

Introduction to Image Processing

Ch 1. Introduction

Kuan-Wen Chen

What is Digital Image?

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

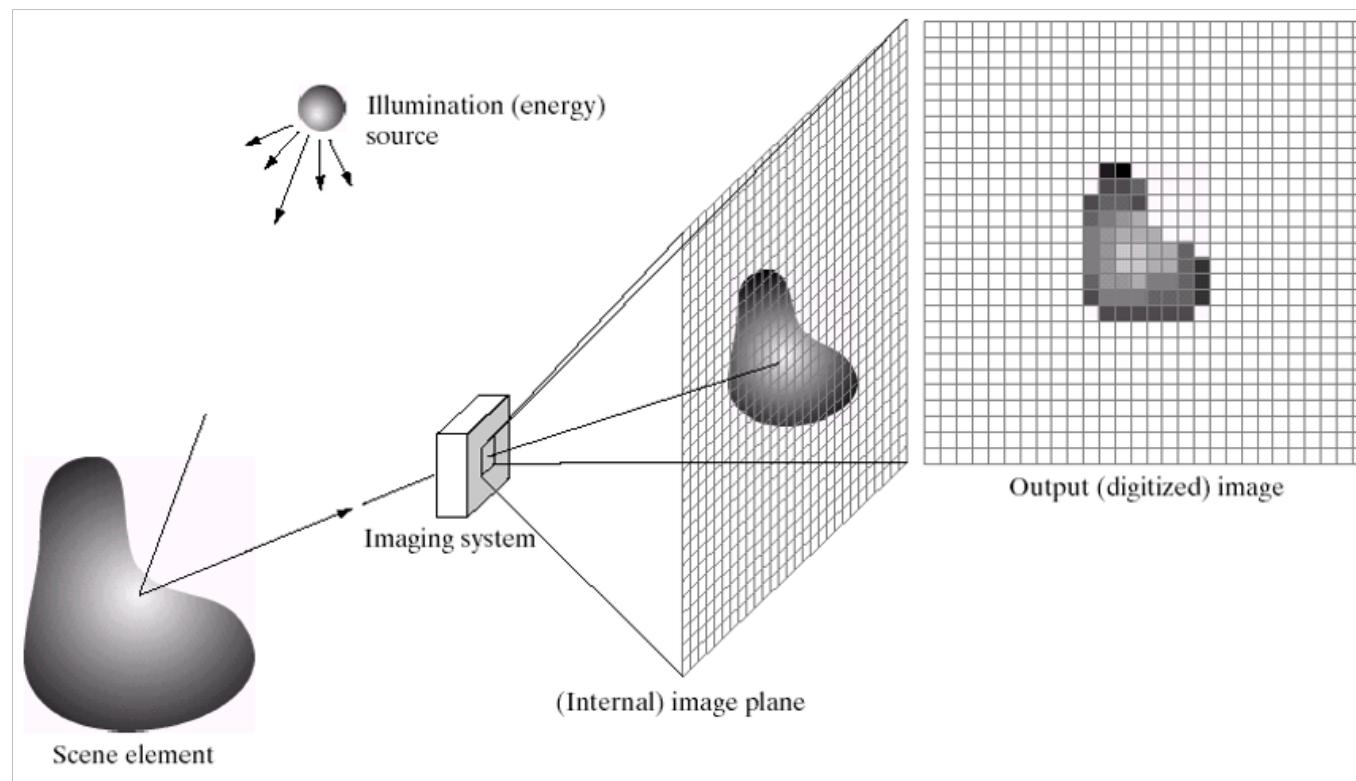
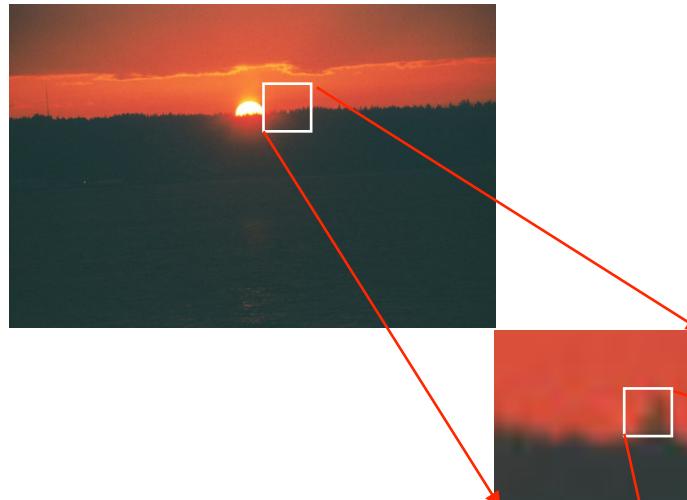


Image Format

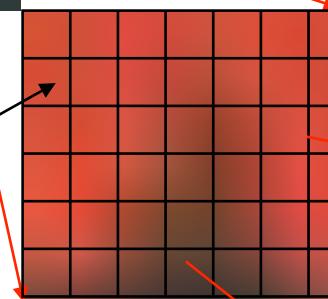


Pixel: 像素

Each component in the image called pixel associates with the pixel value (a single number in the case of intensity images or a vector in the case of color images).

Digital image = a multidimensional array of numbers (such as intensity image) or vectors (such as color image)

- **grayscale image = intensity image:** 灰阶影像
- **color image:** 彩色影像



10	10	16	281
9	65	70	56
15	32	99	70
32	21	56	781

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9	65	70	56
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10	10	16	281
9	65	70	56
15	32	99	70
32	21	56	781

What is Digital Image Processing?

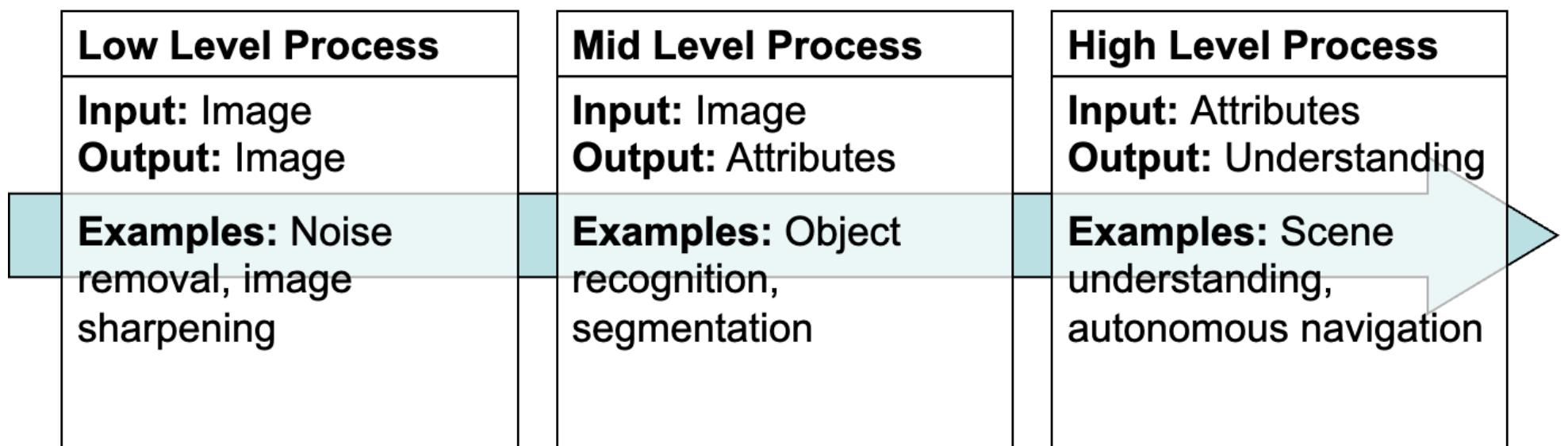
Digital image processing focuses on two major tasks

- Improvement of pictorial information **for human interpretation**
- Processing of image data **for tasks** such as storage, transmission, and extraction of pictorial information

What is Digital Image Processing?

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

Low Level Process	Mid Level Process	High Level Process
Input: Image Output: Image	Input: Image Output: Attributes	Input: Attributes Output: Understanding
Examples: Noise removal, image sharpening	Examples: Object recognition, segmentation	Examples: Scene understanding, autonomous navigation



The Origins of Digital Image Processing

Early 1920s: One of the first applications of digital imaging was in the newspaper industry

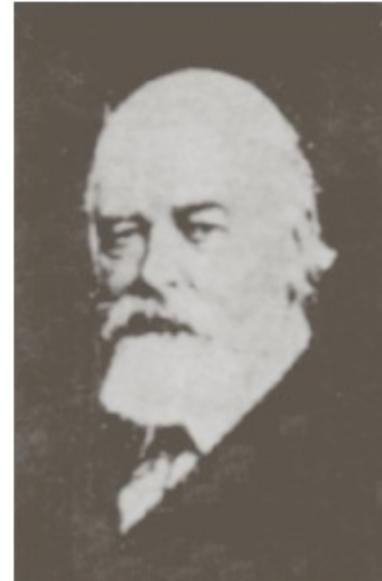
- The Bartlane cable picture transmission service
- Images were transferred by submarine cable between London and New York
- Pictures were coded for cable transfer and reconstructed at the receiving end on a telegraph printer



The Origins of Digital Image Processing

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
(5 distinct levels of gray)



Early 15 tone digital image

The Origins of Digital Image Processing

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

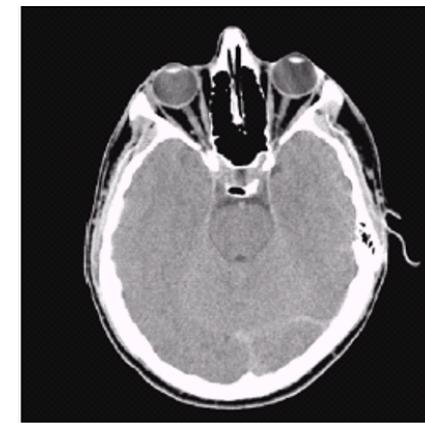


A picture of the moon taken by the Ranger 7 probe minutes before landing

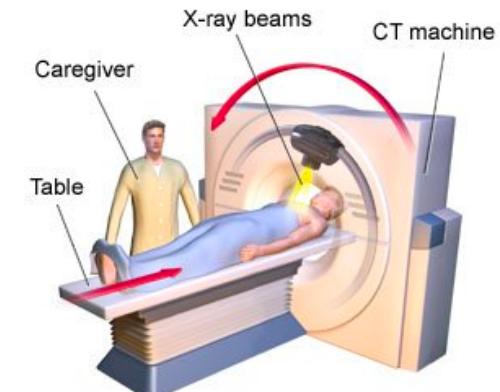
The Origins of Digital Image Processing

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



Computerized Axial Tomography Scan

電腦斷層掃描 (Computed Tomography, 簡稱CT) 又稱電腦斷層攝影，是一種影像診斷學的檢查。這一技術曾被稱為**電腦軸向斷層掃描** (Computed Axial Tomography)

credit of photo: <https://www.drugs.com/cg/pelvic-and-abdominal-computerized-axial-tomography.html>

credit of this slide: C. Nikou

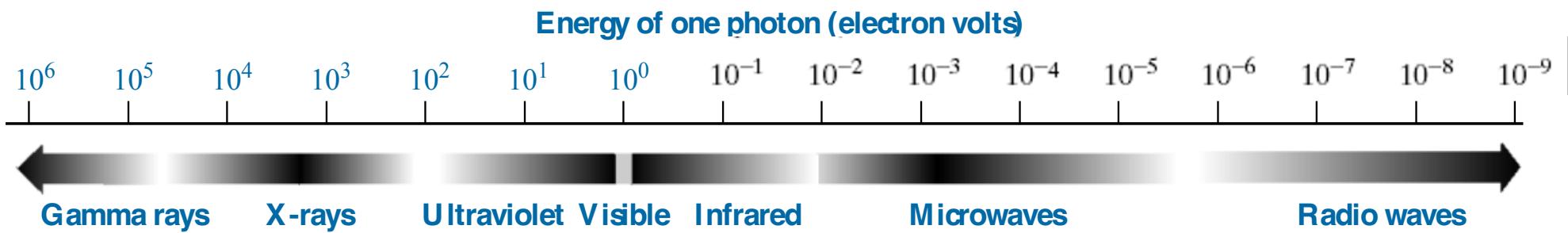
The Origins of Digital Image Processing

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

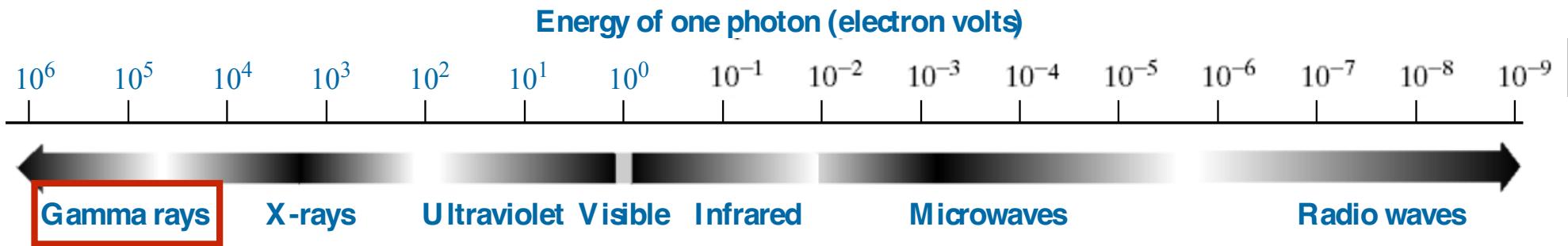
- Image enhancement/restoration
- Artistic effects
- Medical visualisation
- Industrial inspection
- Law enforcement
- Human computer interfaces

Examples of Digital Image Processing

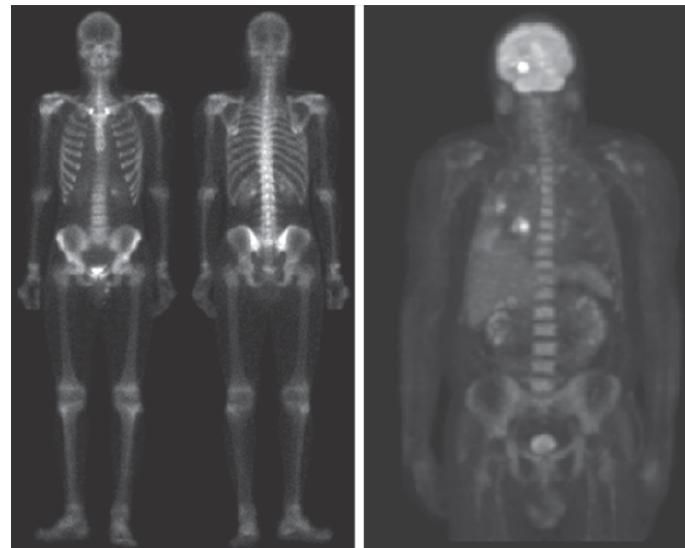
Imaging machines cover almost the entire
EM spectrum (電磁波譜)



Examples of Digital Image Processing



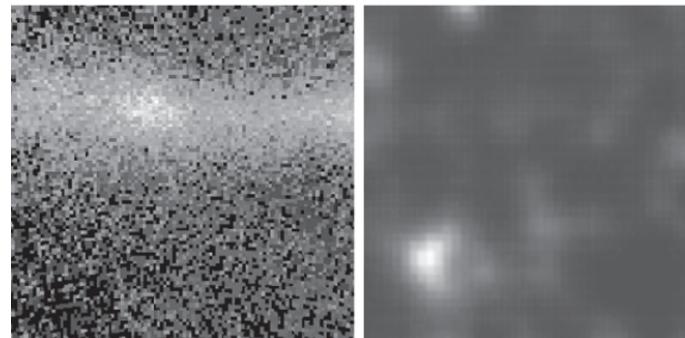
骨骼掃描 (Bone Scan)



正子斷層造影(Positron Emission Tomography)

