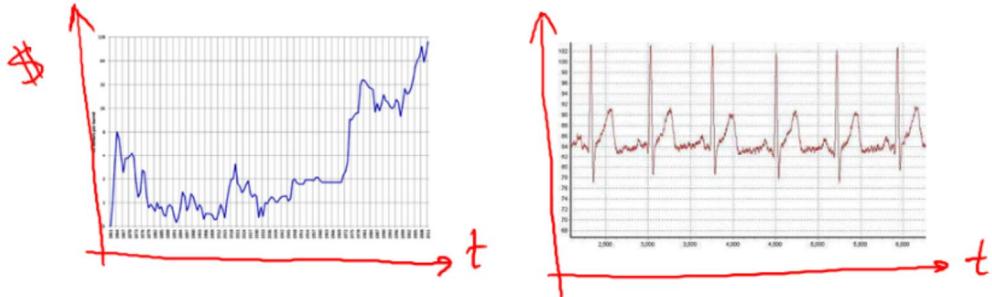


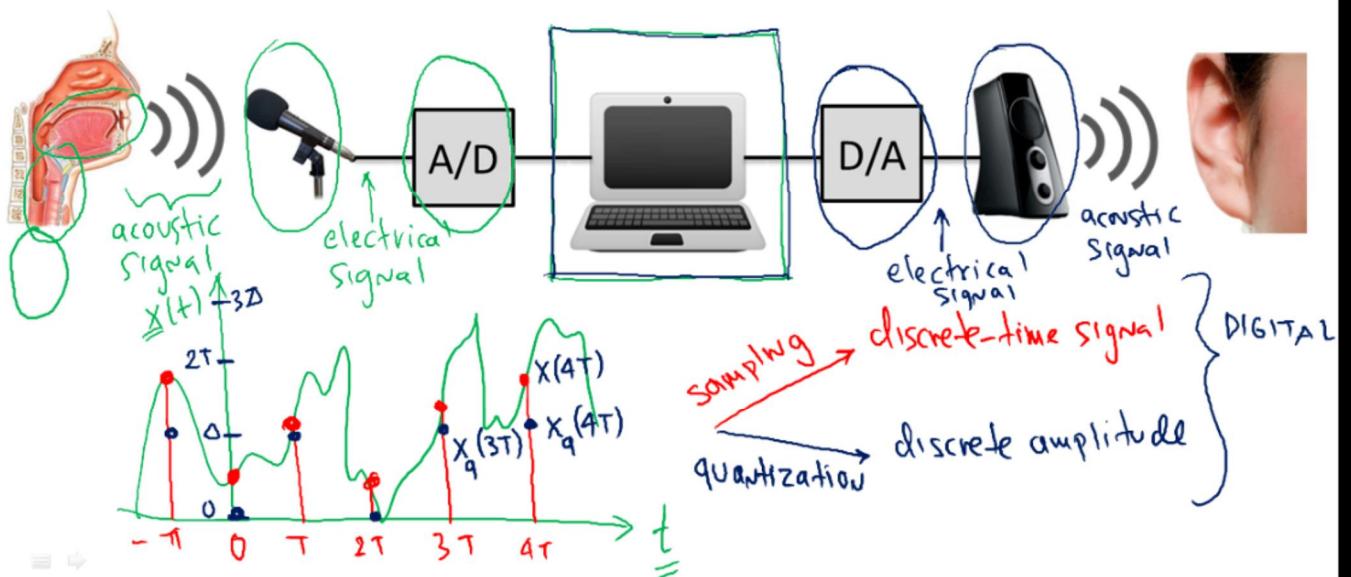
# Signals

$X(t)$   $X(t_1, t_2)$

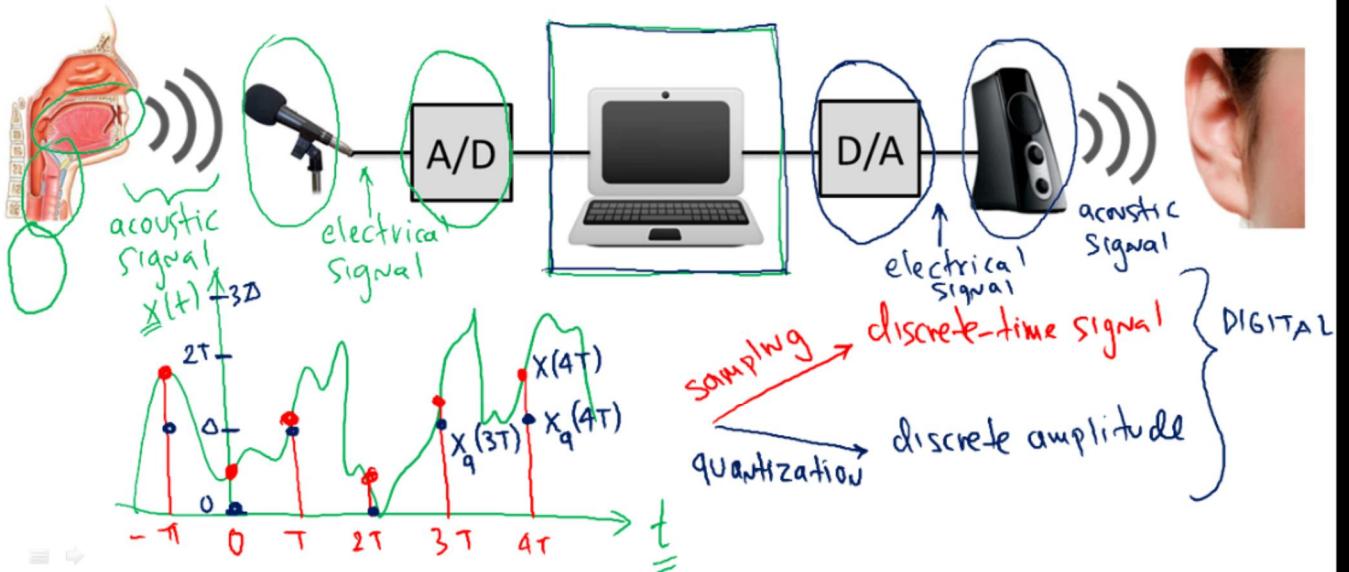
- A function containing information about the behavior or nature of some phenomenon of interest.
- In the physical world, any quantity exhibiting variation in time and/or space is potentially a signal.



