

# Digital Image Processing (CSE/ECE 478)

## Lecture # 01: Overview

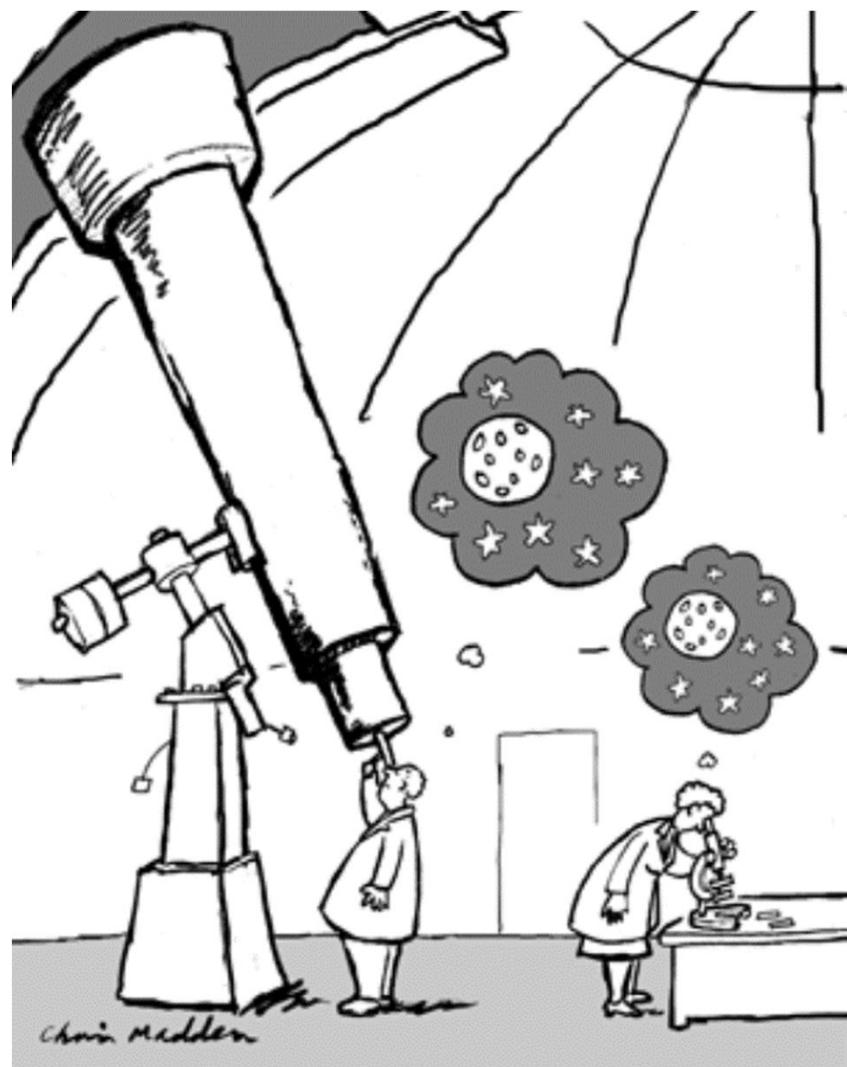
Avinash Sharma

Center for Visual Information Technology (CVIT),  
IIIT Hyderabad





Courtesy: Youtube



Courtesy: Chris Madden

# Guidelines

- Understand
- Focus on ideas and insights
- Implement



## About the course - Material

- DIP by Gonzalez and Woods
- <http://szeliski.org/Book/>
- Coursera courses ( Northwestern and Duke )

PLEASE SIGN UP FOR THE MAILING LIST

(cse478@lists.iiit.ac.in)



# About the course – Grading Policy

- Assessment
    - 2 mid semester exams (24%) + 1 Final Exam (28%)
    - Assignments\* (20%) + 1 final project (26%) + Quiz (02%)
- \* If copying is detected, you will get 0 marks for the assignment



# About the course – Project

- Replicate an interesting research paper
- A new solution to an existing problem
- Original research
- Comparing different existing algorithms for a known problem
  
- Write a 8 page report summarizing your results
- Release the final code
- Give a presentation

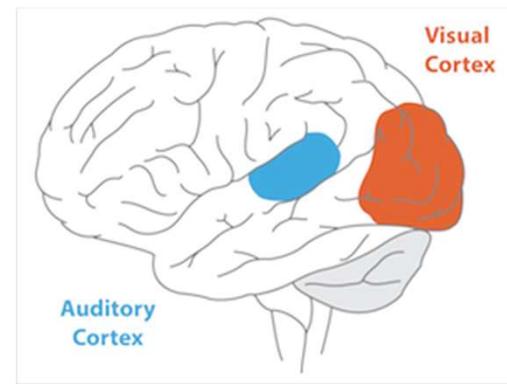
**PROJECTS NEEDS TO BE APPROVED**

**ANY PLAGIARISM WILL NOT BE TOLERATED, BE EXTREMELY CAREFUL**

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# Why image processing?

- Visual cortex (large segment in brain)
- Images are everywhere!
- Most images are preprocessed before display (or storage)
- Rich and fertile corpus (needs to be harnessed)



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# Trends!



AUTODESK®  
PIXLR®



Adobe® Premiere®



AUTODESK®  
PIXLR®



Canon

You Tube



SAMSUNG

Microsoft

PHILIPS

xerox

SIEMENS

intel®

QUALCOMM®



# Organization (today's lecture)

1. SIGNALS (Analog Signals, Digital Signals)

**UNDERSTAND BASICS**

2. DIGITAL IMAGES (image formation, classification of images)

**IMAGES ARE EVERYWHERE**

3. PROCESSING DIGITAL IMAGES (example applications, tasks of interest)

**WHY PROCESS?**

# Organization (today's lecture)

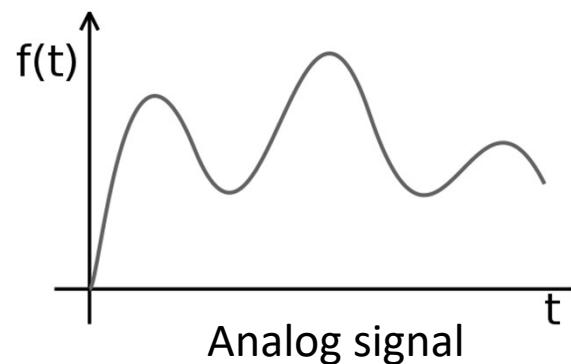
1. SIGNALS (Analog Signals, Digital Signals)

2. DIGITAL IMAGES (image formation, classification of images)

3. PROCESSING DIGITAL IMAGES (example applications, tasks of interest)

# Signal

"Function that conveys information about the behavior or attributes of some phenomenon" (wikipedia)



# Analog vs. Digital signal

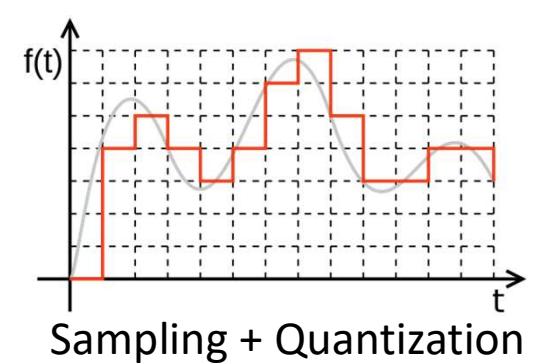
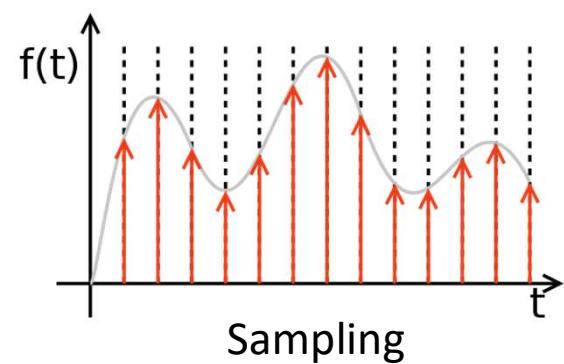
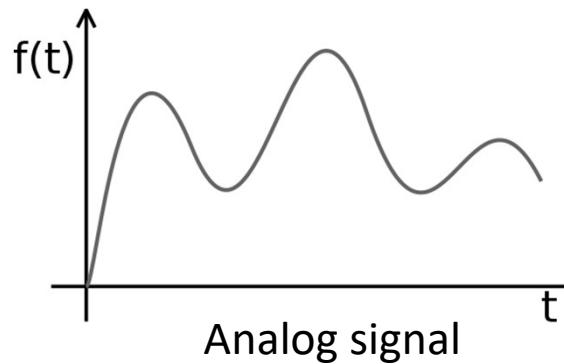
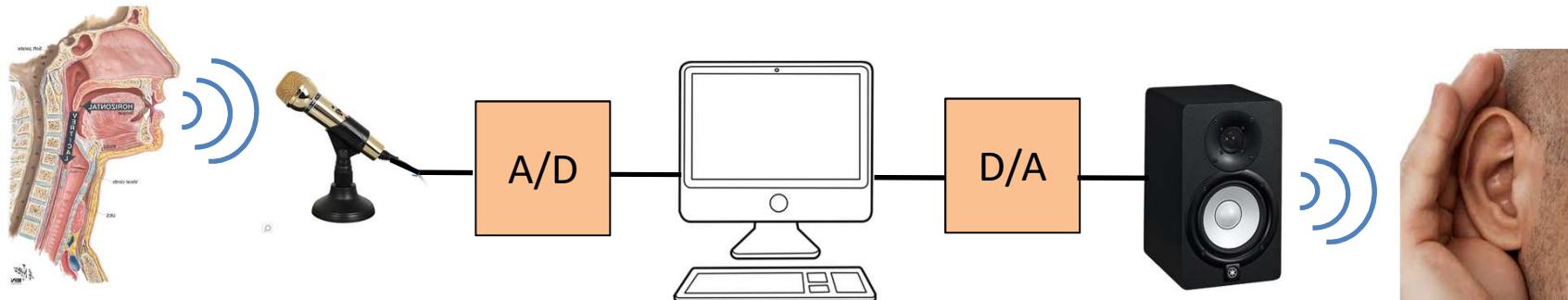
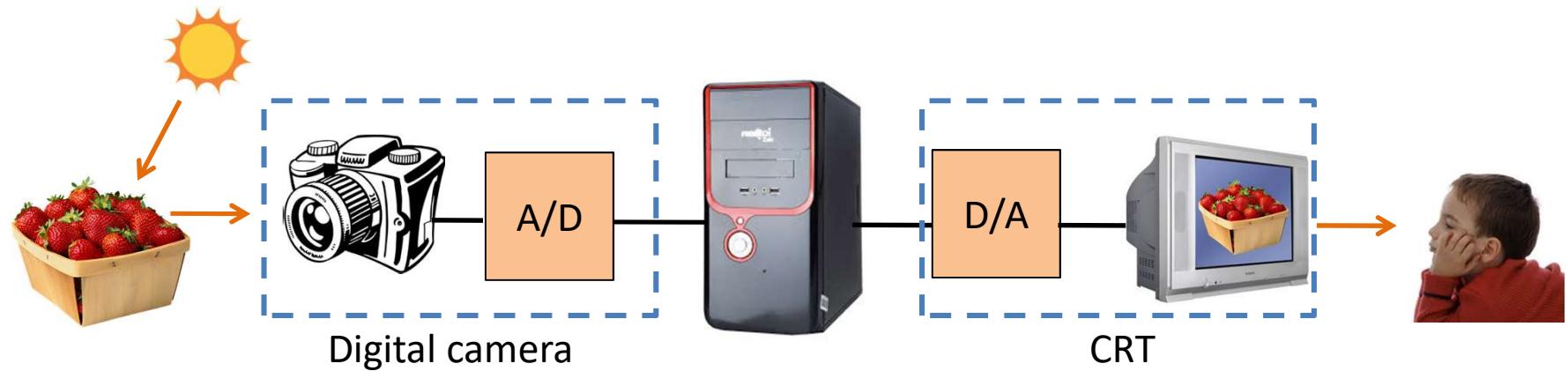


