30.07.2018

Digital Image Processing (CSE/ECE 478)
Lecture-1: Overview

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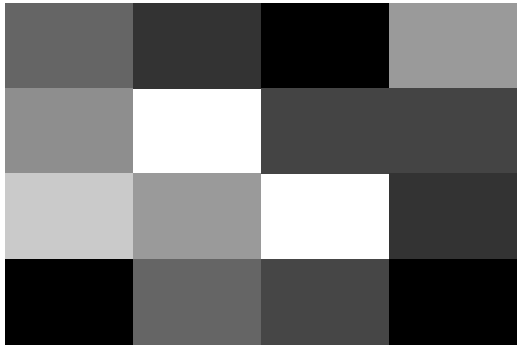
Center for Visual Information Technology (CVIT), IIIT Hyderabad

Many slides borrowed from Vineet Gandhi @CVIT!

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



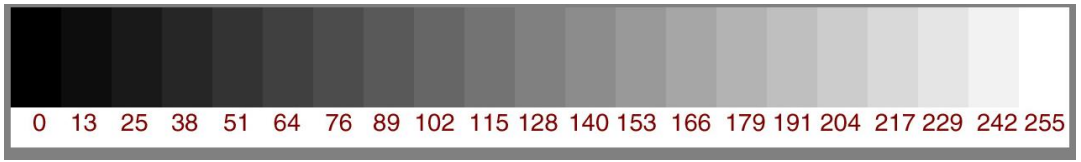


Image acquisition process

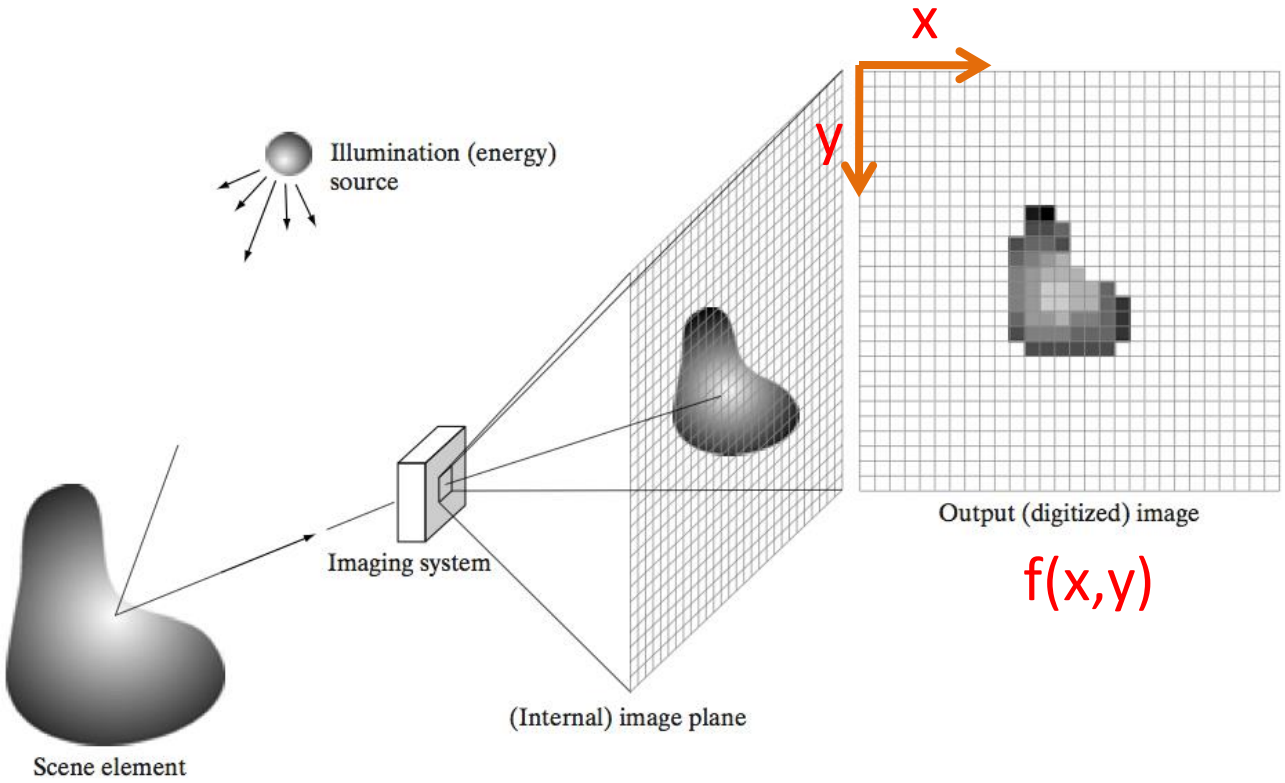


Image courtesy: Gonzalez and Woods

Image acquisition process

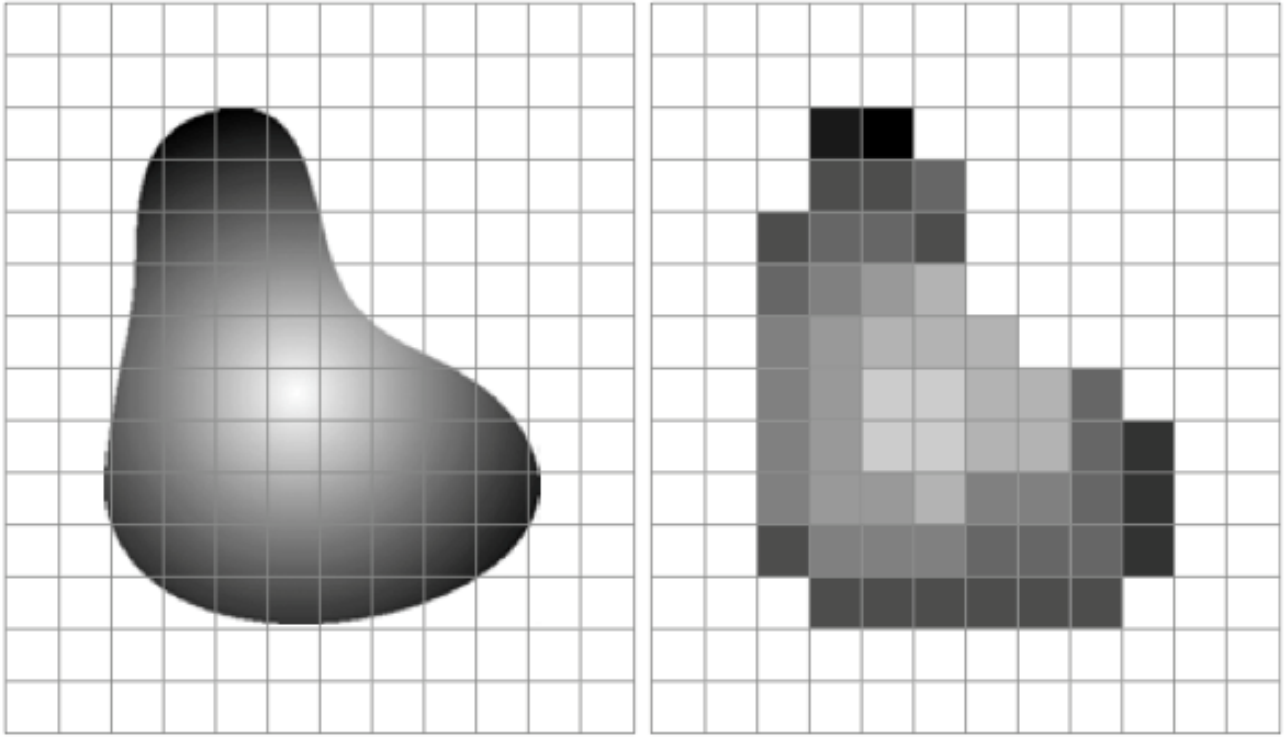
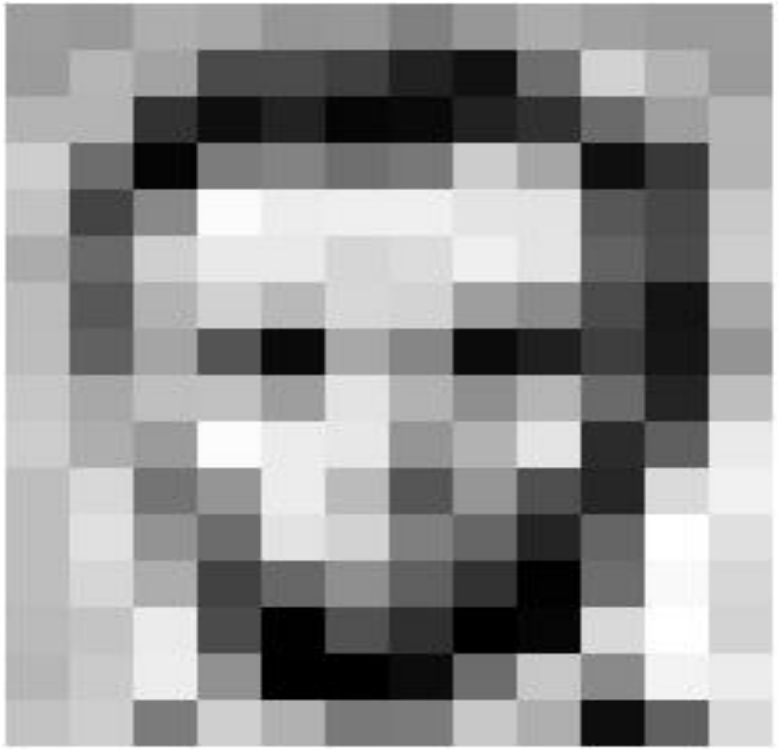


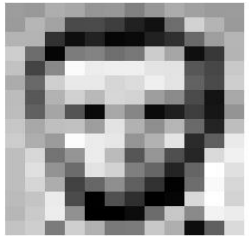
Image courtesy: Gonzalez and Woods

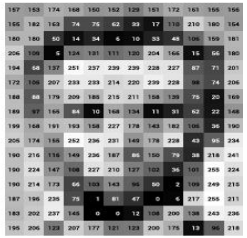
Image Representation

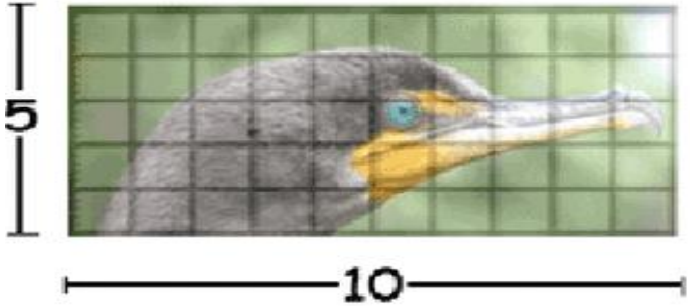


157	153	174	168	150	152	129	151	172	161	155	156
155	182	163	74	75	62	33	17	110	210	180	154
180	180	50	14	34	6	10	33	48	106	159	181
206	109	5	124	131	111	120	204	166	15	56	180
194	68	137	251	237	239	239	228	227	87	71	201
172	105	207	233	233	214	220	239	228	98	74	206
188	88	179	209	185	215	211	158	139	75	20	169
189	97	165	84	10	168	134	11	31	62	22	148
199	168	191	193	158	227	178	143	182	106	36	190
205	174	155	252	236	231	149	178	228	43	95	234
190	216	116	149	236	187	86	150	79	38	218	241
190	224	147	108	227	210	127	102	36	101	255	224
190	214	173	66	103	143	95	50	2	109	249	215
187	196	235	75	1	81	47	0	6	217	255	211
183	202	237	145	0	0	12	108	200	138	243	236
196	206	123	207	177	121	123	200	175	13	96	218

