

Digital Image Processing (CSE/ECE 478)

Lecture-1: Overview

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Many slides borrowed from Vineet Gandhi @CVIT!

A picture is
worth a
thousand
words



A picture is
worth a
thousand
words



Before there were images



Prehistoric Painting, Lascaux Cave, France
~ 13,000 -- 15,000 B.C. (Aurochs, dun horses, deer.)

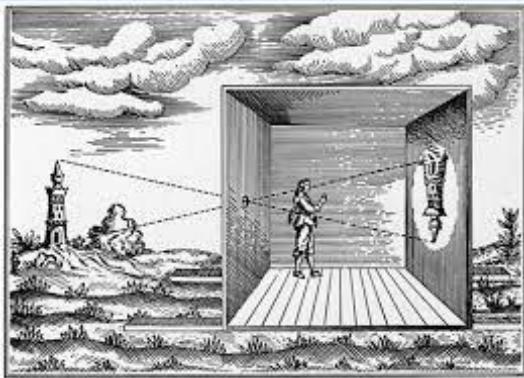
Before there were images

Depicting Our World: Middle Ages

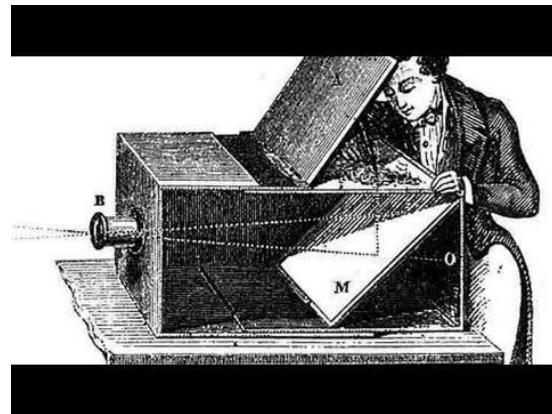


The Empress Theodora with her court.
Ravenna, St. Vitale 6th c.

Before there were images



Camera Obscura



Girl with a pearl earring, J. Vermeer, 1665



Forever ...



And then there were images

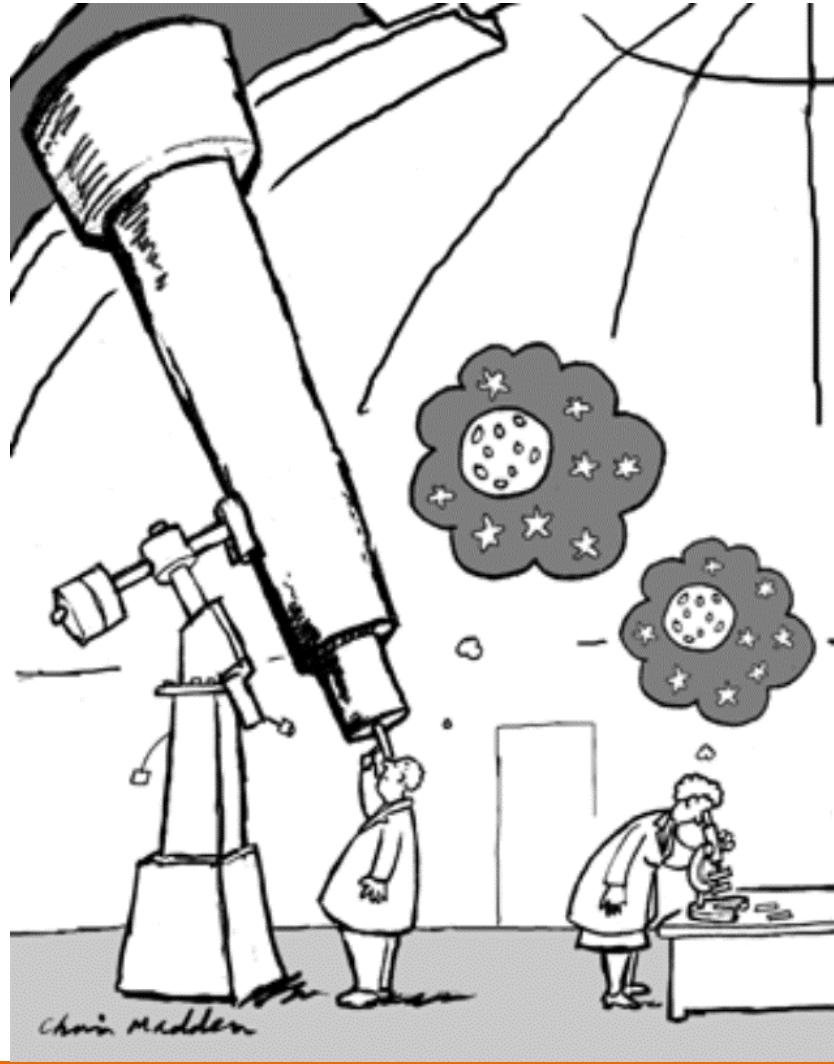


Still Life, Louis Jaques Mande Daguerre, 1837

SELFIES!

SELFIES EVERYWHERE!





Courtesy: Chris Madden

Trends!



Adobe Premiere



Canon



SAMSUNG



PHILIPS



SIEMENS



QUALCOMM

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

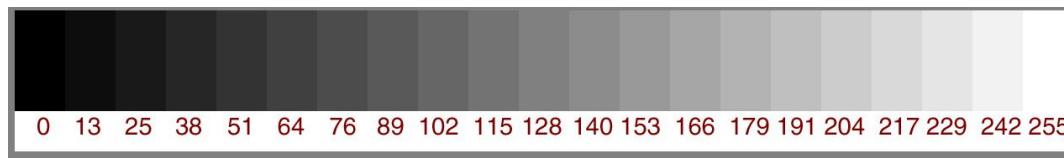
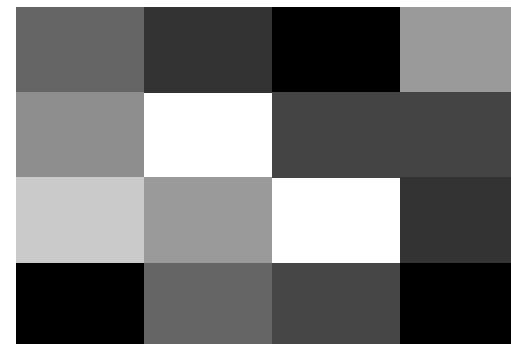