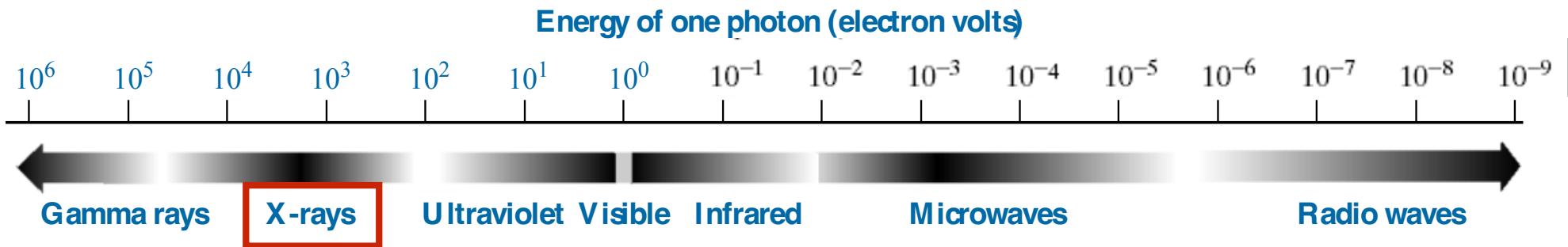


天鵝座環狀星雲

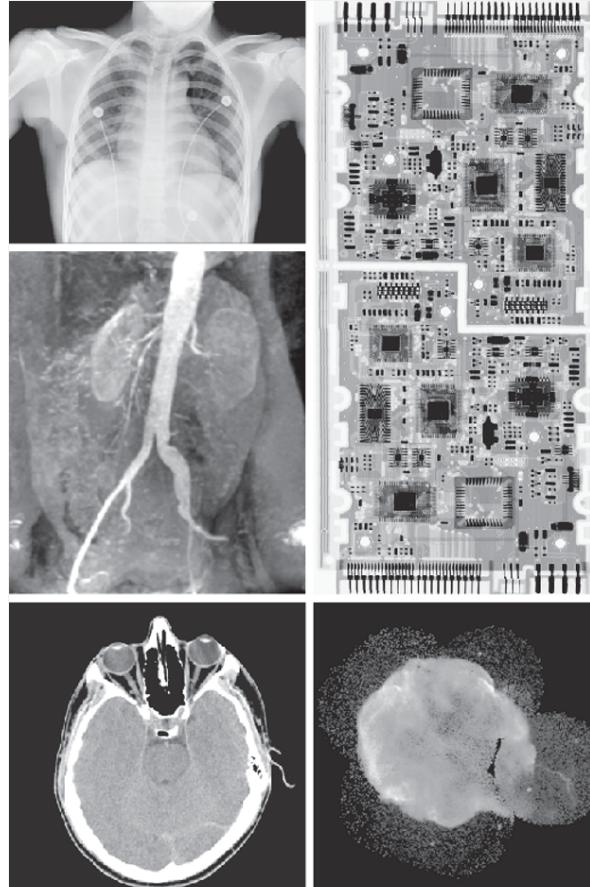


Gamma radiation

Examples of Digital Image Processing

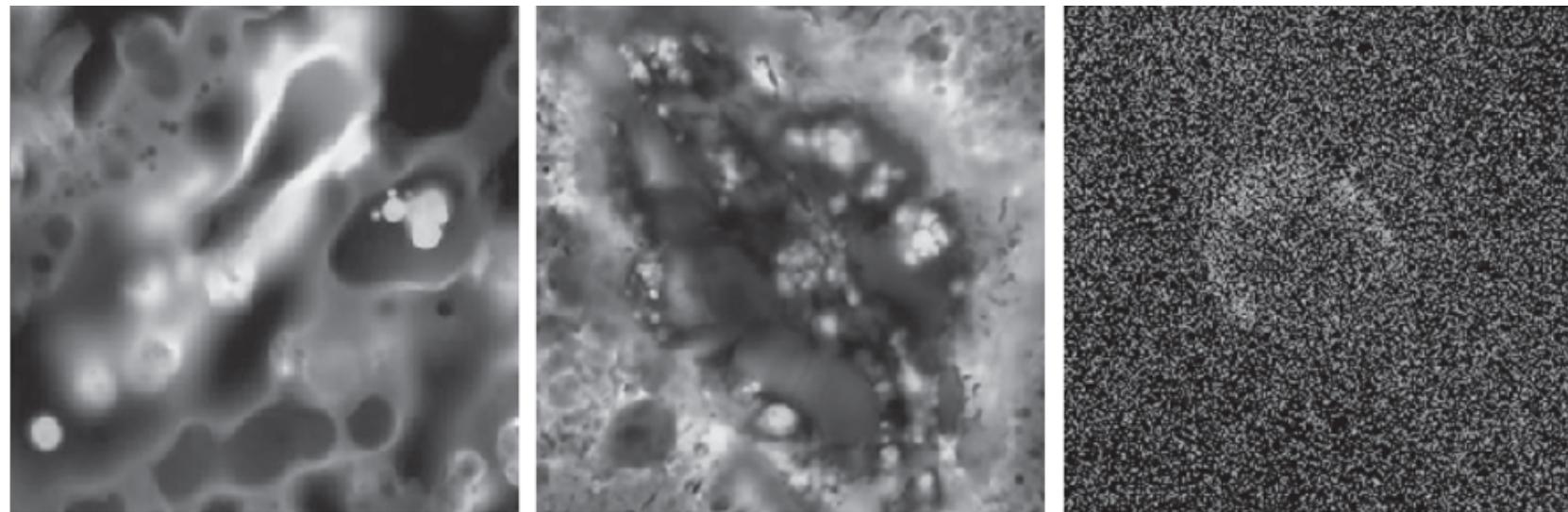
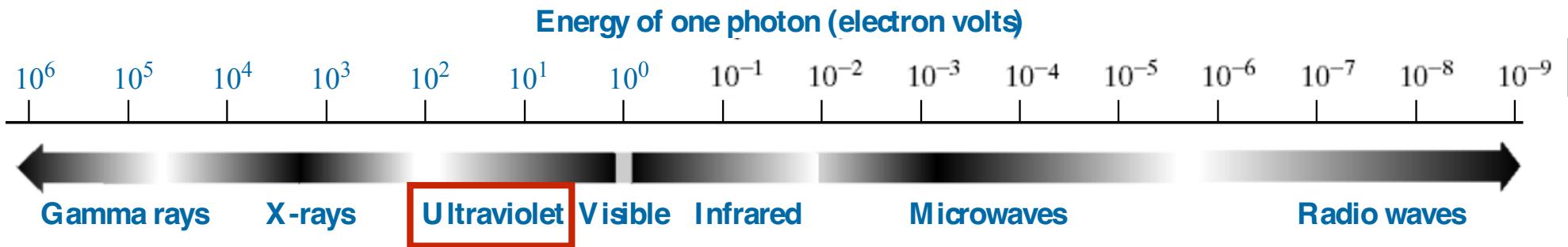


血管造影術



天鵝座環狀星雲

Examples of Digital Image Processing

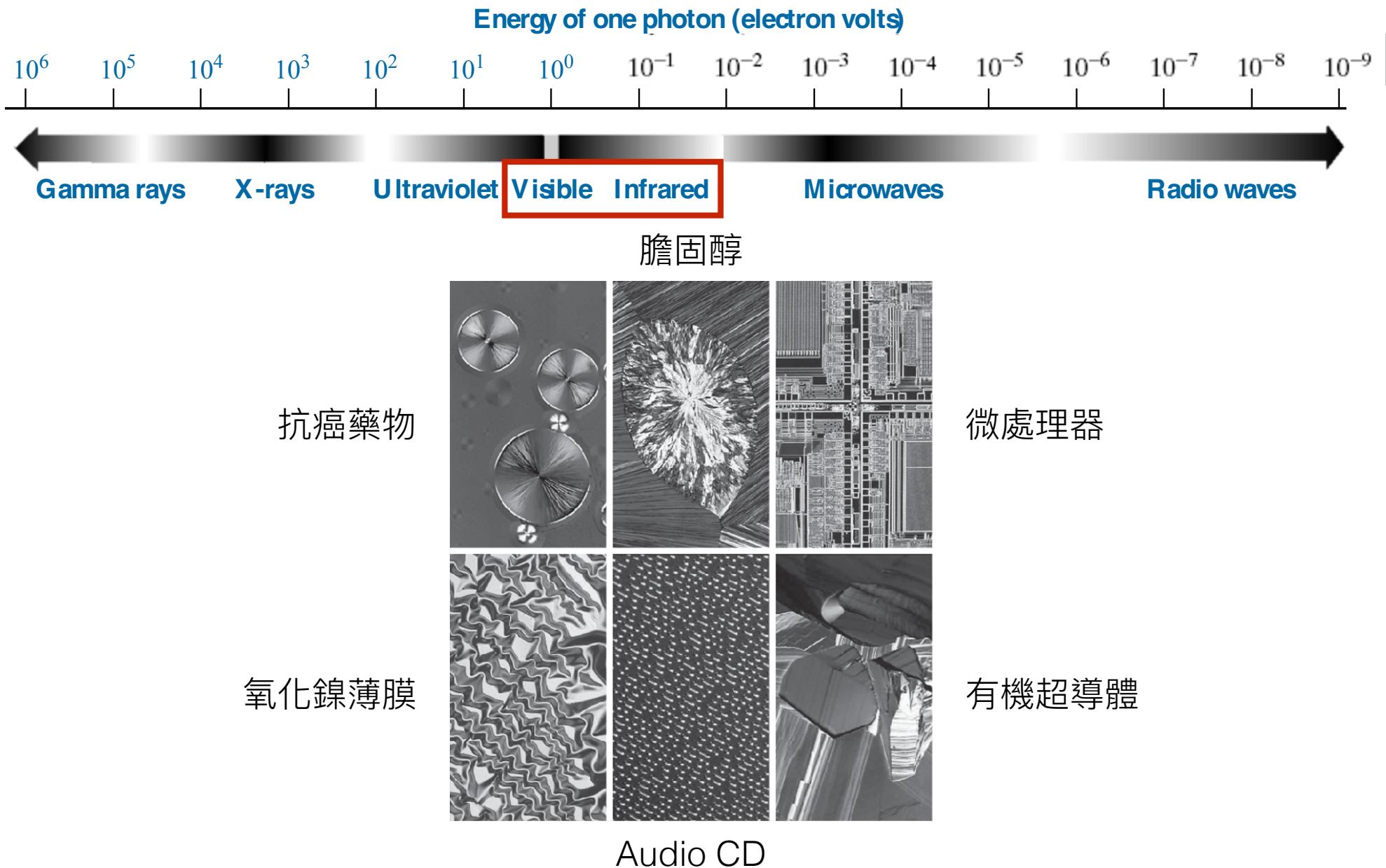


螢光顯微技術
— 正常玉米

螢光顯微技術
— 染病玉米

天鵝座環狀星雲

Examples of Digital Image Processing



Examples of Digital Image Processing

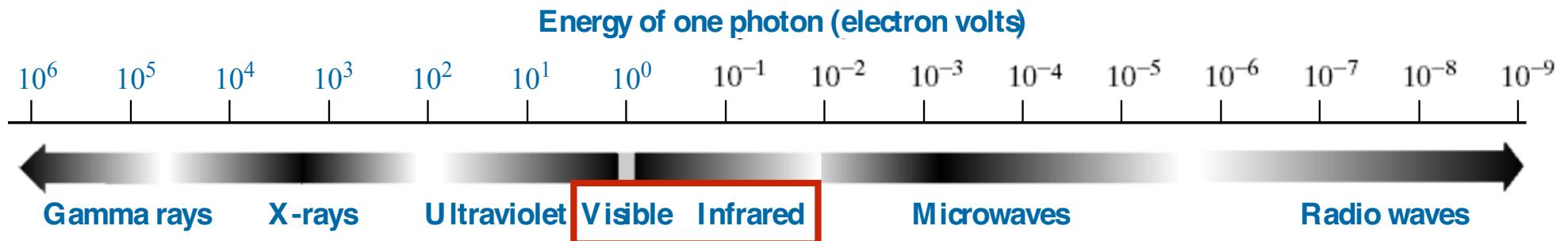


TABLE 1.1
Thematic bands
of NASA's
LANDSAT
satellite.

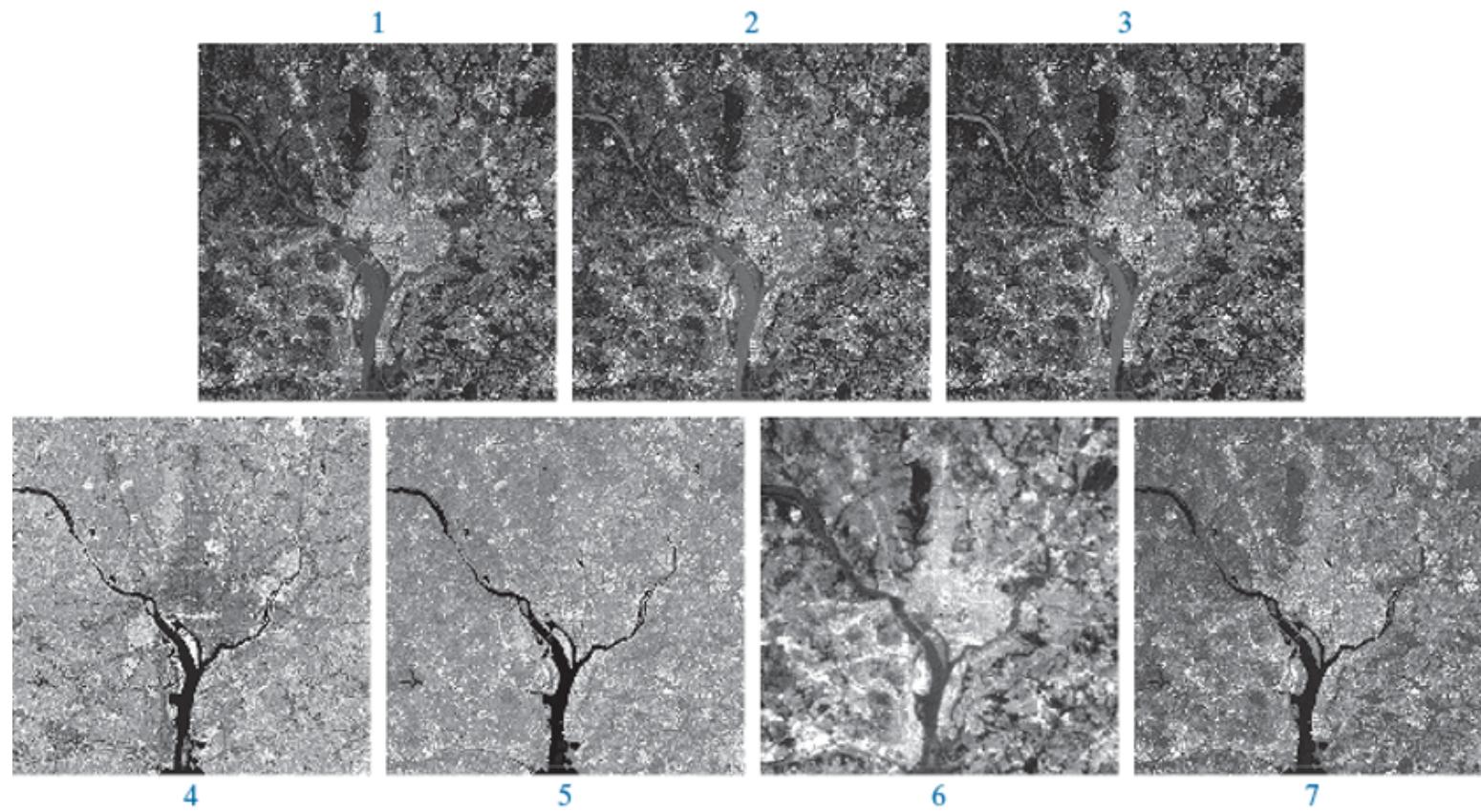
Band No.	Name	Wavelength (μm)	Characteristics and Uses
1	Visible blue	0.45–0.52	Maximum water penetration
2	Visible green	0.53–0.61	Measures plant vigor
3	Visible red	0.63–0.69	Vegetation discrimination
4	Near infrared	0.78–0.90	Biomass and shoreline mapping
5	Middle infrared	1.55–1.75	Moisture content: soil/vegetation
6	Thermal infrared	10.4–12.5	Soil moisture; thermal mapping
7	Short-wave infrared	2.09–2.35	Mineral mapping