Image courtesy: wikipedia

# Analog vs. Digital signal



# Organization (today's lecture)

1. SIGNALS (Analog Signals, Digital Signals)

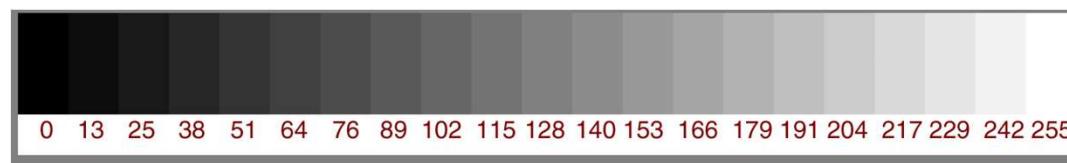
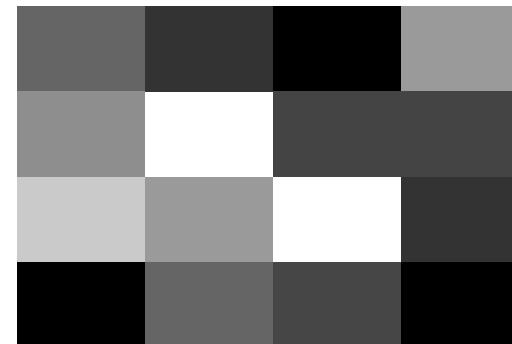
2. DIGITAL IMAGES (image formation, classification of images)

3. PROCESSING DIGITAL IMAGES (example applications, tasks of interest)

# What is a digital image?

- 2D matrix of intensities (gray or color values) or numbers

100	50	0	150
90	255	70	70
200	150	255	50
0	100	80	0



# Image acquisition process

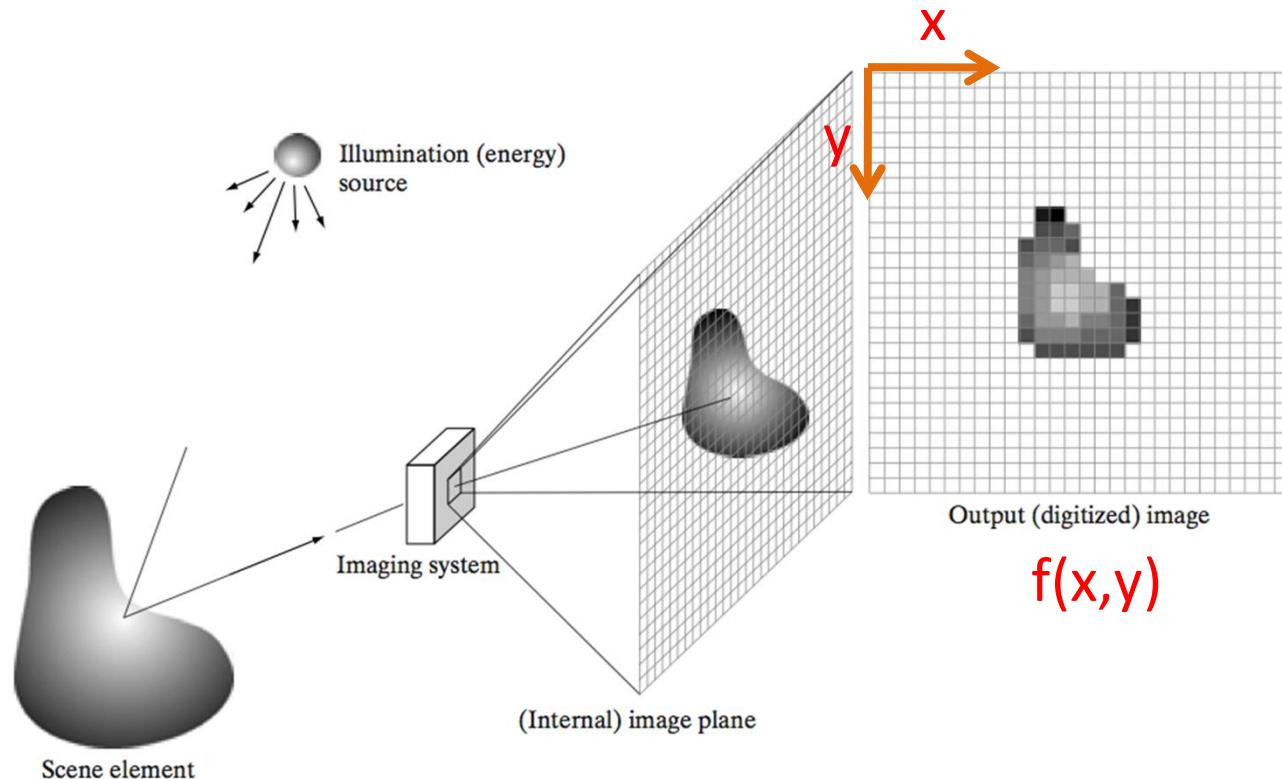


Image courtesy: Gonzalez and Woods

# Image acquisition process

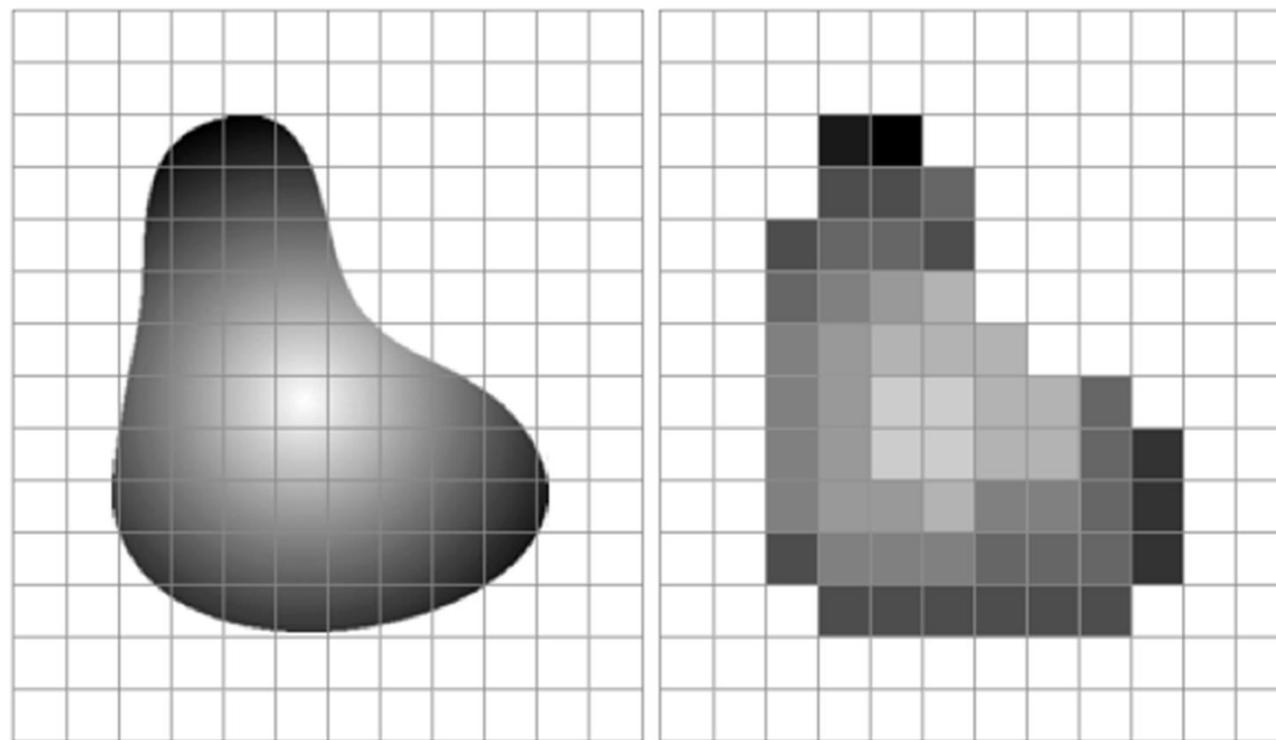
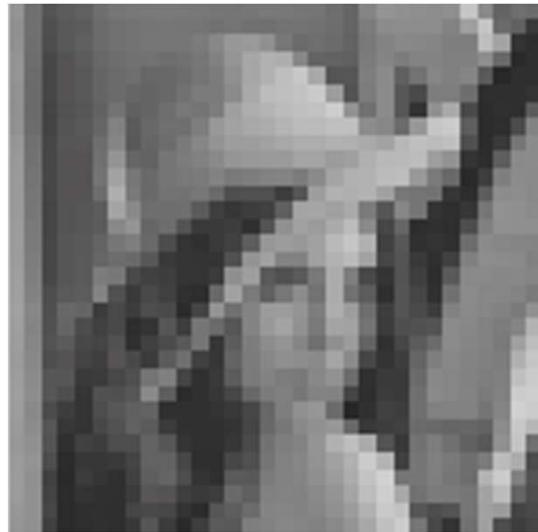


Image courtesy: Gonzalez and Woods

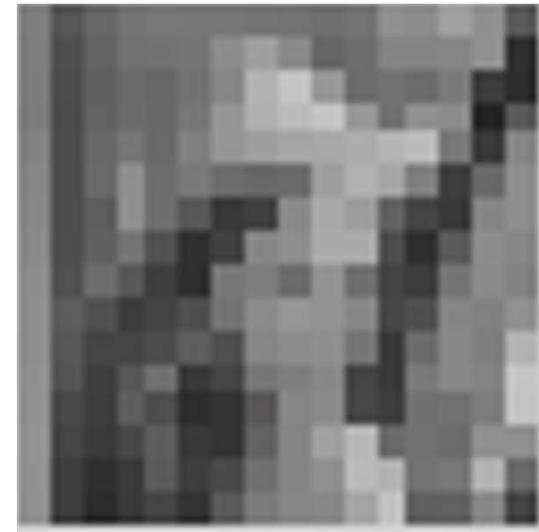
# Sampling



$256 \times 256$



$32 \times 32$



$16 \times 16$



# Quantization



8 bits per pixel



4 bits per pixel

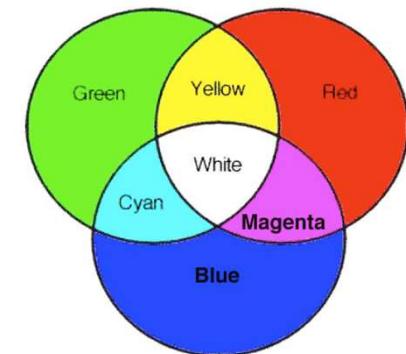


2 bits per pixel



1 bit per pixel

# Color Images



R



8 bits per pixel

G



8 bits per pixel

B



8 bits per pixel

+

+



# Digital Images

ABCDEFHIJKLMNOP  
OPQRSTUVWXYZÀ  
abcdefghijklmnopqr  
stuvwxyzàåéîõøü&  
1234567890(\$£€.,!?)

