Digital Image Processing
Chapter 1: Introduction

General Information

- Please do not print out the lecture material – wasting resources
  - If you want it, please print 4 pages in a sheet
- Assignments : present MATLAB code results
  - Always be prepared to present it in the class
  - Upload into the e-class
- Midterm Exam : project proposal
- Final Project : write a survey or a research paper,
  - No copy with figures, experimental results, paragraphs
  - Produce the results your self
  - Survey paper : write the summary of the topic in your terms
  - Research paper : newly written one, not old one

Course Introduction

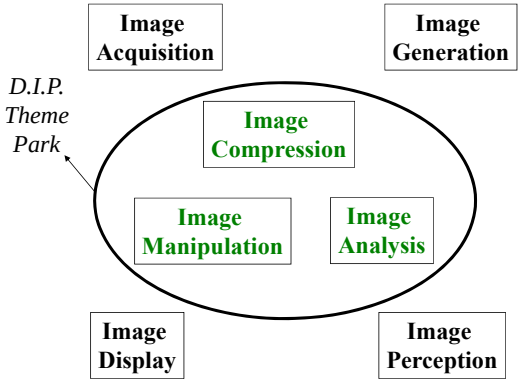
- Instructor: Gueesang Lee
  Email: gslee@jnu.ac.kr

- Research interests:
  Image processing, computer vision, multimedia, video coding
- Suggested textbook:
  - R.C. Gonzalez and R.E. Woods, "Digital Image Processing", 3rd Ed., Prentice-Hall'2007
  - R.C. Gonzalez and R.E. Woods, " Digital Image Processing using MATLAB ", 3rd Ed., Prentice-Hall'2004

Specific Teaching Objectives

- By the end of this semester, you will
  - Know basics of digital image processing including image acquisition, perception, transformation, compression, enhancement, interpolation, restoration, analysis, and so on
  - Be able to use MATLAB to implement basic image processing algorithms and get familiar with some functions provided by MATLAB image processing toolbox

Tour Guide



Digital Images in Early Era

The number of distinct gray levels coded by Bartlane system was improved from 5 to 15 by the end of 1920s

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

(Images from Rafael C. Gonzalez and Richard E. Wood, Digital Image Processing, 2nd Edition.

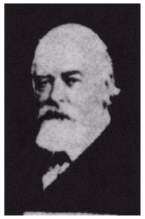
Digital Images in Early Era

1921 Telegraphing image

Newspaper industry used Bartlane cable picture transmission system to send pictures by submarine cable between London and New York in 1920s

Textile industrial Printing industrial

These images are not computerized processed.



1922: image from Photographic reproduction Using punched tape

(Images from Rafael C. Gonzalez and Richard E. Wood, Digital Image Processing, 2nd Edition.

The Born of Digital Computers

- The images in previous slides are digital; but they are NOT considered as the results of DIP
- What do we mean by *Digital Image Processing*
  - Processing digital images by a digital computer
- DIP has been dependent on the development of digital computers and other supporting technologies (e.g., data storage, display and transmission)

Digital Image Processing in Early Space Projects

The first picture of moon by US spacecraft *Ranger 7* on July 31, 1964 at 9:09AM EDT

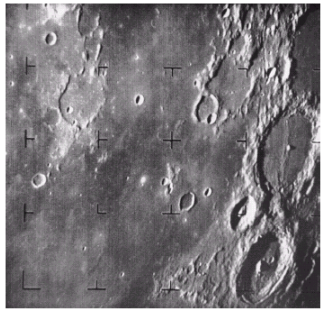


FIGURE 1.4 The first picture of the moon by a U.S. spacecraft. *Ranger 7* took this image on July 31, 1964 at 9:09 A.M. EDT, about 17 minutes before impacting the lunar surface. (Courtesy of NASA.)

(Images from Rafael C. Gonzalez and Richard E. Wood, Digital Image Processing, 2nd Edition.