Examples of Digital Image Processing

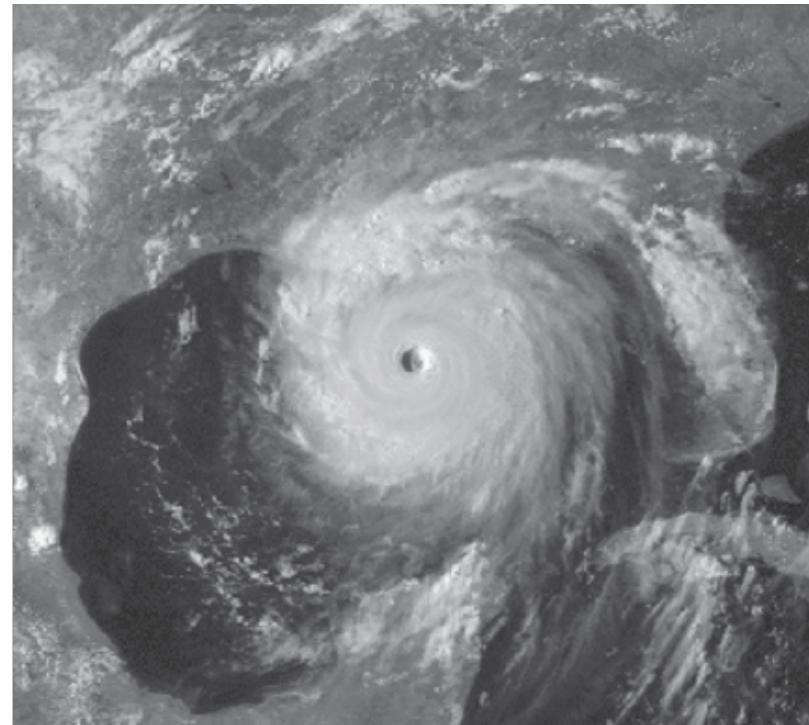
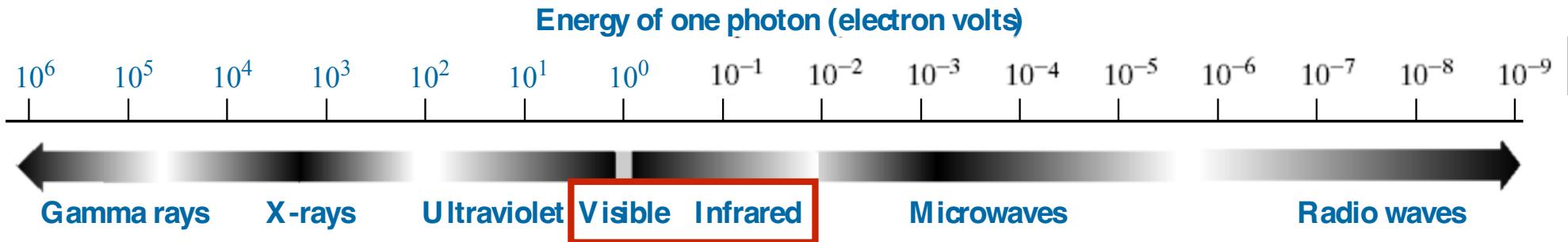
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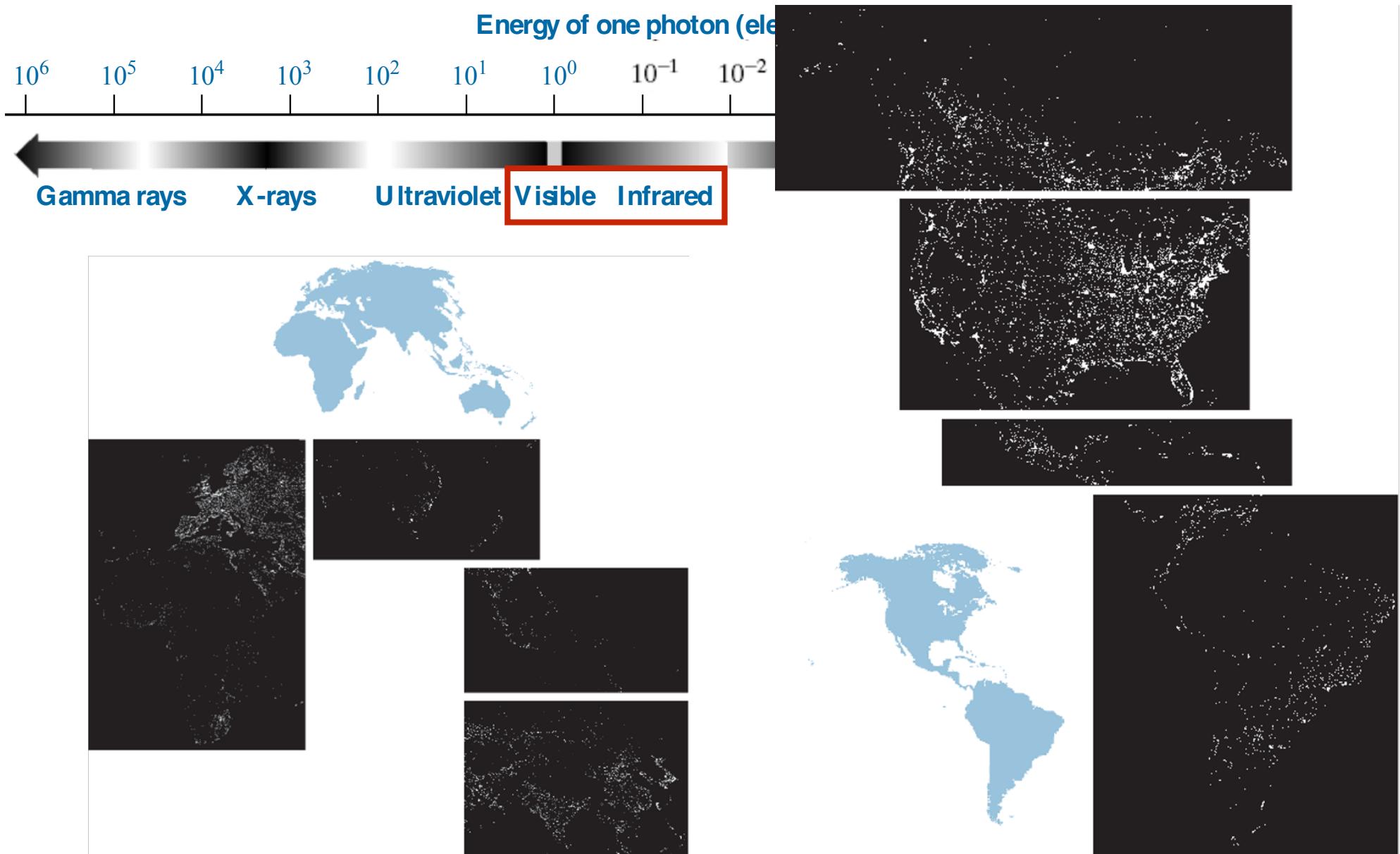
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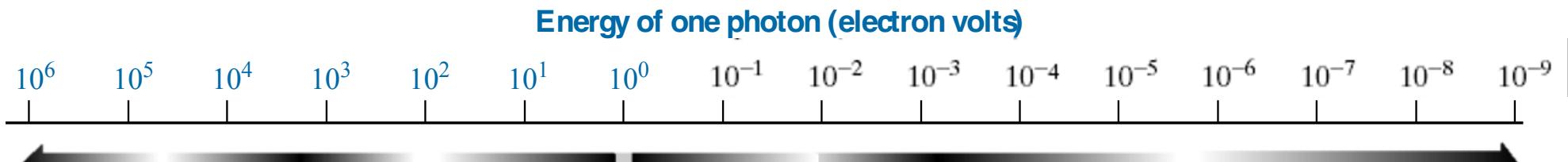
Examples of Digital Image Processing



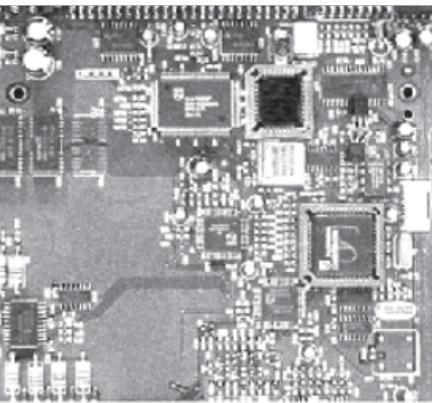
Examples of Digital Image Processing



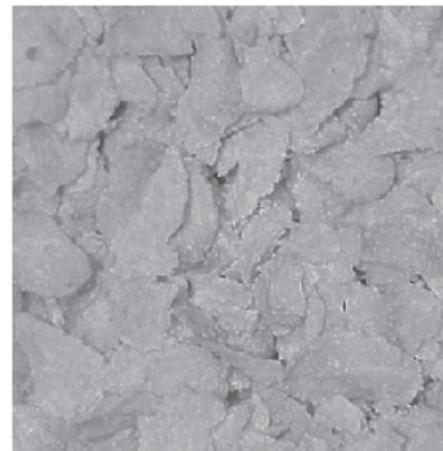
Examples of Digital Image Processing



Gamma rays



X-rays



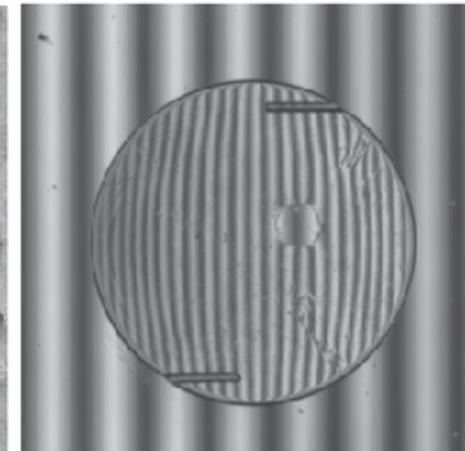
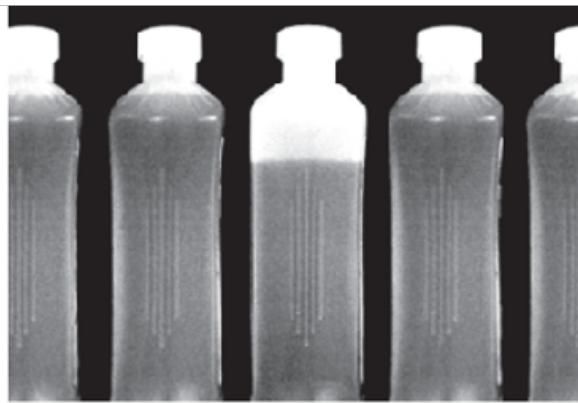
Ultraviolet