Image acquisition process

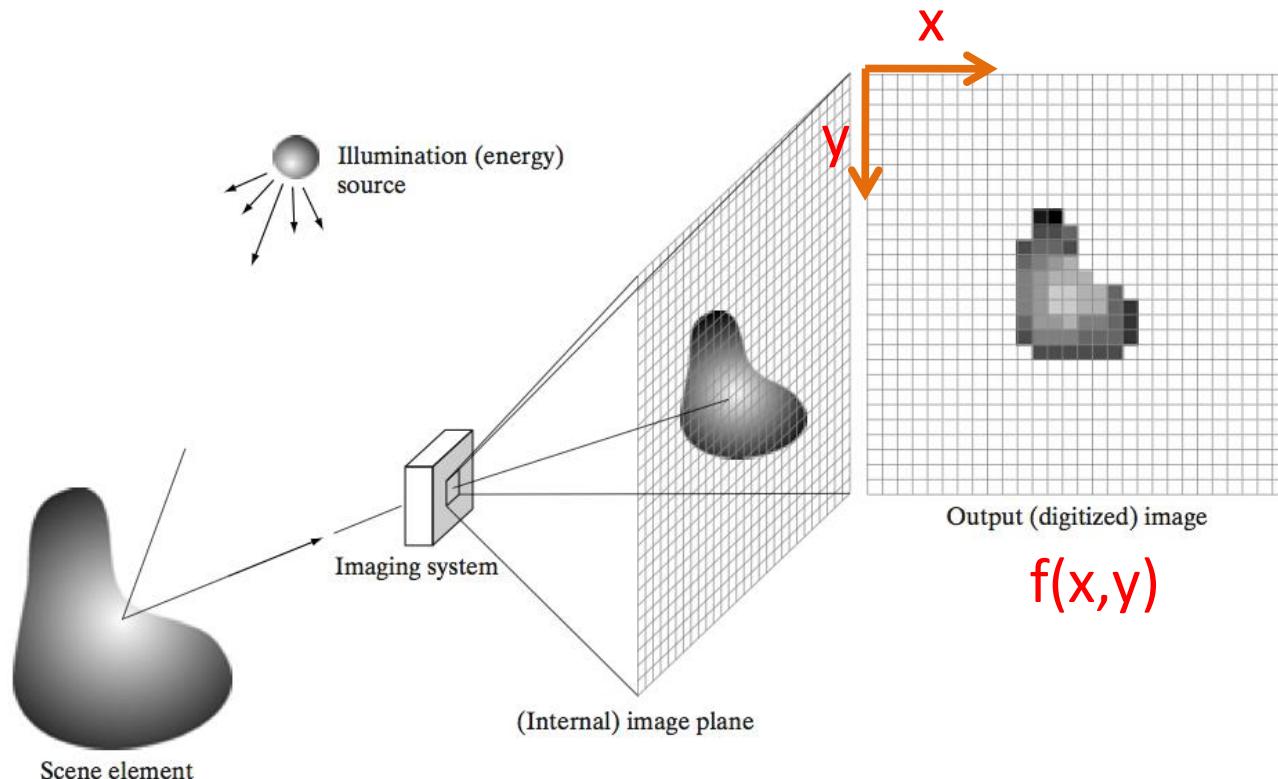


Image acquisition process

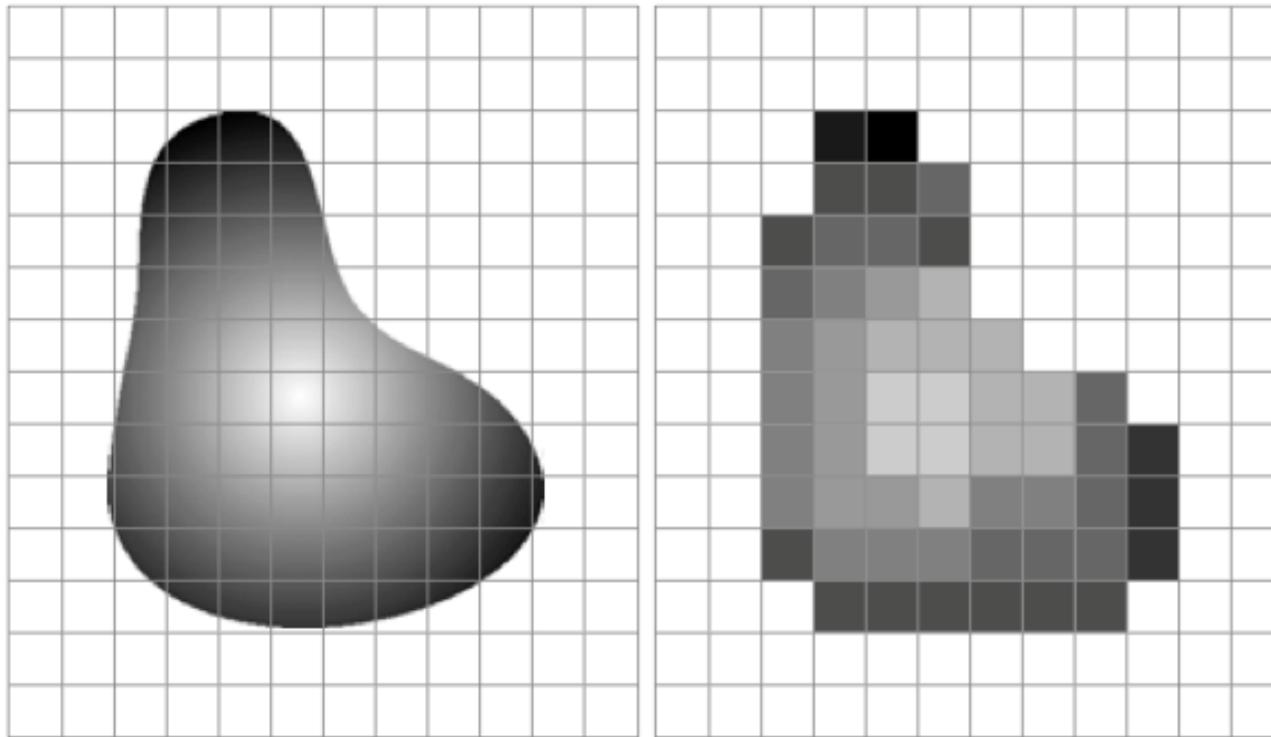
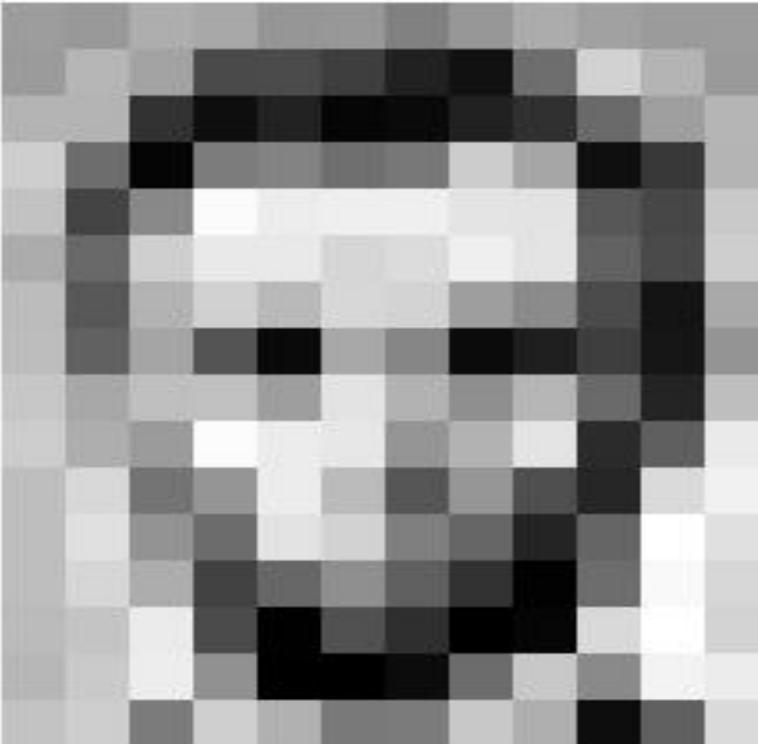


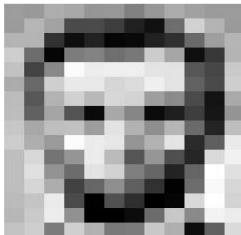
Image courtesy: Gonzalez and Woods

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	84	6	10	33	48	106	159	181
206	109	5	124	131	111	120	204	166	15	56	180
194	58	137	251	297	299	299	228	227	87	71	201
172	105	207	233	233	214	220	239	228	98	74	206
188	83	179	209	186	215	211	158	139	75	20	169
189	97	165	64	10	168	134	11	31	62	22	148
199	168	191	193	158	227	178	143	182	106	36	190
205	174	156	252	236	231	149	178	228	43	95	234
190	216	116	149	236	187	85	150	79	38	218	241
190	224	147	106	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
195	206	123	207	177	121	123	200	175	13	96	218

Image Representation



197	153	174	166	152	129	151	172	161	156	154
155	182	163	74	75	62	33	17	170	210	180
180	180	50	14	34	6	10	33	48	105	159
205	109	5	124	131	111	130	204	160	15	56
194	56	127	261	237	239	230	228	227	87	71
172	104	207	233	233	214	220	239	228	66	74
188	83	179	209	185	216	211	198	196	76	20
189	37	150	84	10	168	174	11	21	63	22
190	160	181	182	188	237	178	182	180	59	99
205	174	155	282	246	231	140	178	220	43	90
190	216	116	140	236	187	46	150	75	38	218
190	234	147	108	227	210	127	102	36	101	258
190	214	173	64	103	143	96	50	2	109	249
187	196	236	75	1	81	47	0	217	256	211
183	202	237	149	0	0	12	108	200	138	243
195	204	123	207	177	121	120	200	175	13	66

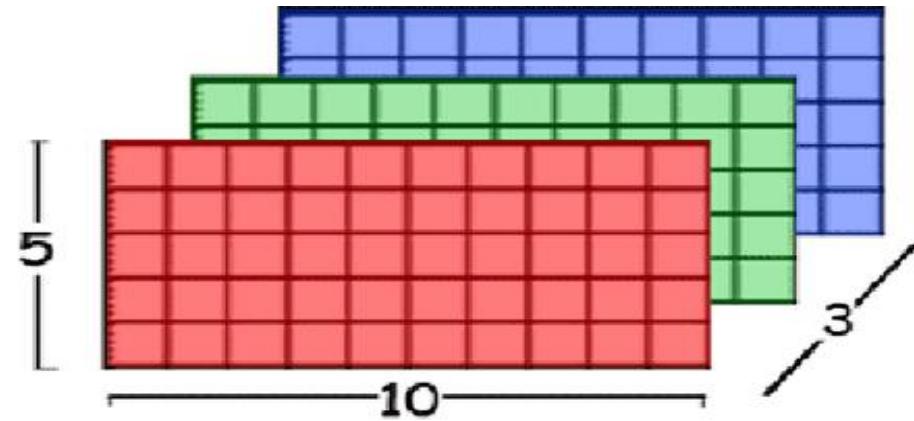
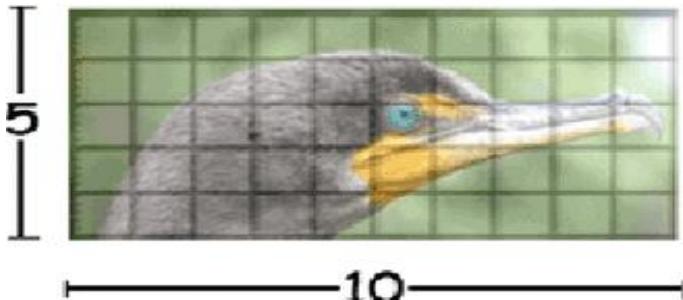
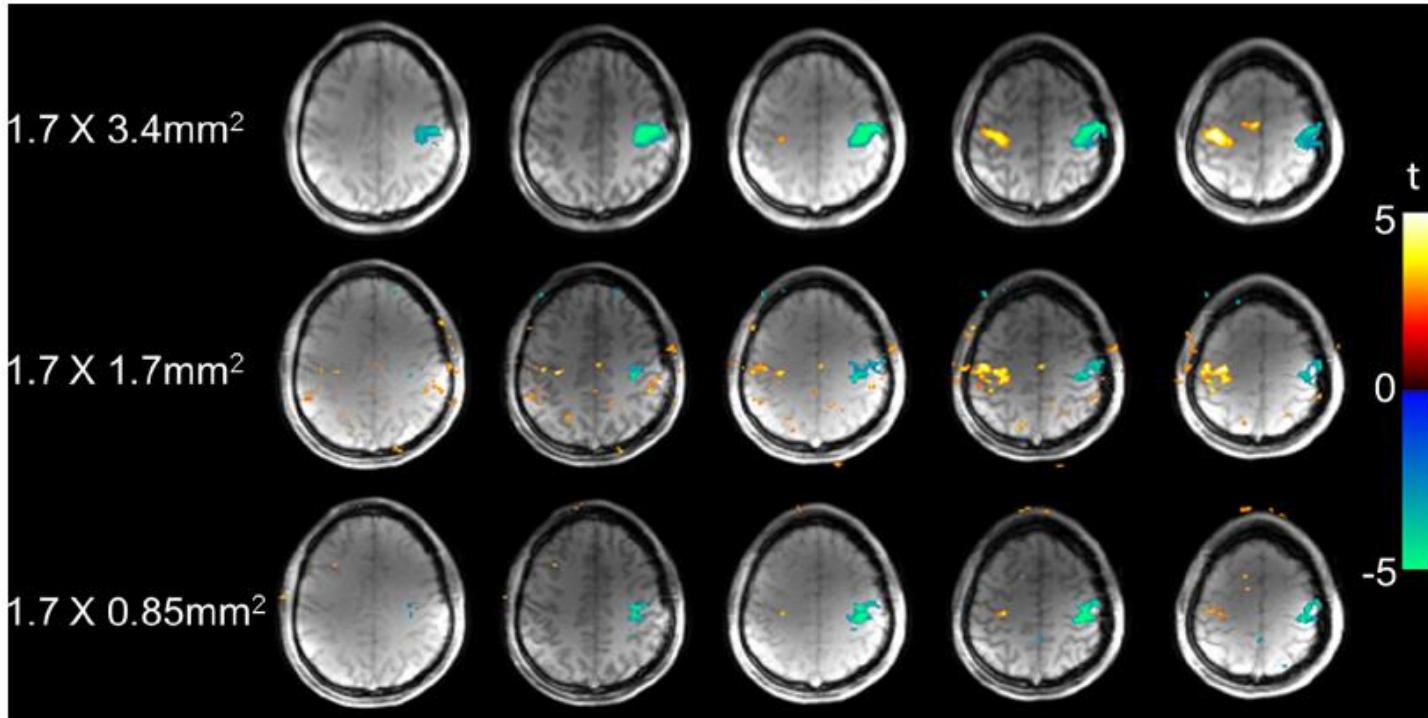


Image Representation



fMRI image slices

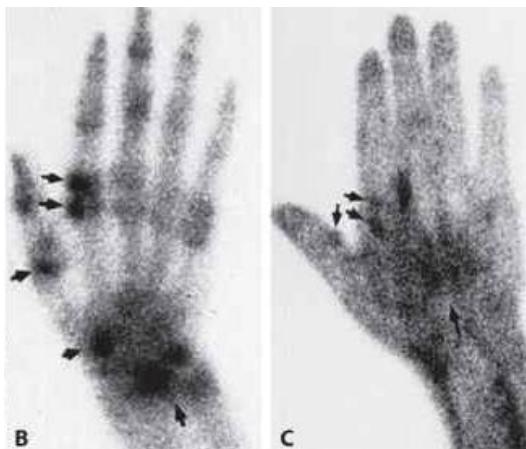
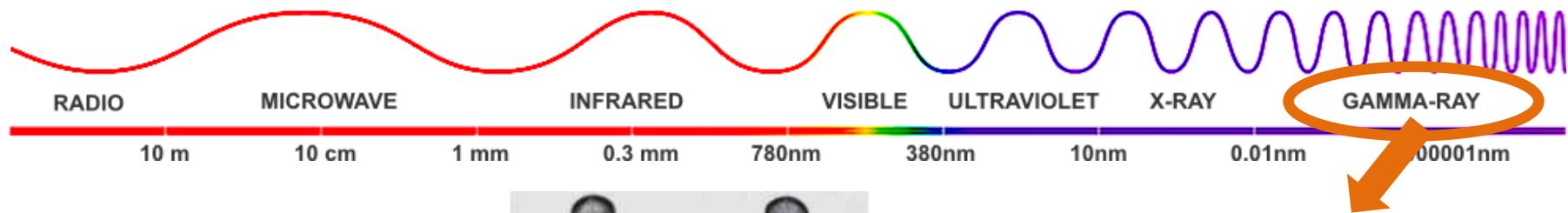
Types of Images (classification on source)