The Boom of Digital Images in the Last 20 Years

- Acquisition
  - Digital cameras, scanners
  - MRI and Ultrasound imaging
  - Infrared and microwave imaging
- Transmission
  - Internet, wireless communication
- Display
  - Printers, LCD monitor, digital TV

The Born of Computer Tomography

Sir Godfrey N. Housefield and Prof. Allan M. Cormack shared 1979 Nobel Prize in Medicine for the invention of CT

Energy Sources for Images

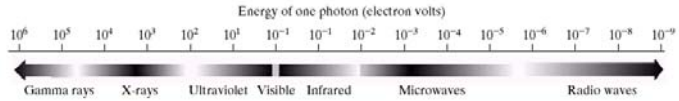


FIGURE 1.5 The electromagnetic spectrum arranged according to energy per photon.

- Extend the capabilities of human vision systems
  - From visible spectrum to non-visible electromagnetic power spectrum
  - From close-distance sensing to remote sensing

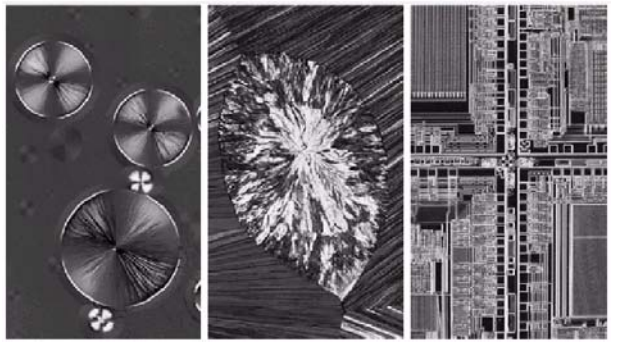
(Images from Rafael C. Gonzalez and Richard E. Wood, Digital Image Processing, 2nd Edition.

Visible (I): Photography

Visible (II): Motion Pictures

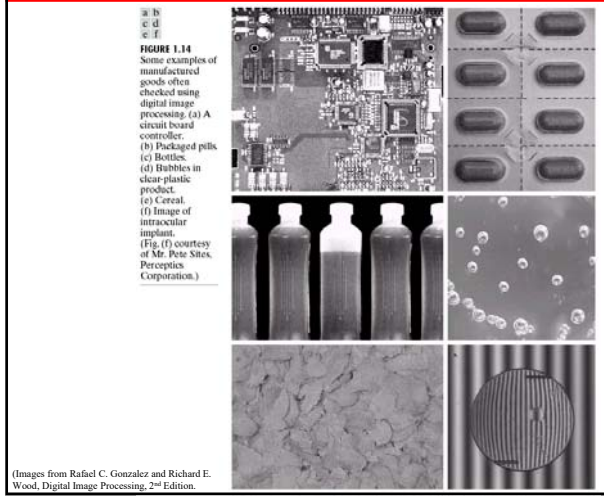
Visible (III): Law Enhancement and Biometrics

Visible (IV): Light Microscopy



Taxol (250×) Cholesterol (40×) Microprocessor (60×)

Automated Visual Inspection



a b
c d
e f

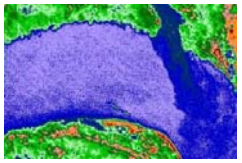
FIGURE 1.14 Some examples of manufactured goods often checked using digital image processing. (a) A circuit board controller. (b) Packaged pills. (c) Bottles. (d) Bubbles in clear-plastic product. (e) Cereal. (f) Image of intraocular implant. (Fig. (f) courtesy of Mr. Pete Sites, Perceptics Corporation.)

(Images from Rafael C. Gonzalez and Richard E. Wood, Digital Image Processing, 2nd Edition.

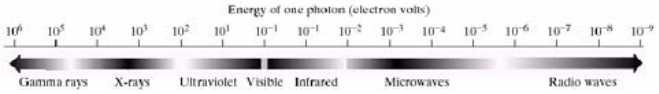
Beyond Visible (I): Thermal Images

Operate in infrared frequency

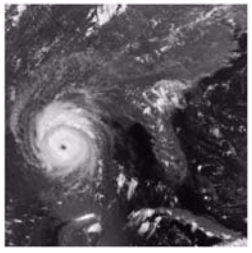
Human body disperses heat (red pixels)