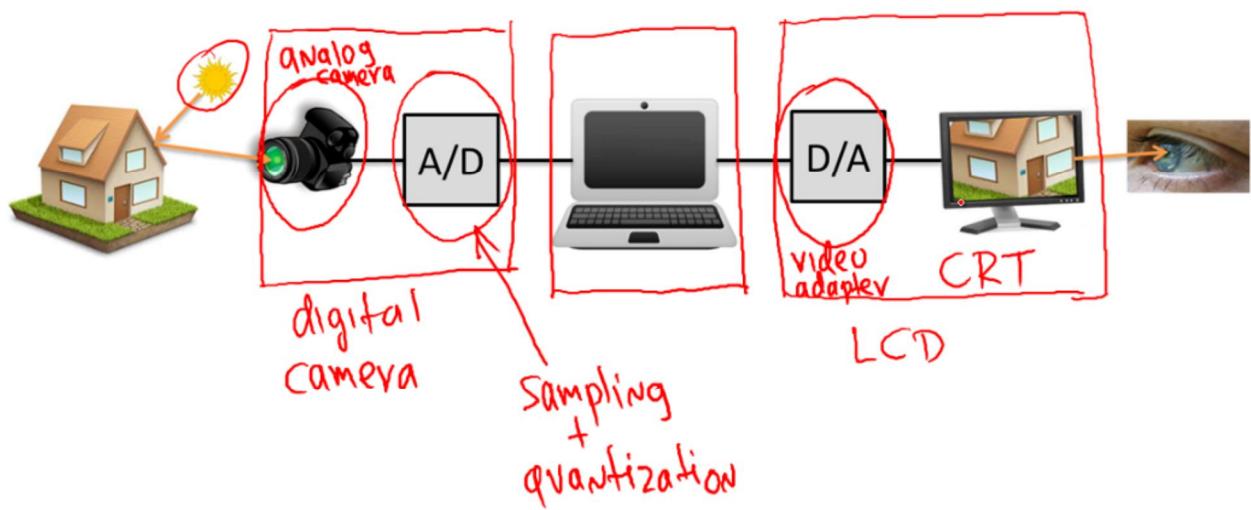
## Analog vs Digital Signals



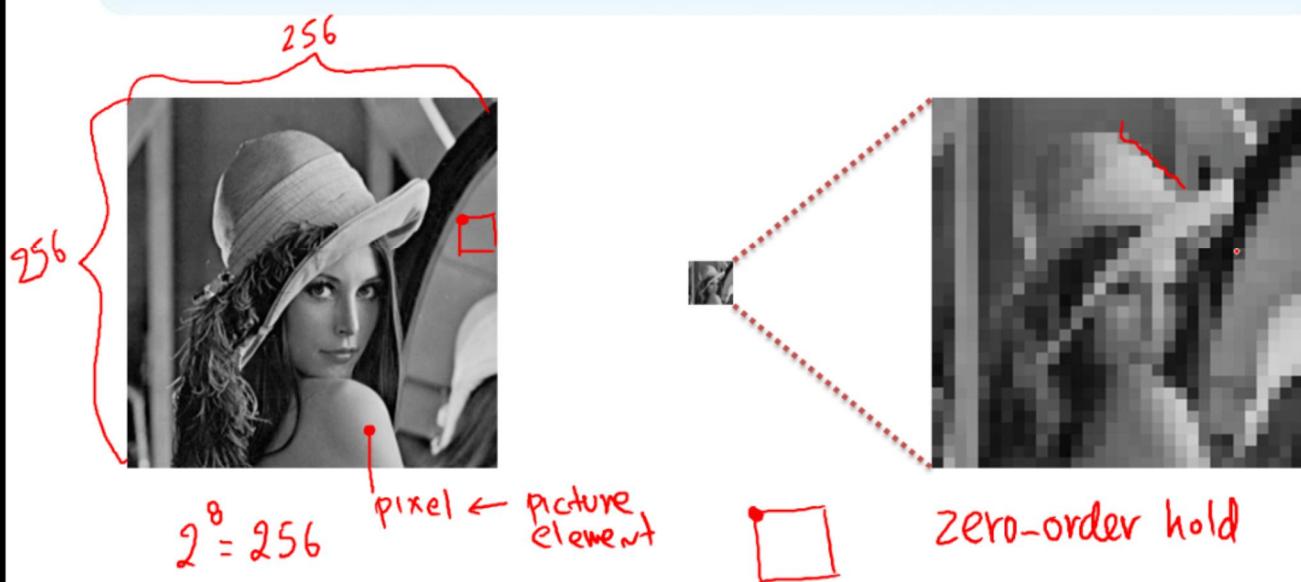
## Analog vs Digital Signals



## Analog vs Digital Signals



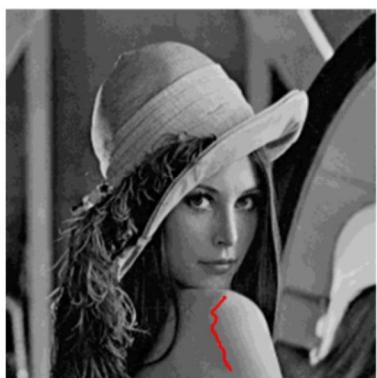
## Sampling



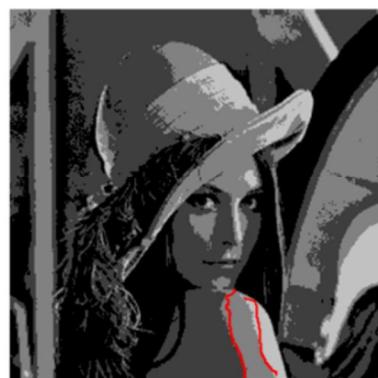
## Quantization



8 bits per pixel  
 $2^8 = 256$



4 bits per pixel  
 $2^4 = 16$



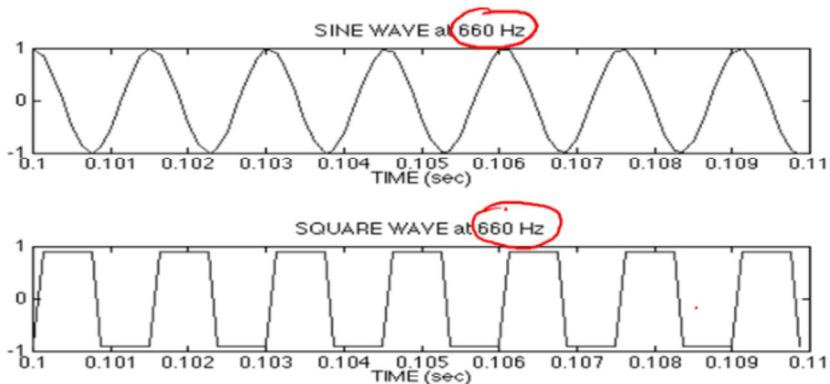
2 bits per pixel  
 $2^2 = 4$

# Images and Videos

- 1D: tones, speech, audio, biomedical, remote sensing, etc  $s(t)$
- 2D: text, grayscale, color, multispectral, hyperspectral  $s(n)$   
images, etc  $s(x,y)$
- 3D: video, 3D volume, etc  $s(x,y,t)$   $s(x,y,z)$
- MD: video of a volume, etc  $s(x,y,z,t)$



