江西理工大學 信息工程学院
JIANGXI UNIVERSITY OF SCIENCE AND TECHNOLOGY SCHOOL OF INFORMATION ENGINEERING

Digital Image Processing

数字图像处理

Lecture 02:
Introduction to Digital Image Processing

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Jiangxi University of Science and Technology

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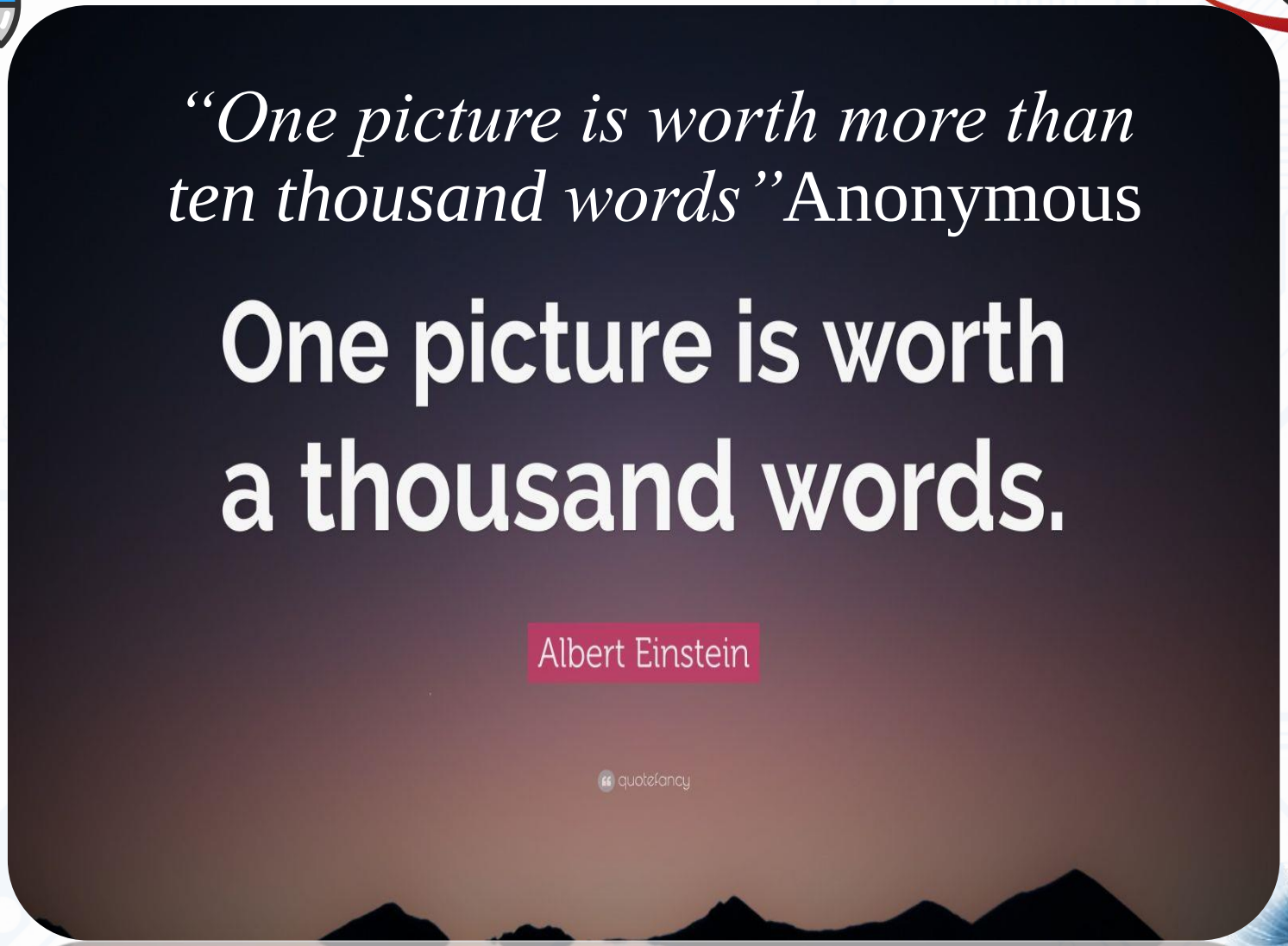
LECTURE 01: Introduction to Digital Image Processing

Introduction

"One picture is worth more than ten thousand words" Anonymous



Contents

- What is a digital image?
- What is digital image processing?
- History of digital image processing

What is an image?

- A two-dimensional array of numbers(or pixels) ranging between **0 and 255.**

- It is defined by the **mathematical function f(x,y)** where x and y are the two co-ordinates **horizontally** and **vertically.**

Introduction

What is Digital Image Processing?

Digital Image

— a two-dimensional function $f(x, y)$

x and *y* are spatial coordinates

The amplitude of *f* is called **intensity** or **gray level** at the point (x, y)

Digital Image Processing

— process digital images by means of computer, it covers low-, mid-, and high-level processes

low-level: inputs and outputs are images

mid-level: outputs are attributes extracted from input images

high-level: an ensemble of recognition of individual objects

Pixel

— the elements of a digital image

Origins of Digital Image Processing

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

Sent by submarine cable between London and New York, the transportation time was reduced to less than three hours from more than a week

Origins of Digital Image Processing

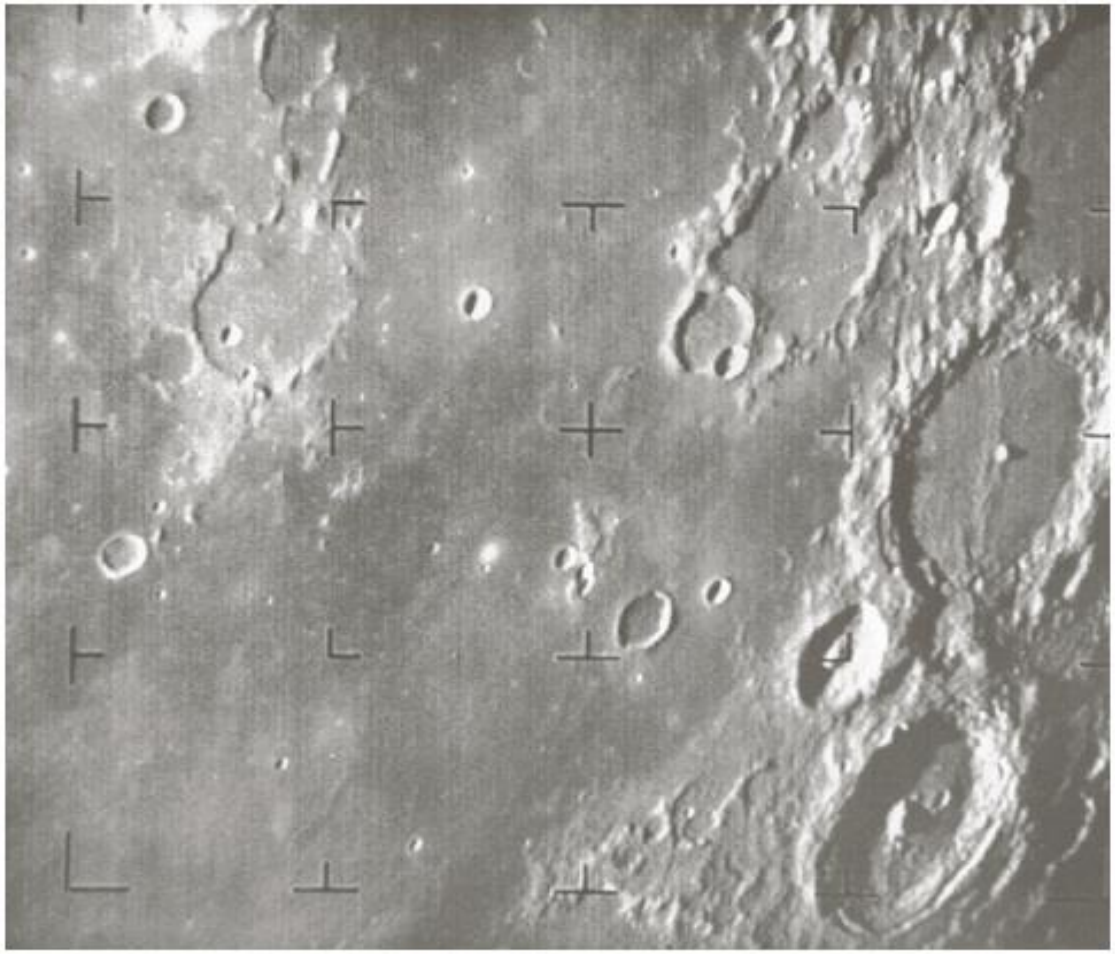


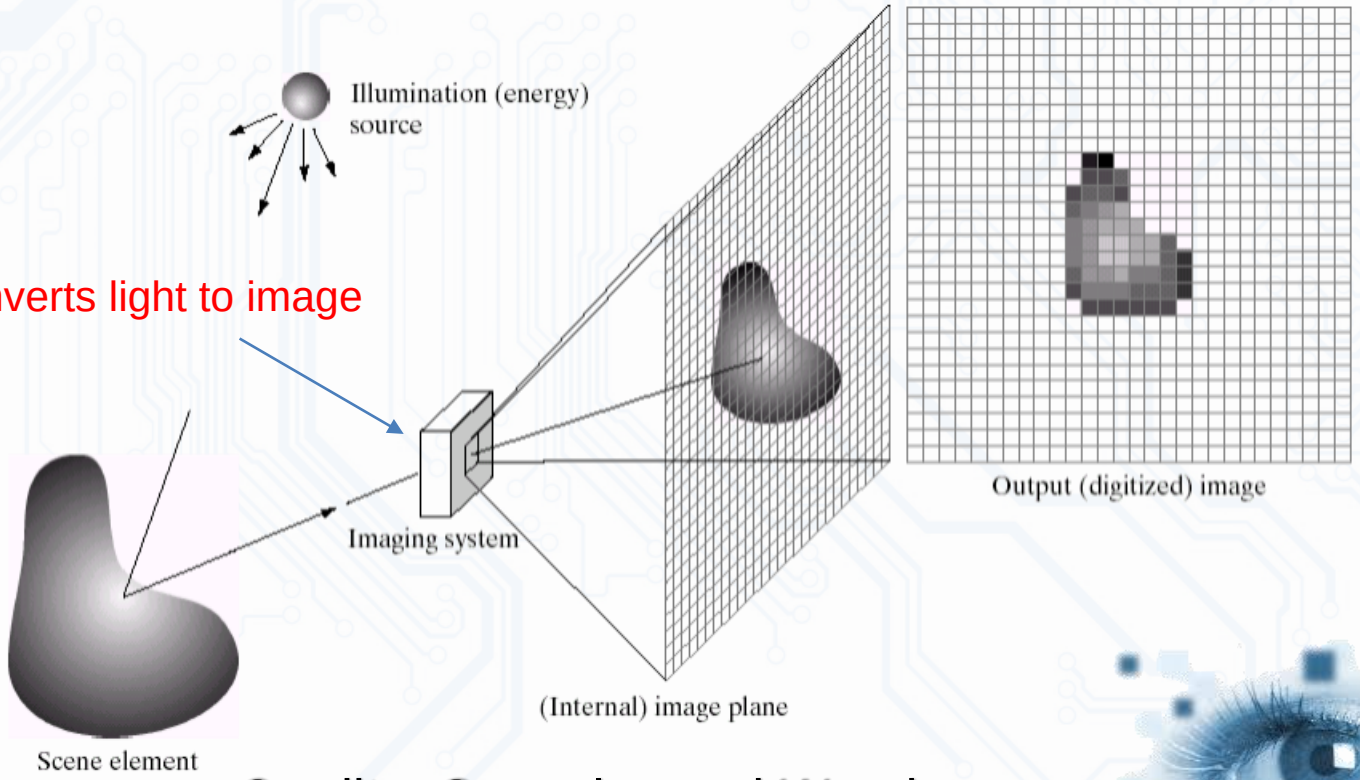
FIGURE 1.4 The first picture of the moon by a U.S. spacecraft. *Ranger 7* took this image on July 31, 1964 at 9 : 09 A.M. EDT, about 17 minutes before impacting the lunar surface. (Courtesy of NASA.)

