

Digital Image Processing (CSE/ECE 478)

Lecture # 01: Overview

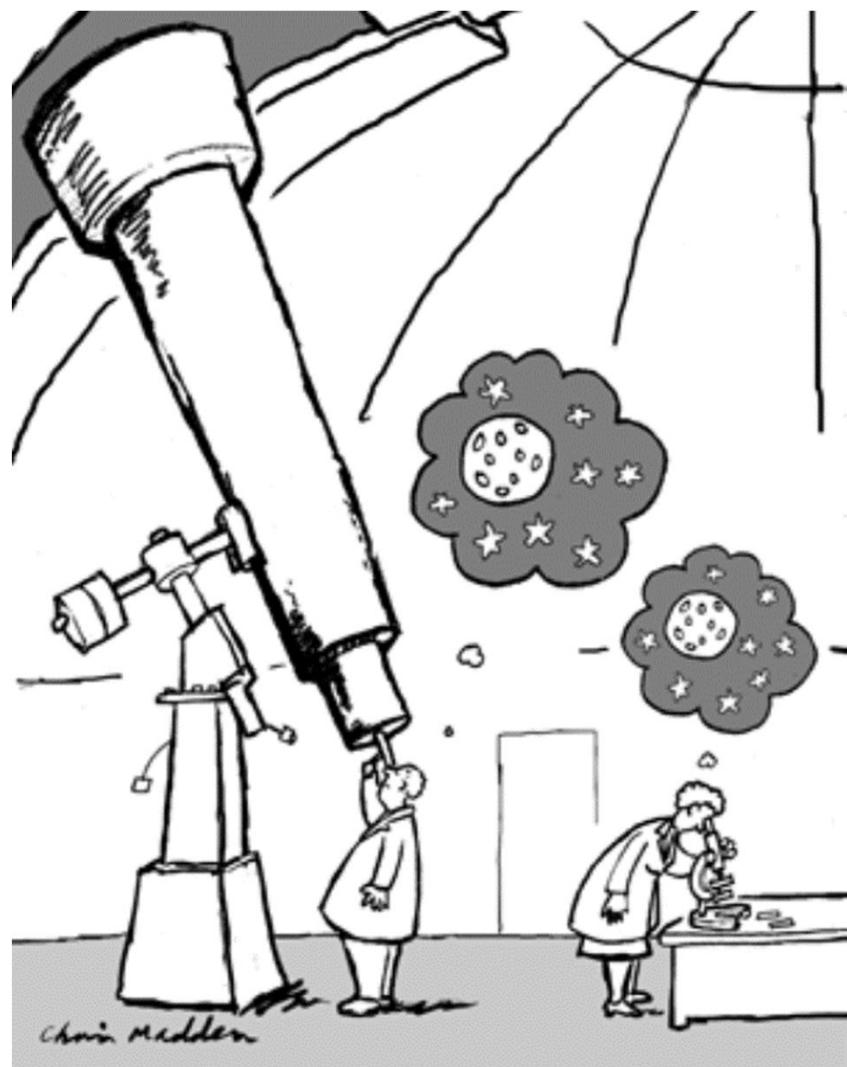
Avinash Sharma

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

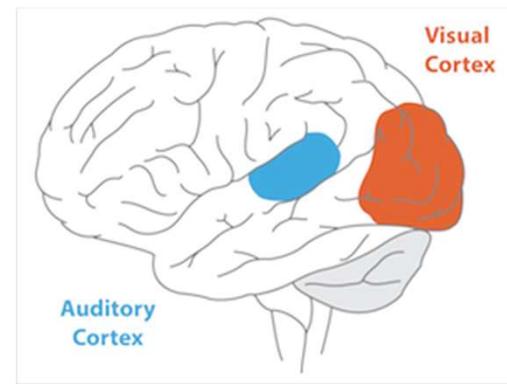
- Write a 8 page report summarizing your results
- Release the final code
- Give a presentation

PROJECTS NEEDS TO BE APPROVED

ANY PLAGIARISM WILL NOT BE TOLERATED, BE EXTREMELY CAREFUL

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)



Trends!



AUTODESK®
PIXLR®



Adobe® Premiere®

Final Cut Pro X
Everything just changed in post.



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)

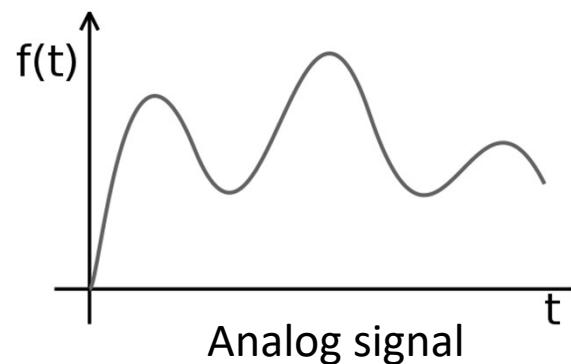
1. SIGNALS (Analog Signals, Digital Signals)

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

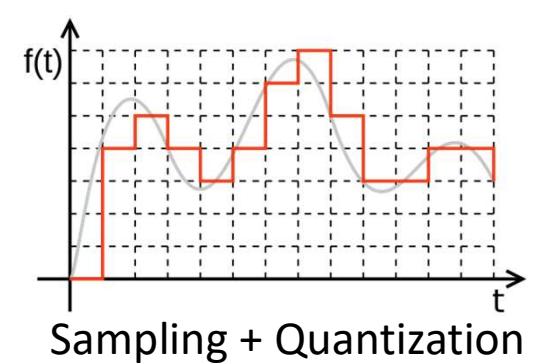
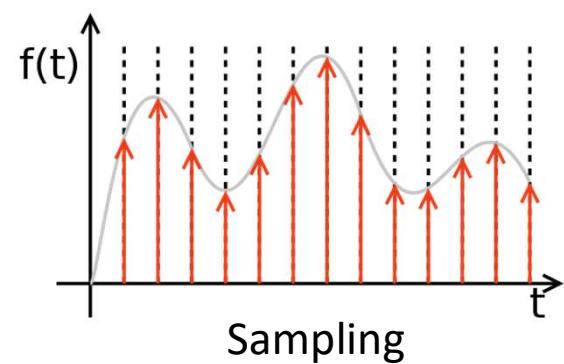
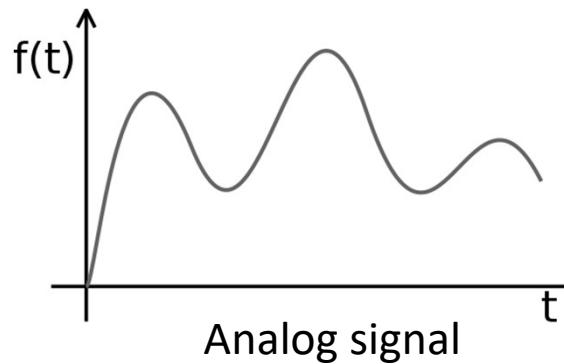
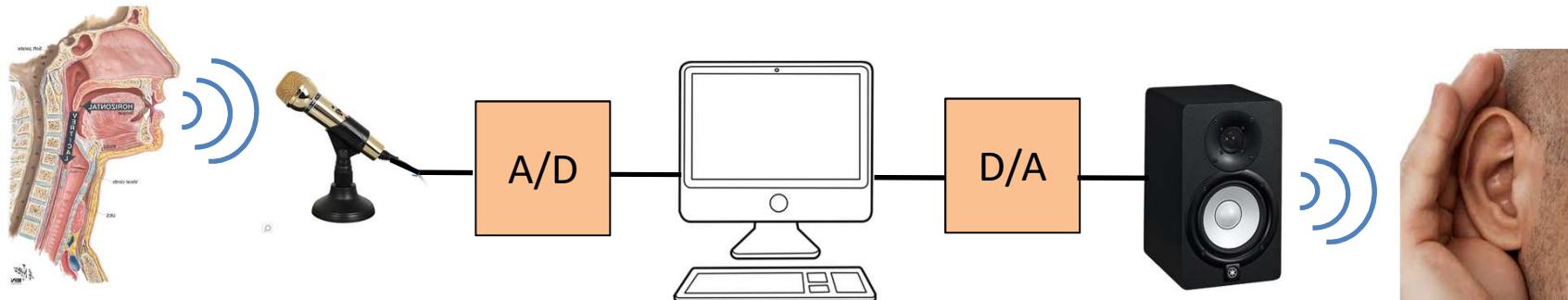
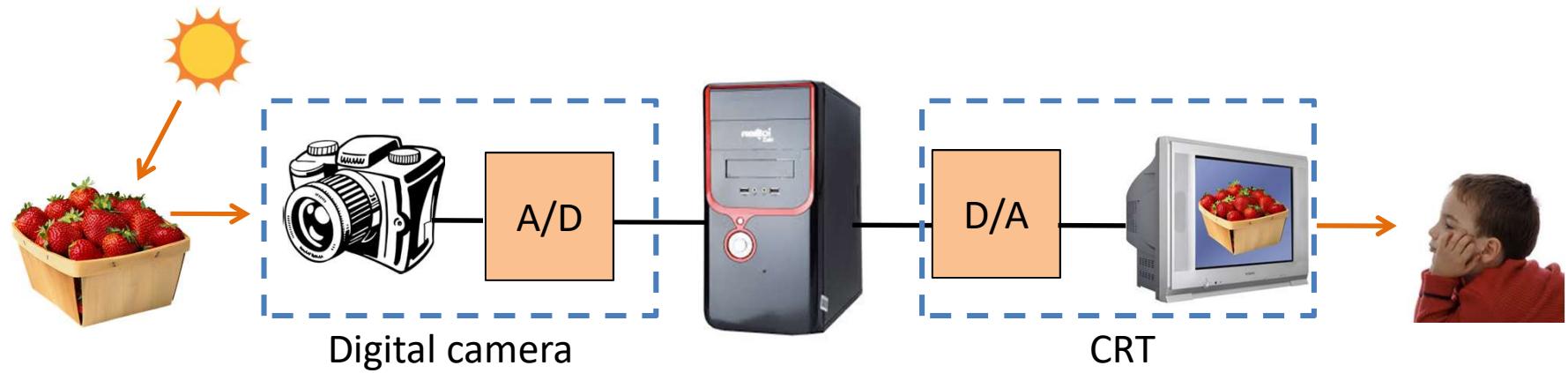


Image courtesy: wikipedia

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

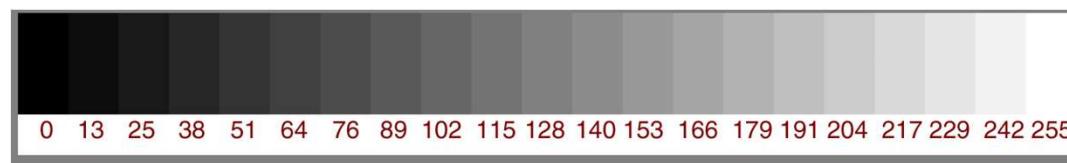
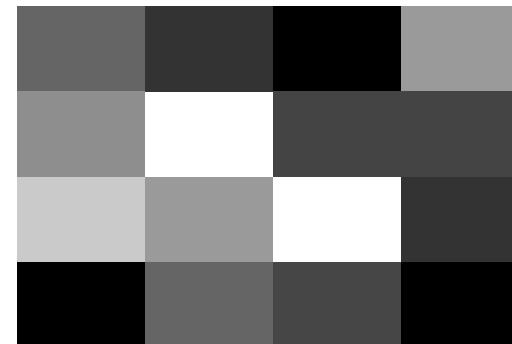


