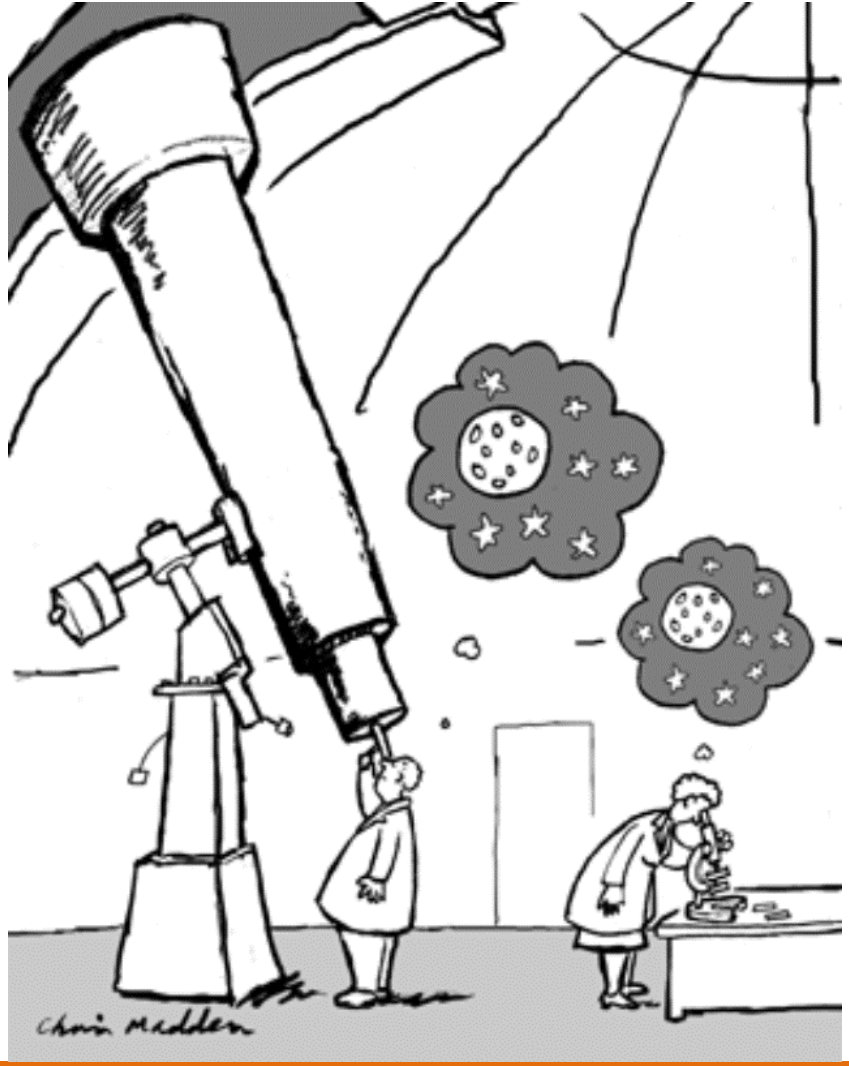
Digital Image Processing (CSE/ECE 478)
Lecture1: Overview

Vineet Gandhi

Center for Visual Information Technology (CVIT), IIIT Hyderabad


watchmojo.com


CITY HOARDING



Courtesy: Chris Madden

About the course (3 Guidelines)

- Understand, don’t memorize
- Capture the broad idea and insights (useful even 10 years down the line)
- Implement to get the real feel

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 (25%) + 1 Final Exam (25%)
  - Weekly assignments* (25%) + 1 final project (25%)

  * If copying is detected, you will get 0 marks for the assignment

About the course – Grading Policy

- **Homework Late Policy:** 50% if one day late; zero percent if more than one day late
- **Project Late Policy:** 25% if one day late; 50% if two days late; zero credit if more than two days late
- **A one time late submission bonus:** only applicable to HW (with maximum of three days delay). You must adhere to standard late submission policy after using your bonus. No exceptions will be made
- **No Late submission of projects/exams**

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

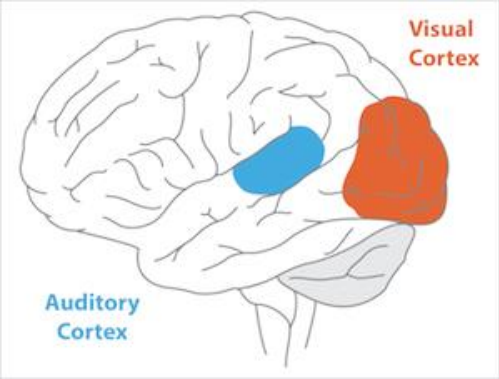
ANY PLAGIARISM WILL NOT BE TOLERATED, BE EXTREMELY CAREFUL

About the course - Exception clauses

- Get a paper accepted in a good conference in Image processing and get a direct A (no questions asked)
- Students with original and exceptional projects may get a direct A in the course as well

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!


Adobe Photoshop cs


AUTODESK
PIXLR


Adobe Premiere


Final Cut Pro X
Everything just changed in post.


Picasa


flickr


Nikon


Canon


YouTube


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)

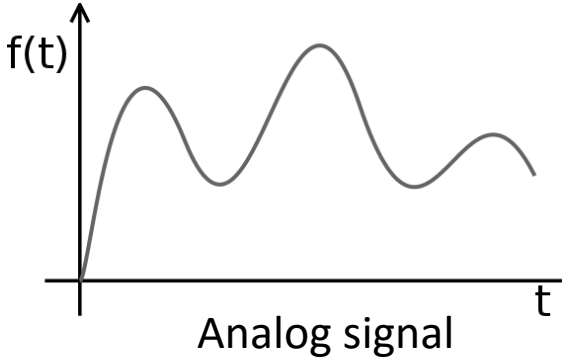
1. SIGNALS (Analog Signals, Digital Signals)

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

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

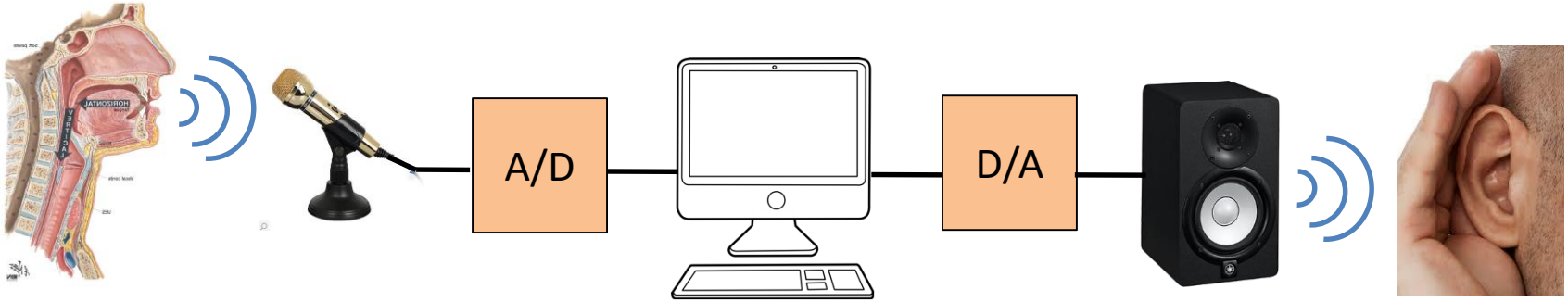
Signal

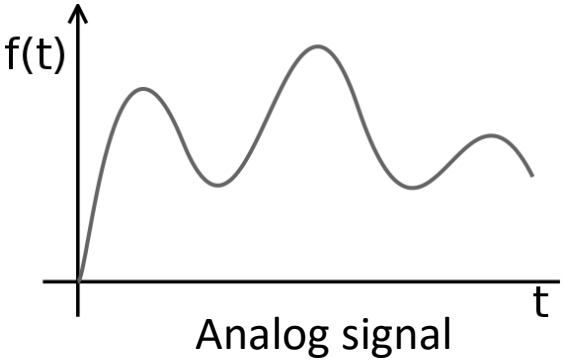
"Function that conveys information about the behavior or attributes of some phenomenon” (wikipedia)



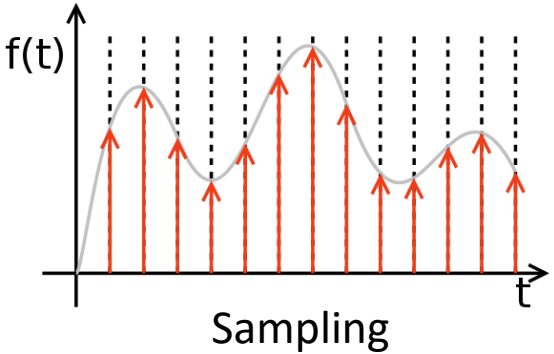
Analog signal

Analog vs. Digital signal

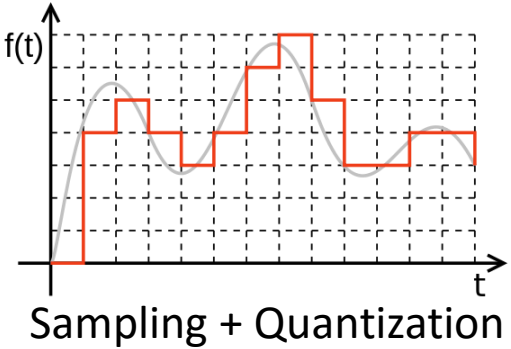




Analog signal



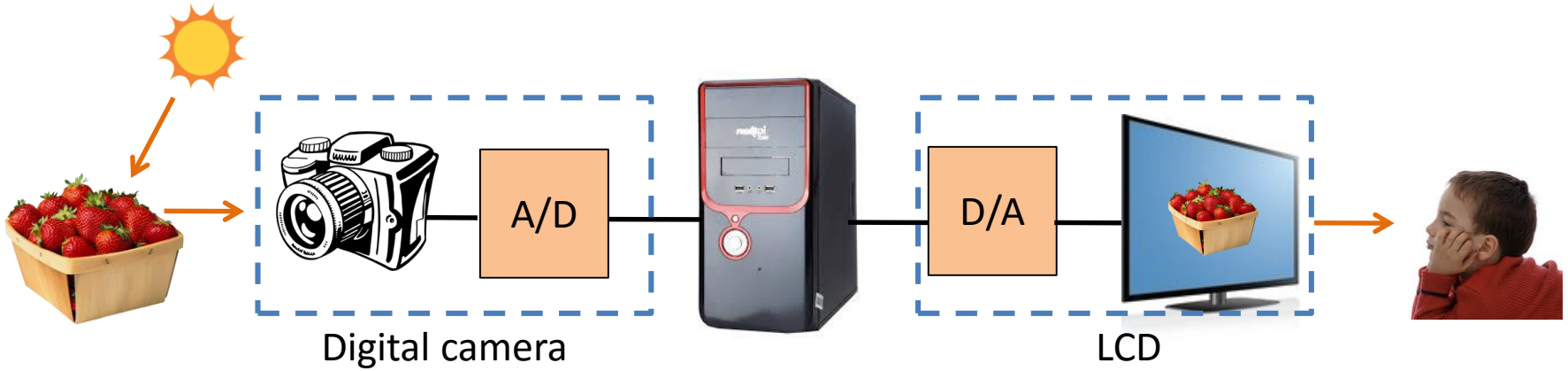
Sampling



Sampling + Quantization

Image courtesy: wikipedia

Analog vs. Digital signal



Organization (today's lecture)

1. SIGNALS (Analog Signals, Digital Signals)

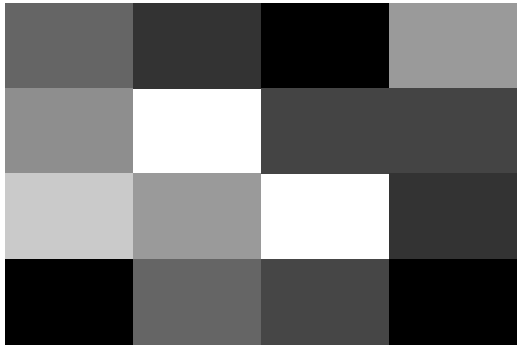
2. DIGITAL IMAGES (image formation, classification of images)

