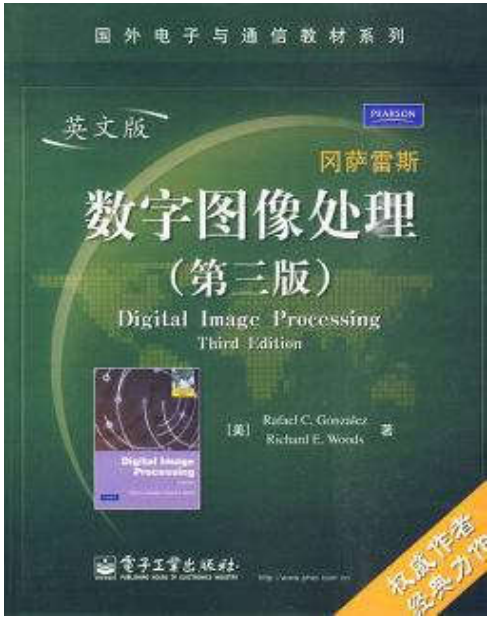
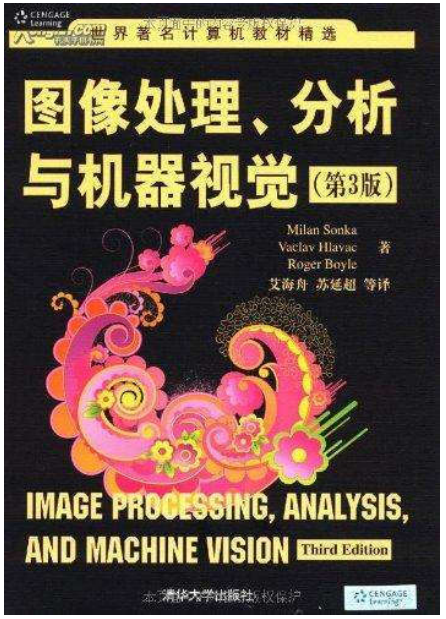
References: Books

- R. C. Gonzales，《 数字图像处理》电子工业出版社
- 《图像处理、分析与机器视觉》， Milan Sonka著，清华大学出版社





Signals

- A *function* containing *information* about the behavior or nature of some phenomenon of interest.
- In the physical world, any quantity exhibiting variation in time and/or space is potentially a signal.

Analog vs Digital Signals

Analog vs Digital Signals

Types of Images

Images and Videos

- 1D: tones, speech, audio, biomedical, remote sensing, etc
- 2D: text, grayscale, color, multispectral, hyperspectral images, etc
- 3D: video, 3D volume, etc
- MD: video of a volume, etc

Digital image

162	161	159	161	162	160	158	156	156	161
162	161	159	161	162	160	158	156	156	161
163	158	159	159	160	158	155	155	156	158
159	157	159	156	159	159	154	152	155	153
155	157	156	156	158	157	156	155	154	156
156	157	155	151	157	156	155	156	156	154
157	156	156	156	156	156	154	156	155	155
158	157	155	155	156	155	155	155	155	155
156	155	156	153	156	155	156	155	154	156
155	155	157	154	157	155	157	158	158	158

The pixels in the top left corner (10*10)

gray image

Digi

64	63	75	95	157	99
120	135	55	75	116	67
99	132	60	54	100	75
64	150	113	50	81	138
110	130	162	60	76	109
97	82	179	81	74	113

150	57	43	94	140	97
125	97	35	72	86	52
74	118	41	46	106	58
79	144	98	51	89	127
84	132	132	46	83	84
84	80	166	53	77	97

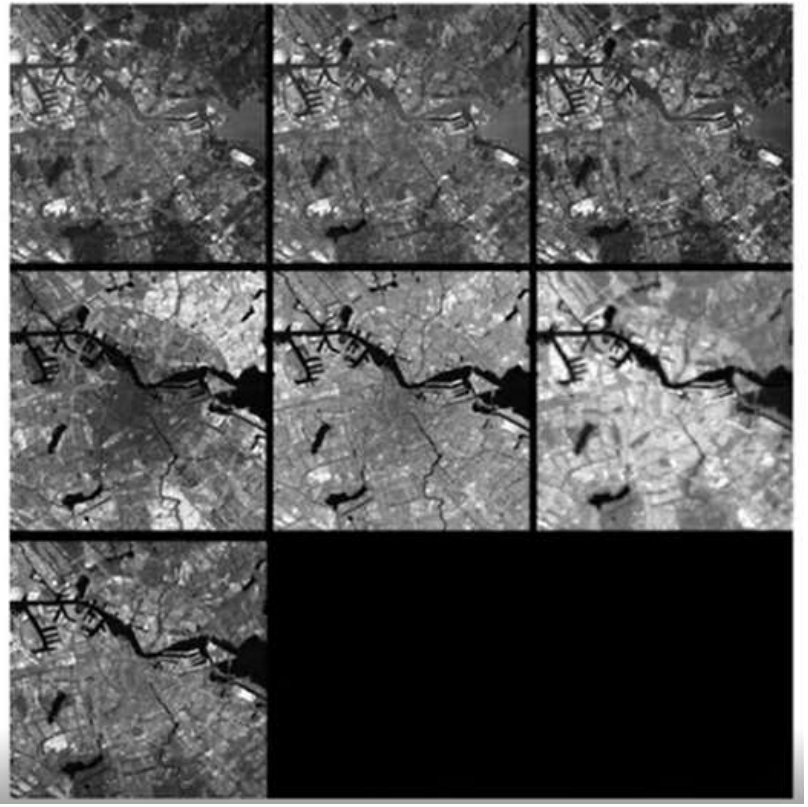
Color image

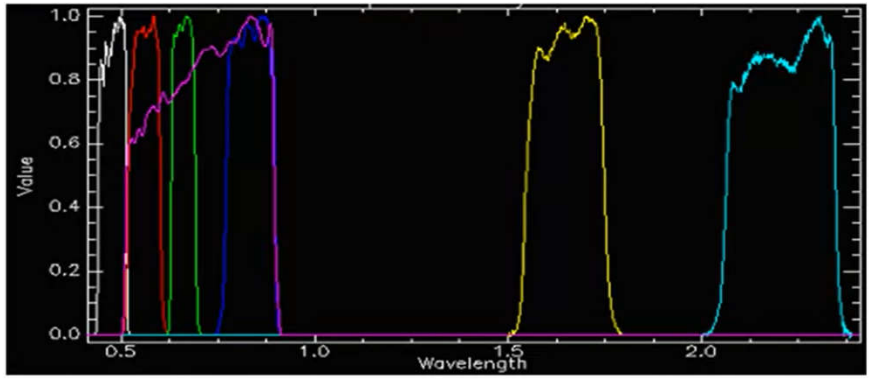
71	31	10	46	73	33
62	33	23	24	46	34
31	46	36	29	51	30
48	57	35	28	54	36
39	46	52	42	40	48
29	39	69	46	42	43

Pixels in RGB components

Left top (6*6)

LANDSAT Multi-Spectral Images





Color	LANDSAT ETM+ band
White	1 (0.45 µm to 0.515 µm)
Red	2 (0.525 µm to 0.605 µm)
Green	3 (0.63 µm to 0.69 µm)
Blue	4 (0.75 µm to 0.9 µm)

Color	LANDSAT ETM+ band
Yellow	5 (1.55 µm to 1.75 µm)
Not shown	6 (10.4 µm to 12.5 µm)
Cyan	7 (2.08 µm to 2.35 µm)
Magenta	Pan (0.51 µm to 0.9 µm)