Image acquisition process

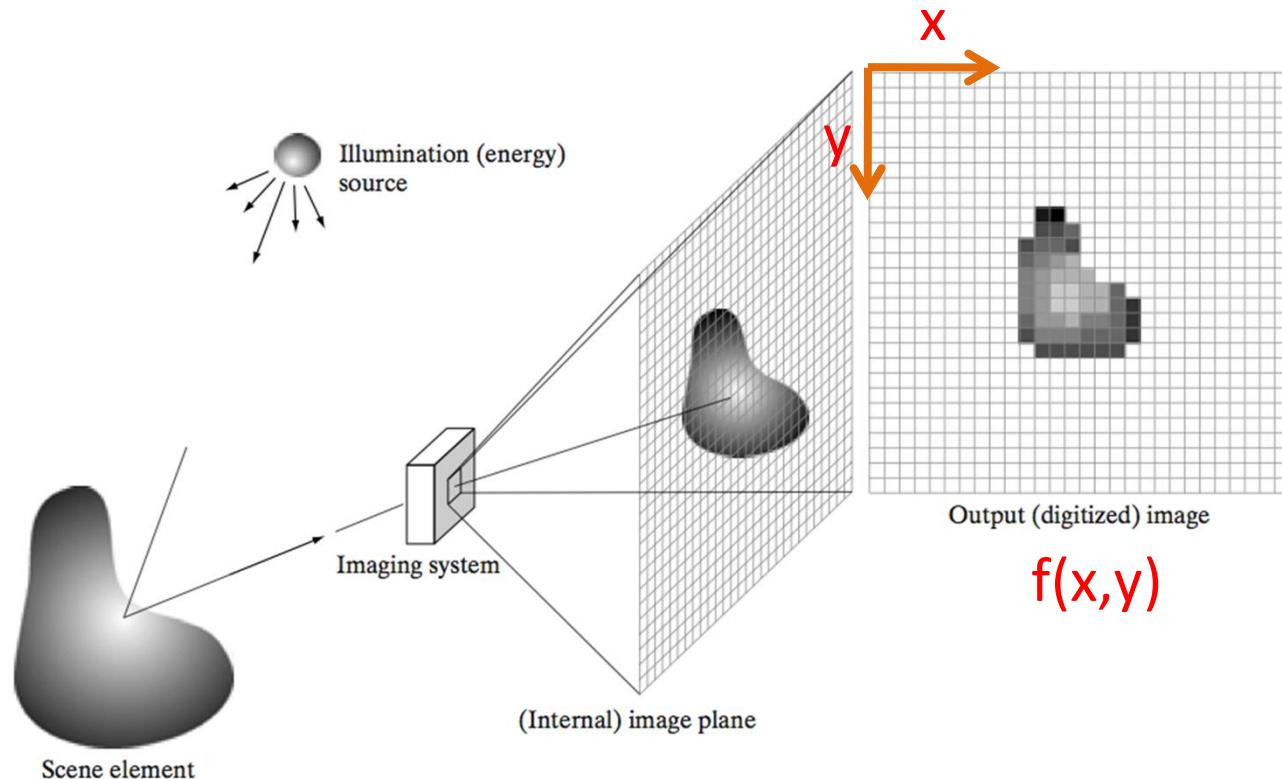


Image courtesy: Gonzalez and Woods

Image acquisition process

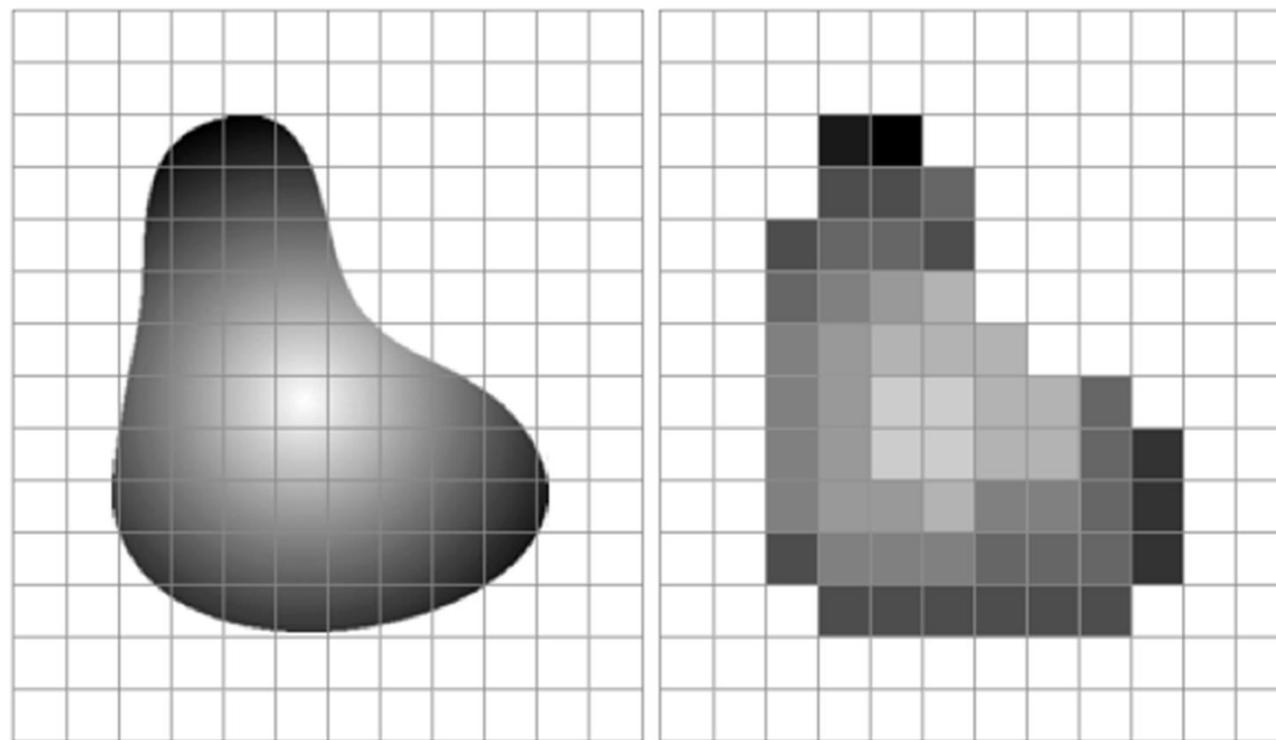
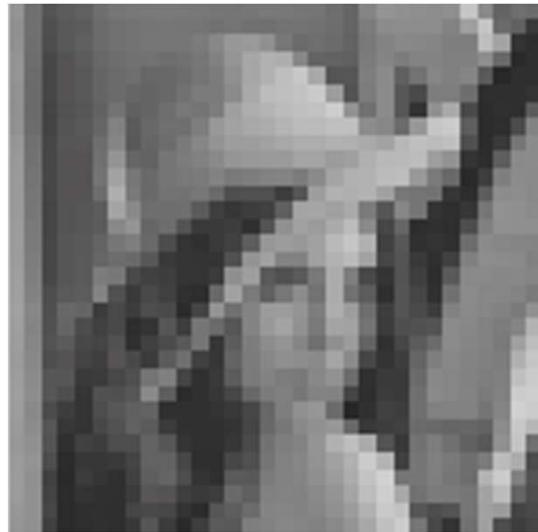


Image courtesy: Gonzalez and Woods

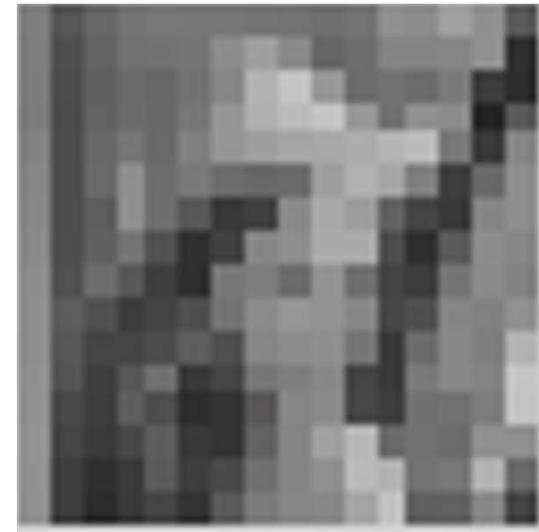
Sampling



256×256



32×32



16×16



Quantization



8 bits per pixel



4 bits per pixel

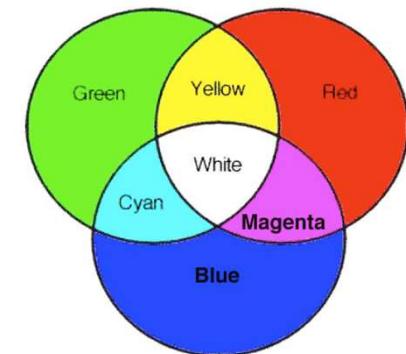


2 bits per pixel



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

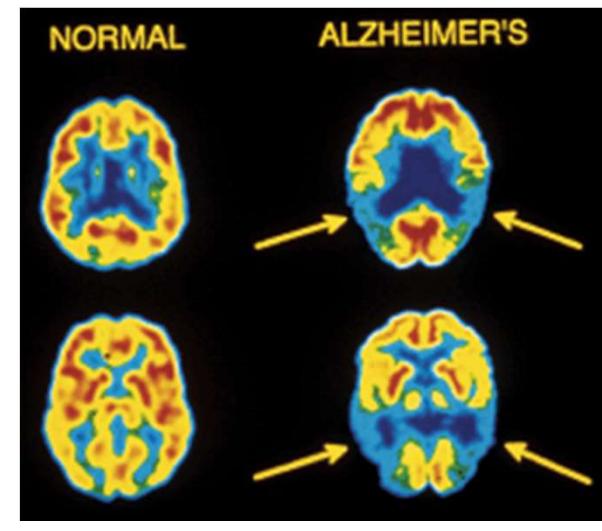
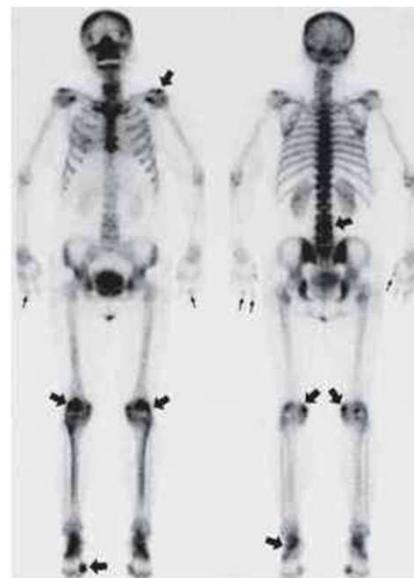
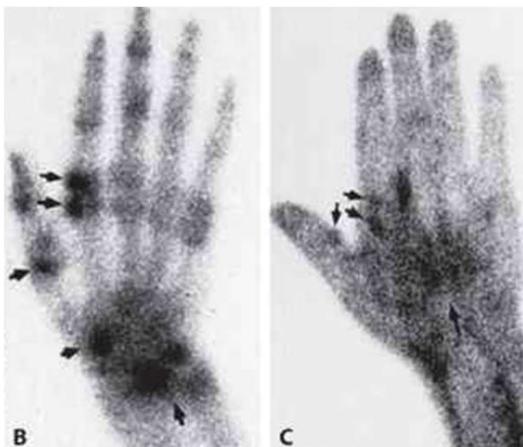
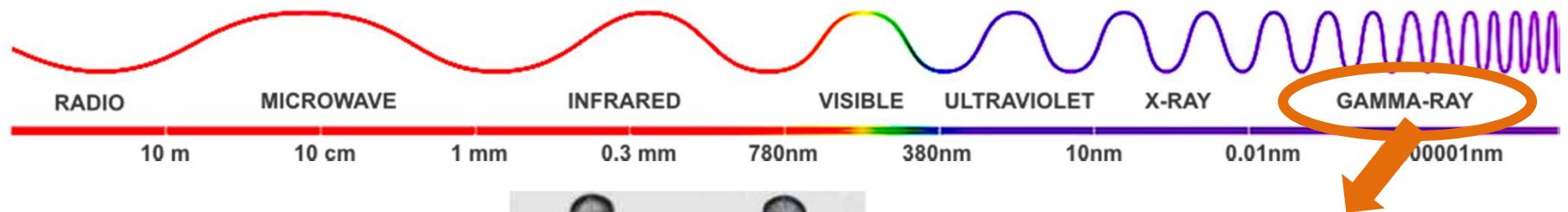