Visible

Infrared

Microwaves

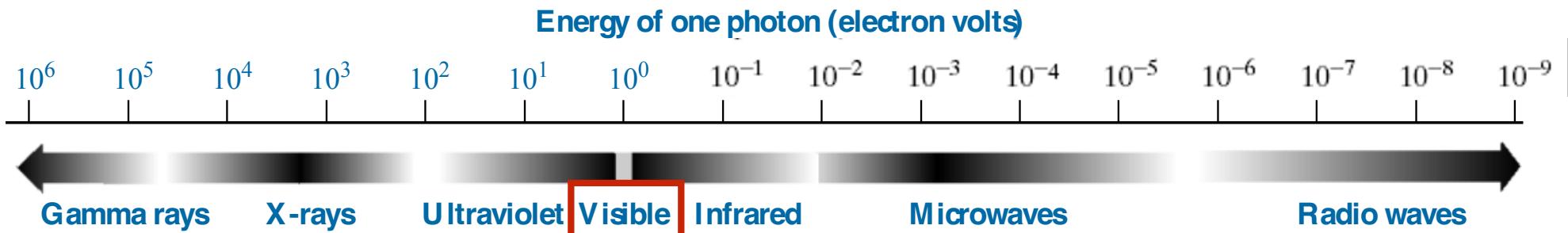
Radio waves



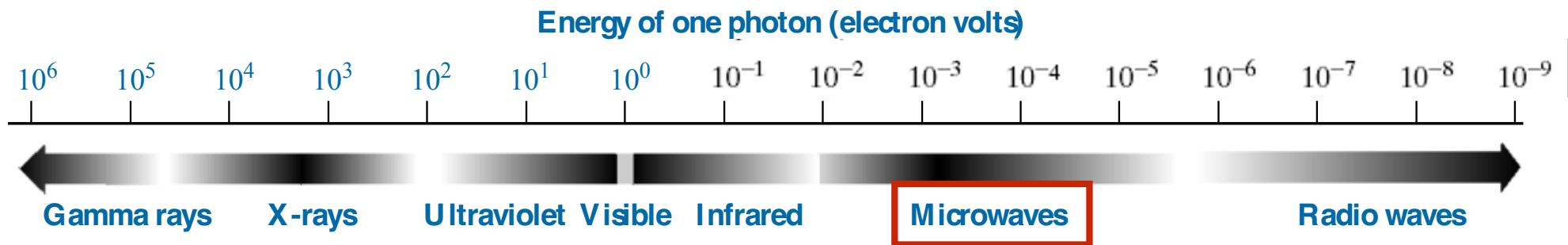
穀物

人工水晶體

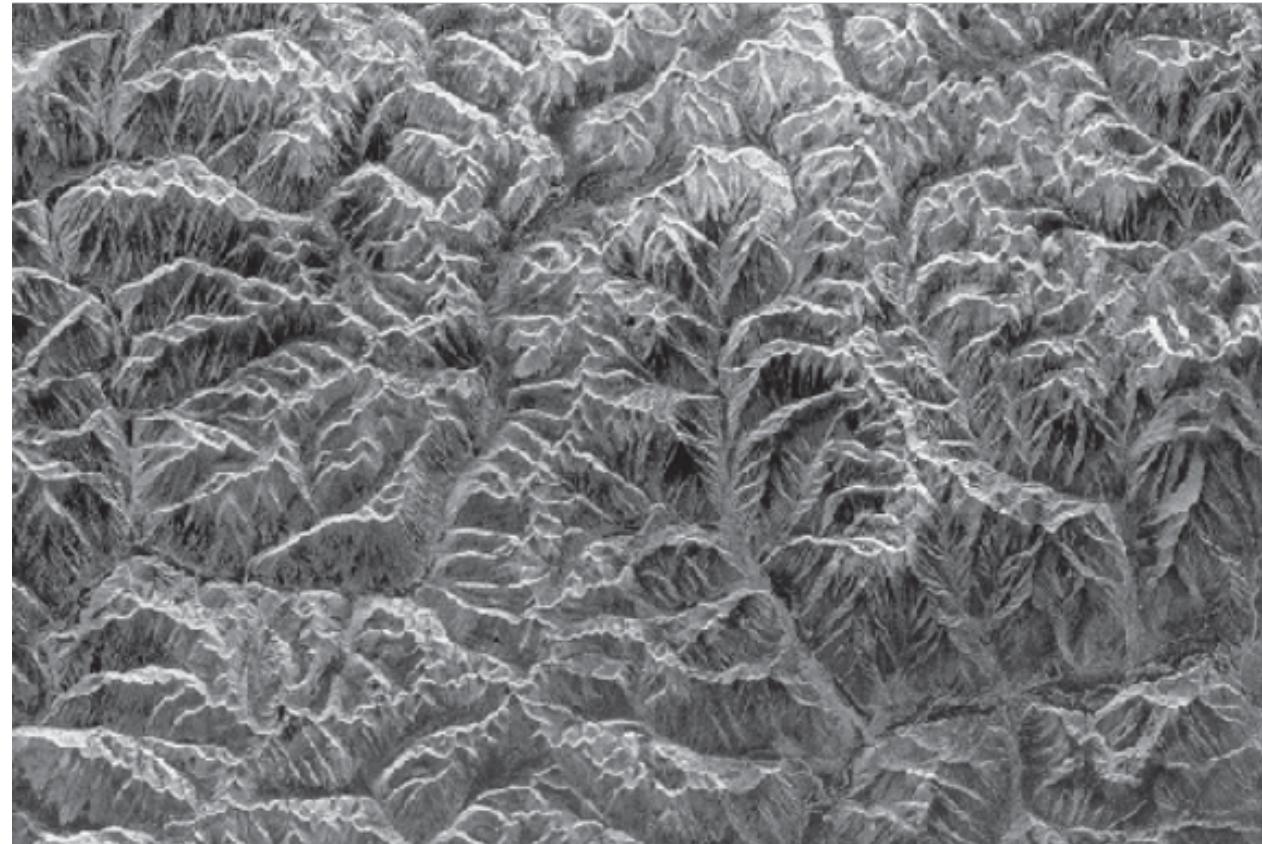
Examples of Digital Image Processing



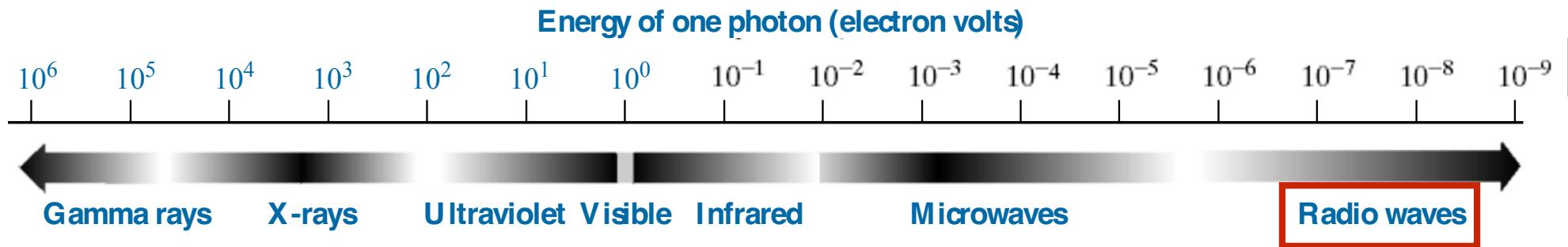
Examples of Digital Image Processing



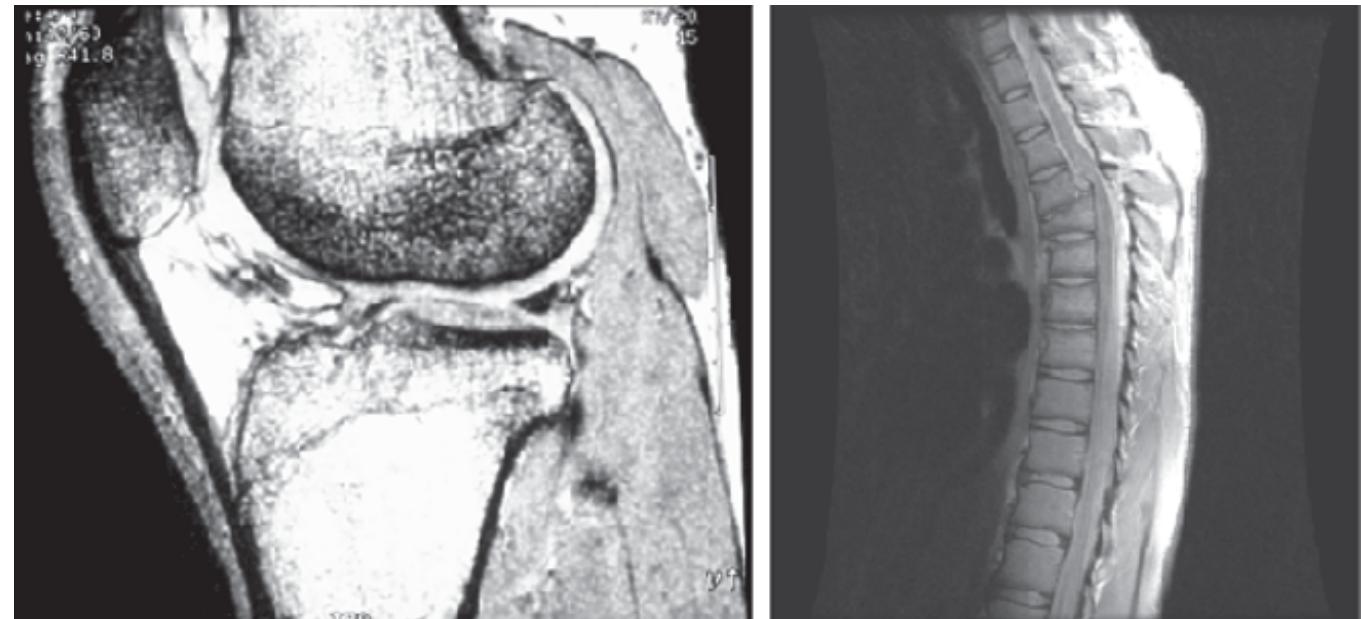
微波雷達影像



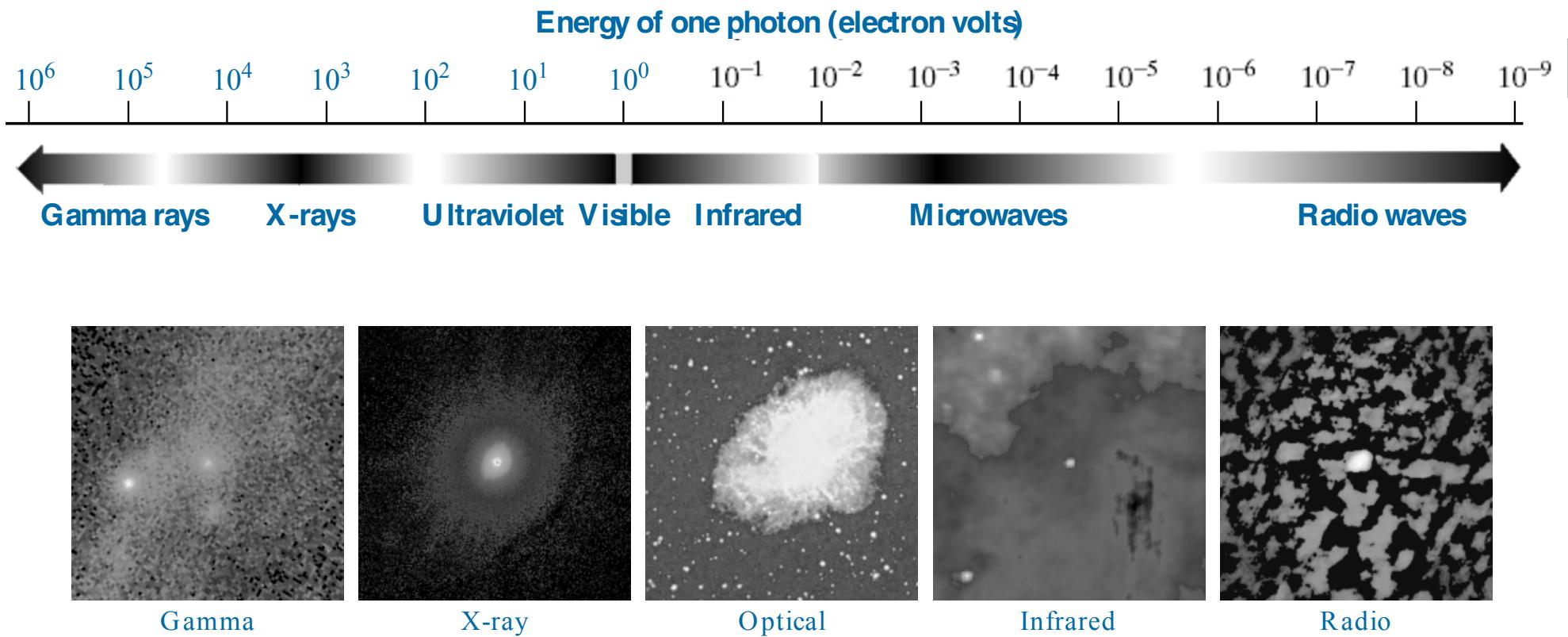
Examples of Digital Image Processing



MRI 磁振造影



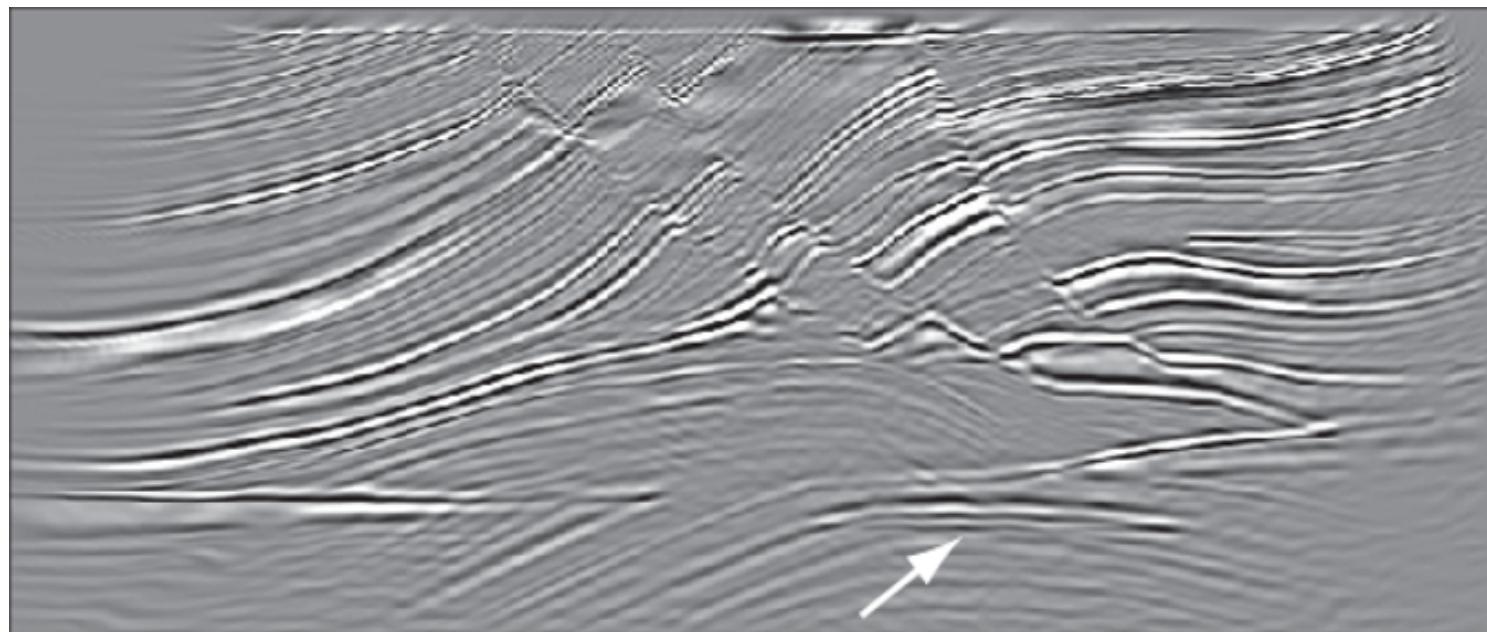
Examples of Digital Image Processing



蟹狀星雲脈衝星

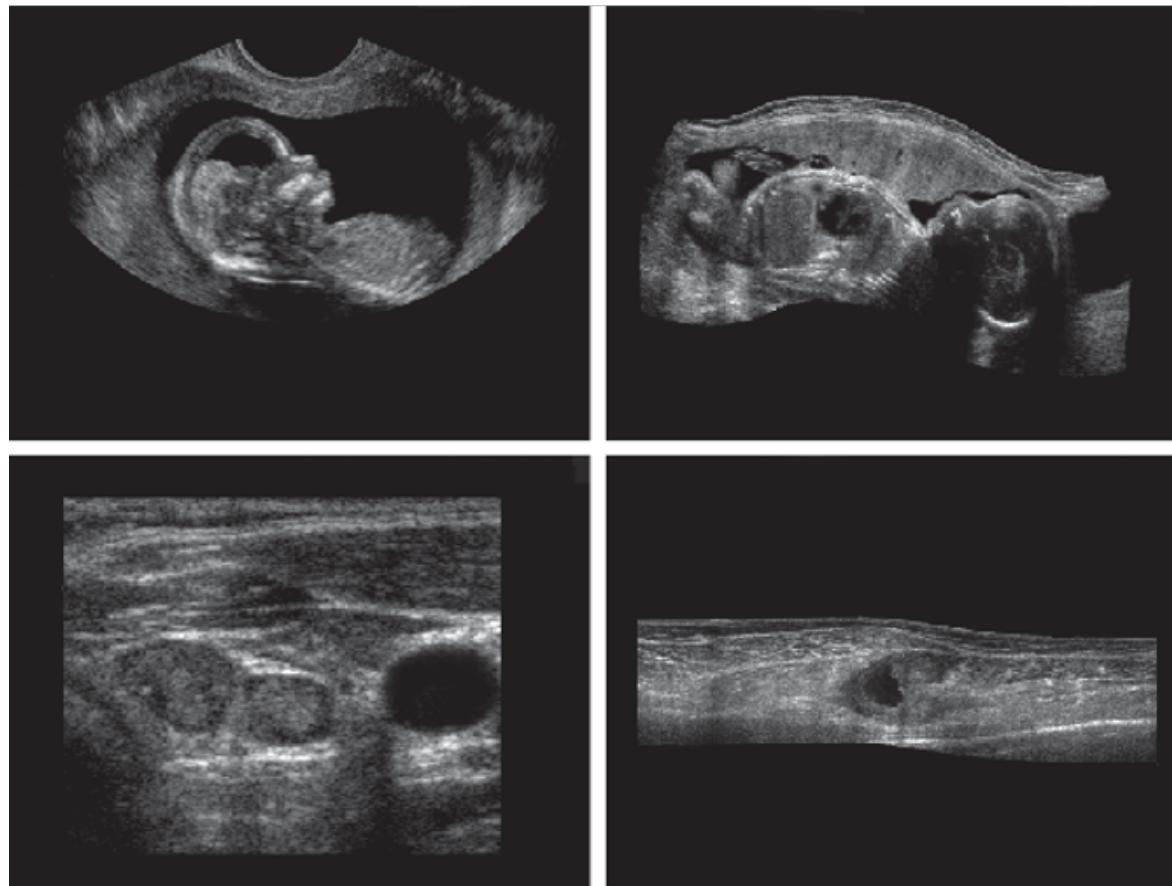
Examples of Digital Image Processing Other than EM

Seismic Imaging 震測影像



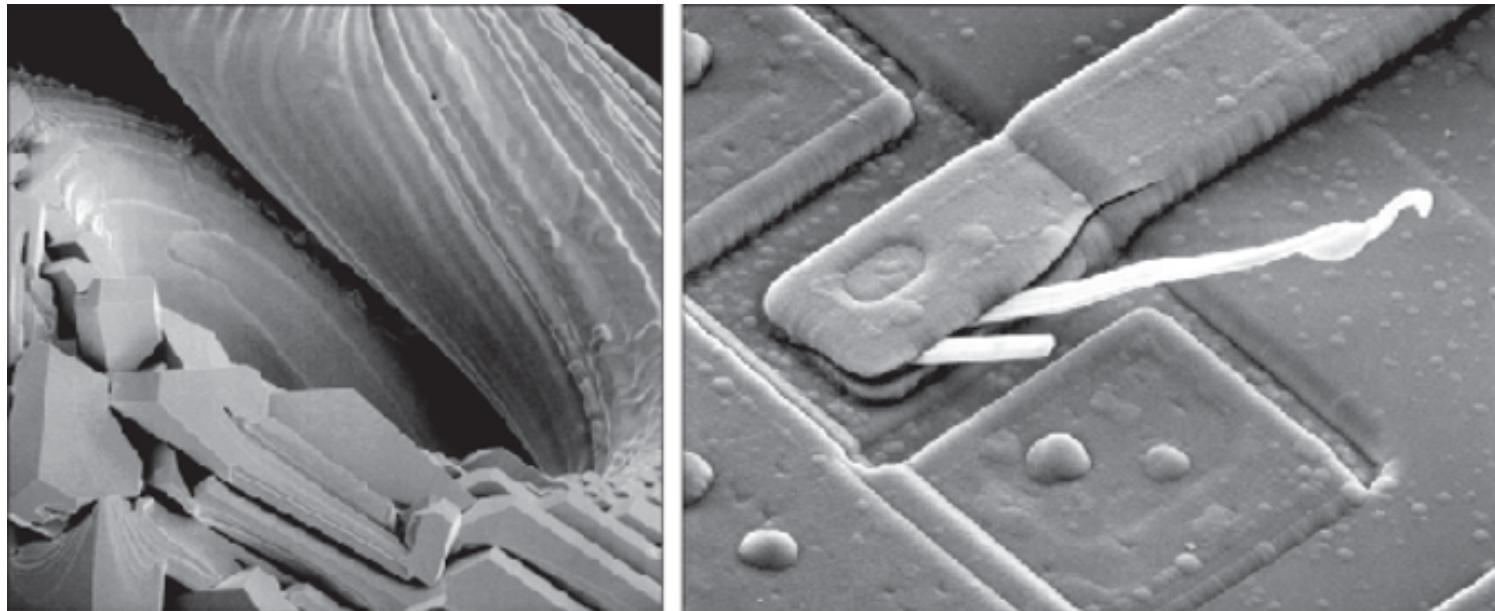
Examples of Digital Image Processing Other than EM

