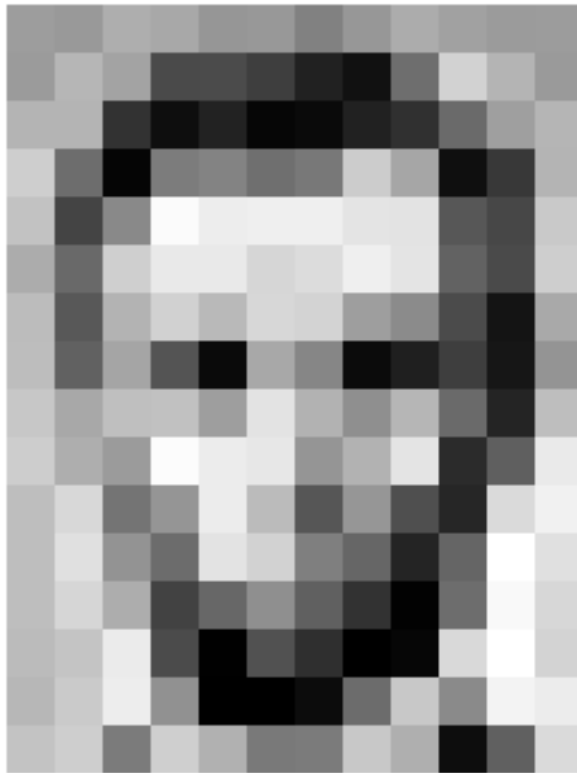
248

Numerical Value Brightness or Color Value

For Computer Systems

Sprawls

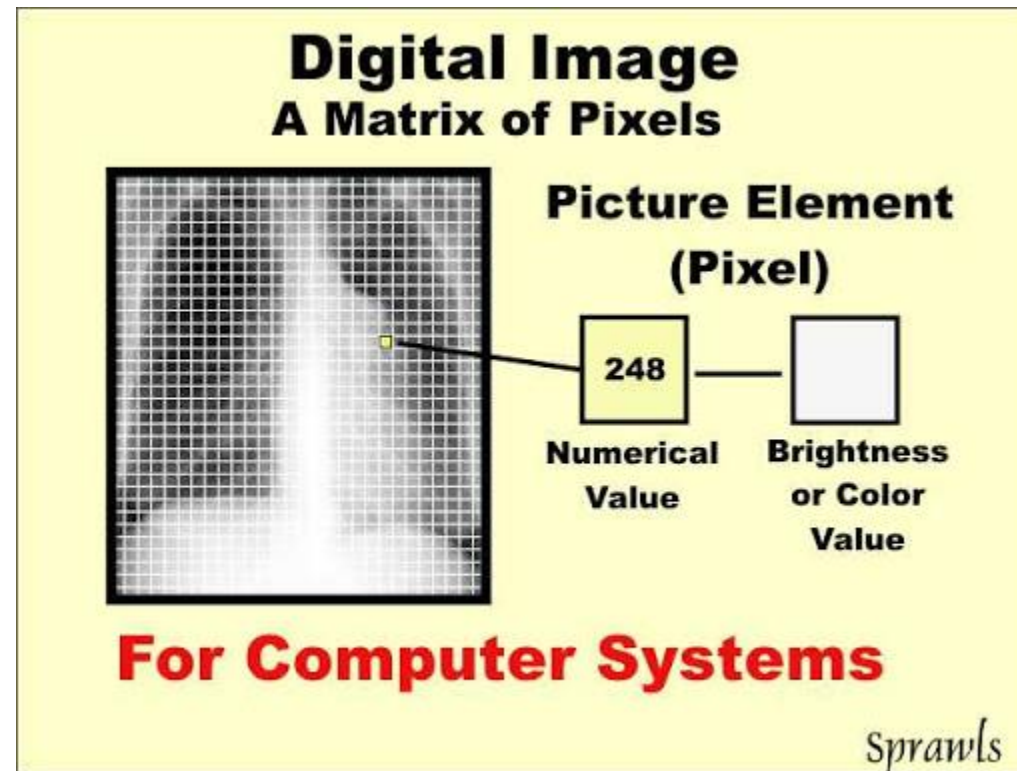
Digital Image Array



157	153	174	168	150	152	129	151	172	161	155	156
155	182	163	74	75	62	33	17	110	210	180	154
180	180	50	14	34	6	10	33	48	106	159	181
206	109	5	124	131	111	120	204	166	15	56	180
194	68	137	251	237	239	239	228	227	87	71	201
172	106	207	233	233	214	220	239	228	98	74	206
188	88	179	209	185	215	211	158	139	75	20	169
189	97	165	84	10	168	134	11	31	62	22	148
199	168	191	193	158	227	178	143	182	106	36	190
205	174	155	252	236	231	149	178	228	43	95	234
190	216	116	149	236	187	86	150	79	38	218	241
190	224	147	108	227	210	127	102	36	101	255	224
190	214	173	66	103	143	96	50	2	109	249	215
187	196	235	75	1	81	47	0	6	217	255	211
183	202	237	145	0	0	12	108	200	138	243	236
195	206	123	207	177	121	123	200	175	13	96	218

157	153	174	168	150	152	129	151	172	161	155	156
155	182	163	74	75	62	33	17	110	210	180	154
180	180	50	14	34	6	10	33	48	106	159	181
206	109	5	124	131	111	120	204	166	15	56	180
194	68	137	251	237	239	239	228	227	87	71	201
172	106	207	233	233	214	220	239	228	98	74	206
188	88	179	209	185	215	211	158	139	75	20	169
189	97	165	84	10	168	134	11	31	62	22	148
199	168	191	193	158	227	178	143	182	106	36	190
205	174	155	252	236	231	149	178	228	43	95	234
190	216	116	149	236	187	86	150	79	38	218	241
190	224	147	108	227	210	127	102	36	101	255	224
190	214	173	66	103	143	96	50	2	109	249	215
187	196	235	75	1	81	47	0	6	217	255	211
183	202	237	145	0	0	12	108	200	138	243	236
195	206	123	207	177	121	123	200	175	13	96	218