Types of Images (classification on source)

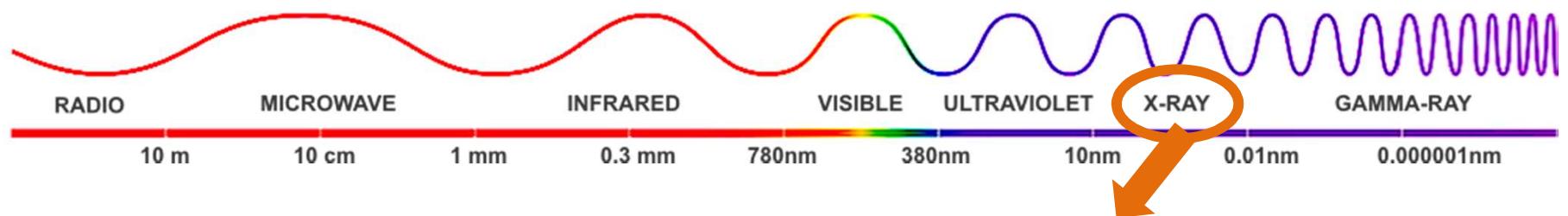
- Radiation from EM spectrum
- Acoustic/ultrasonic/spectrogram
- Electronic
- Computer generated



EM spectrum



EM spectrum



Wilhelm Röntgen



HAND MIT RINGEN

courtesy: wikipedia



CHEST RADIOGRAPH

courtesy: wikipedia



CT SCAN

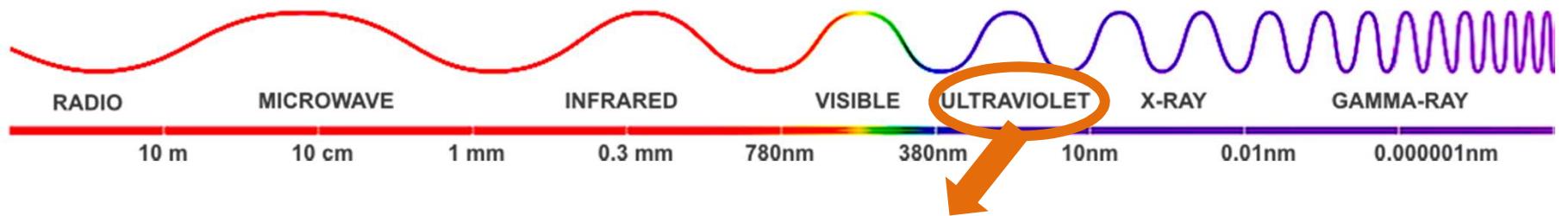
courtesy: wikipedia



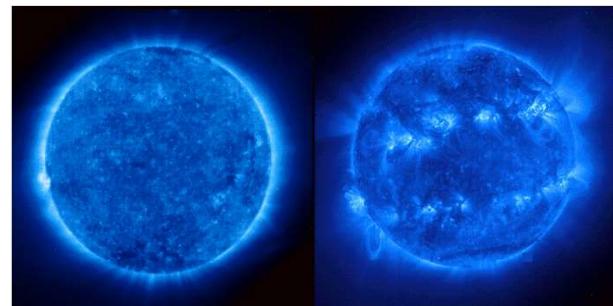
AIRPORT SCAN

courtesy: dpl-surveillance-equipment

EM spectrum



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



SUN (2 years apart)

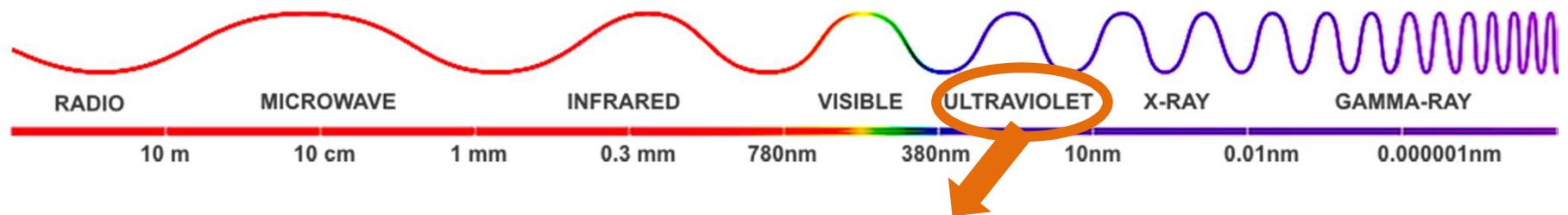
courtesy: NASA



100 EURO BILL

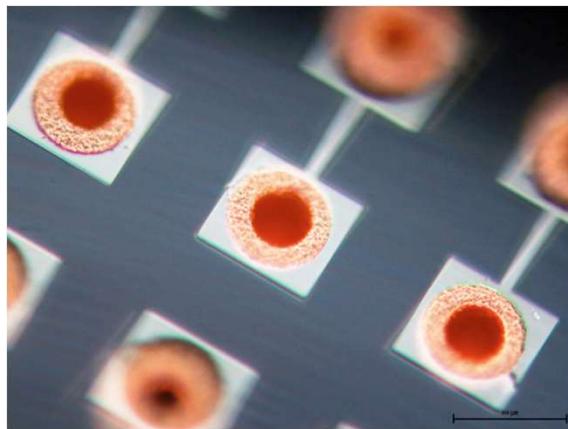
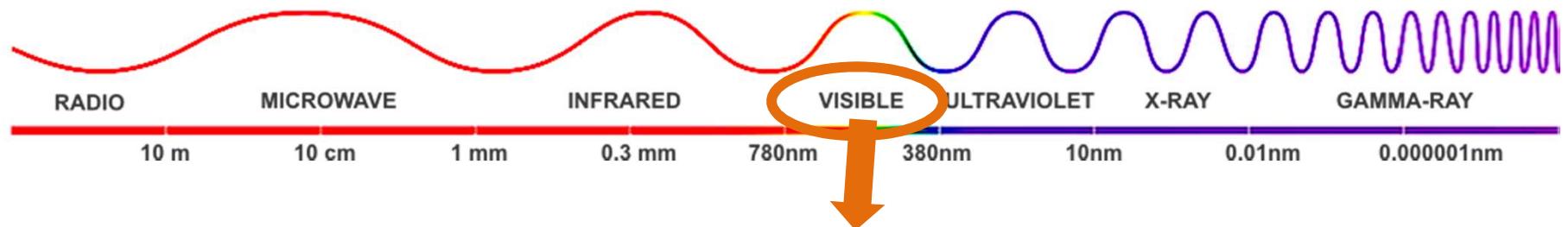
courtesy: lifepixel.com

EM spectrum



Source:
Lifepixel.com

EM spectrum



Chips (optical microscopy)
courtesy: EPFL microelectronics systems laboratory

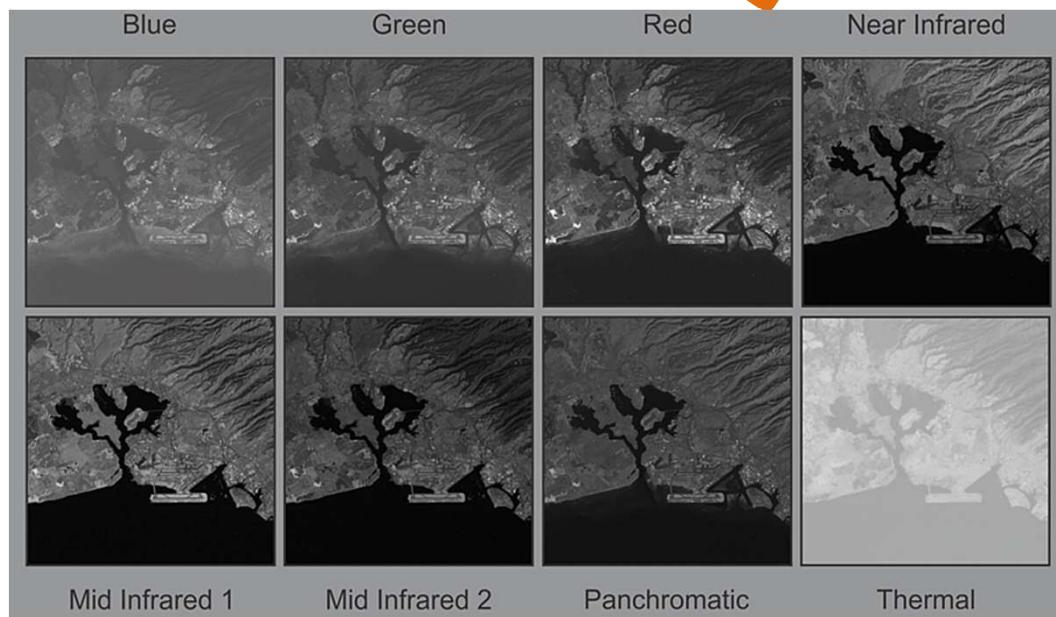
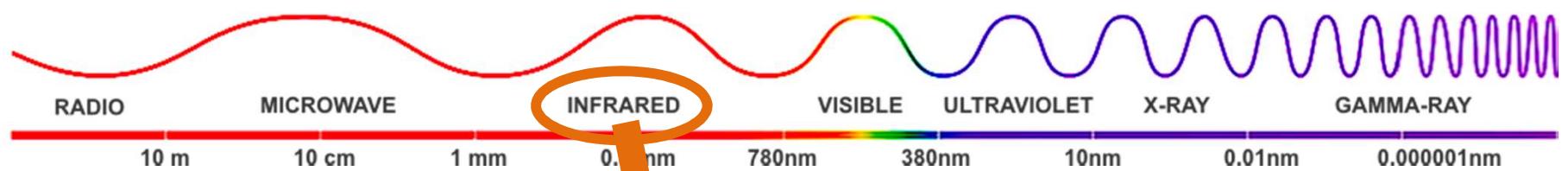