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



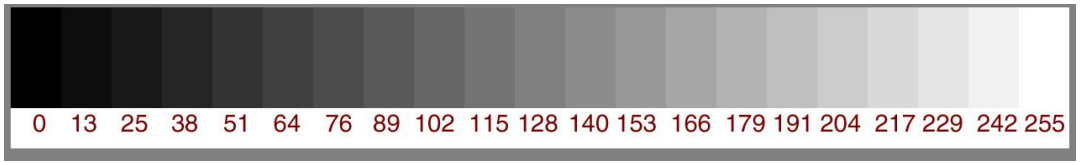


Image acquisition process

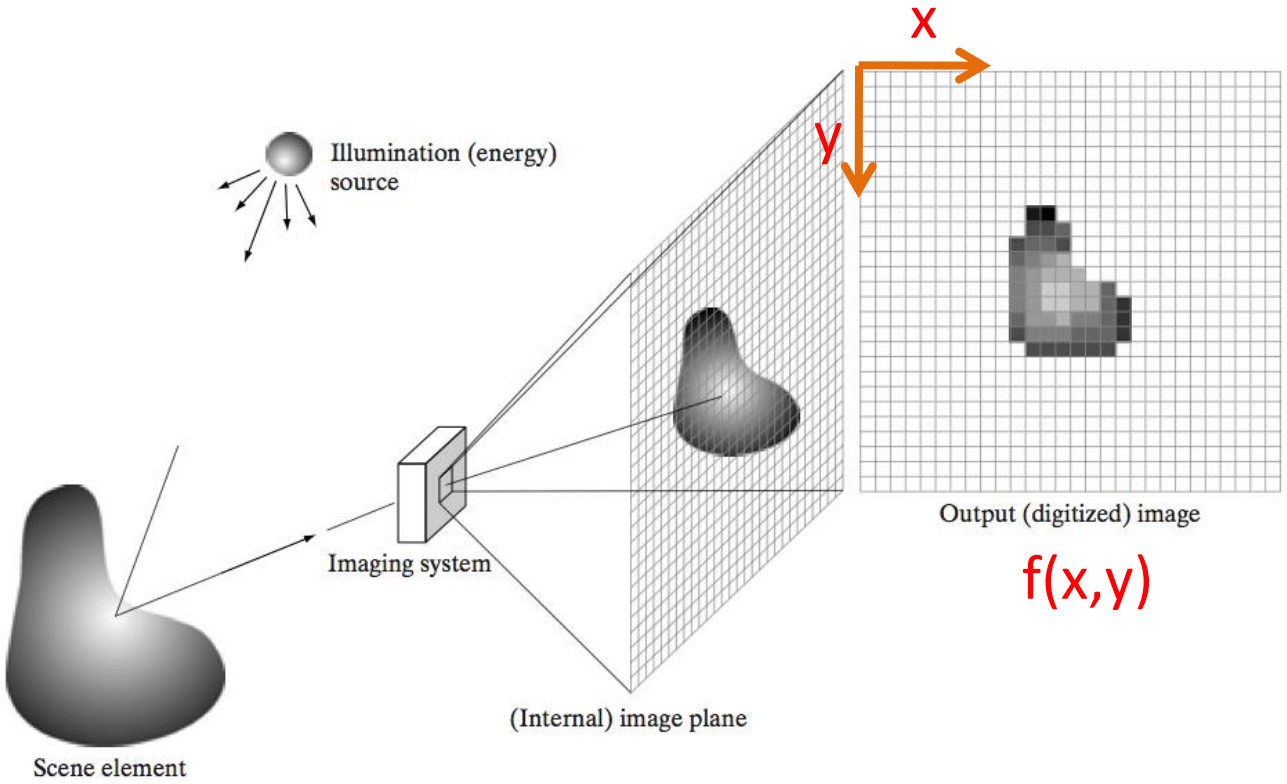


Image courtesy: Gonzalez and Woods

Image acquisition process

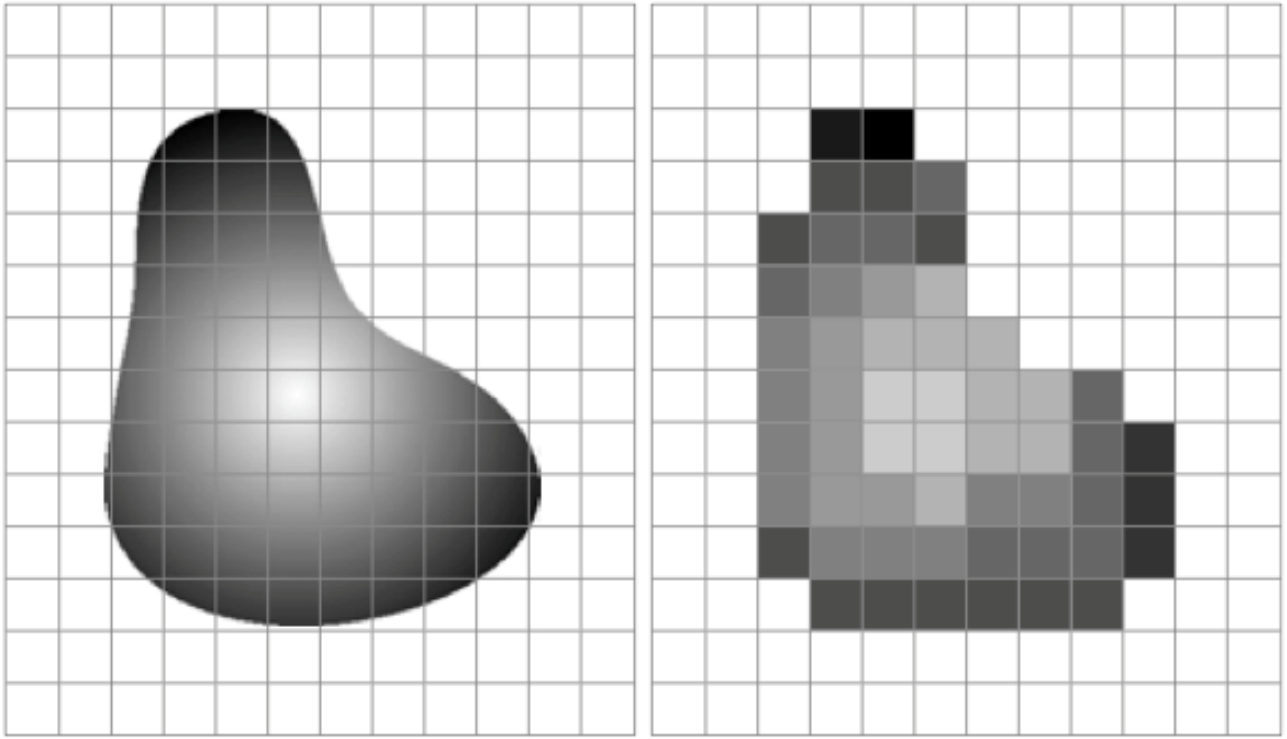
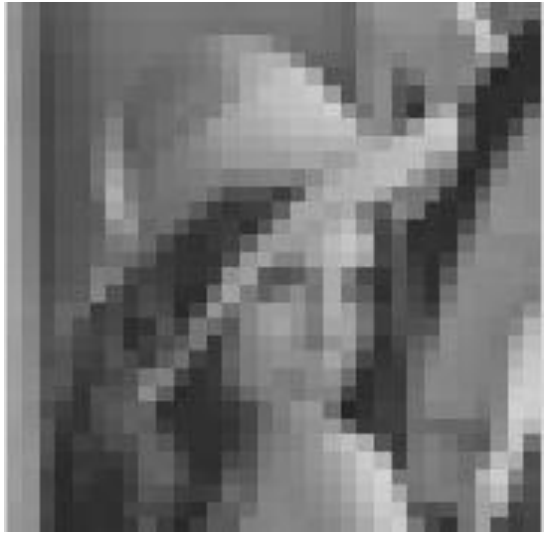


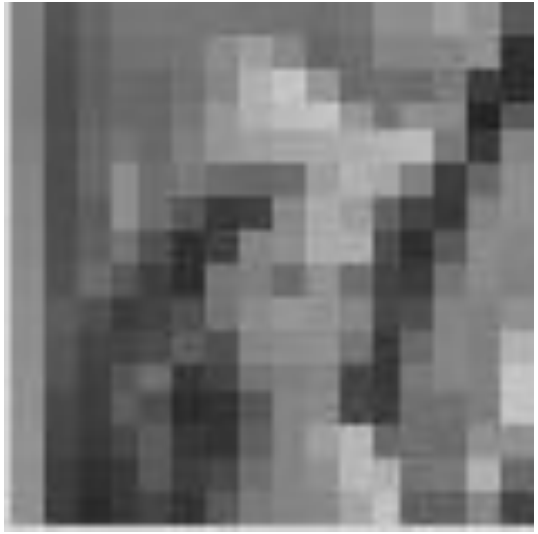
Image courtesy: Gonzalez and Woods

Sampling

256 × 256



32 × 32



16 × 16

Quantization

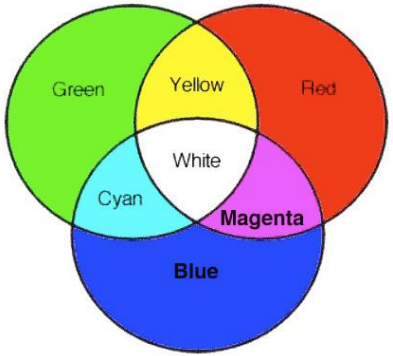
8 bits per pixel

4 bits per pixel

2 bits per pixel

1 bit per pixel

Color Images



R

G

B

8 bits per pixel + 8 bits per pixel + 8 bits per pixel

Digital Images

1 bit per pixel

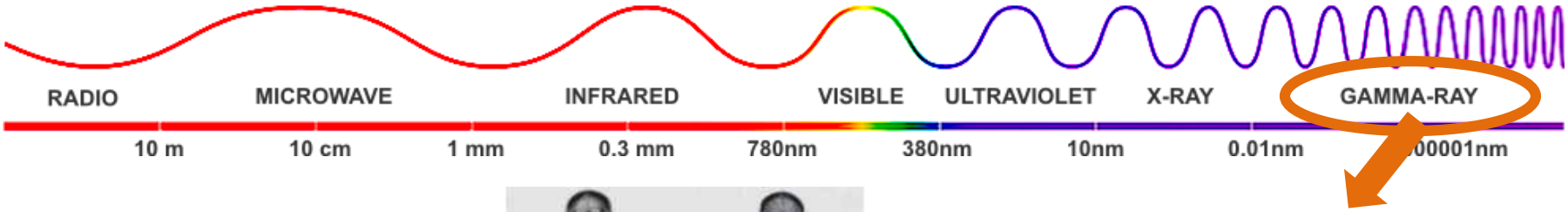
8 bit per pixel

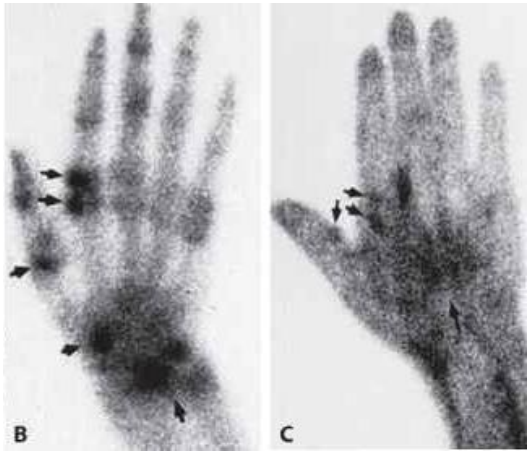
24 bit per pixel

Types of Images (classification on source)