36

1 bit per pixel



8 bit per pixel



24 bit per pixel

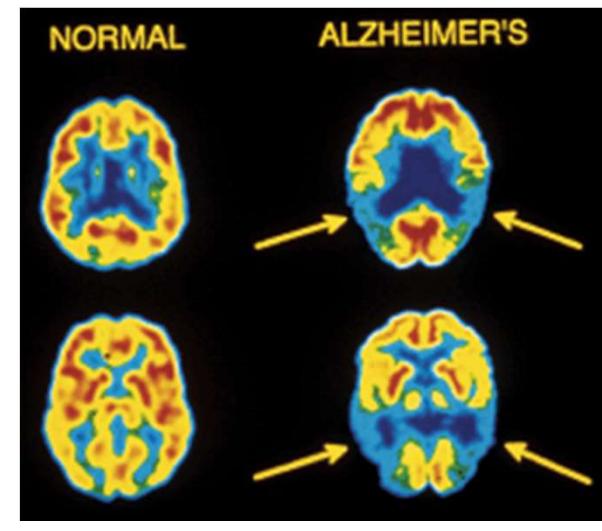
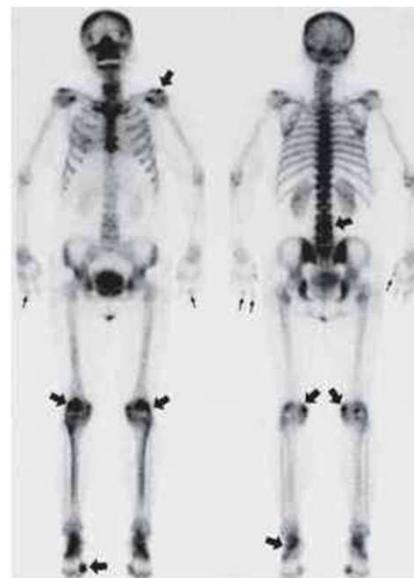
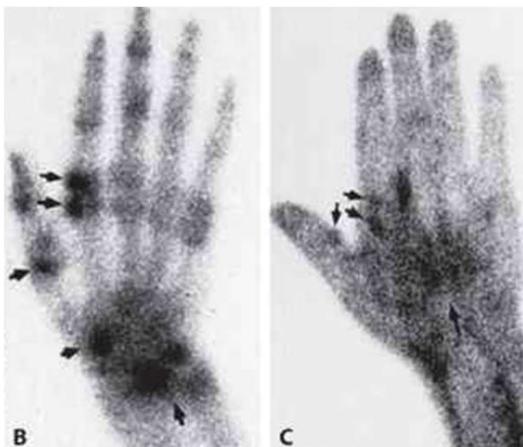
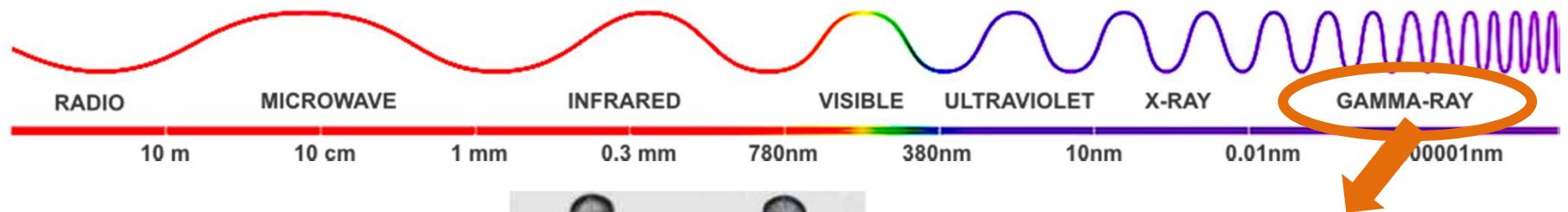


# Types of Images (classification on source)

- Radiation from EM spectrum
- Acoustic/ultrasonic/spectrogram
- Electronic
- Computer generated



# EM spectrum



# EM spectrum



Wilhelm Röntgen



HAND MIT RINGEN

courtesy: wikipedia



CHEST RADIOGRAPH

courtesy: wikipedia



CT SCAN

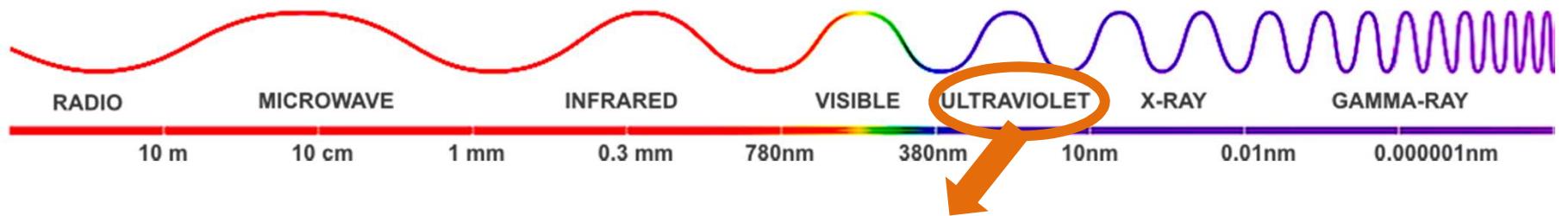
courtesy: wikipedia



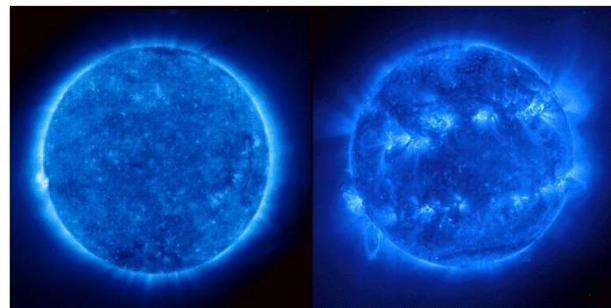
AIRPORT SCAN

courtesy: dpl-surveillance-equipment

# EM spectrum



Lithography, industrial inspection, microscopy, lasers, astronomical observations, fluorescence microscopy etc.



SUN (2 years apart)

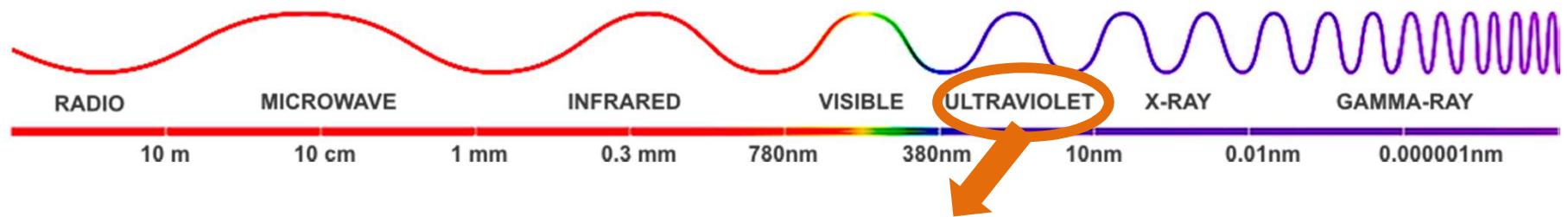
courtesy: NASA



100 EURO BILL

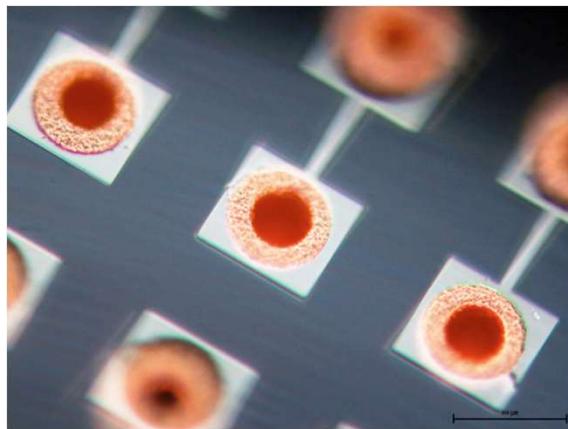
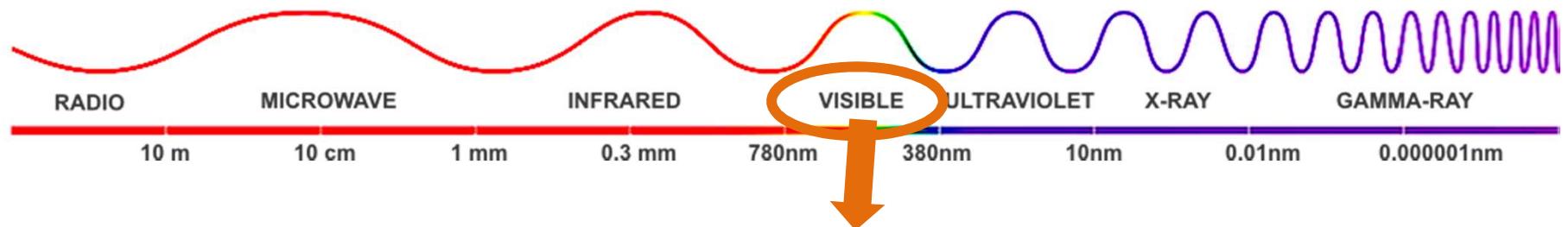
courtesy: lifepixel.com

# EM spectrum



Source:  
Lifepixel.com

# EM spectrum



Chips (optical microscopy)  
courtesy: EPFL microelectronics systems laboratory

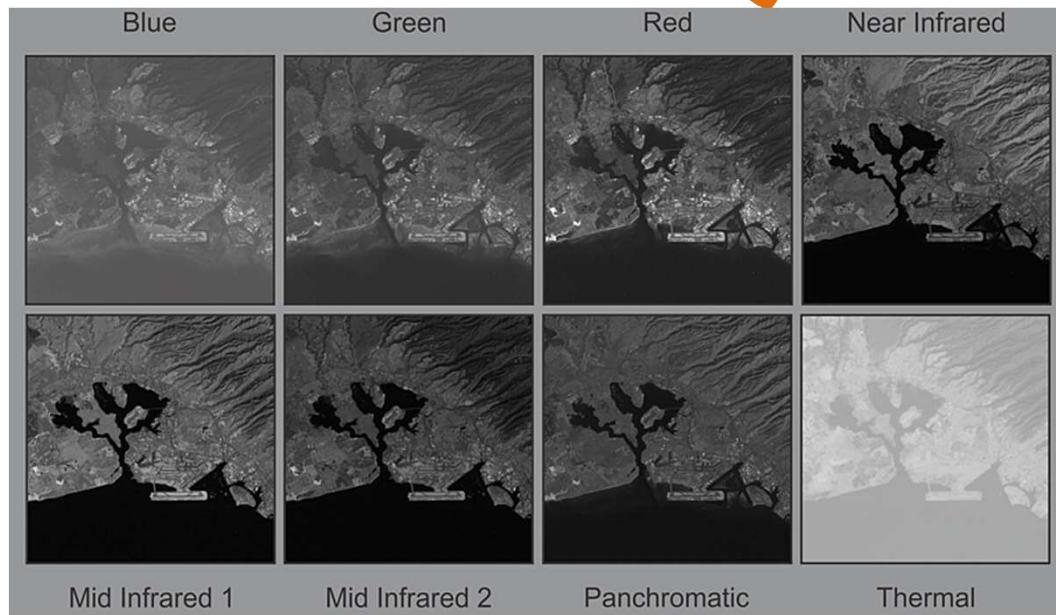
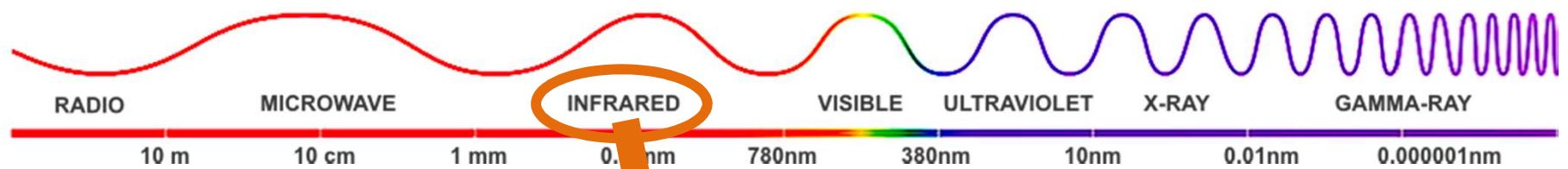