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

Example:

a camera Converts light to image

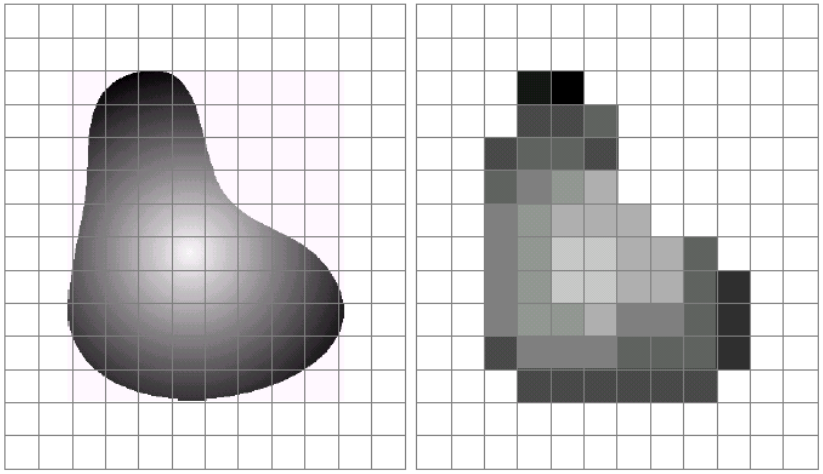


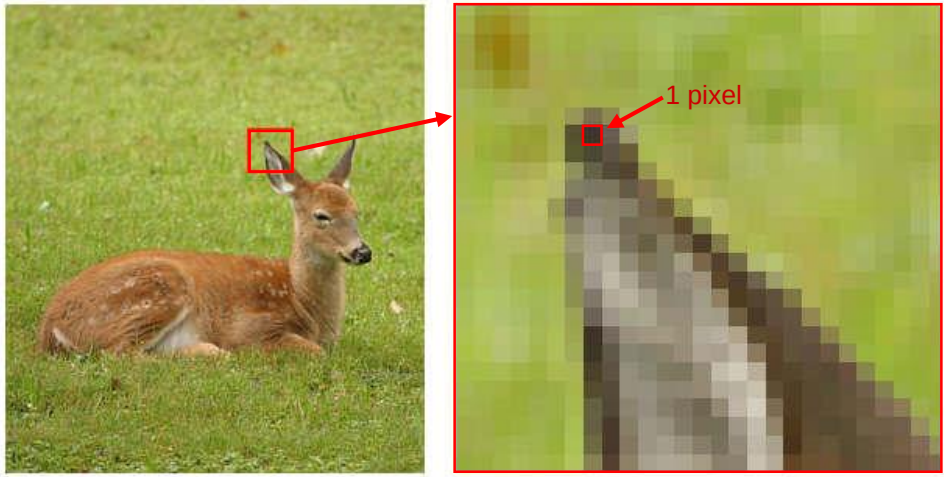
Credits: Gonzales and Woods

What is a Digital Image? (cont…)

Pixel values typically represent gray levels, colours, heights, opacities etc

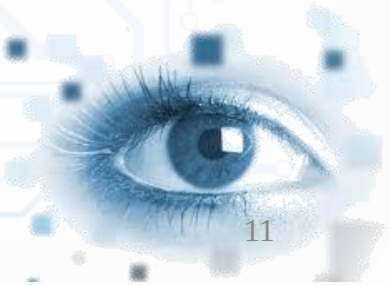
Remember *digitization* implies that a digital image is an *approximation* of a real scene





Sources for Images

- Electromagnetic (EM) energy spectrum
- Acoustic
- Ultrasonic
- Electronic
- Synthetic images produced by computer



Imaging types and application

–Gamma Ray Imaging(Nuclear Medicine And Astronomical Observations)

–x-ray imaging(medical diagnostics, industry, and astronomy, etc)

–Imaging in Ultrviolet band(industrial inspection, astronomical observation)

lithography, industrial inspection, microscopy, lasers, biological imaging, and astronomical observation

–Imaging in visible & Infra Red band

light microscopy, astronomy, remote sensing, industry, and law enforcement

–Imaging in MicroWave band radar

–The dominant application of imaging in the microwave band is wave

–The unique feature of imaging radar is its ability to collect data over virtually any region at anytime, regardless of weather or ambient lighting condition

–Imaging in Radio band medicine (such as MRI) and astronomy

–Imaging Modeleties using non EM Spectrum band

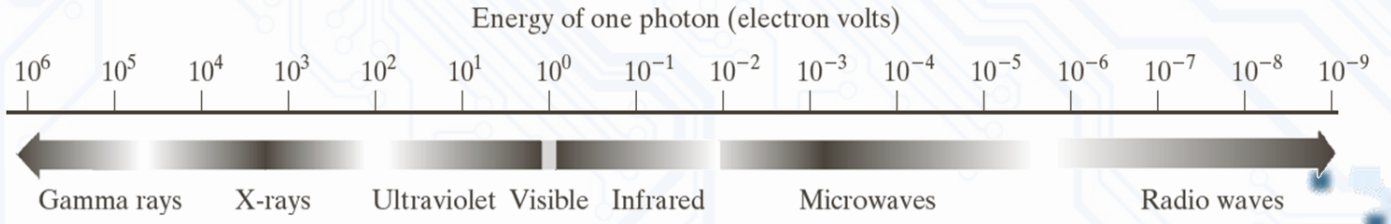
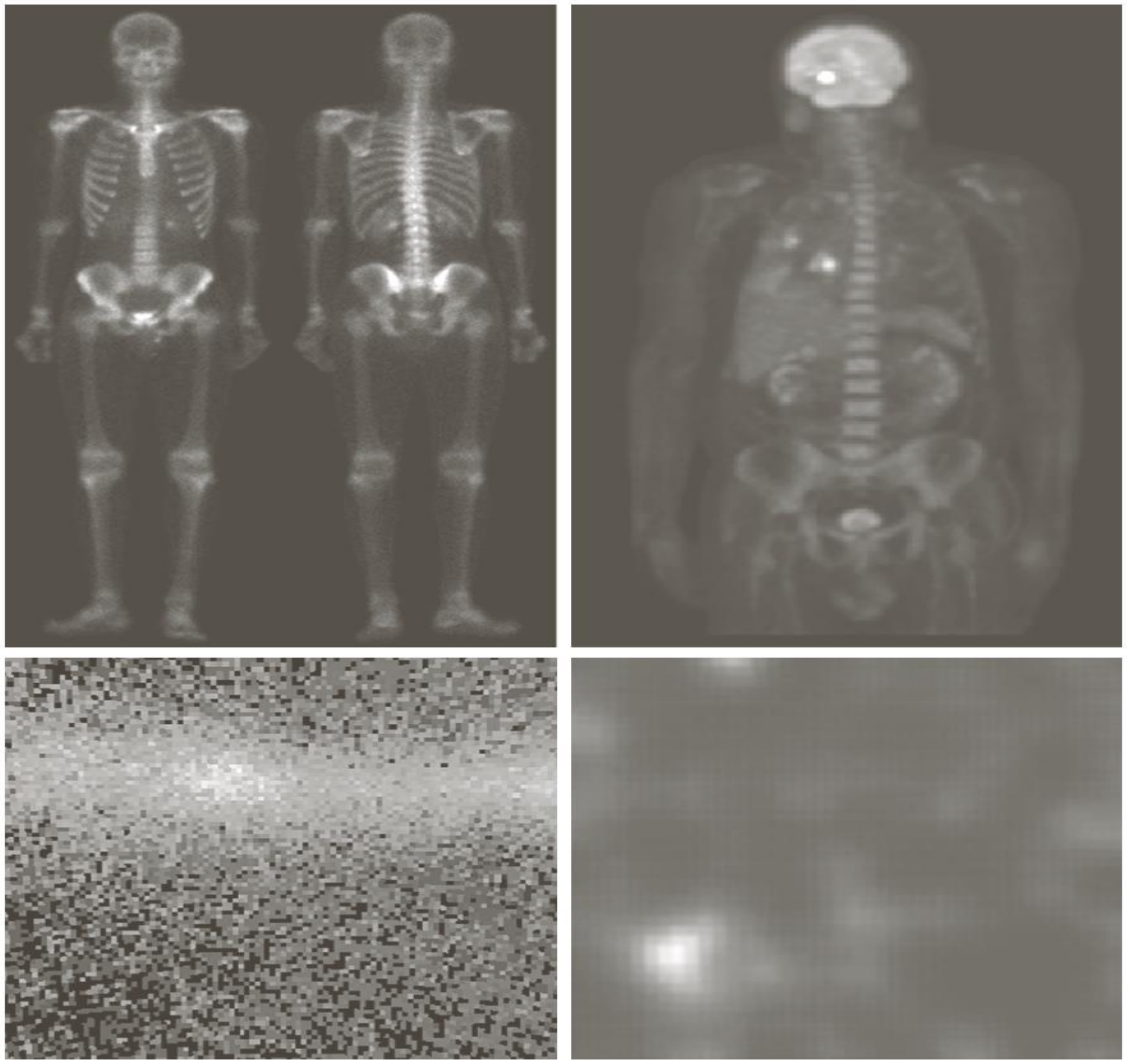


FIGURE 1.5 The electromagnetic spectrum arranged according to energy per photon.