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

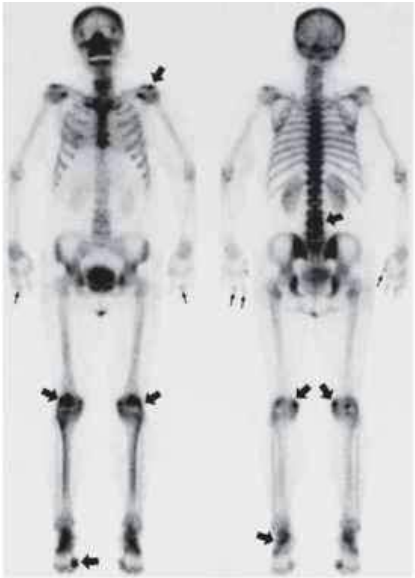
EM spectrum





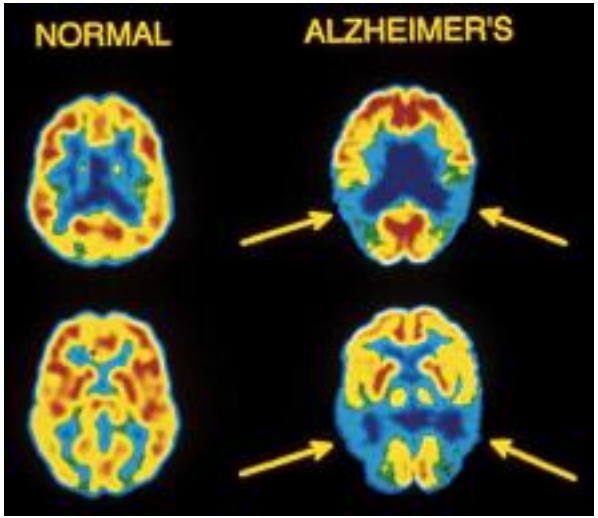
BLOOD FLOW SCAN

courtesy: artheristisresearch.us



BONE SCAN

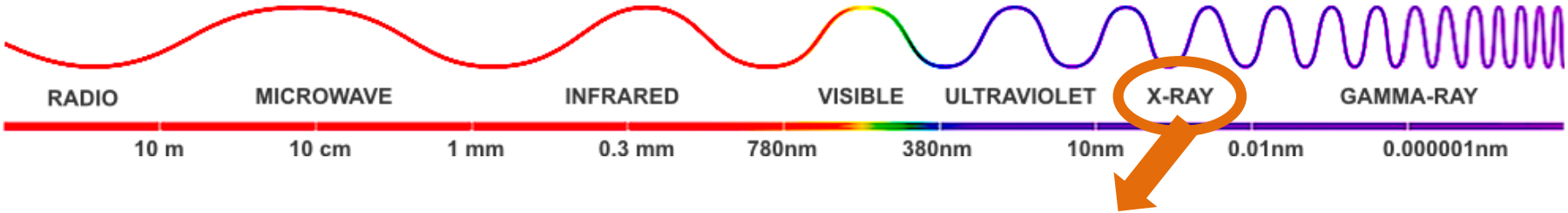
courtesy: artheristisresearch.us



PET SCAN

courtesy: research.ucla.edu

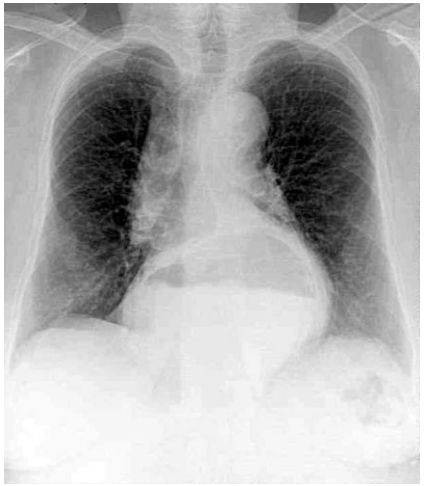
EM spectrum



Wilhelm Röntgen

HAND MIT RINGEN

courtesy: wikipedia



CHEST RADIOGRAPH

courtesy: wikipedia

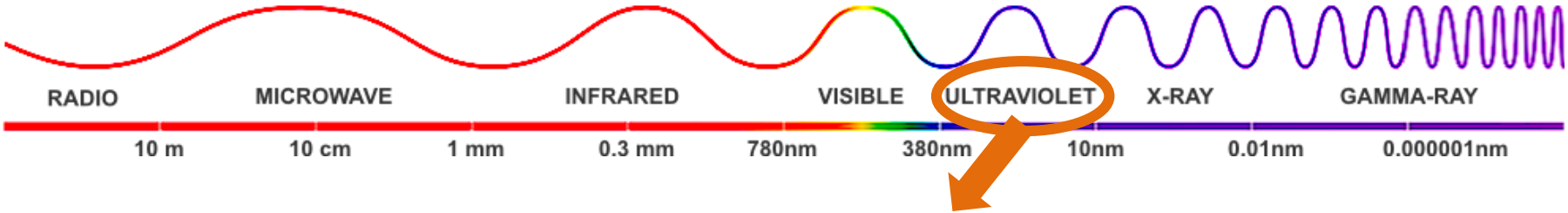
CT SCAN

courtesy: wikipedia

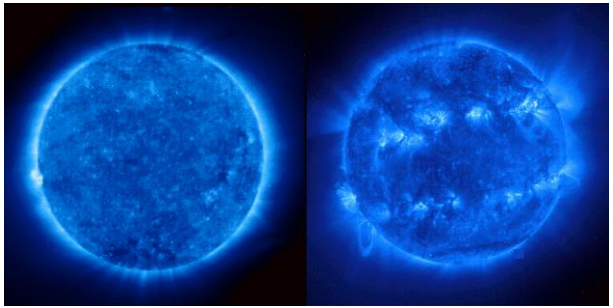
AIRPORT SCAN

courtesy: dpl-surveillance-equipment

EM spectrum



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



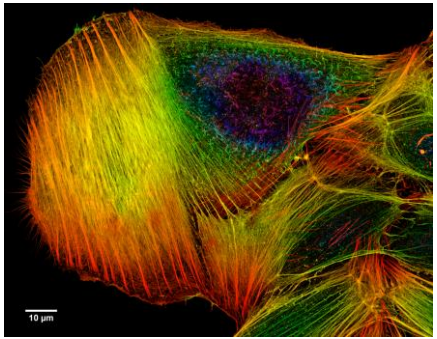
SUN (2 years apart)

courtesy: NASA

100 EURO BILL

courtesy: lifepixel.com

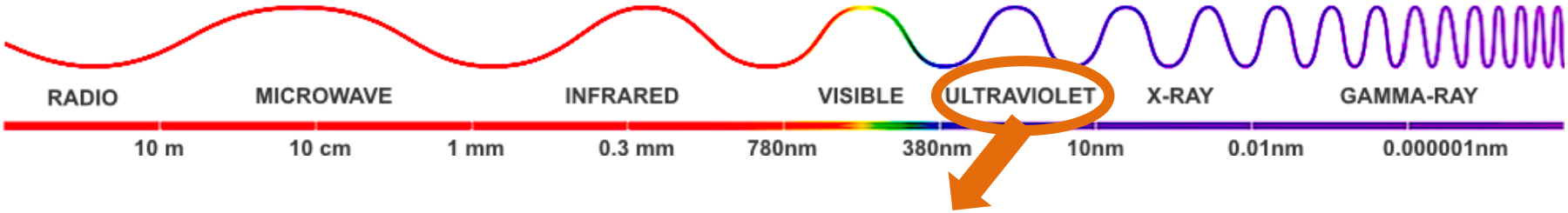
Eric Betzig, William Moerner and Stefan Hell



Cell Phalloidin

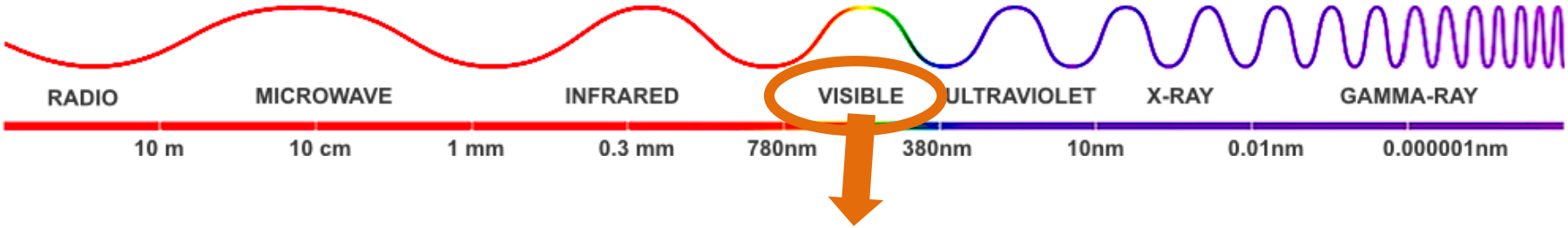
courtesy: wikipedia

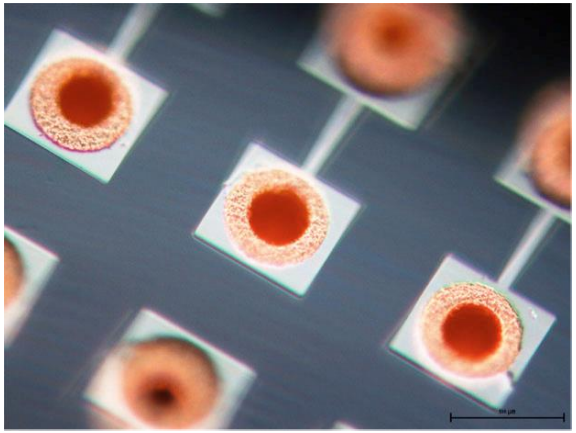
EM spectrum



Source:
Lifepixel.com

EM spectrum



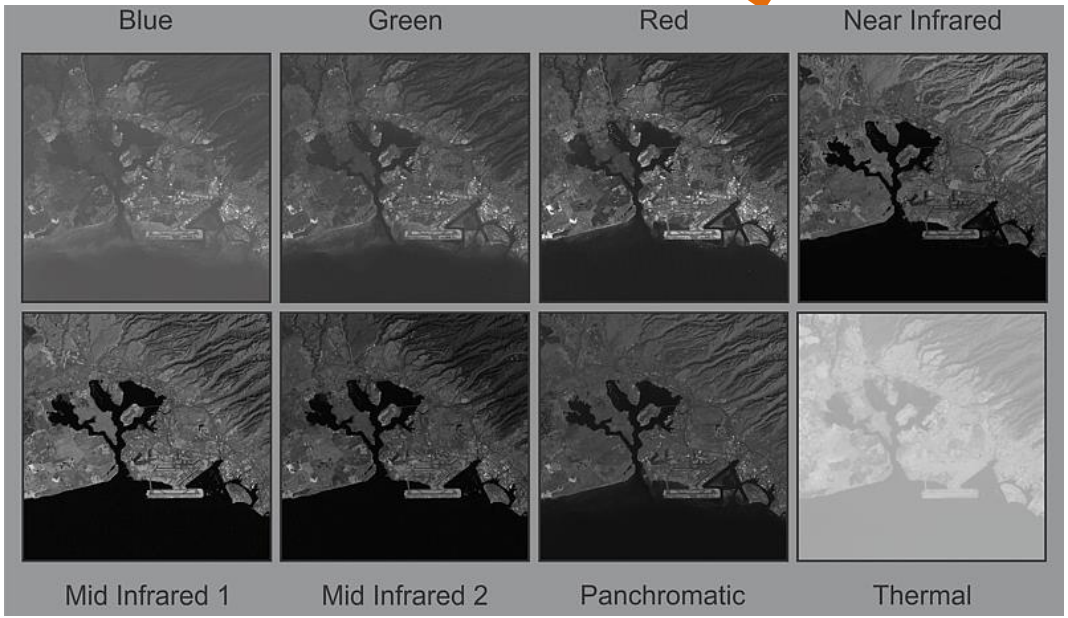


Chips (optical microscopy)
courtesy: EPFL microelectornics systems laboratory

High Speed Photograph
courtesy:Alan Sailer

Satellite Image (Hurricane Katrina)
courtesy: britannica.com

EM spectrum



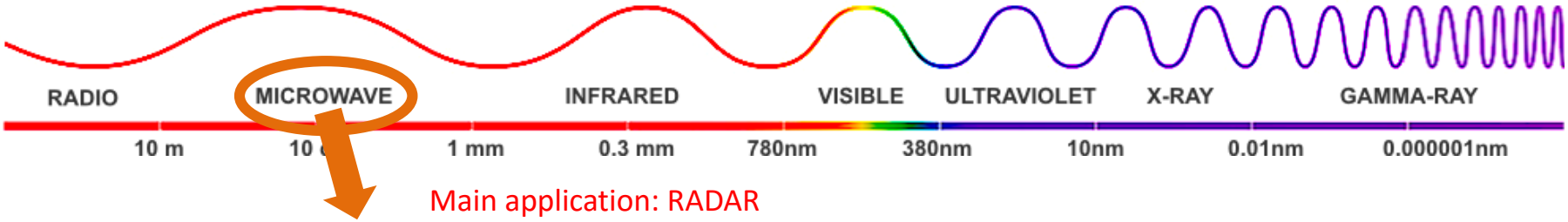
courtesy: LANDSAT (NASA)