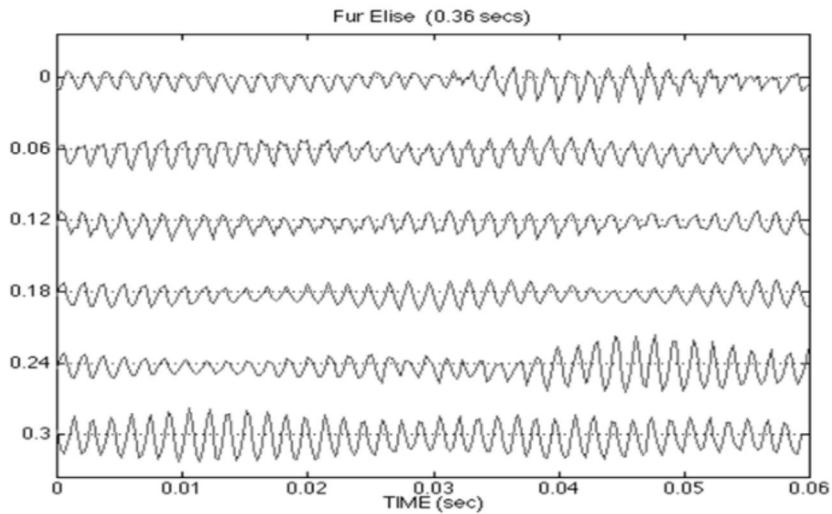
## 1D Signals: Tones



J. H. McClellan, R. W. Schafer, and M. A. Yoder, "DSP First: A Multimedia Approach," Prentice Hall, 1998.



# 1D Signal: Piano Piece



J. H. McClellan, R. W. Schafer, and M. A. Yoder, "DSP First: A Multimedia Approach," Prentice Hall, 1998.

# Images

This is a Coursera Course on the "Fundamentals of Digital Image and Video Processing"

1 bit per pixel

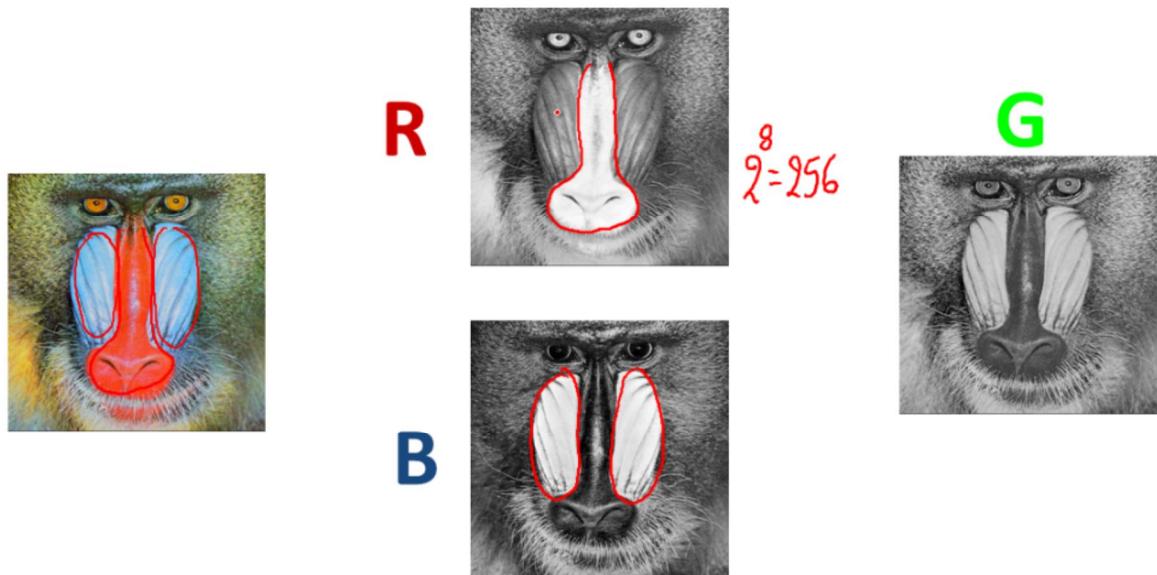


8 bits per pixel

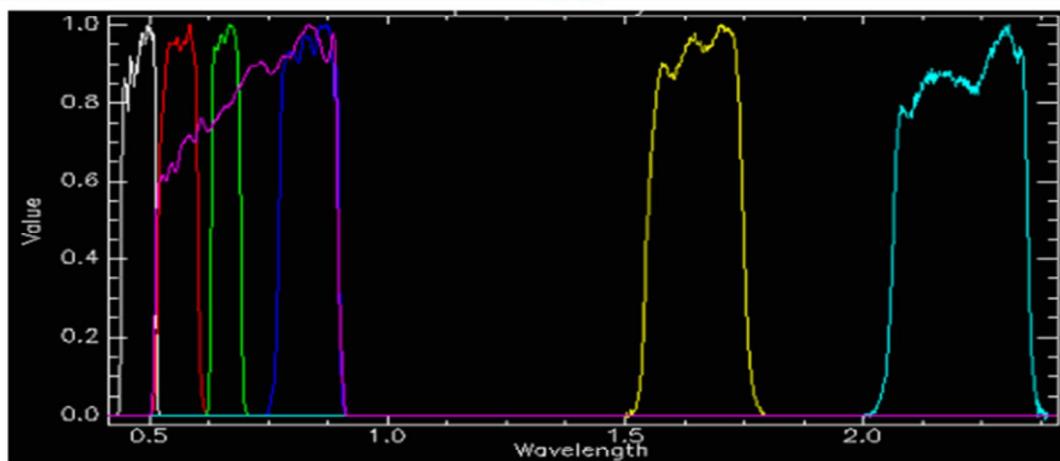


24 bits per pixel

## RGB Color Image



## LANDSAT ETM+ Spectral



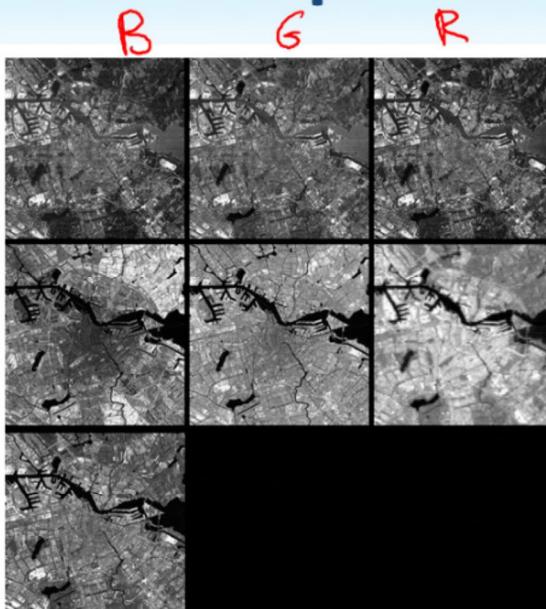
Color	LANDSAT ETM+ band
White	1 (0.45 μm to 0.515 μm)
Red	2 (0.525 μm to 0.605 μm)
Green	3 (0.63 μm to 0.69 μm)
Blue	4 (0.75 μm to 0.9 μm)