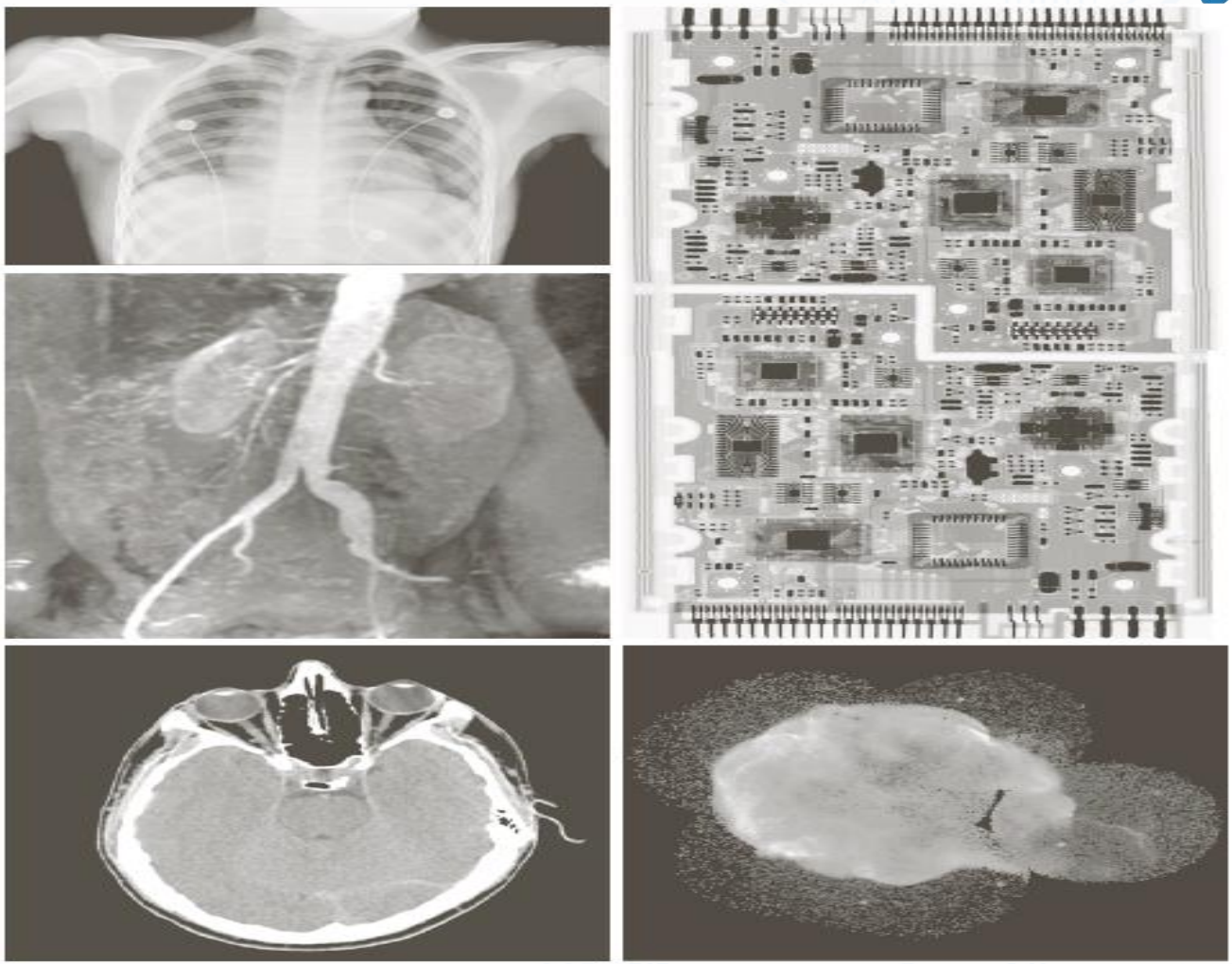
Examples: Gama-Ray Imaging



a b
c d

FIGURE 1.6
Examples of gamma-ray imaging. (a) Bone scan. (b) PET image. (c) Cygnus Loop. (d) Gamma radiation (bright spot) from a reactor valve. (Images courtesy of (a) G.E. Medical Systems, (b) Dr. Michael E. Casey, CTI PET Systems, (c) NASA, (d) Professors Zhong He and David K. Wehe, University of Michigan.)

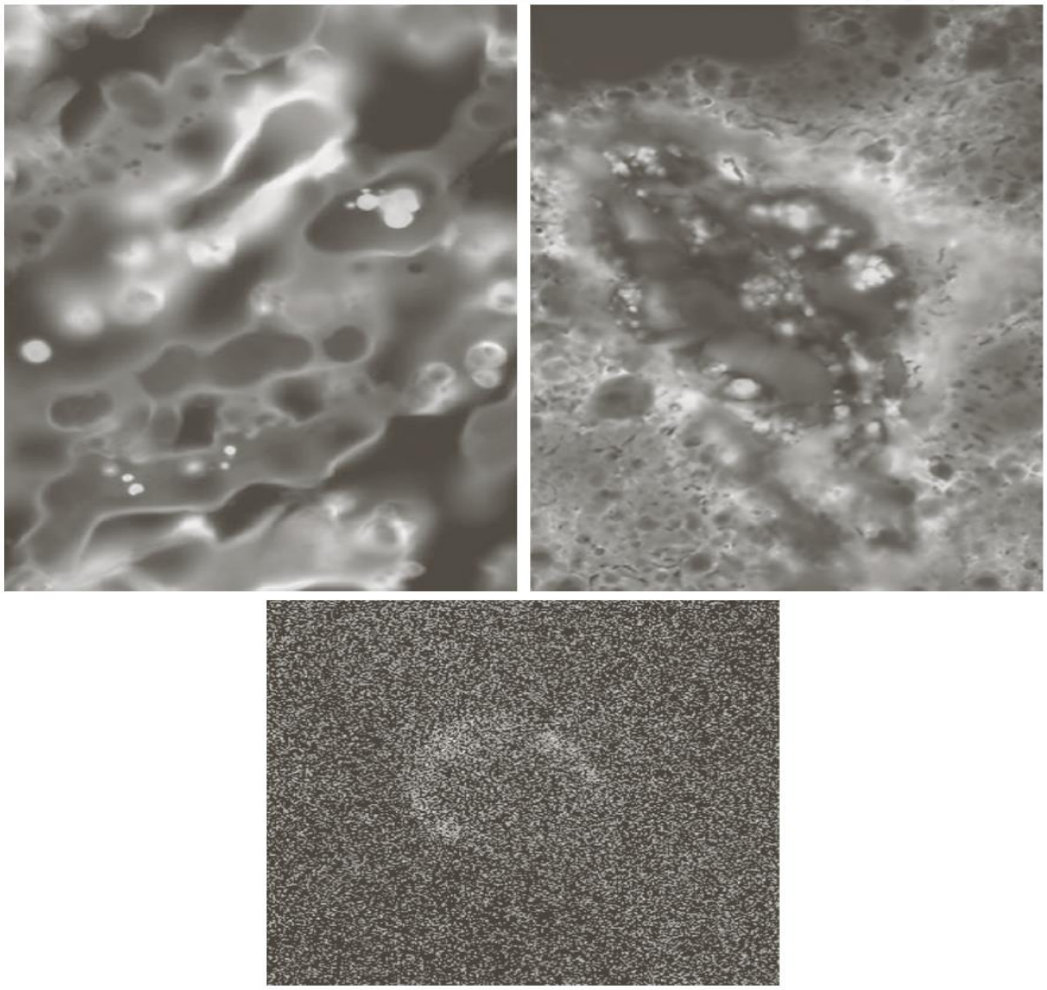
Examples: X-Ray Imaging



a b c d e

FIGURE 1.7 Examples of X-ray imaging. (a) Chest X-ray. (b) Aortic angiogram. (c) Head CT. (d) Circuit boards. (e) Cygnus Loop. (Images courtesy of (a) and (c) Dr. David R. Pickens, Dept. of Radiology & Radiological Sciences, Vanderbilt University Medical Center; (b) Dr. Thomas R. Gest, Division of Anatomical Sciences, University of Michigan Medical School; (d) Mr. Joseph E. Pascente, Lixi, Inc.; and (e) NASA.)

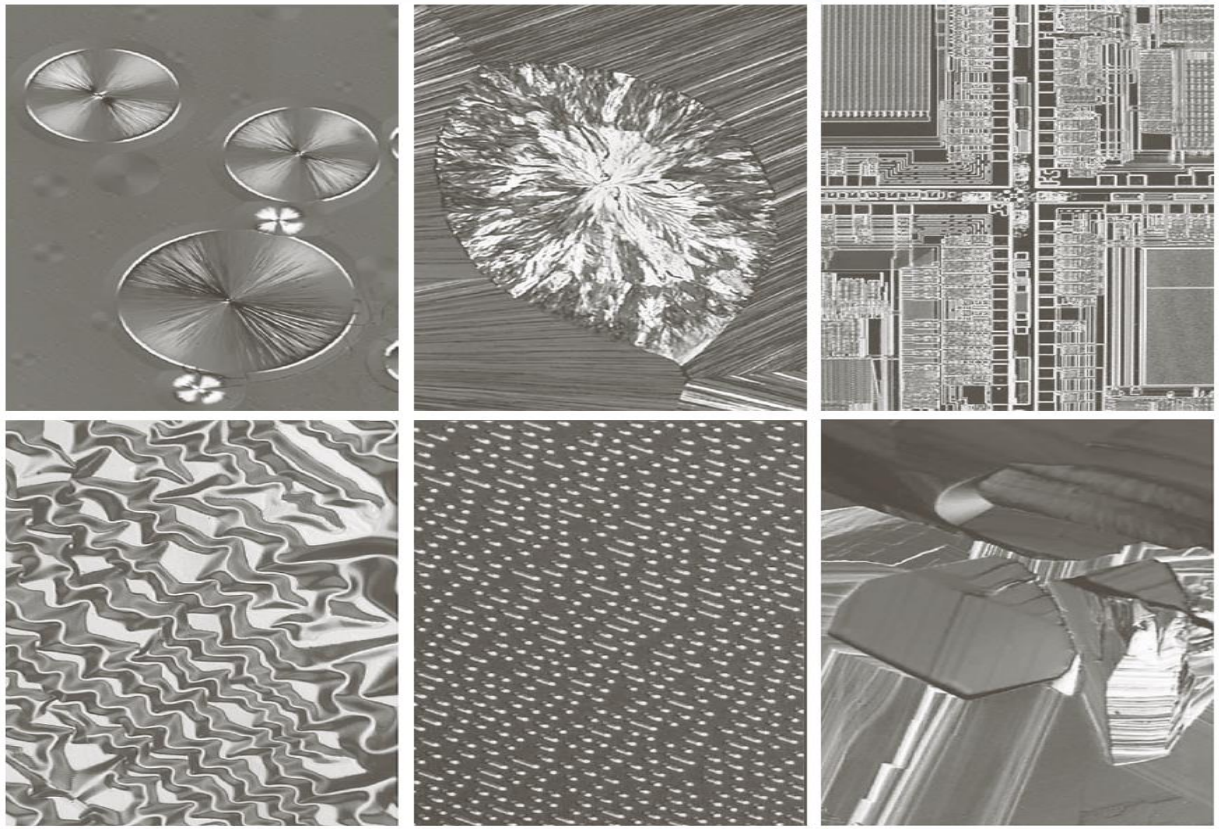
Examples: Ultraviolet Imaging



a b
c

FIGURE 1.8
Examples of ultraviolet imaging.
(a) Normal corn.
(b) Smut corn.
(c) Cygnus Loop.
(Images courtesy of (a) and (b) Dr. Michael W. Davidson, Florida State University,
(c) NASA.)