Image Representation







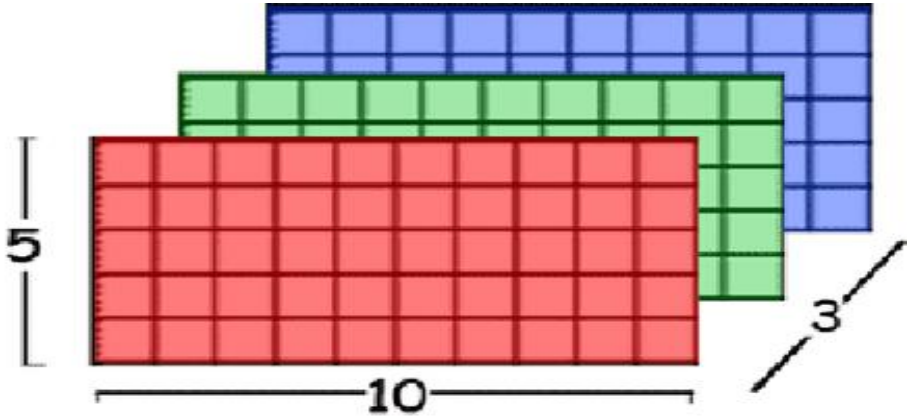
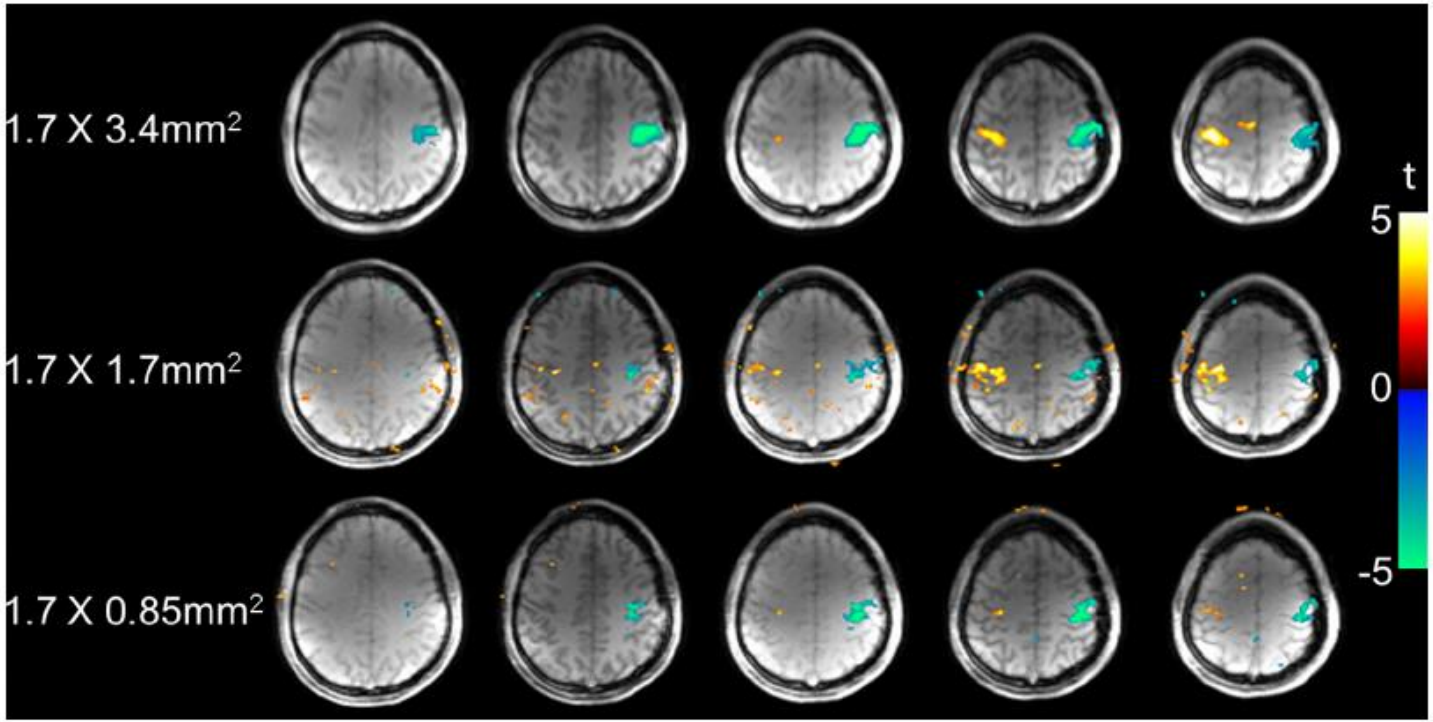


Image Representation



fMRI image slices

Types of Images (classification on source)

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

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- Radiation from EM spectrum
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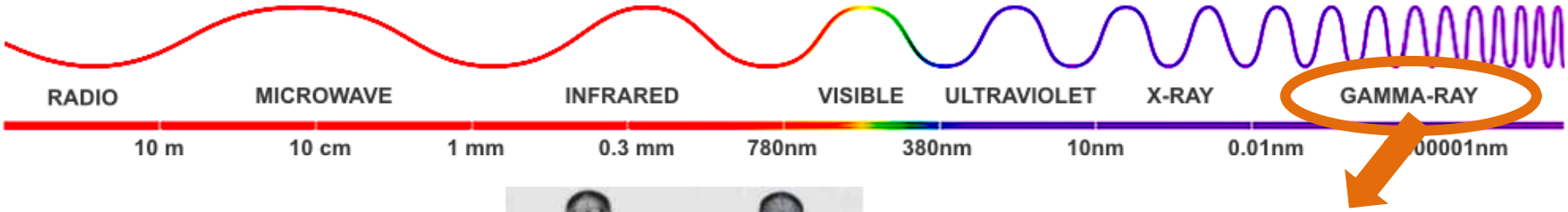
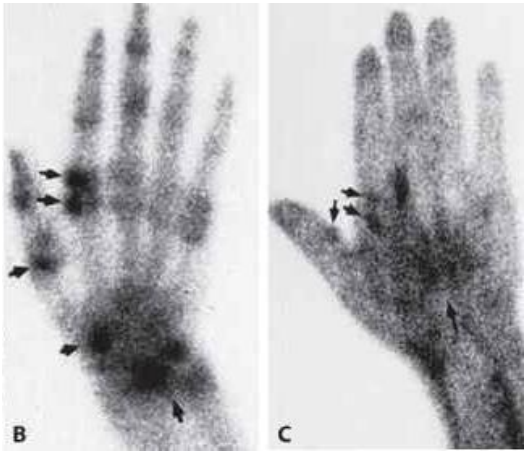
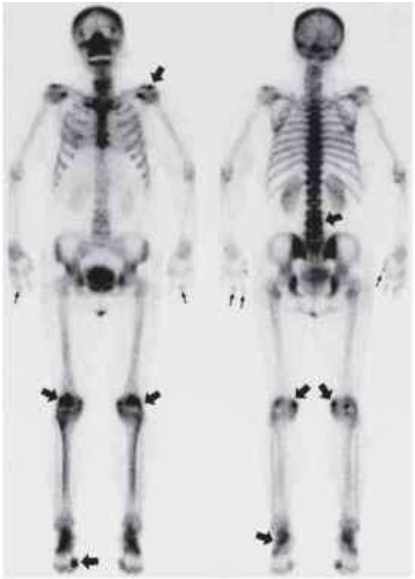
EM spectrum





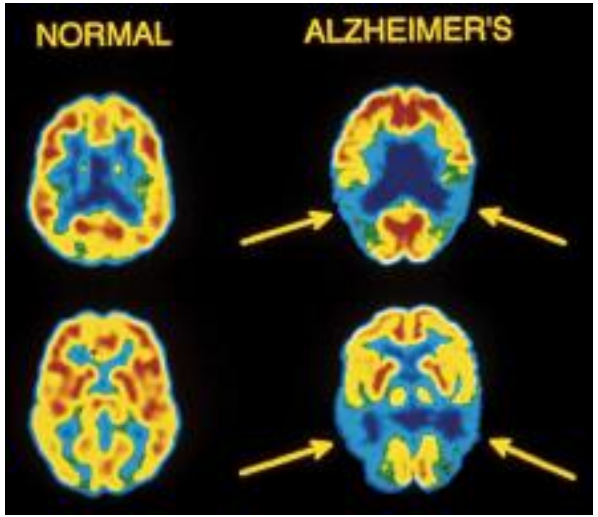
BLOOD FLOW SCAN

courtesy: artheristisresearch.us



BONE SCAN

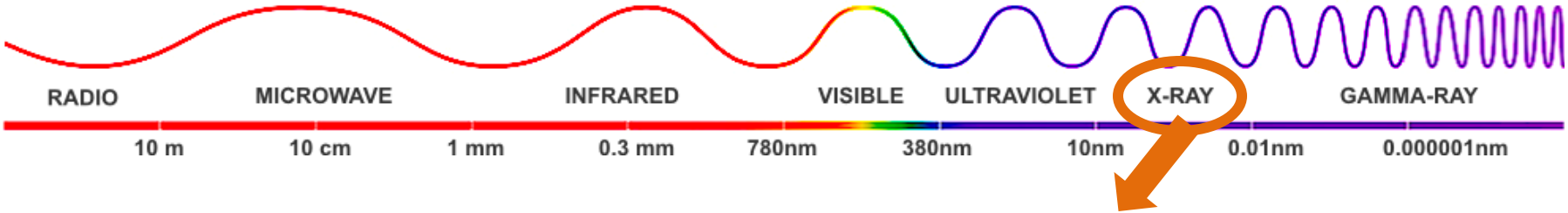
courtesy: artheristisresearch.us



PET SCAN

courtesy: research.ucla.edu

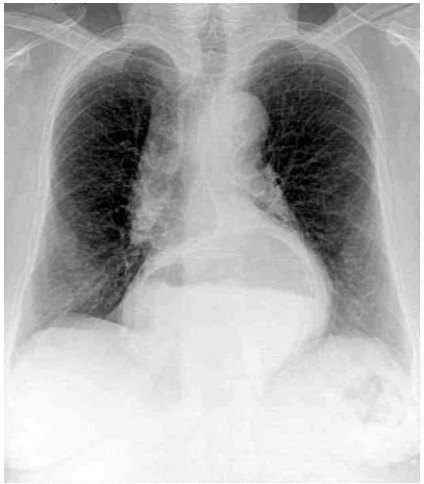
EM spectrum



Wilhelm Röntgen

HAND MIT RINGEN

courtesy: wikipedia



CHEST RADIOGRAPH

courtesy: wikipedia

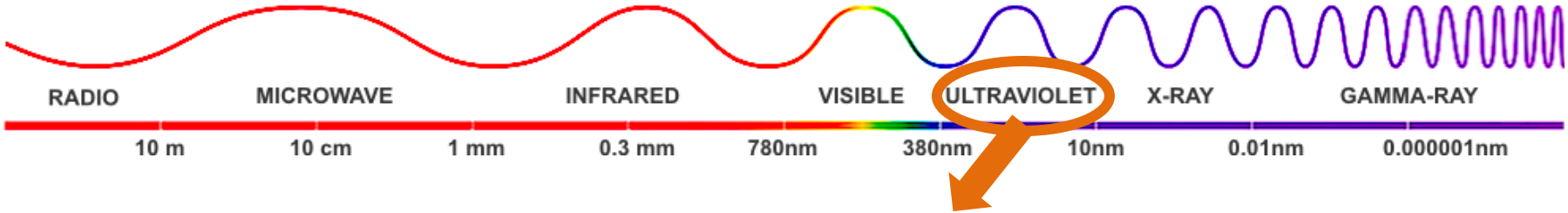
CT SCAN

courtesy: wikipedia

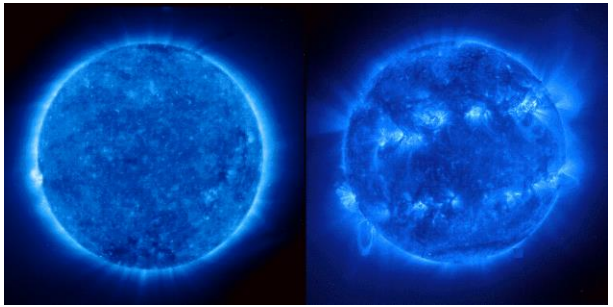
AIRPORT SCAN

courtesy: dpl-surveillance-equipment

EM spectrum



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



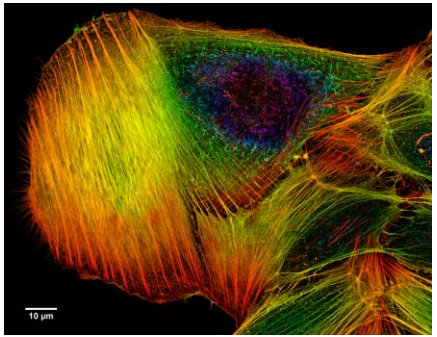
SUN (2 years apart)

courtesy: NASA

100 EURO BILL

courtesy: lifepixel.com

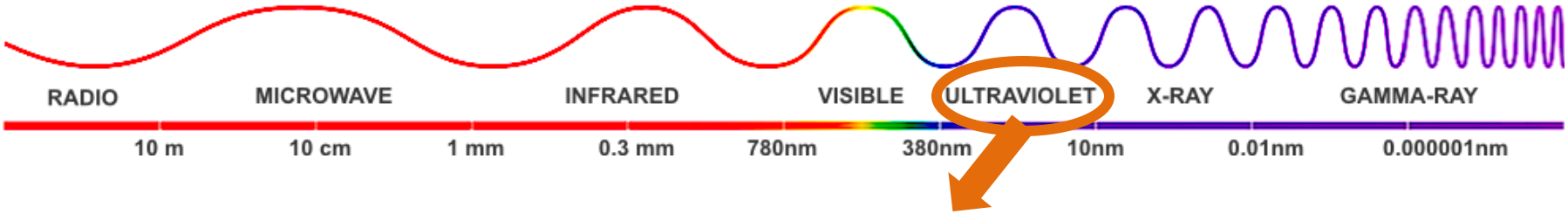
Eric Betzig, William Moerner and Stefan Hell