超音波影像



Examples of Digital Image Processing Other than EM

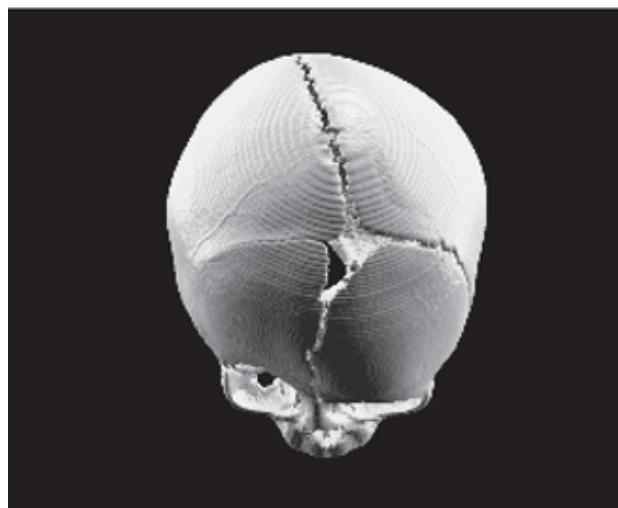
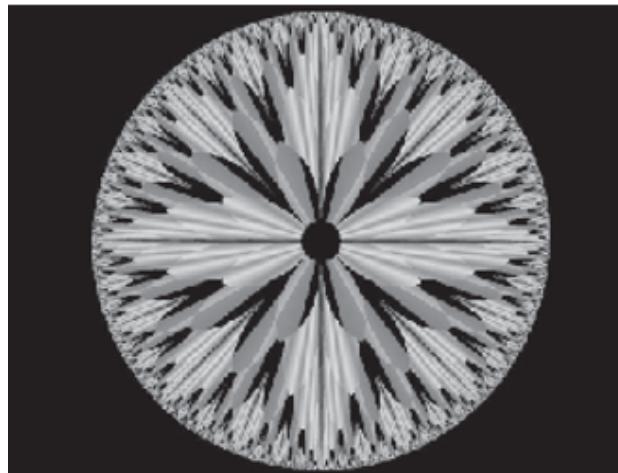
掃描式電子顯微鏡



燒斷之鎢絲燈燈絲

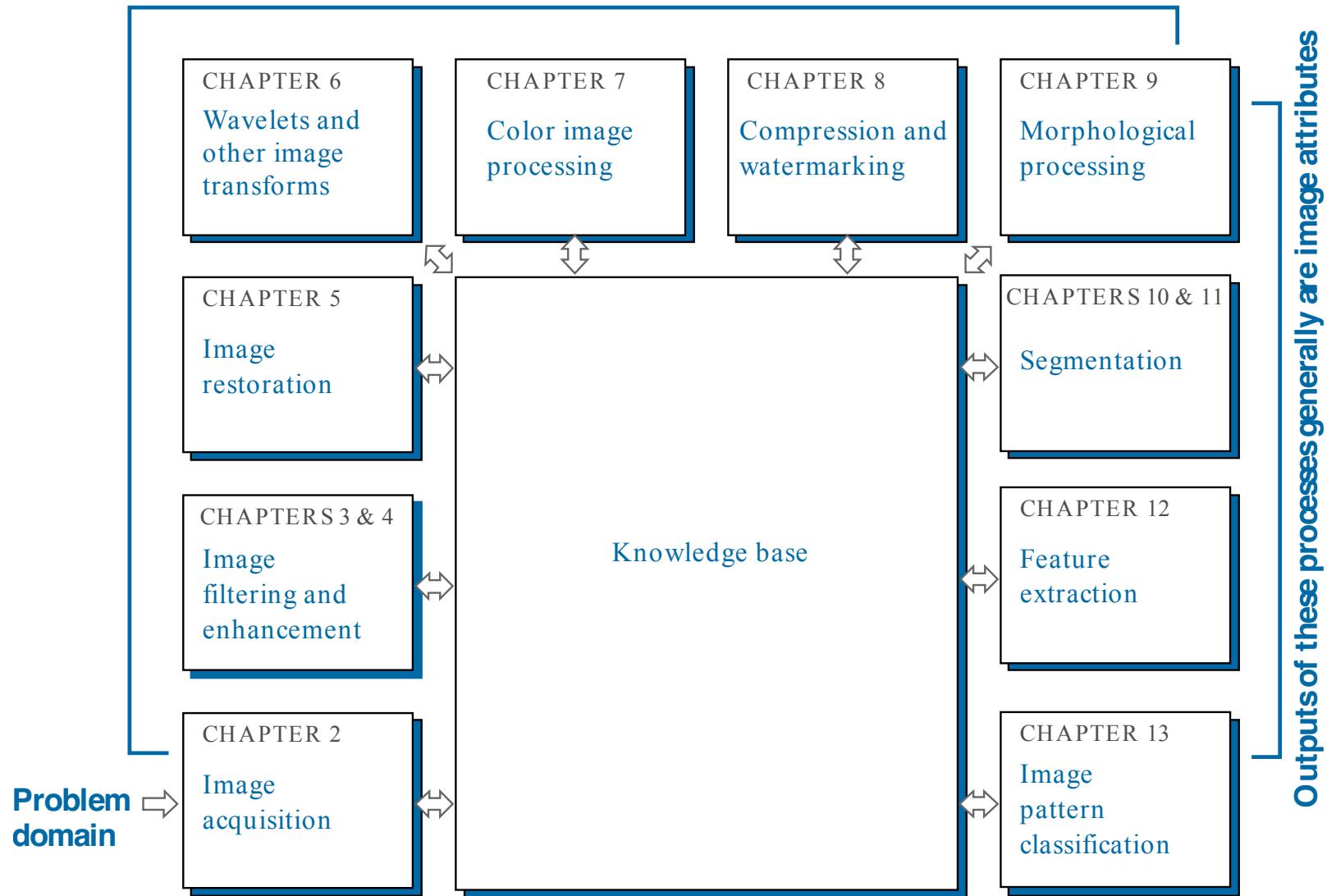
Examples of Digital Image Processing Other than EM

Computer Generated Images

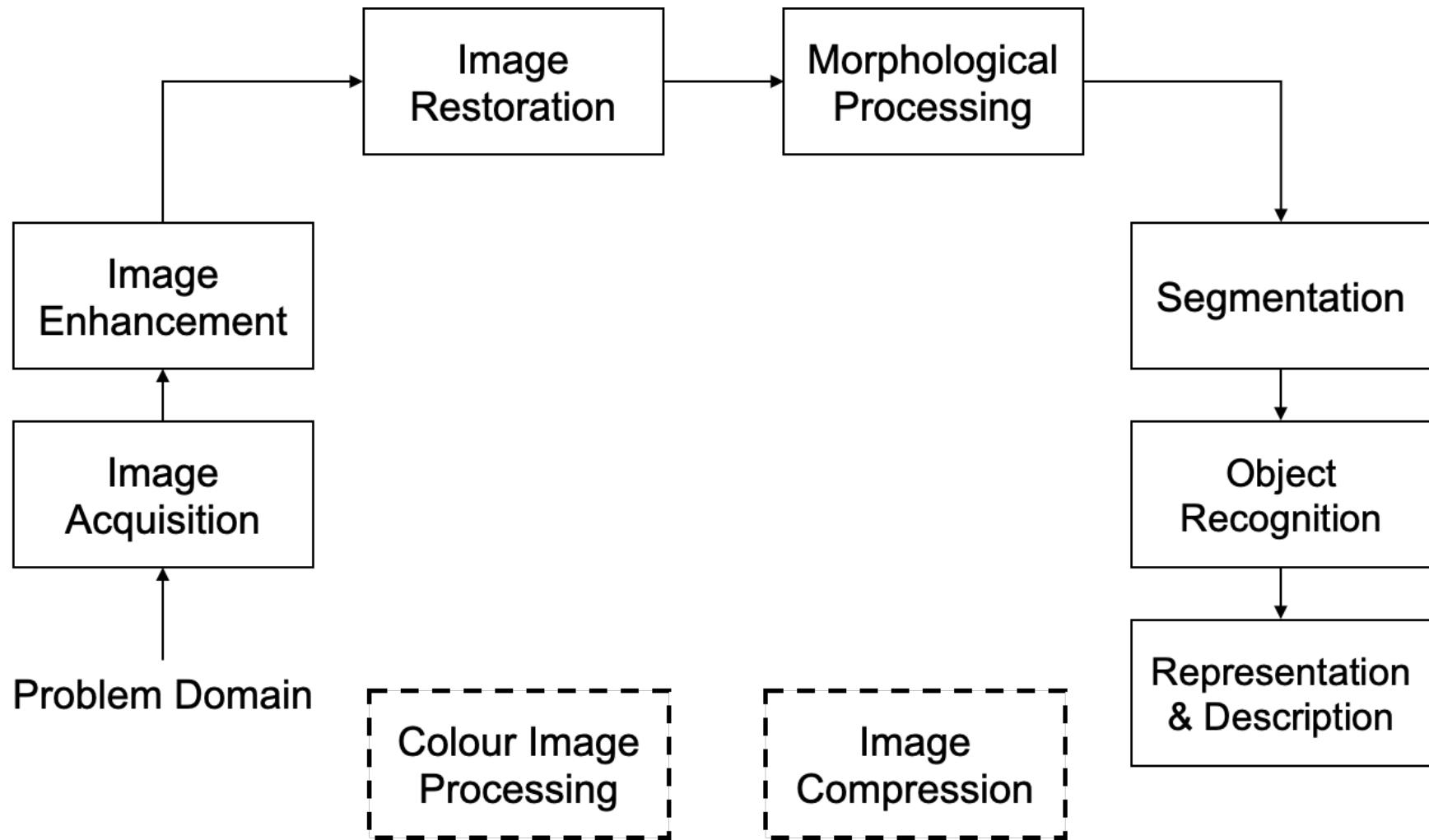


Fundamental Steps in Digital Image Processing

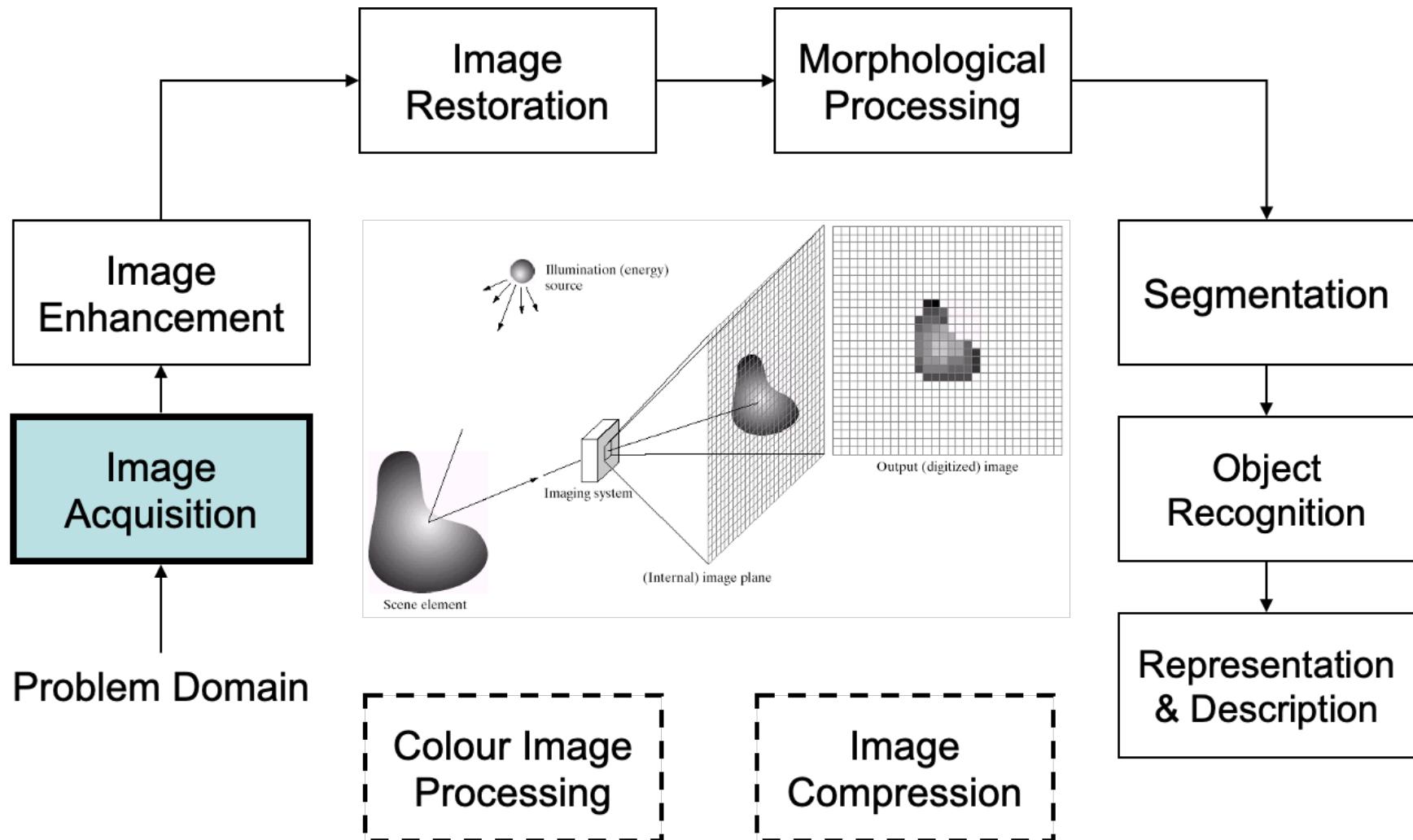
Outputs of these processes generally are images



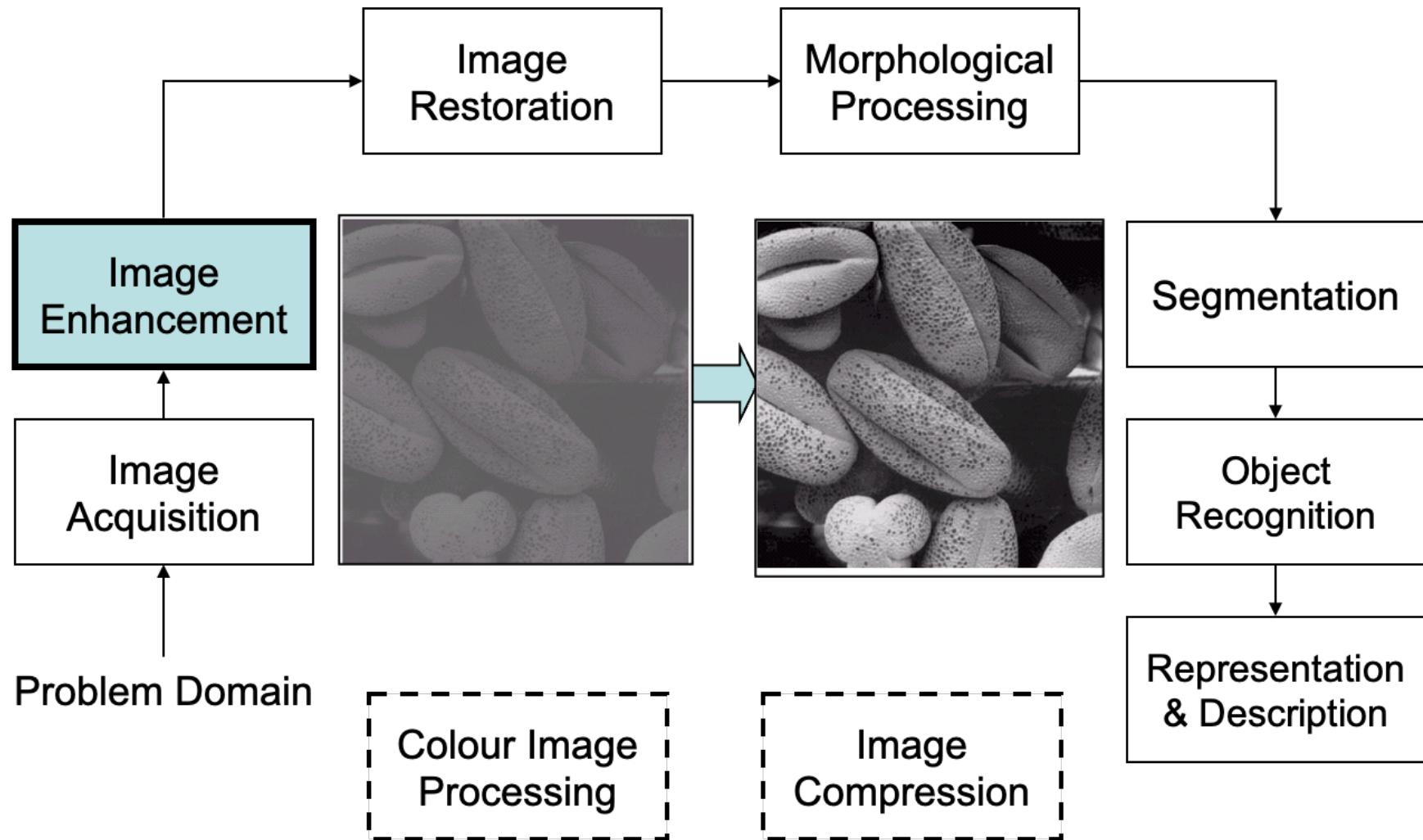
Fundamental Steps in Digital Image Processing