Examples: Light Microscopy Imaging



a b c
d e f

FIGURE 1.9 Examples of light microscopy images. (a) Taxol (anticancer agent), magnified 250×. (b) Cholesterol—40×. (c) Microprocessor—60×. (d) Nickel oxide thin film—600×. (e) Surface of audio CD—1750×. (f) Organic superconductor—450×. (Images courtesy of Dr. Michael W. Davidson, Florida State University.)

Examples: Visual and Infrared Imaging

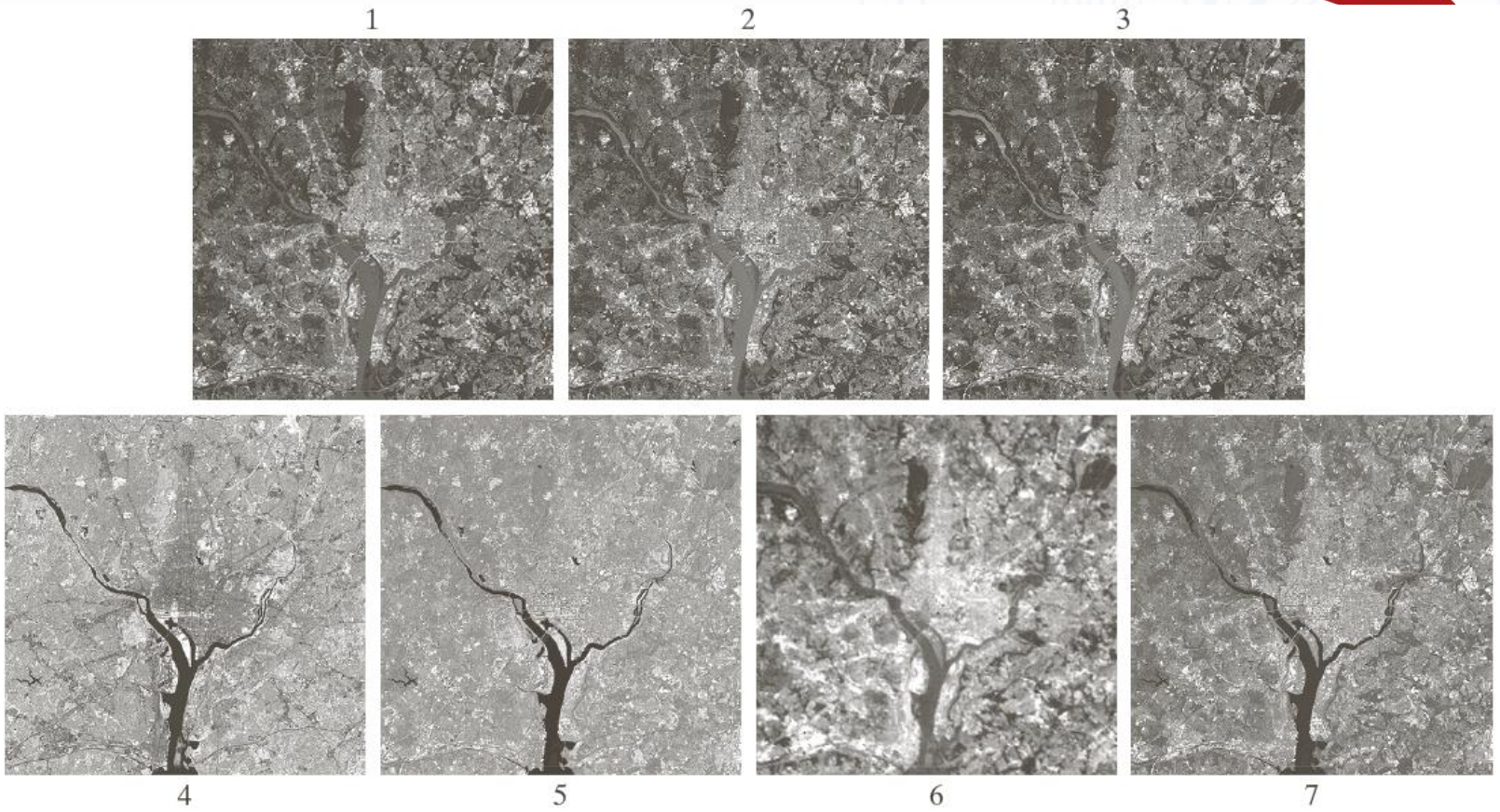


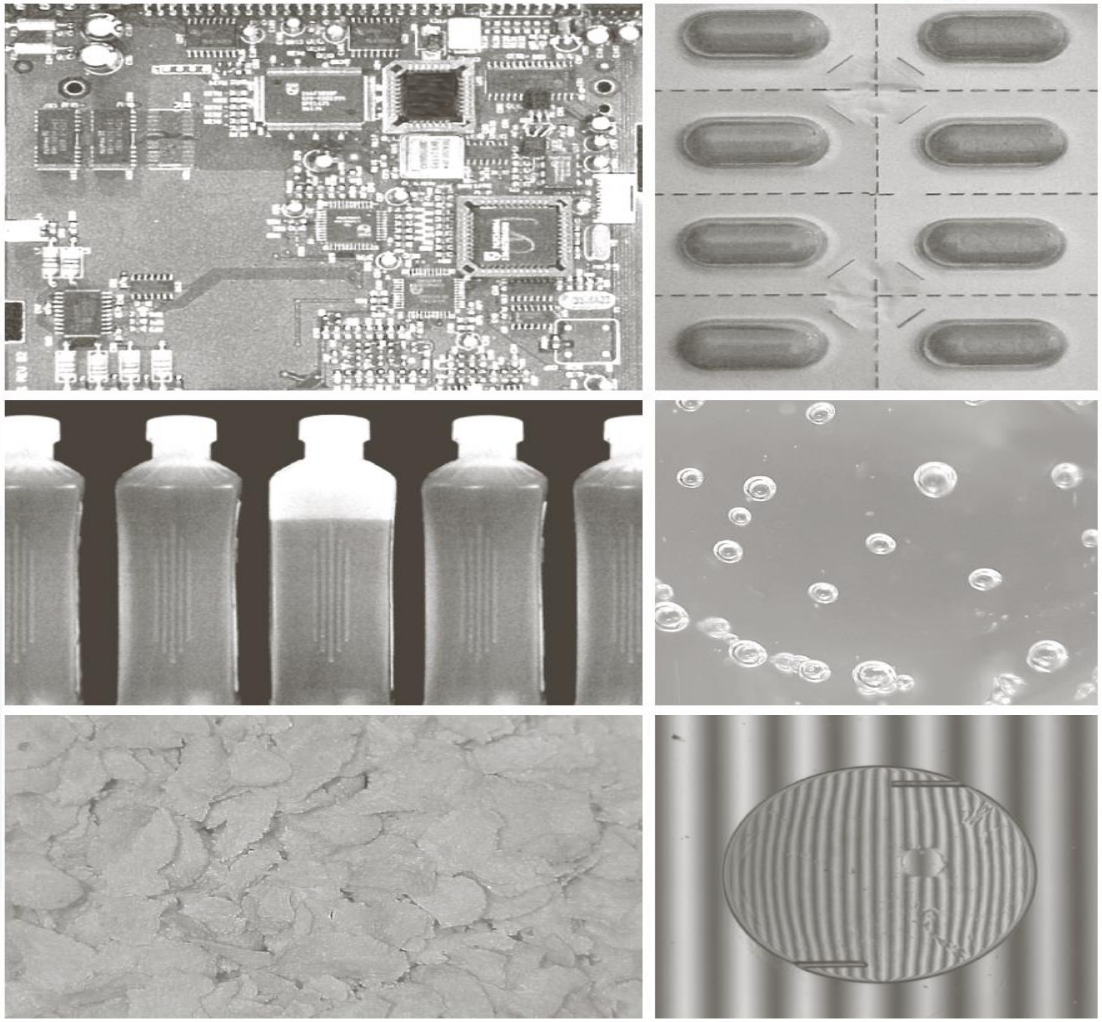
FIGURE 1.10 LANDSAT satellite images of the Washington, D.C. area. The numbers refer to the thematic bands in Table 1.1. (Images courtesy of NASA.)

Examples: Visual and Infrared Imaging

TABLE 1.1
Thematic bands in 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	0.52–0.60	Good for measuring plant vigor
3	Visible red	0.63–0.69	Vegetation discrimination
4	Near infrared	0.76–0.90	Biomass and shoreline mapping
5	Middle infrared	1.55–1.75	Moisture content of soil and vegetation
6	Thermal infrared	10.4–12.5	Soil moisture; thermal mapping
7	Middle infrared	2.08–2.35	Mineral mapping

Examples: Automated Visual Inspection



a b
c d
e f

FIGURE 1.14
Some examples of manufactured goods often checked using digital image processing.
(a) A circuit board controller.
(b) Packaged pills.
(c) Bottles.
(d) Air bubbles in a clear-plastic product.
(e) Cereal.
(f) Image of intraocular implant.
(Fig. (f) courtesy of Mr. Pete Sites, Perceptics Corporation.)