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

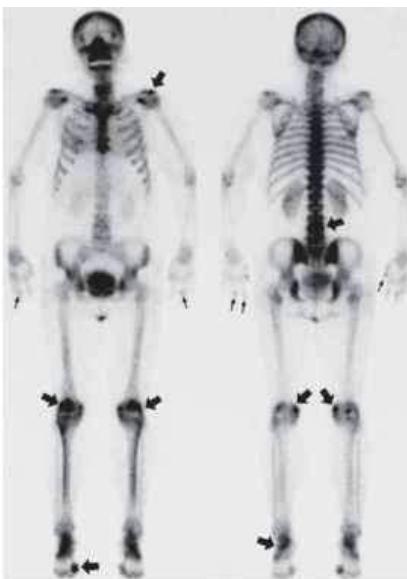
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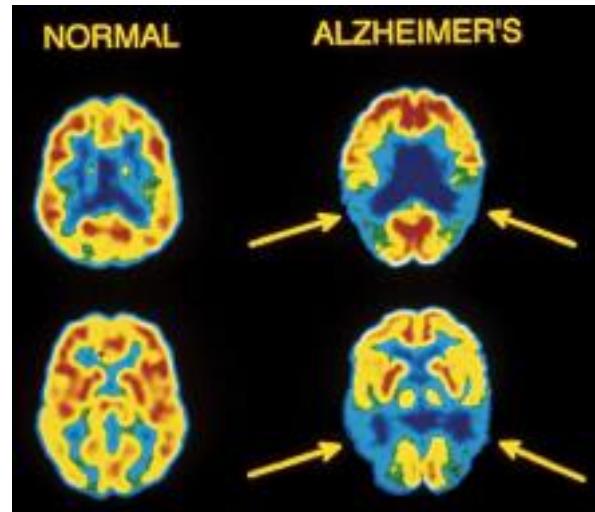
EM spectrum



courtesy: artheritisresearch.us

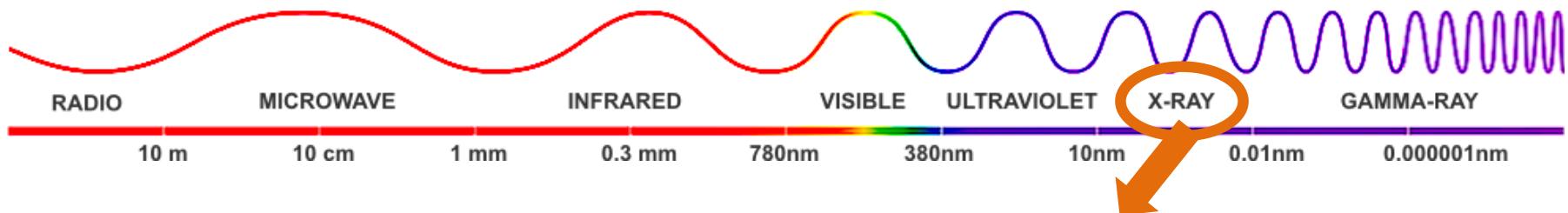


courtesy: artheritisresearch.us



PET SCAN
courtesy: research.ucla.edu

EM spectrum



Wilhelm Röntgen



HAND MIT RINGEN

courtesy: wikipedia



CHEST RADIOGRAPH

courtesy: wikipedia



CT SCAN

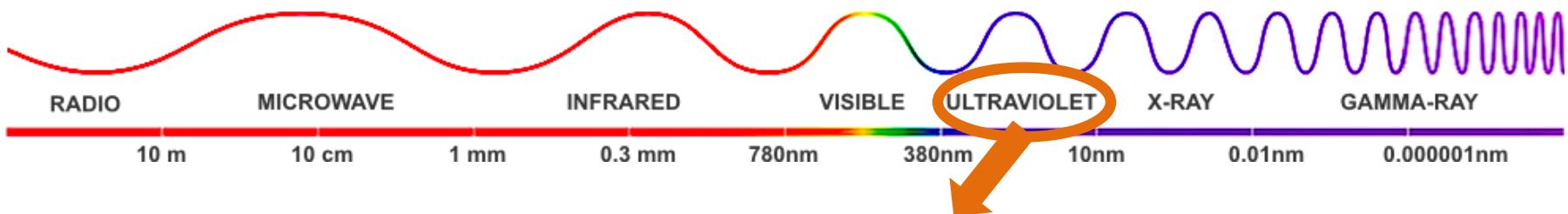
courtesy: wikipedia



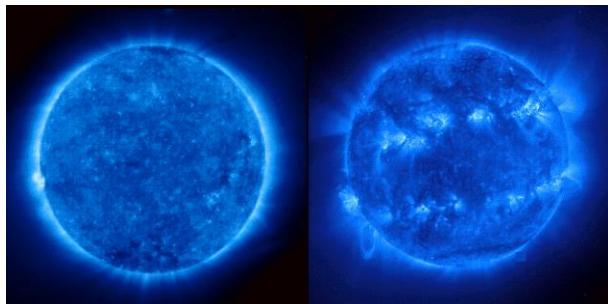
AIRPORT SCAN

courtesy: dpl-surveillance-equipment

EM spectrum



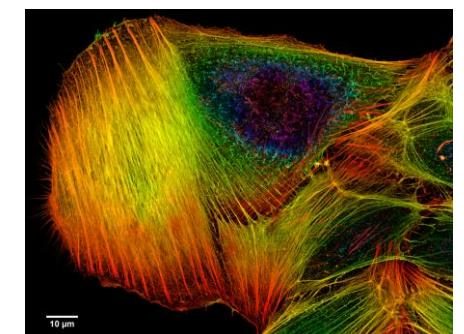
Lithography, industrial inspection, microscopy, lasers, astronomical observations, fluorescence microscopy etc.



SUN (2 years apart)
courtesy: NASA



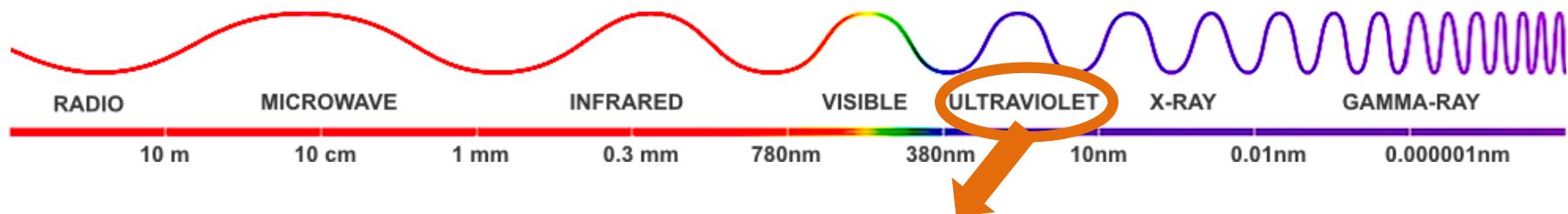
100 EURO BILL
courtesy: lifepixel.com



Cell Phalloidin
courtesy: wikipedia

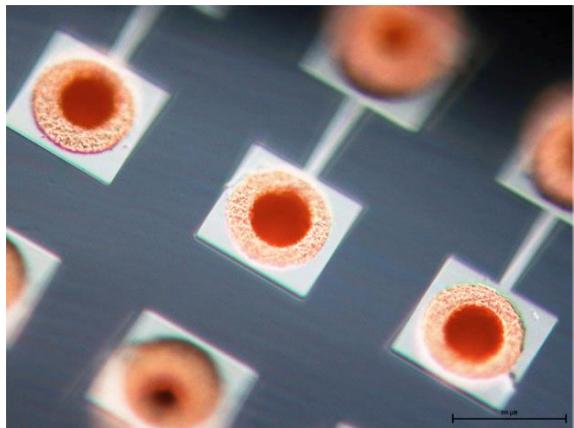
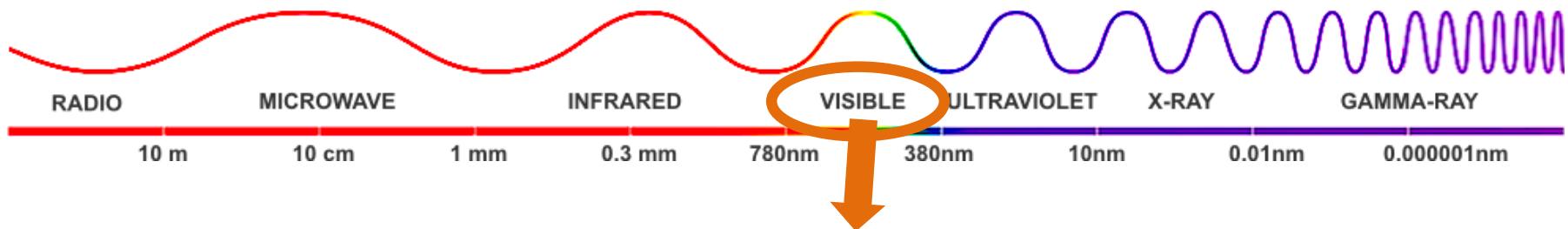
Eric Betzig, William Moerner and Stefan Hell

EM spectrum



Source:
Lifepixel.com

EM spectrum



Chips (optical microscopy)
courtesy: EPFL microelectronics systems laboratory

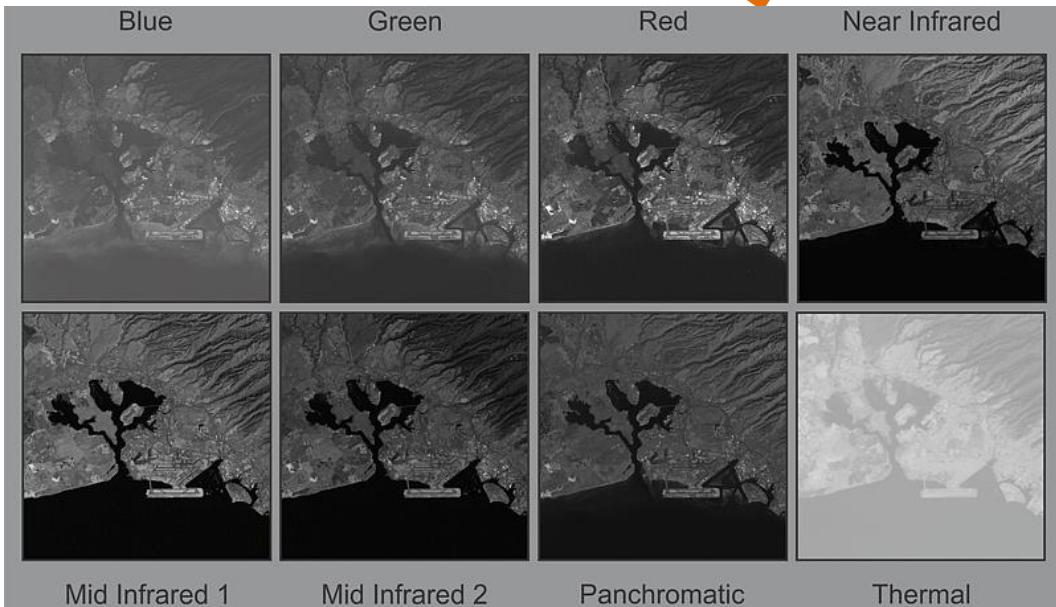


High Speed Photograph
courtesy: Alan Sailer



Satellite Image (Hurricane Katrina)
courtesy: britannica.com

EM spectrum

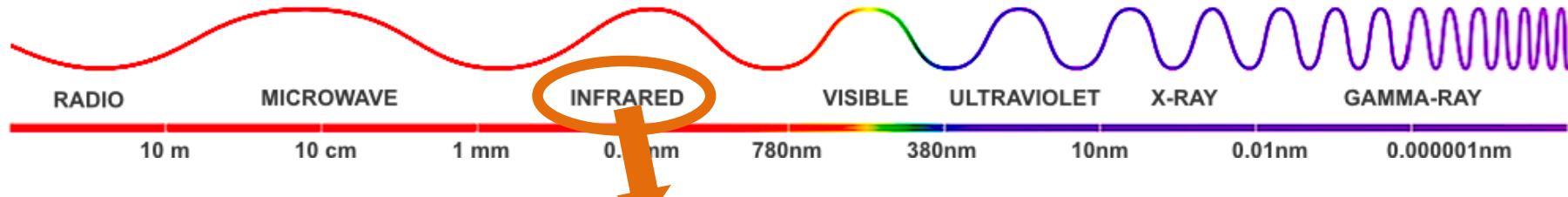


courtesy: LANDSAT (NASA)