High Speed Photograph  
courtesy: Alan Sailer



Satellite Image (Hurricane Katrina)  
courtesy: britannica.com

# EM spectrum

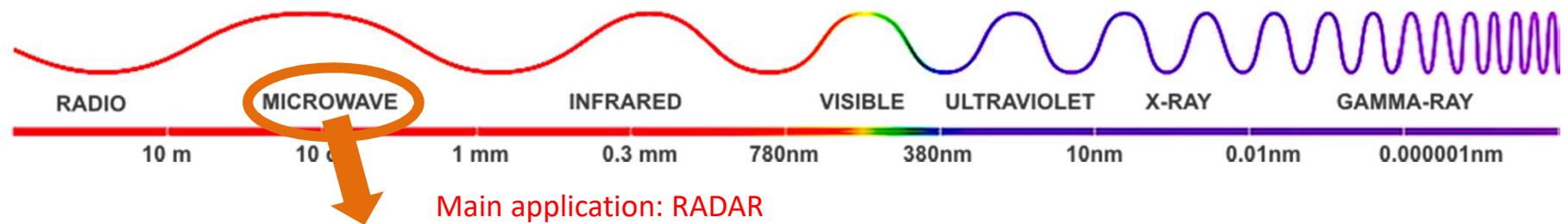


courtesy: LANDSAT (NASA)



courtesy: imaging1.com

# EM spectrum



Main application: RADAR



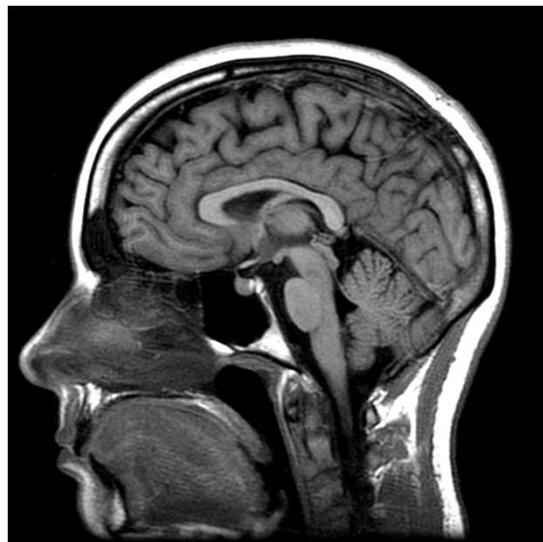
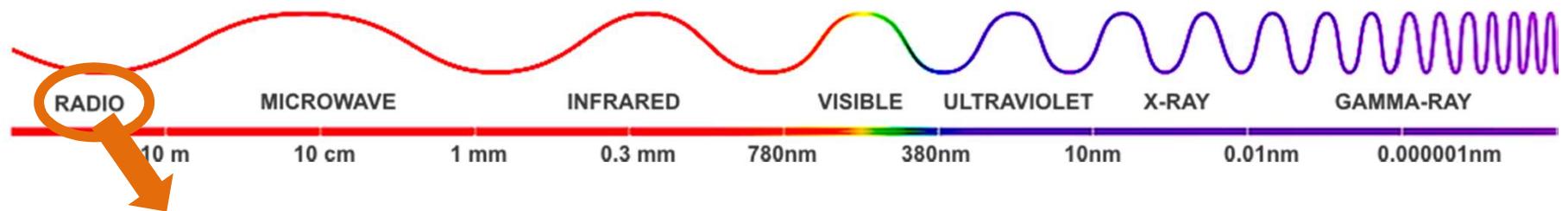
SOUTHEAST TIBET MOUNTAINS

courtesy: NASA

Main advantages of Radar:

- works regardless of weather or ambient lighting conditions
- can penetrate clouds, can see through vegetation, ice etc.
- in many cases only way to explore inaccessible regions of the Earth's surface

# EM spectrum



**MRI Brain**

courtesy: [mritnt.com](http://mritnt.com)



**MRI Knee**

courtesy: [mri-tip.com](http://mri-tip.com)