LANDSAT Multi-Spectral Images

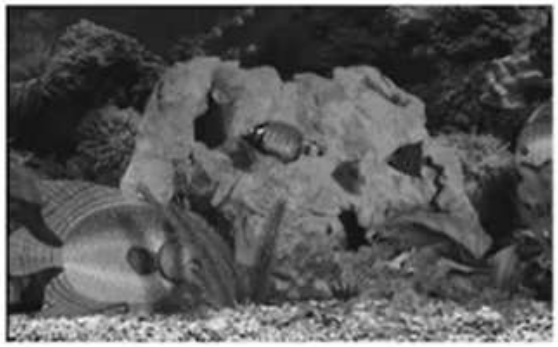
Bands 1-2-3

Bands 4-3-2

Bands 7-4-2

Stereo Images and Disparity

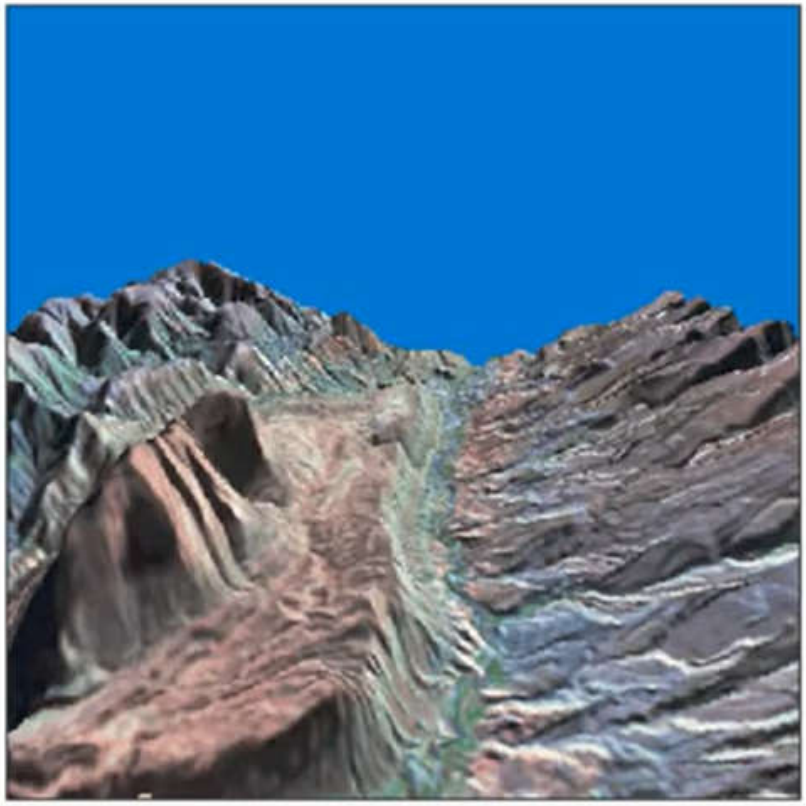
Left camera



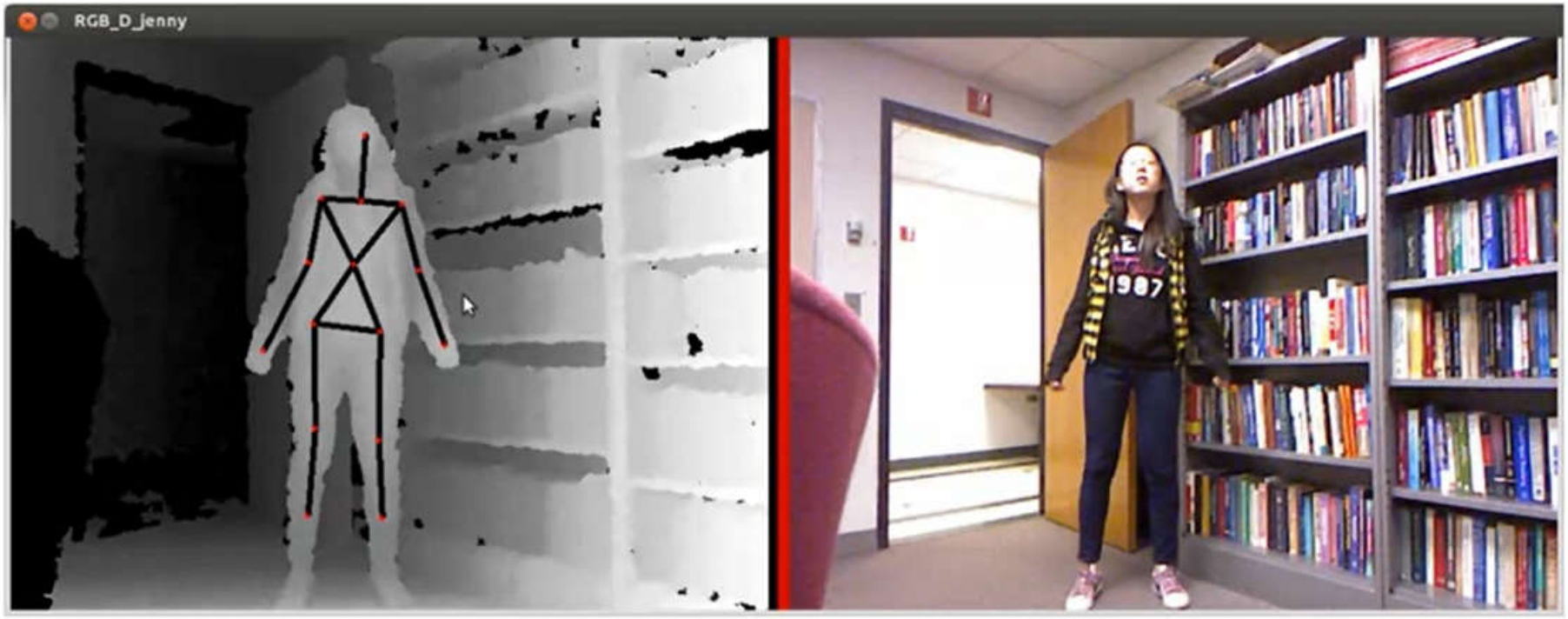
Right camera

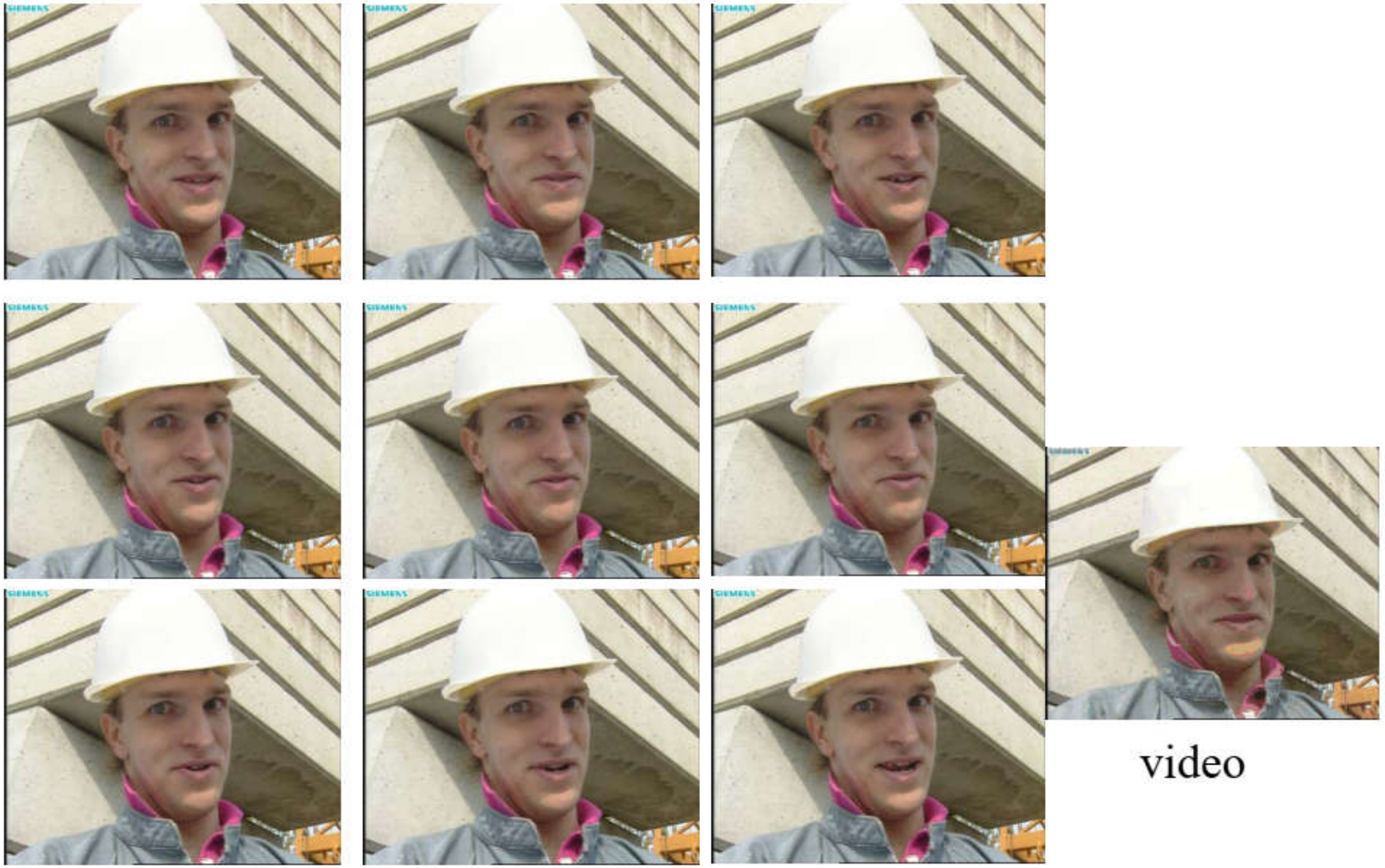
Disparity Map

LANDSAT Stereo



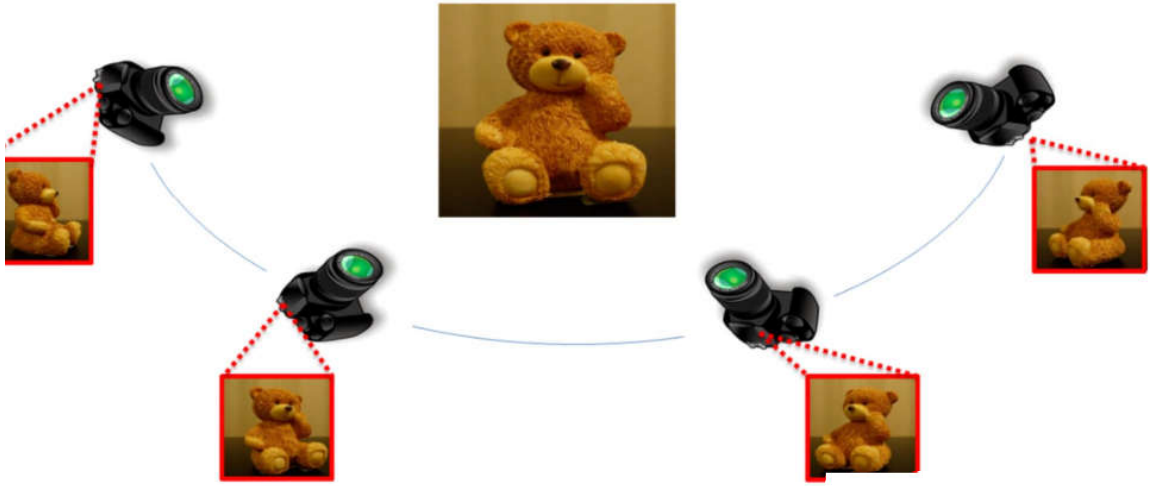
Kinect Images

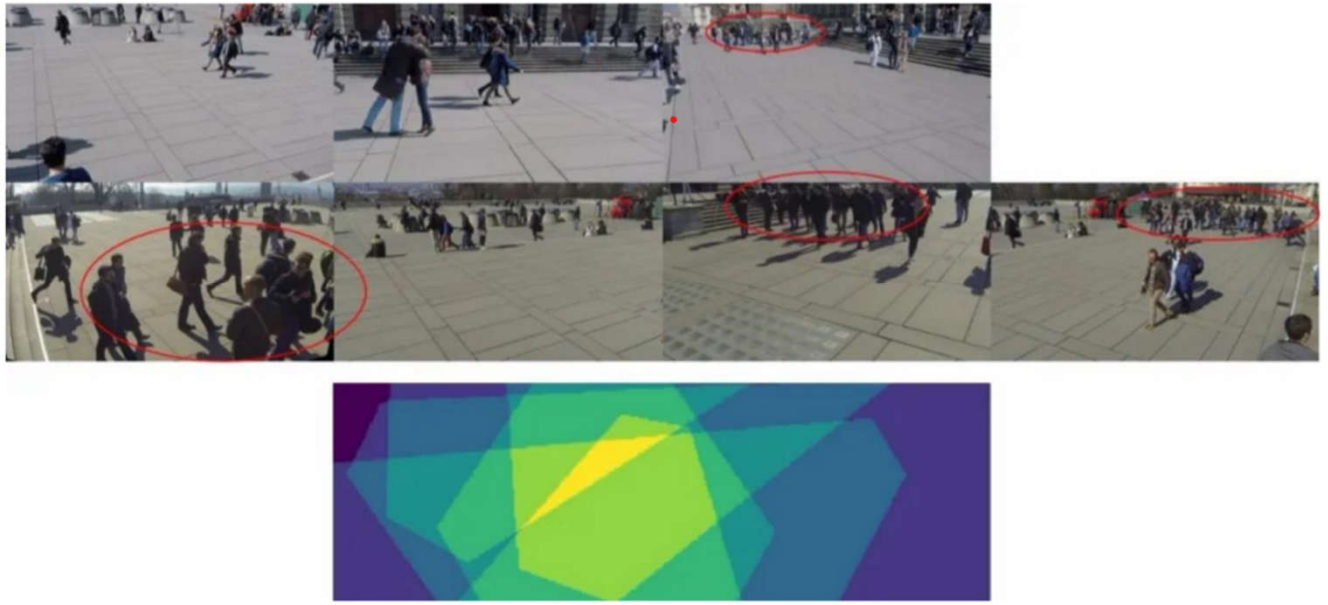




video

Multi-Camera Imaging



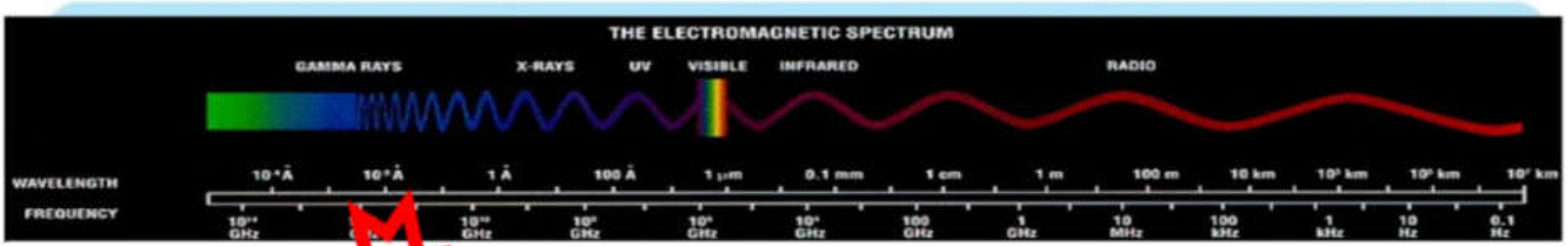