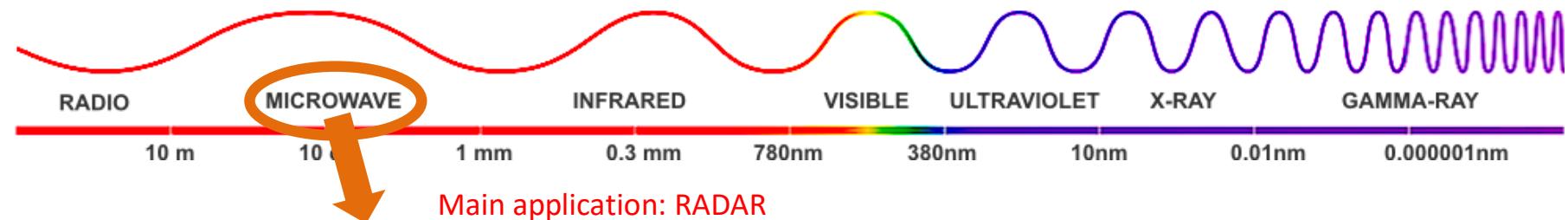
courtesy: imaging1.com

EM spectrum



C
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EM spectrum



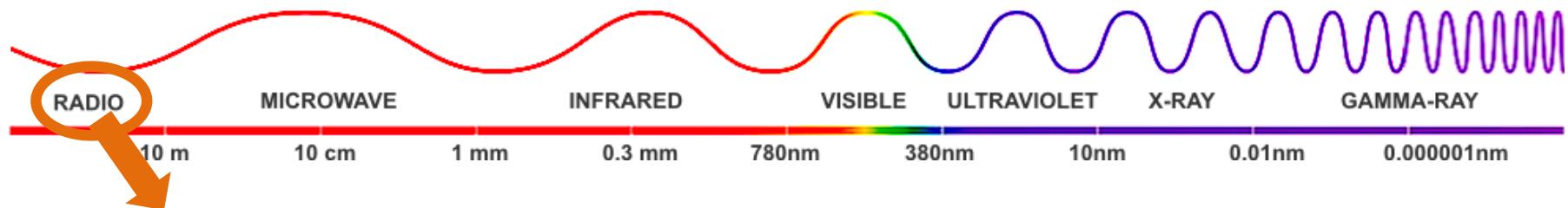
SOUTHEAST TIBET MOUNTAINS

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

Types of Images (classification on source)

- Radiation from EM spectrum
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Ultrasound



ULTRASOUND

courtesy: wikipedia



ULTRASOUND TWINS

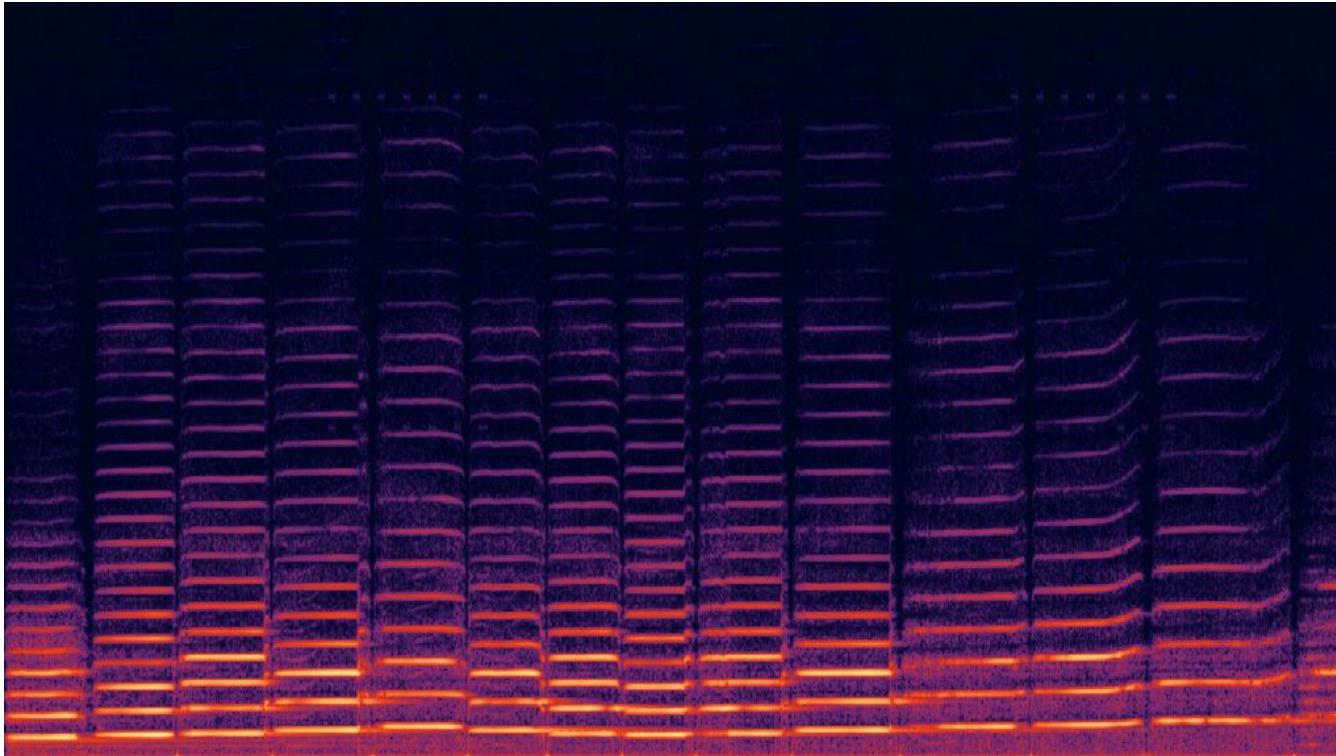
courtesy: pinterest



ULTRASOUND 3D

courtesy: peek3D.com

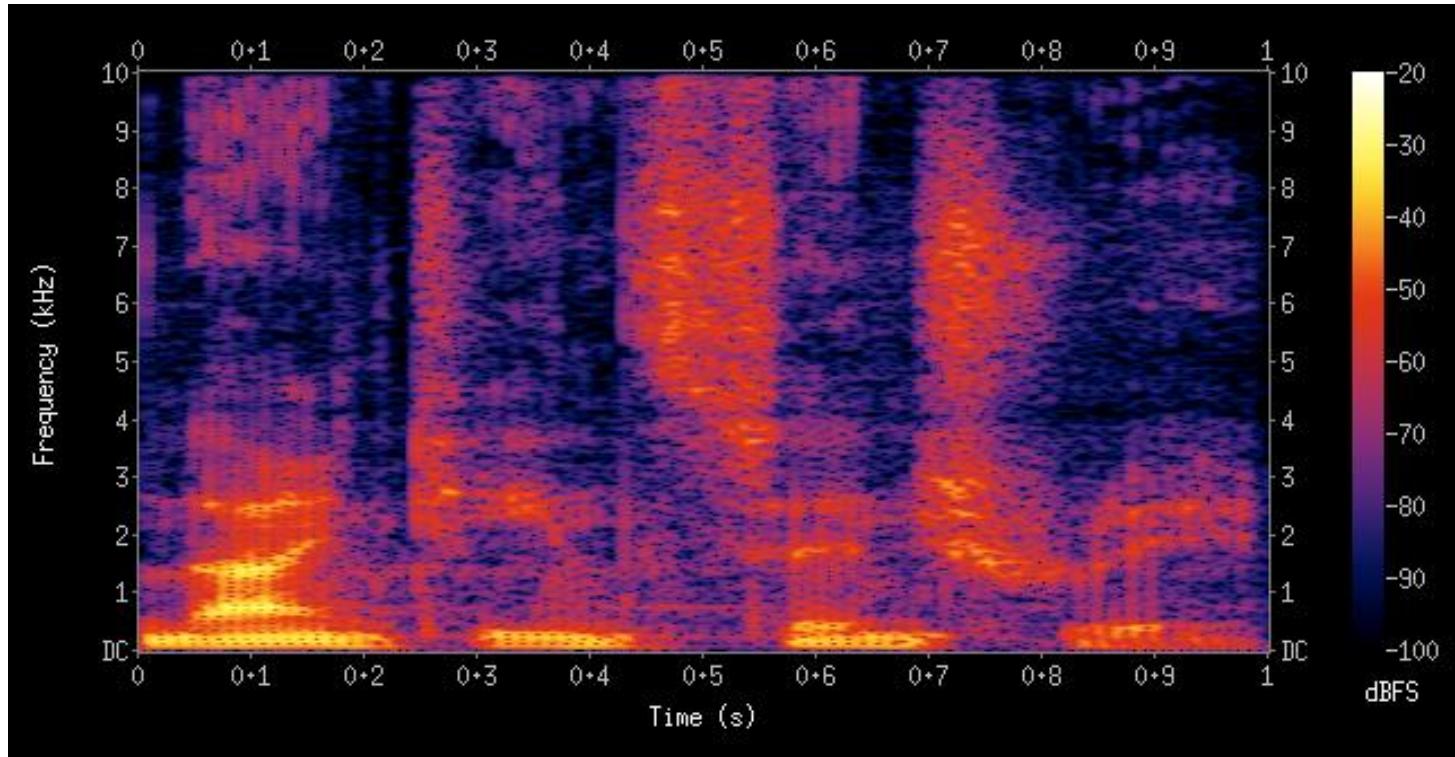
Spectrogram



Violin Recording
courtesy: wikipedia



Spectrogram

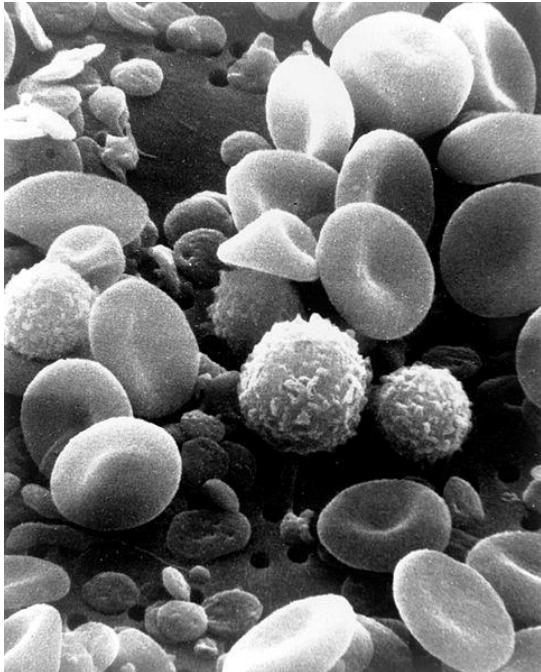


Saying Nineteenth Century
courtesy: wikipedia

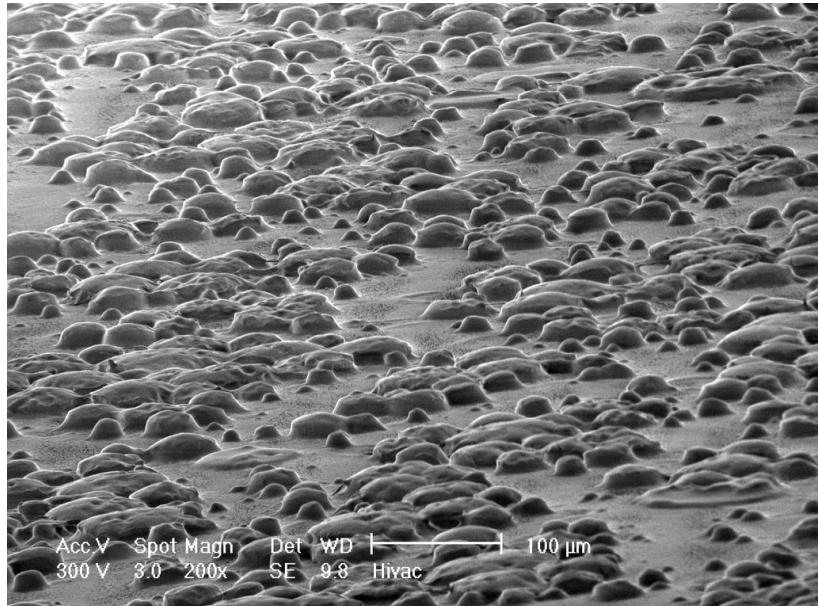
Types of Images (classification on source)