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)

→ 60m

→ 15m

## LANDSAT Multi-Spectral Images



ESA Landsat

## LANDSAT Multi-Spectral Images



Bands 4-3-2

Bands 1-2-3

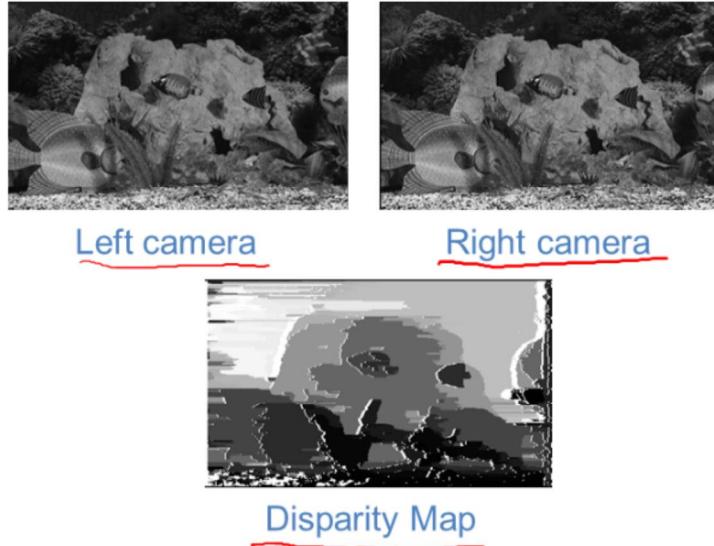


Bands 7-4-2

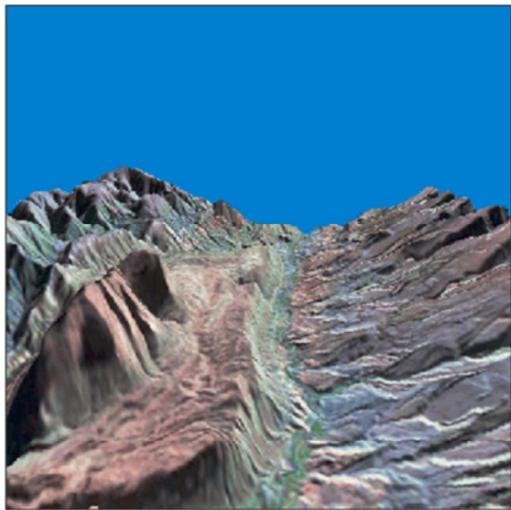


USGS/NASA Landsat