High Speed Photograph
courtesy: Alan Sailer



Satellite Image (Hurricane Katrina)
courtesy: britannica.com

EM spectrum

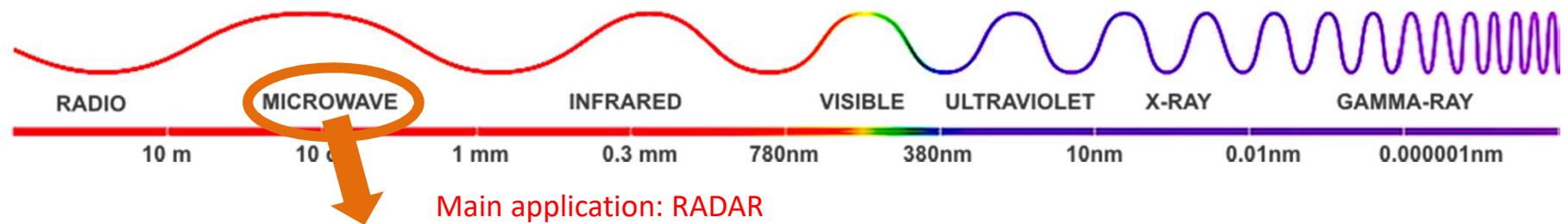


courtesy: LANDSAT (NASA)



courtesy: imaging1.com

EM spectrum



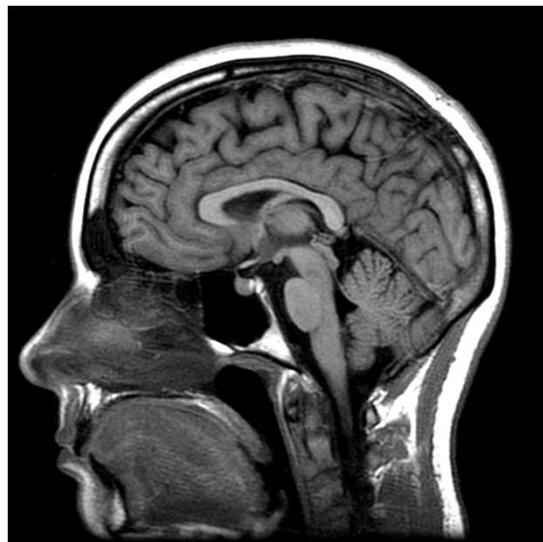
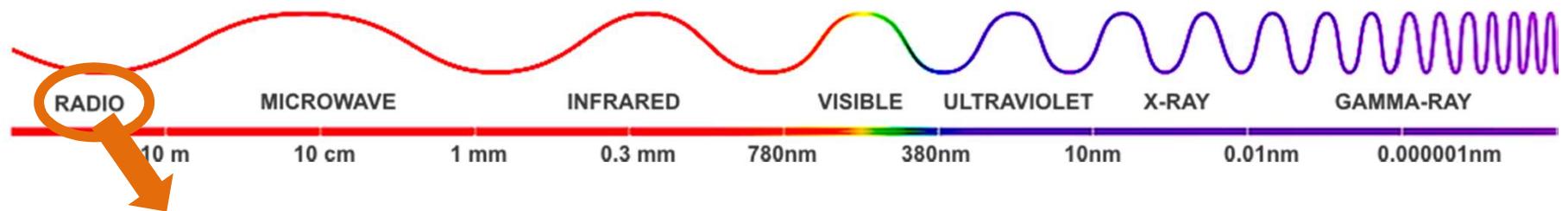
SOUTHEAST TIBET MOUNTAINS