Different colors indicate varying temperatures



Visible (V): Remote Sensing



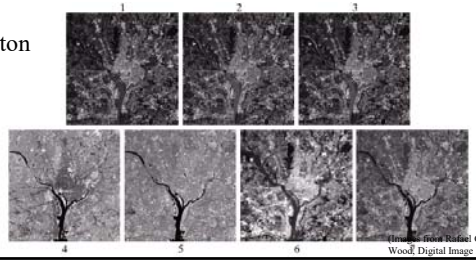
Hurricane Andrew taken by NOAA GEOS

America at night (Nov. 27, 2000)

Visible Light and Infrared

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

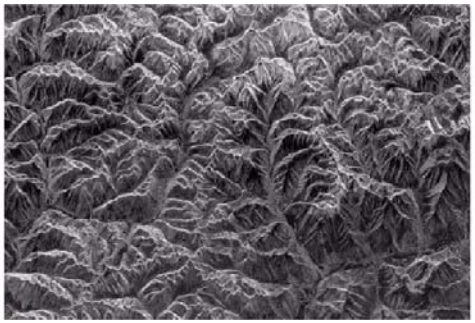
Washington D.C.



(Images from Rafael C. Gonzalez and Richard E. Wood, Digital Image Processing, 2nd Edition.

Beyond Visible (II): Radar Images

Operate in microwave frequency



Moutains in Southeast Tibet

Beyond Visible (III): MRI and Astronomy

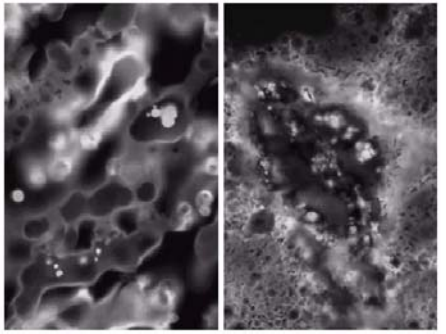
Operate in radio frequency

knee spine head

visible infrared radio

Beyond Visible (IV): Fluorescence Microscopy

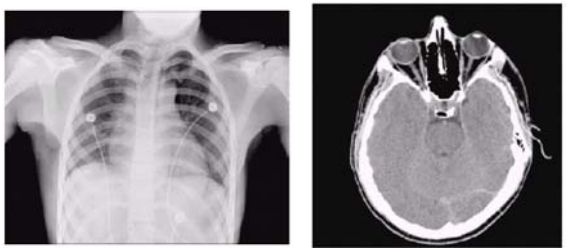
Operate in ultraviolet frequency



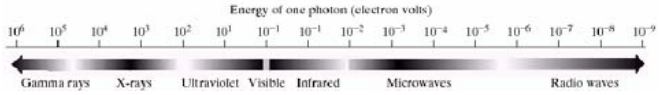
normal corn smut corn

Beyond Visible (V): Medical Diagnostics

Operate in X-ray frequency



chest head



Beyond Visible (VI): PET and Astronomy

Operate in gamma-ray frequency

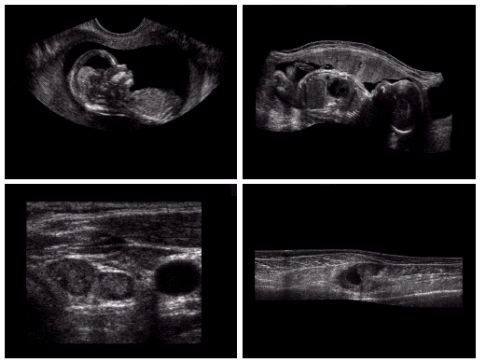
Positron Emission Tomography

Cygnus Loop in the constellation of Cygnus

Other Non-Electro-Magnetic Imaging Modalities

- Acoustic imaging
  - Translate “sound waves” into image signals
- Electron microscopy
  - Shine a beam of electrons through a speciman
- Synthetic images in Computer Graphics
  - Computer generated (non-existent in the real world)

Ultrasound imaging



a b
c d

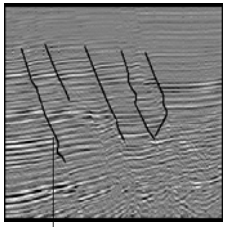
FIGURE 1.20 Examples of ultrasound imaging. (a) Baby. (2) Another view of baby. (c) Thyroids. (d) Muscle layers showing lesion. (Courtesy of Siemens Medical Systems, Inc., Ultrasound Group.)