Cell Phalloidin

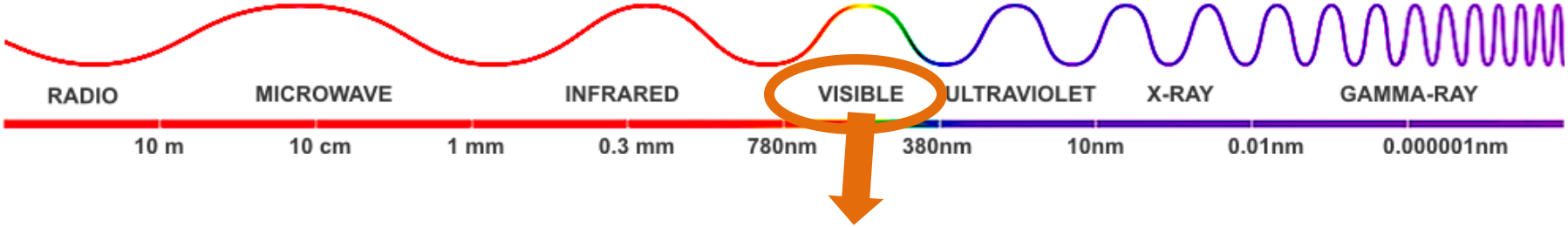
courtesy: wikipedia

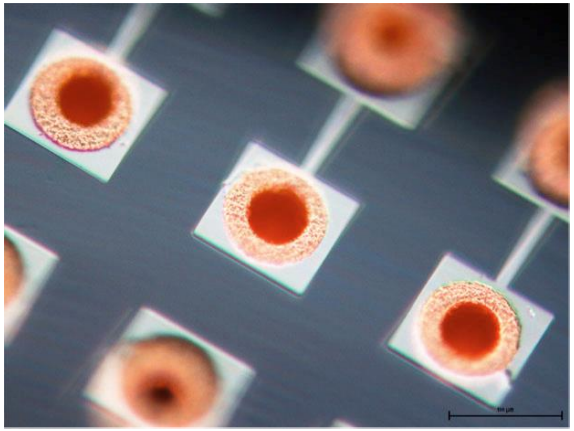
EM spectrum



Source:
Lifepixel.com

EM spectrum



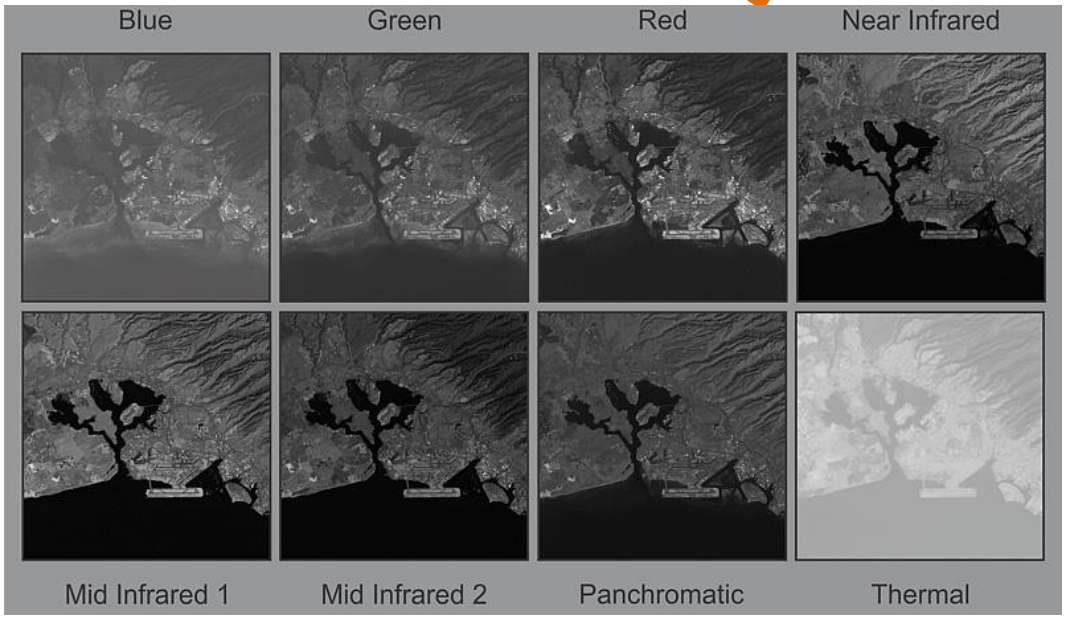


Chips (optical microscopy)
courtesy: EPFL microelectornics systems laboratory

High Speed Photograph
courtesy:Alan Sailer

Satellite Image (Hurricane Katrina)
courtesy: britannica.com

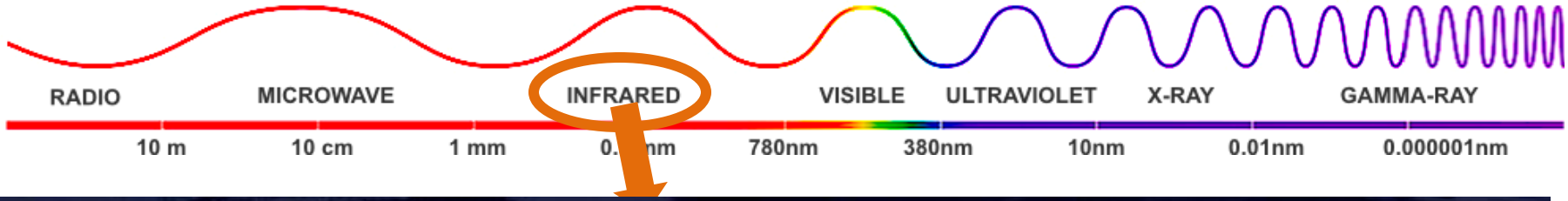
EM spectrum



courtesy: LANDSAT (NASA)

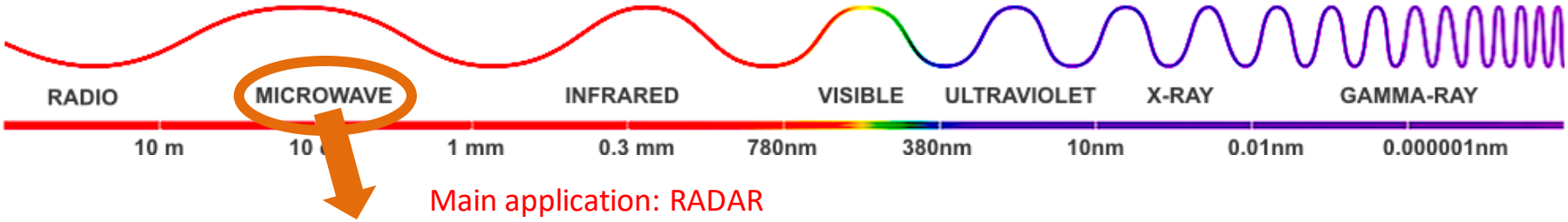
courtesy: imaging1.com

EM spectrum



courtesy NASA

EM spectrum



Main application: RADAR

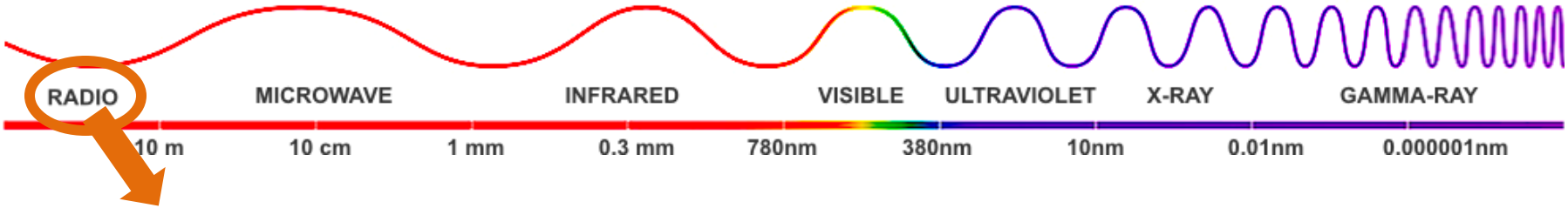
SOUTHEAST TIBET MOUNTAINS

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

Types of Images (classification on source)