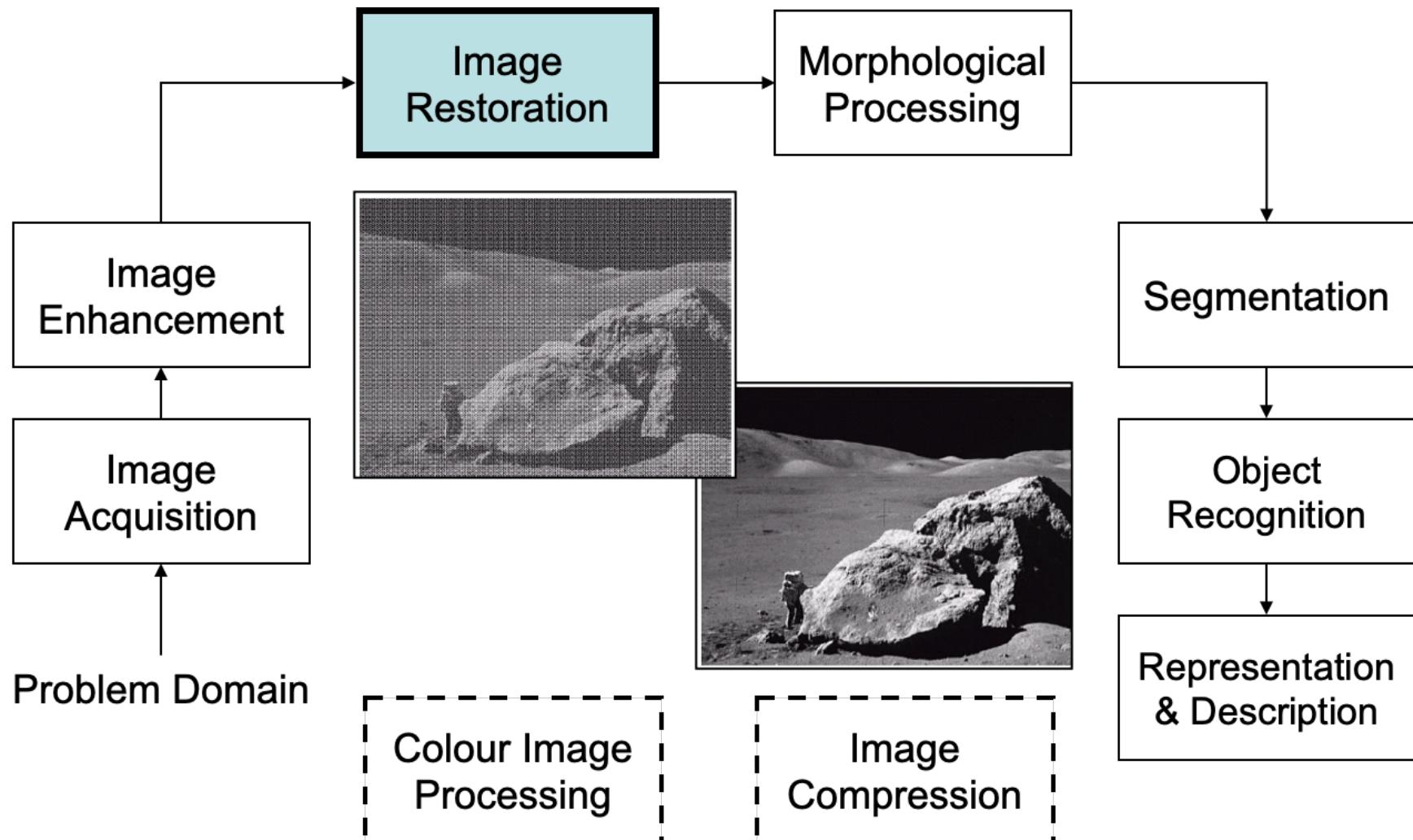
Fundamental Steps in Digital Image Processing



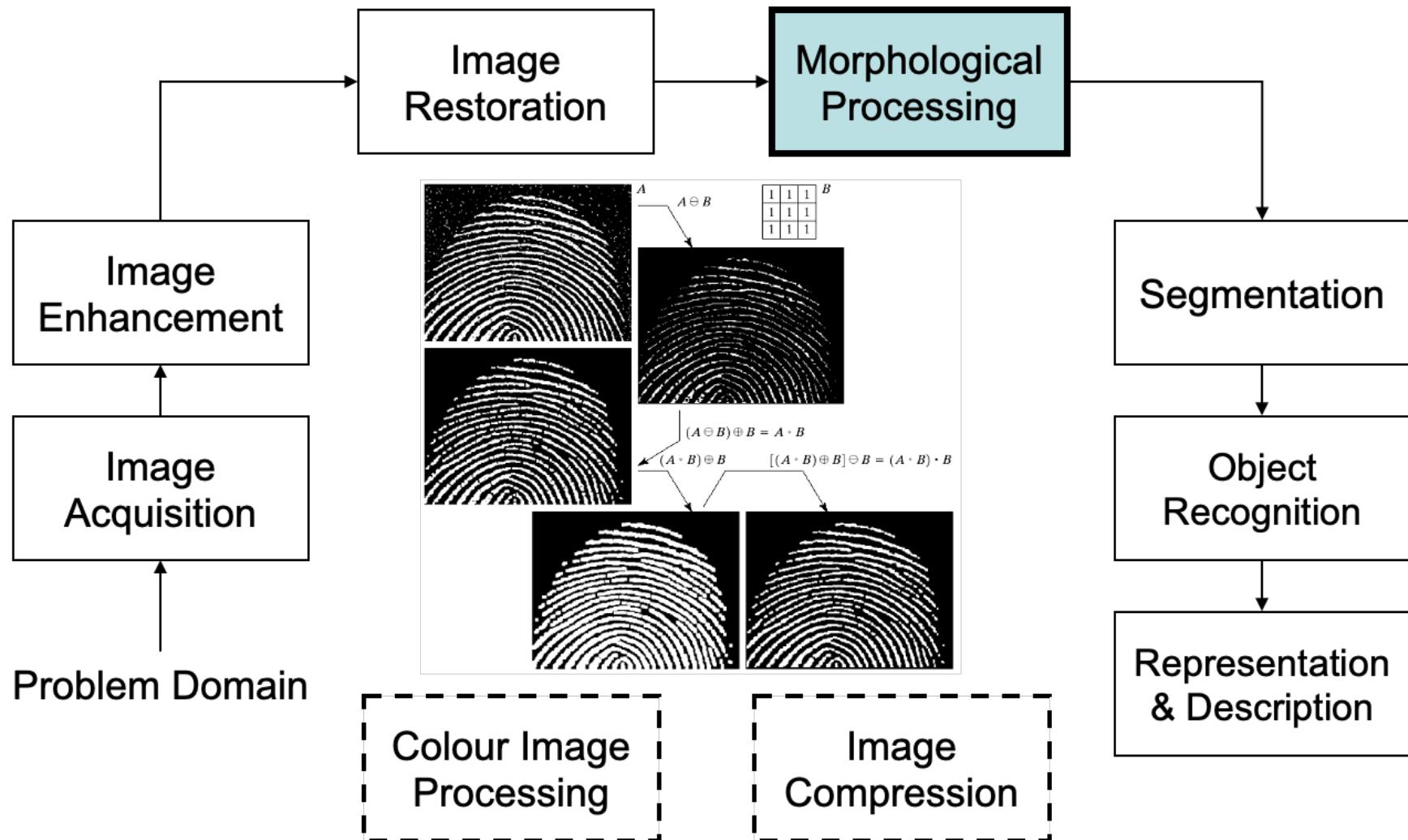
Fundamental Steps in Digital Image Processing



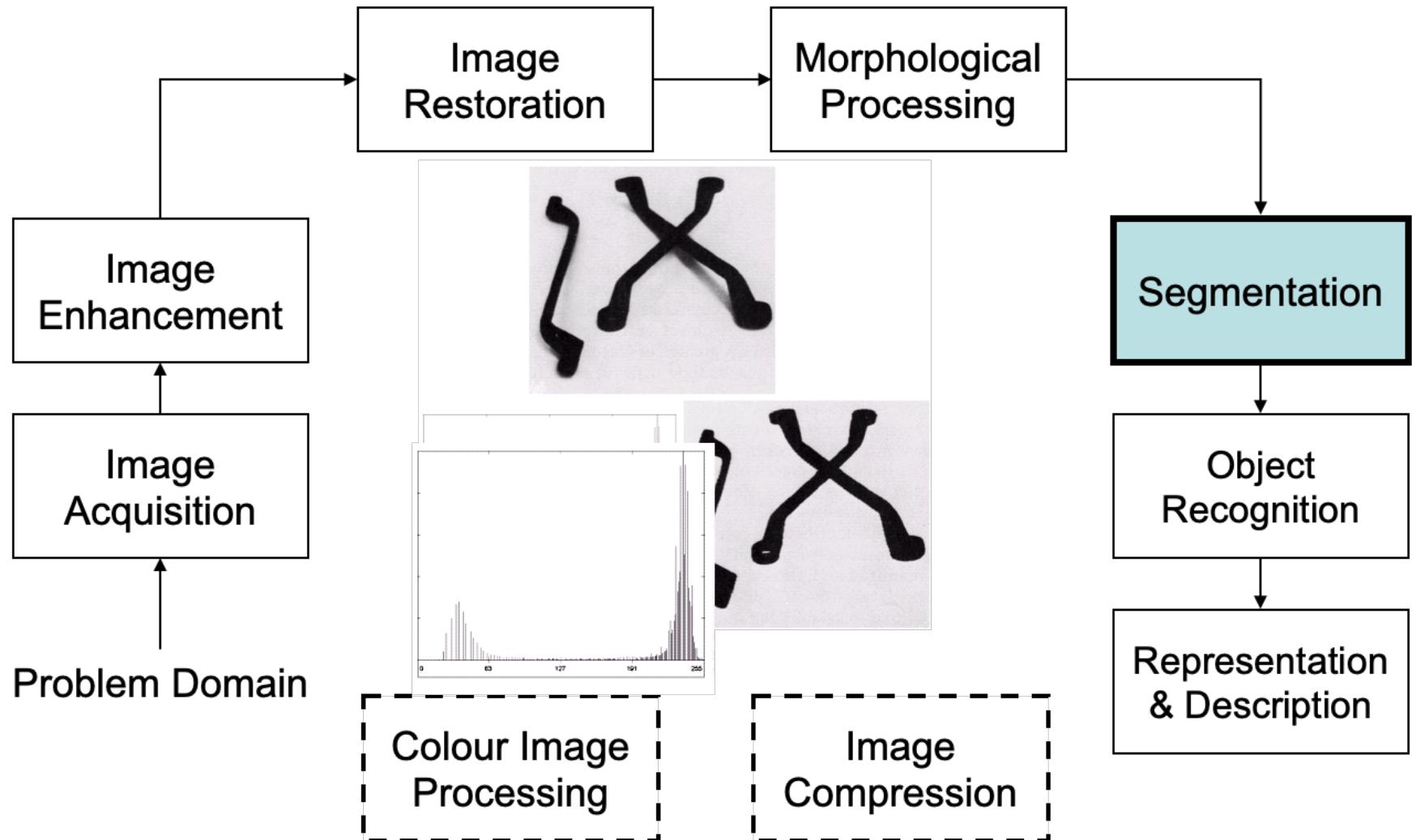
Fundamental Steps in Digital Image Processing



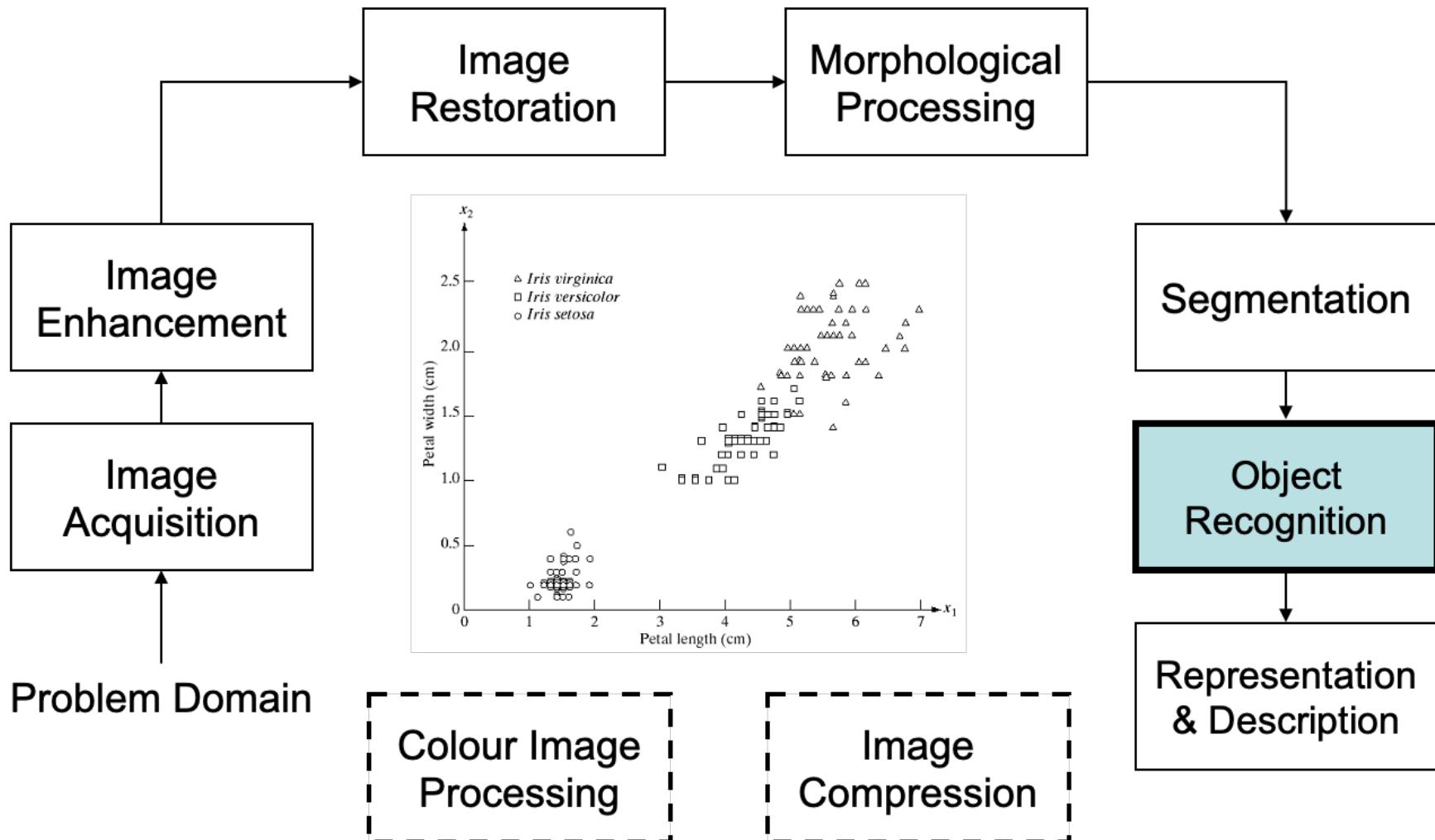
Fundamental Steps in Digital Image Processing