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- Computer generated

Scanning Electron Microscopy



Normal Circulating Human Blood
courtesy: National Cancer Institute



Adhesive on Post-it note
courtesy: wikipedia

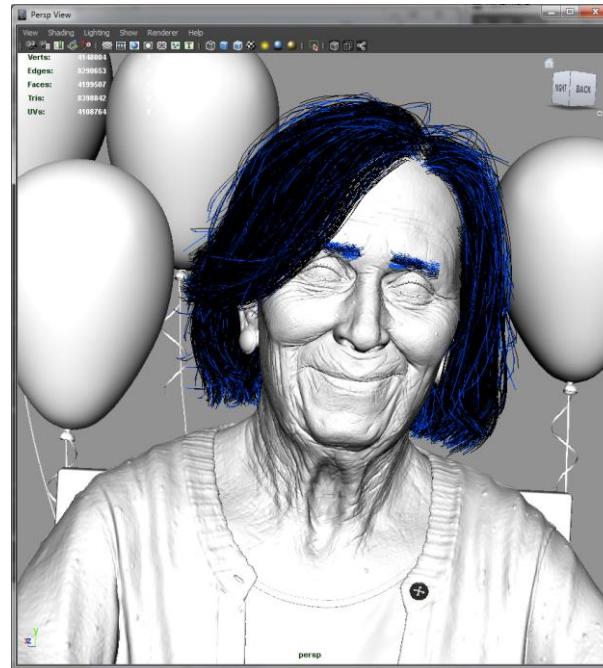
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- Computer generated

Computer generated

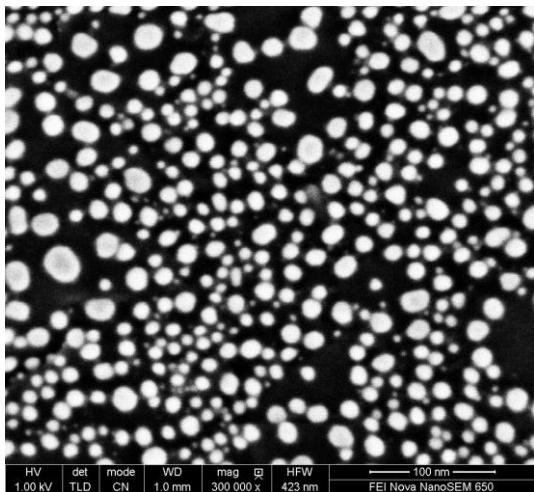


Happy Birthday Nana
courtesy: Dan Roarty



Scale

Microscopes



10^{-9}m

courtesy: nanolab technologies.com

Telescopes



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

courtesy: wikipedia

Types of Images (classification on optics)

1. Reflection Images



2. Emission Images



3. Absorption Images



Information primarily about objects surface

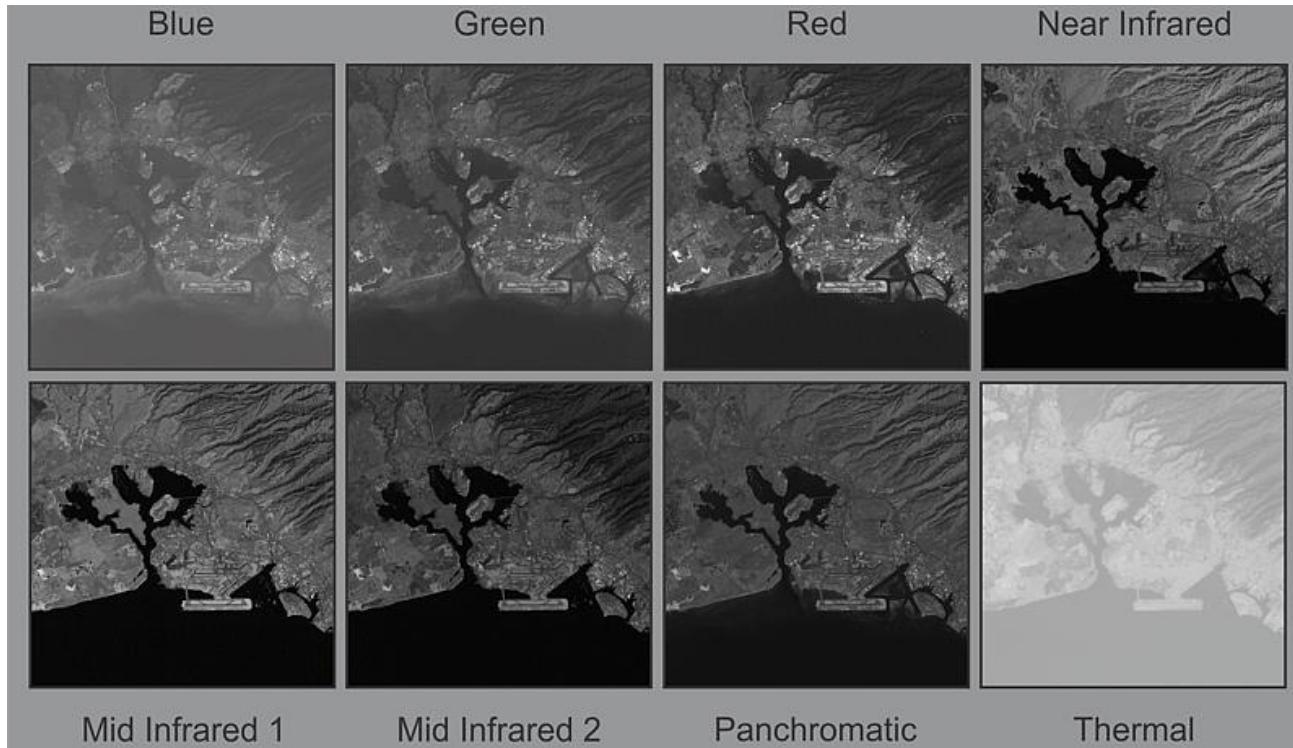
Information primarily about internal properties

Information primarily about internal structure

Types on images (classification on arrangement)

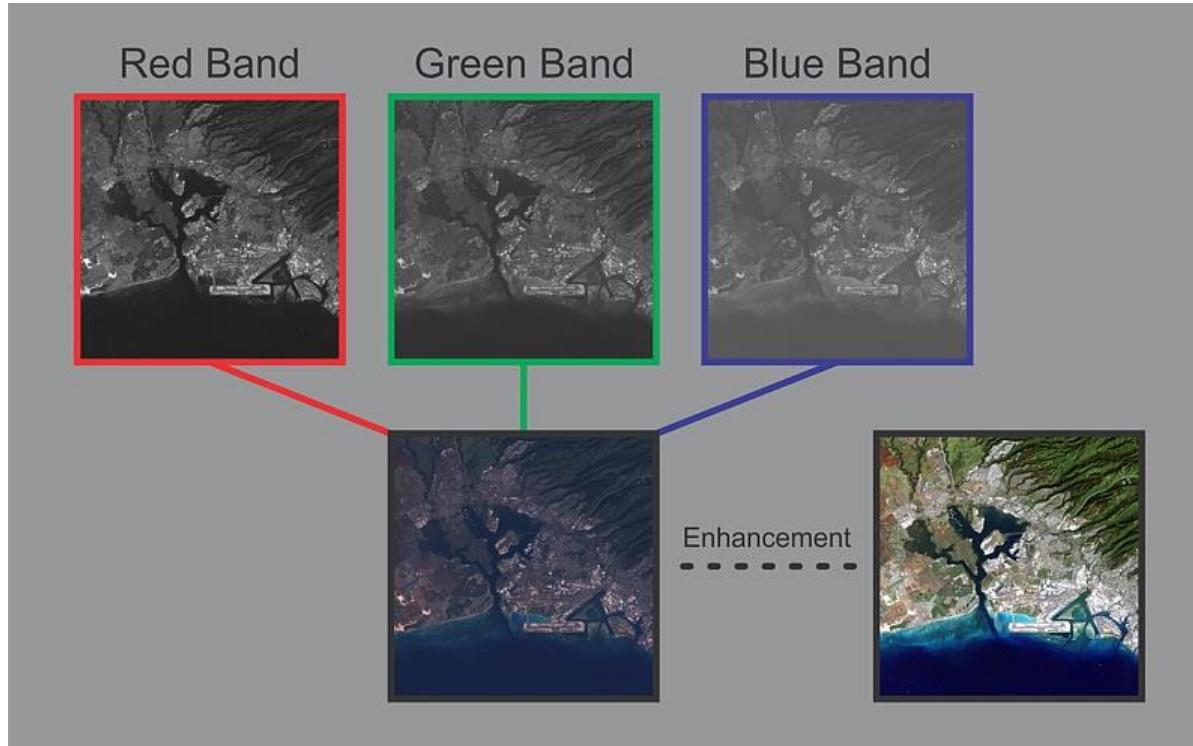
- Grayscale
- RGB
- Multispectral images
- Stereo images
- Multi-view images