## Stereo Images and Disparity

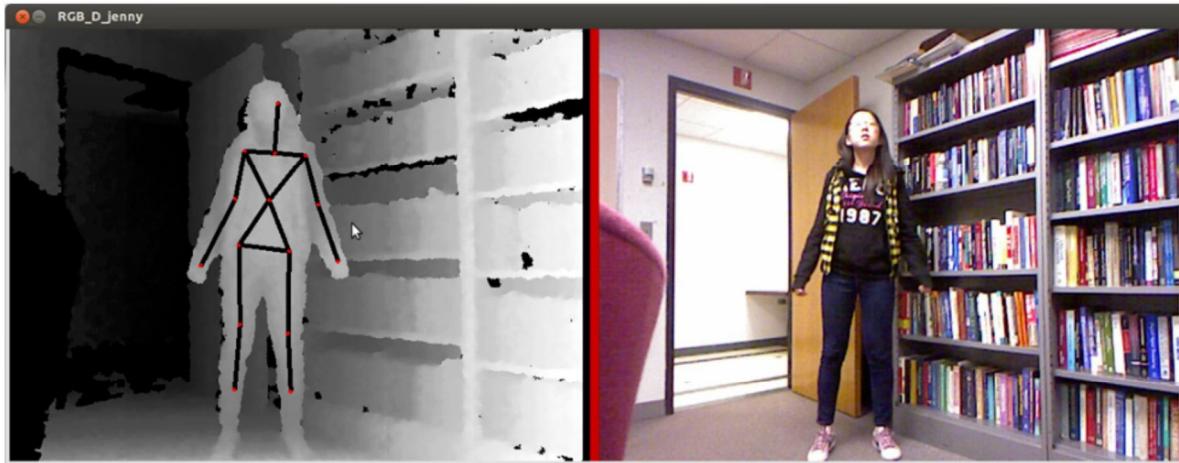


## LANDSAT Stereo

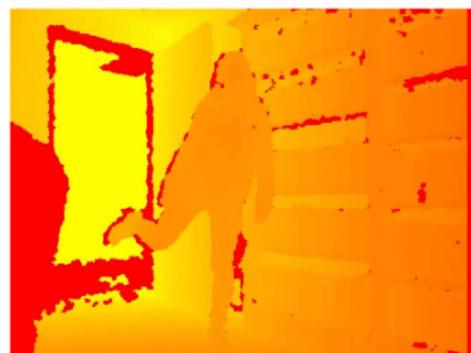


USGS/NASA Landsat

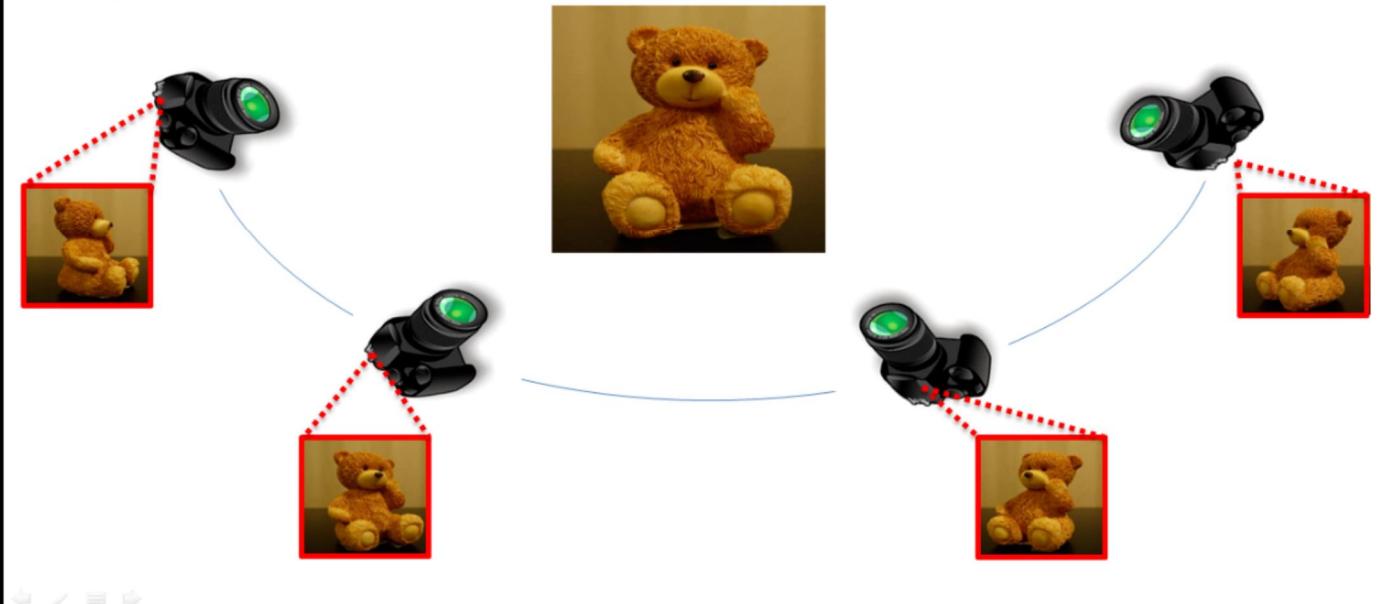
## Kinect Images



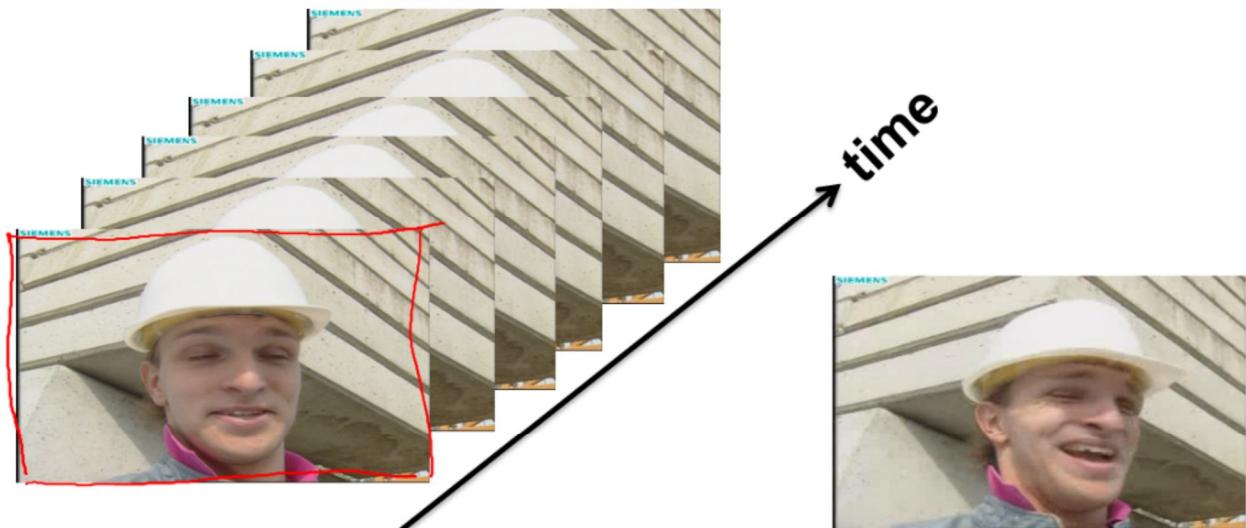
## Kinect Videos



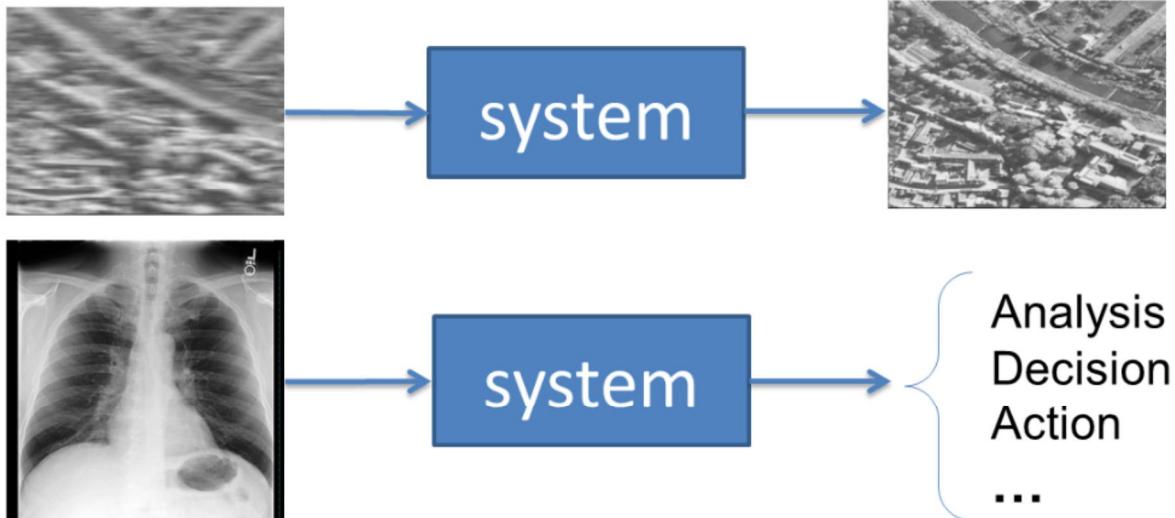