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- Computer generated

Ultrasound

ULTRASOUND

courtesy: wikipedia

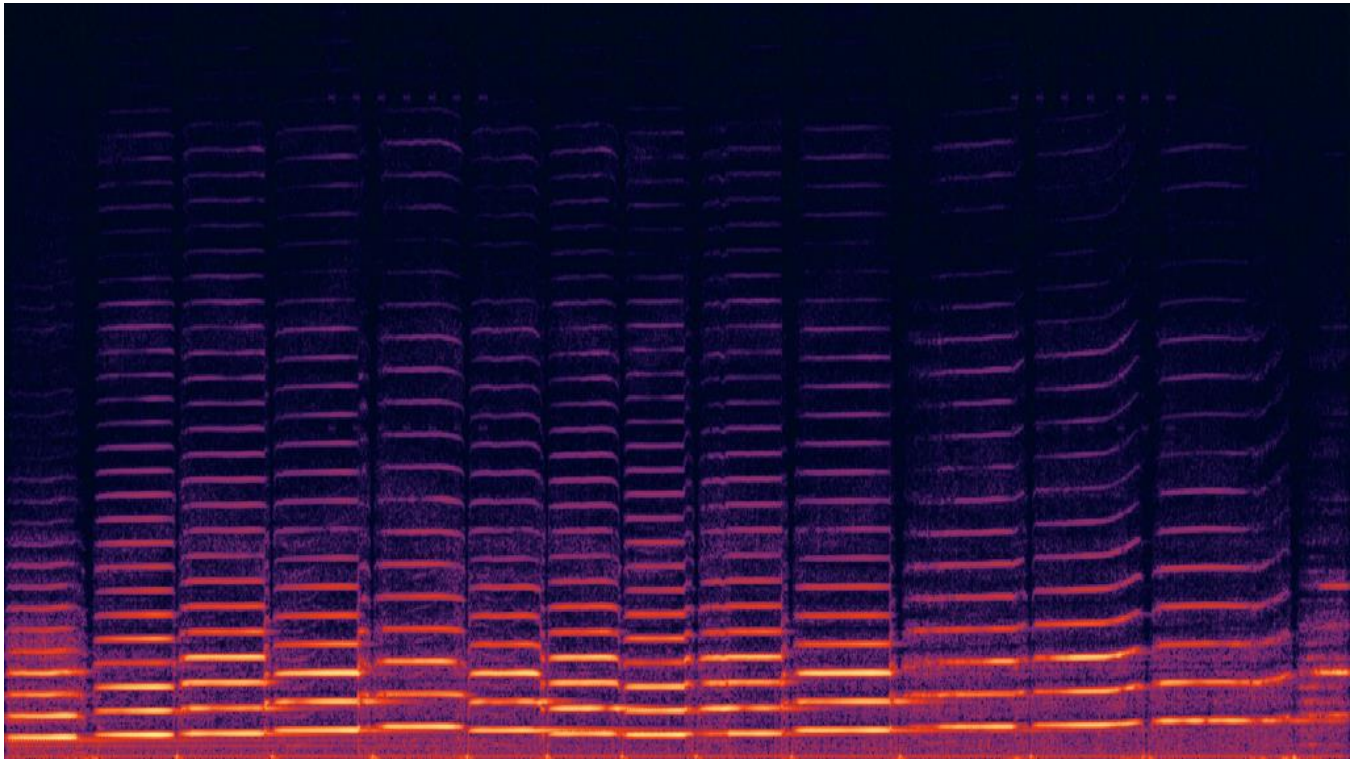
ULTRASOUND TWINS

courtesy: pinterest

ULTRASOUND 3D

courtesy: peek3D.com

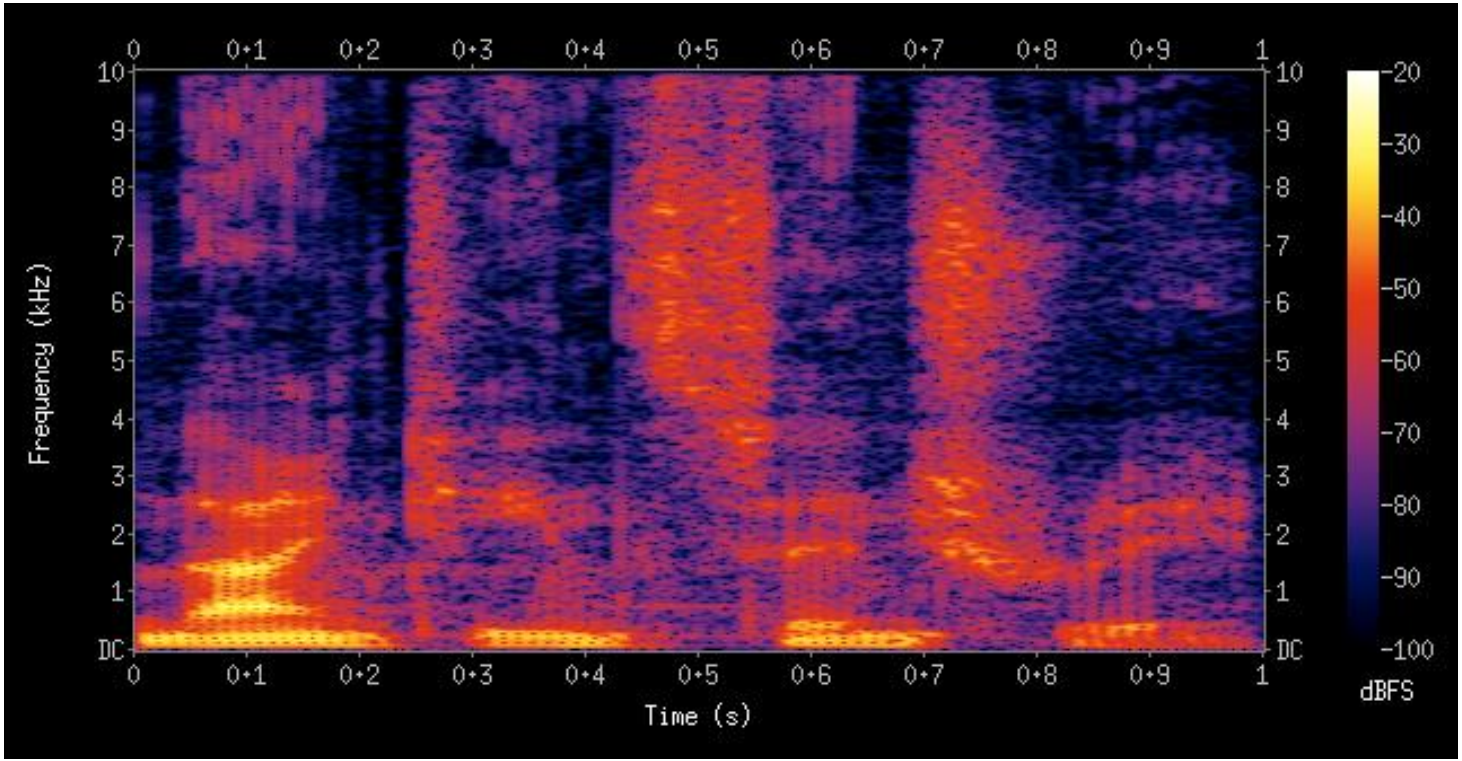
Spectrogram



Violin Recording

courtesy: wikipedia

Spectrogram



Saying Nineteenth Century

courtesy: wikipedia

Types of Images (classification on source)

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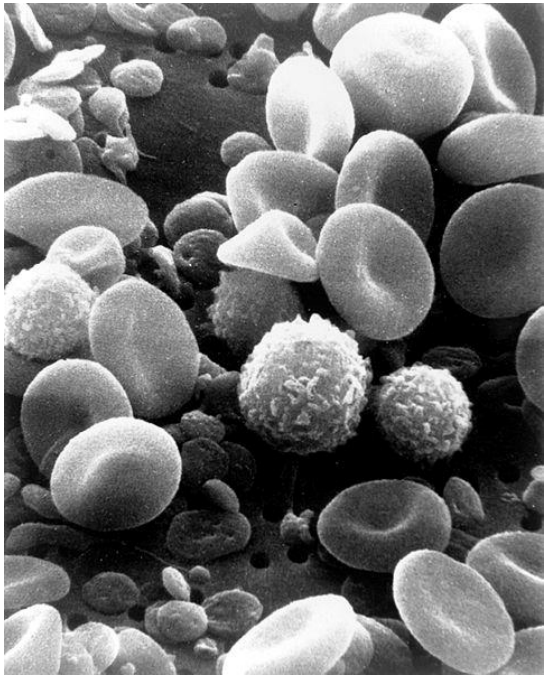
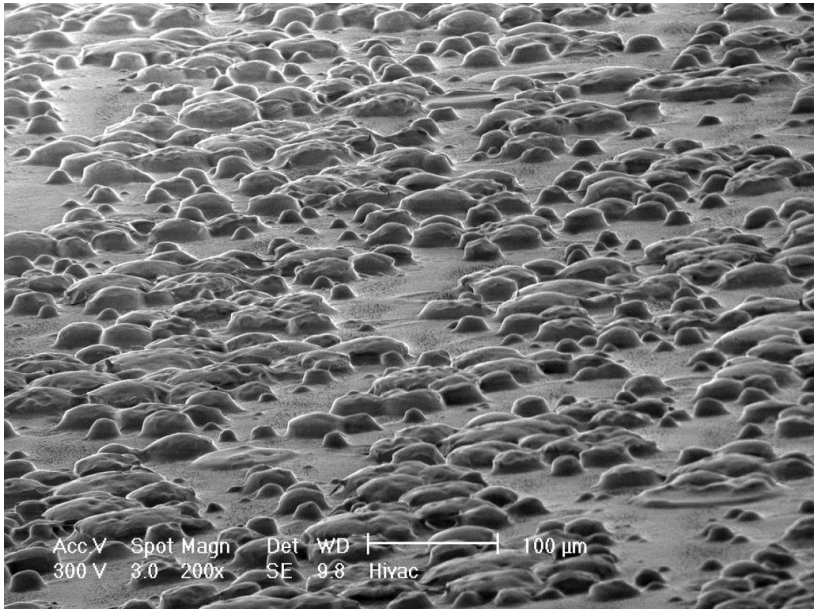
Scanning Electron Microscopy



Normal Circulating Human Blood

courtesy: National Cancer Institute



Adhesive on Post-it note

courtesy: wikipedia

Types of Images (classification on source)

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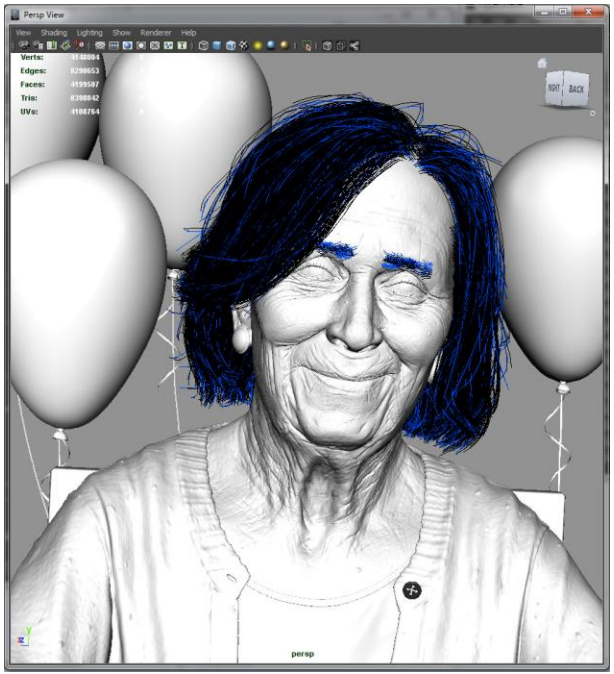
- Computer generated

Computer generated

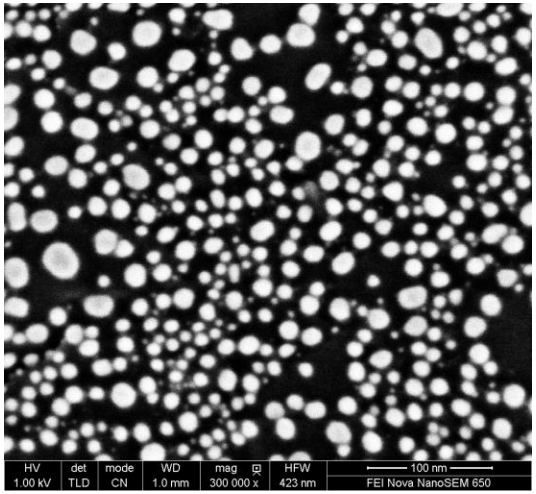
Happy Birthday Nana

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)

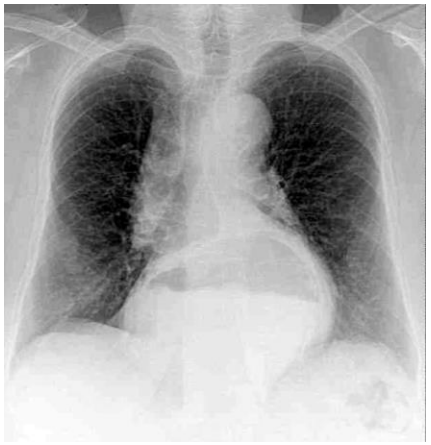
1. Reflection Images

Information primarily about objects surface

2. Emission Images

Information primarily about internal properties

3. Absorption Images

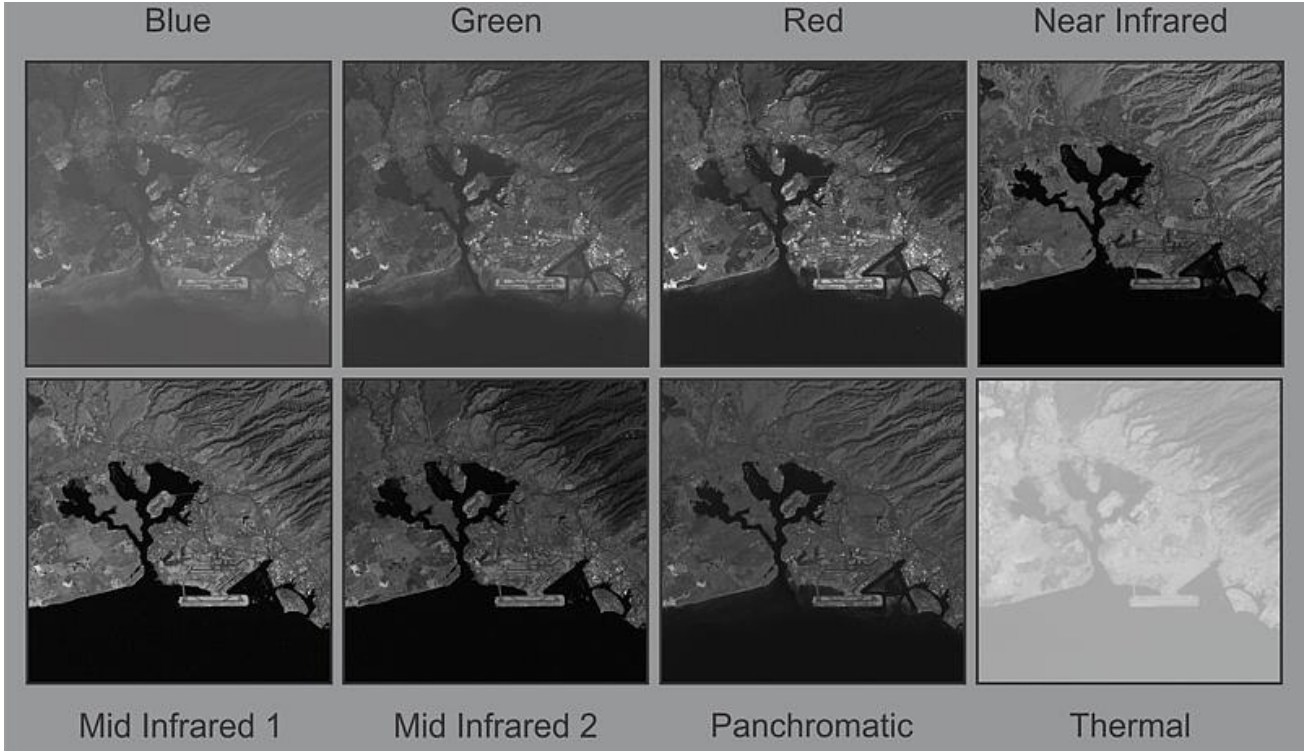


Information primarily about internal structure

Types on images (classification on arrangement)