Examples: Automated Visual Inspection

Results of automated reading of the plate content by the system

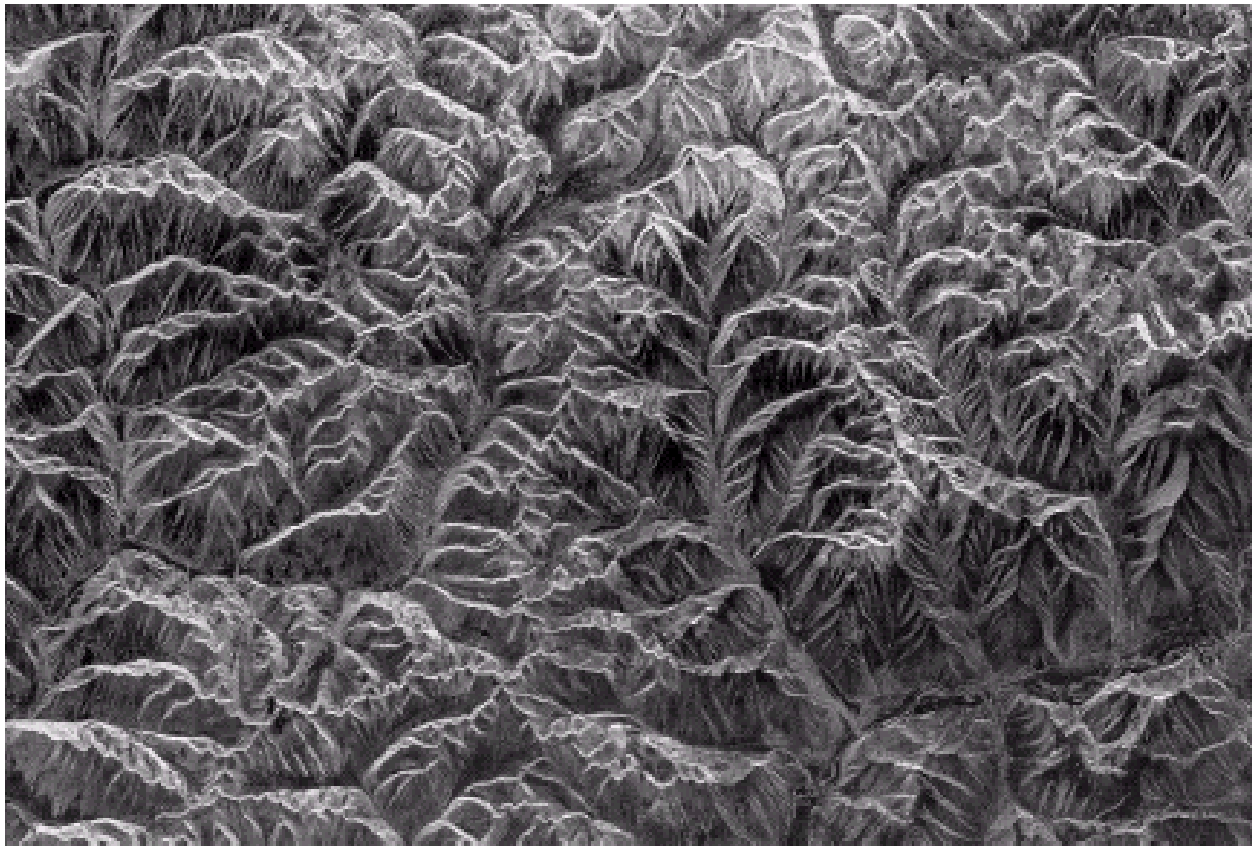
The area in which the imaging system detected the plate

a b
c
d

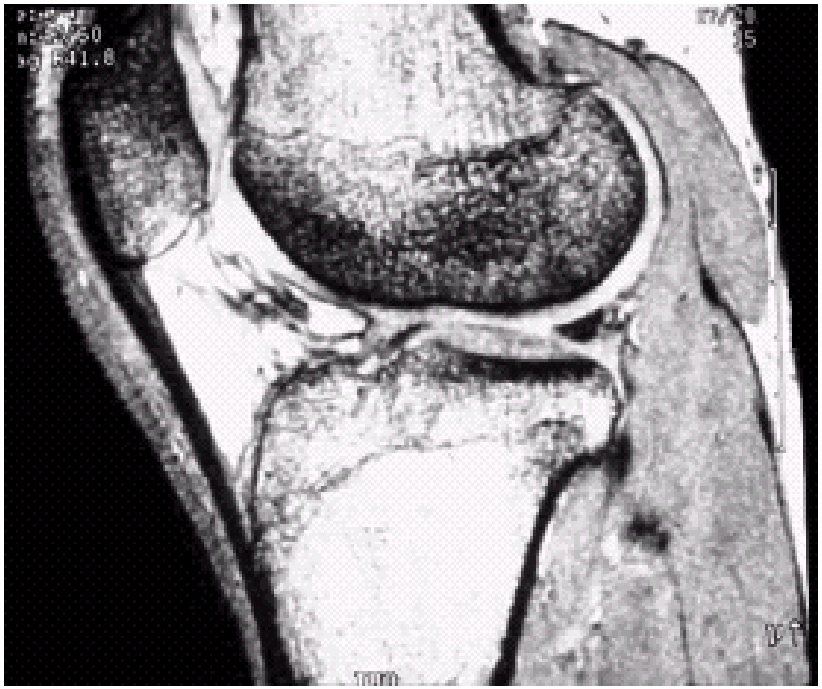
FIGURE 1.15 Some additional examples of imaging in the visual spectrum. (a) Thumb print. (b) Paper currency. (c) and (d) Automated license plate reading. (Figure (a) courtesy of the National Institute of Standards and Technology. Figures (c) and (d) courtesy of Dr. Juan Herrera, Perceptics Corporation.)

Example of Radar Image

FIGURE 1.16
Spaceborne radar image of mountains in southeast Tibet. (Courtesy of NASA.)



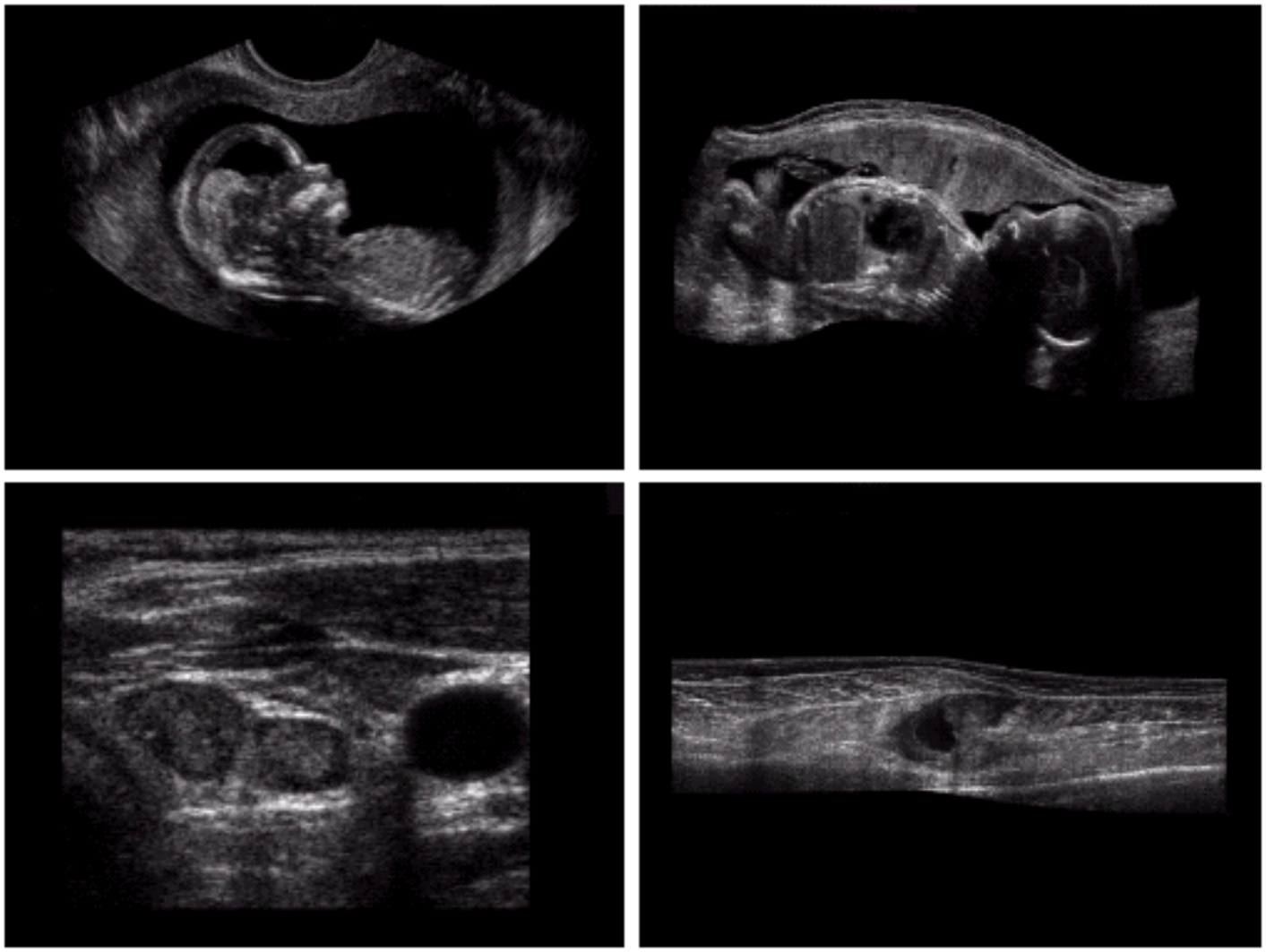
Examples: MRI (Radio Band)



a b

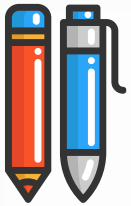
FIGURE 1.17 MRI images of a human (a) knee, and (b) spine. (Image (a) courtesy of Dr. Thomas R. Gest, Division of Anatomical Sciences, University of Michigan Medical School, and (b) Dr. David R. Pickens, Department of Radiology and Radiological Sciences, Vanderbilt University Medical Center.)

Examples: Ultrasound Imaging



a b
c d

FIGURE 1.20 Examples of ultrasound imaging. (a) Baby. (2) Another view of baby. (c) Thyroids. (d) Muscle layers showing lesion. (Courtesy of Siemens Medical Systems, Inc., Ultrasound Group.)



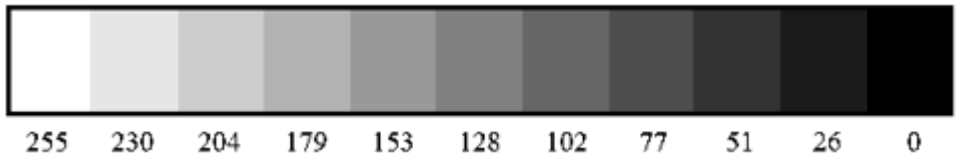
manipulation 8 bit grey colour sample per point shades of grey	操纵8 位灰色 每点样本灰色 的影子			

Types Of Methods Used For Image Processing

- There are two types of methods used for image processing namely, analog and digital image processing.
- **Analog** image processing can be used for hard copies like **printouts** and **photographs.**
- **Digital** image processing techniques help in the **manipulation** of digital images by **using computers**.

What is a Digital Image?(cont…)

- **The range of the colors in 8 bit vary from 0–255 where:**
  - 0 — black
  - 255 — white
  - 127 — grey colour.