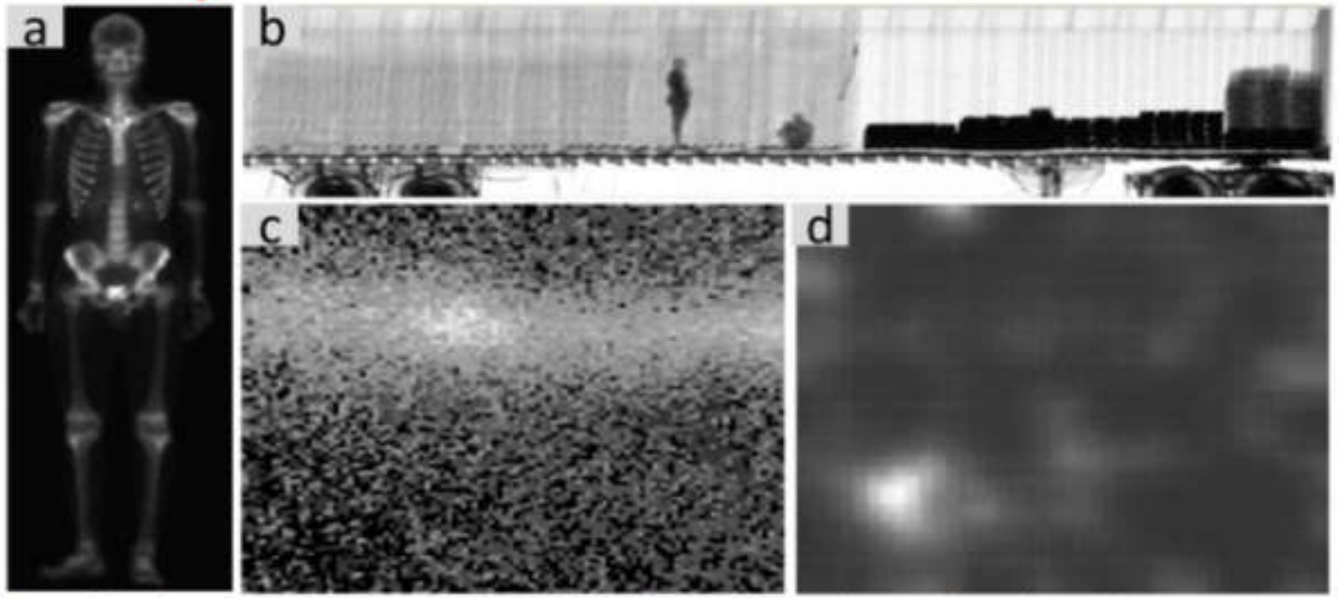
Types of Images

- Based on radiation from the EM spectrum
- Acoustic/ultrasonic
- Electronic
- Synthetic

Types of Images

- Reflection Images
  - information primarily about object surfaces
  - Optical imaging, radar, sonar, laser
- Emission Images
  - Information primarily internal to the object
  - Thermal, infrared, MRI
- Absorption Images
  - Information primarily about the internal structure to the object
  - X-rays, transmission microscopy, types of sonic images