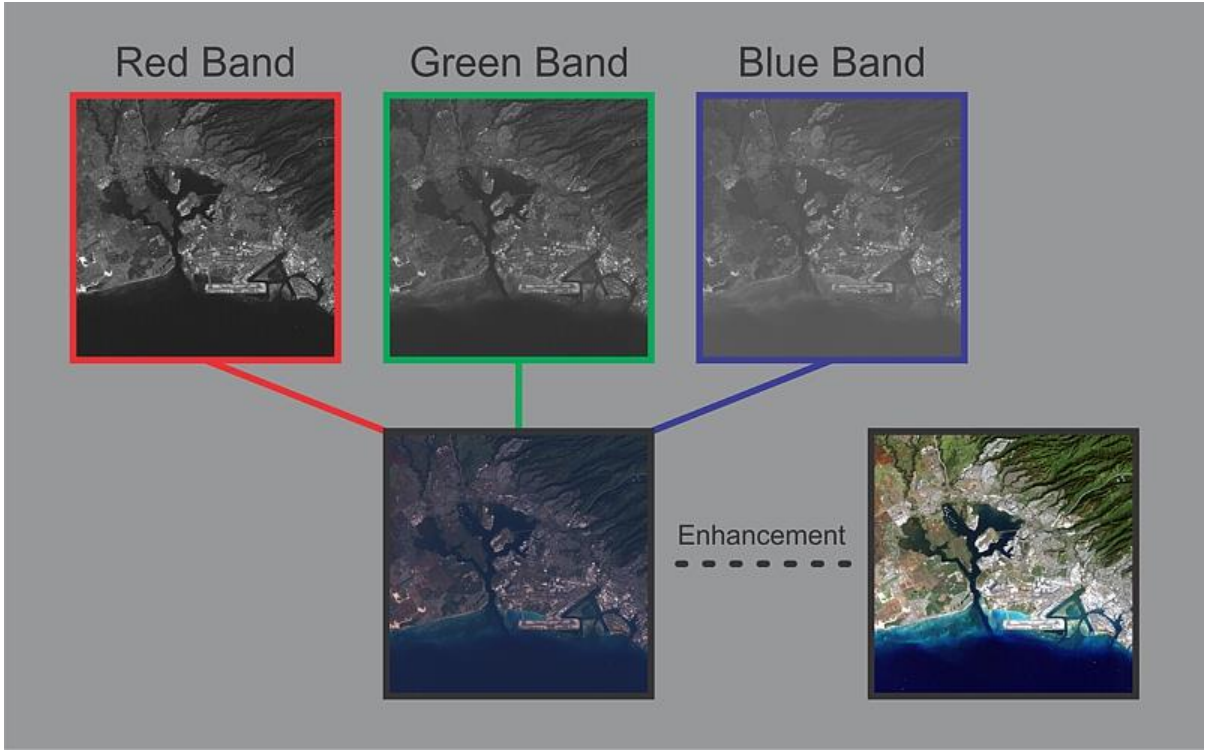
- Grayscale
- RGB
- Multispectral images
- Stereo images
- Multi-view images