# Ultrasound



ULTRASOUND

courtesy: wikipedia



ULTRASOUND TWINS

courtesy: pinterest

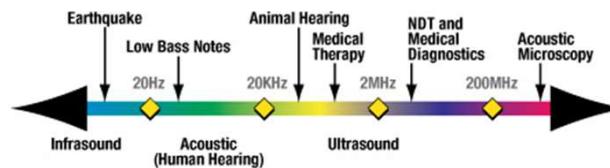


ULTRASOUND 3D

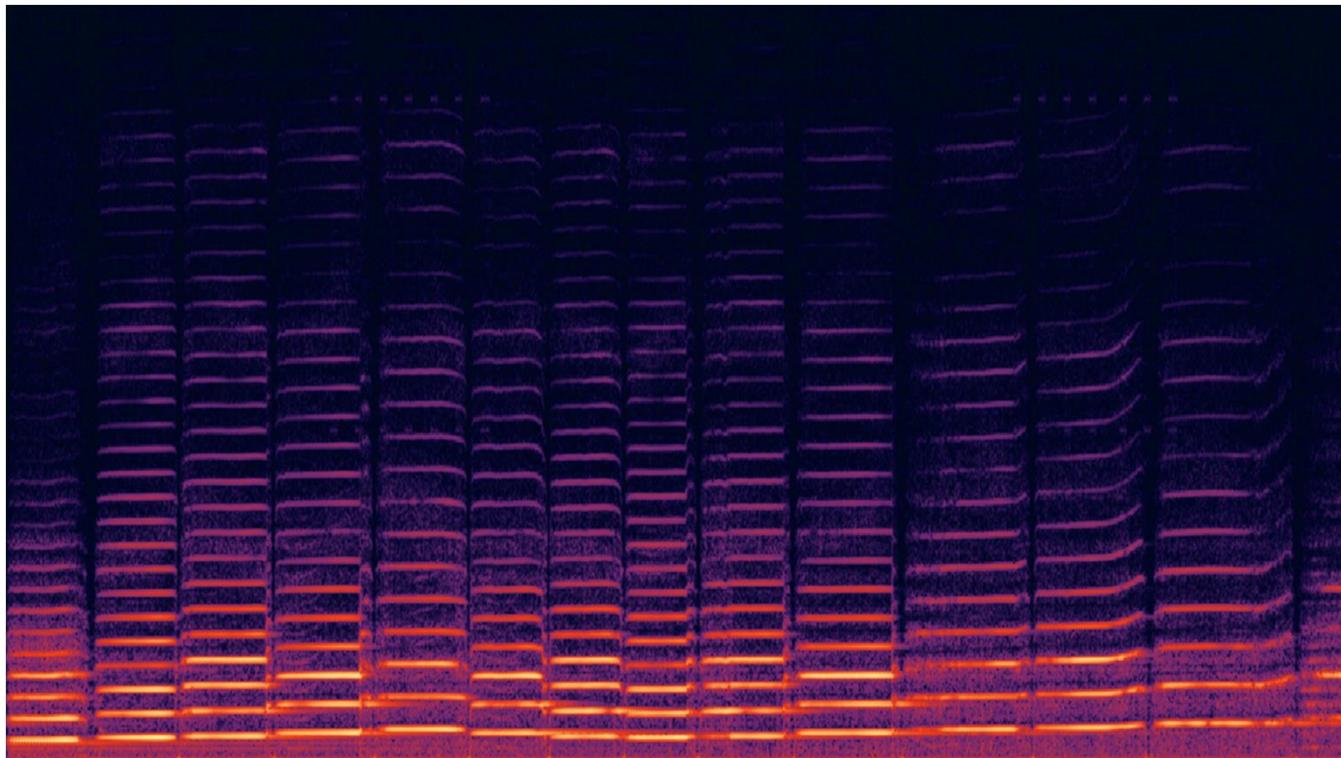
courtesy: peek3D.com

Sound Spectrum

courtesy: olympus-ims.com



# Spectrogram

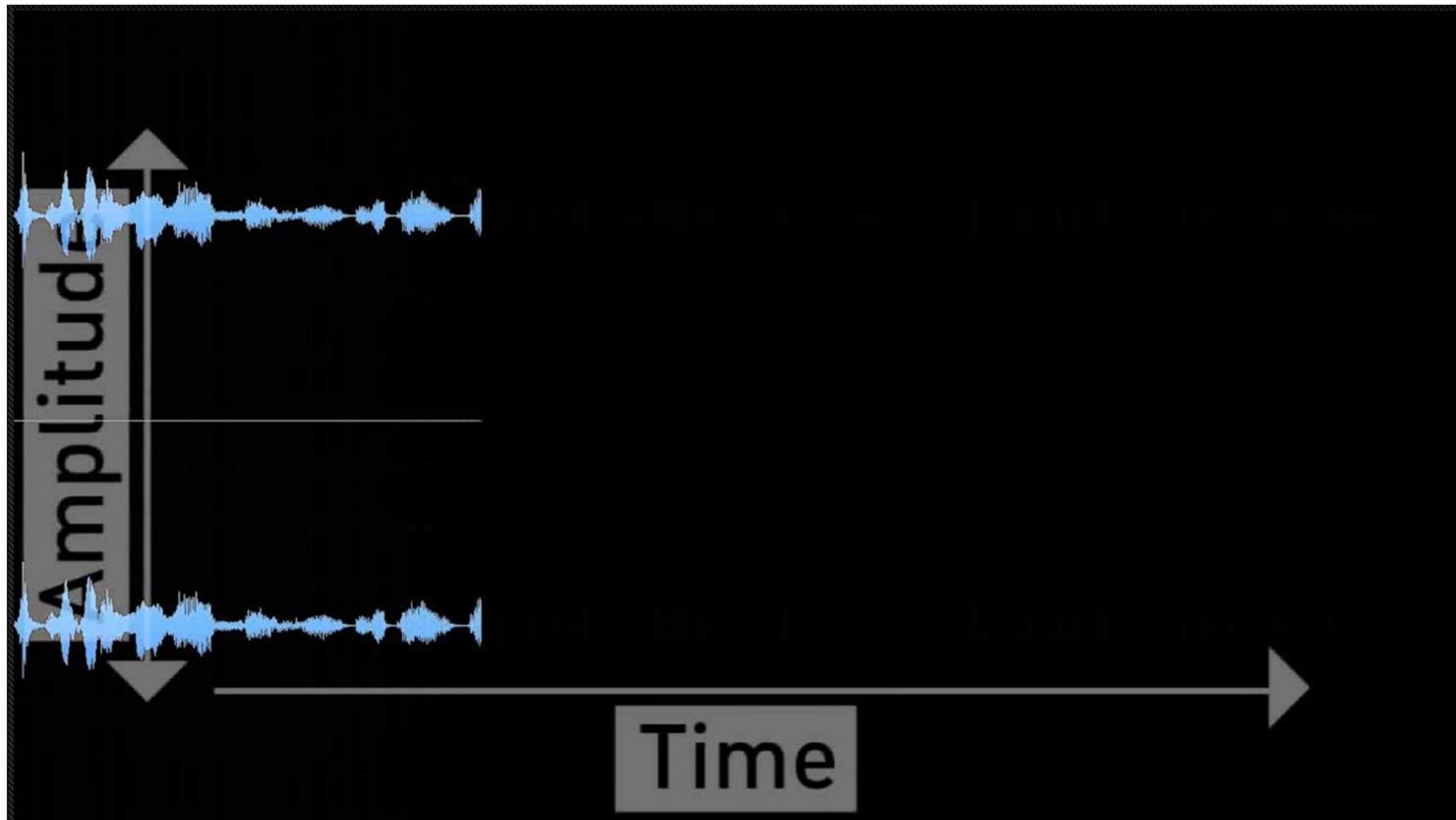


Violin Recording

courtesy: wikipedia

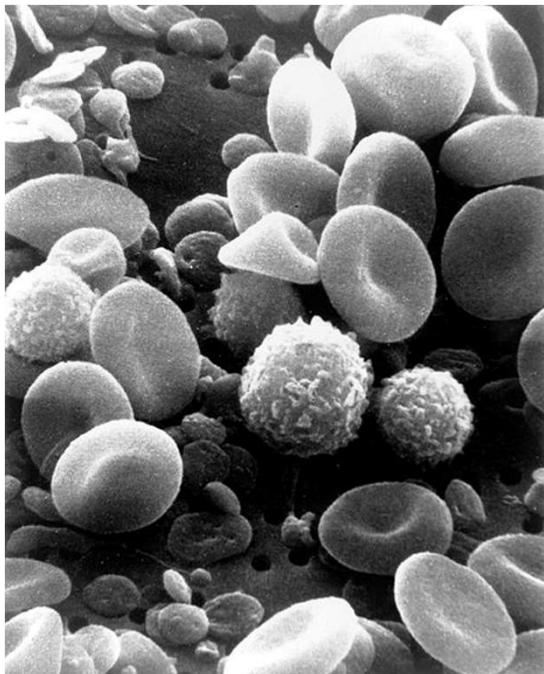


# Spectrogram



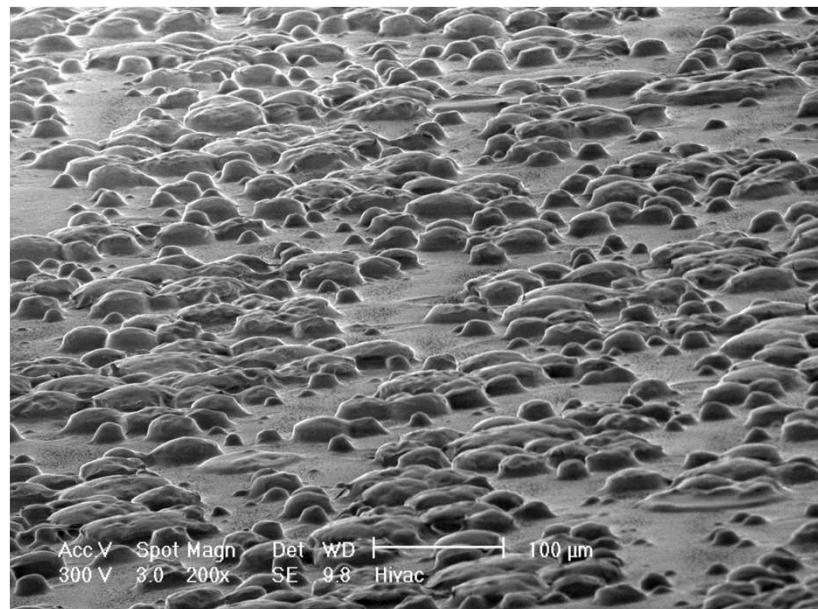
courtesy: [iZotope, Inc.](#)

# Scanning Electron Microscopy



Normal Circulating Human Blood

courtesy: National Cancer Institute



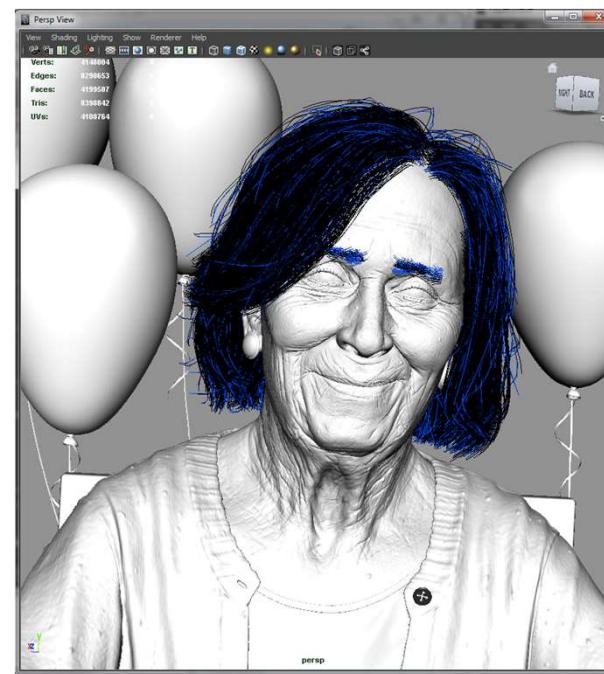
Adhesive on Post-it note

courtesy: wikipedia

# Computer generated

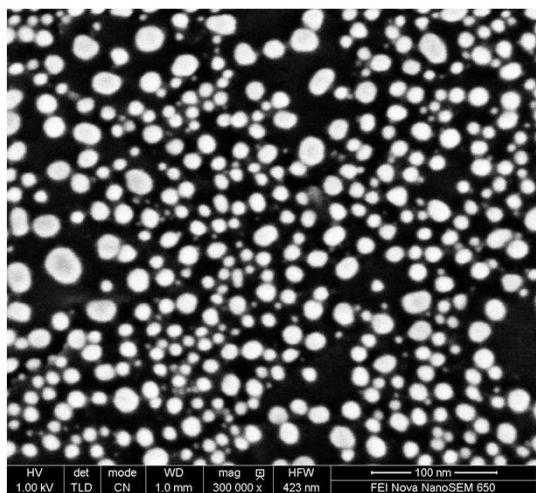


Happy Birthday Nana  
courtesy: Dan Roarty



# Scale

Microscopes



$10^{-9}\text{m}$

courtesy: nanolab technologies.com

Telescopes



$220\text{ kly} \approx 10^{21}\text{m}$

courtesy: wikipedia

# Types of Images (classification on optics)

1. Reflection Images



Information primarily about objects surface

2. Emission Images



Information primarily about internal properties

3. Absorption Images

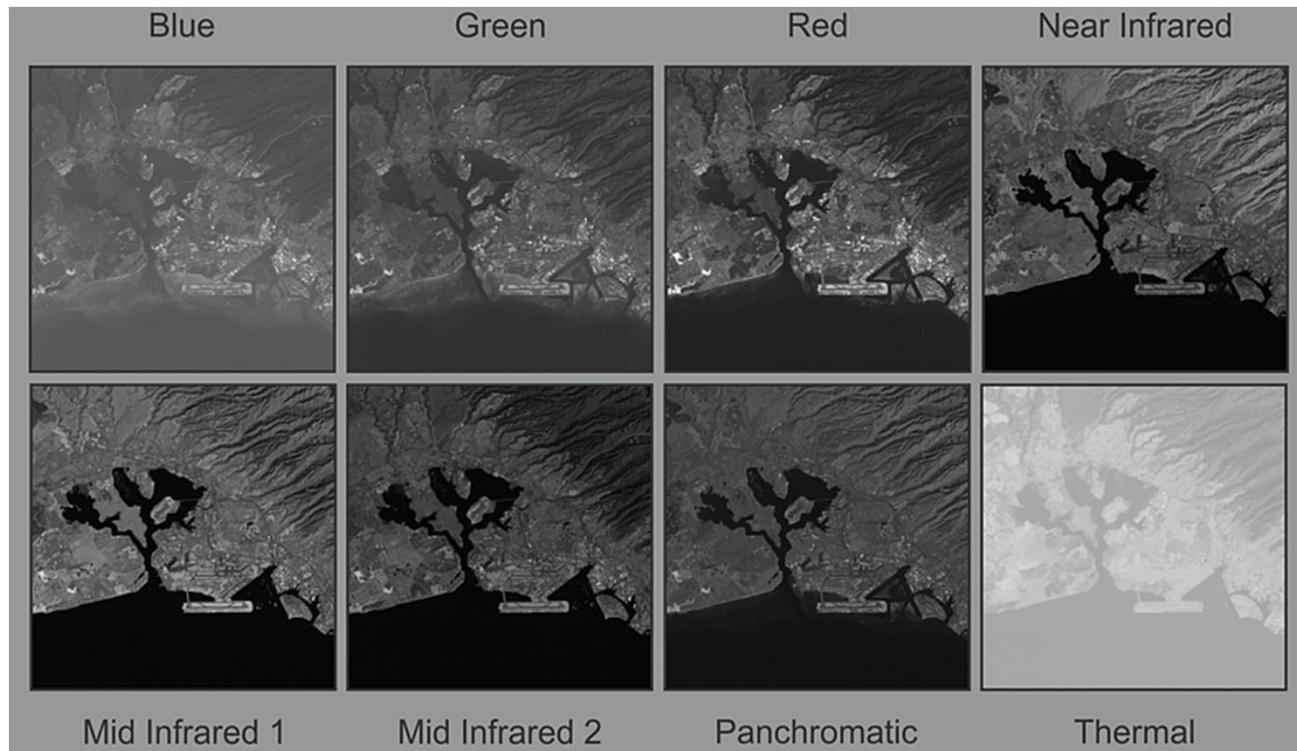


Information primarily about internal structure

# Types on images (classification on arrangement)

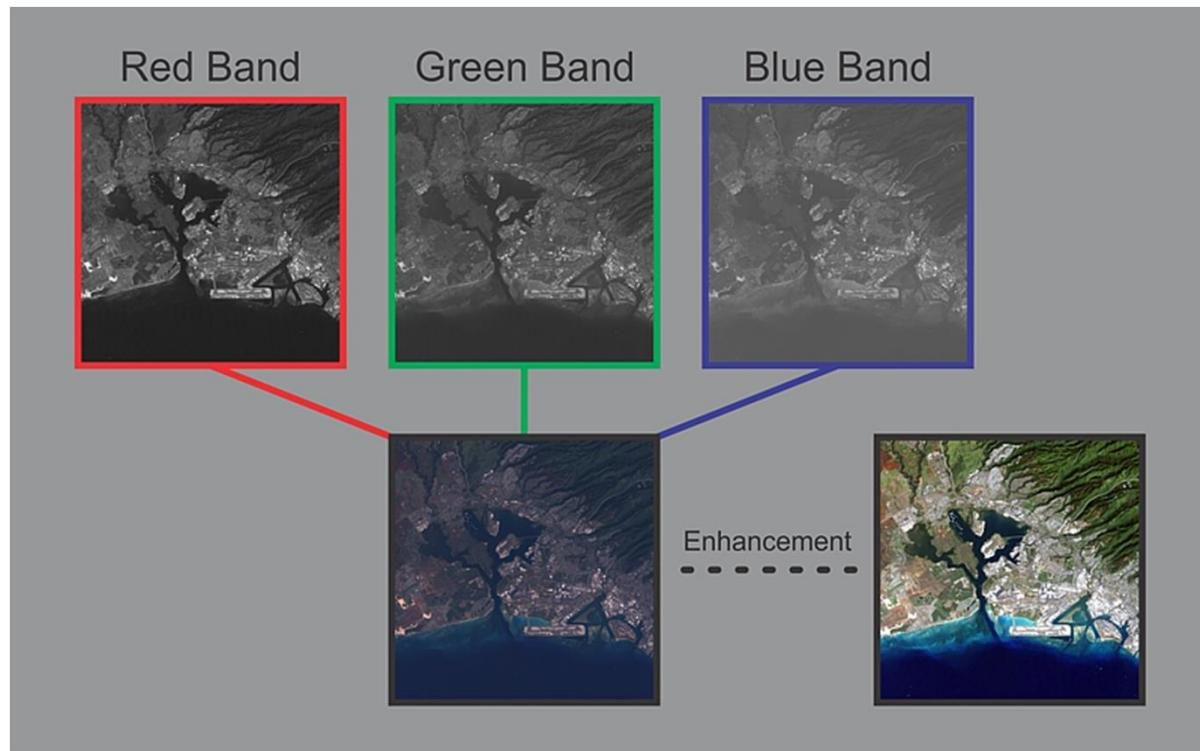
- Grayscale
  - RGB
  - Multispectral images
  - Stereo images
  - Multi-view images
-