Digital Image Array



Digital Image Acquisition

CCD Scanning Formats

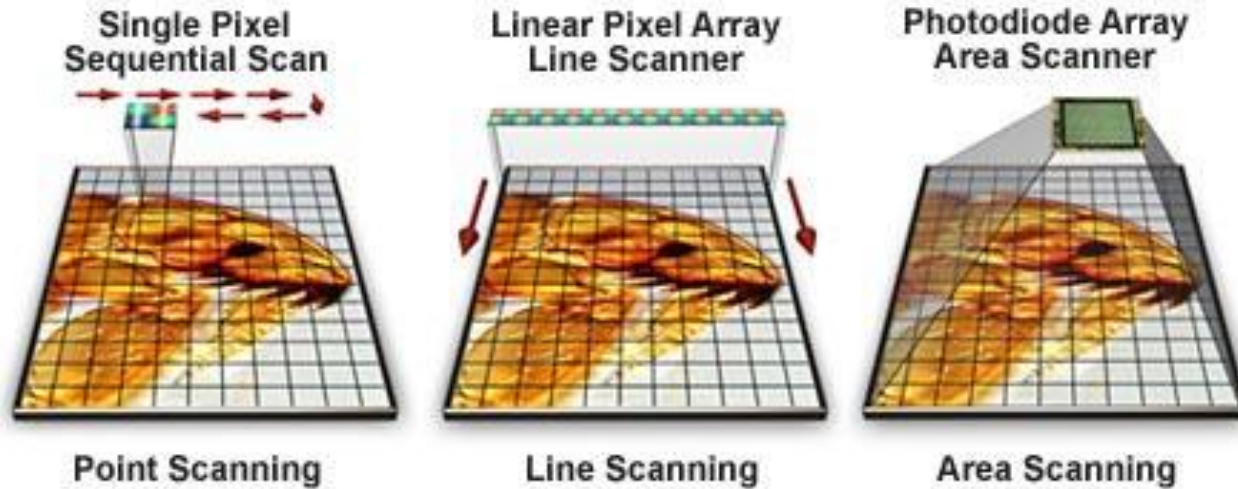
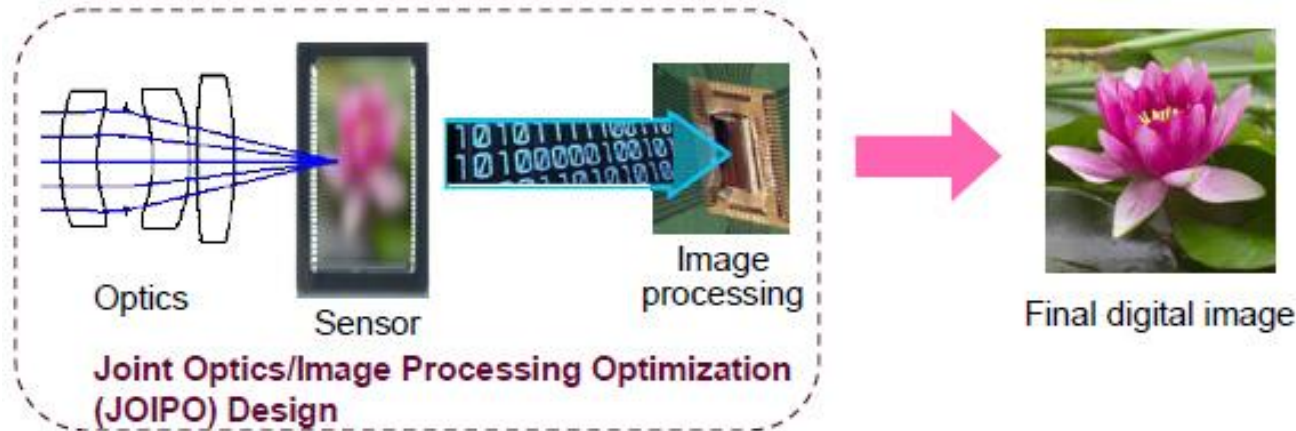
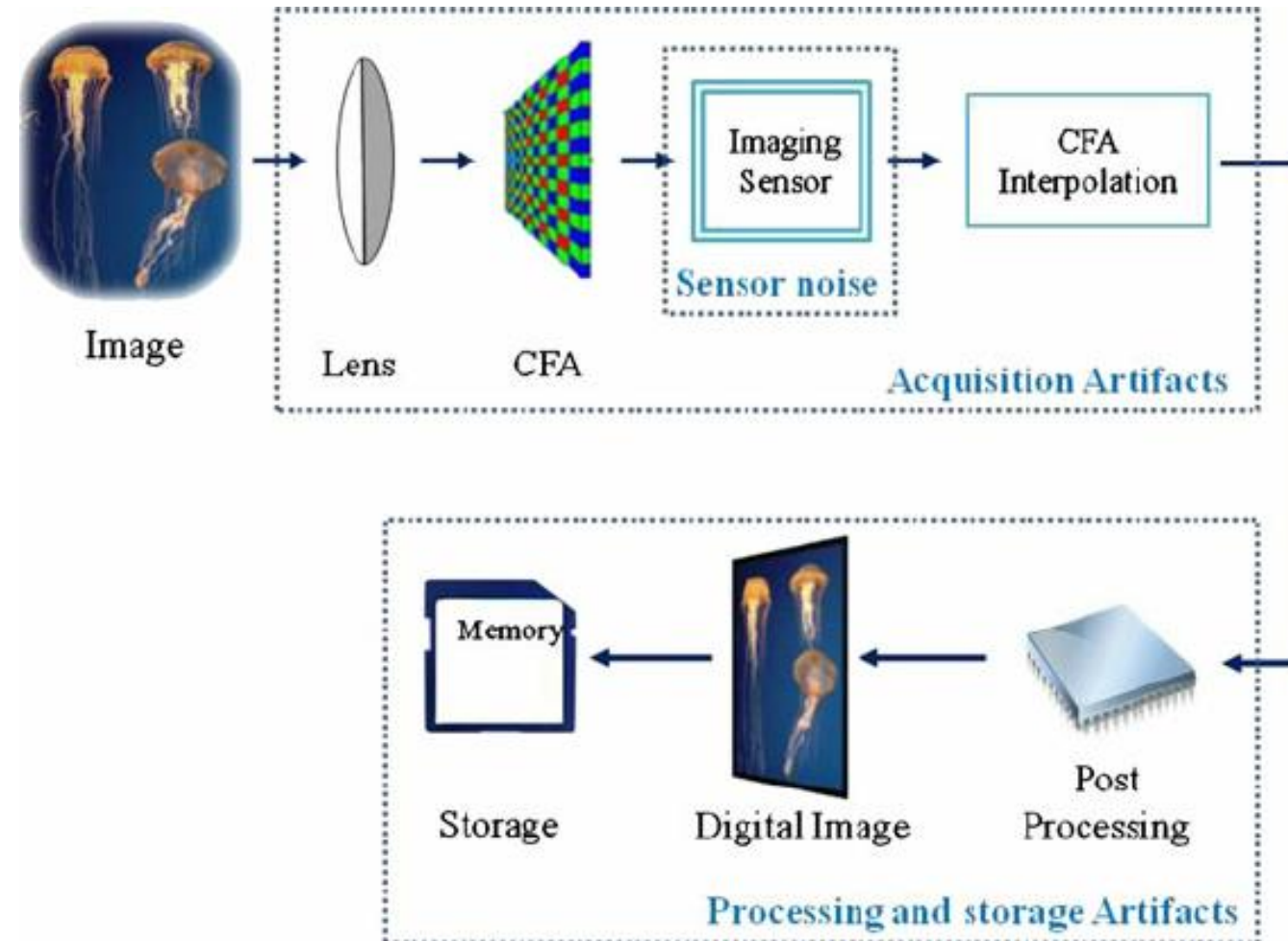


Figure 1



Digital Image Acquisition and Storage





What is Digital Image Processing?

- *Digital image processing* is an area that uses digital circuits, systems, and software algorithms to carry out the image processing operations. The image processing operations may include quality enhancement and restoration of an image, segmentation of foreground and background objects/scenes, image compression, image analysis and classification.



Reasons for Popularity of DIP

1. It is easy to post-process the image. Small corrections can be made in the captured image using software.
2. It is easy to store the image in the digital memory.
3. It is possible to transmit the image over networks. So sharing an image is quite easy.
4. A digital image does not require any chemical process. So it is very environment friendly, as harmful film chemicals are not required or used.
5. It is easy to operate a digital camera.

Image Processing and Related Fields

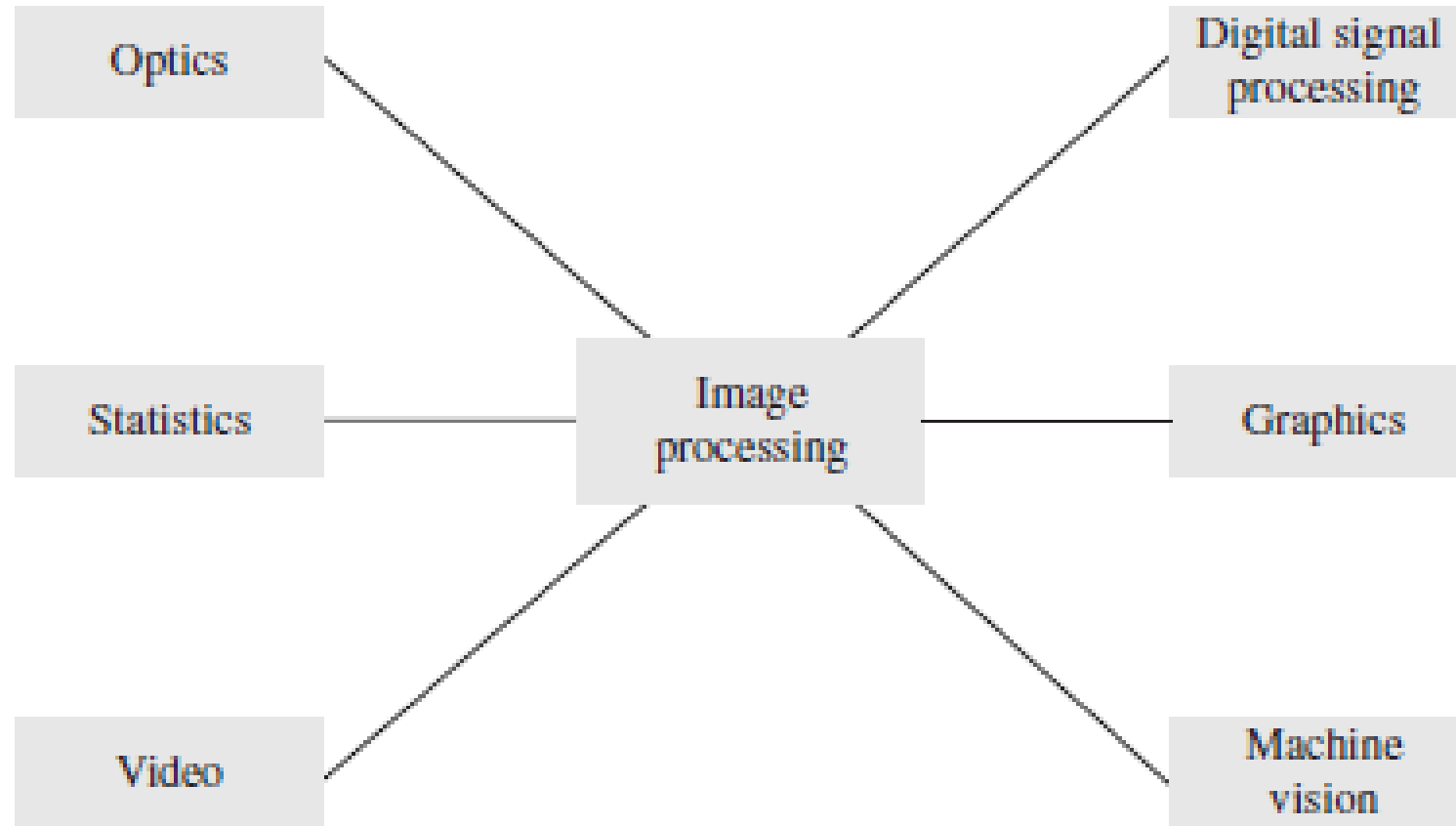


Fig. 1.2 Image processing and other closely related fields



Relations with other branches

- Image processing deals with raster data or bitmaps, whereas computer graphics primarily deals with vector data.
- In digital signal processing, one often deals with the processing of a one-dimensional signal. In the domain of image processing, one deals with visual information that is often in two or more dimensions.
- The main goal of machine vision is to interpret the image and to extract its physical, geometric, or topological properties. Thus, the output of image processing operations can be subjected to more techniques, to produce additional information for interpretation.



Relations with other branches

- Image processing is about still images. Thus, video processing is an extension of image processing. In addition, images are strongly related to multimedia, as the field of multimedia broadly includes the study of audio, video, images, graphics, and animation.
- Optical image processing deals with lenses, light, lighting conditions, and associated optical circuits. The study of lenses and lighting conditions has an important role in the study of image processing.



Relations with other branches

- Image analysis is an area that concerns the extraction and analysis of object information from the image. Imaging applications involve both simple statistics such as counting and mensuration and complex statistics such as advanced statistical inference. So statistics play an important role in imaging applications.