Multi spectral images



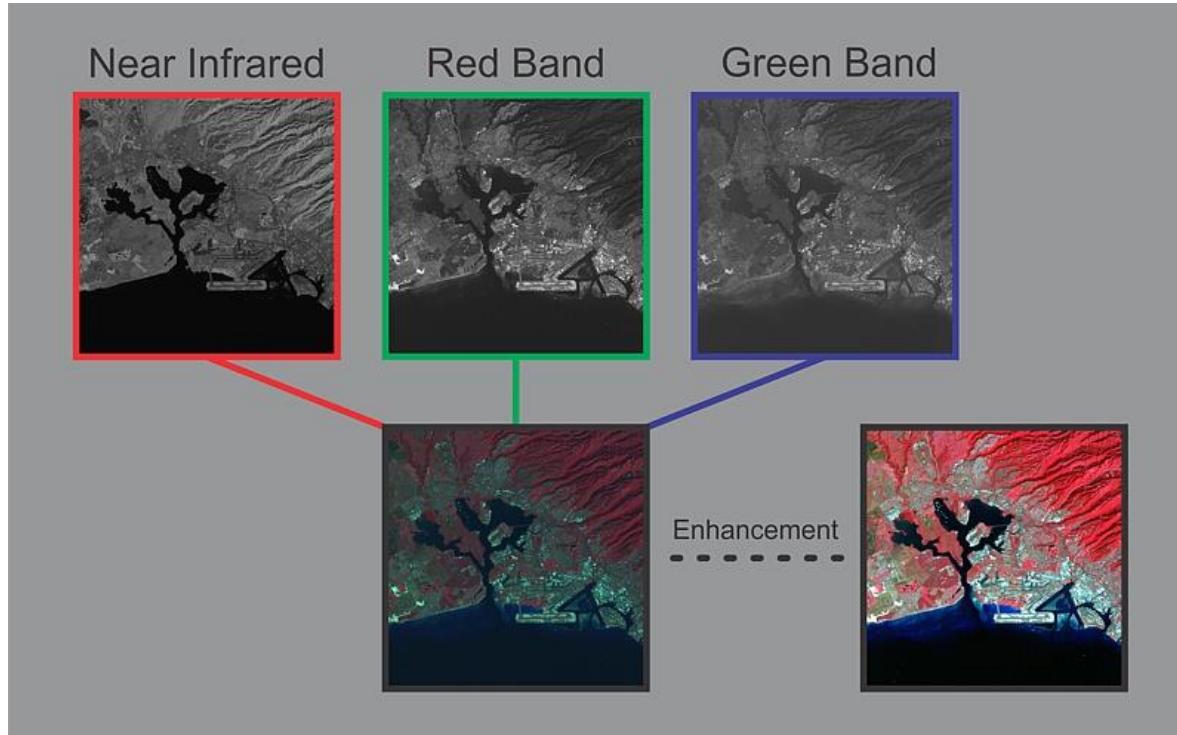
Courtesy: LANDSAT

Multi spectral images



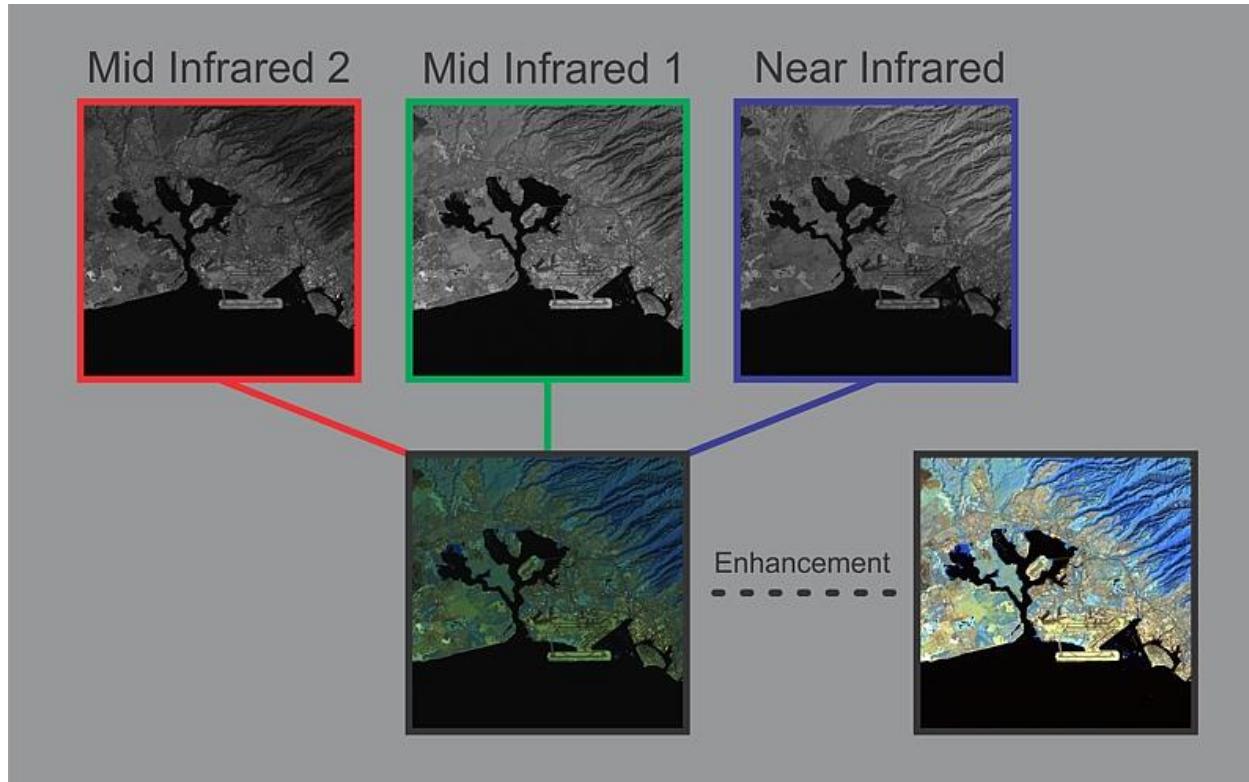
Courtesy: LANDSAT

Multi spectral images



Courtesy: LANDSAT

Multi spectral images



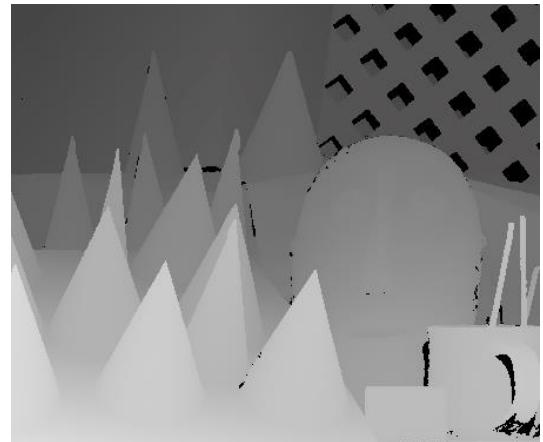
Courtesy: LANDSAT

Stereo Images



courtesy: [wikimedia.com](https://commons.wikimedia.org)

Stereo Images



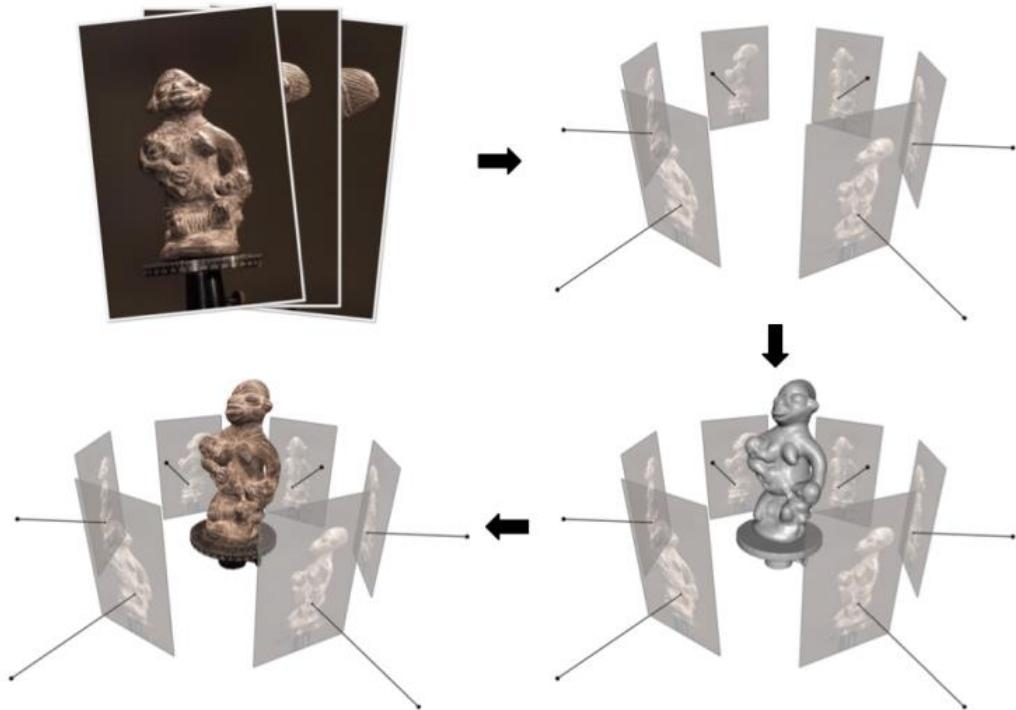
courtesy: vision.middlebury.edu

Multi-view images

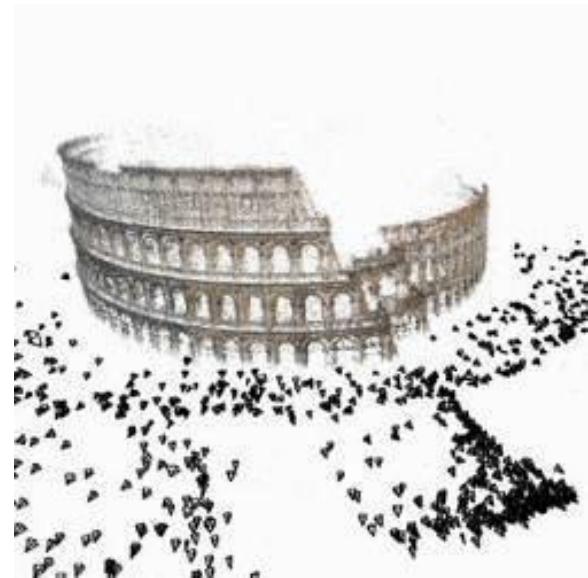


courtesy: Maxime Lhuillier

Multi-view images



courtesy: Yasutaka Furukawa



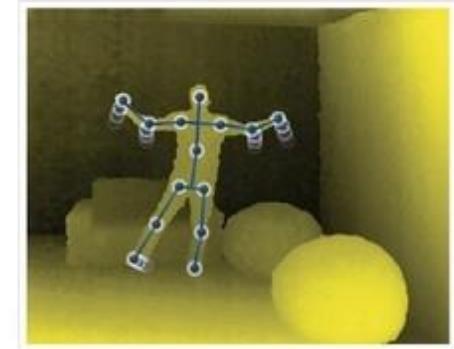
courtesy: Sameer Agarwal

Kinect images

Color (RGB) Image



Depth Image



courtesy: kinect and prime sense

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



Before



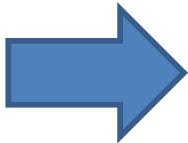
After

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

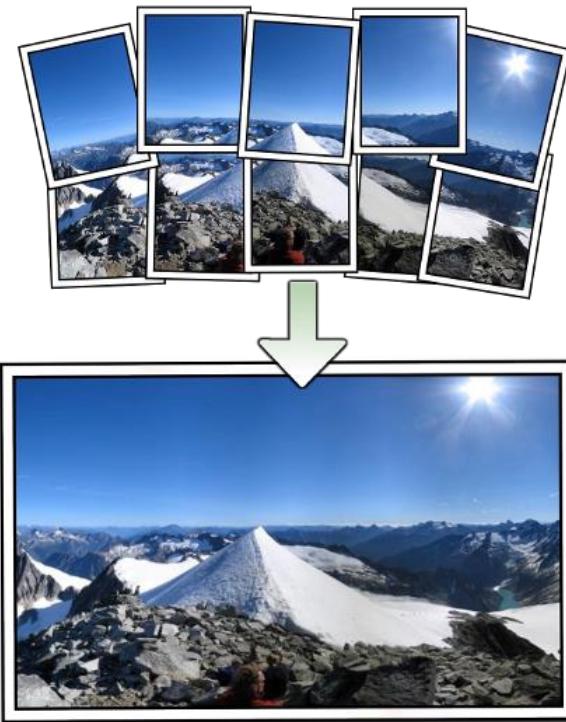
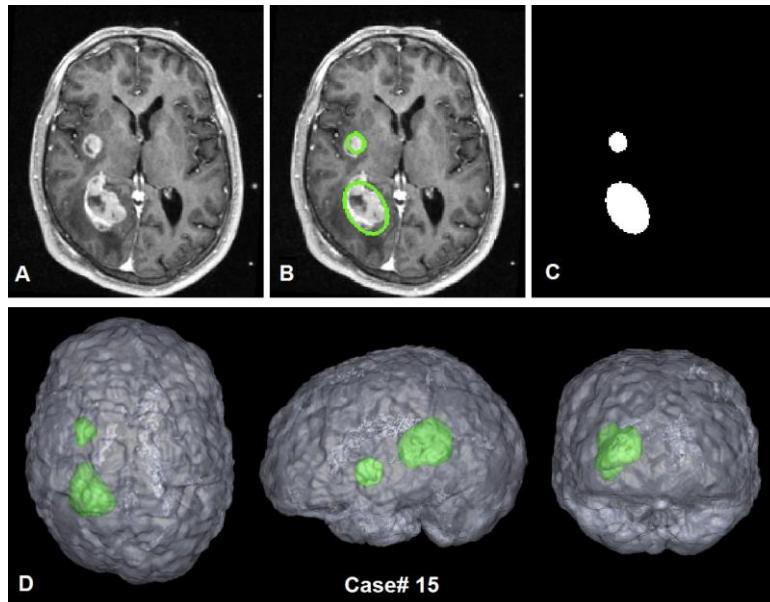
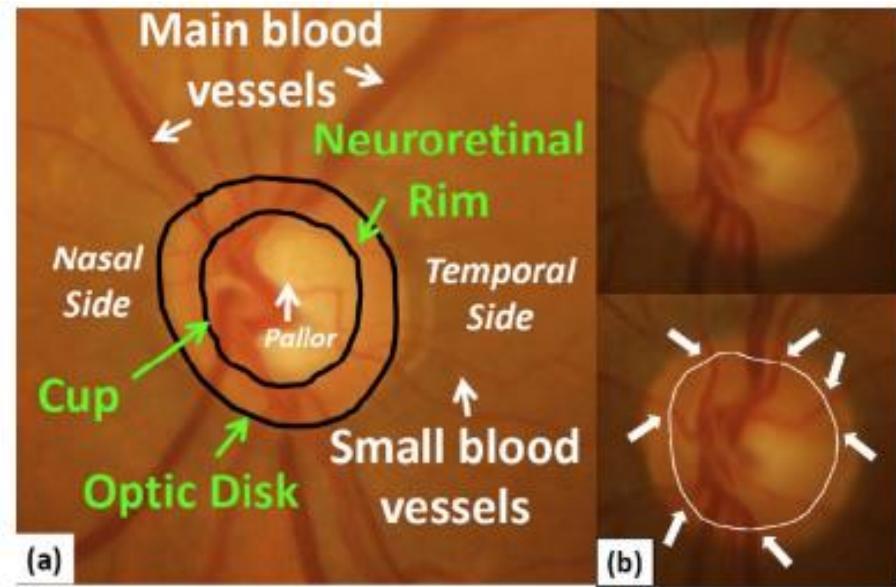