# Multi spectral images



Courtesy: LANDSAT

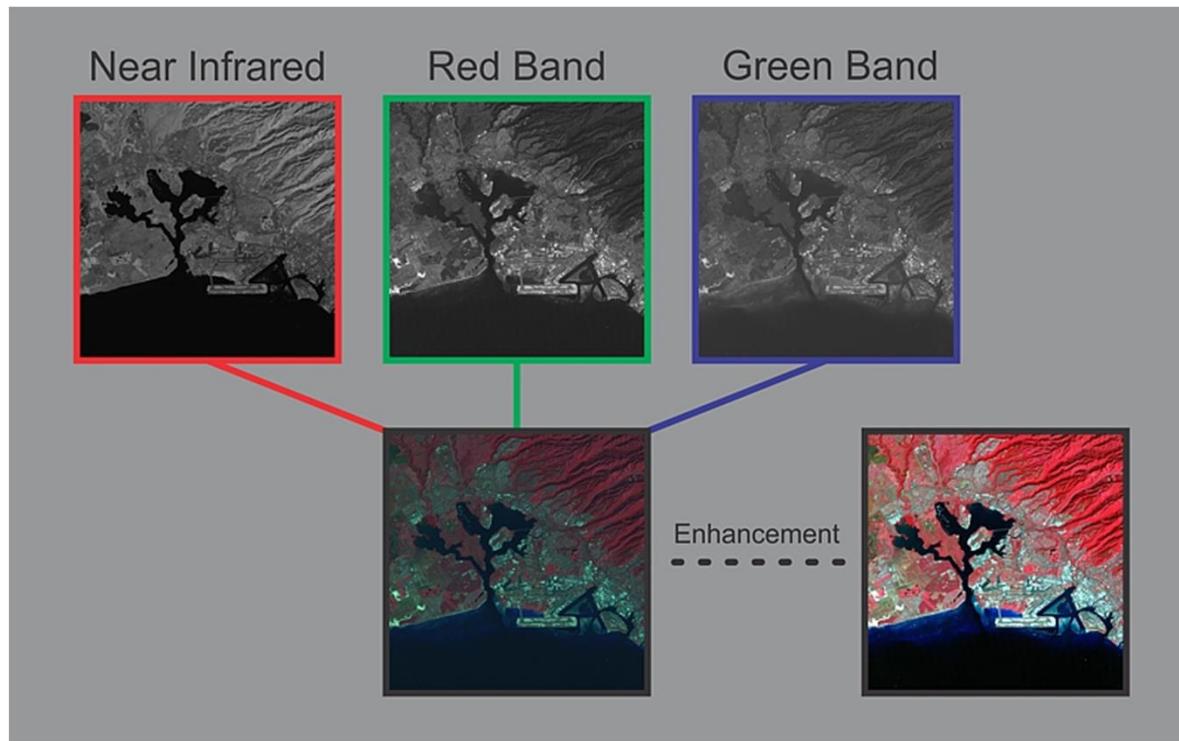
# Multi spectral images



Courtesy: LANDSAT

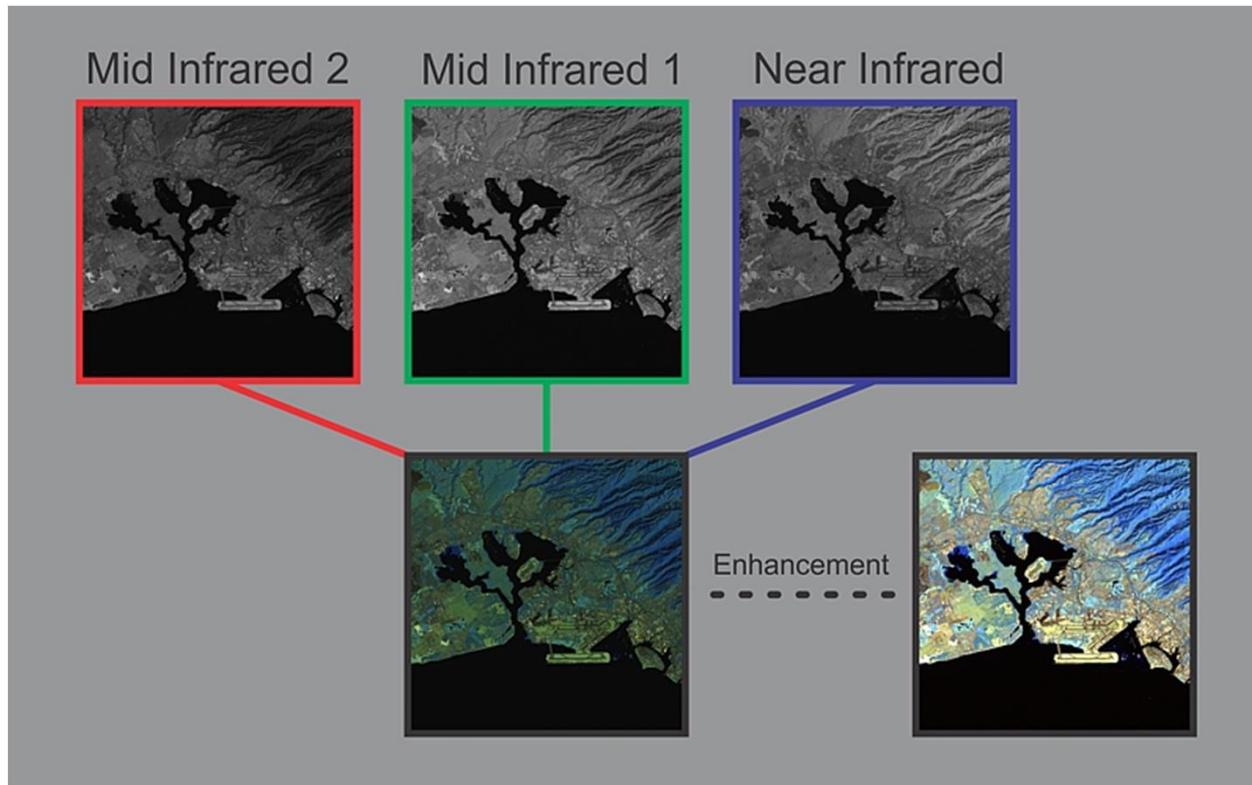
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# Multi spectral images



Courtesy: LANDSAT

# Multi spectral images



Courtesy: LANDSAT

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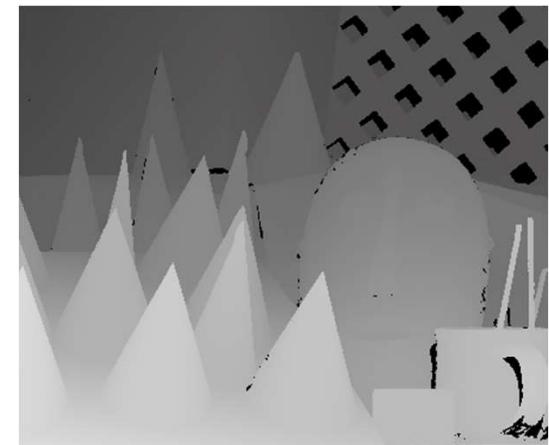
# Stereo Images



courtesy: wikipedia.com

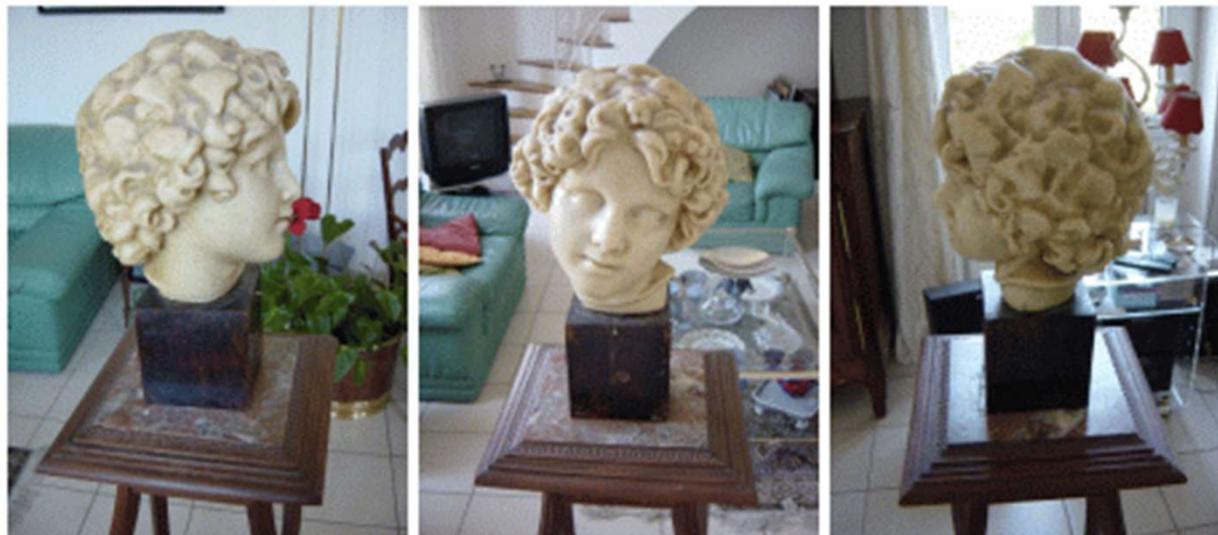


# Stereo Images



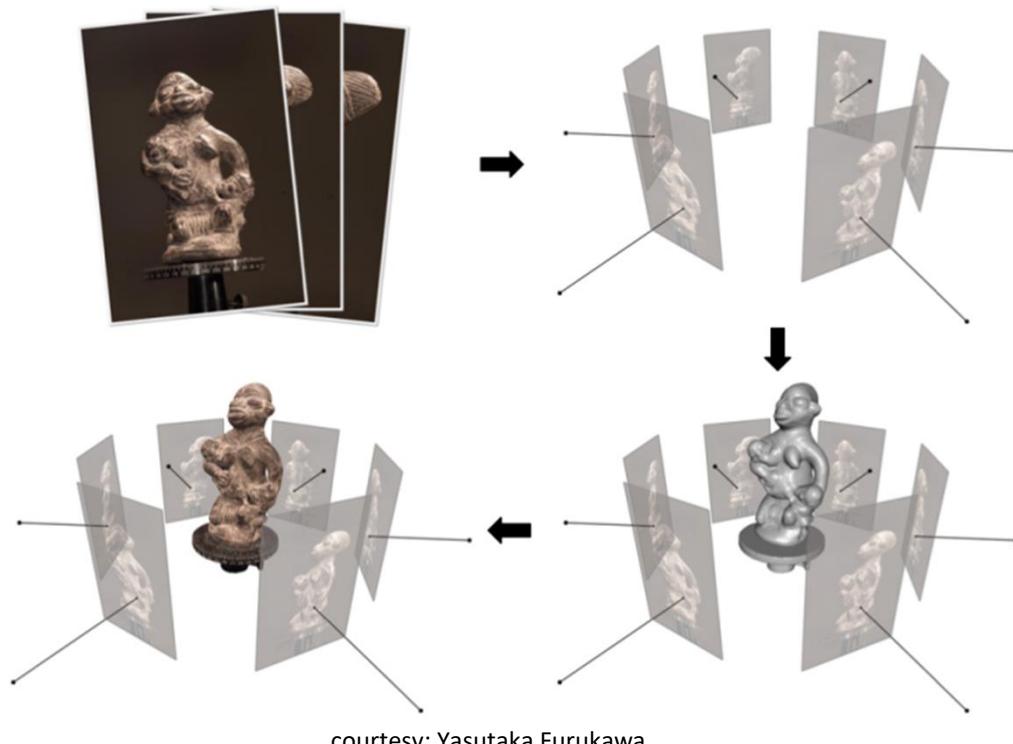
courtesy: [vision.middlebury.edu](http://vision.middlebury.edu)

# Multi-view images



courtesy: Maxime Lhuillier

# Multi-view images

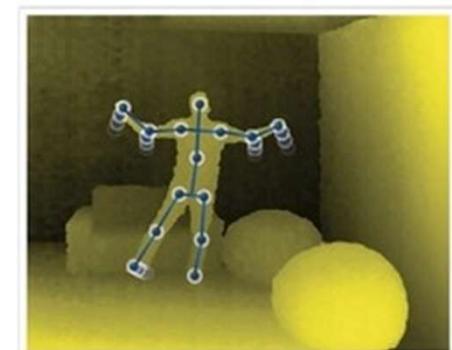
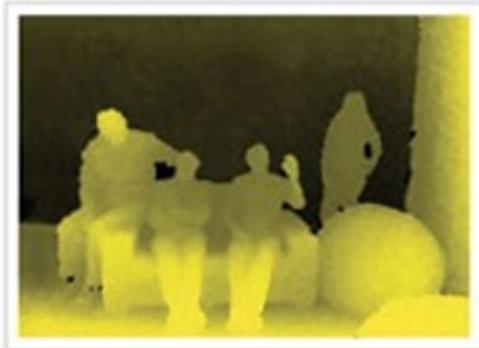