(Images from Rafael C. Gonzalez and Richard E. Wood, Digital Image Processing, 2nd Edition.

Acoustic Imaging

visible

seismic



potential locations of oil/gas

Seismic imaging

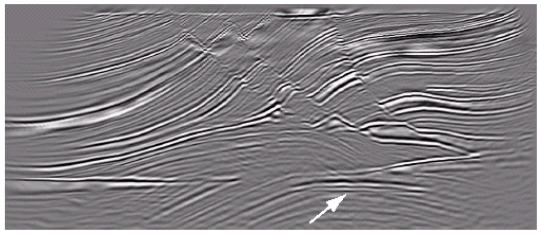
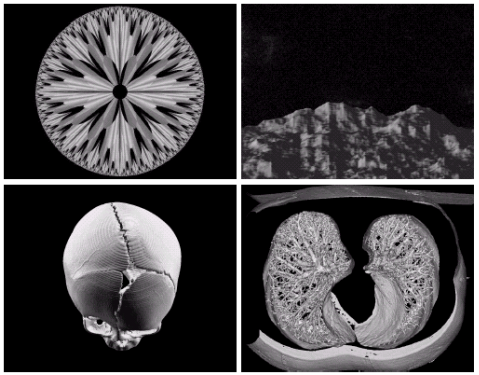


FIGURE 1.19
Cross-sectional image of a seismic model. The arrow points to a hydrocarbon (oil and/or gas) trap. (Courtesy of Dr. Curtis Ober, Sandia National Laboratories.)

- Seismic imaging directs an intense sound source into the ground to evaluate subsurface conditions and to possibly detect high concentrations of contamination.
- Receivers called geophones, analogous to microphones, pick up "echoes" that come back up through the ground and record the intensity and time of the "echo" on computers.
- Data processing turns these signals into images of the geologic structure.

(Images from Rafael C. Gonzalez and Richard E. Wood, Digital Image Processing, 2nd Edition.

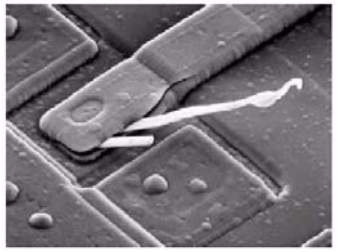
Synthesis Images



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.)

(Images from Rafael C. Gonzalez and Richard E. Wood, Digital Image Processing, 2nd Edition.

Electron Microscope



2500× Scanning Electron Microscopy (SEM) image of damaged integrated circuit
(white fibers are oxides resulting from thermal destruction)

Cartoon Pictures (Non-photorealistic)

Synthetic Images in Gaming

Age of Empire III by Ensemble Studios

Mixture of Graphics and Photos

Morgantown, WV in Google Map

Virtual Reality (Photorealistic)

Summary: Why do we need images?

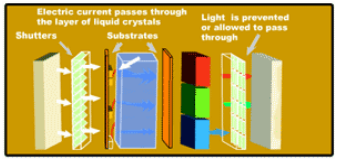
- Various imaging modalities help us to see invisible objects due to
  - Opaqueness (e.g., see through human body)
  - Far distance (e.g., remote sensing)
  - Small size (e.g., light microscopy)
- Other signals (e.g., seismic) can also be translated into images to facilitate the analysis
- Images are important to convey information and support reasoning
- *A picture is worth a thousand words!*

Image Display and Perception

- Display
  - CRT, LCD, DLP, Plasma, LCOS, D-ILA
  - HDTV, display wall
  - PDA, cellular phone, Gameboy
  - Stereoscopic (3D)
- Perception
  - Human Vision System (HVS)
  - Vision-related diseases and healthcare