courtesy: imaging1.com

EM spectrum

courtesy NASA

EM spectrum



Main application: RADAR

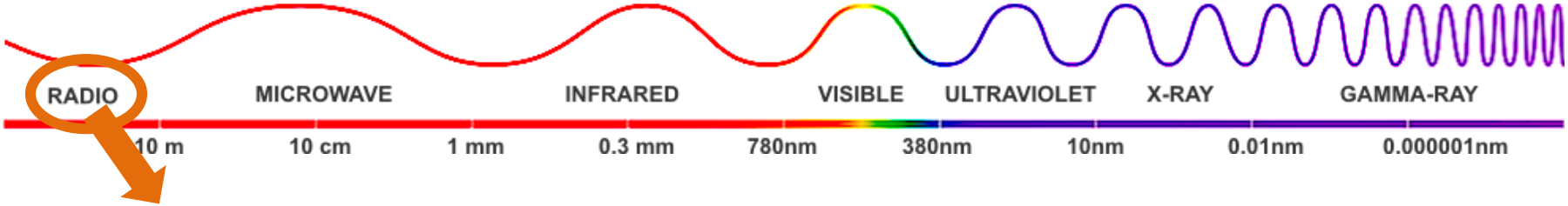
SOUTHEAST TIBET MOUNTAINS

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

MRI Knee

courtesy: mri-tip.com

Ultrasound

ULTRASOUND

courtesy: wikipedia

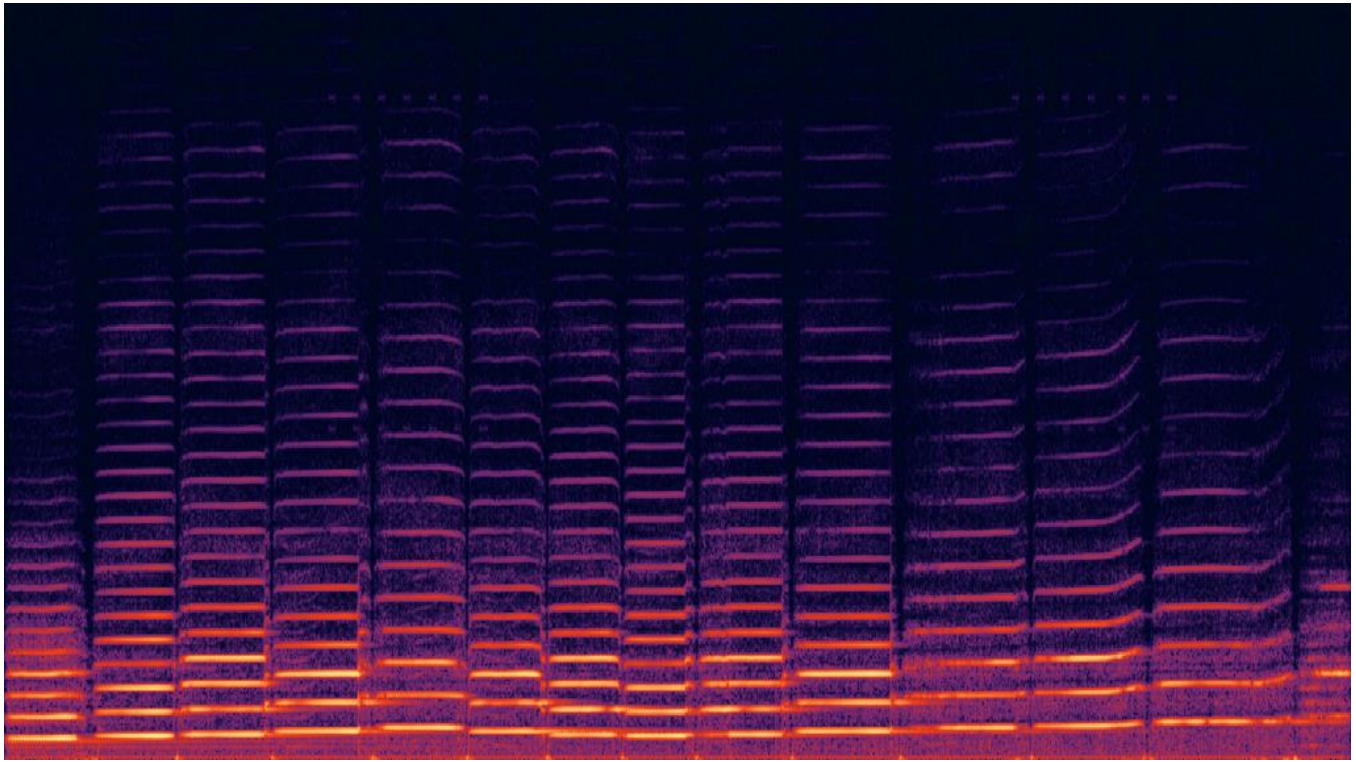
ULTRASOUND TWINS

courtesy: pinterest

ULTRASOUND 3D

courtesy: peek3D.com

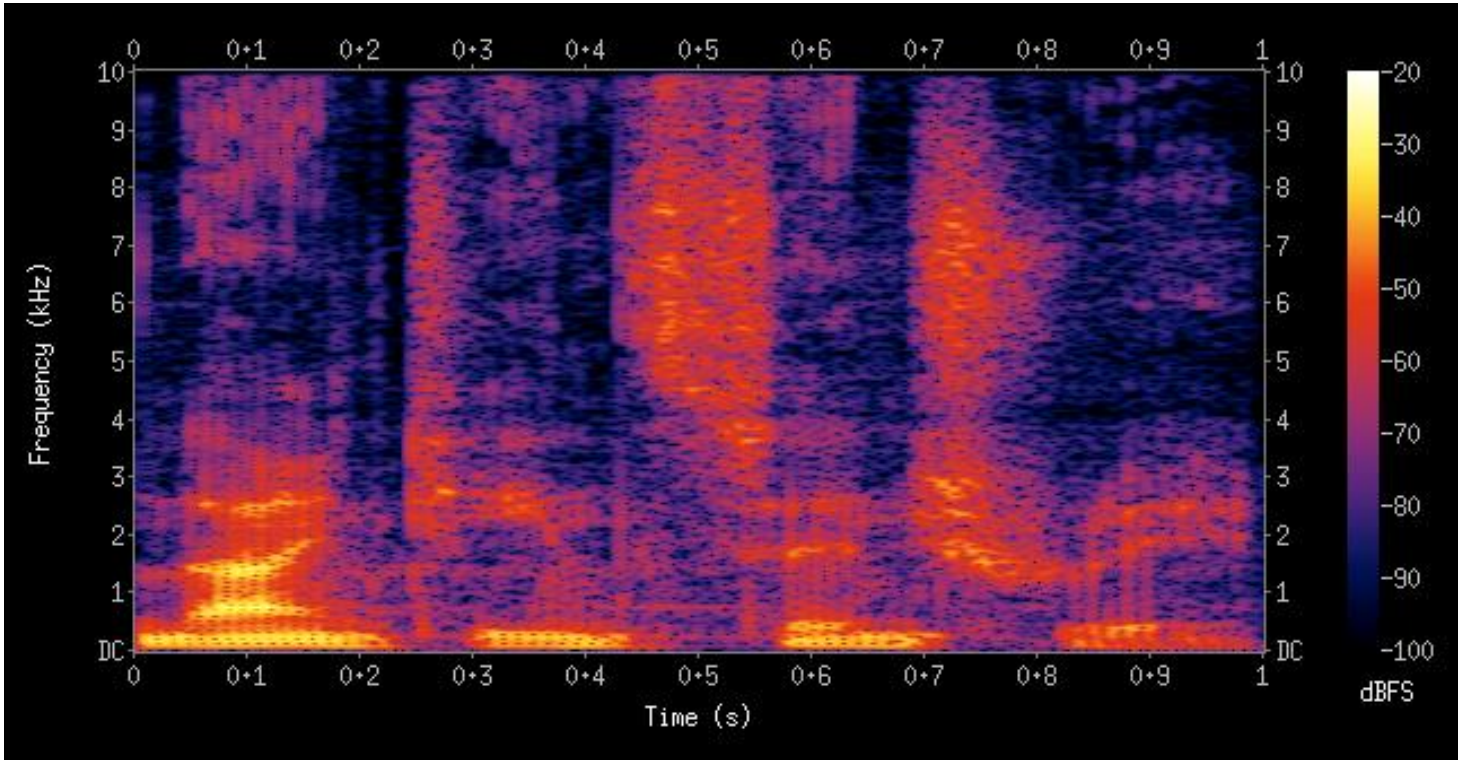
Spectrogram



Violin Recording

courtesy: wikipedia

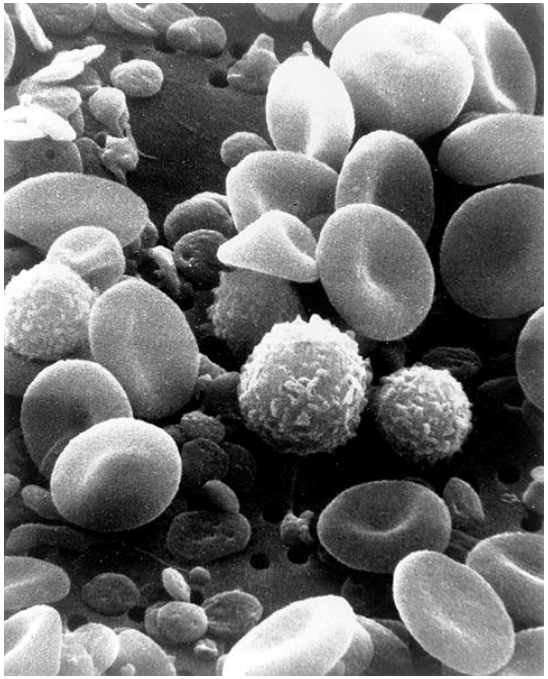
Spectrogram



Saying Nineteenth Century

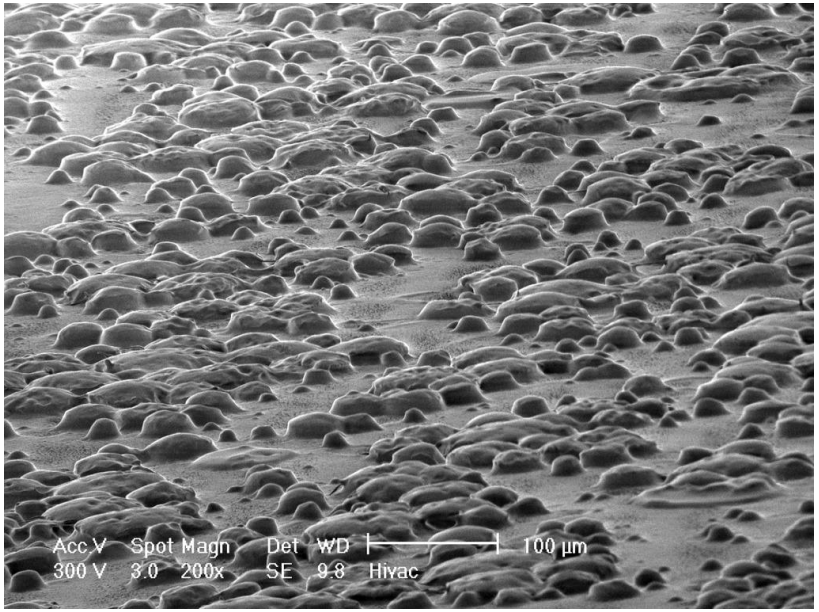
courtesy: wikipedia

Scanning Electron Microscopy



Normal Circulating Human Blood

courtesy: National Cancer Institute



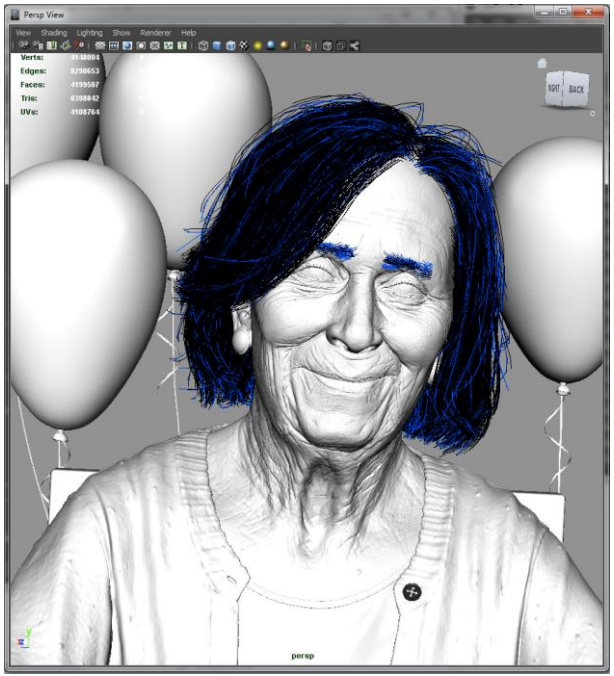