Image courtesy: autostitch

Tasks of interest: Segmentation

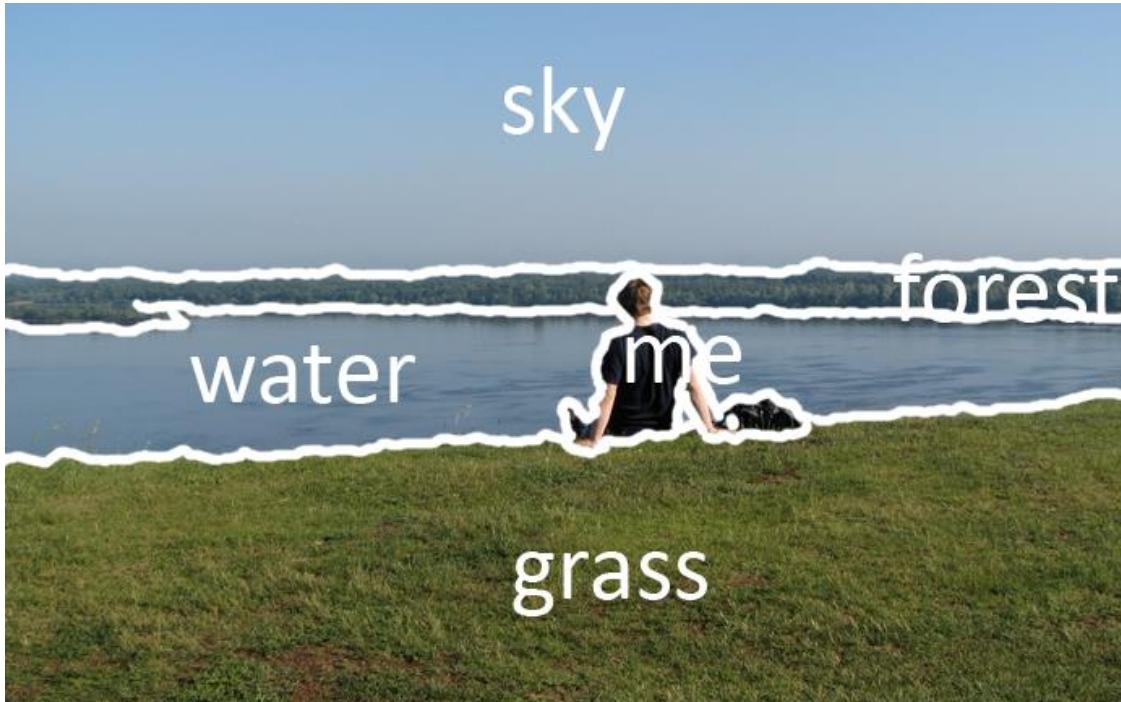


Tumour Segmentation [Yu et al. MICCAI 2010]



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

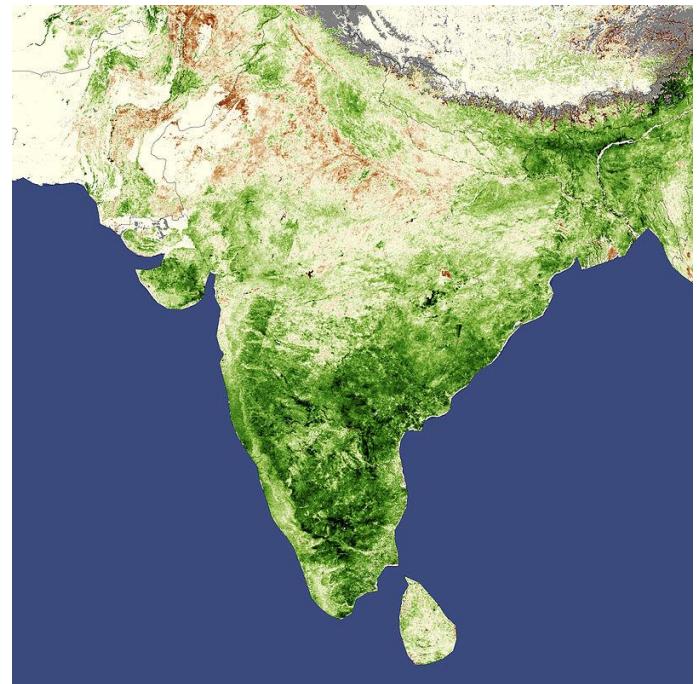
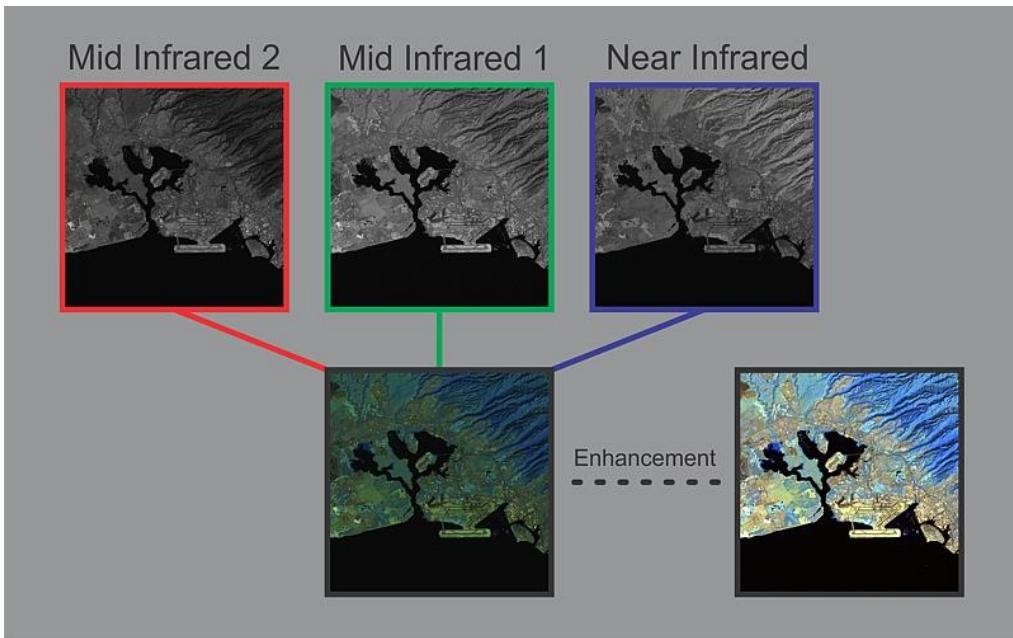


courtesy: wachowsky brothers (matrix)



courtesy: Miller et al. (sin city)

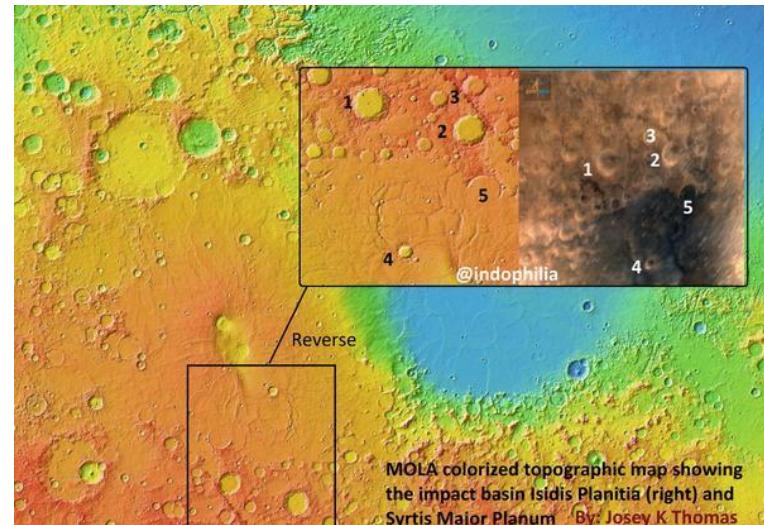
Tasks of interest: Satellite imaging



Terrain classification, weather predictions etc.