# Kinect images

Color (RGB) Image



Depth Image



courtesy: kinect and prime sense

# Organization (today's lecture)

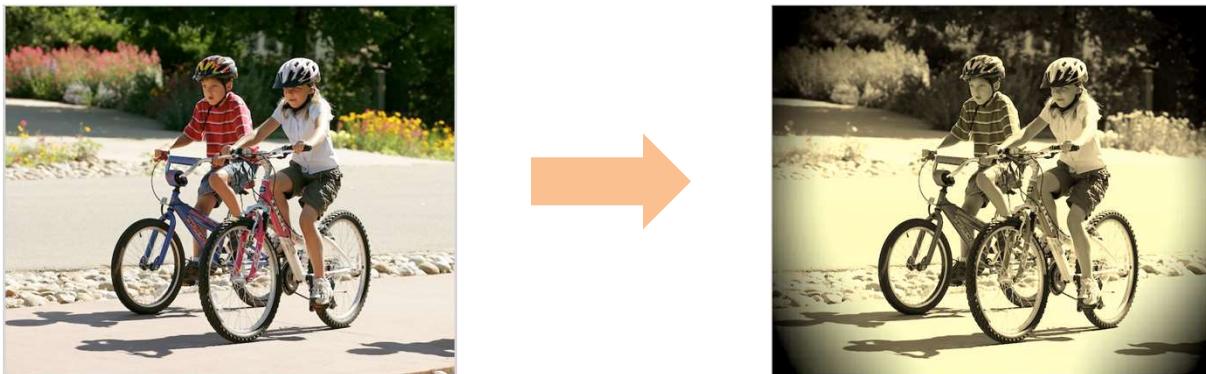
1. SIGNALS (Analog Signals, Digital Signals)

2. DIGITAL IMAGES (image formation, classification of images)

3. PROCESSING DIGITAL IMAGES (example applications, tasks of interest)

# Digital Image processing

- Computer algorithms that alter an image to create new image



- Computer algorithms to retrieve important information automatically from an image



# Tasks of interest: Noise Removal



Total variation denoising [Chambolle JMIV 2004]

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# Tasks of interest: Haze Removal



Single Image Haze Removal [He et al. CVPR 2009]

# Tasks of interest: Contrast adjustment



Image courtesy: mathworks

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# Retouch Personal Photos!



©Images taken from the web.

# Tasks of interest: Artistic enhancement



Image courtesy: [webneel.com](http://webneel.com)



Image courtesy: Jon Morse

# BW to Color



# Tasks of interest: Cinematic Grading



Image courtesy: juanmelara.com

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# Tasks of interest: Edge Detection



Image courtesy: mathworks



# Tasks of interest: Feature detection + stitching

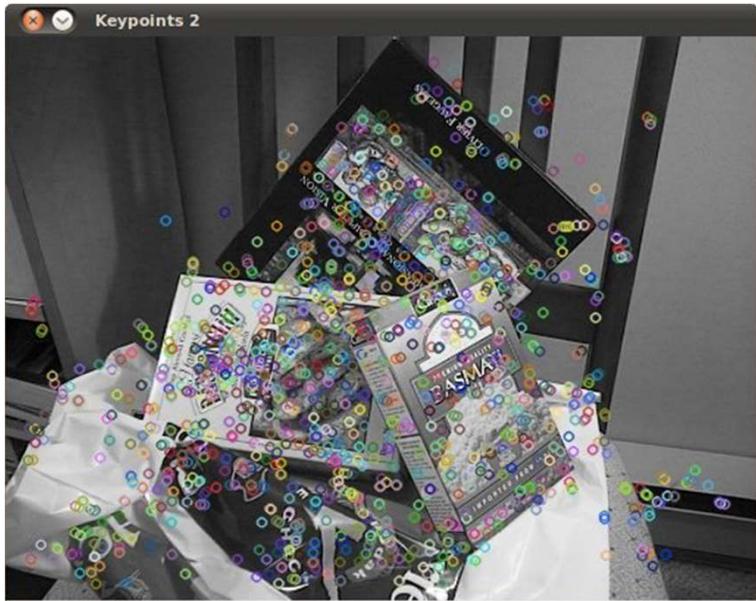


Image courtesy: opencv

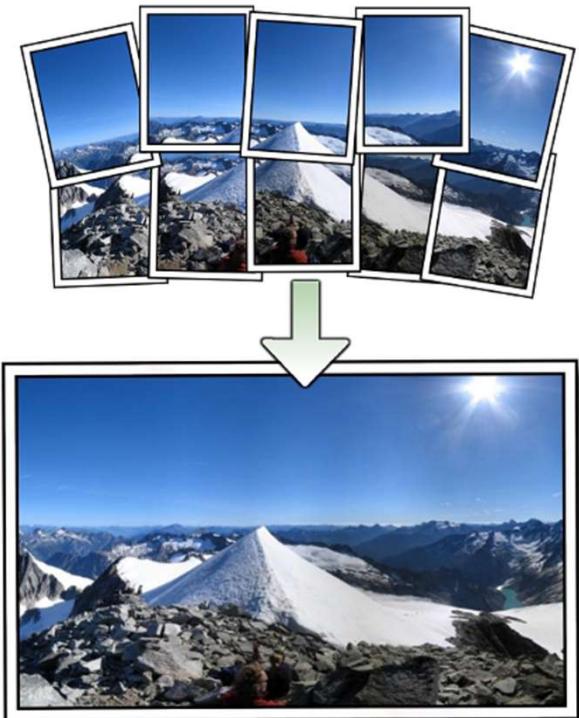
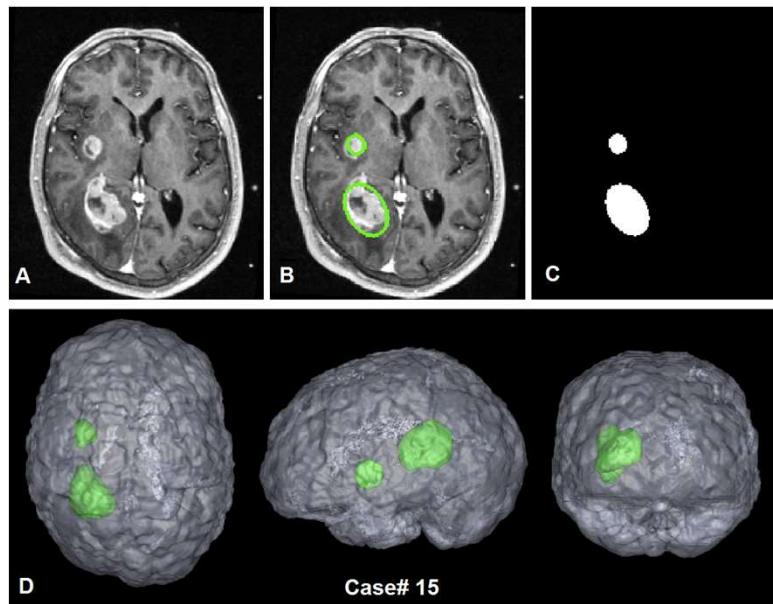
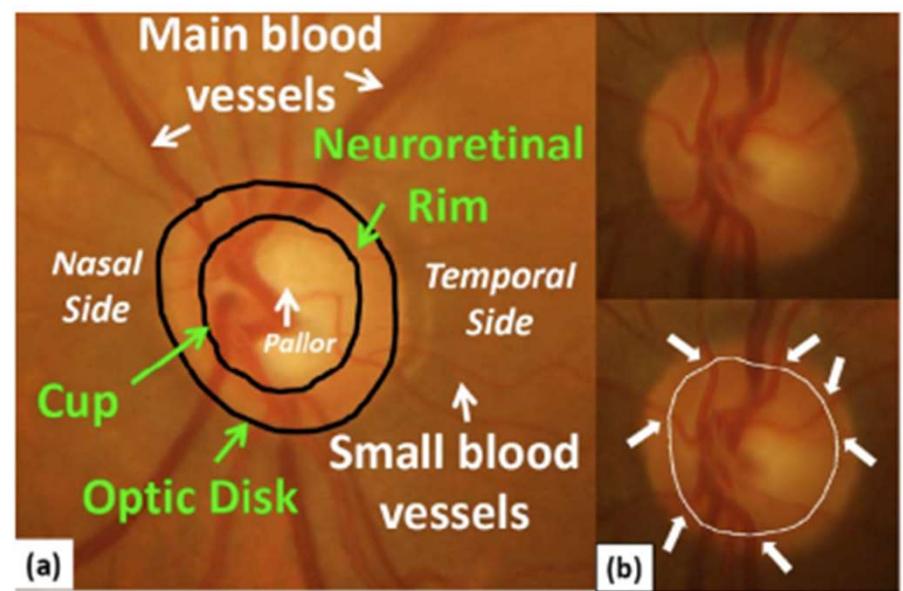


Image courtesy: autostitch

# Tasks of interest: Segmentation

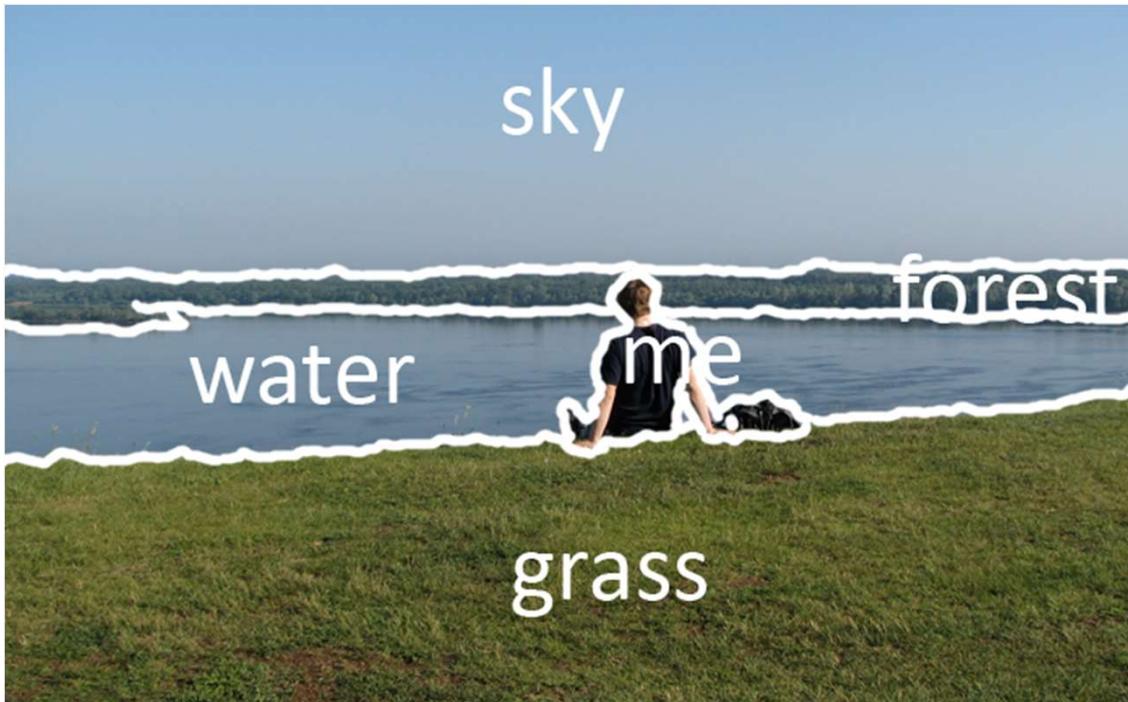


Tumour Segmentation [Yu et al. MICCAI 2010]