Adhesive on Post-it note

courtesy: wikipedia

Computer generated

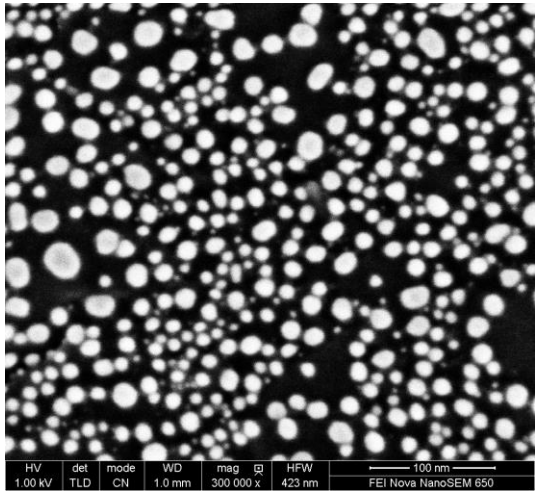
Happy Birthday Nana

courtesy: Dan Roarty



Scale

Microscopes



10^(-9)m

courtesy: nanolab technologies.com

Telescopes

220 kly ≈ 10^(21)m

courtesy: wikipedia

Types of Images (classification on optics)

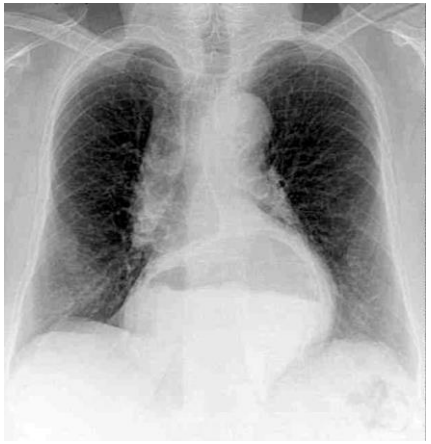
1. Reflection Images

Information primarily about objects surface

2. Emission Images

Information primarily about internal properties

3. Absorption Images

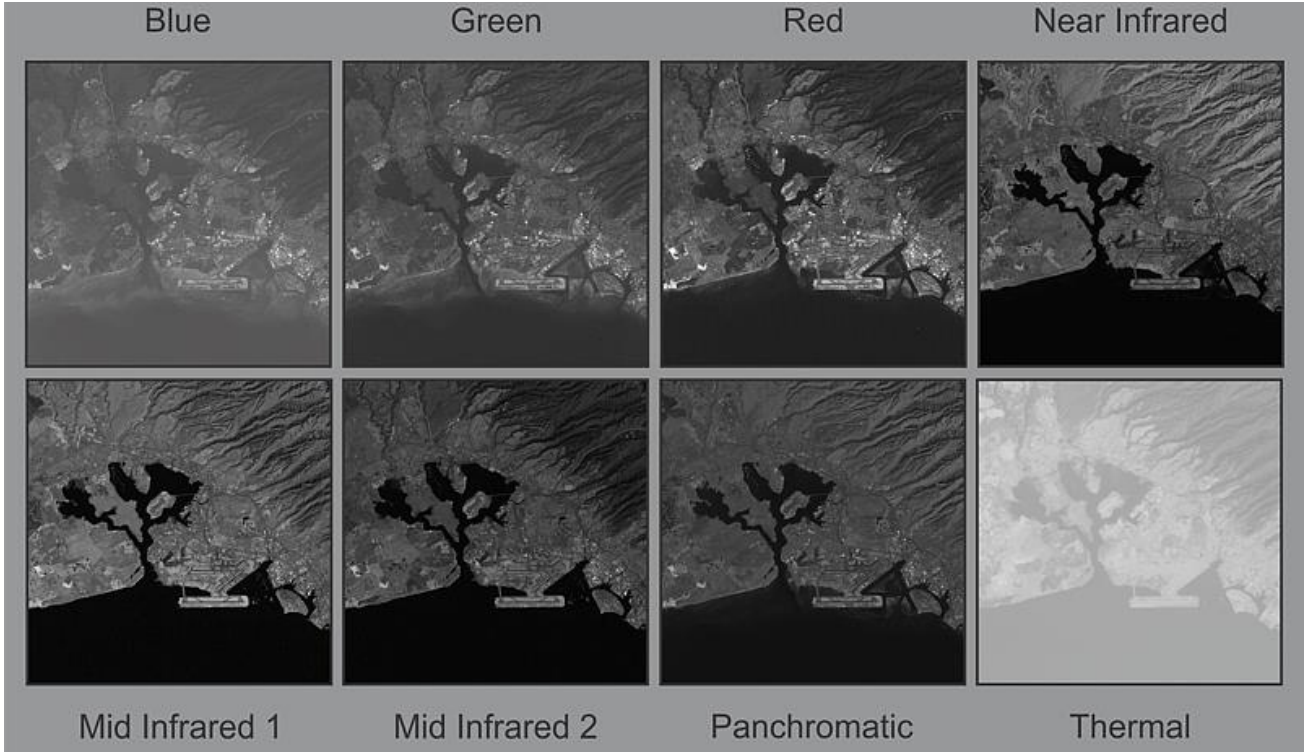


Information primarily about internal structure

Types on images (classification on arrangement)

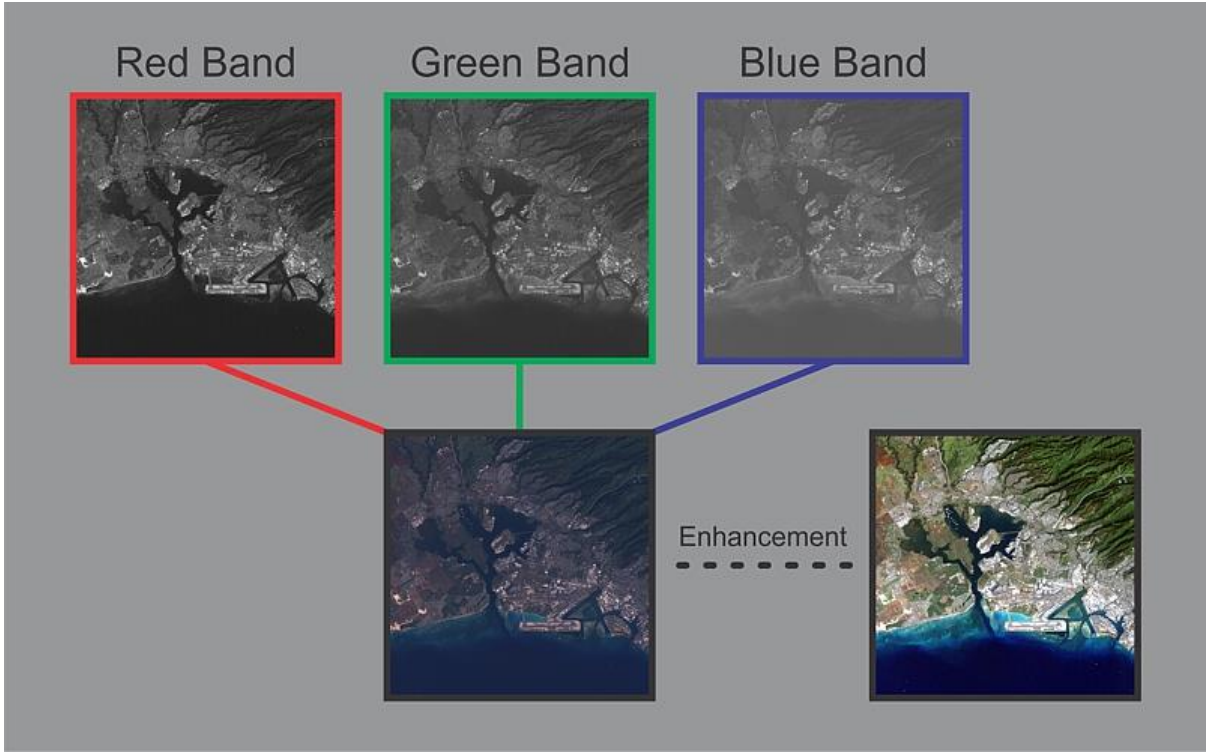
- Grayscale
- RGB
- Multispectral images
- Stereo images
- Multi-view images