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



MRI Knee

courtesy: mri-tip.com

Ultrasound



ULTRASOUND

courtesy: wikipedia



ULTRASOUND TWINS

courtesy: pinterest

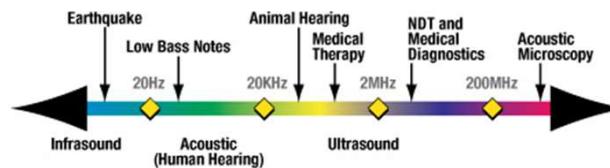


ULTRASOUND 3D

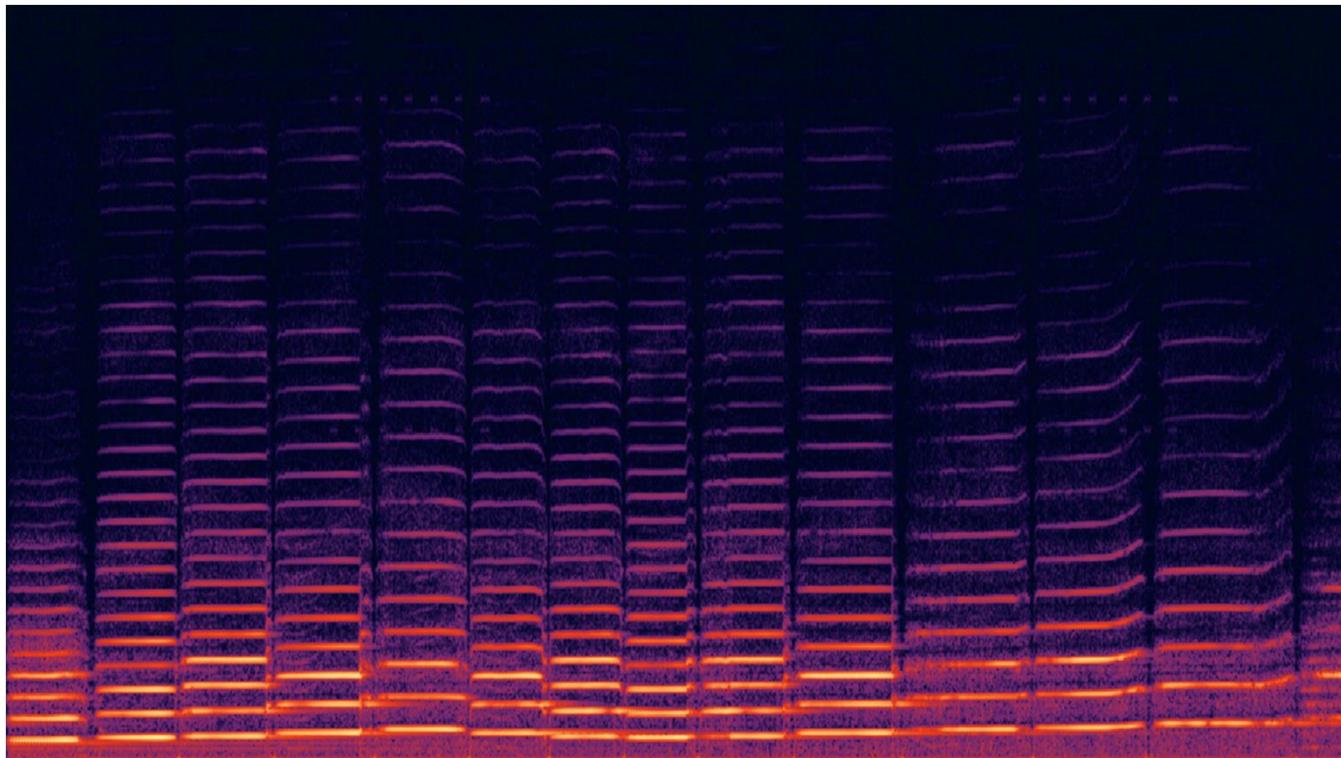
courtesy: peek3D.com

Sound Spectrum

courtesy: olympus-ims.com



Spectrogram

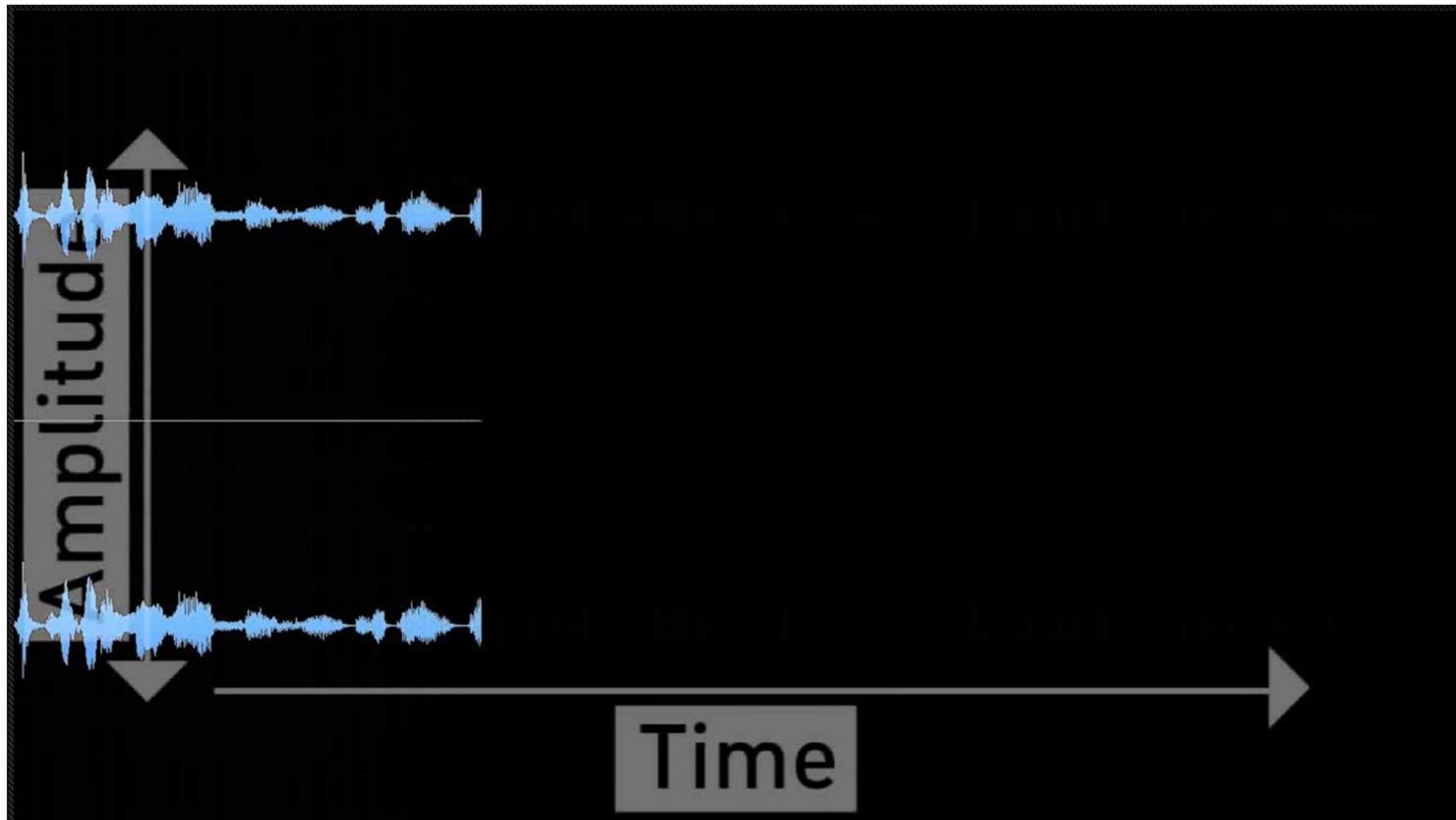


Violin Recording

courtesy: wikipedia

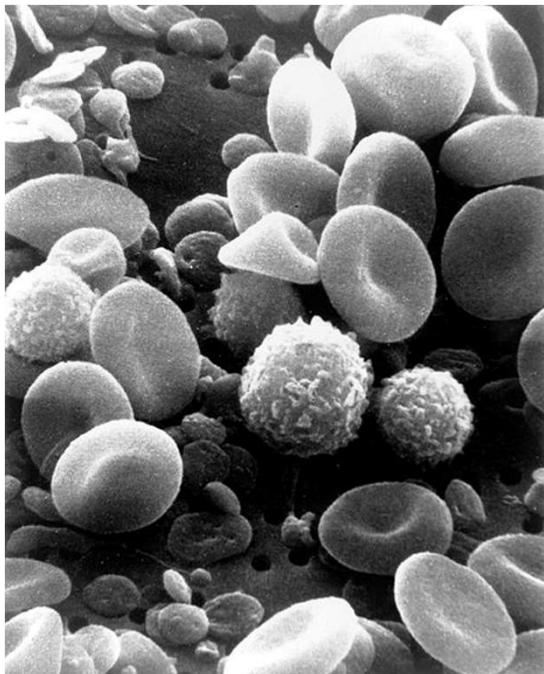


Spectrogram



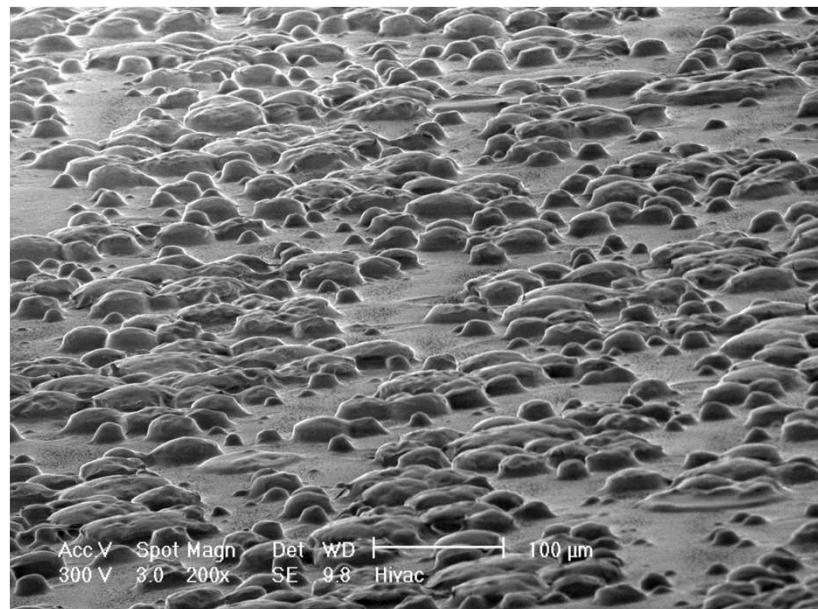
courtesy: [iZotope, Inc.](#)

Scanning Electron Microscopy



Normal Circulating Human Blood

courtesy: National Cancer Institute



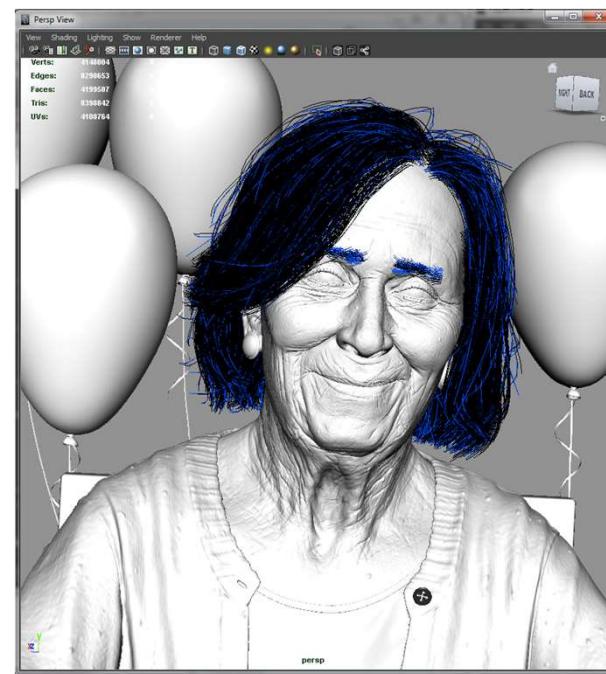
Adhesive on Post-it note

courtesy: wikipedia

Computer generated

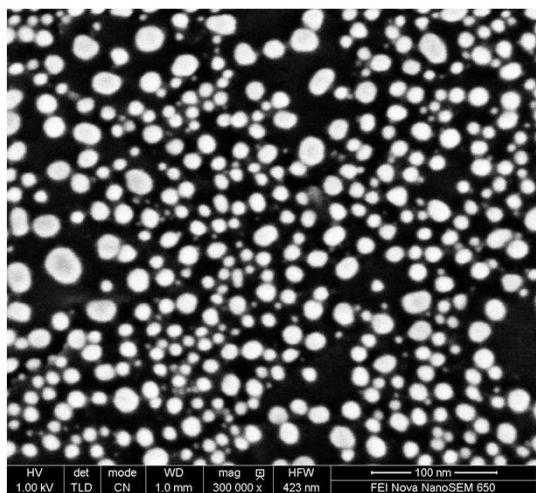


Happy Birthday Nana
courtesy: Dan Roarty



Scale

Microscopes



10^{-9}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

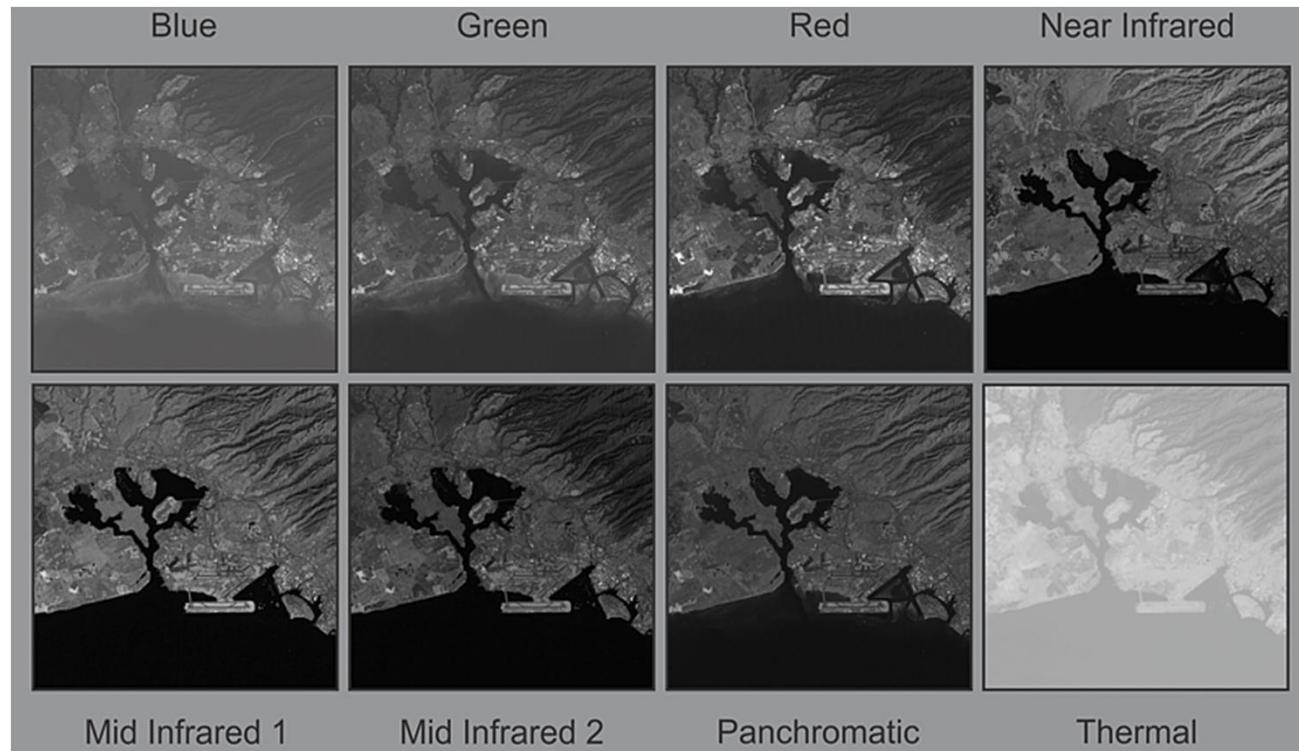


Information primarily about internal structure

Types on images (classification on arrangement)

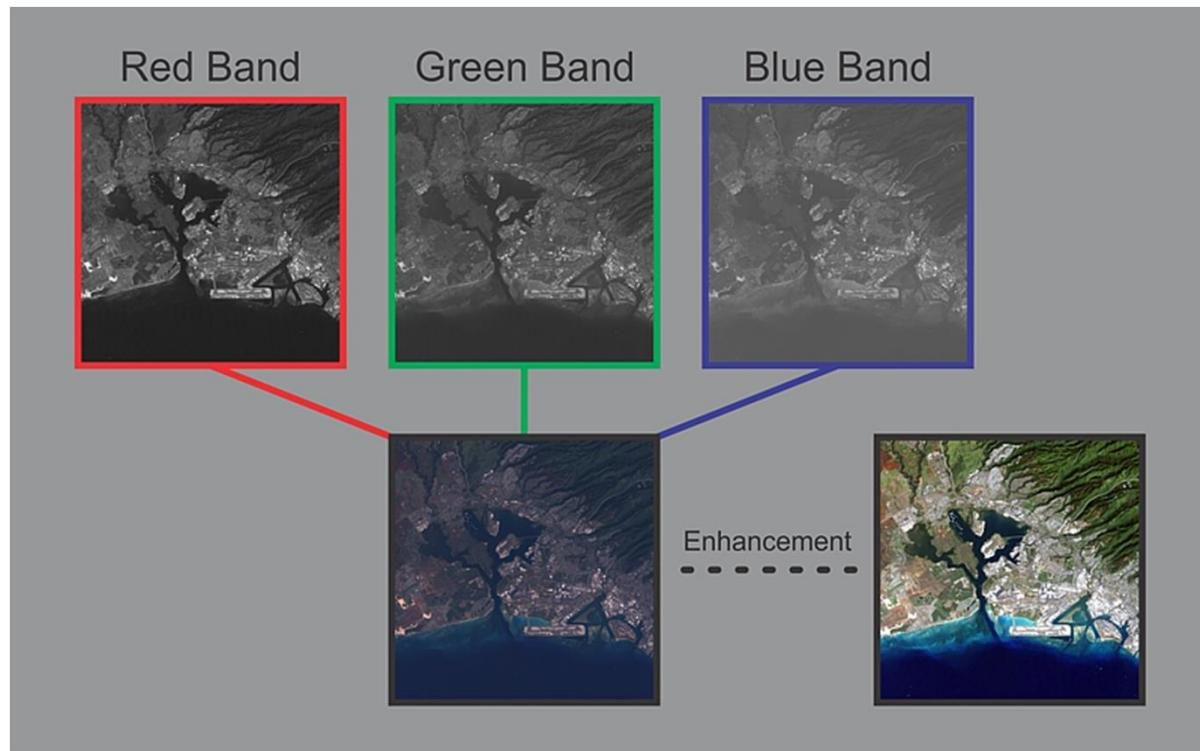
- Grayscale
 - RGB
 - Multispectral images
 - Stereo images
 - Multi-view images
-