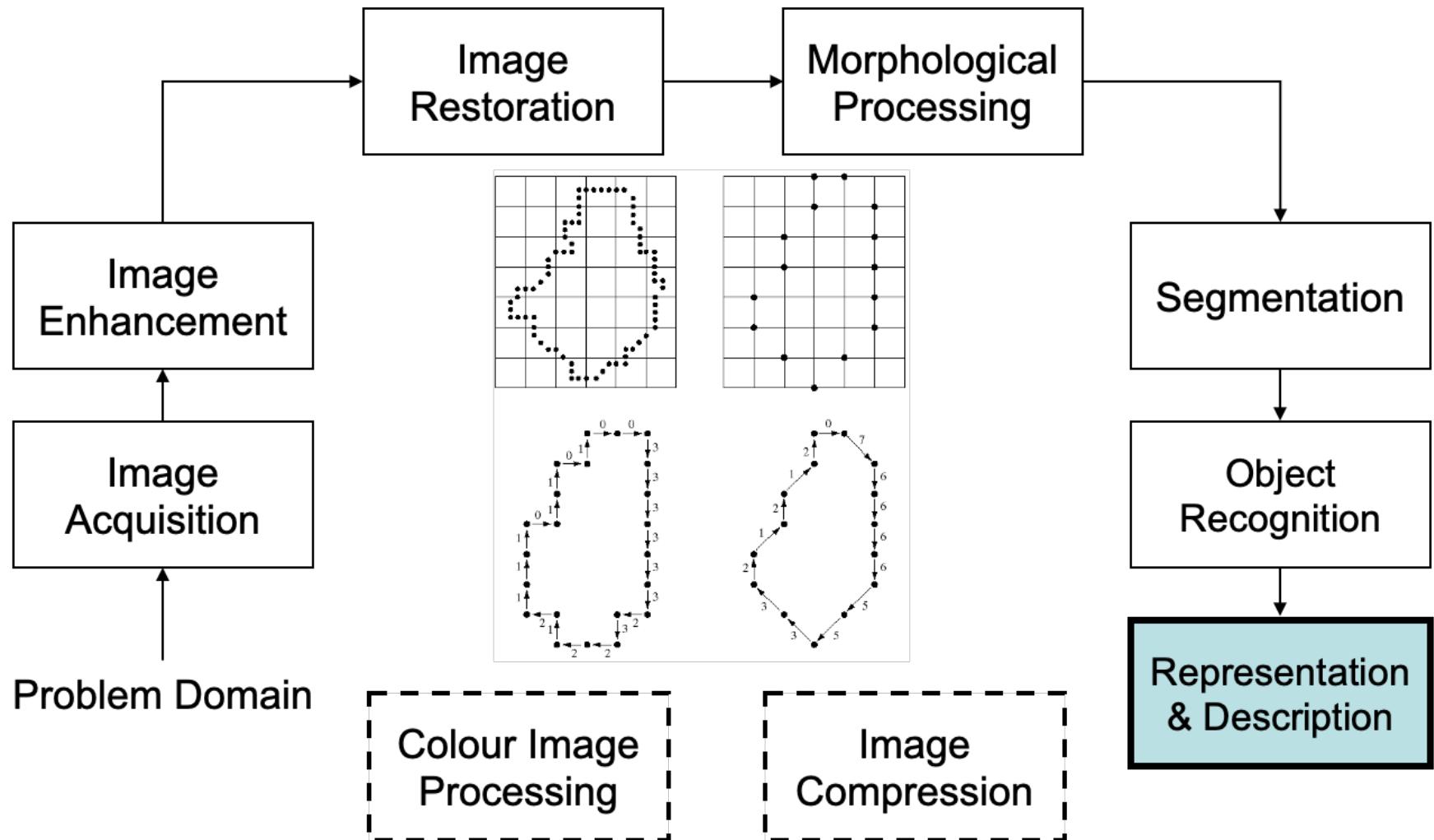
Fundamental Steps in Digital Image Processing



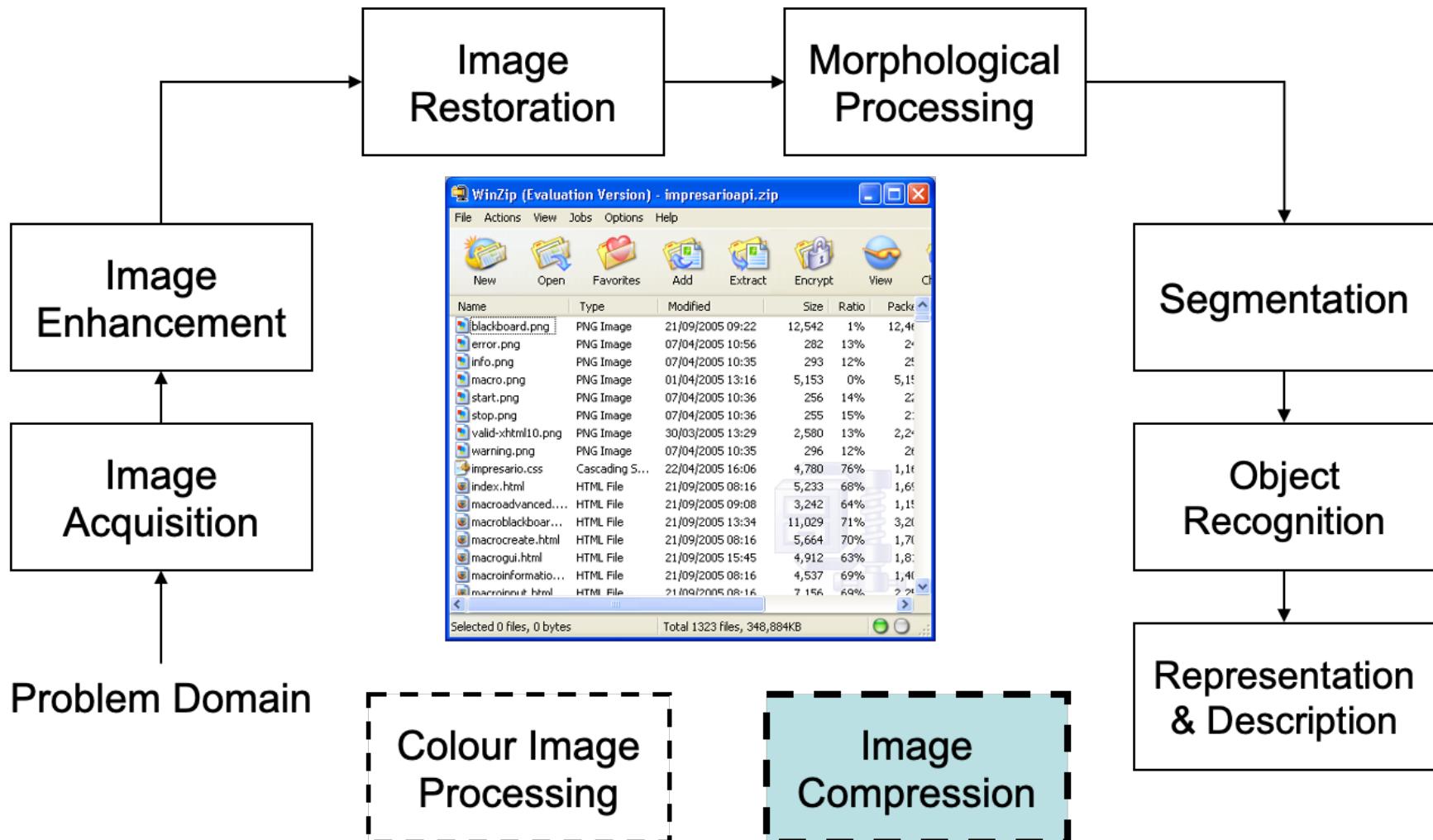
Fundamental Steps in Digital Image Processing



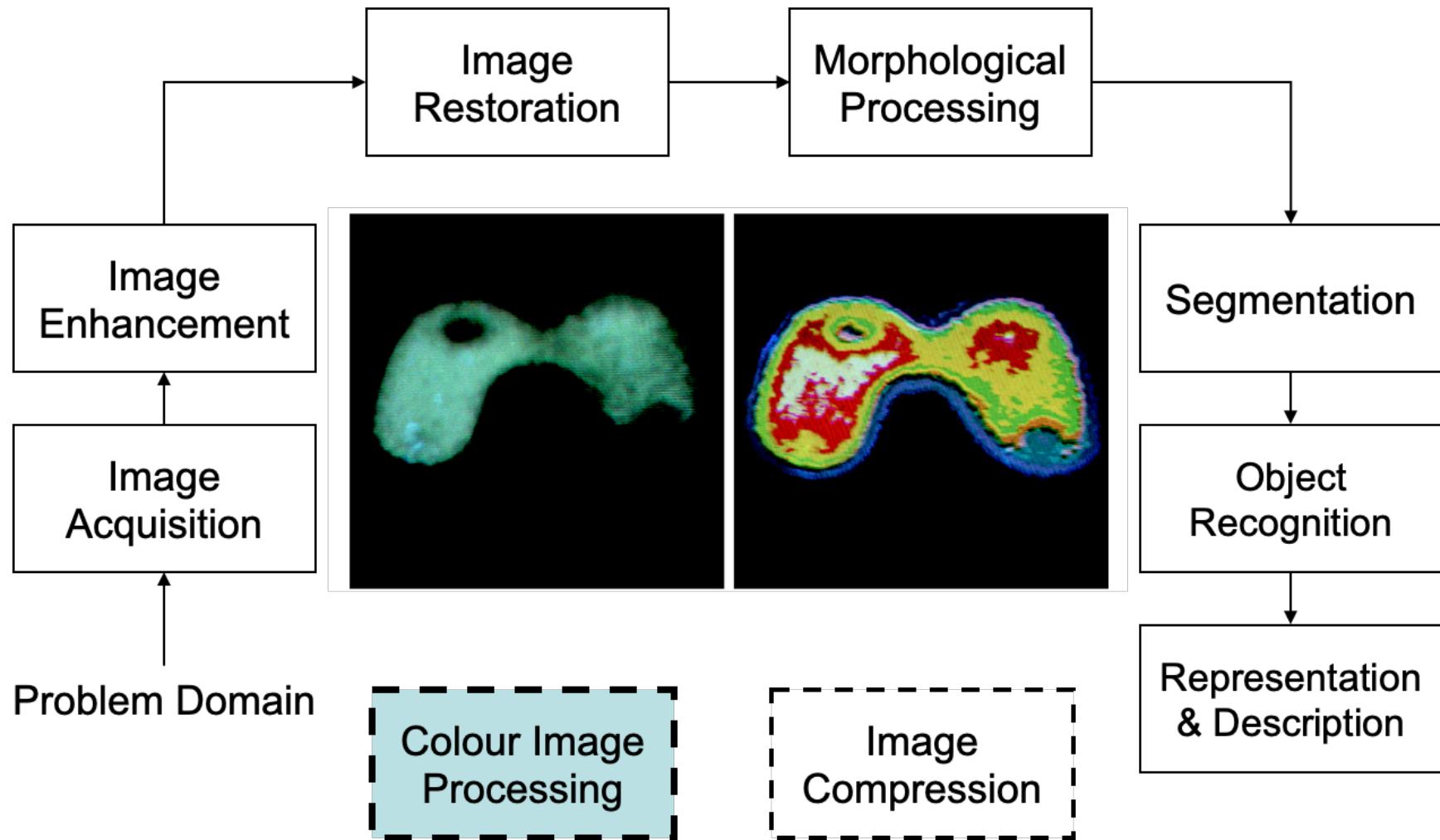
Fundamental Steps in Digital Image Processing



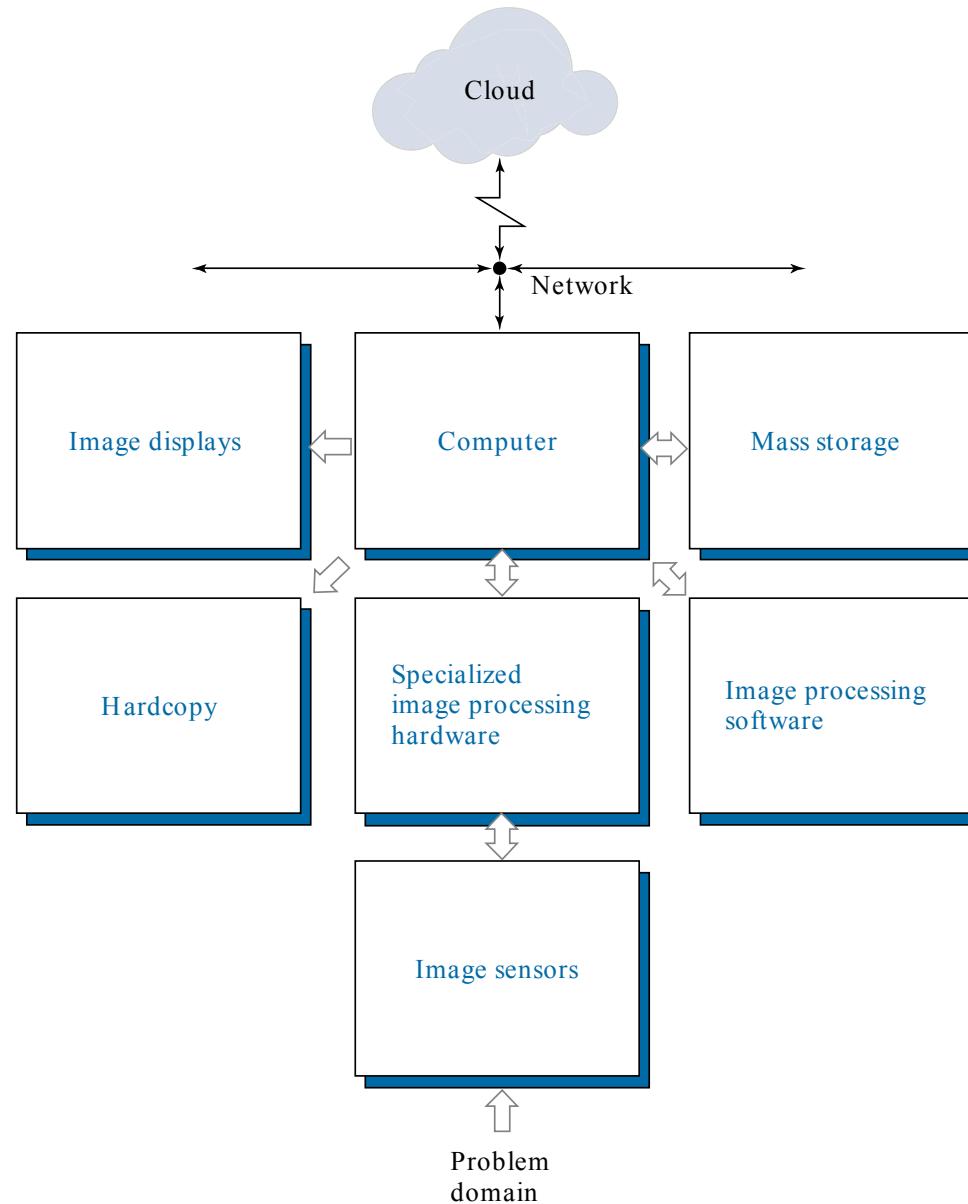
Fundamental Steps in Digital Image Processing