Digital Image Processing

- Processing of digital images on a digital computer
- Not just limited to the visual band of the electromagnetic(EM) spectrum
 - Entire EM spectrum
 - Ultrasound
 - Electron microscopy
 - Computer generated images

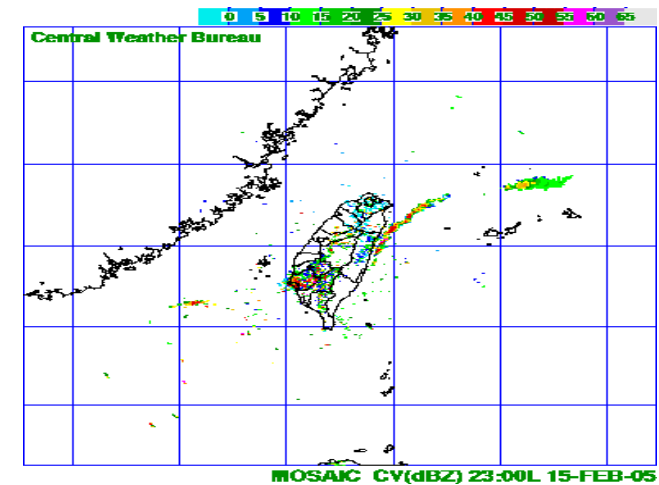
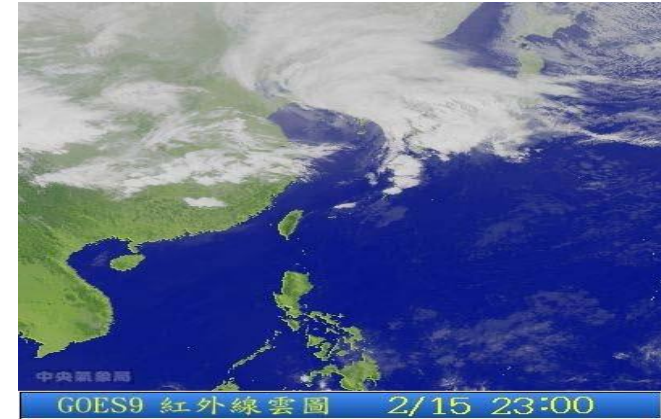
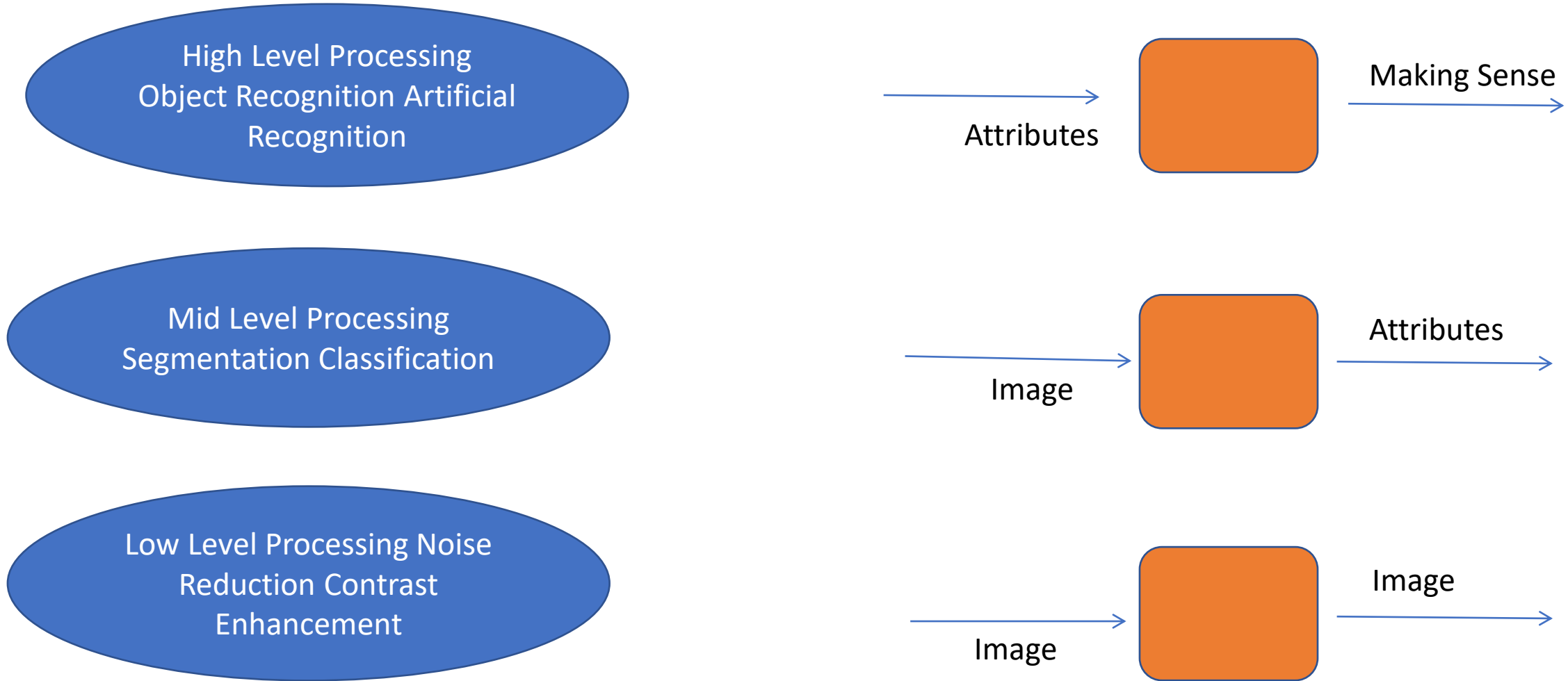


Image Processing to Computer Vision



Origins of Digital Image Processing

- Reproduced by a telegraph printer with a special typeface
- This printing method was abandoned toward the end of 1921



FIGURE 1.1 A digital picture produced in 1921 from a coded tape by a telegraph printer with special type faces. (McFarlane.)

Origins of Digital Image Processing

- 1929
 - Reproduced with 15 levels of grey.

FIGURE 1.3
Unretouched
cable picture of
Generals Pershing
and Foch,
transmitted in
1929 from
London to New
York by 15-tone
equipment.
(McFarlane.)





Origins of Digital Image Processing

▪ *Computer Advances*

- the invention of the transistor by Bell Labs. in 1948
- the development of the high-level programming languages
- the invention of the IC at Texas Instruments in 1958
- the development of operation systems in the early 1960s
- the development of microprocessor by Intel in the early 1970s
- introduction by IBM of the personal computer in 1981
- Large Scale IC in the late 1970s
- VLSI in the 1980s, ULSI present
- **IC Technology, Mass storage and display systems**
- **Computers with powerful processing capability to handle processing of images.**
- **Embedded Vision**

Origins of Digital Image Processing

▪ *Image processing applications*

- The first computers powerful enough to carry out meaningful image processing tasks appeared in the early 1960s



FIGURE 1.4 The first picture of the moon by a U.S. spacecraft. *Ranger 7* took this image on July 31, 1964 at 9:09 A.M. EDT, about 17 minutes before impacting the lunar surface. (Courtesy of NASA.)

Image Processing Applications

- From 1960s to present
 - Image processing are used in **a broad range of applications**
 - **Contrast enhancement** or **code the intensity into colour**
 - X-RAY, Industrial, Medicine, Biological sciences
 - To study pollution patterns from aerial and satellite imagery
 - **Image enhancement** and **restoration**
 - Used to process degraded images of unrecoverable objects or experimental results too expensive to duplicate
 - Archaeology - image restoration
 - Physics - electron microscopy
 - Astronomy, biology, nuclear medicine, law enforcement, defence, industrial applications

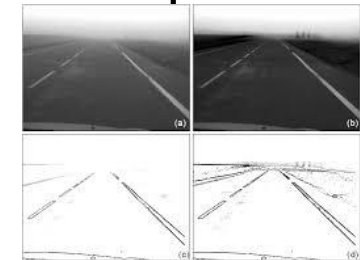
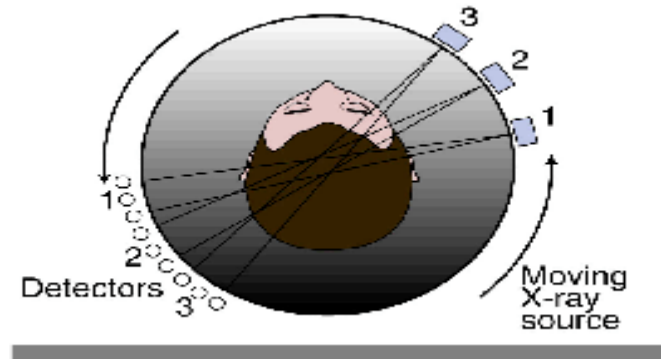


Image Processing Applications

- Computerized Axial Tomography (CAT)