Multi spectral images



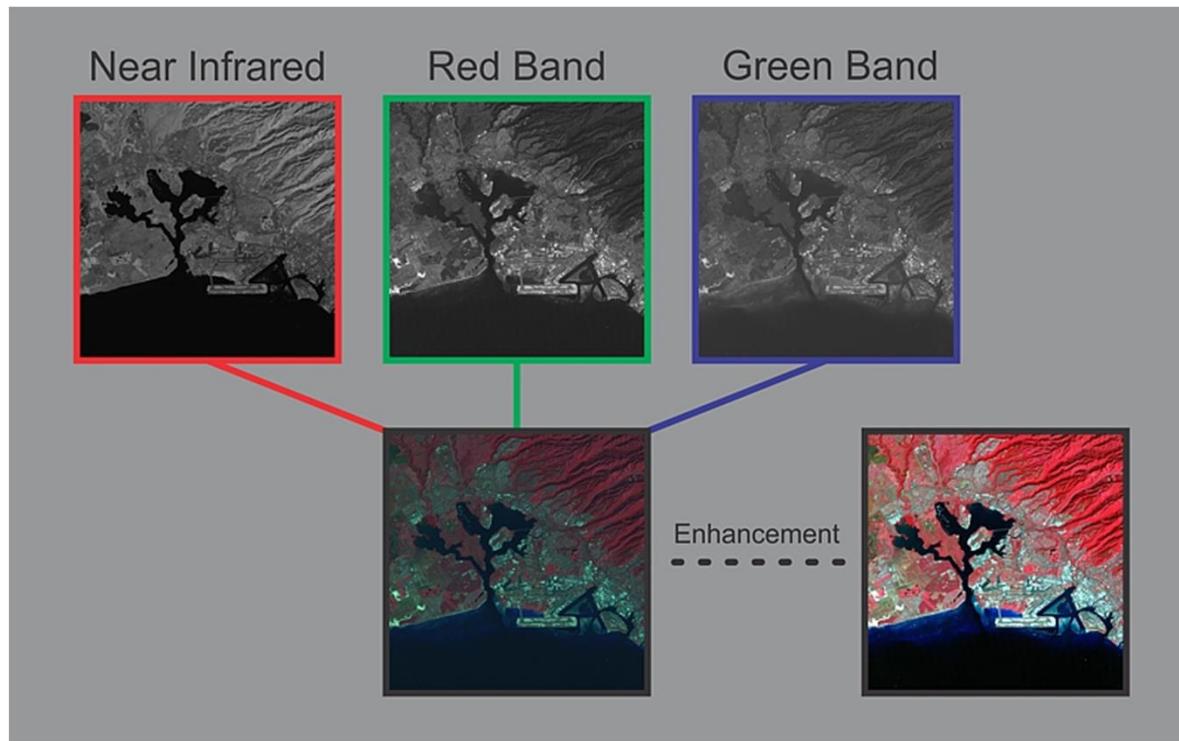
Courtesy: LANDSAT

Multi spectral images



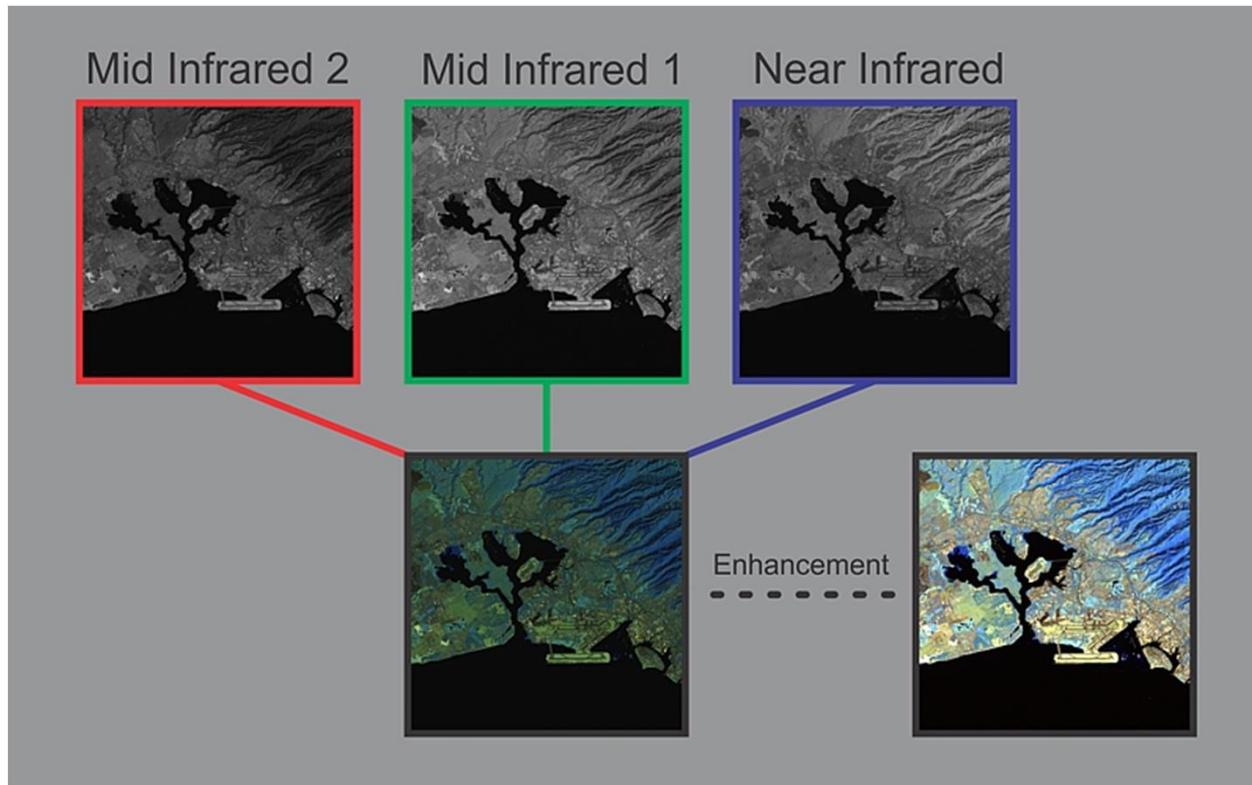
Courtesy: LANDSAT

Multi spectral images



Courtesy: LANDSAT

Multi spectral images



Courtesy: LANDSAT

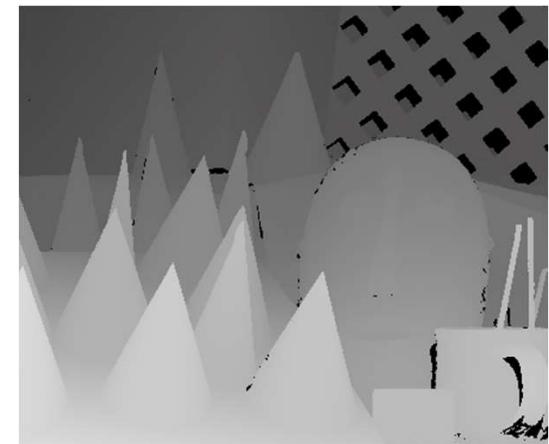
Stereo Images



courtesy: wikipedia.com

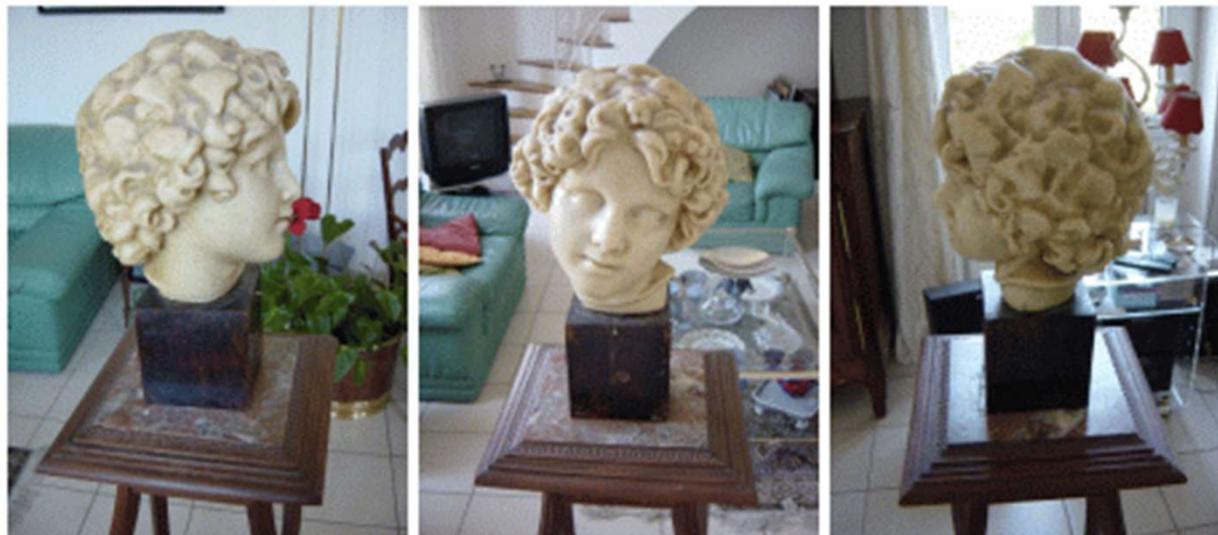


Stereo Images



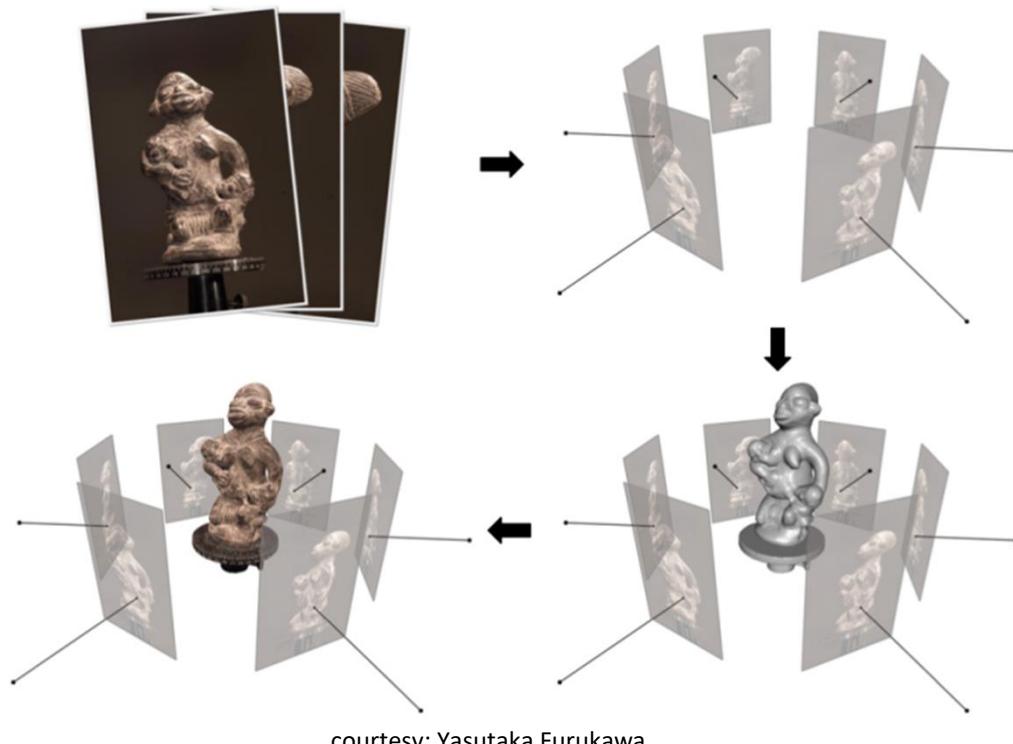
courtesy: vision.middlebury.edu

Multi-view images



courtesy: Maxime Lhuillier

Multi-view images

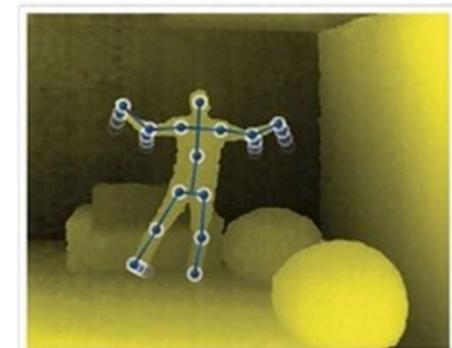
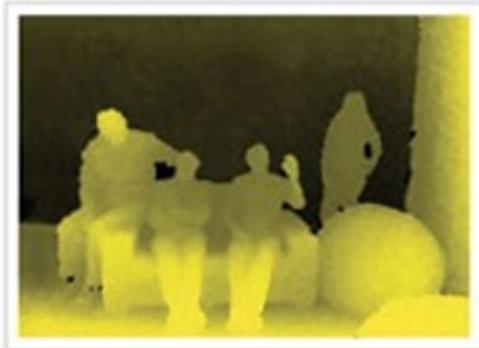