courtesy: NASA

Tasks of interest: Astronomy

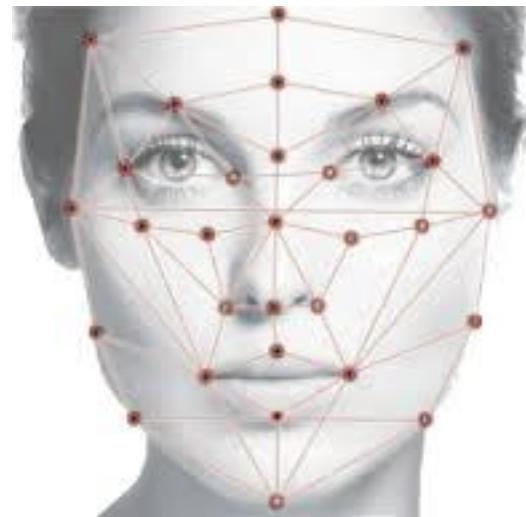


courtesy: ISRO

Tasks of interest: Biometrics

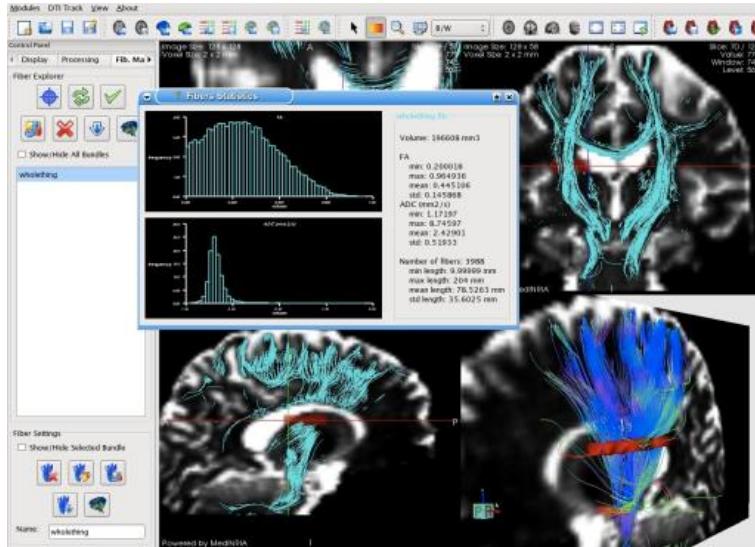


courtesy: dqindia.com

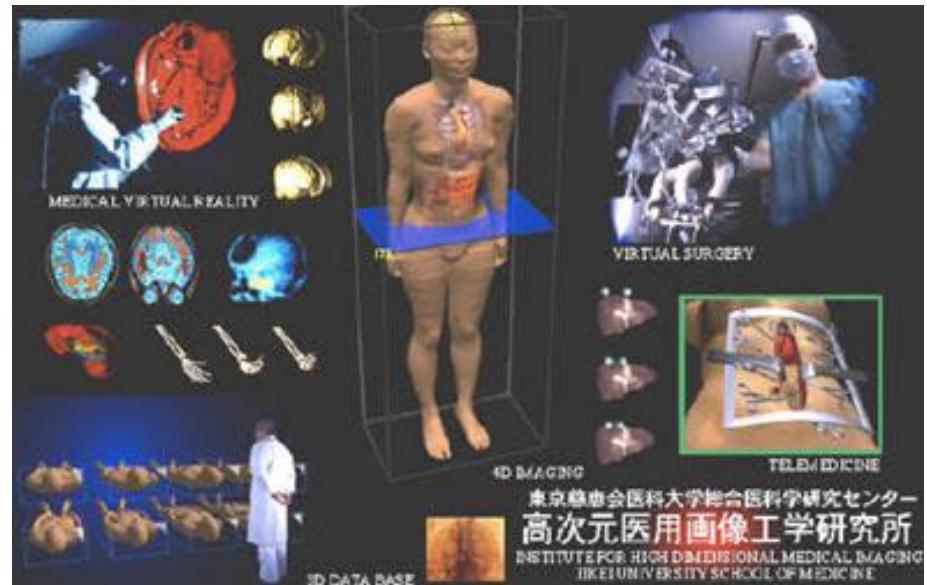


courtesy: heyce.com

Tasks of interest: Medicine



Courtesy: medINRIA

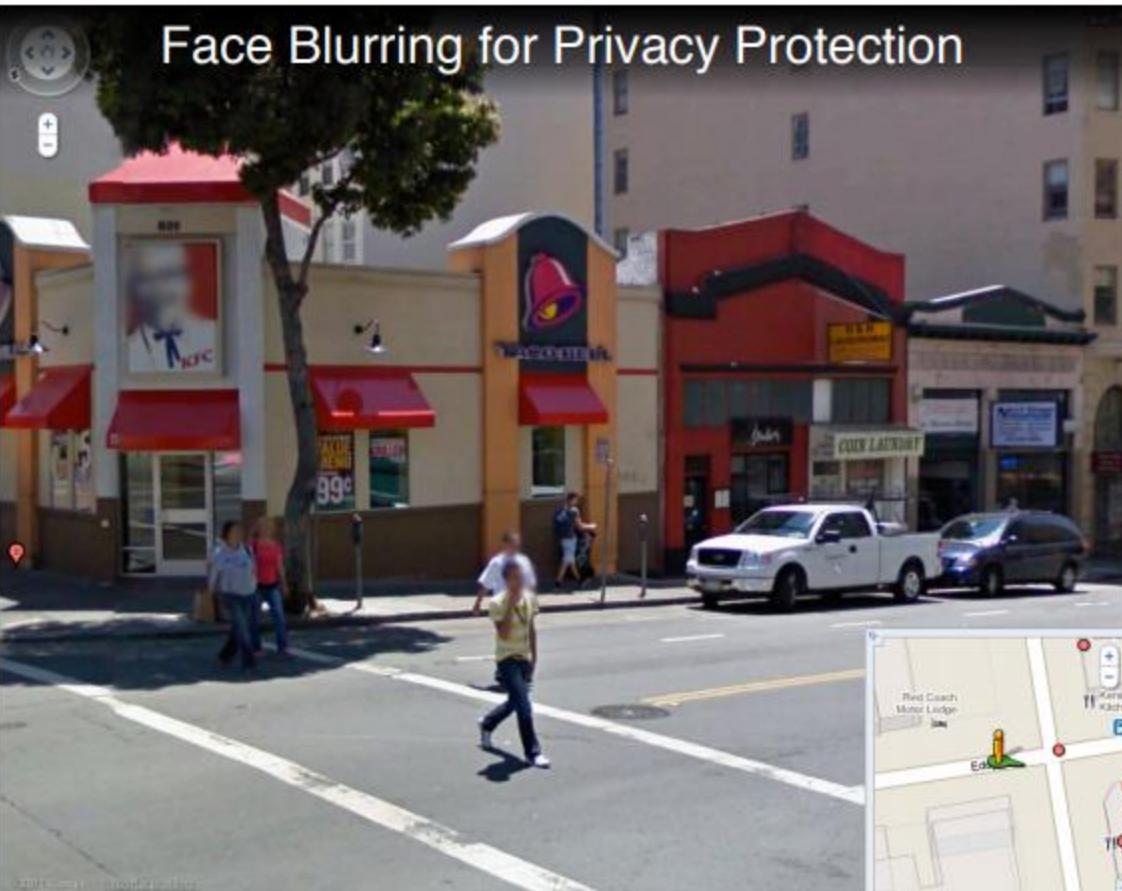


Courtesy: Naoki Suzuki

Tasks of interest: Driverless Vehicle Systems



Face Blurring for Privacy Protection

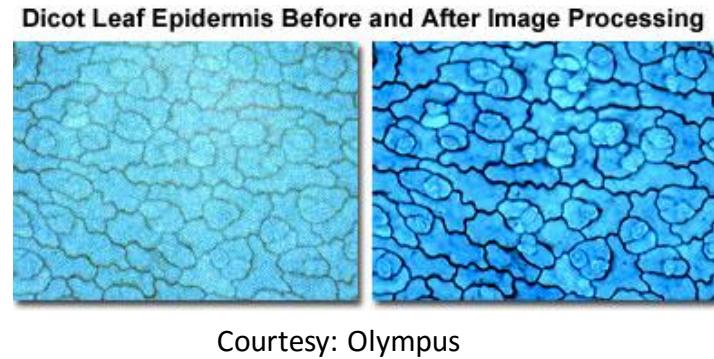


Tasks of interest: Many more

- Biology
- HCI
- Number Plate recognition
- Gesture recognition

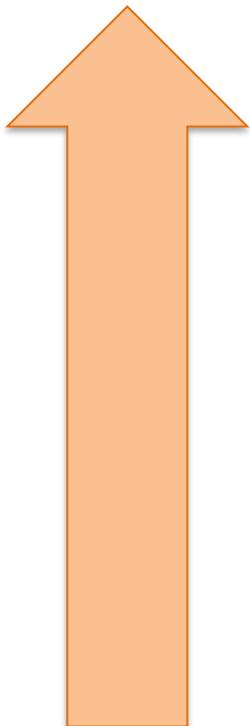


Courtesy: Perviverzov et al. 2012





Relationship with computer vision



Computer vision (high level)

Object detection, recognition, tracking (**AI + ML**)

Next semester

CSE471

Image Analysis (mid level)

Segmentation, feature matching etc.

Image Processing (low level)

Compression, morphology, noise removal, restoration etc.

Research

- Journals



Research

- Conferences



Research

- Conferences



**International Conference on Document Analysis and Recognition
ICDAR 2019, Sydney, Australia**

[Home](#) | [Calls](#) | [Committees](#) |



About the course

- Timings: M, Th (Himalaya 103, 2.00p – 3.30p)
- Website/Moodle :
<https://moodle.iiit.ac.in/course/view.php?id=1422>
- 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:
 - Tuesday : 3.30p – 4.30p, KRB, CVIT, F23 : RK
 - Wednesday : 3.30p – 4.30p, KRB, CVIT : RS

About the course – Grading Policy

- Assessment
 - 2 mid semester exams ($10 \times 2\% = 20\%$) + 1 Final Exam (20%)
 - Assignments ($10 \times 3\% = 30\%$) + 1 Final project (30%)
- NOTE:
 - **The grading policy might be modified/updated.**

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 – final projects

- Teams of 2/(> 2 members → more ambitious projects)
- Project Proposal (max 2 pages)

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

About the course – Grading Policy

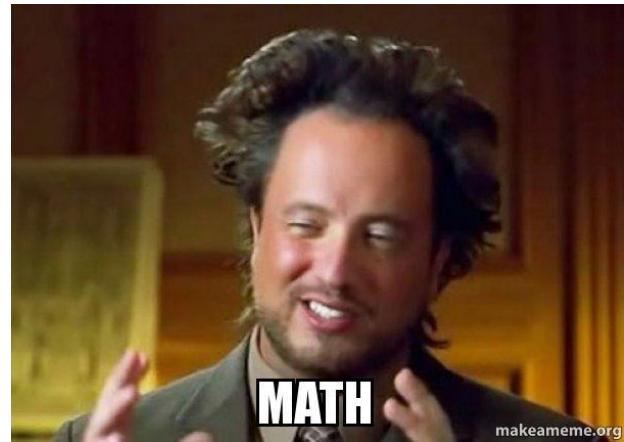
- **Homework Late Policy:** 50% if one day late; zero percent if more than one day late
- **Project Late Policy:** 25% if one day late; 50% if two days late; zero credit if more than two days late
- **A one time late submission bonus:** only applicable to HW (with maximum of three days delay). You must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

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

Additionally ...

- **Understand**, don't just memorize
- Love the math, not the toolbox !
- Capture the broad ideas and insights (useful years down the line)
- Implement ! No substitute for experience.



About the course - Material

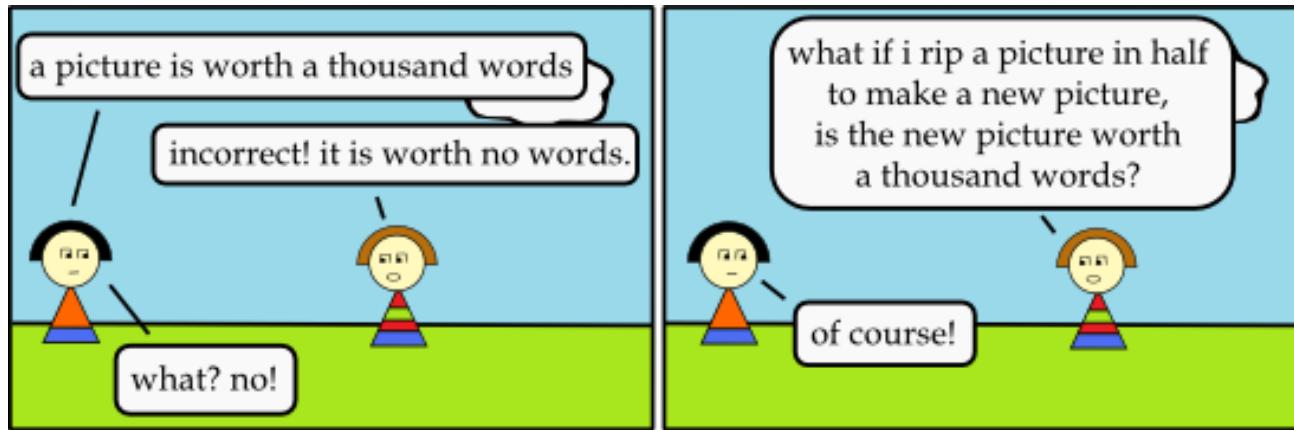
- DIP by Gonzalez and Woods
- Scattered Resources across Internet

**PLEASE SIGN UP FOR THE MAILING LIST
(cse478@lists.iiit.ac.in)**

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>
- Next Lecture: Digital Image Fundamentals

Snack/Food for thought



Spoiler alert – answer is on next slide !

a picture is worth a thousand words

incorrect! it is worth no words.



what? no!

what if i rip a picture in half
to make a new picture,
is the new picture worth
a thousand words?



of course!



Then, if P is the worth of one picture,

$$P = 0.5 P$$

$$P - 0.5 P = 0$$

$$0.5 P = 0$$

$$P = 0$$

Hence, a picture is worth no words!

nerd.