Multi spectral images



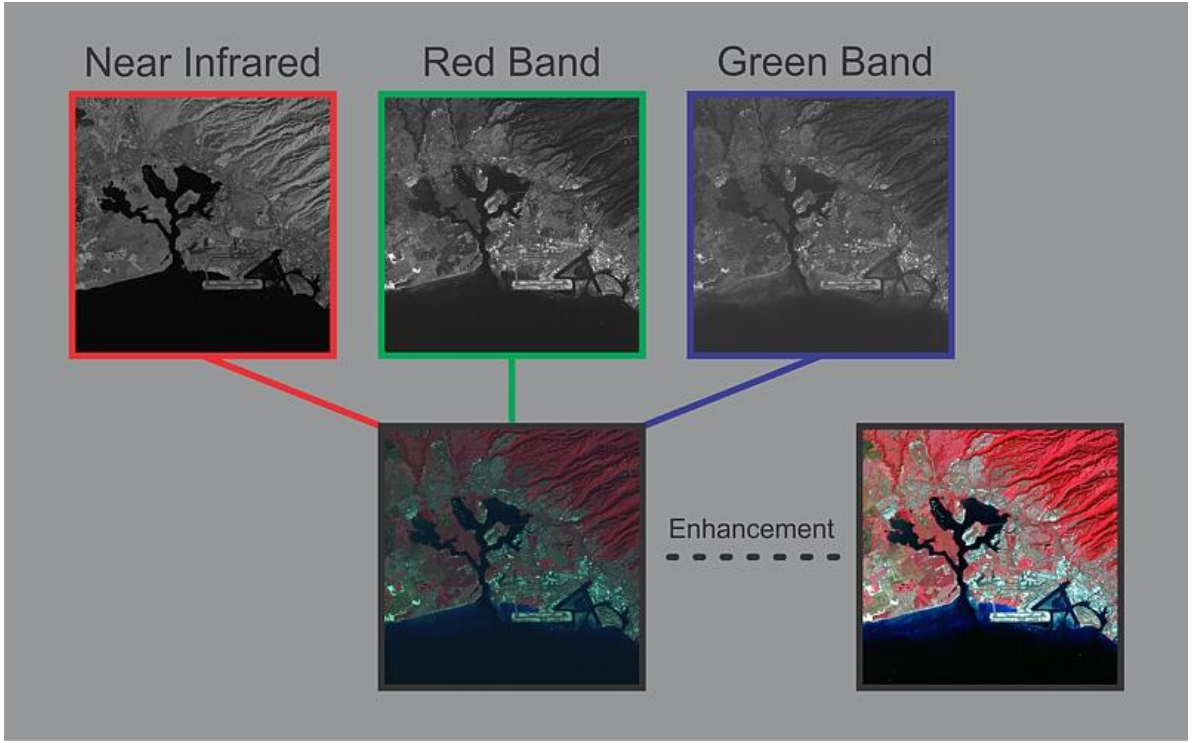
Courtesy: LANDSAT

Multi spectral images



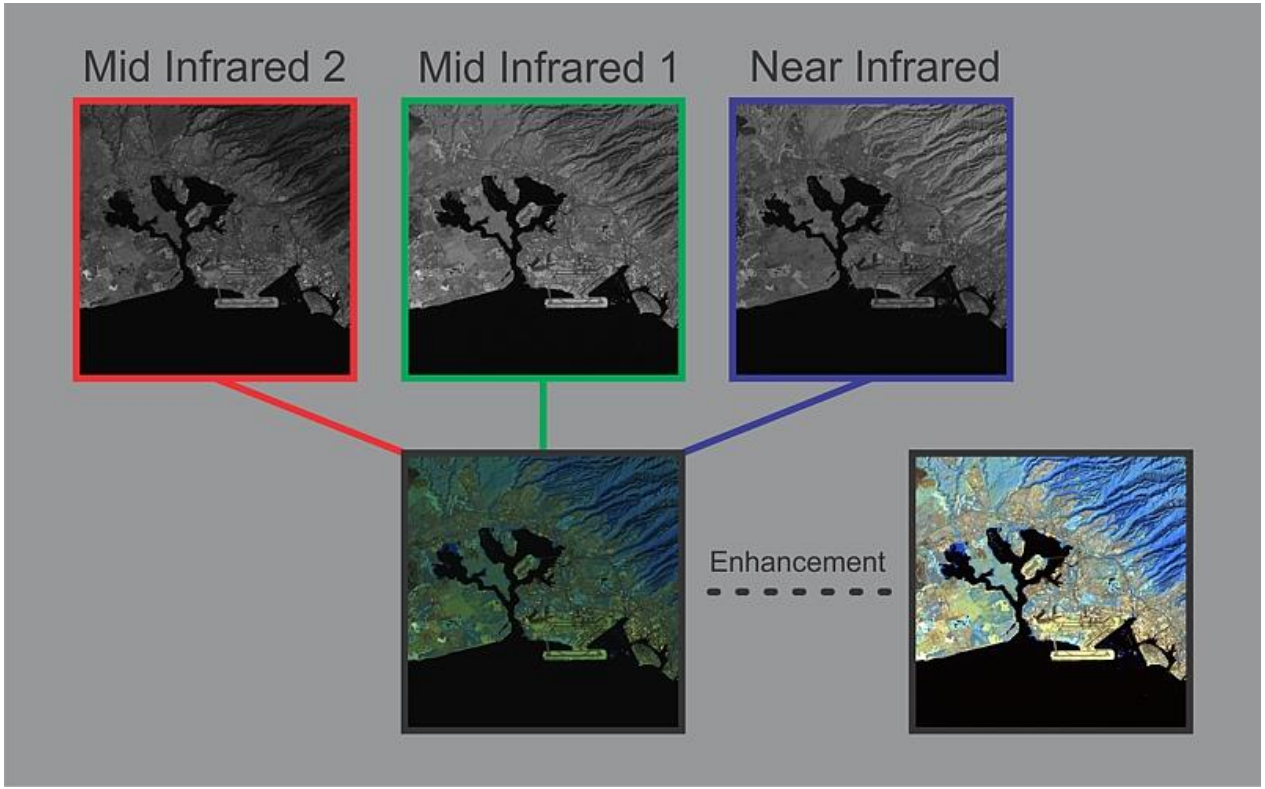
Courtesy: LANDSAT

Multi spectral images



Courtesy: LANDSAT

Multi spectral images

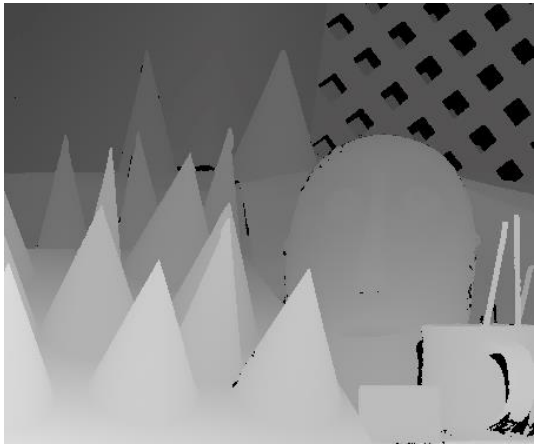


Courtesy: LANDSAT

Stereo Images

courtesy: wikimedia.com

Stereo Images

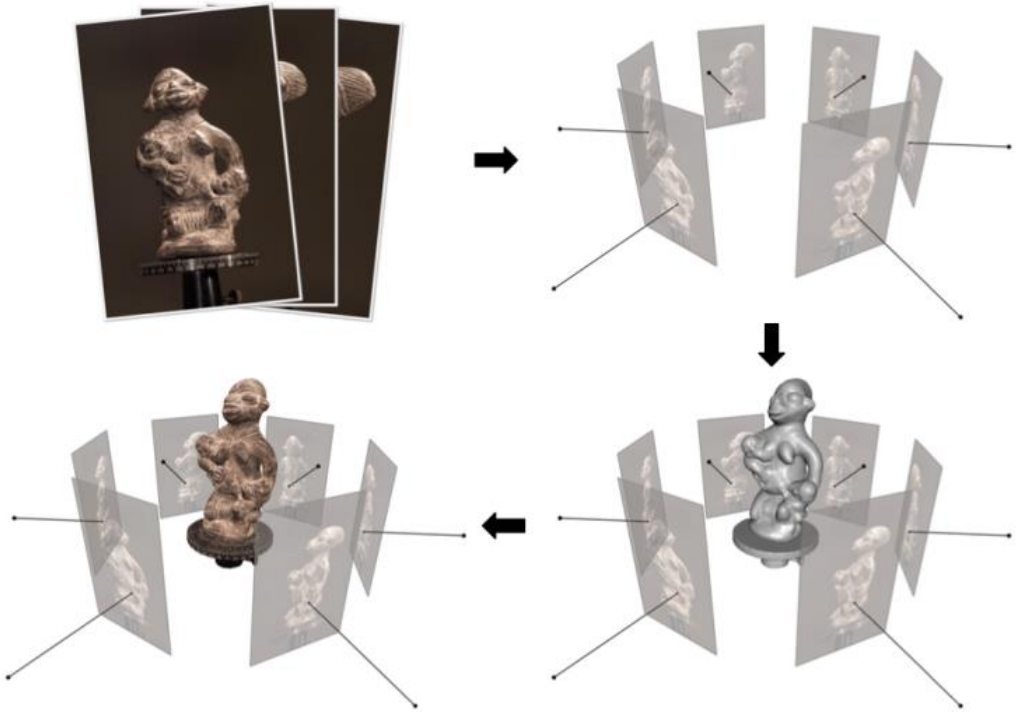


courtesy: vision.middlebury.edu

Multi-view images

courtesy: Maxime Lhuillier

Multi-view images



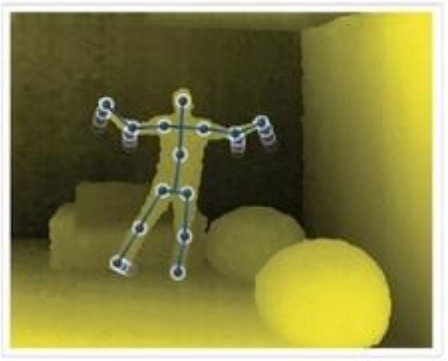
courtesy: Yasutaka Furukawa

courtesy: Sameer Agarwal

Kinect images

Color (RGB) Image

Depth Image



courtesy: kinect and prime sense

Organization (today's lecture)

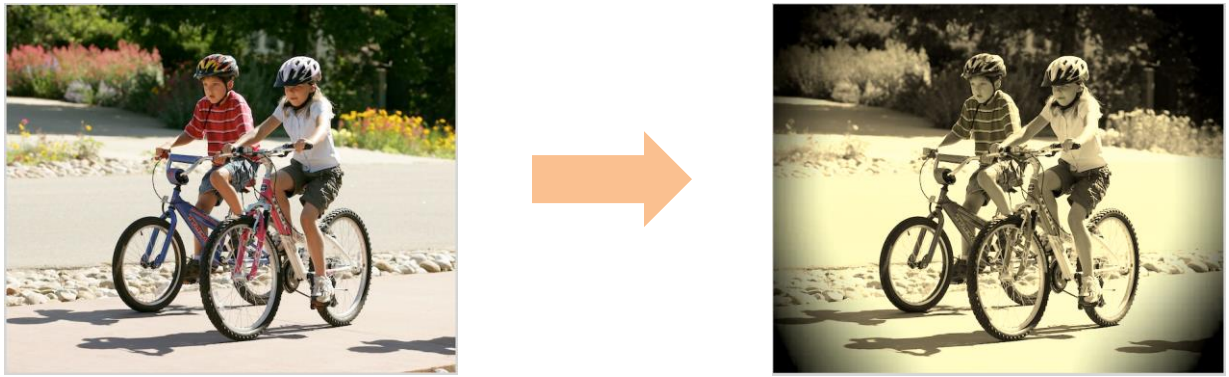
1. SIGNALS (Analog Signals, Digital Signals)

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!