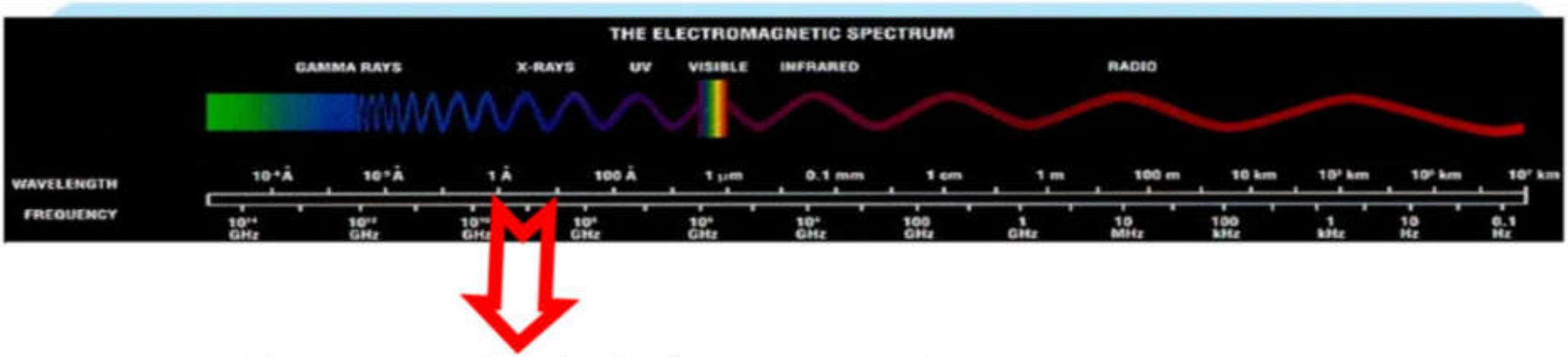


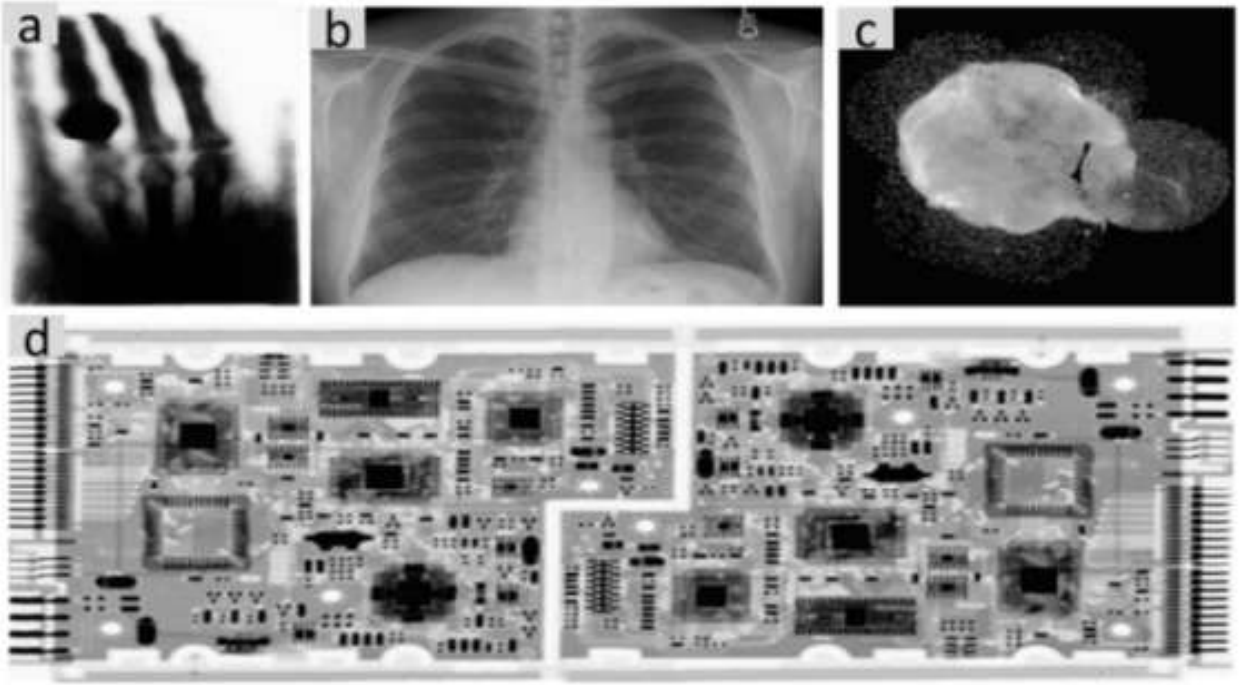
Examples of gamma-ray imaging. (a) Bone scan. (b) Gamma ray image of a truck. (c) Cygnus Loop. (d) Gamma radiation (bright spot) from a reactor valve

Images courtesy of (a) G.E. Medical Systems, (c) NASA, (d) Professors Zhong He and David K.Wehe, University of Michigan.

(a)(c)(d) Gonzalez & Woods, Digital Image Processing, 3rd edition

(b) U.S. Customs and Border Protection

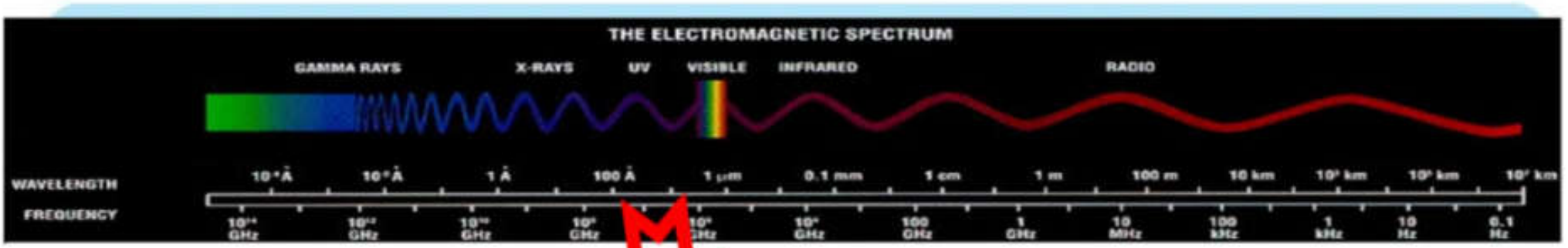




Examples of X-ray imaging. (a) X-ray of hand with a ring. (b) Chest X-ray. (c) Cygnus Loop. (d) Circuit boards.
Images courtesy of (c) NASA, and (d) Mr. Joseph E. Pascente, Lixi, Inc.

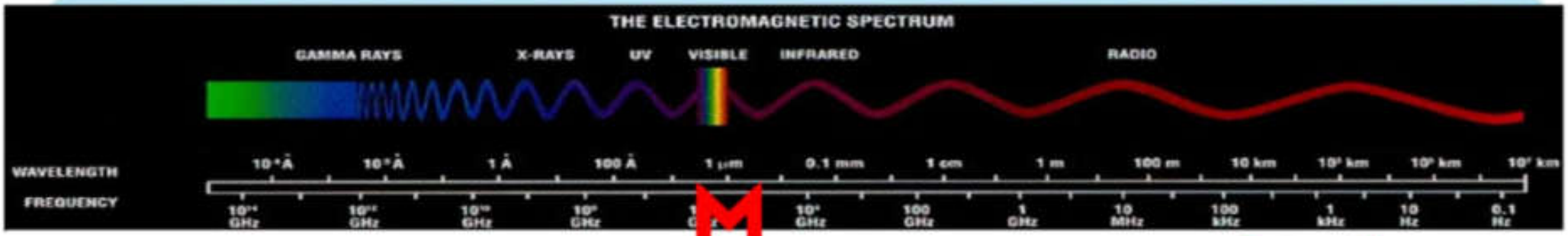
(a) NASA

(c)(d) Gonzalez & Woods, Digital Image Processing, 3rd edition

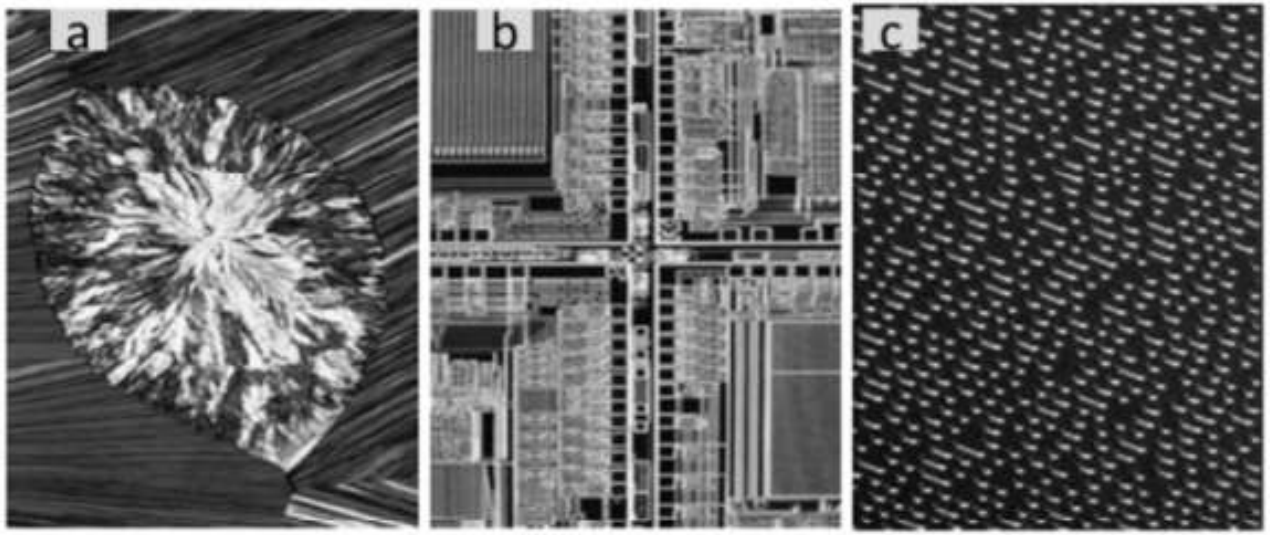


Lithography, industrial inspection, fluorescence microscopy, lasers, biological imaging, astronomical observations

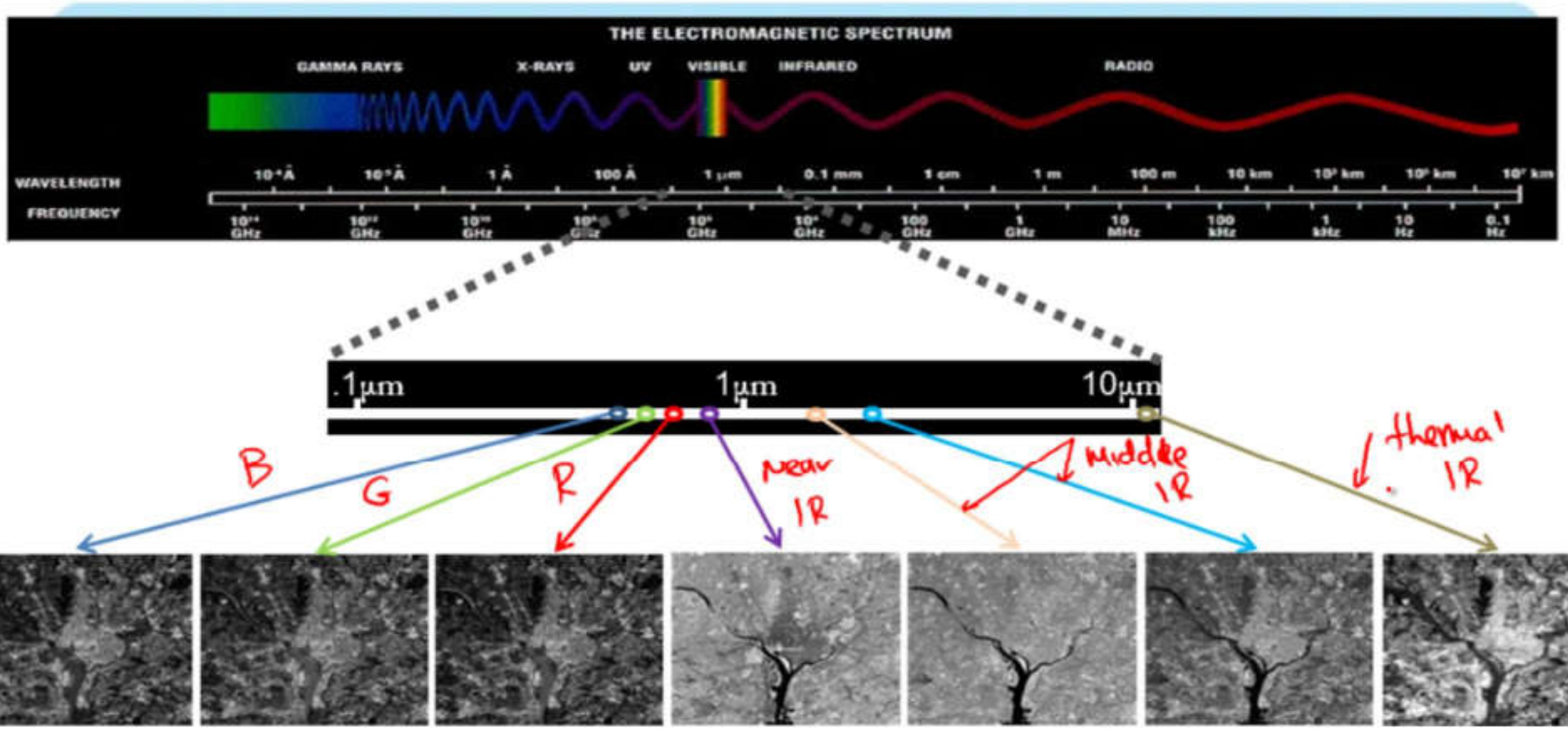
Ultraviolet image of the globular cluster NGC 1851 in the southern constellation Columba (NASA).