Visible Range in EM Spectrum

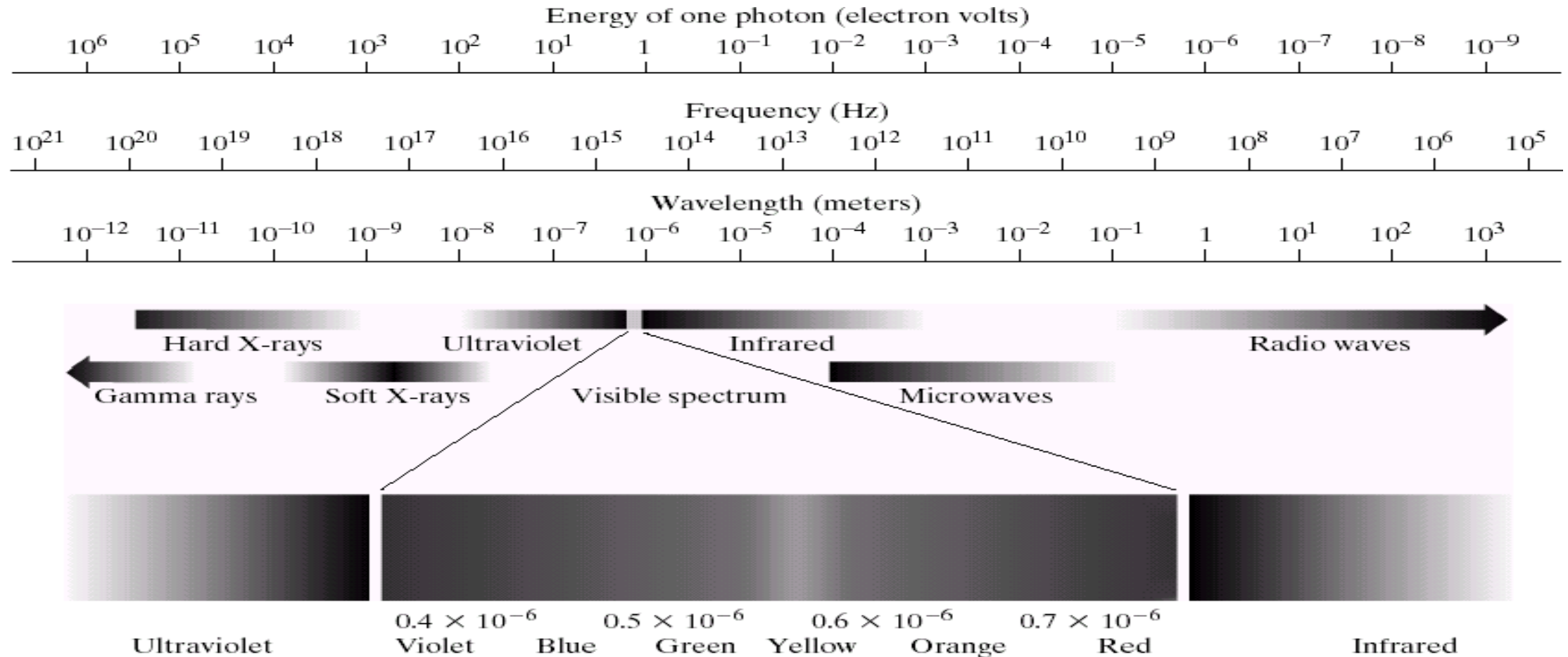


FIGURE 2.10 The electromagnetic spectrum. The visible spectrum is shown zoomed to facilitate explanation, but note that the visible spectrum is a rather narrow portion of the EM spectrum.

Visible Spectrum

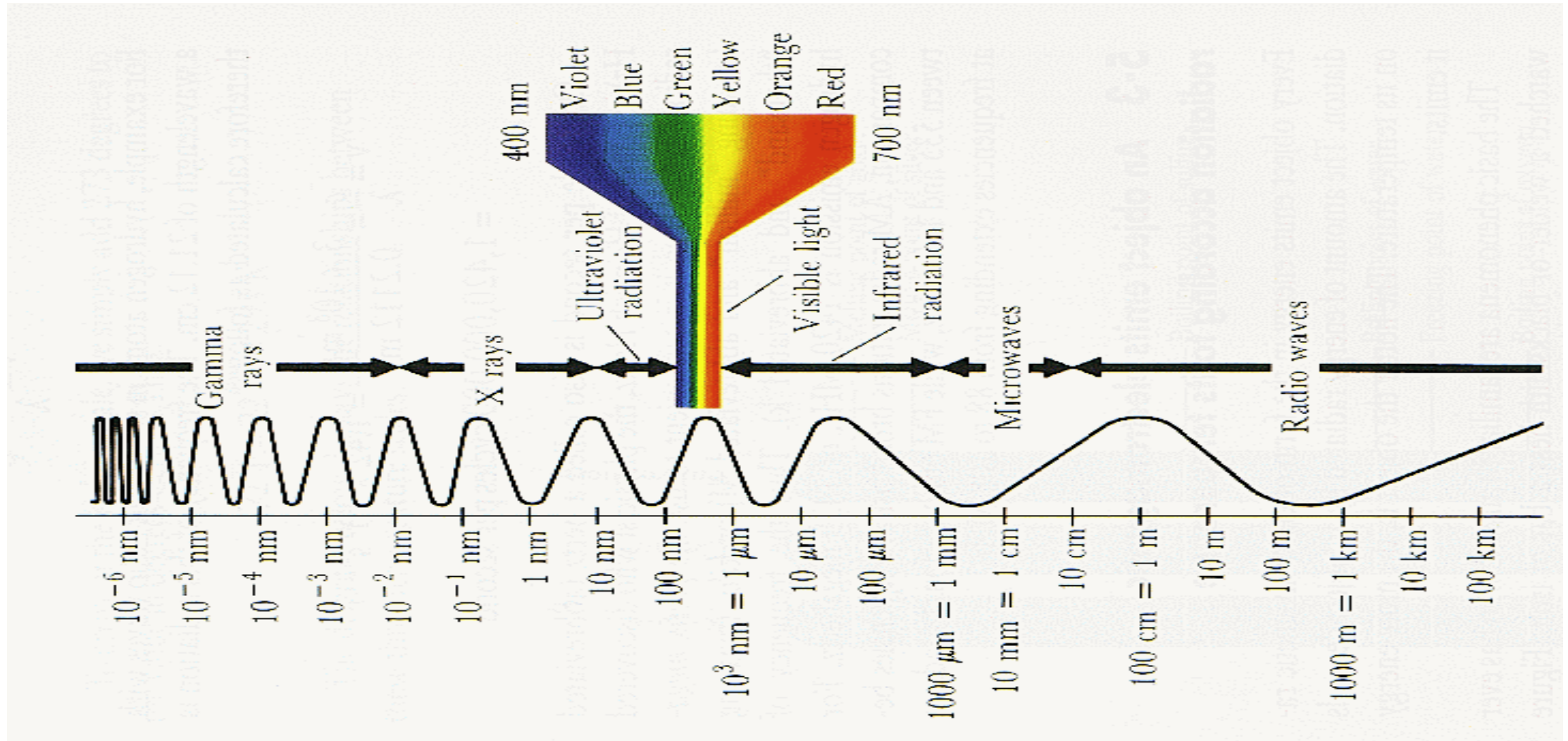




Image Processing in Images formed by EM waves of various wavelengths

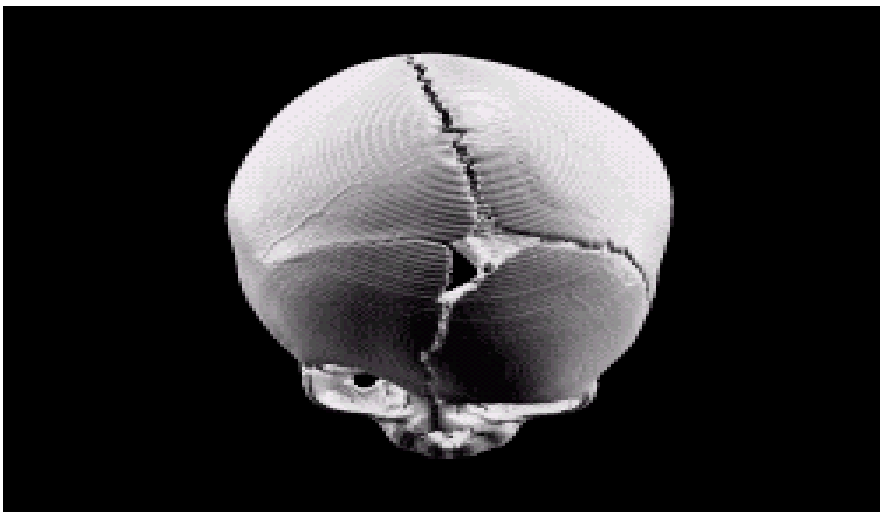
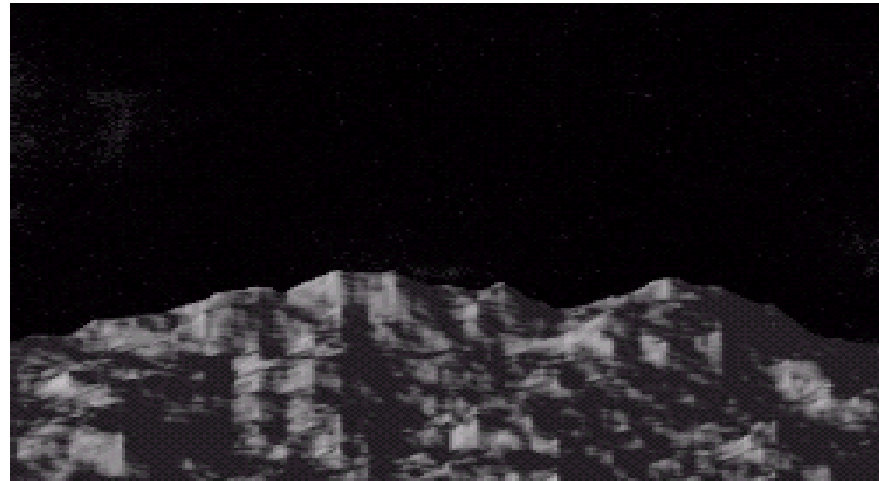
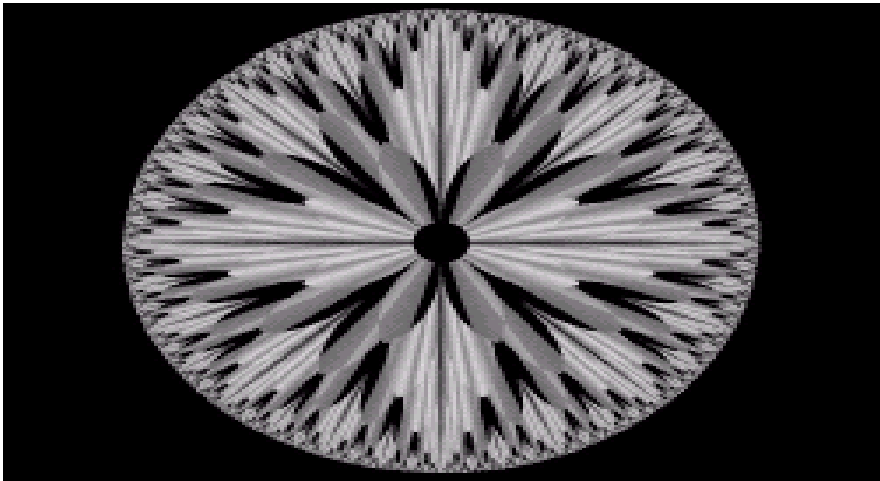
- 1. Gamma-Ray Imaging**
- 2. X-Ray Imaging**
- 3. Imaging in the Ultraviolet Band**
- 4. Imaging in the Visible and Infrared Bands**
- 5. Imaging in the Microwave Band**
- 6. Imaging in the Radio Band**
- 7. Examples in which other imaging modalities are used**



Current Image Processing Applications

- Autonomous Vehicles
- Medical Image Processing
- Scene Classification
- Remote Sensing
- Forensic Science
- Surveillance Systems
- And Many More.....