Tasks of interest: Artistic enhancement

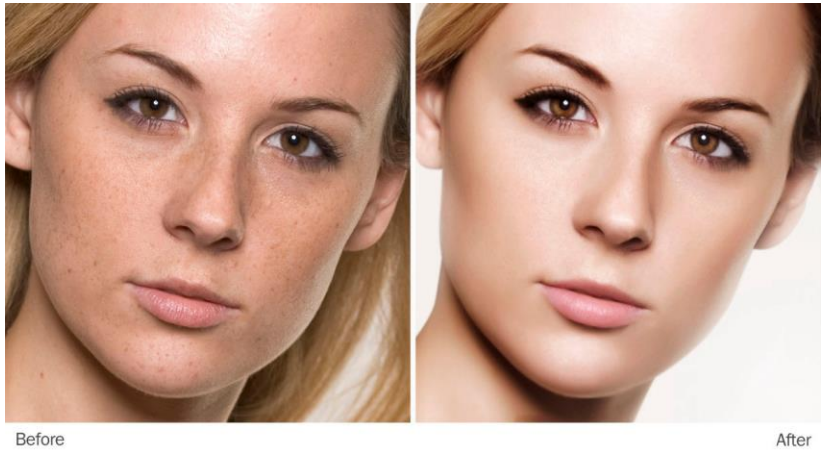


Image courtesy: webneel.com

Image courtesy: Jon Morse

BW to Color

Tasks of interest: Cinematic Grading

Image courtesy: juanmelara.com

Tasks of interest: Edge Detection

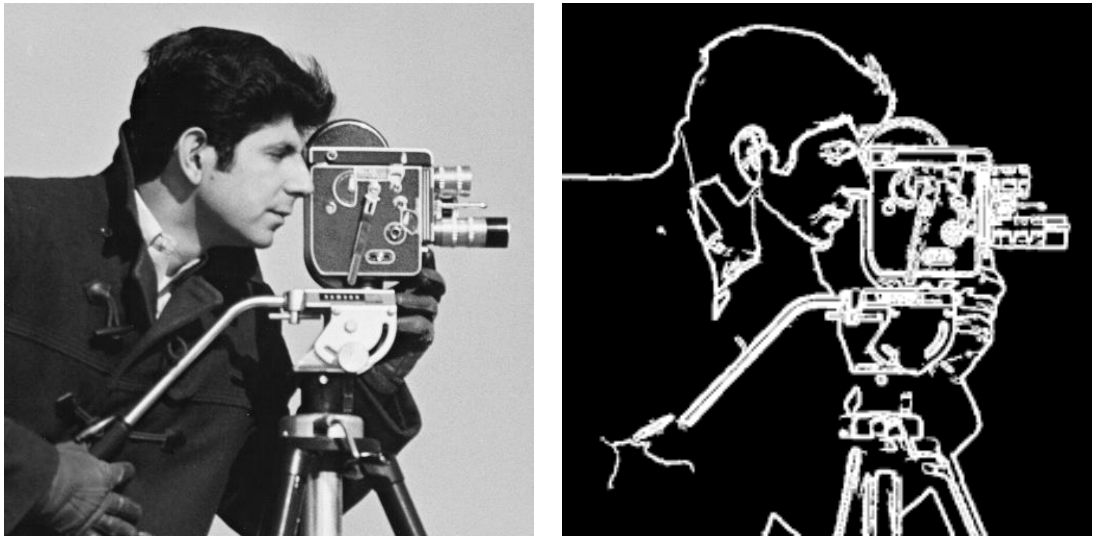


Image courtesy: mathworks

Tasks of interest: Feature detection + stitching

Image courtesy: opencv

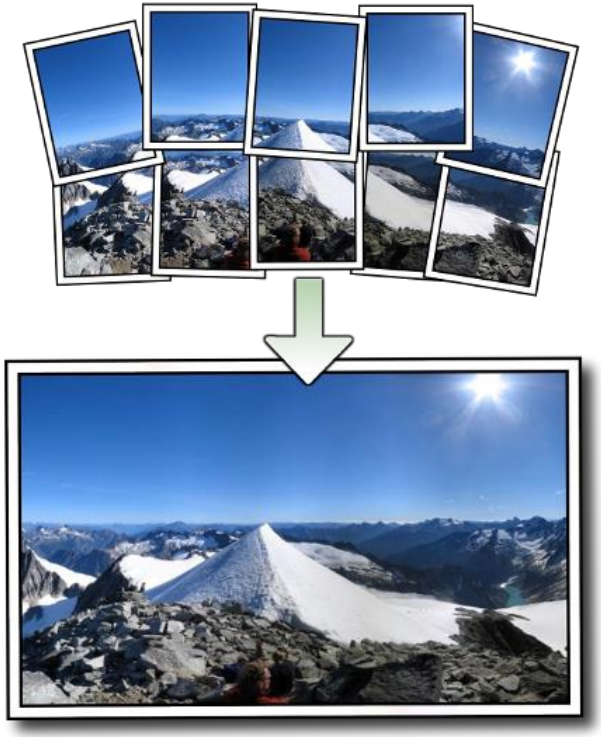
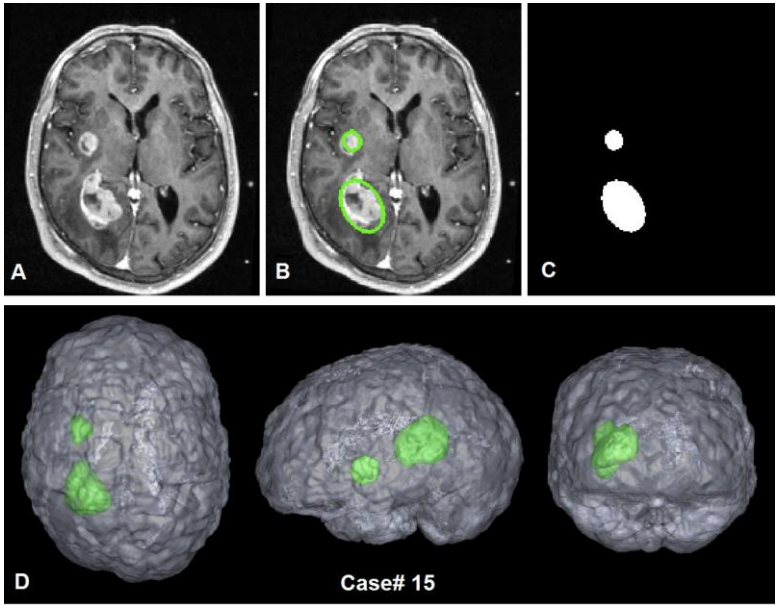
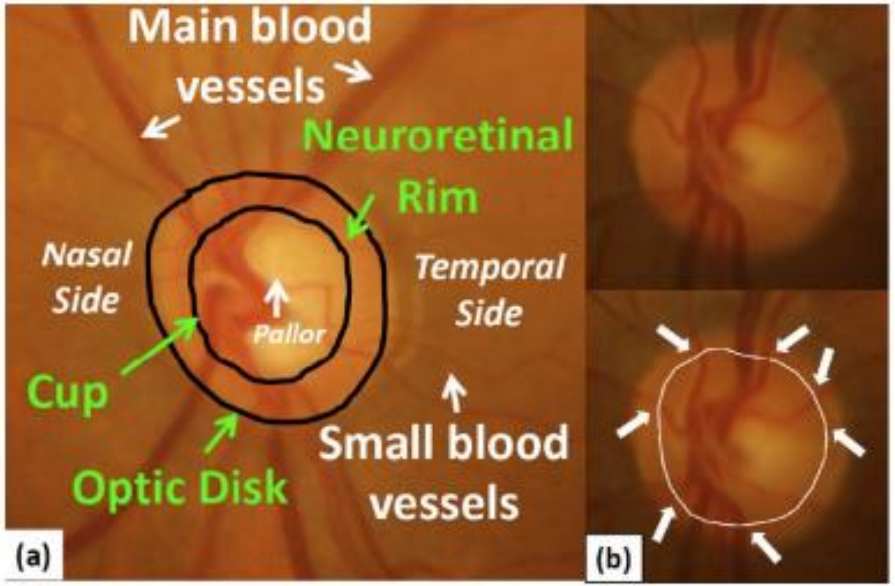


Image courtesy: autostitch

Tasks of interest: Segmentation

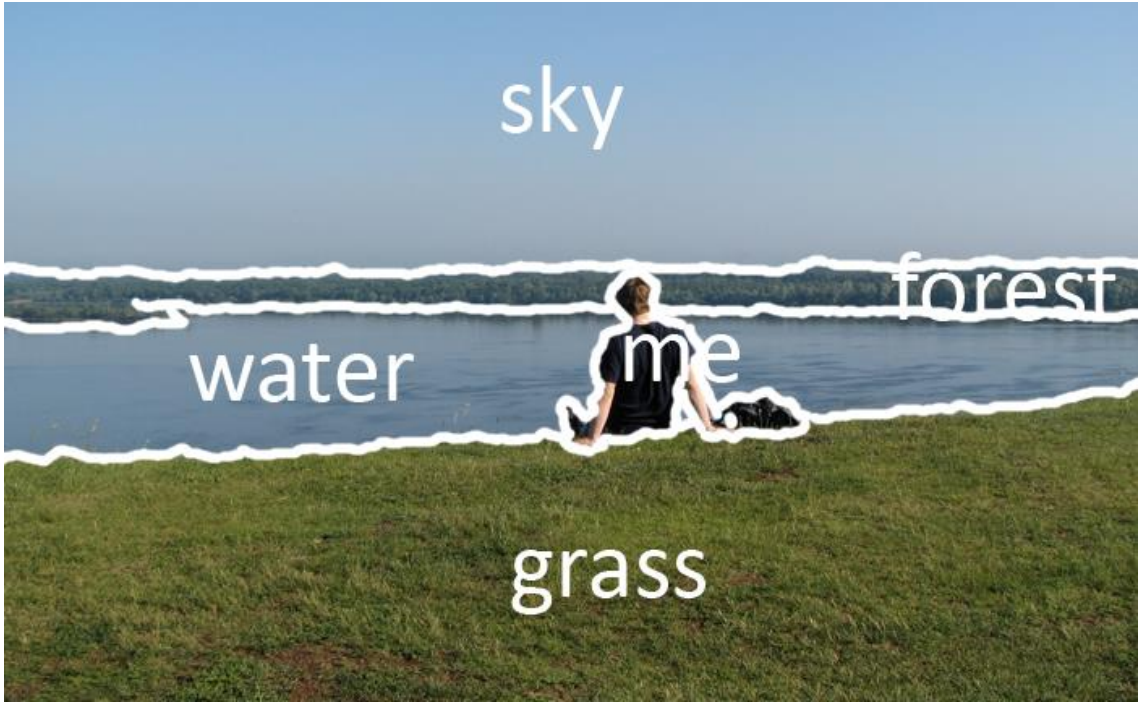


Tumour Segmentation [Yu et al. MICCAI 2010]



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

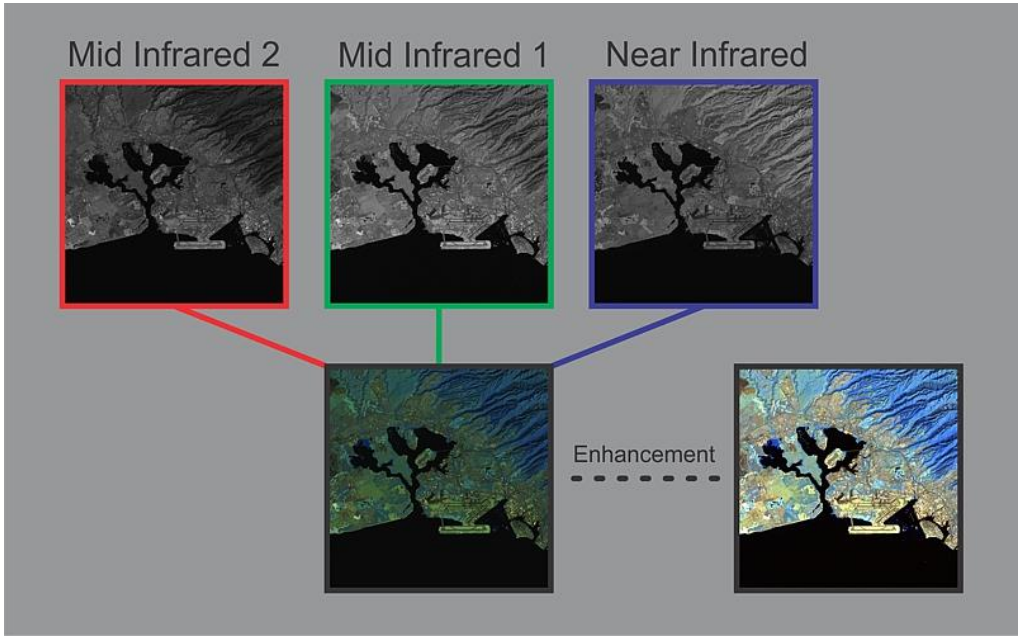
Bertalmio et al. SIGGRAPH 2010

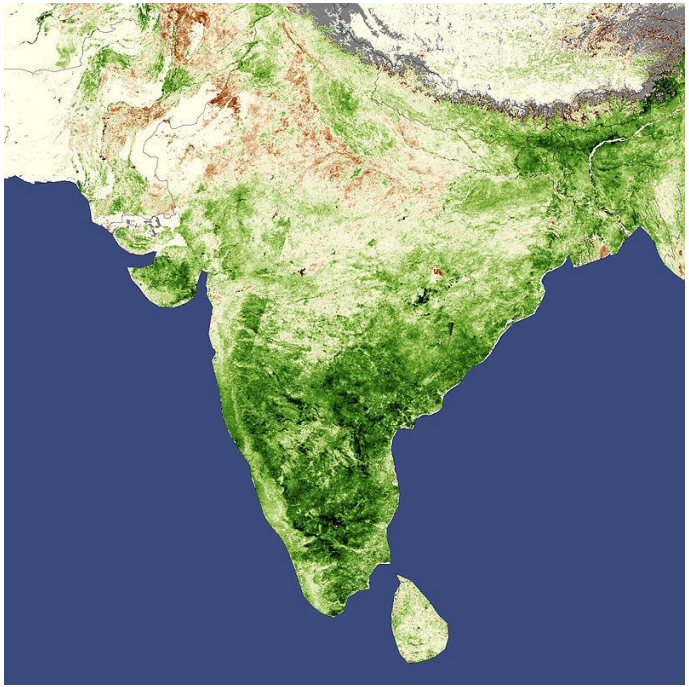
Tasks of interest: Special effects

courtesy: wachowski brothers (matrix)

courtesy: Miller et al. (sin city)