Kinect images

Color (RGB) Image



Depth Image



courtesy: kinect and prime sense

Organization (today's lecture)

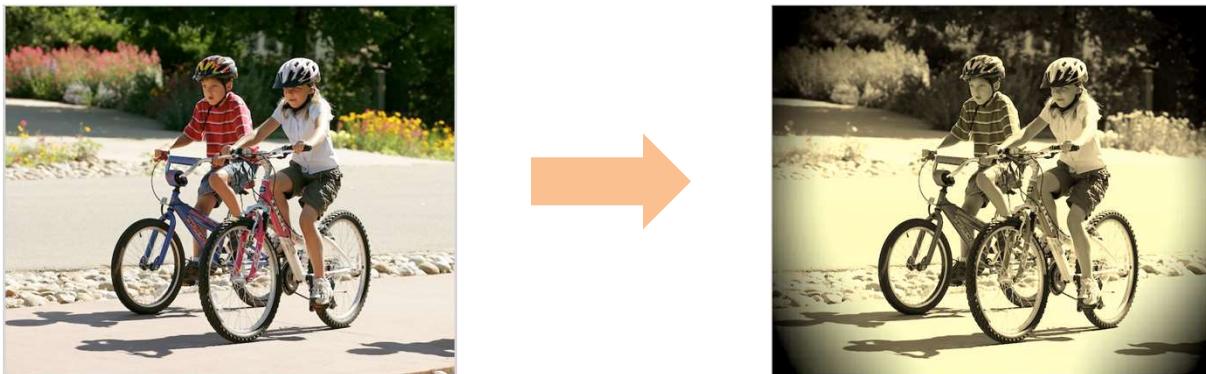
1. SIGNALS (Analog Signals, Digital Signals)

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]

Tasks of interest: Haze Removal



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

Tasks of interest: Contrast adjustment



Image courtesy: mathworks

Retouch Personal Photos!



©Images taken from the web.

Tasks of interest: Artistic enhancement



Image courtesy: webneel.com



Image courtesy: Jon Morse

BW to Color



Tasks of interest: Cinematic Grading



Image courtesy: juanmelara.com

Tasks of interest: Edge Detection



Image courtesy: mathworks



Tasks of interest: Feature detection + stitching

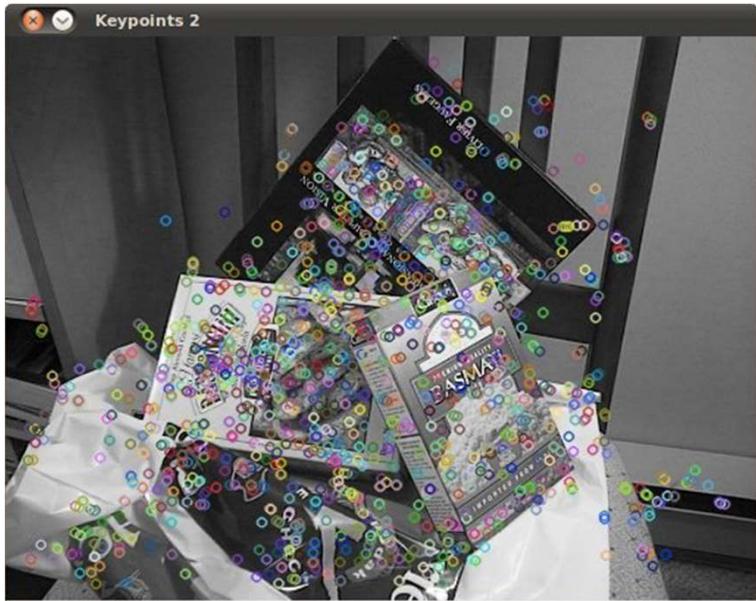


Image courtesy: opencv

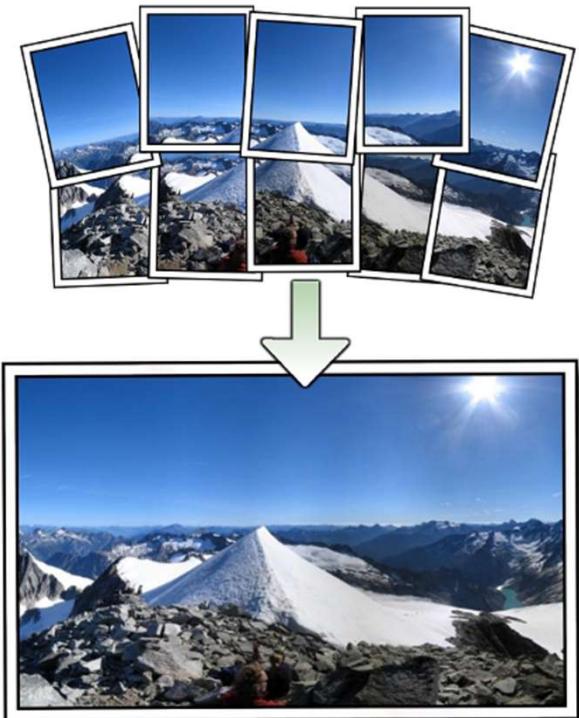
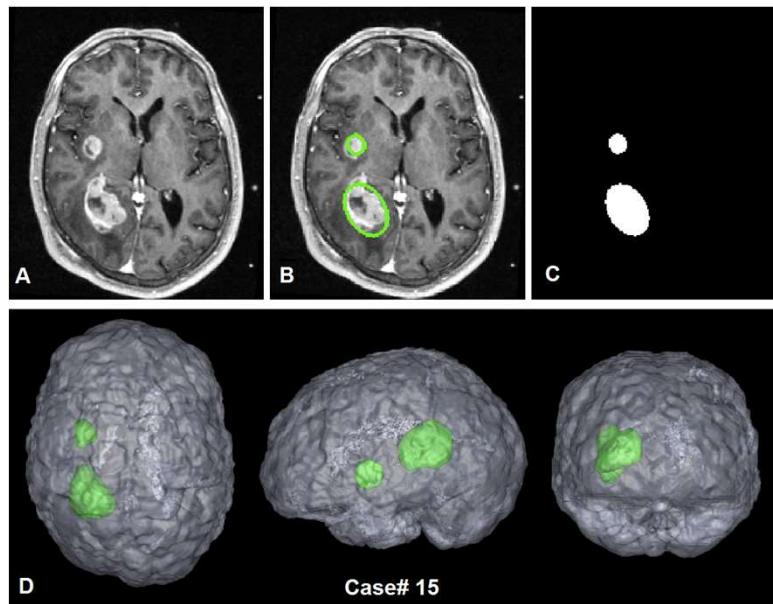
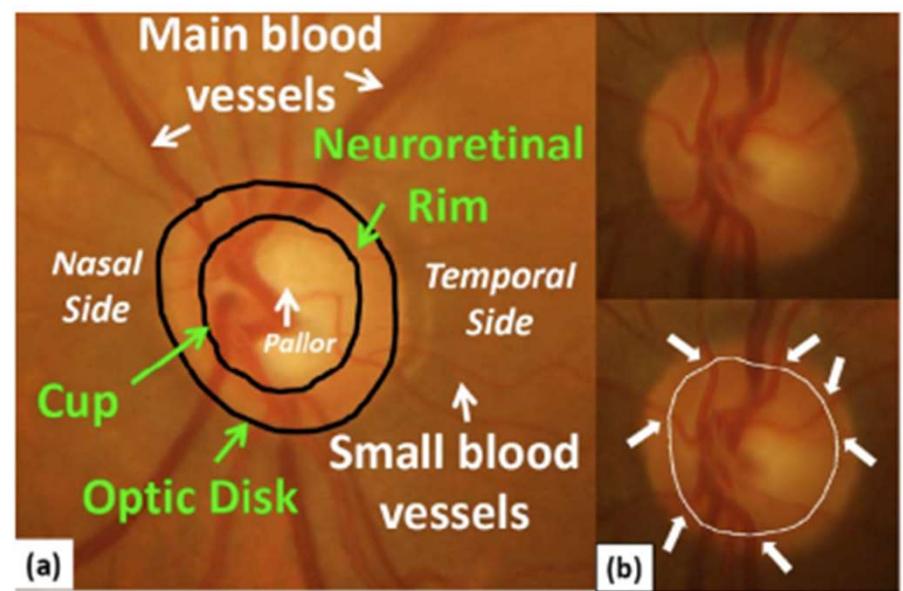


Image courtesy: autostitch

Tasks of interest: Segmentation

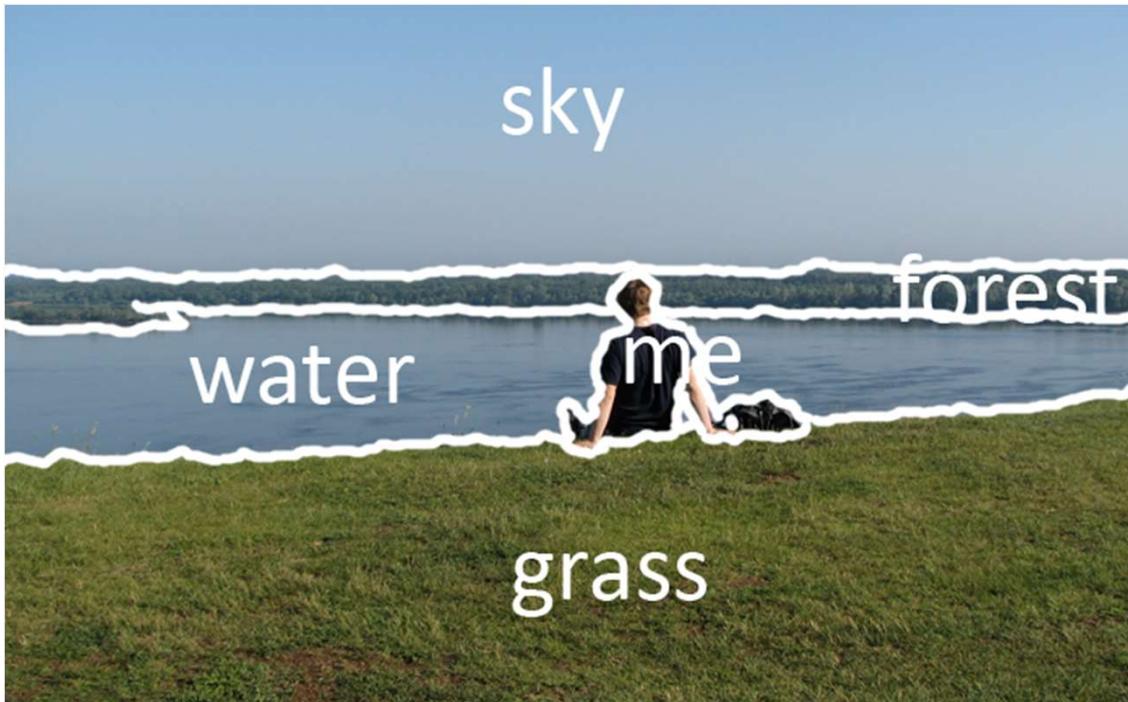


Tumour Segmentation [Yu et al. MICCAI 2010]