## Multi-Camera Imaging



## Video



# Image and Video Processing

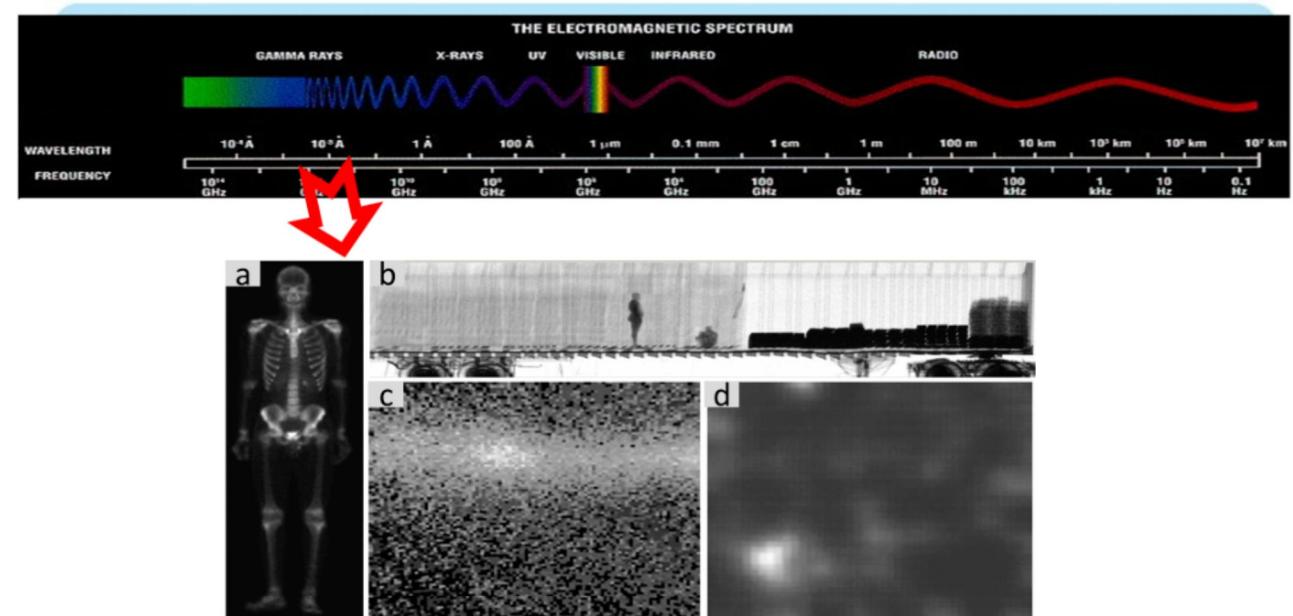


## Types of Images

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

# Classification 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

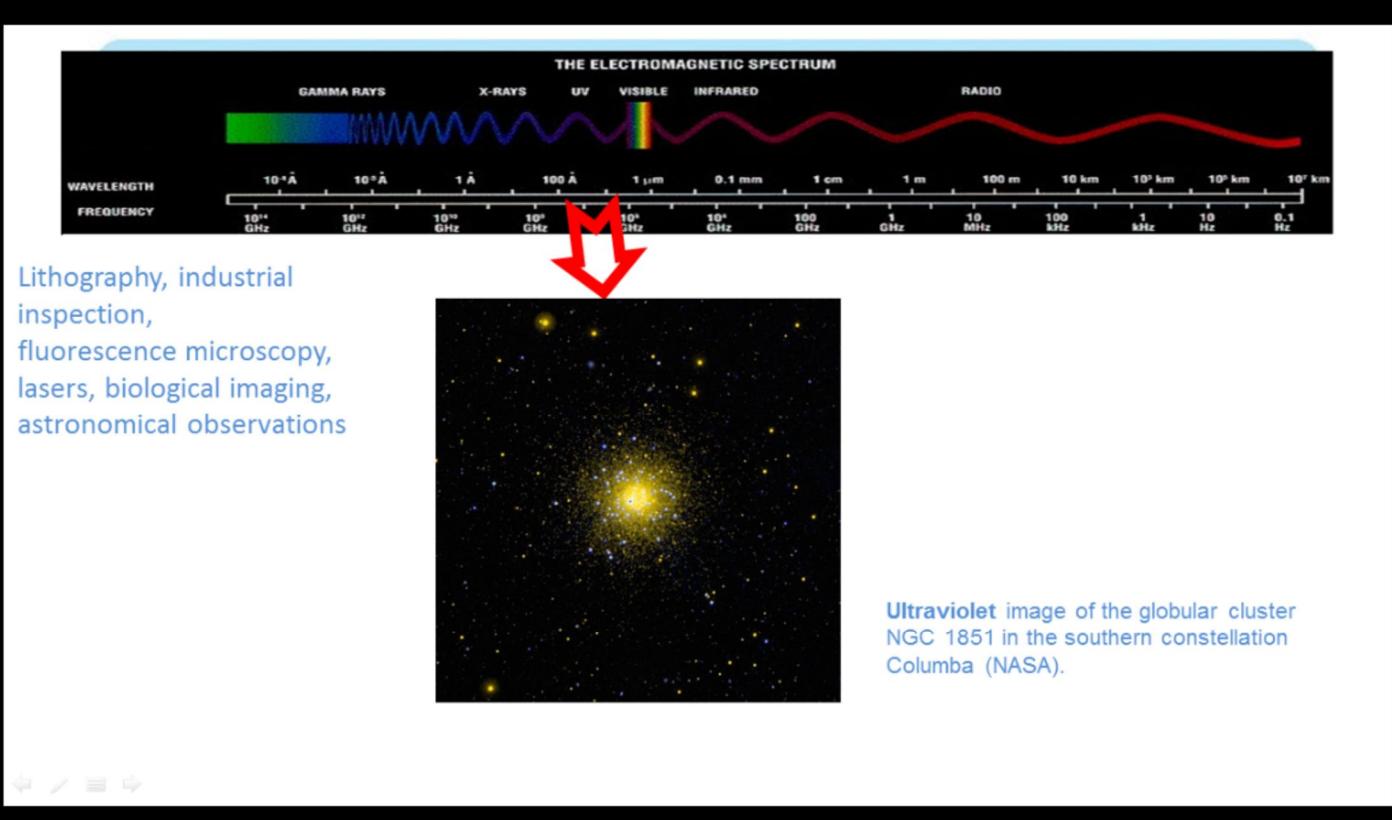
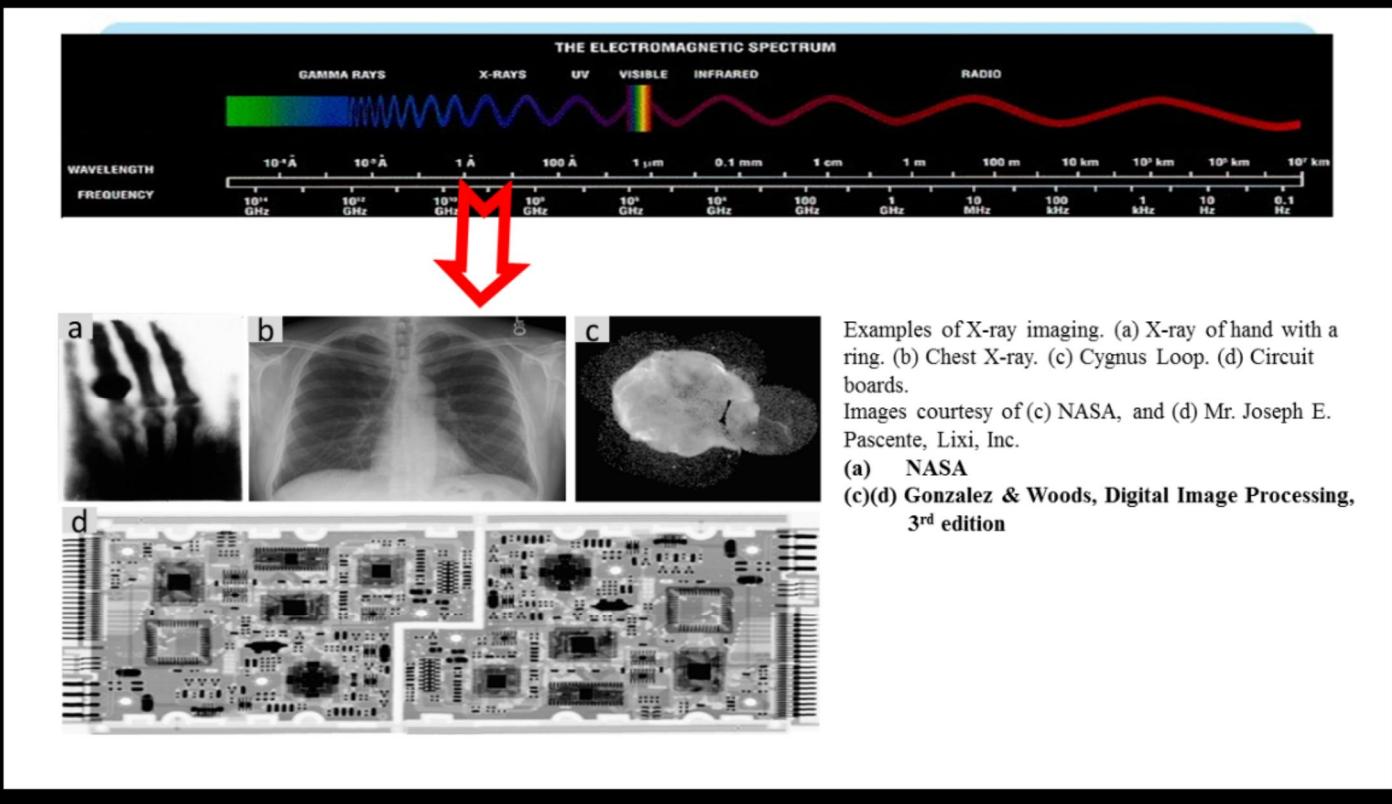