Tasks of interest: Satellite imaging

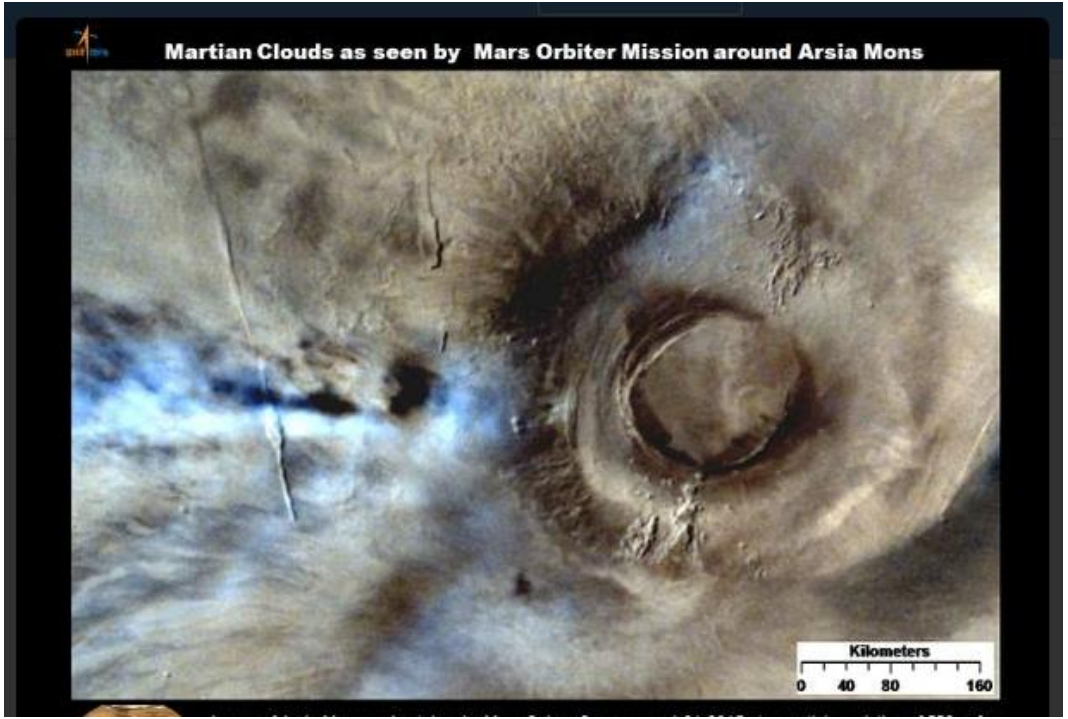


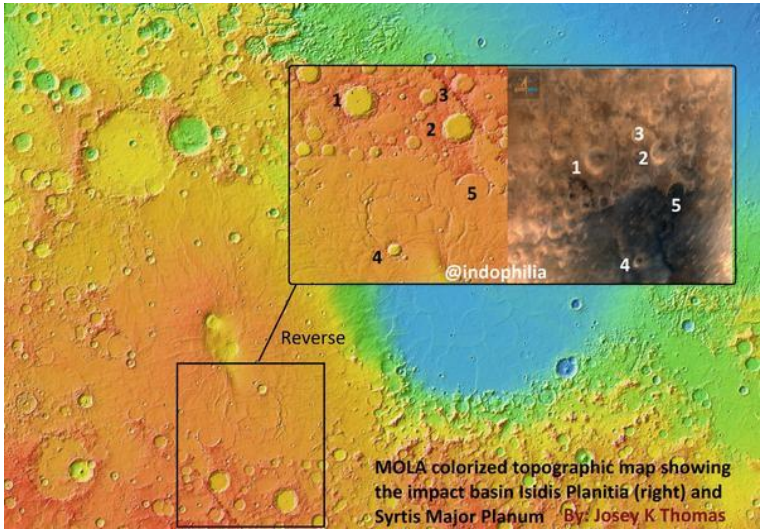


Terrain classification, weather predictions etc.

courtesy: NASA

Tasks of interest: Astronomy

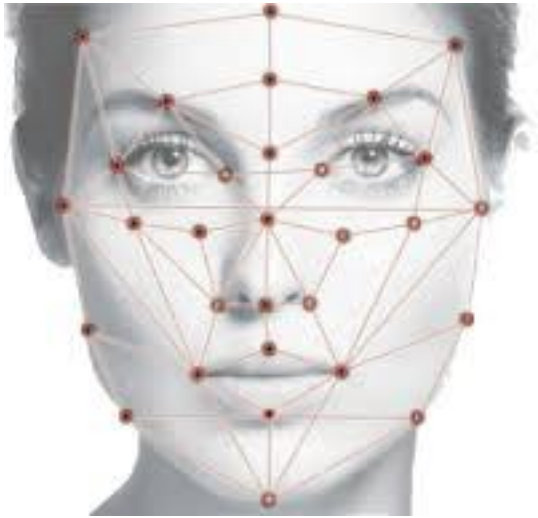




courtesy: ISRO

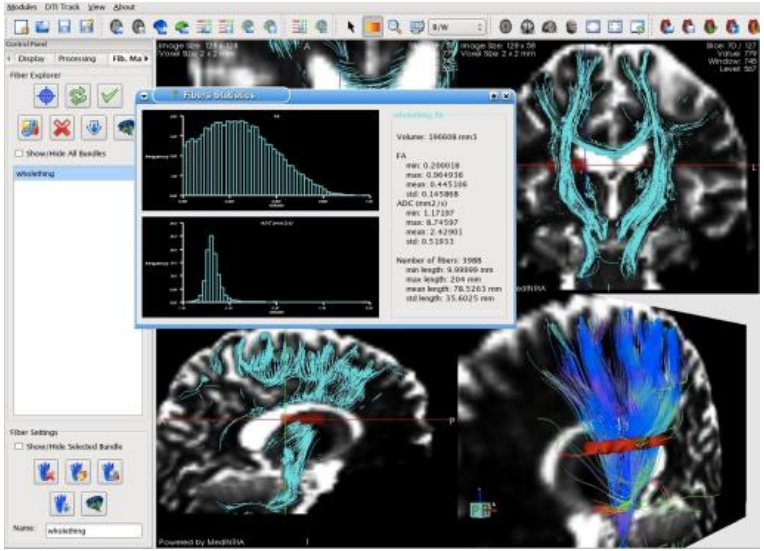
Tasks of interest: Biometrics

courtesy: dqindia.com

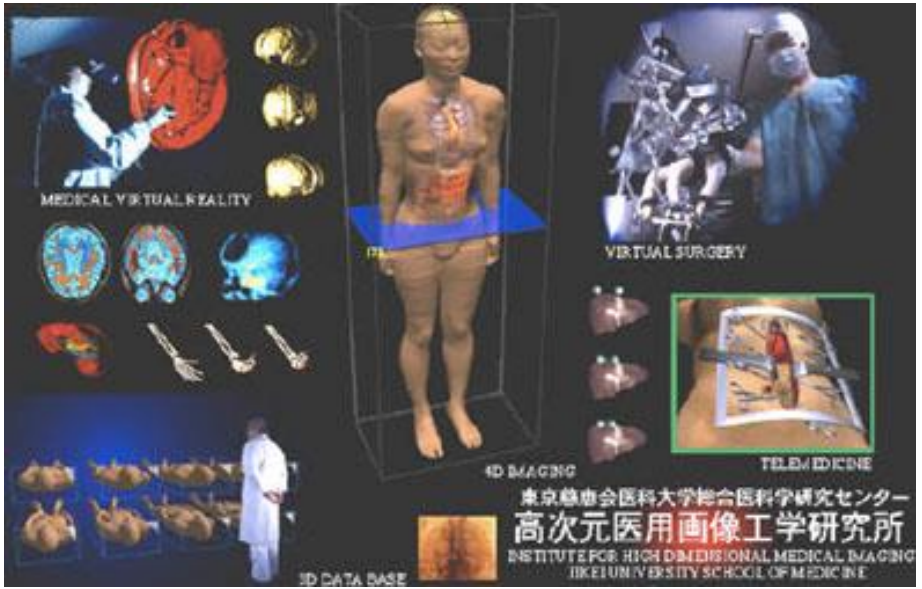


courtesy: heyce.com

Tasks of interest: Medicine



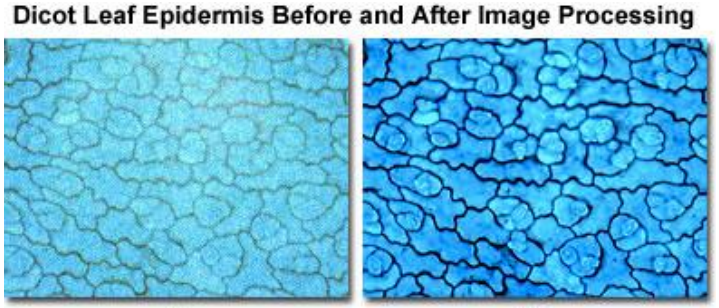
Courtesy: medINRIA



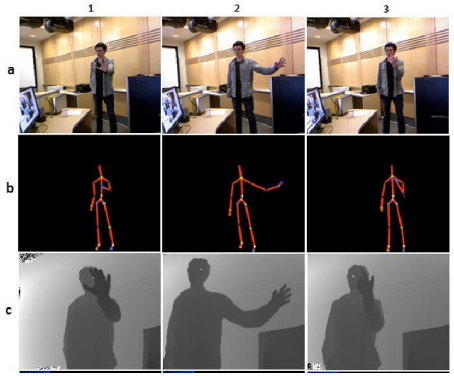
Courtesy: Naoki Suzuki

Tasks of interest: Many more

- Biology
- HCI
- Number Plate recognition
- Gesture recognition



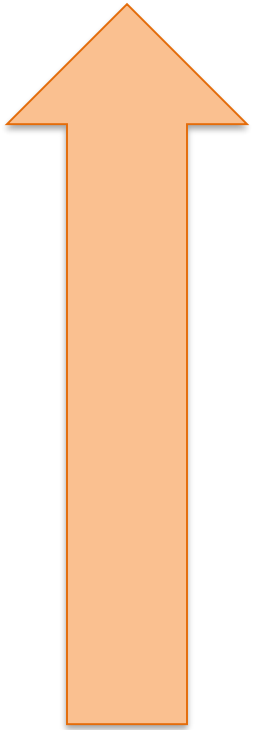
Courtesy: Olympus



Courtesy: Perviverzov et al. 2012

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.