390-700 nm
430-790 THz

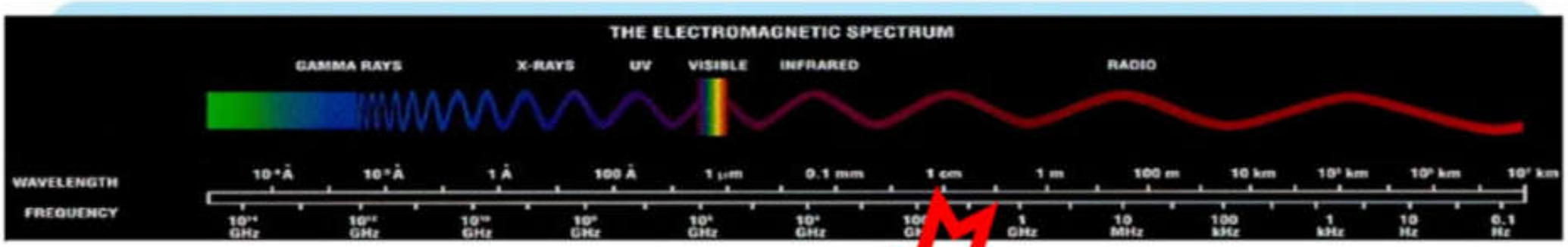


Examples of light microscopy images. (a) Cholesterol-40x. (b) Microprocessor-60x. (c) Surface of audio CD-1750x.
Images courtesy of Dr. Michael W. Davidson, Florida State University.
(a)(b)(c) Gonzalez & Woods, Digital Image Processing, 3rd edition

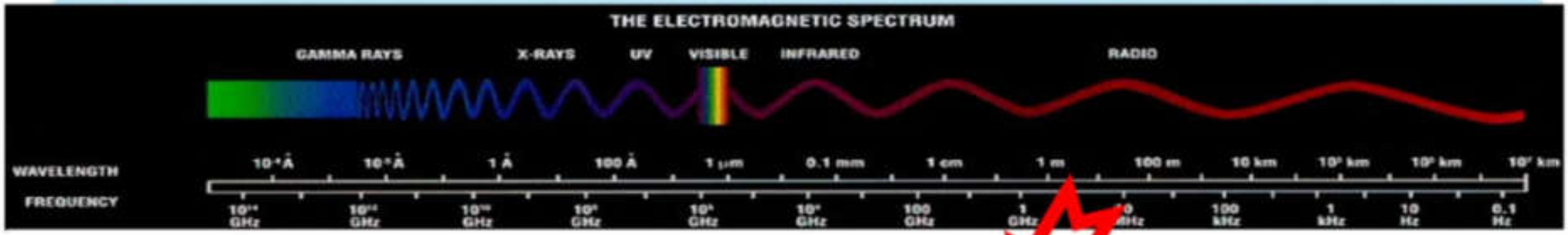


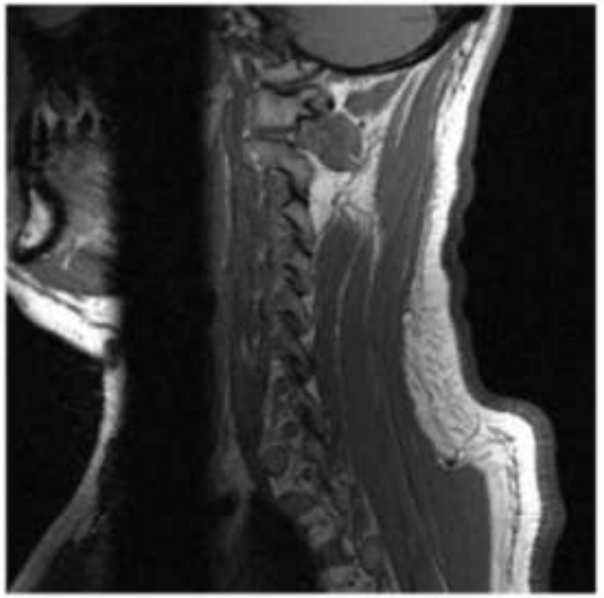
LANDSAT satellite images of the Washington, D.C. area. Images courtesy of NASA

Gonzalez & Woods, Digital Image Processing, 3rd edition



Death Valley as seen from the Space Shuttle's synthetic aperture radar instrument (NASA).



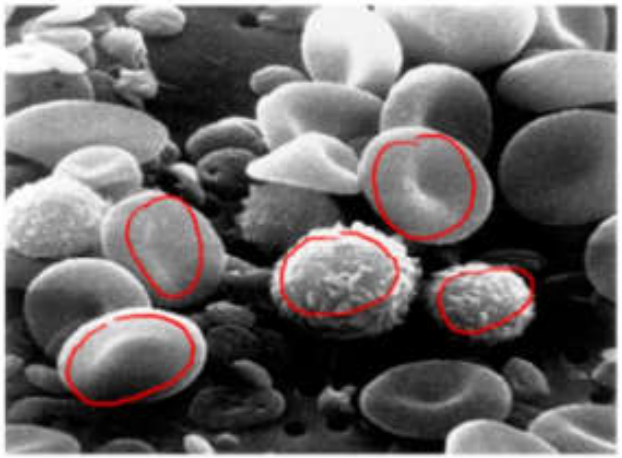


MRI image of a human spine

Ultrasound Images

Example of ultrasound imaging.
Embryo at 14 weeks.

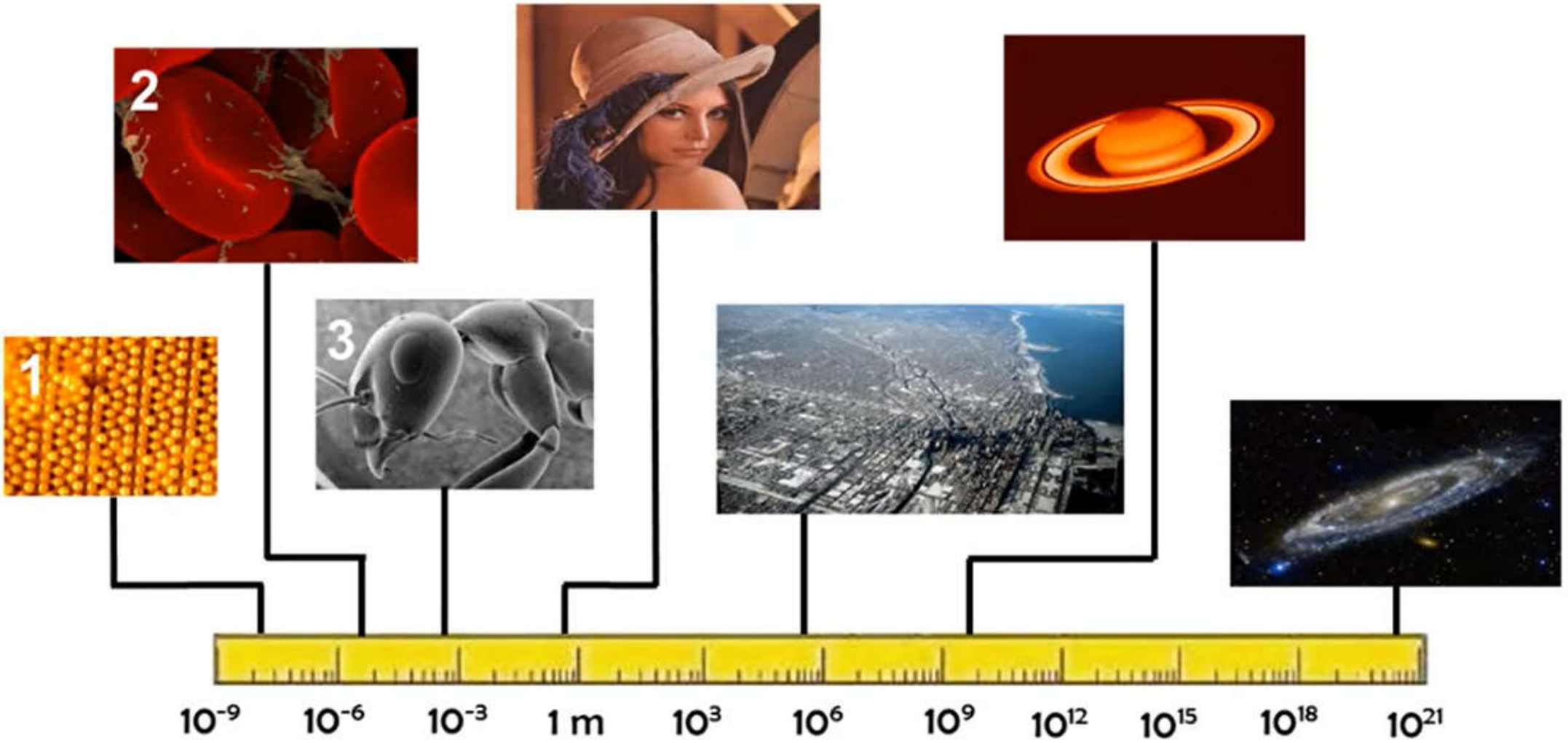
Scanning Electron Microscopy (SEM)