Synthetic Imaging

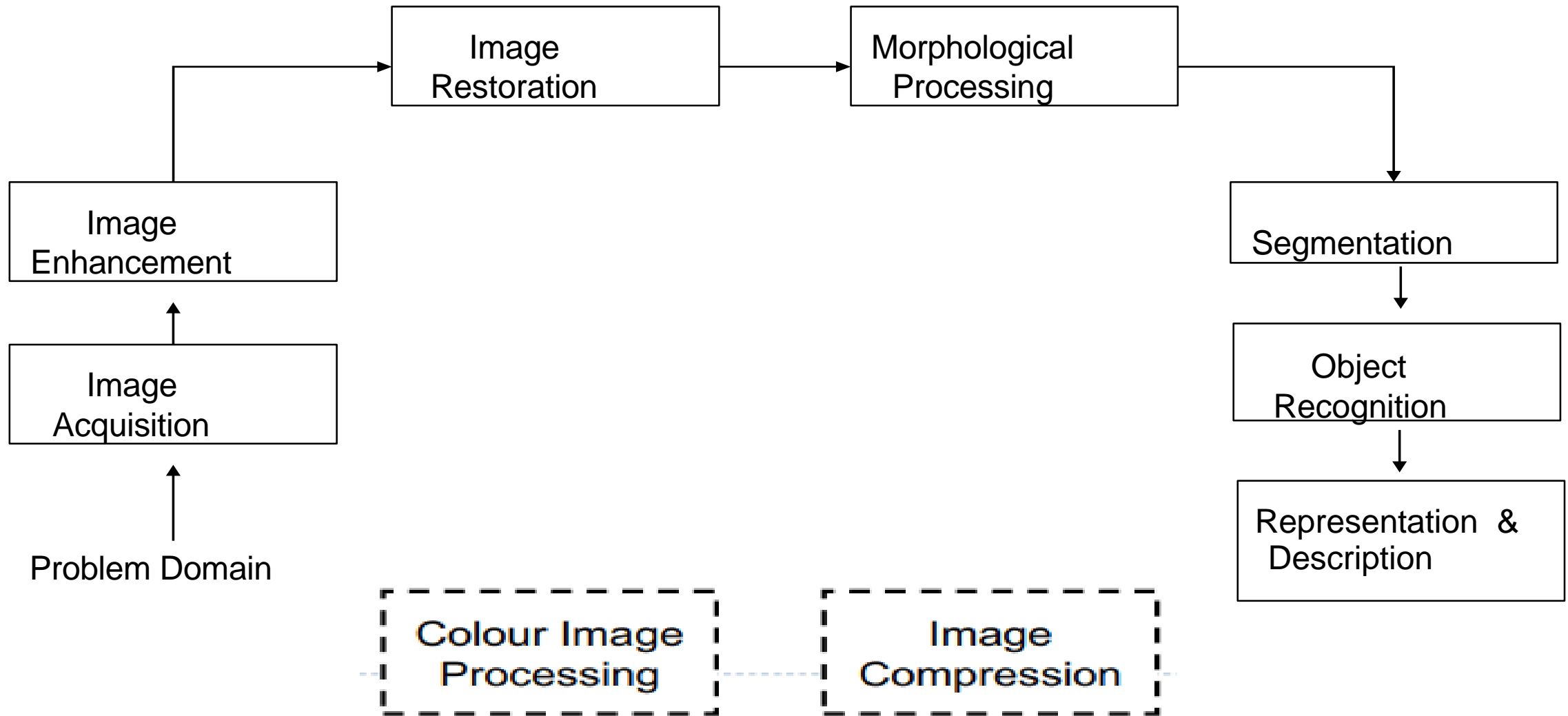


a	b
c	d

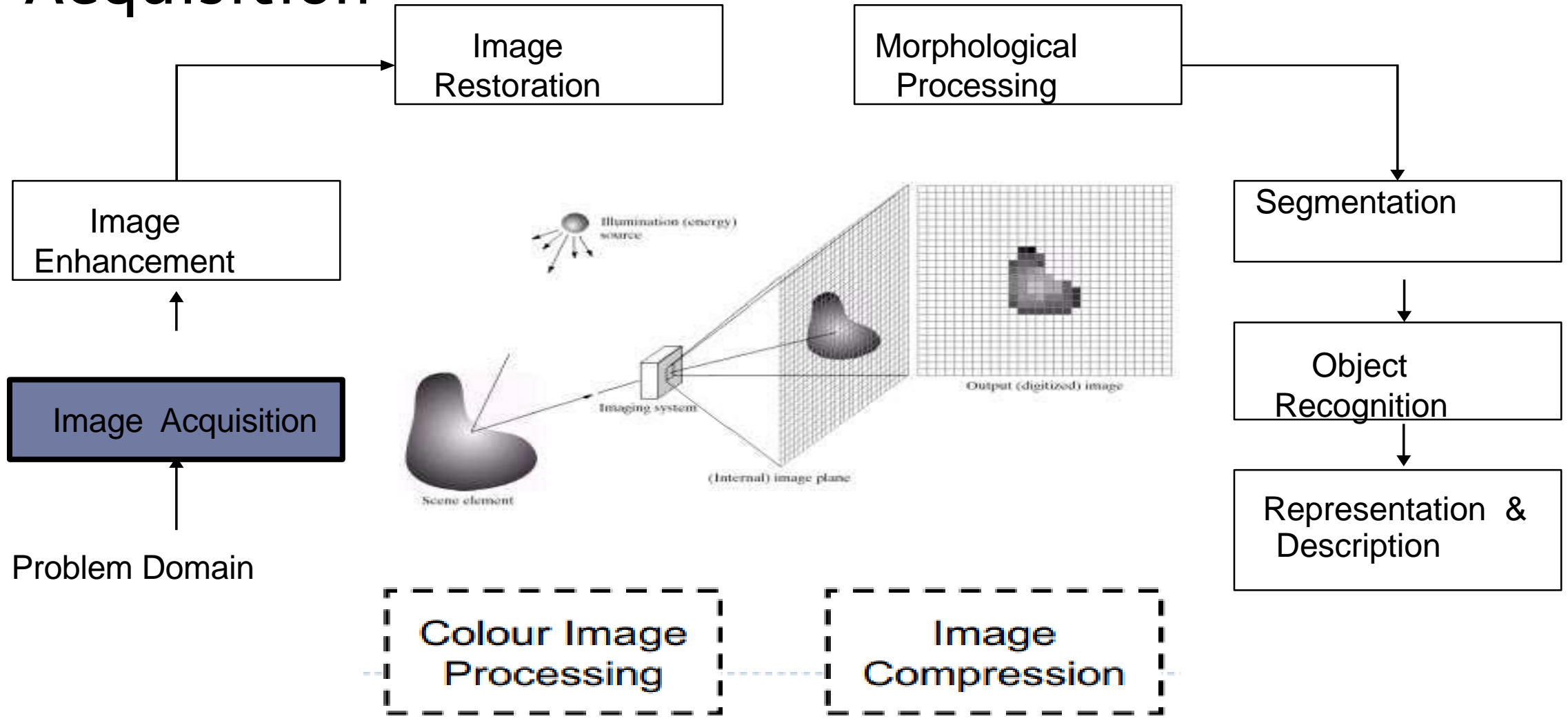
FIGURE 1.22
(a) and (b) Fractal images. (c) and (d) Images generated from 3-D computer models of the objects shown. (Figures (a) and (b) courtesy of Ms. Melissa D. Binde, Swarthmore College, (c) and (d) courtesy of NASA.)