Cup Segmentation [Joshi and Sivaswamy 2011]

Tasks of interest: Segmentation



Courtesy: Roman Shapovalov

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

Tasks of interest: Special effects

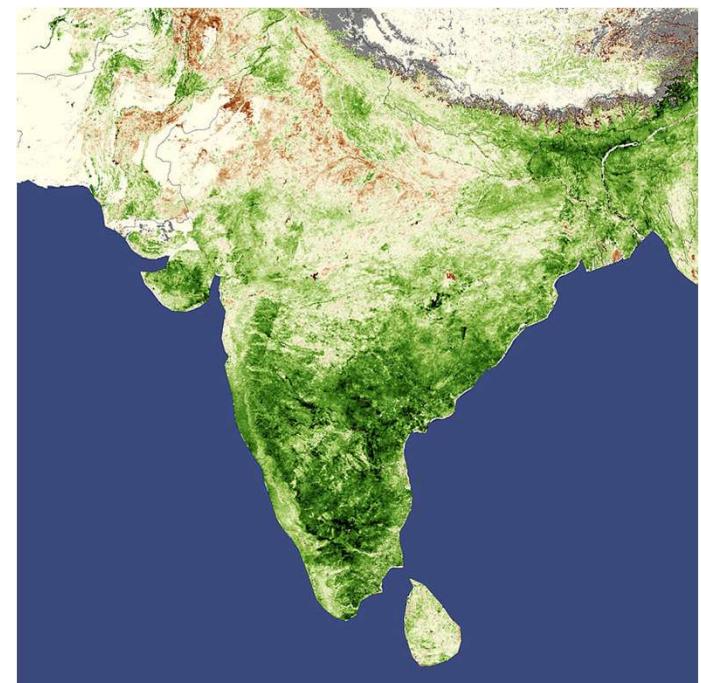
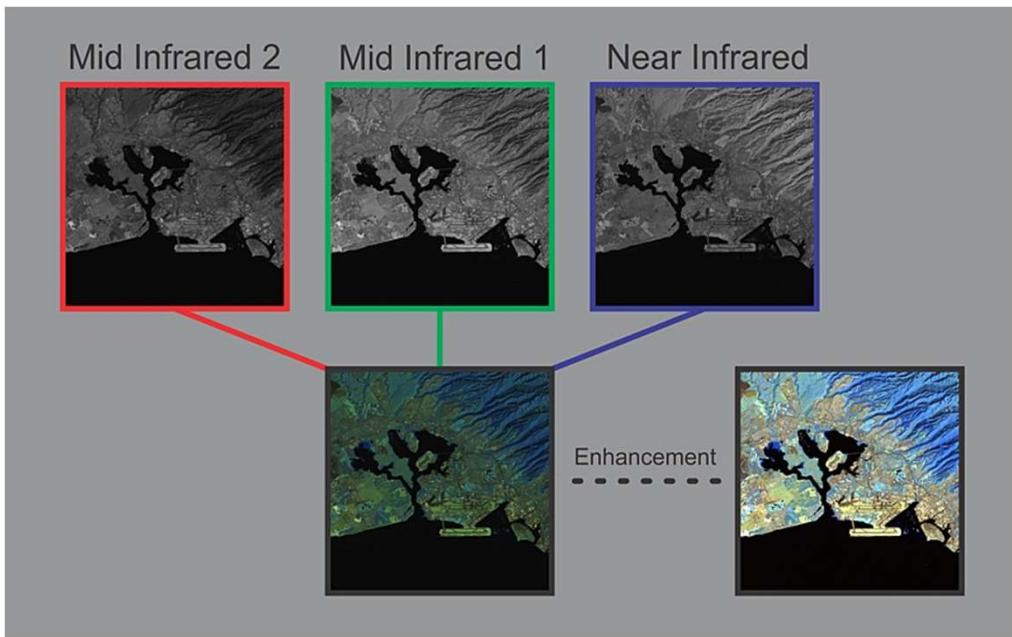


courtesy: wachowski brothers (matrix)



courtesy: Miller et al. (sin city)

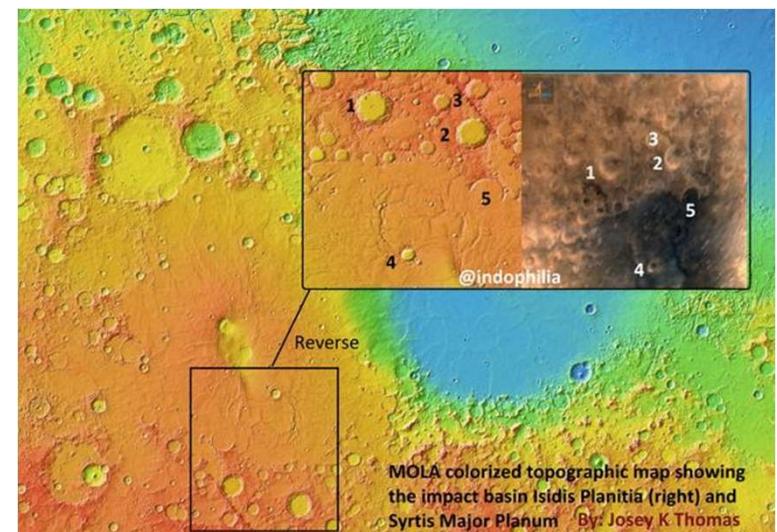
Tasks of interest: Satellite imaging



Terrain classification, weather predictions etc.

courtesy: NASA

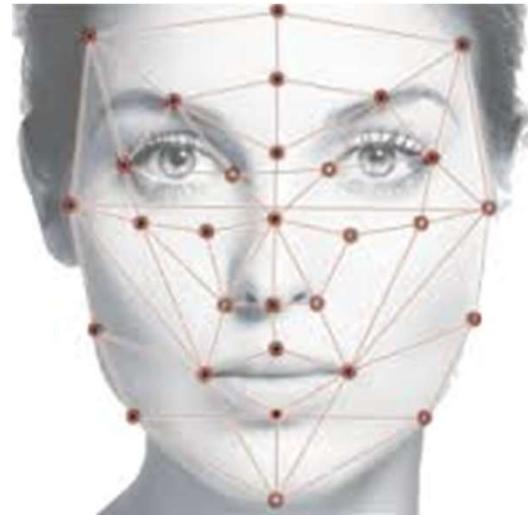
Tasks of interest: Astronomy



Tasks of interest: Biometrics



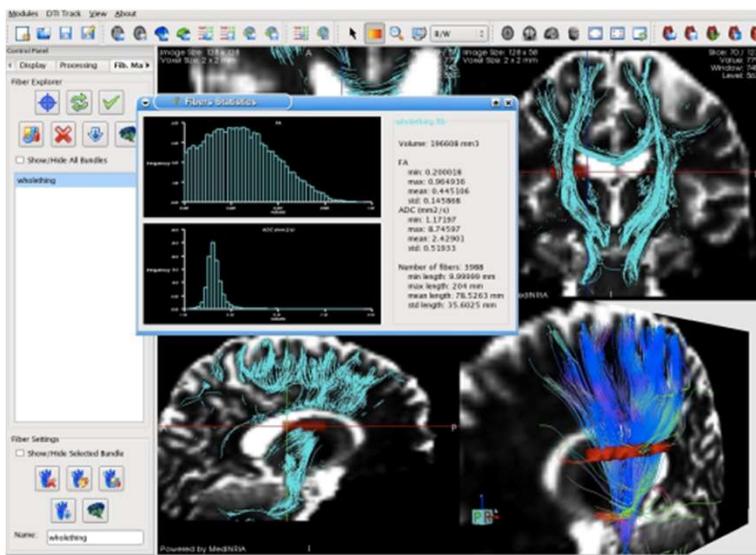
courtesy: dqindia.com



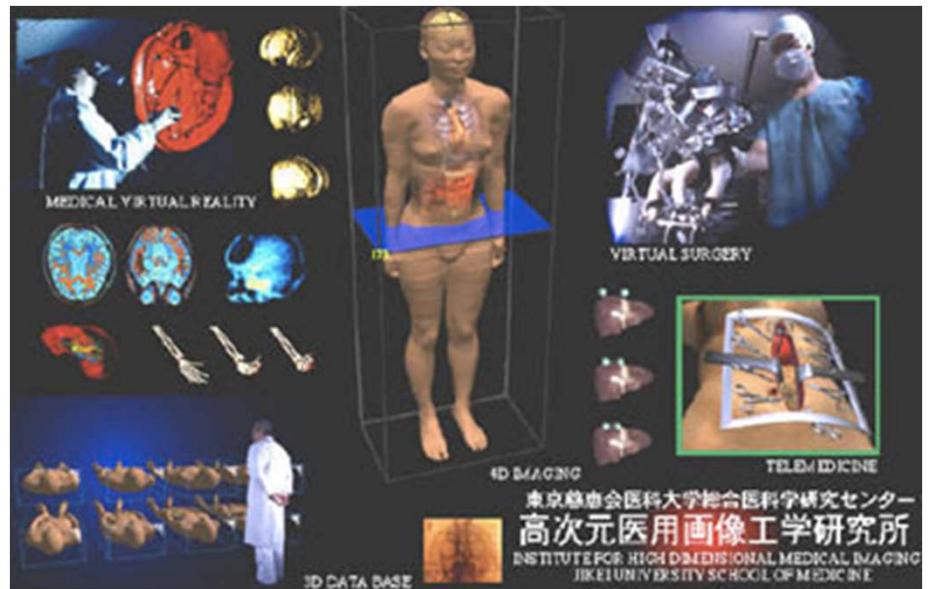
courtesy: heyce.com



Tasks of interest: Medicine



Courtesy: medINRIA



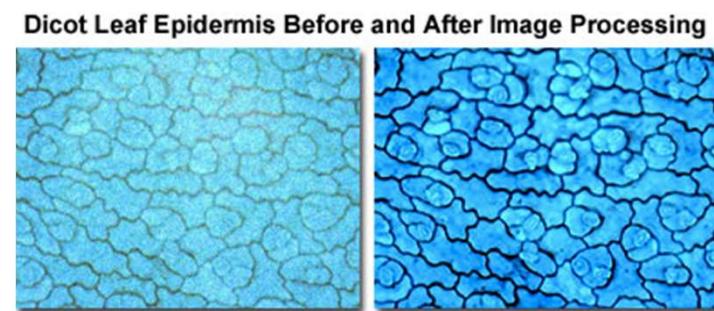
Courtesy: Naoki Suzuki

Tasks of interest: Many more

- Biology
- HCI
- Number Plate recognition
- Gesture recognition



Courtesy: Perviverzov et al. 2012

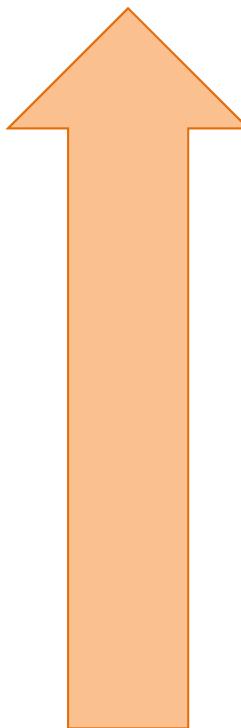


Courtesy: Olympus



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 !