Fundamental Steps in Digital Image Processing



Components of a General-purpose Image Processing System

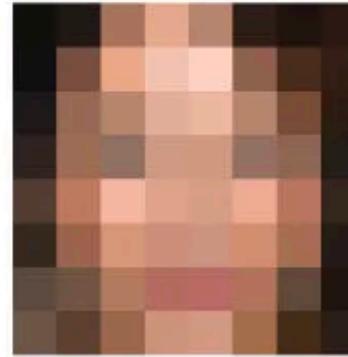


Other New Technologies beyond This Book

Image Enhancement

Super Resolution

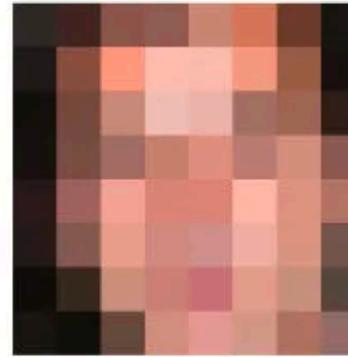
8×8 input



32×32 samples

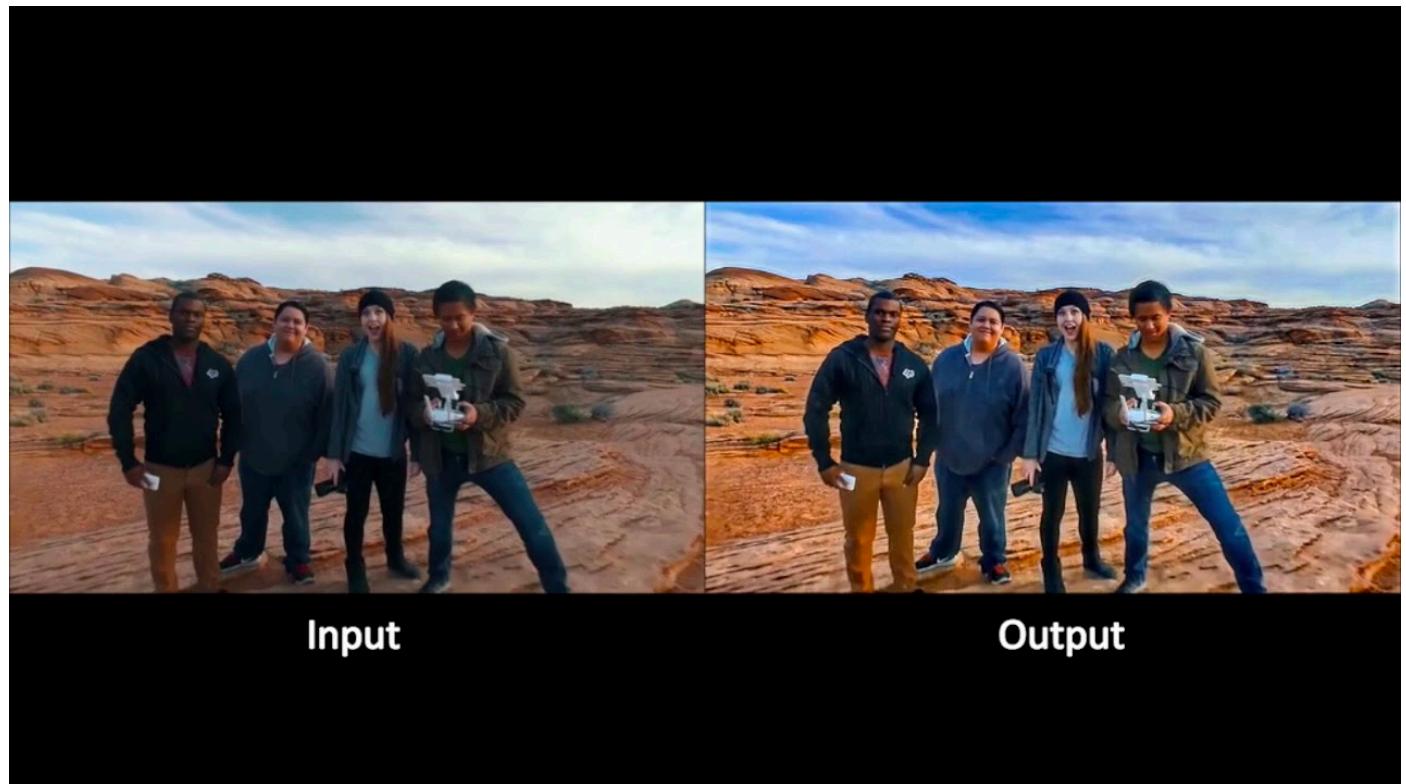


ground truth



Other New Technologies beyond This Book

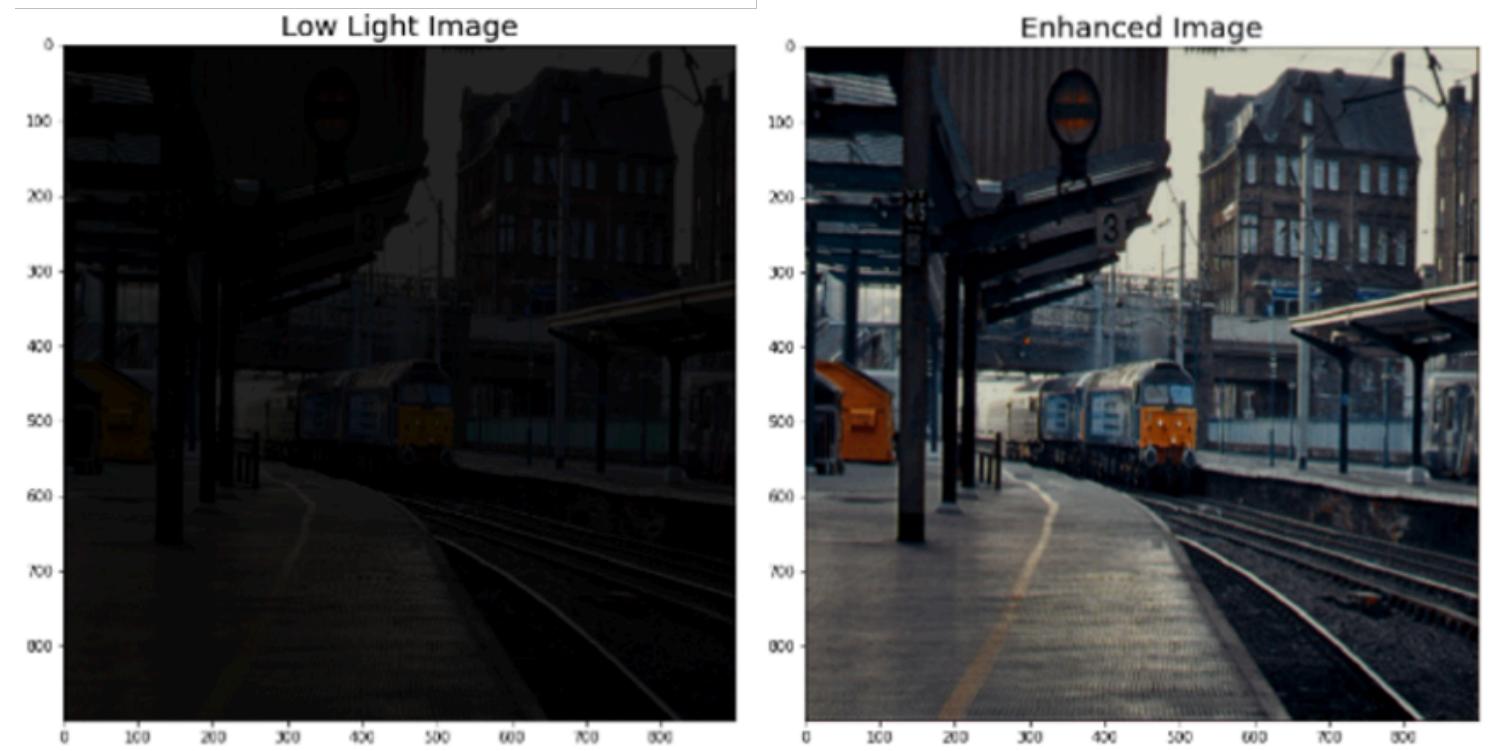
Image
Enhancement



Chen et al., “Deep Photo Enhancer: Unpaired Learning for Image Enhancement From Photographs With GANs,” *CVPR* 2018.

Other New Technologies beyond This Book

Image Enhancement



<https://cde.nus.edu.sg/edic/projects/innovations-in-intelligent-systems/low-light-enhancement-via-deep-learning-for-autonomous-systems/>

Other New Technologies beyond This Book

Image
Enhancement

Colorization

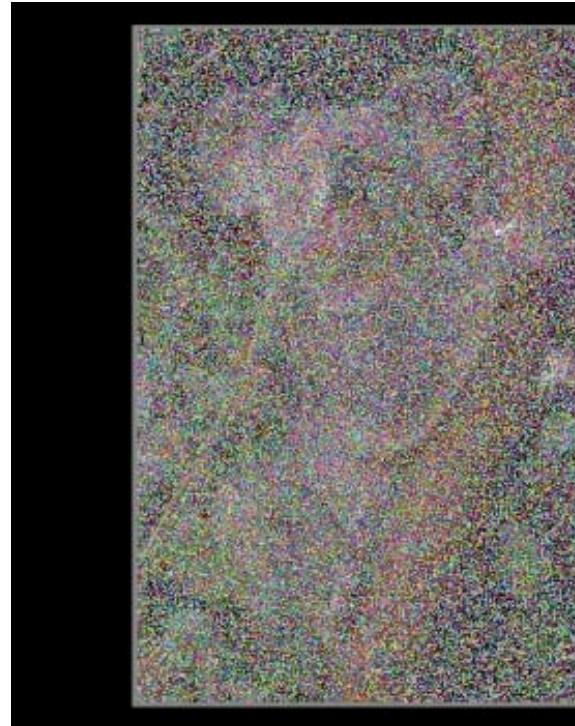


<https://learnopencv.com/convolutional-neural-network-based-image-colorization-using-opencv/>

Other New Technologies beyond This Book

Image
Restoration

Denoising

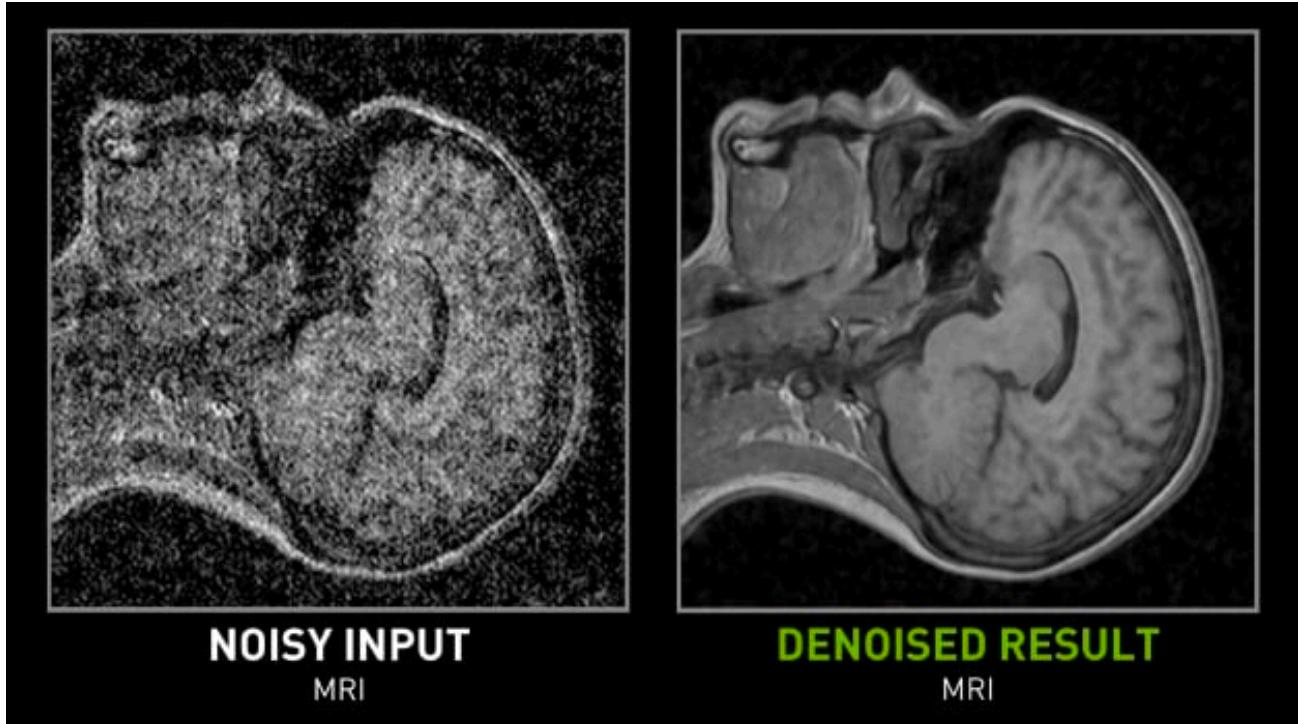


<https://hothardware.com/news/nvidia-noise2noise-machine-learning-ai-magically-restores-your-grainy-photos>

Other New Technologies beyond This Book

Image
Restoration

Denoising

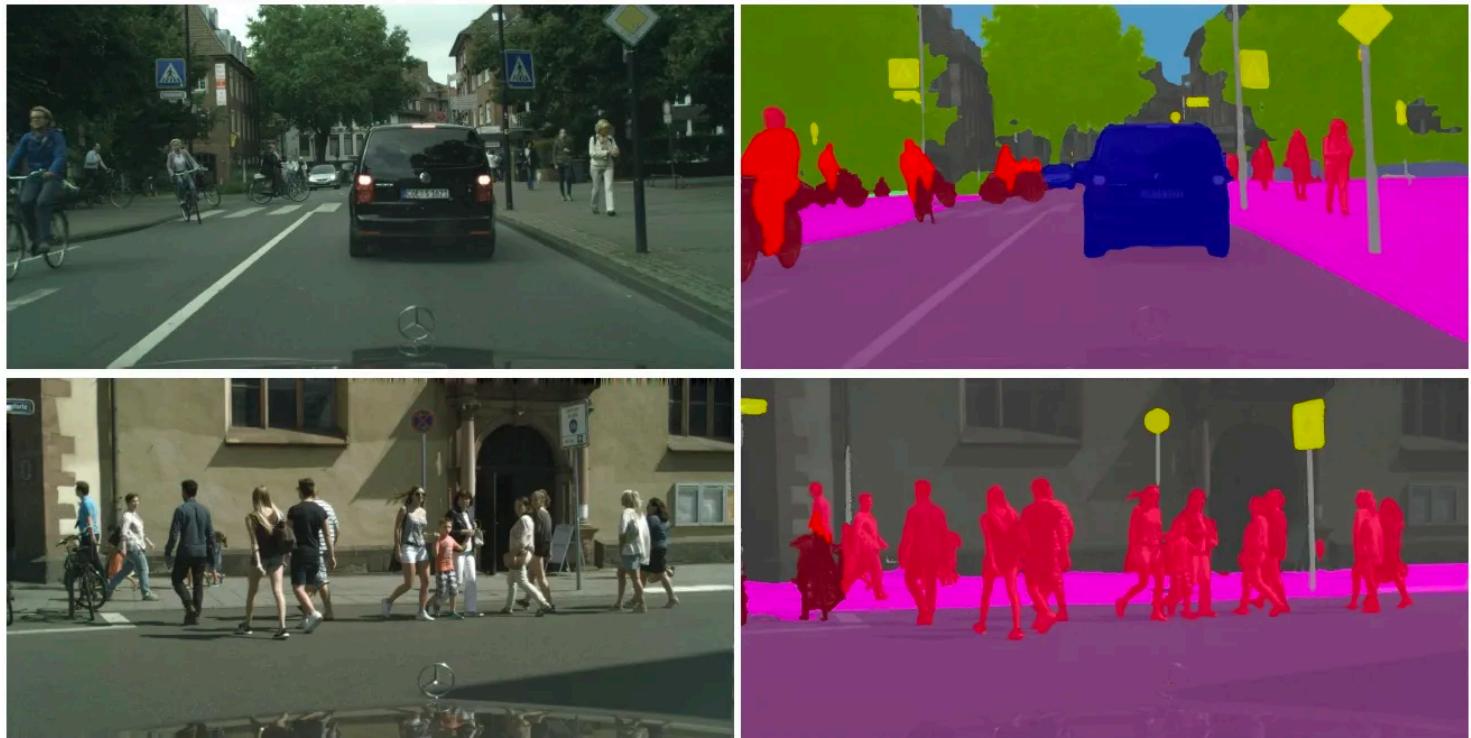


<https://hothardware.com/news/nvidia-noise2noise-machine-learning-ai-magically-restores-your-grainy-photos>

Other New Technologies beyond This Book

Segmentation

Semantic Segmentation



Kundu et al., "Feature Space Optimization for Semantic Video Segmentation," *CVPR* 2016.

Introduction to Image Processing

Ch 1. Introduction

Kuan-Wen Chen