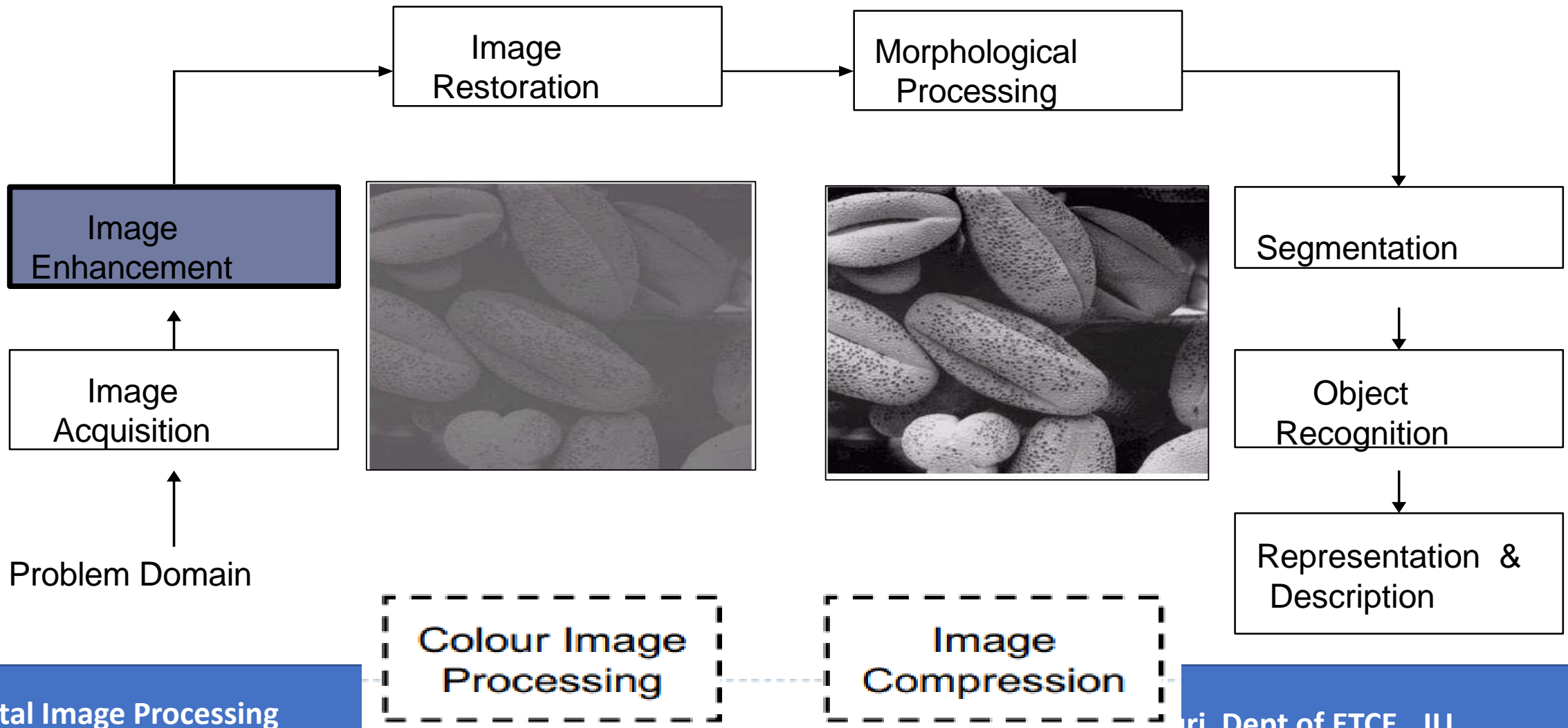
Key Stages in Digital Image Processing



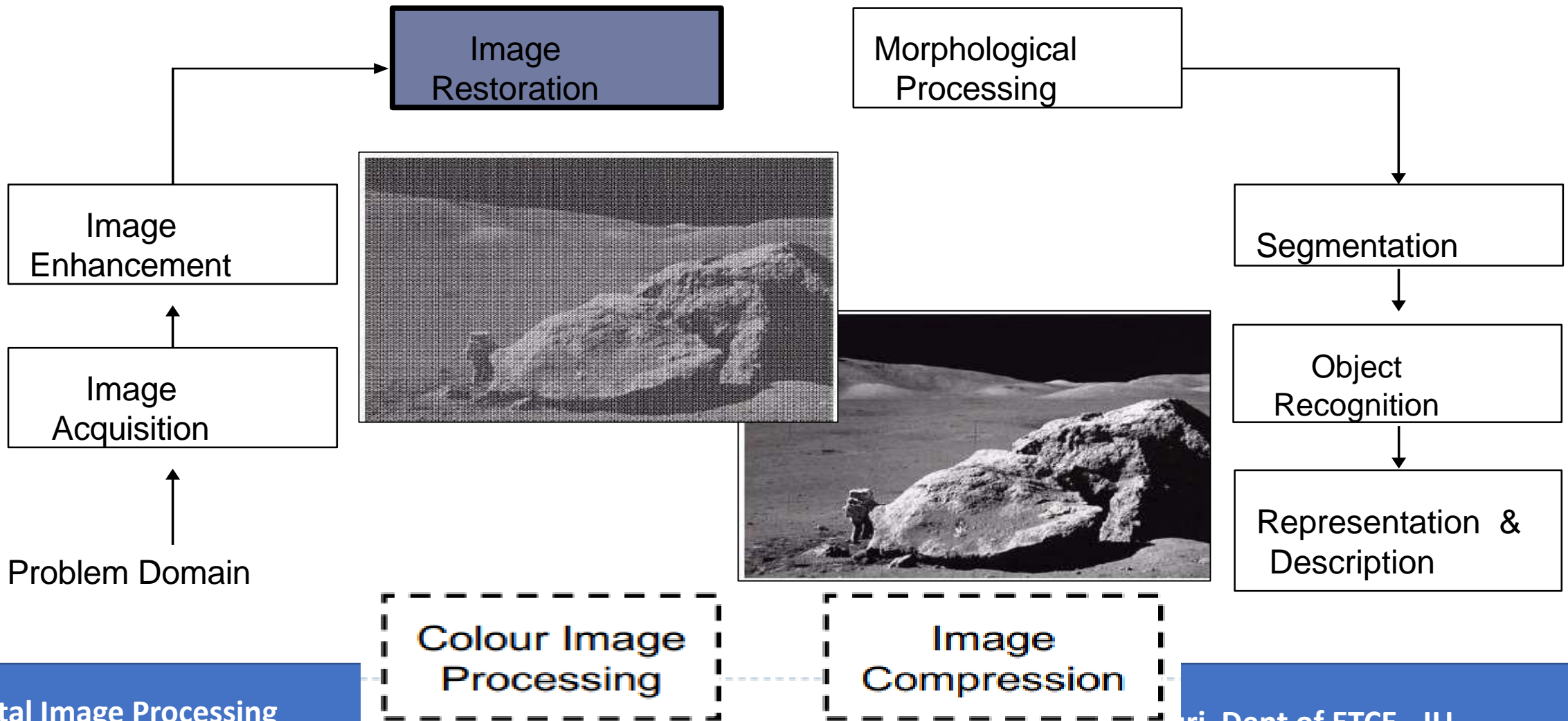
Key Stages in Digital Image Processing: Image Acquisition



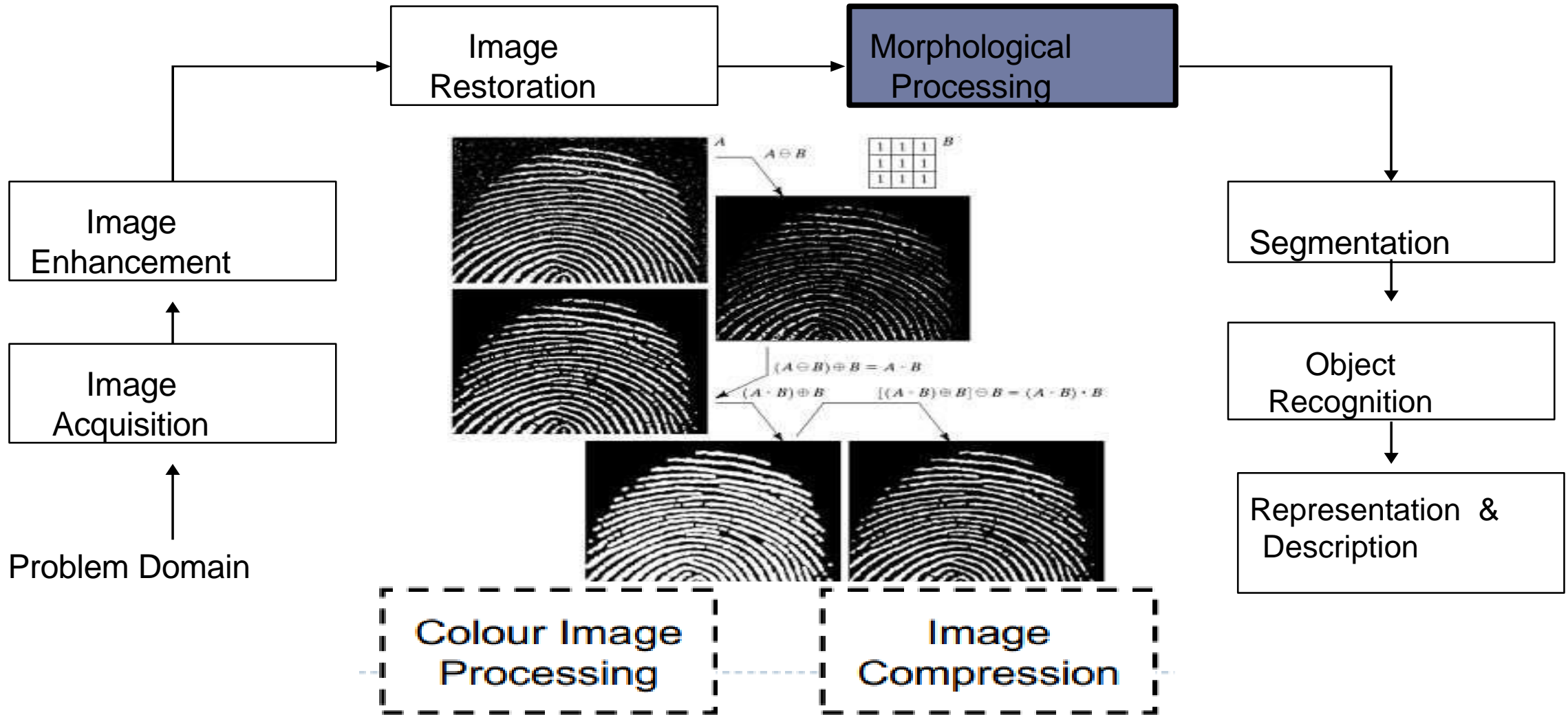
Key Stages in Digital Image Processing: Image Enhancement