Example SEM image of normal circulating human blood. Image courtesy of Bruce Wetzel and Harry Schaefer. **National Cancer Institute**

Computer Generated Images

Example of a computer generated image. Created by Gilles Tran.
www.oyonale.com


1
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1 m
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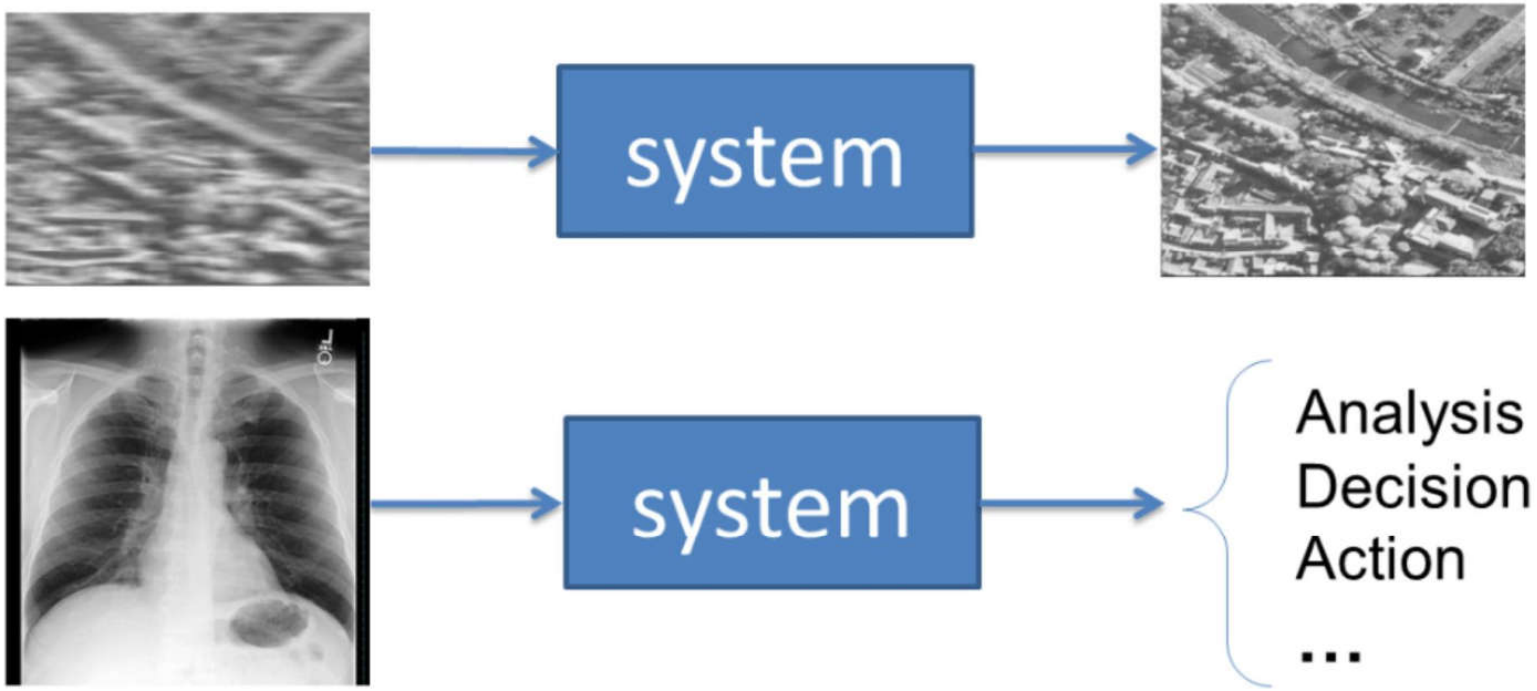
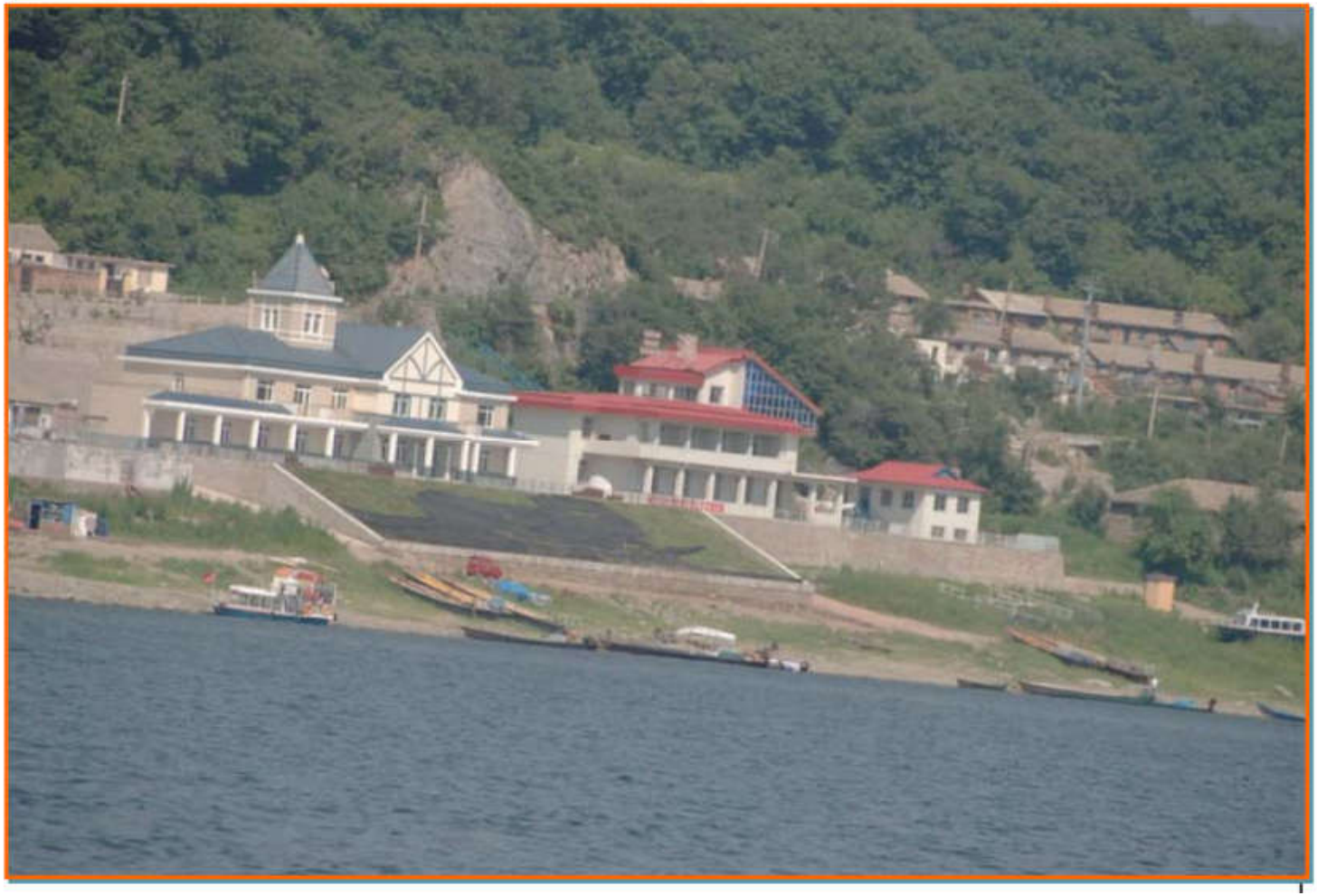
10^{12}
10^{15}
10^{18}
10^{21}