Cup Segmentation [Joshi and Sivaswamy 2011]

# Tasks of interest: Segmentation



Courtesy: Roman Shapovalov

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# Tasks of interest: Compression



Original Image (1.2 mb)



Compressed JPEG Image (100 kb)

# Tasks of interest: Inpainting

DAMAGED



RESTORED



Bertalmio et al. SIGGRAPH 2010

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# Tasks of interest: Special effects

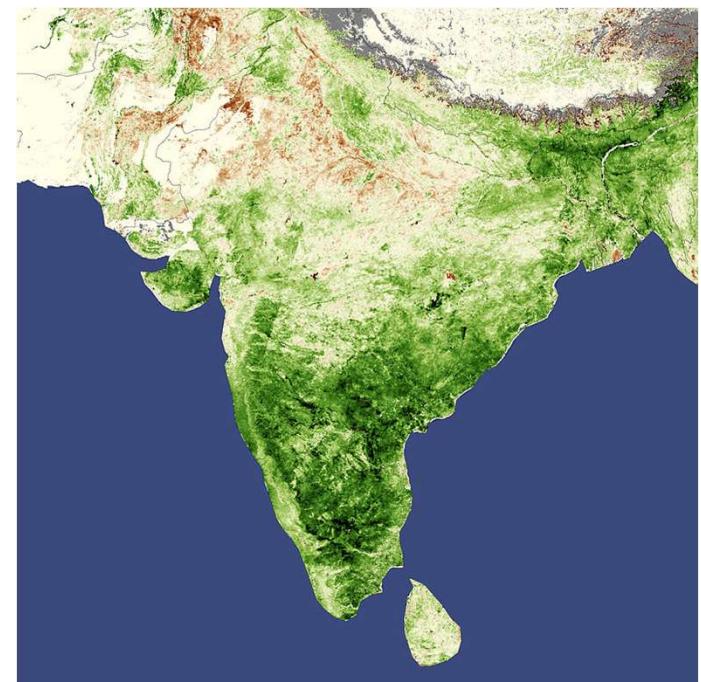
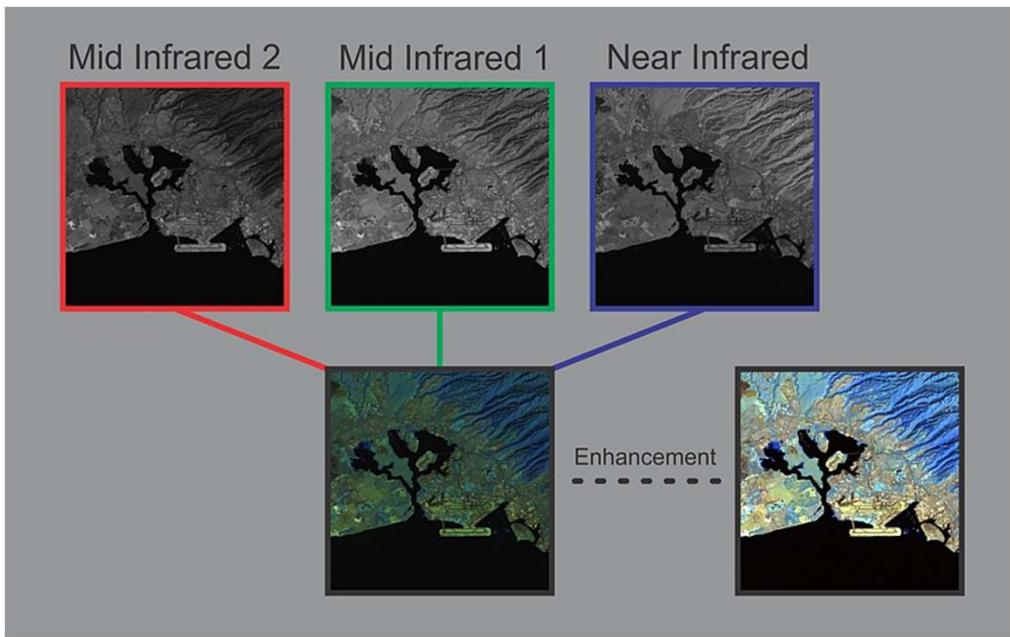


courtesy: wachowski brothers (matrix)



courtesy: Miller et al. (sin city)

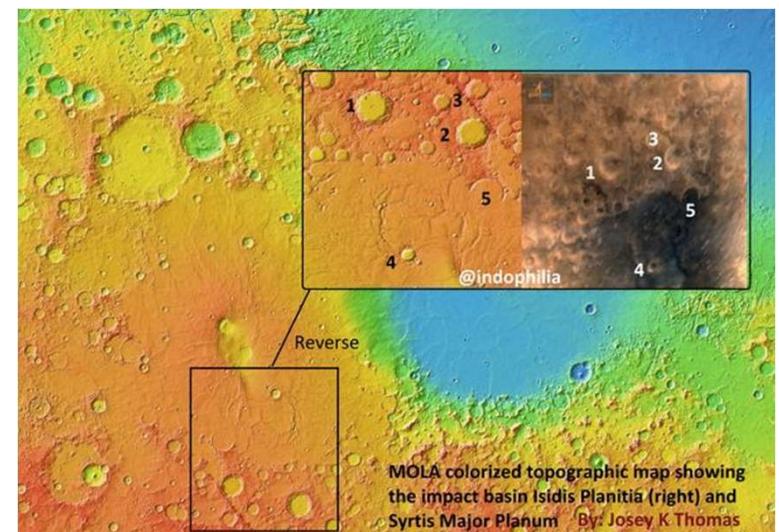
# Tasks of interest: Satellite imaging



Terrain classification, weather predictions etc.

courtesy: NASA

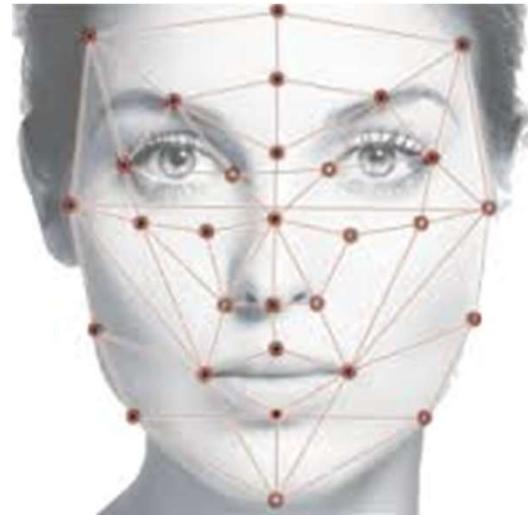
# Tasks of interest: Astronomy



# Tasks of interest: Biometrics



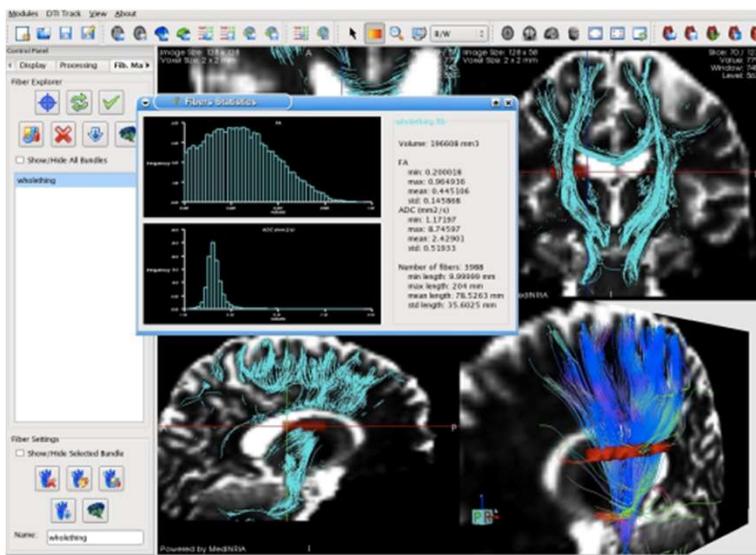
courtesy: dqindia.com



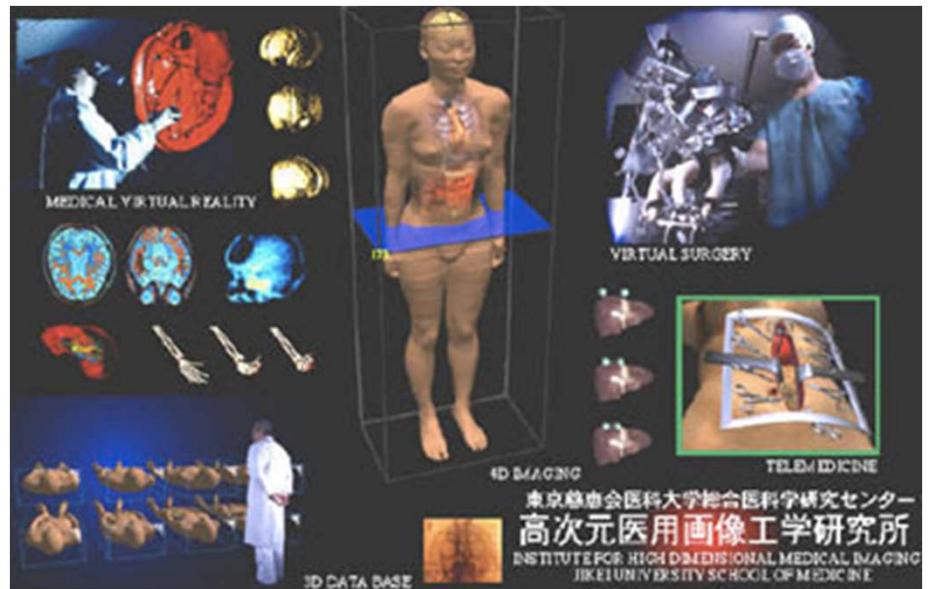
courtesy: heyce.com



# Tasks of interest: Medicine



Courtesy: medINRIA



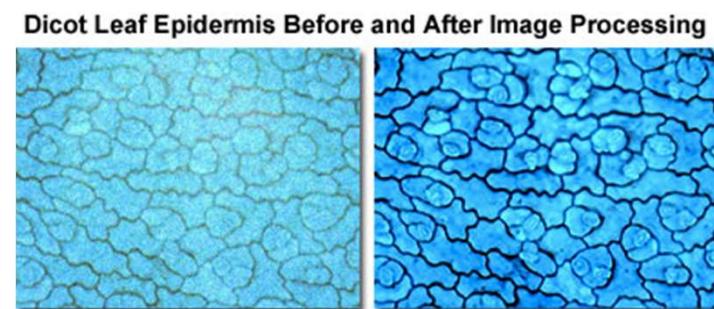
Courtesy: Naoki Suzuki

# Tasks of interest: Many more

- Biology
- HCI
- Number Plate recognition
- Gesture recognition



Courtesy: Perviverzov et al. 2012

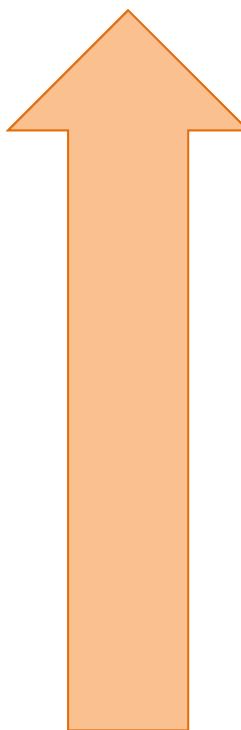


Courtesy: Olympus



Courtesy: researchdesignlab.com

# Relationship with computer vision



**Computer vision (high level)**

Object detection, recognition, tracking (AI + ML)

**Image Analysis (mid level)**

Segmentation, feature matching etc.

**Image Processing (low level)**

Compression, morphology, noise removal, restoration etc.

# When it all fails !