Multi spectral images



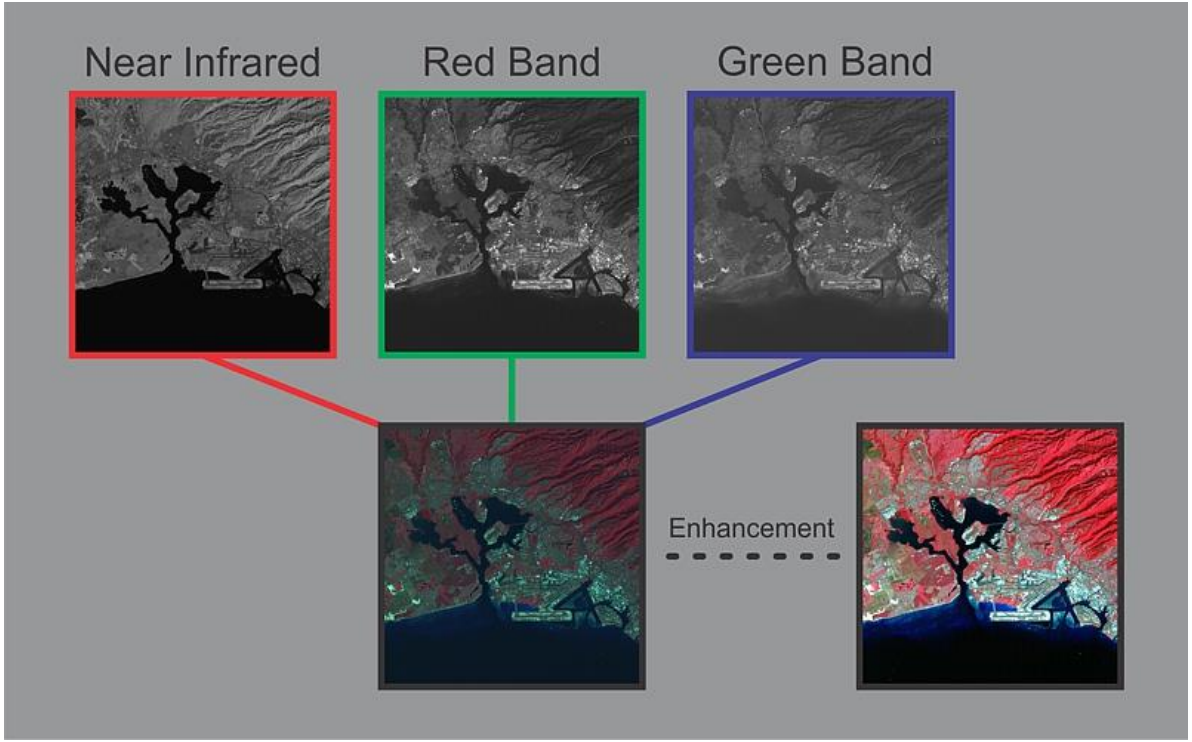
Courtesy: LANDSAT

Multi spectral images



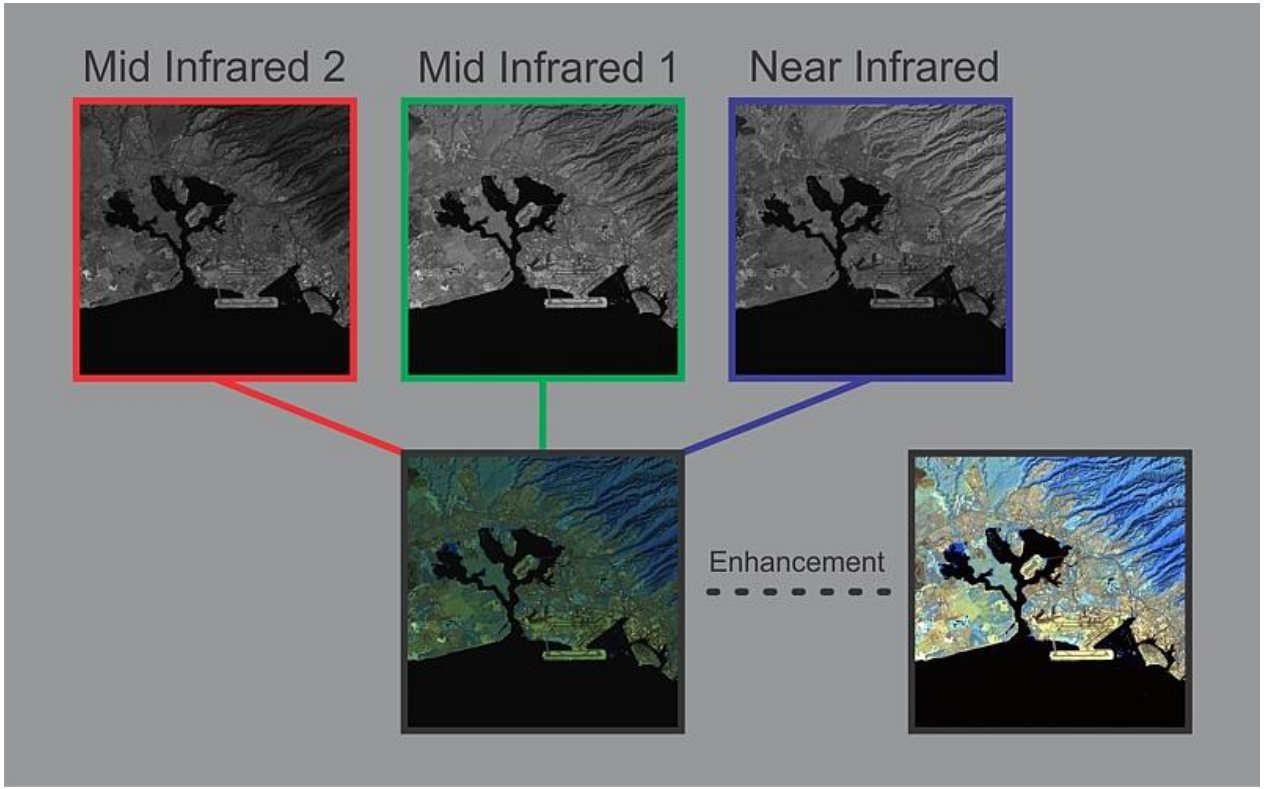
Courtesy: LANDSAT

Multi spectral images



Courtesy: LANDSAT

Multi spectral images

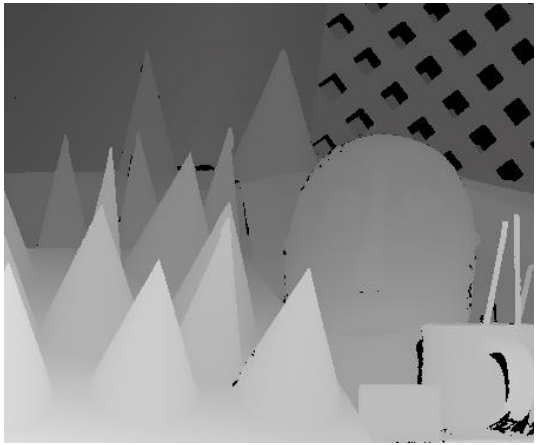


Courtesy: LANDSAT

Stereo Images

courtesy: wikimedia.com

Stereo Images

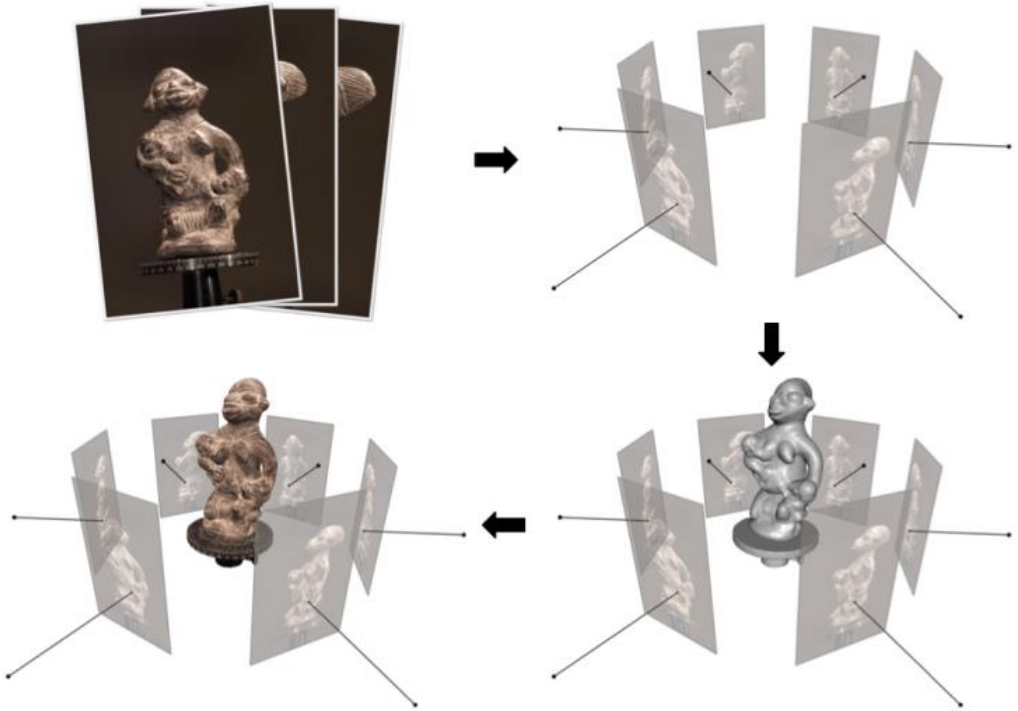


courtesy: vision.middlebury.edu

Multi-view images

courtesy: Maxime Lhuillier

Multi-view images



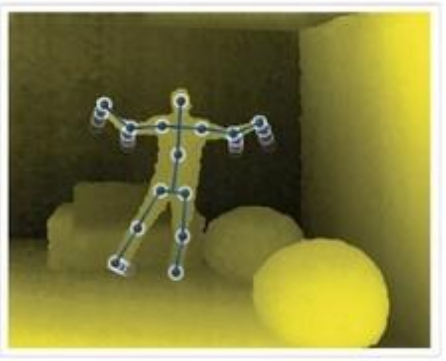
courtesy: Yasutaka Furukawa

courtesy: Sameer Agarwal

Kinect images

Color (RGB) Image

Depth Image



courtesy: kinect and prime sense

Definition: Digital Image **processing**

- Computer algorithms that alter an image
  - To create new image(s)
  - To retrieve important information

- Consumer-based view
  - For consumption by human eyes
  - For consumption by machine-based processes
  - For efficient storage and transmission (to satisfy needs of human eyes / machine-based processes)

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

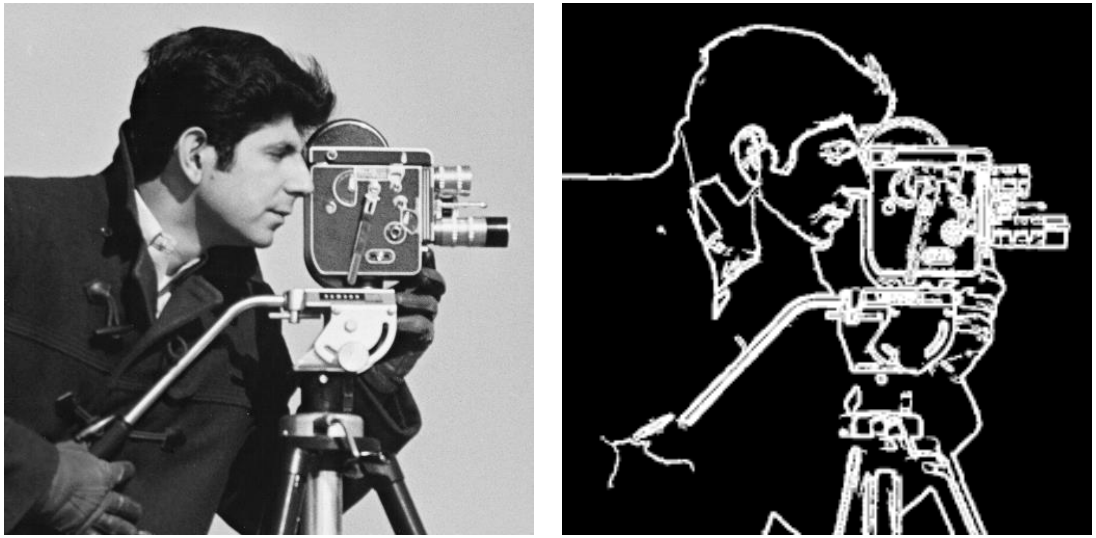


Image courtesy: mathworks

Tasks of interest: Feature detection + stitching

Image courtesy: opencv

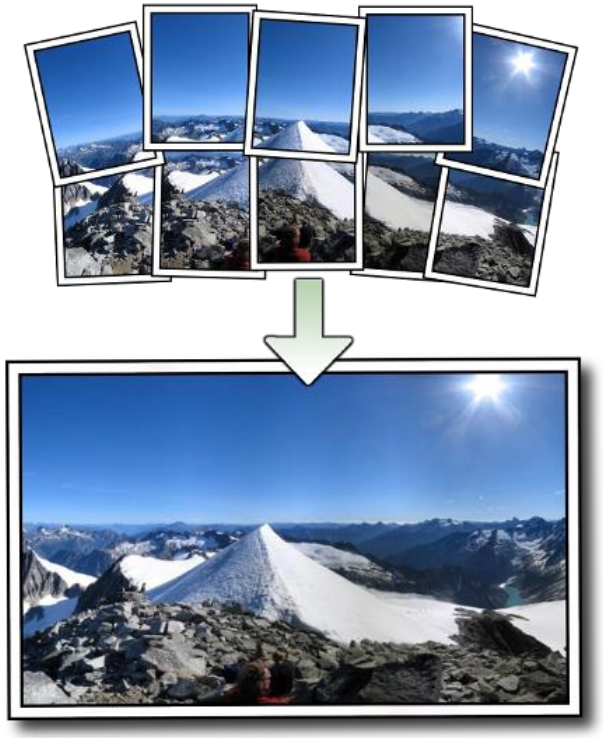
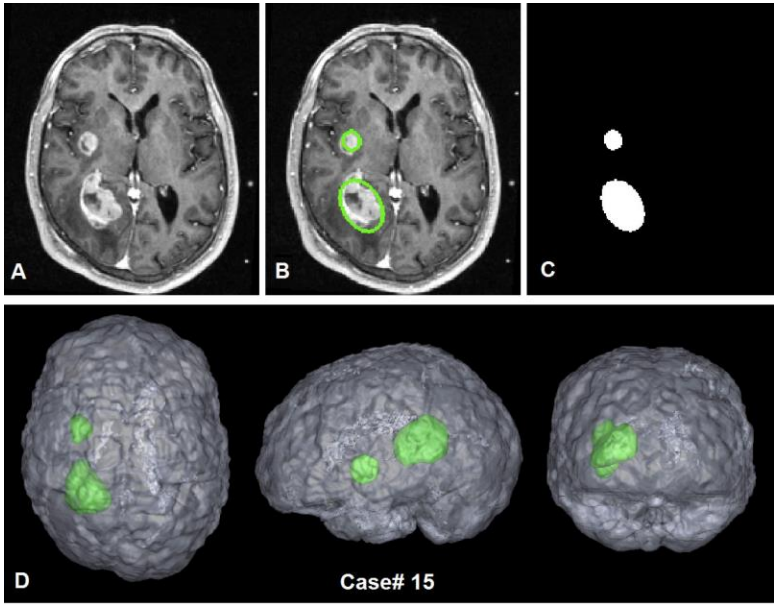
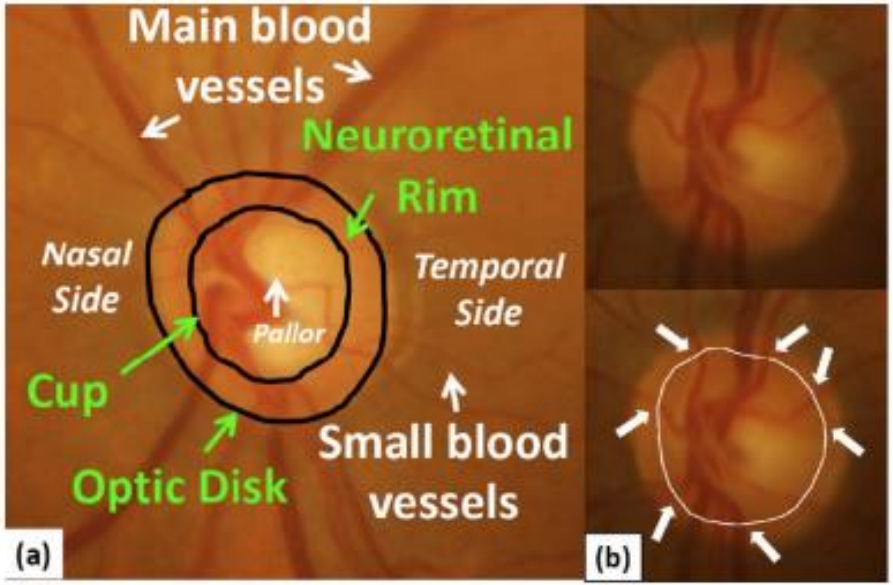


Image courtesy: autostitch

Tasks of interest: Segmentation

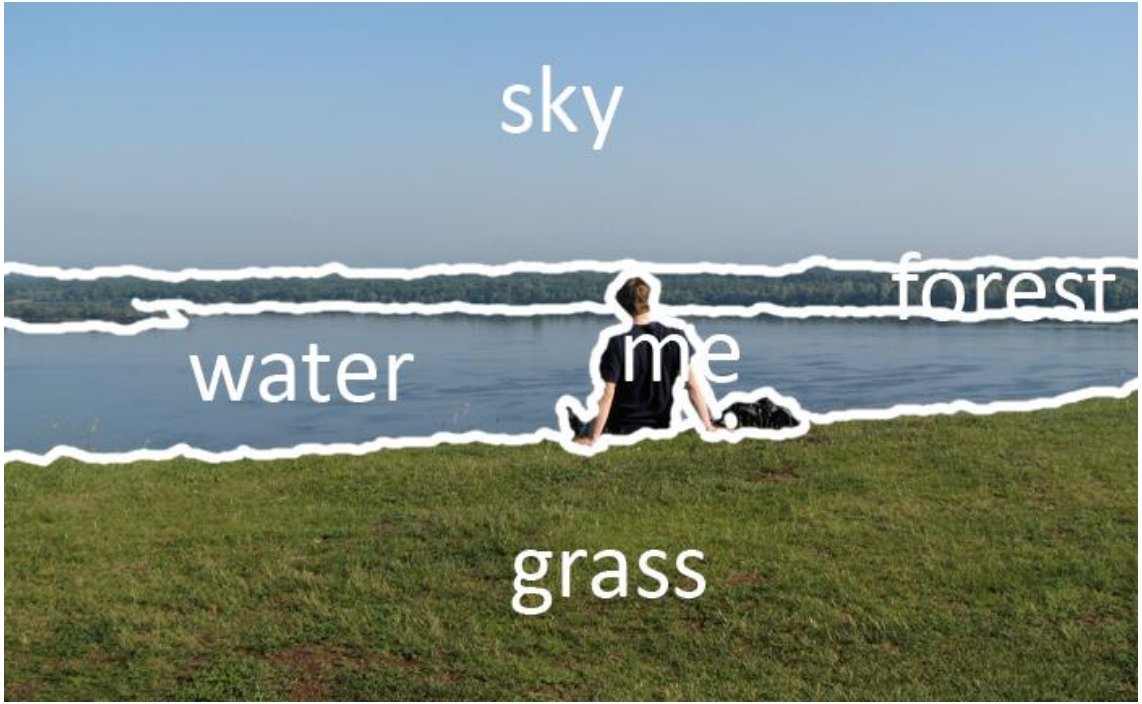


Tumour Segmentation [Yu et al. MICCAI 2010]