Chapter1 Introduction

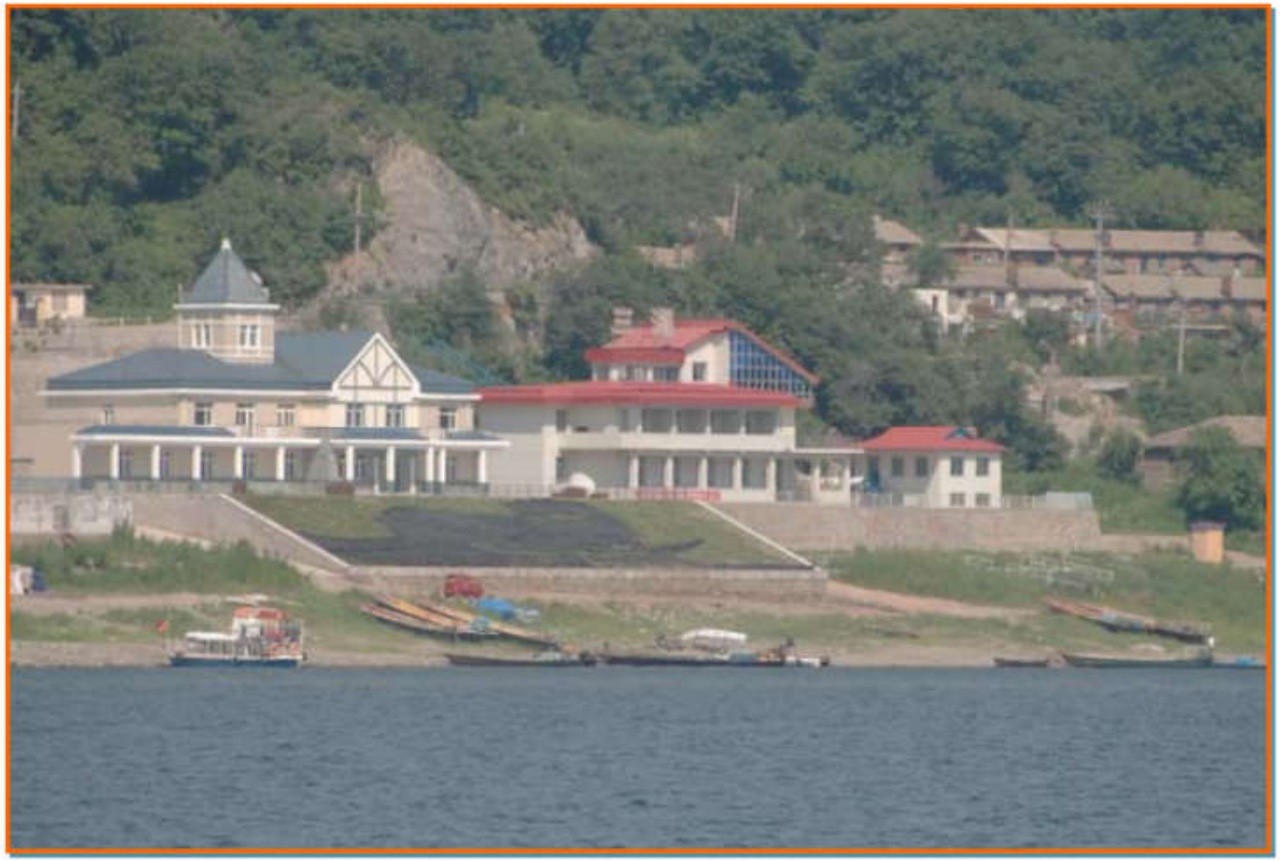
- **1.1 What Is Digital Image Processing**



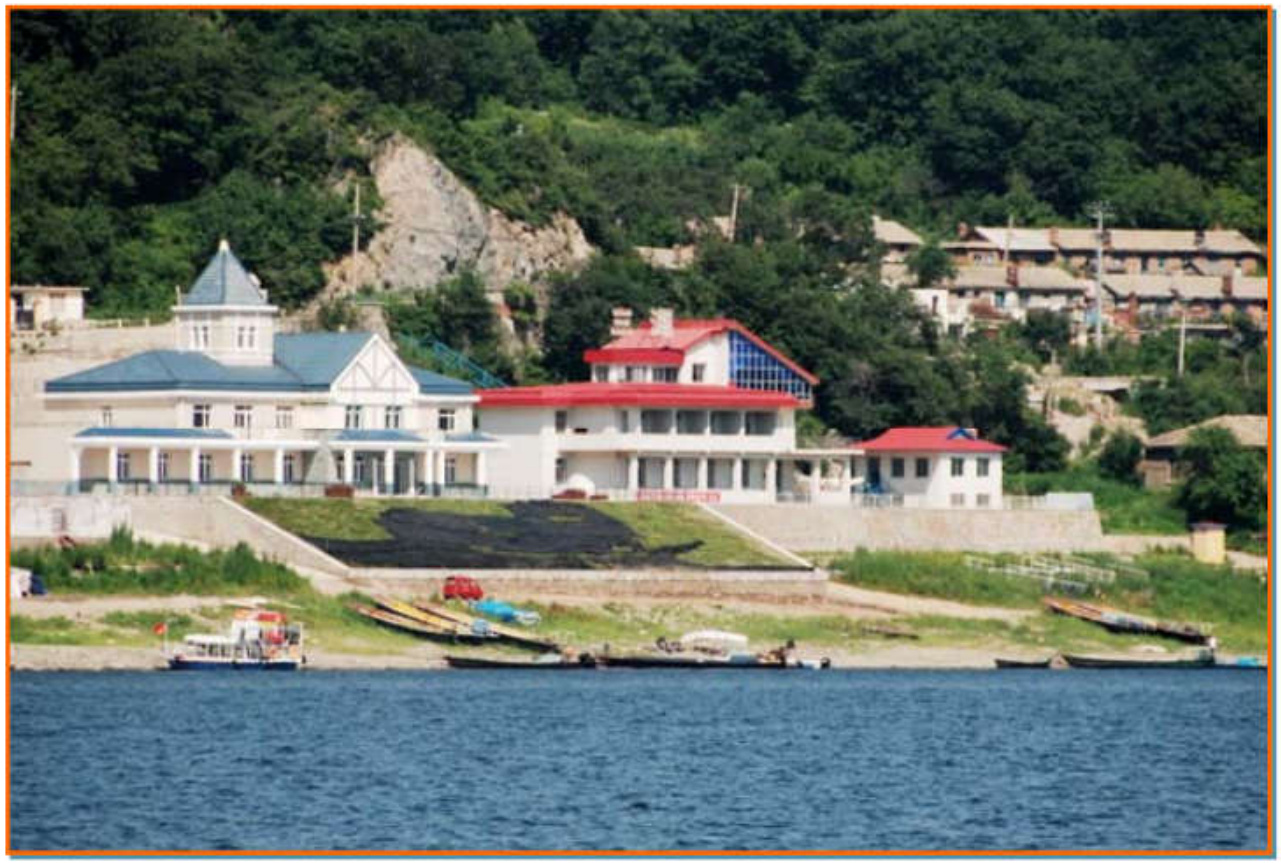
Original image



Rotated



Enhanced



Zoomed: before processing

Zoomed: after processing

Original

Enhanced

Detailed comparison

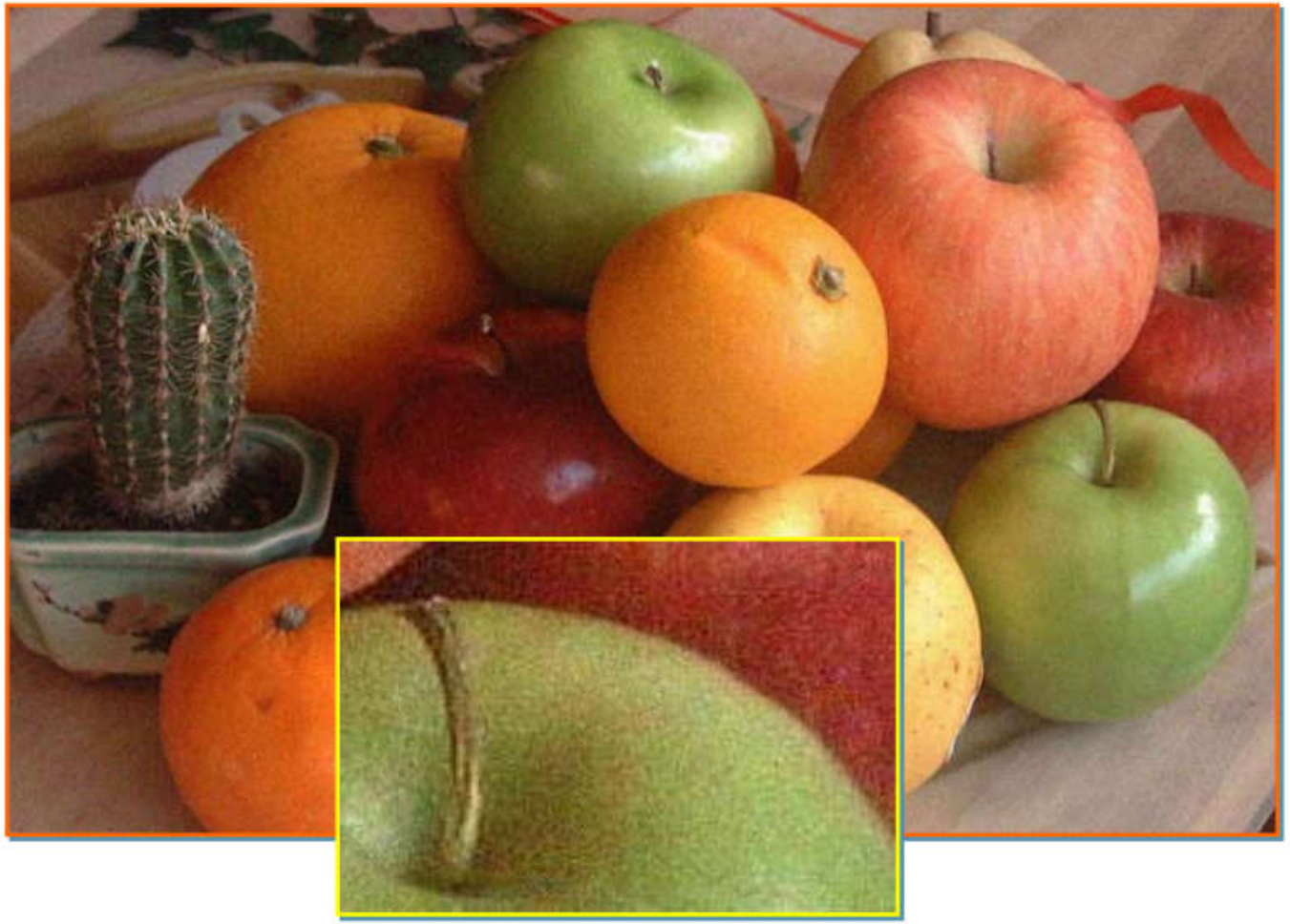
Correction of Geometric Distortion

Original

Barrel distortion corrected

Final

Noisy Image



Filtered

Image inpainting

Optical character recognition (OCR)