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

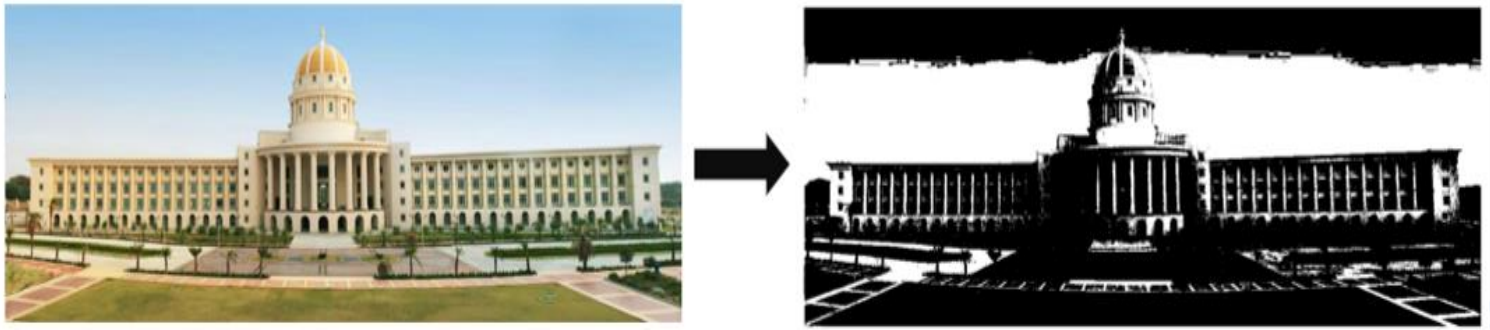
Grayscale

RGB

RGBA

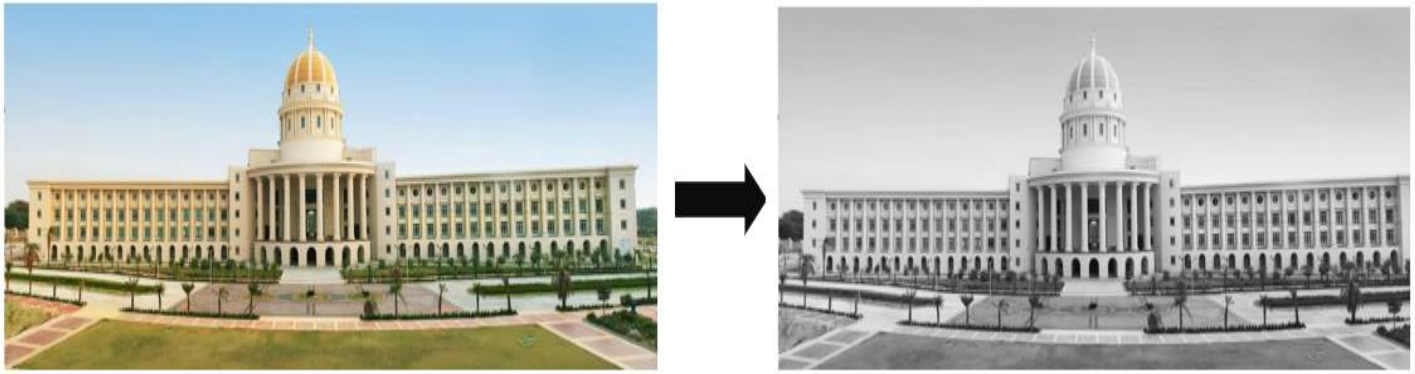
What is a black and white image?

- The image consists of **black and white color** only.



What are greyscale images?

- It is a black and white image, but the name emphasizes that such an image will also include many **shades of grey.**
- The values ranging between **0 and 255**.



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

Why do we process images?

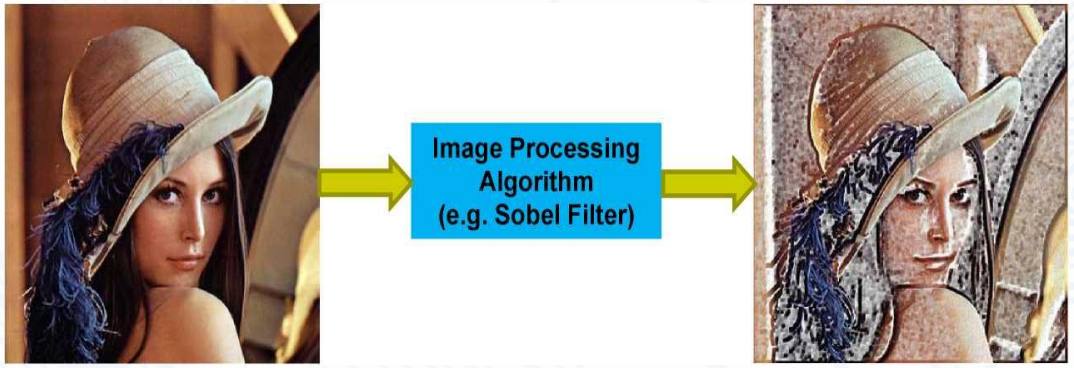
- It has been developed to deal with 3 major problems —
- To improve the **image** data to suppress the unwanted distortions.
- To **enhance** some features of the input **image**.
- As a means of translation between the **human visual system** and **digital imaging devices**.

What is image Processing?

Algorithms that alter an input image to create new image

Input is image, output is image

- Improves an image for human interpretation in ways including:
  - Image display and printing
  - Image editting
  - Image enhancement
  - Image compression



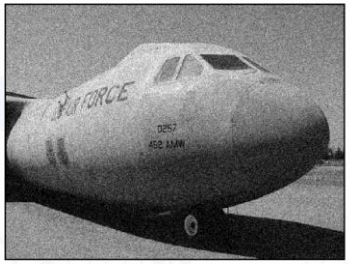
Original Image *Processed Image*

Example Operation:

Noisy Image

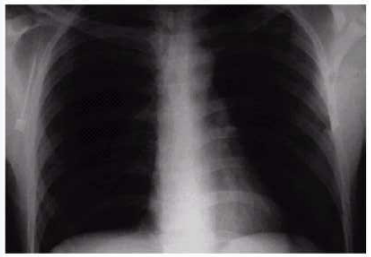
Denoised Image

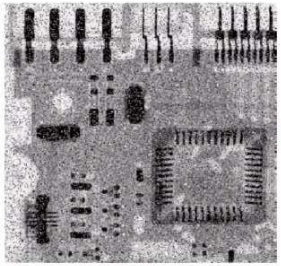
Noise Removal

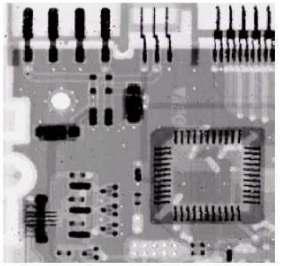


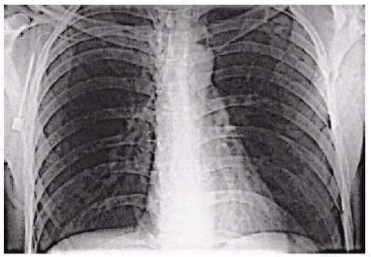
Think of noise as white specks on a picture (random or non-random)

Noise Removal









Example Operation:

Contrast Adjustment

Low Contrast

Original Contrast

High Contrast

Edge Detection

Example Operation:

Region Detection,Segmentation

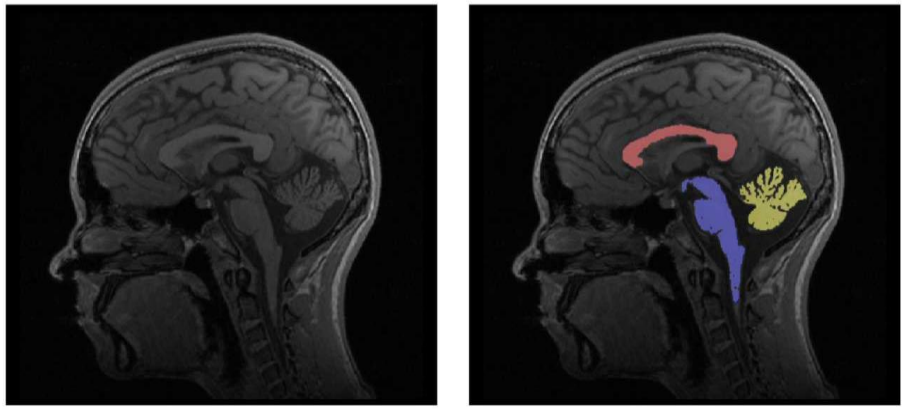


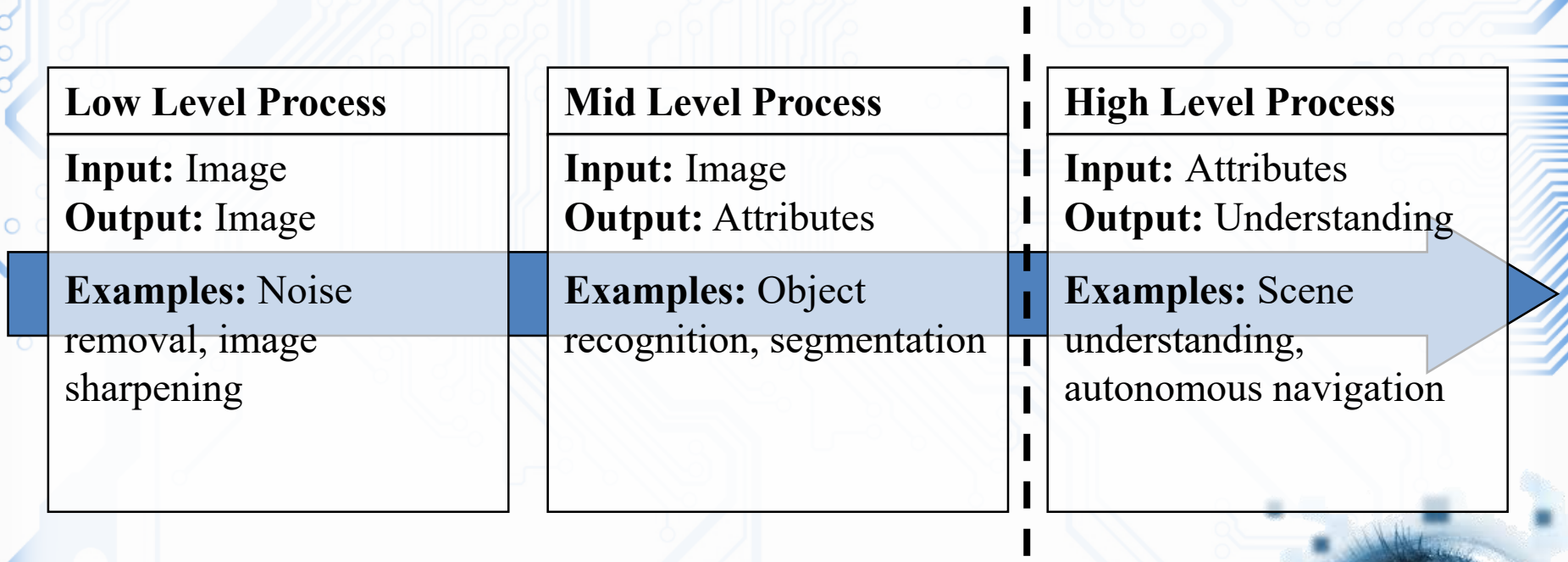
Image Compression

Original, 2.1MB

JPEG Compression, 308KB (15%)

What is DIP? (cont…)

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



In this course we will stop here

History of Digital Image Processing

Early 1920s: One of the first applications of digital imaging was in the news-paper industry