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

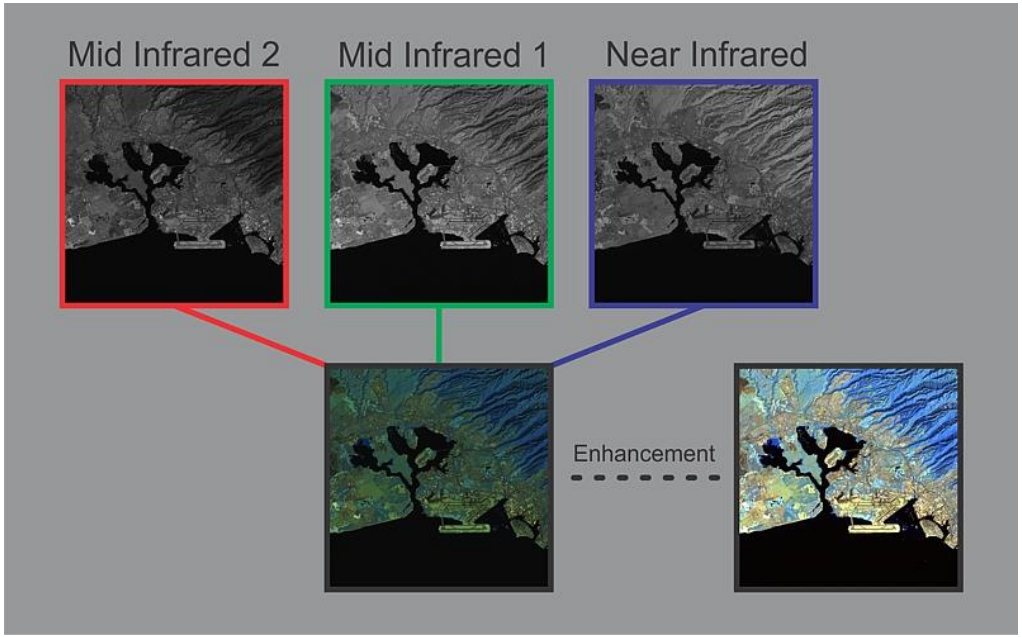
Bertalmio et al. SIGGRAPH 2010

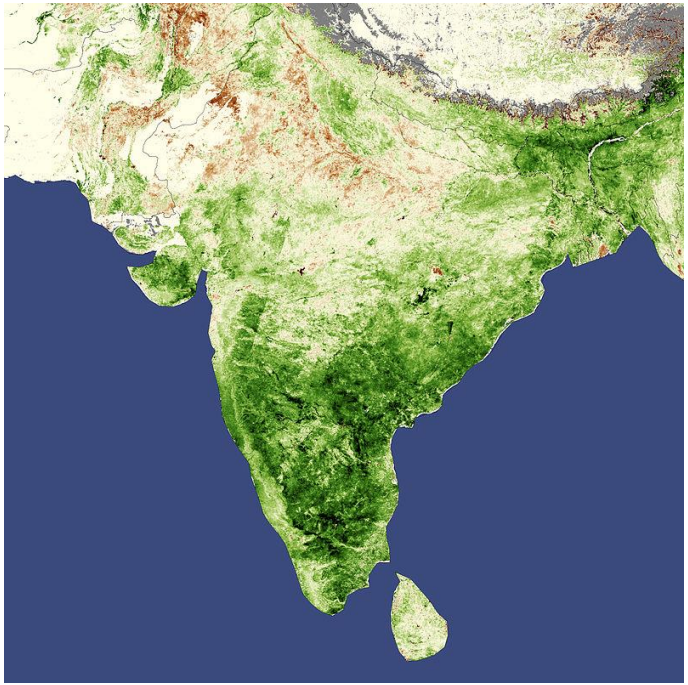
Tasks of interest: Special effects

courtesy: wachowski brothers (matrix)

courtesy: Miller et al. (sin city)

Tasks of interest: Satellite imaging

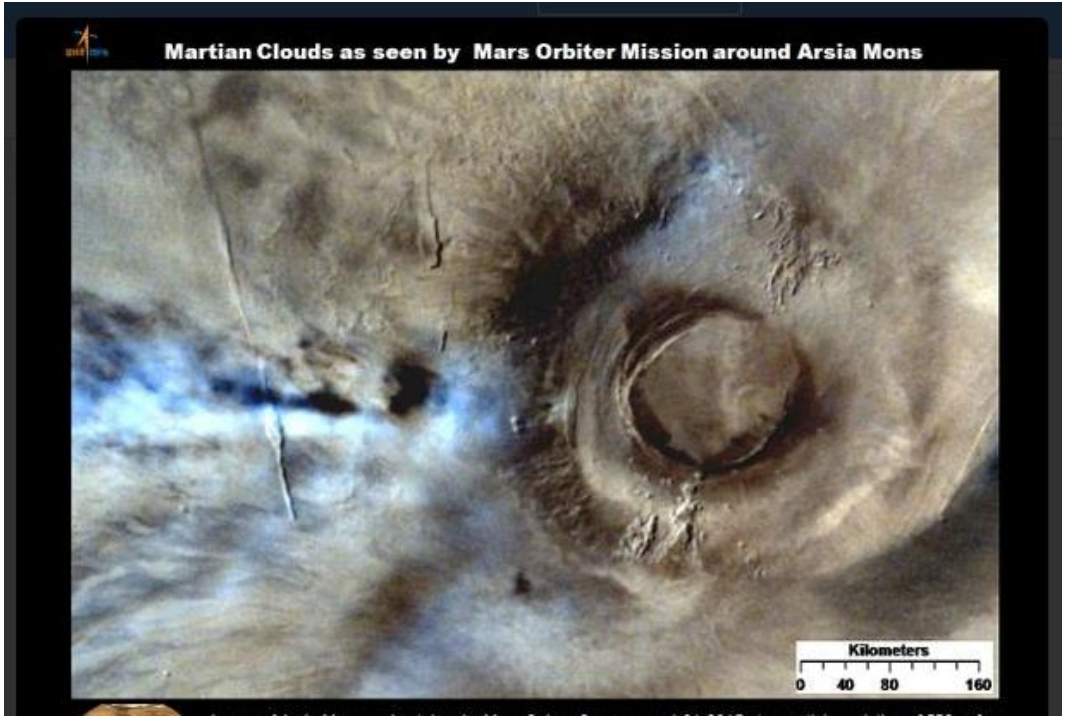


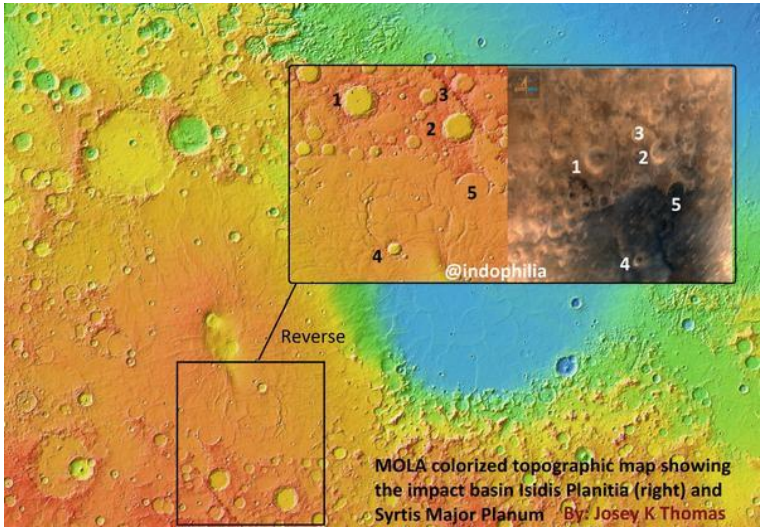


Terrain classification, weather predictions etc.