- If you have a scanner, it probably came with OCR software

Digit recognition, AT&T labs

http://www.research.att.com/~yann/

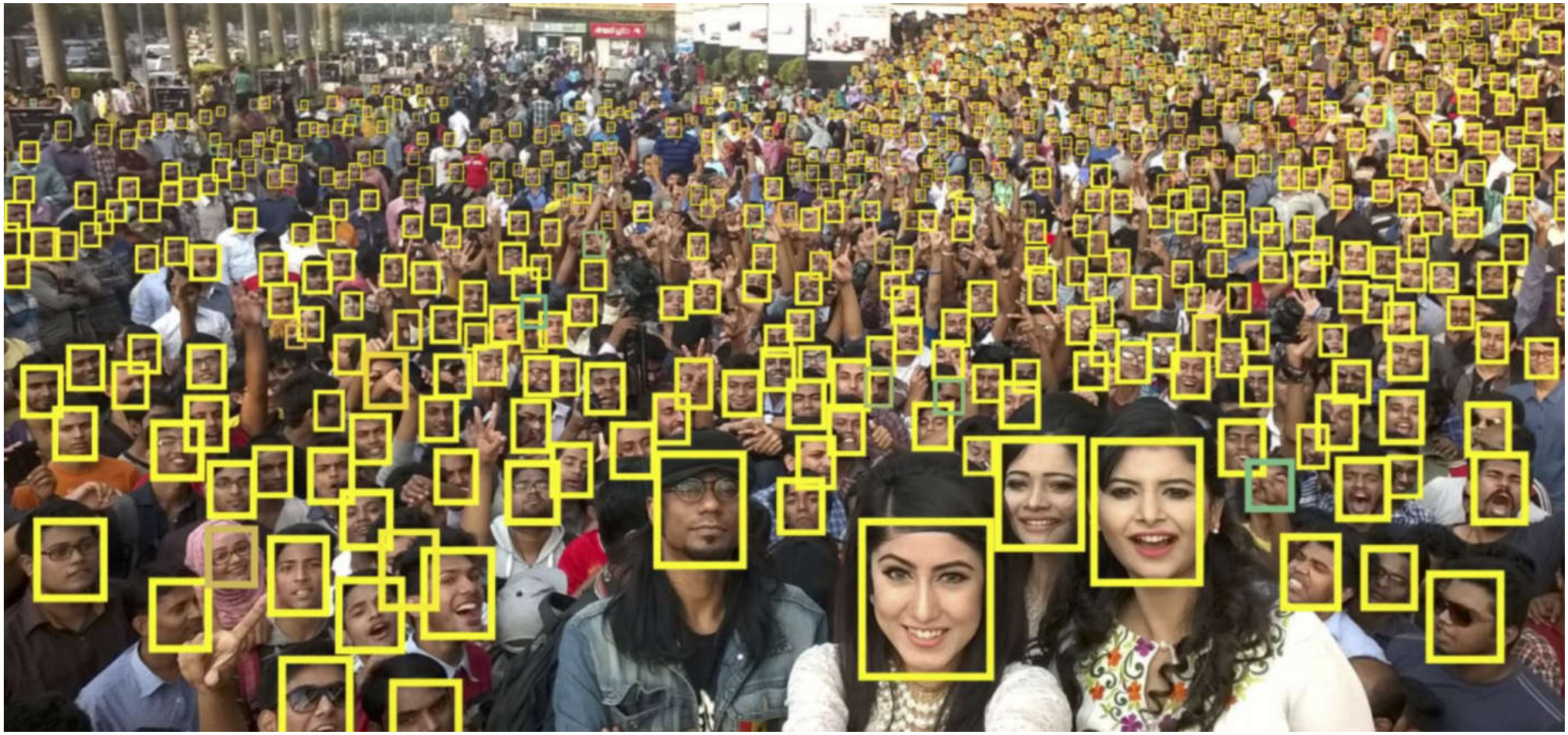
License plate readers

http://en.wikipedia.org/wiki/Automatic_number_plate_recognition

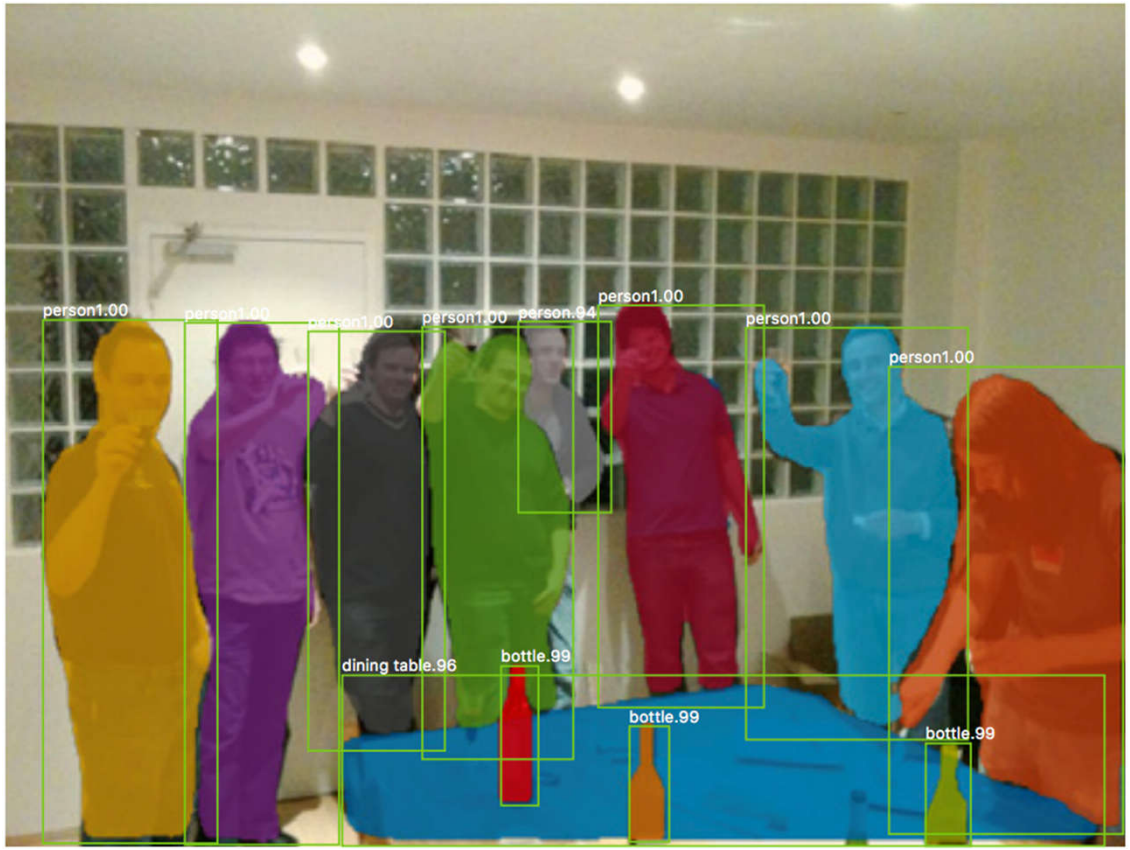
Automatic check processing

Source: S. Seitz

Face detection

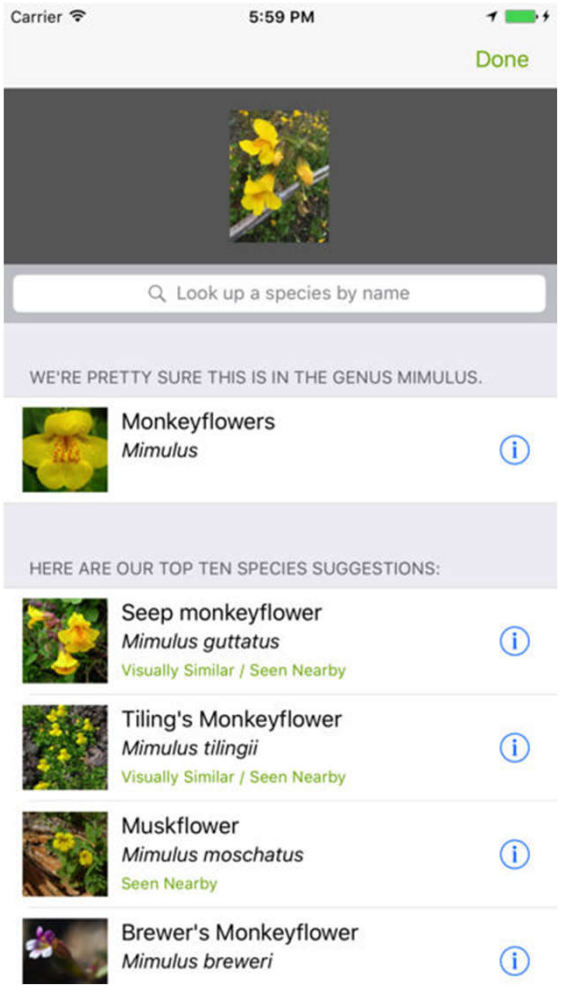


Recognizing objects



Mask R-CNN. Kaiming He, Georgia Gkioxari, Piotr Dollar, Ross Girshick. ICCV 2017

Species recognition



[iNaturalist]

References: Journals

- 《电子学报》
- 《通信学报》
- 《自动化学报》
- 《遥感学报》
- 《中国图象图形学报》
- 《人工智能与模式识别》

References: Journal

- IEEE Transactions on
  - Image Processing
  - Signal Processing
  - Medical Image
  - Geoscience and Remote Sensing
  - Pattern analysis and machine intelligence
- Image and Vision Computing
- Computer Vision and Image Understanding