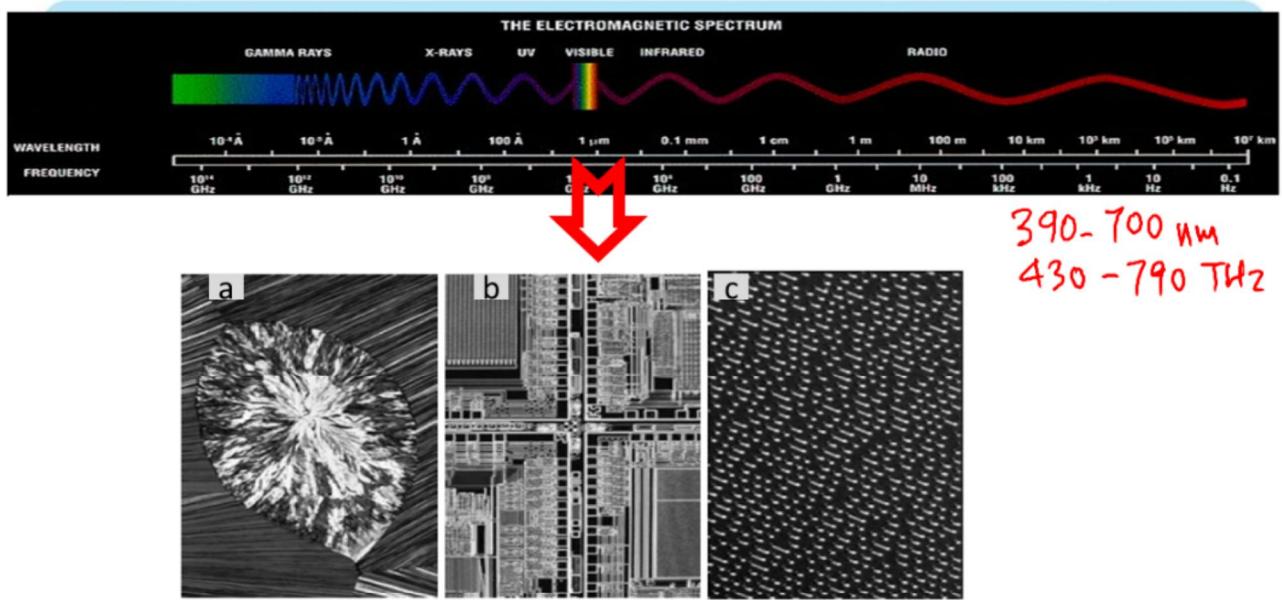
Examples of gamma-ray imaging. (a) Bone scan. (b) Gamma ray image of a truck. (c) Cygnus Loop.  
(d) Gamma radiation (bright spot) from a reactor valve  
Images courtesy of (a) G.E. Medical Systems, (c) NASA, (d) Professors Zhong He and David K. Wehe,  
University of Michigan.