LCD: Liquid Crystal Display

Philips 42FD9954 Flat Screen LCD Display



Future: bigger, faster, cheaper

LCD Display Advantages	LCD Display Disadvantages
• Good color reproduction • Very thin • Lightweight • Perfect sharpness at native resolution • Excellent longevity • No screen burn-in effect	• Fixed resolution • Notorious "screen door" effect on lesser models • Poor contrast ratios (even excellent units have only 700:1) • Very difficult to produce deep blacks (see above) • Weak and "stuck" pixels are common • Viewing angle on older models may be narrow • Potential for slower refresh rates than plasma (some newer models are getting better)

CRT: Cathode Ray Tube

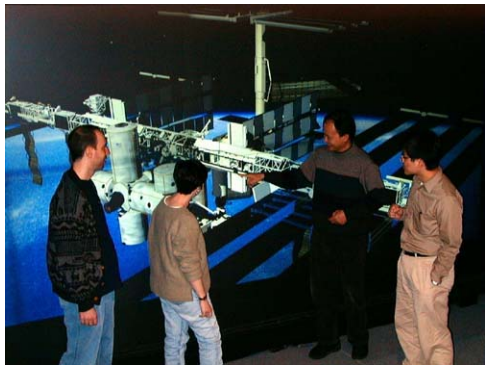
Mitsubishi WS-55813
Rear Projection CRT

Sony KV34XBR910
Direct View CRT

CRT Direct View/Rear Projection Advantages	CRT Direct View/Rear Projection Disadvantages
• Among the brightest and clearest alternatives • Excellent color and contrast potential • Relatively inexpensive • Excellent life expectancy	• Heavy • Very deep • Analogue connectivity or D/A conversion of digital input connections • Potential for screen burn-in

Future: extinction

Virtual Wall



NASA Space Shuttle on the display wall, March 1999

Display on Mobile Devices

cell phone

Gameboy

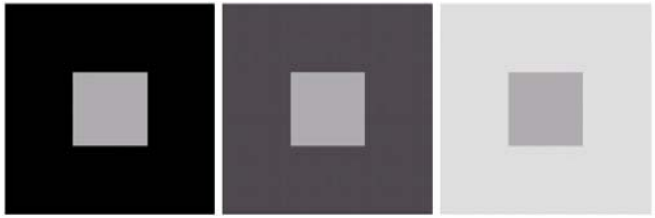
portable DVD

PDA

The Ultimate Display: Virtual Retinal Display

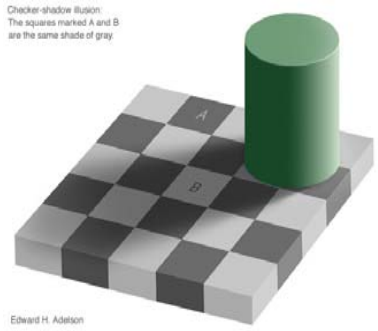
3D Display

Human Vision System



Simultaneous contrast

Fascinating Optical Illusions

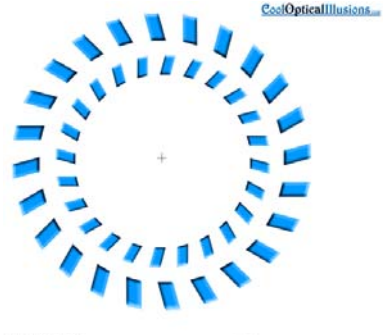


Interpretation Ambiguity

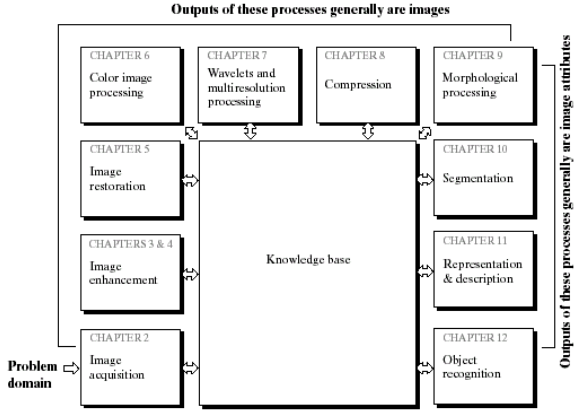
Is it seal or donkey?

Is it duck or hare?

Fascinating Optical Illusions



Contents in the book



(Images from Rafael C. Gonzalez and Richard E. Wood, Digital Image Processing, 2nd Edition.