courtesy: NASA

Tasks of interest: Astronomy

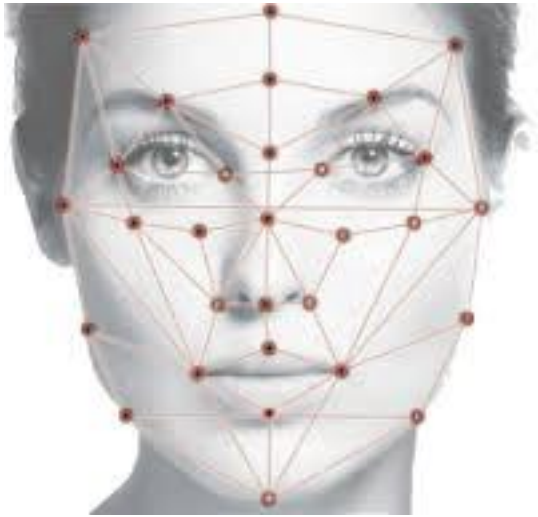




courtesy: ISRO

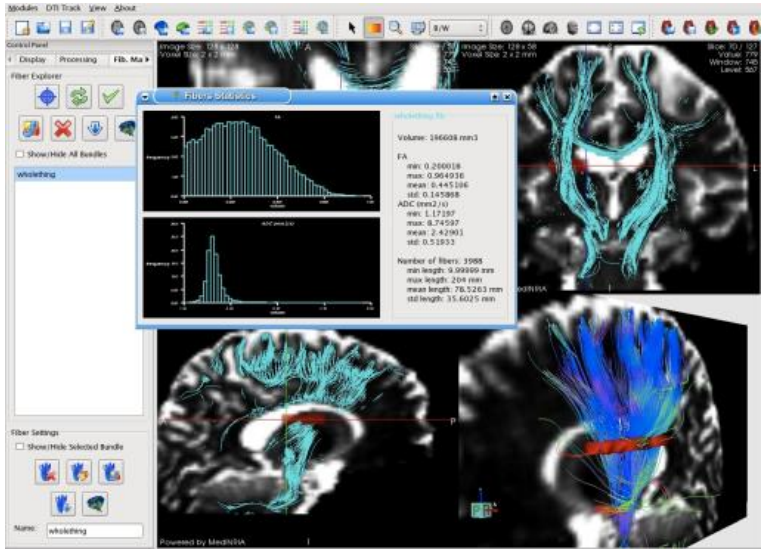
Tasks of interest: Biometrics

courtesy: dqindia.com

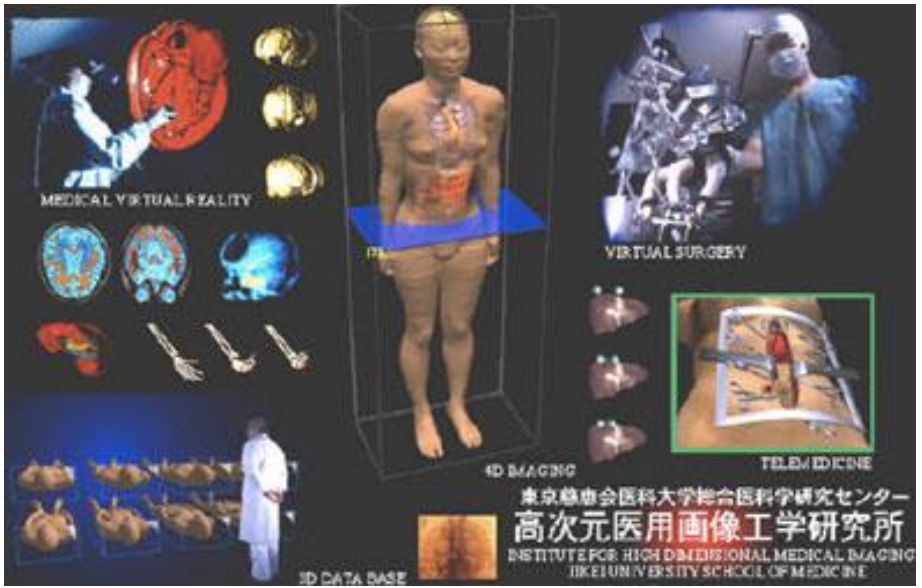


courtesy: heyce.com

Tasks of interest: Medicine



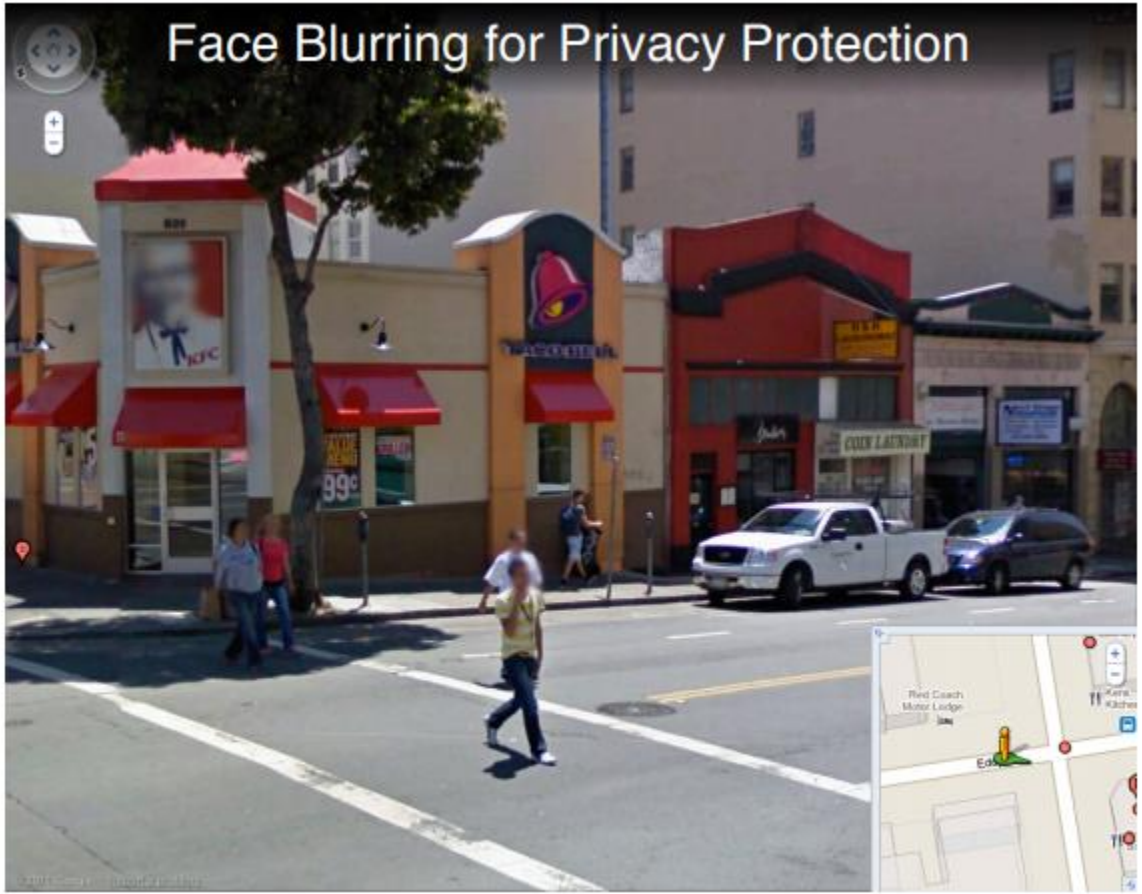
Courtesy: medINRIA

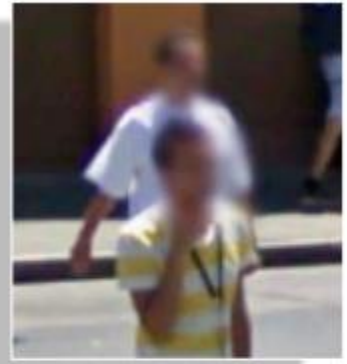


Courtesy: Naoki Suzuki

Tasks of interest: Driverless Vehicle Systems

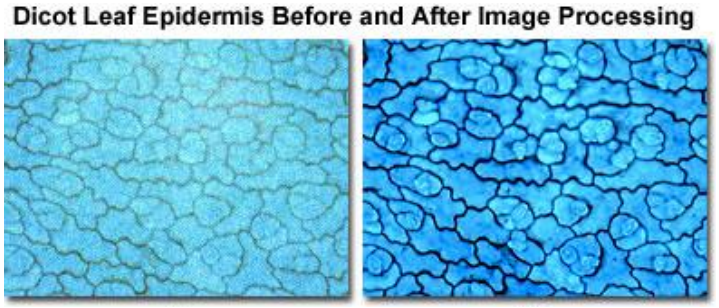
Face Blurring for Privacy Protection



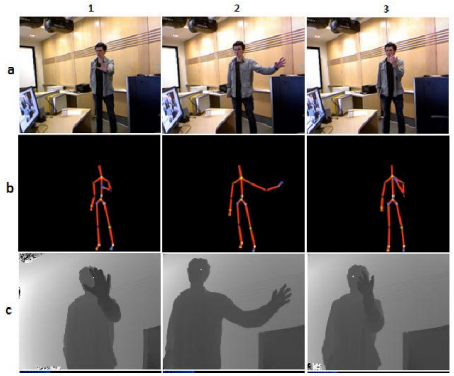


Tasks of interest: Many more

- Biology
- HCI
- Number Plate recognition
- Gesture recognition



Courtesy: Olympus



Courtesy: Perviverzov et al. 2012

Courtesy: researchdesignlab.com

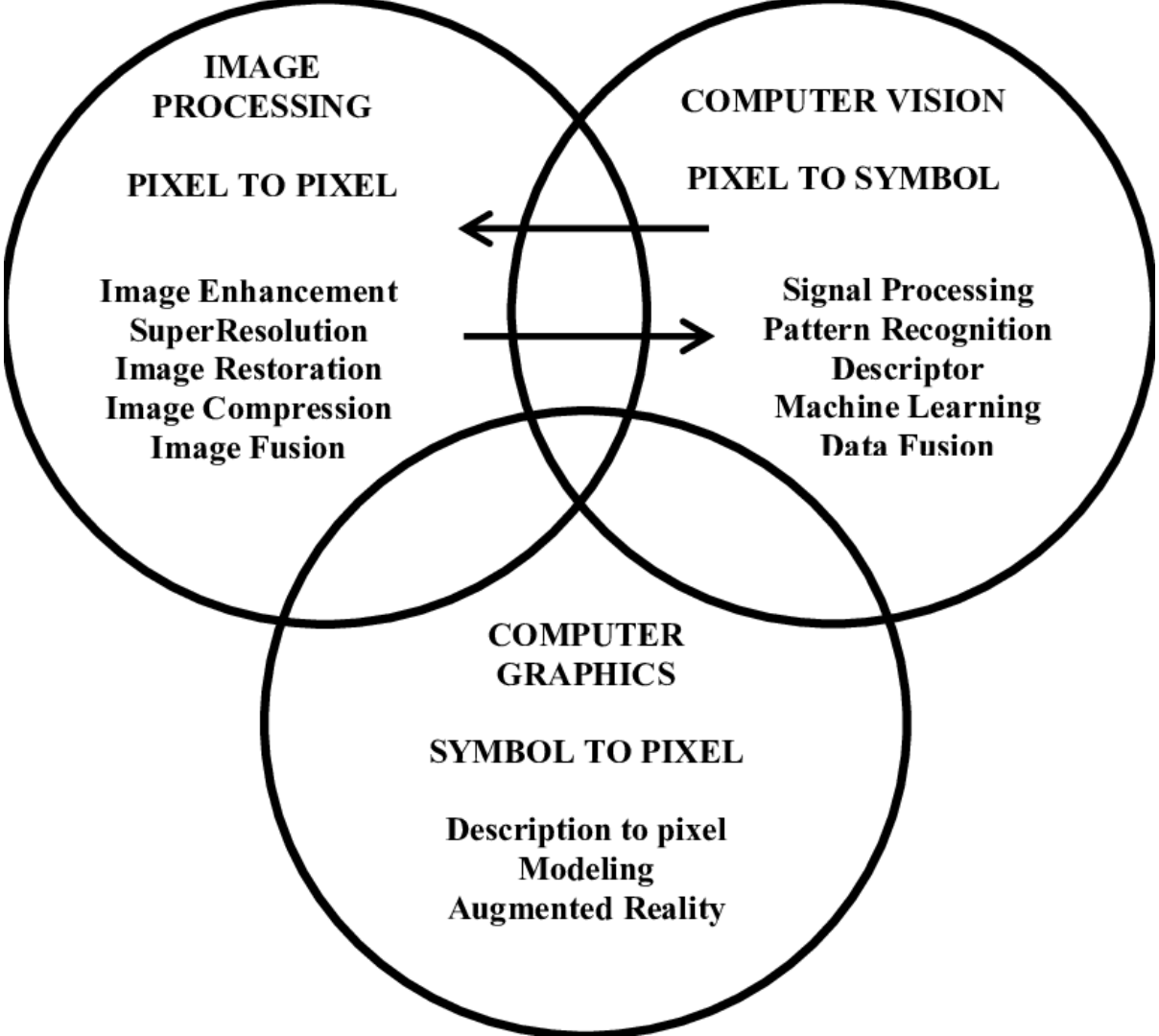
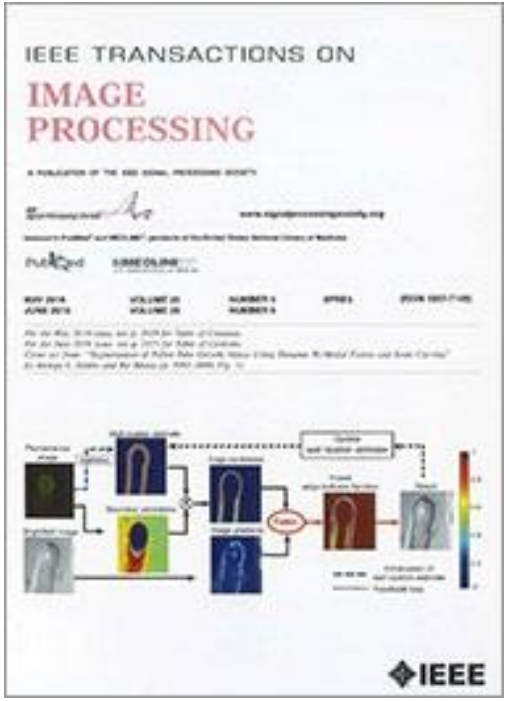


IMAGE PROCESSING
PIXEL TO PIXEL
Image Enhancement
SuperResolution
Image Restoration
Image Compression
Image Fusion
COMPUTER VISION
PIXEL TO SYMBOL
Signal Processing
Pattern Recognition
Descriptor
Machine Learning
Data Fusion
COMPUTER GRAPHICS
SYMBOL TO PIXEL
Description to pixel
Modeling
Augmented Reality

Research

- Journals



Research

- Conferences

Research

- Conferences

About the course

- Timings: Tue, Fri (Himalaya 103, 10.00a – 11.30p)
- Pre-requisites
  - (CS): Programming, Data Structures, Algorithms
  - (EE): Signal Processing
  - (MA): Linear Algebra, Calculus

About the course

- Teaching Assistants : Will be announced in next class
- Office Hours: Saturday, 3.00p – 3.30p, KRB, CVIT, F23

About the course – Grading Policy

- Assessment
  - Quizzes (2) : 10 %
  - Mid-term : 10 %
  - Final exam : 25 %
  - Assignments : 25 %
  - Final project : 30 %

About the course - assignments

- Code
  - **MATLAB**
  - * Python (scikit-image + jupyter notebook)

About the course – collaboration policy

- OK to discuss assignment questions and approaches
- But work must be your own (no copying – partially or fully)
- If you worked with someone, mention their name(s)
- We will be checking for copying/plagiarism.
- Better to own up than be caught !

About the course – Project

- Replicate an interesting research paper [code available ➔ more weightage to viva]
- A new solution to an existing problem
- Original research
- Comparing different existing algorithms for a known problem [code available ➔ more weightage to viva]

- Write a 8 page report summarizing your results
- Release the final code (github – code check-in analytics will form basis of marks)
- Give a presentation

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 assignments (with maximum of three days delay). You must adhere to standard late submission policy after using your late submission bonus. No exceptions will be made
- **No Late submission of projects (→ Do not plan end-of-semester travel until project dates have been finalized !)**

About the course - Material

- [Text] Digital Image Processing by Gonzalez and Woods
  - **For today's lecture : Chap 1.1 – 1.3**
- Scattered Resources across Internet

Announcement(s)

- MATLAB
  - Tutorial: https://www.cs.tau.ac.il/~dcor/Graphics/cg-slides/MATLAB-tutorial.pdf
  - Write fast MATLAB code: http://www.getreuer.info/matopt.pdf?attredirects=0

Announcement(s)

- scikit-learn
  - https://scikit-image.org/docs/dev/user_guide
- Jupyter Notebook
  - https://www.dataquest.io/blog/jupyter-notebook-tutorial/
  - https://www.youtube.com/watch?v=yM229XVkdOA
- Next Lecture: Digital Image Fundamentals