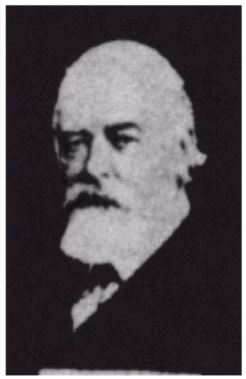
- The Bartlane cable picture transmission service
- Images were transferred by submarine cable between London and New York
- Pictures were coded for cable transfer and reconstructed at the receiving end on a telegraph printer

Early digital image

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



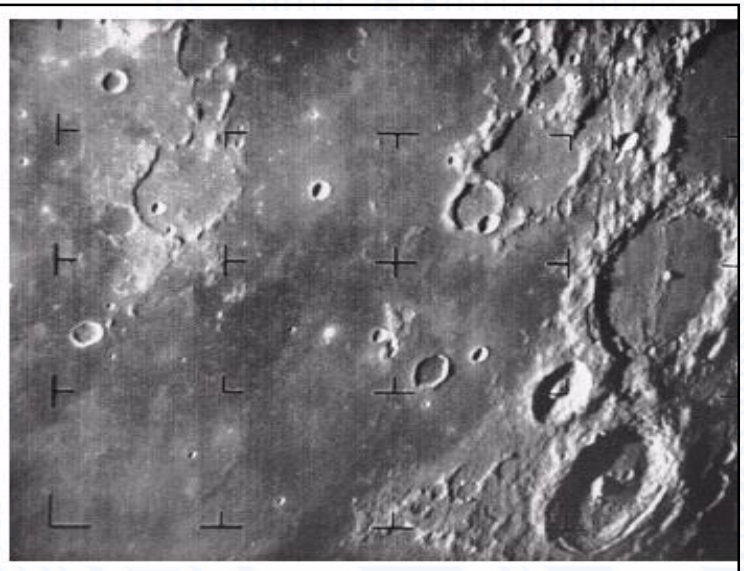
Improved digital image

Early 15 tone digital image

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

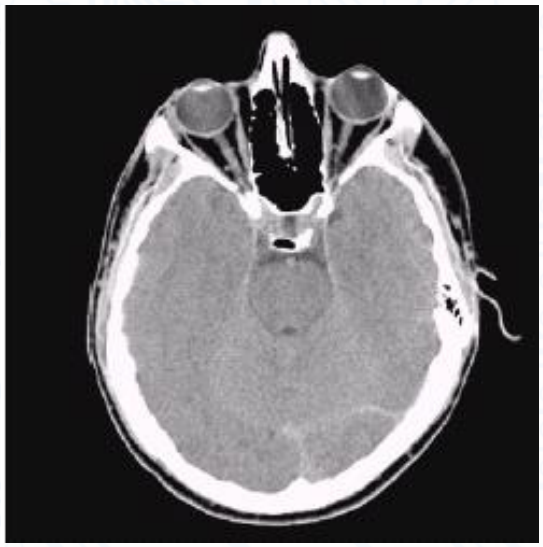


A picture of the moon taken by the Ranger 7 probe minutes before landing

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

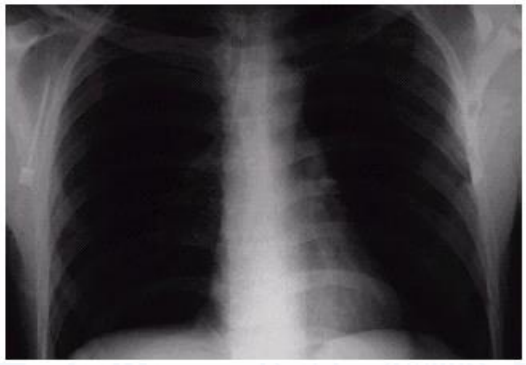
History of DIP (cont…)

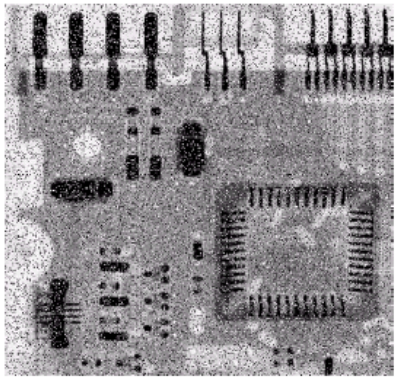
1980s - Today: The use of digital image processing techniques has exploded and they are now used for all kinds of tasks in all kinds of areas

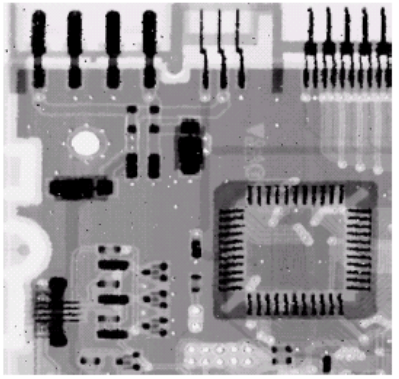
- Image enhancement/restoration
- Artistic effects
- Medical visualisation
- Industrial inspection
- Law enforcement
- Human computer interfaces

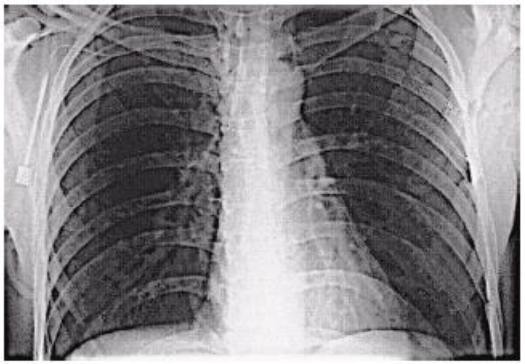
Examples: Image Enhancement

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









Examples: The Hubble Telescope

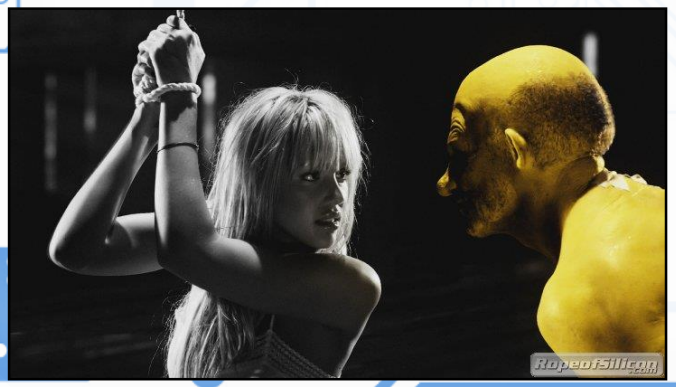
Launched in 1990 the Hubble telescope can take images of very distant objects

However, an incorrect mirror made many of Hubble's images useless

Image processing techniques were used to fix this

Examples: Artistic Effects

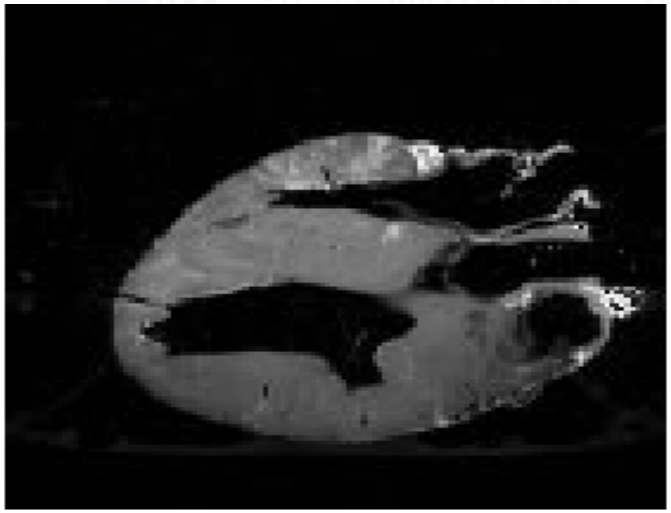
Artistic effects are used to make images more visually appealing, to add special effects and to make composite images