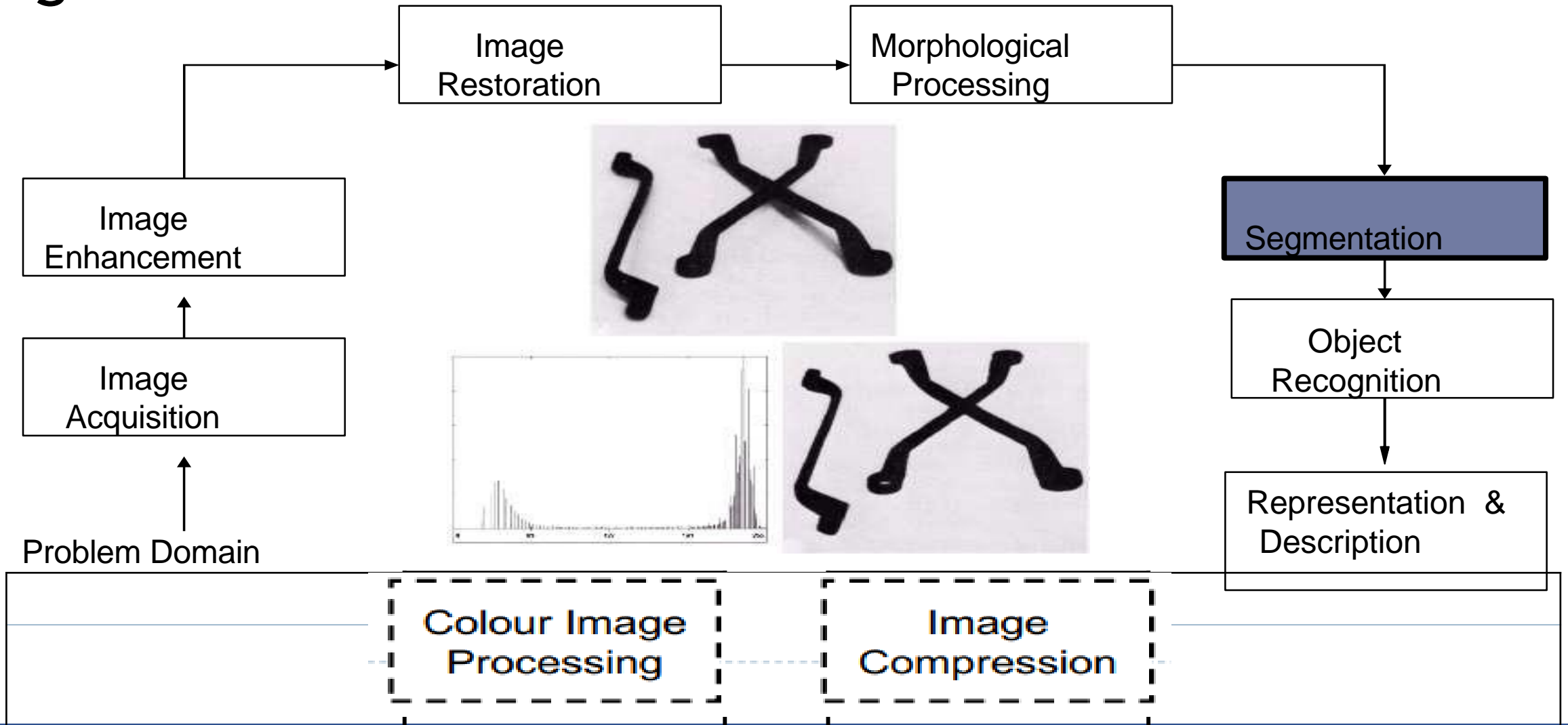
Key Stages in Digital Image Processing: Image Enhancement



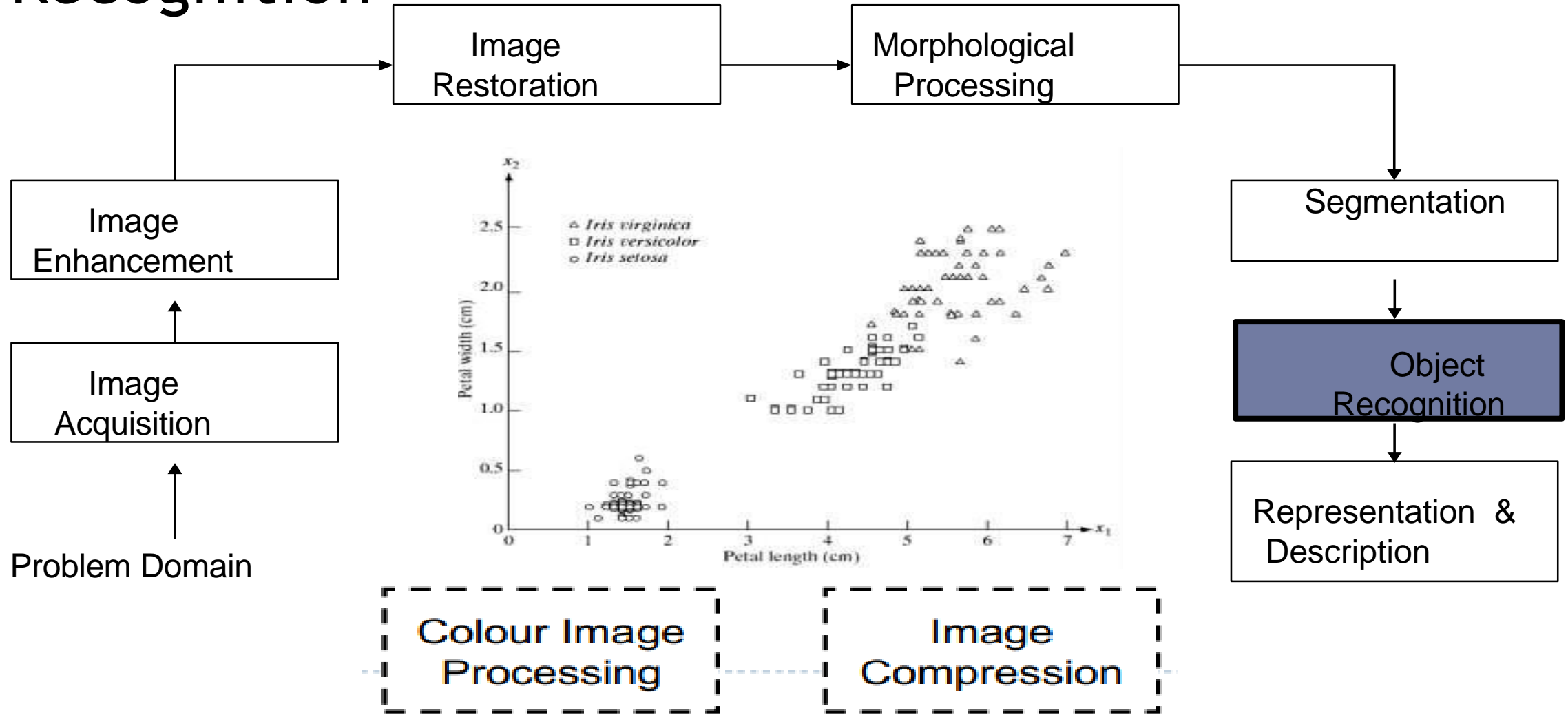
Key Stages in Digital Image Processing: Image Enhancement



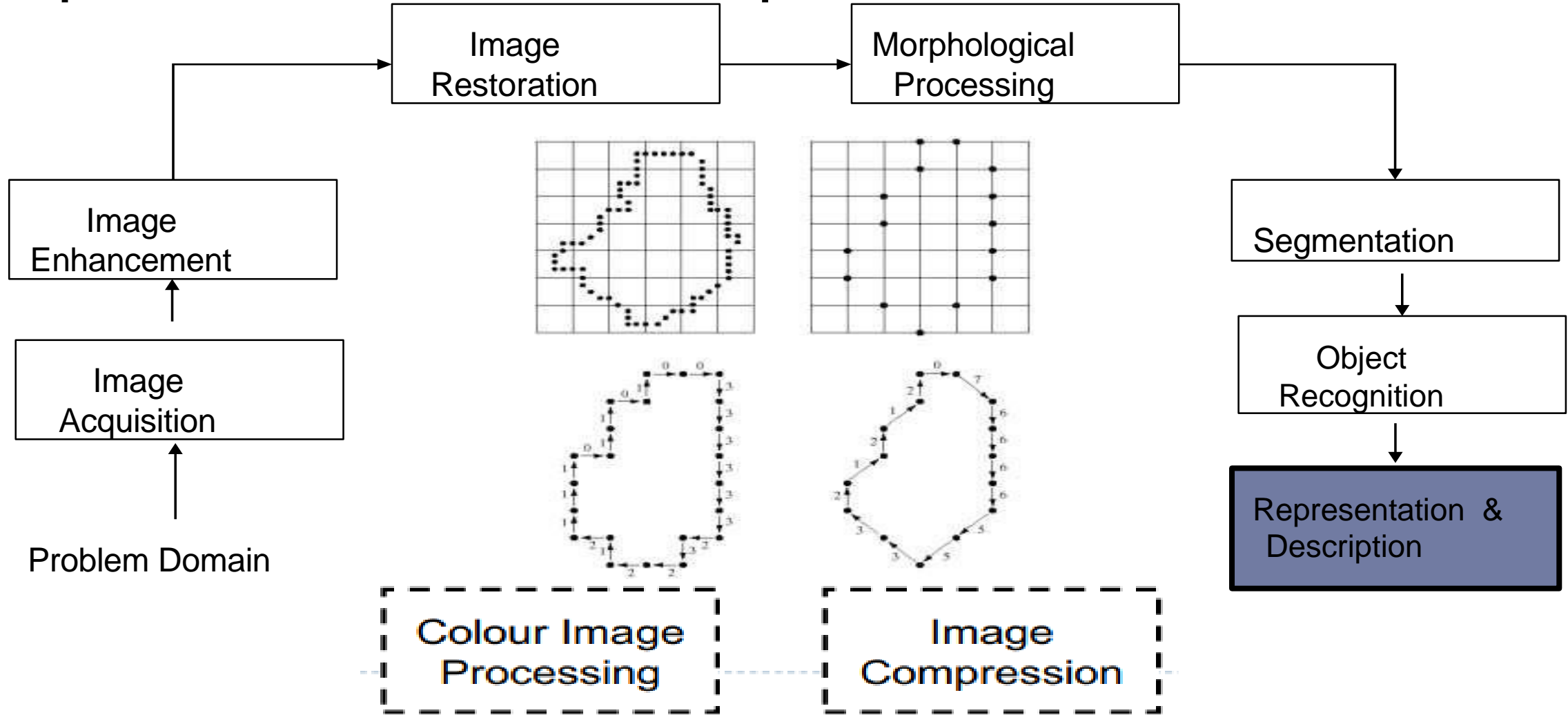
Key Stages in Digital Image Processing: Segmentation