(a)(c)(d) Gonzalez & Woods, Digital Image Processing, 3<sup>rd</sup> edition

(b) U.S. Customs and Border Protection

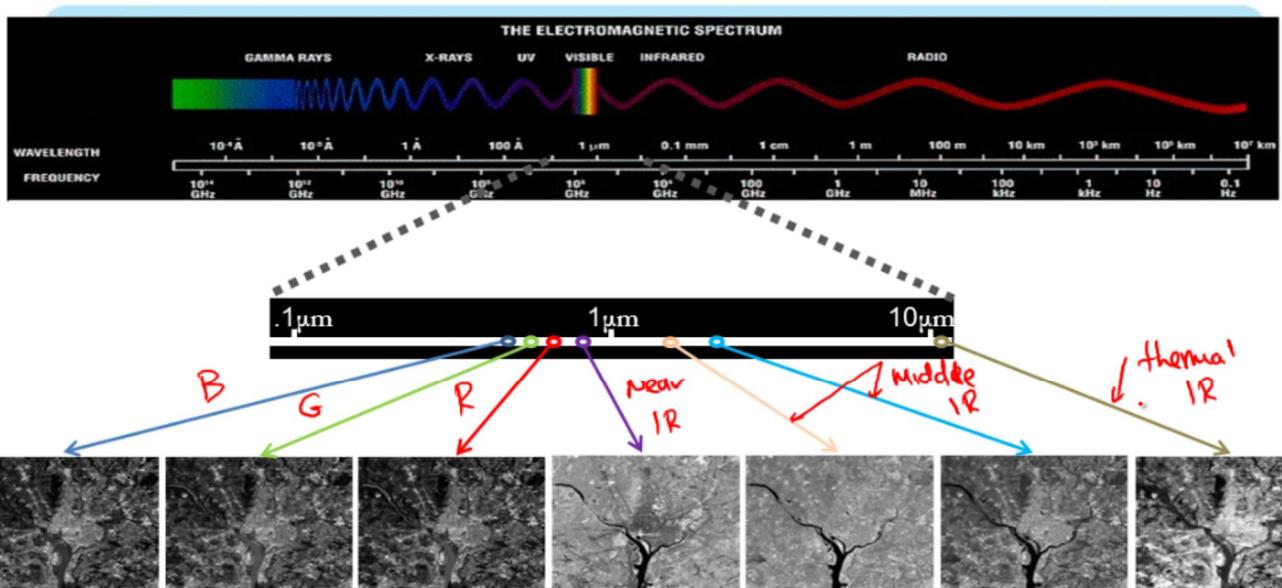




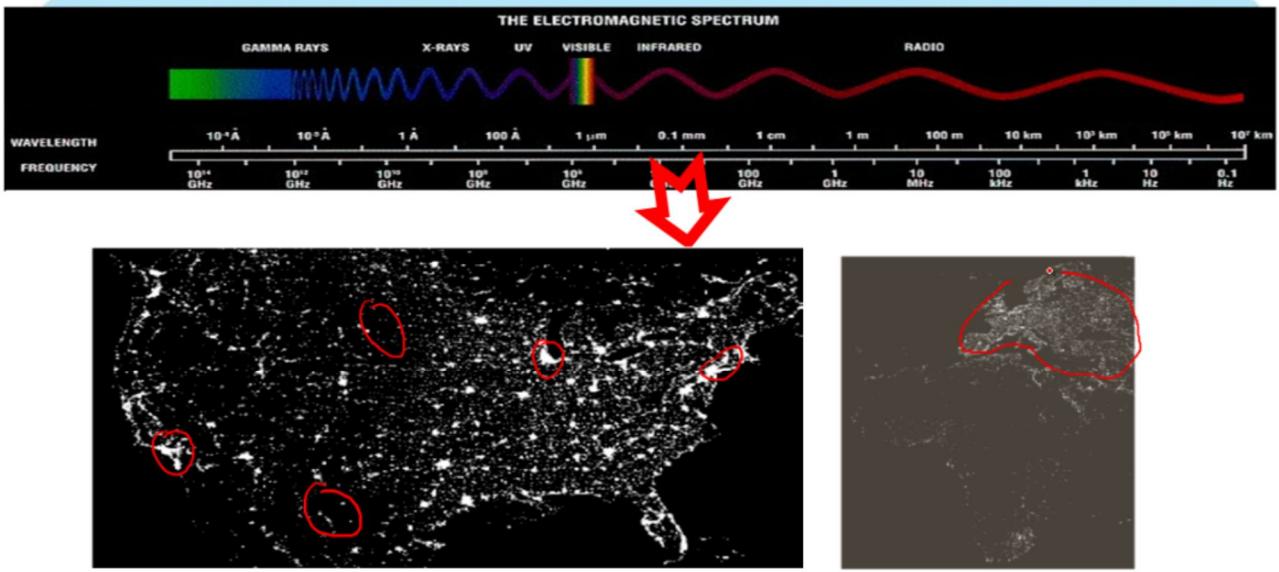


Examples of light microscopy images. (a) Cholesterol-40x.  
(b) Microprocessor-60x.  
(c) Surface of audio CD-1750x.

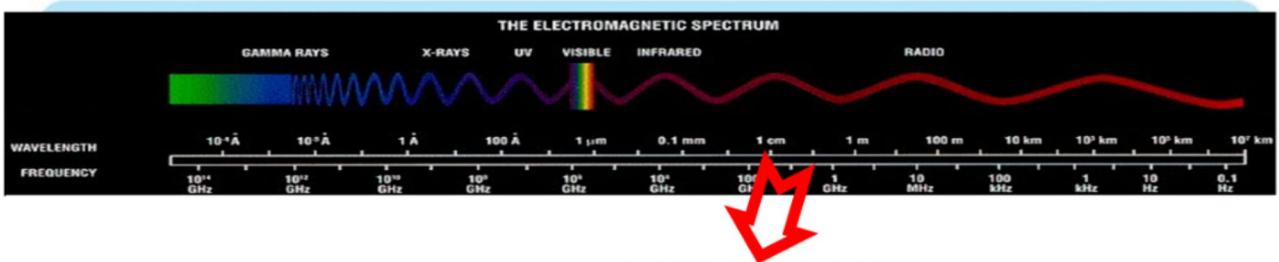
Images courtesy of Dr. Michael W. Davidson, Florida State University.  
(a)(b)(c) Gonzalez & Woods, Digital Image Processing, 3<sup>rd</sup> edition



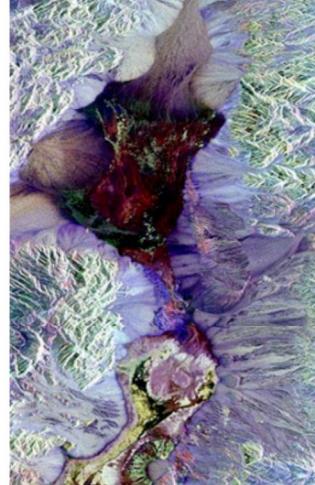
LANDSAT satellite images of the Washington, D.C. area. Images courtesy of NASA  
Gonzalez & Woods, Digital Image Processing, 3<sup>rd</sup> edition

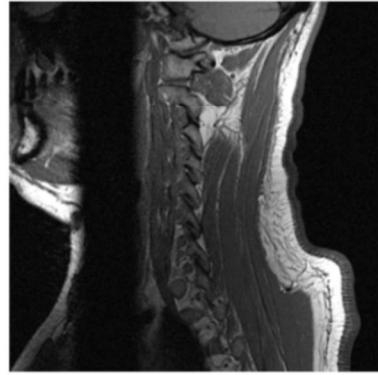
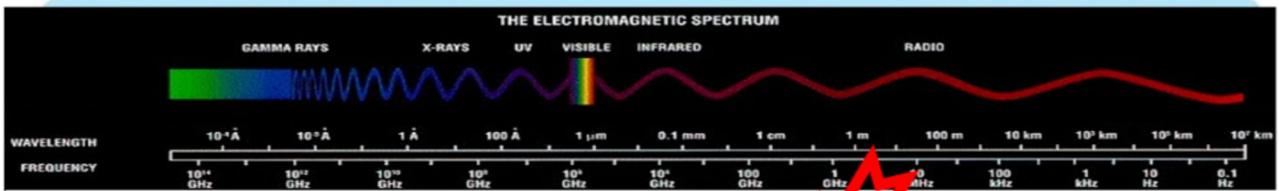


Infrared satellite images of the United States of America. (Courtesy of NOAA)  
Gonzalez & Woods, Digital Image Processing, 3<sup>rd</sup> edition.



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





MRI image of a human spine



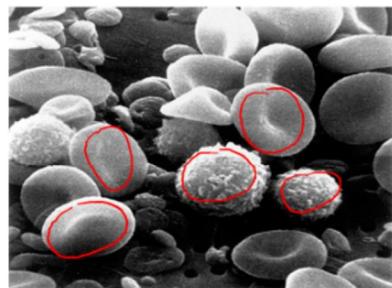
## Ultrasound Images



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](http://www.oyonale.com)