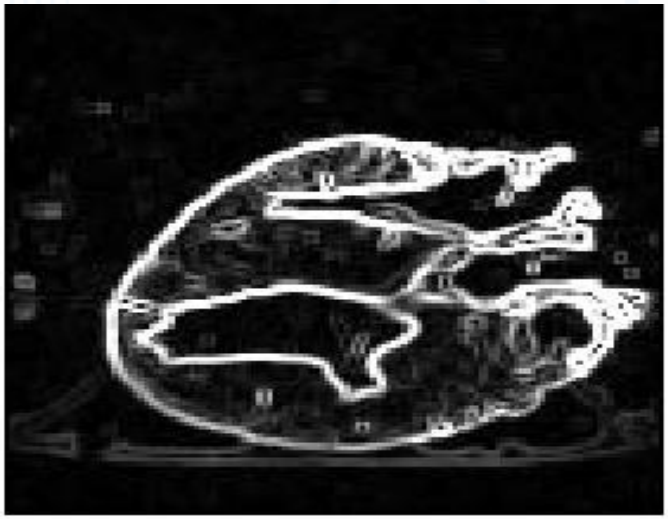
Examples: Medicine

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

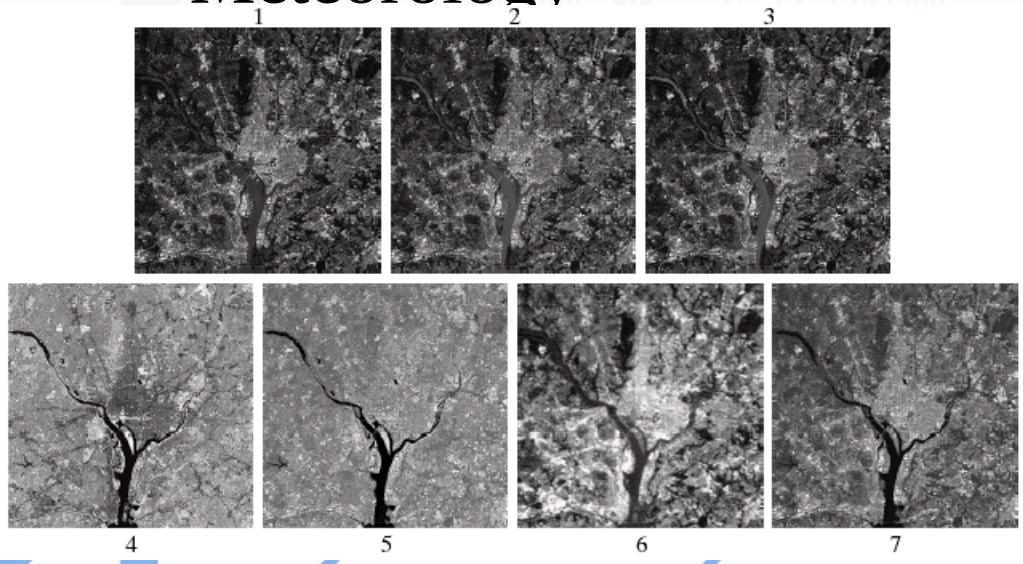


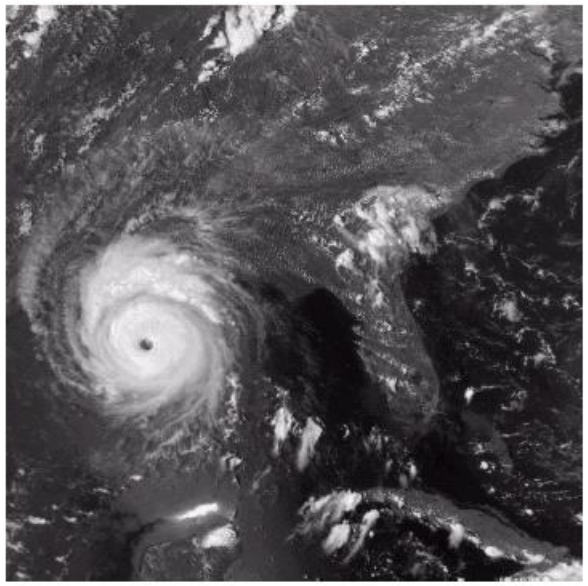
Edge Detection Image

Examples: GIS

Geographic Information Systems

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

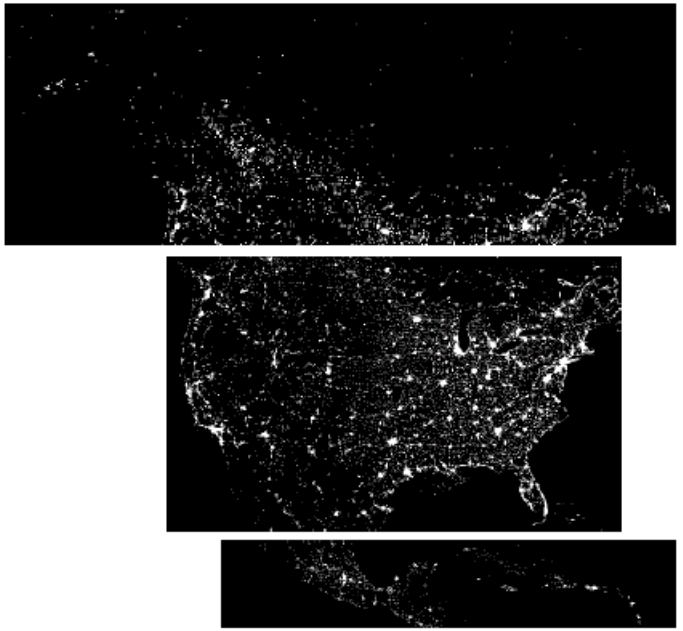




Examples: GIS (cont…)

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



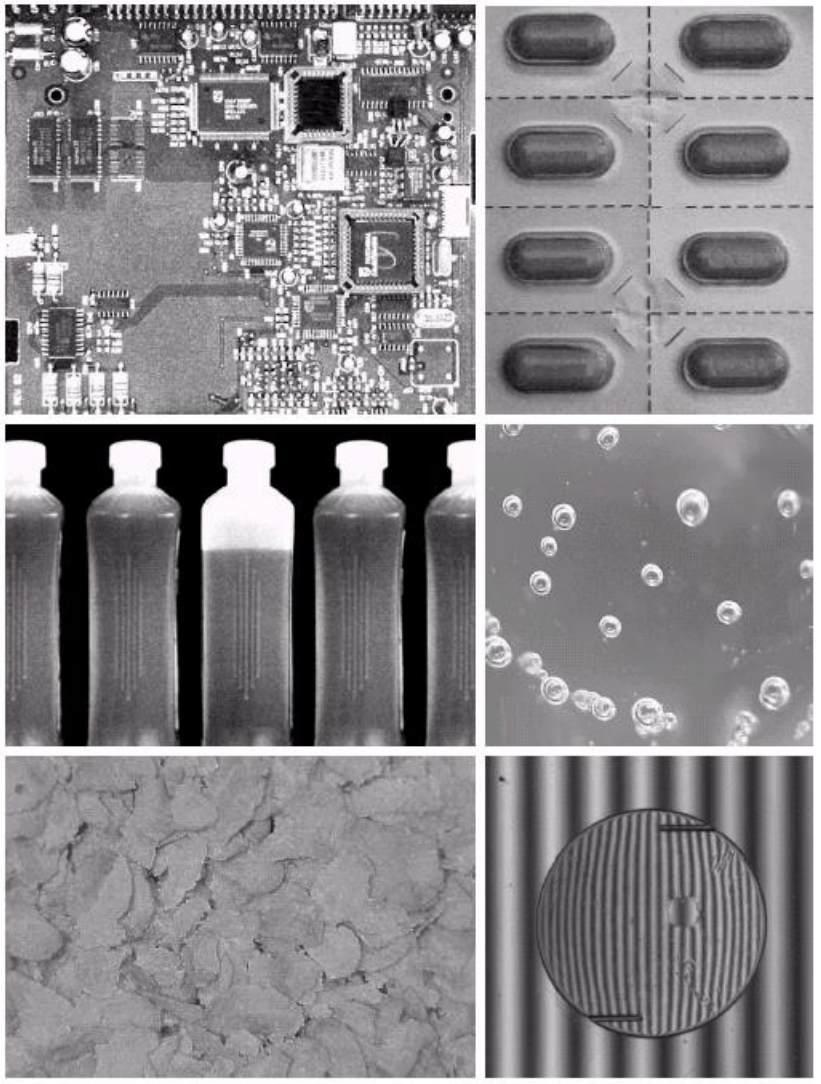
Examples: Industrial Inspection

Human operators are expensive, slow and unreliable

Make machines do the job instead

Industrial vision systems are used in all kinds of industries

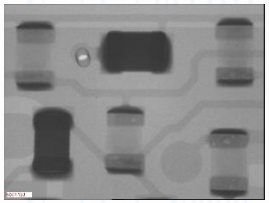
Can we trust them?

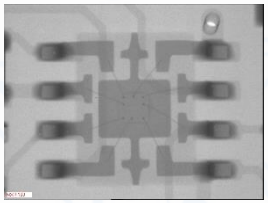


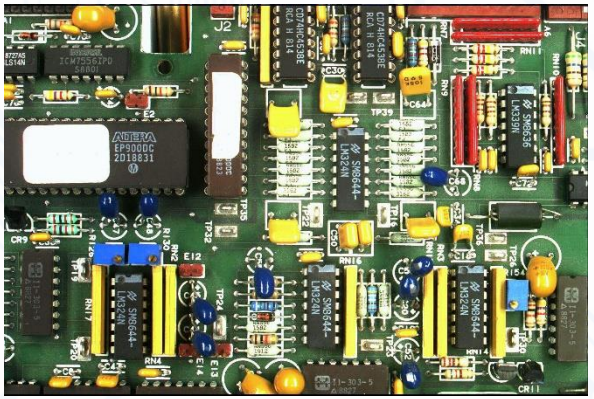
Examples: PCB Inspection

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

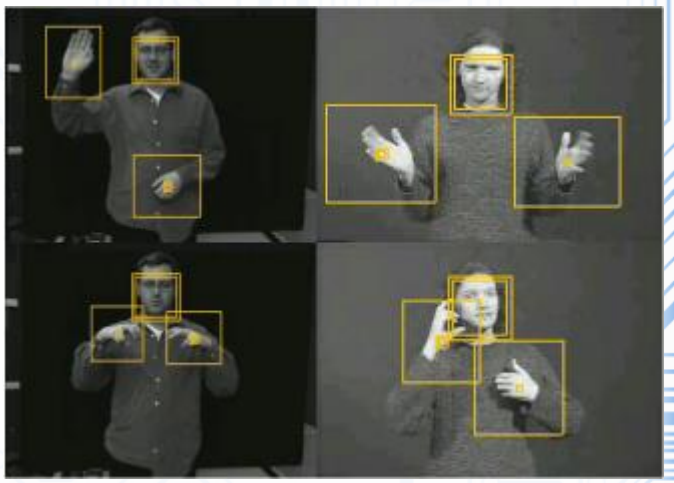
Examples: HCI(HUMAN COMPUTER INTERFACES)

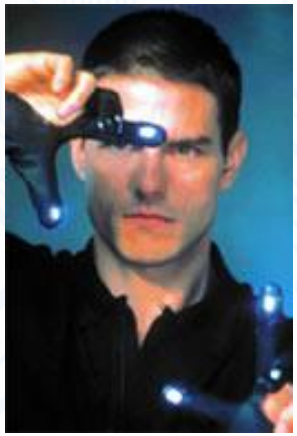
Try to make human computer interfaces more natural

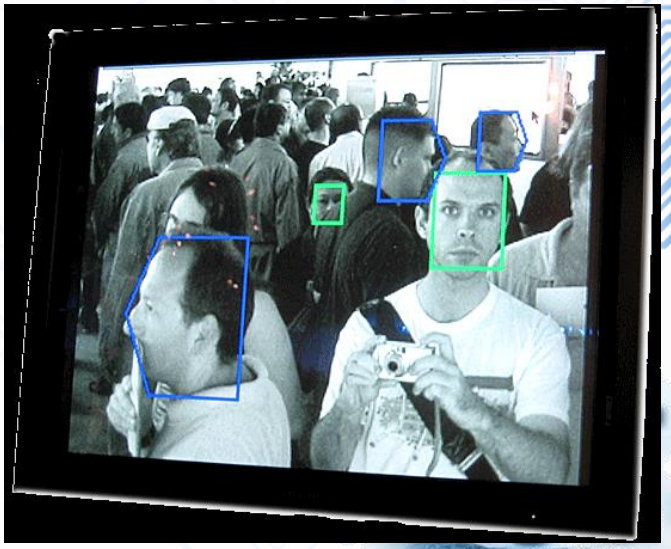
- Face recognition
- Gesture recognition

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

These tasks can be extremely difficult







Reference

- Images Taken From Gonzalez & Woods, Digital Image Processing (2002)
- Wilhelm Burger And Mark J. Burge, Digital Image Processing, Springer, 2008
- University Of Utah, CS 4640: Image Processing Basics,spring 2012
- Gonzales And Woods, Digital Image Processing (3rd Edition), Prentice Hall
- Digital Image Processing Slides By Brian Mac Namee
- Fundamental Steps Of Digital Image Processing,ananta Arora,aug 7, 2019
- Ages Taken From Gonzalez & Woods, Digital Image Processing (2002)

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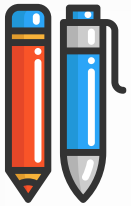
Digital Image Processing

THANK YOU

"The world is not going to change unless we are willing to change ourselves."

RIGOBERTA MENCHÚ TUM
Nobel Peace Prize 1992



"BE HUMBLE. BE HUNGRY. AND ALWAYS BE THE HARDEST WORKER IN THE ROOM."