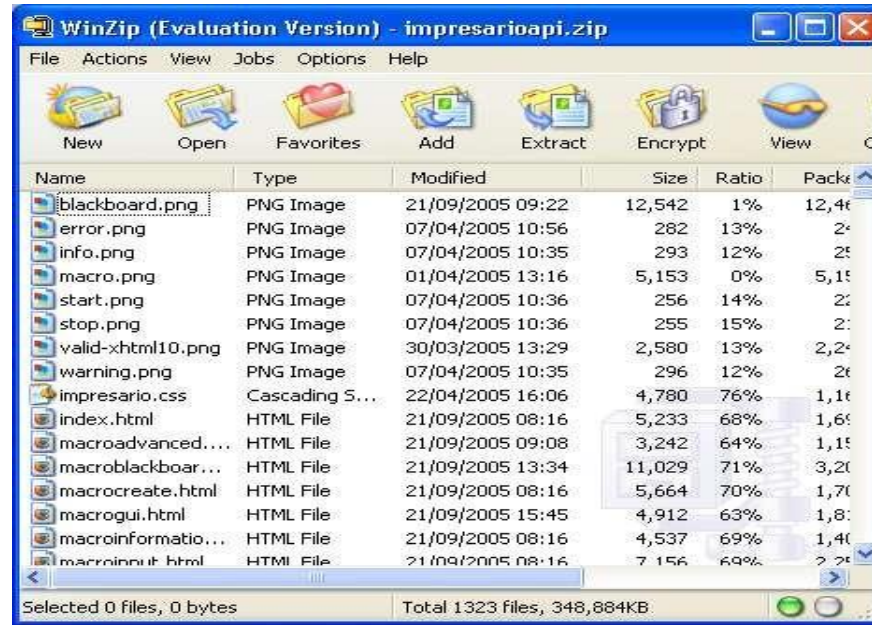
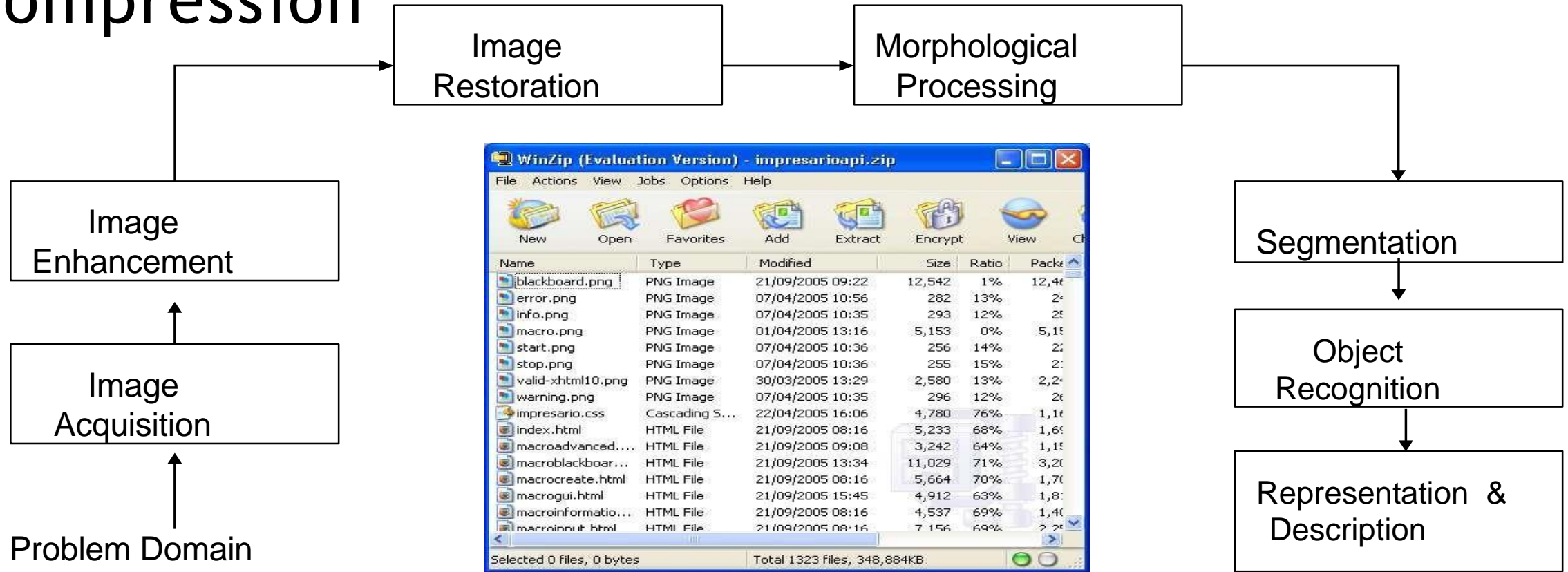
Key Stages in Digital Image Processing: Object Recognition



Key Stages in Digital Image Processing: Representation & Description



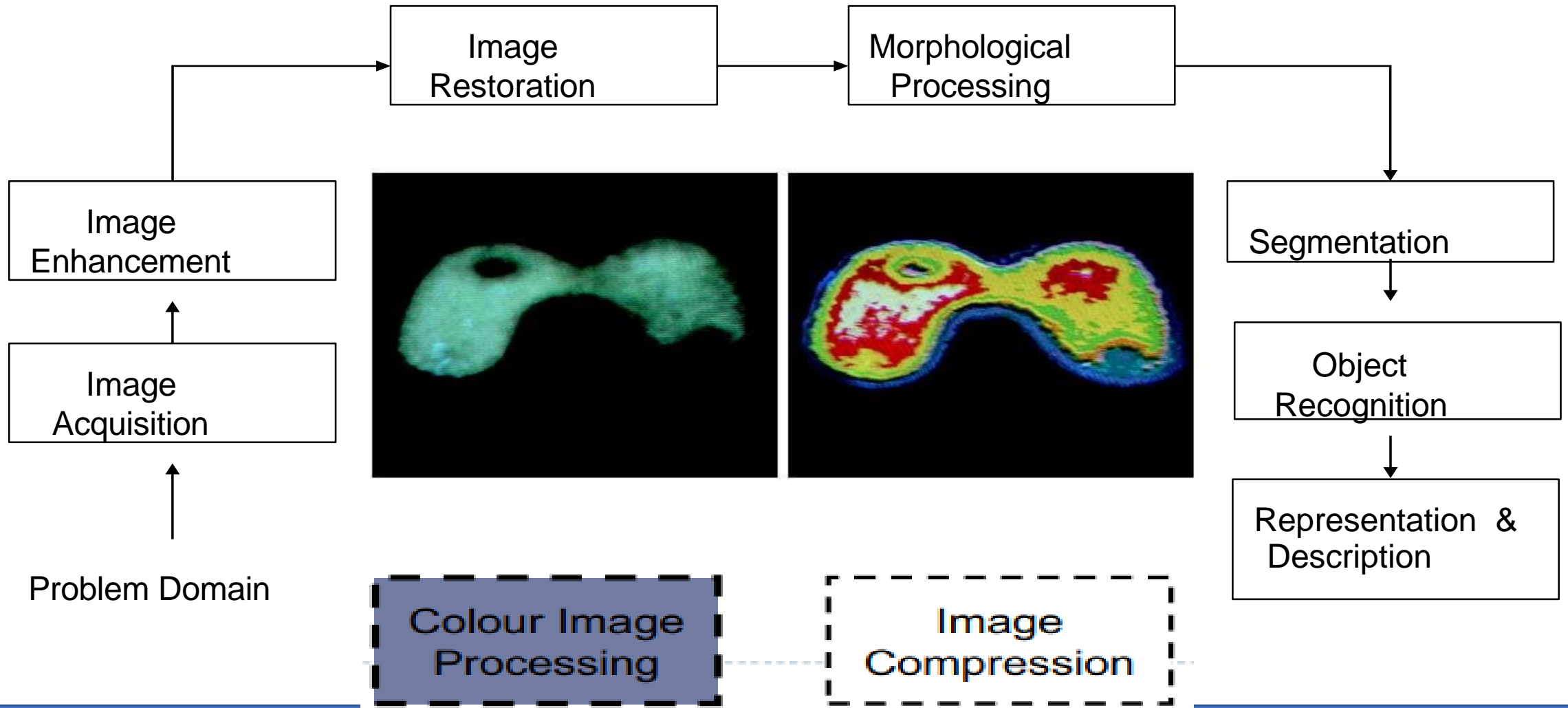
Key Stages in Digital Image Processing: Image Compression



Colour Image Processing

Image Compression

Key Stages in Digital Image Processing: Colour Image Processing



End of Lecture 1

