17.08.2021

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

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Sudipta Banerjee

Center for Visual Information Technology (CVIT), IIIT Hyderabad

Many slides borrowed from Vineet Gandhi @CVIT!

Before there were images ….

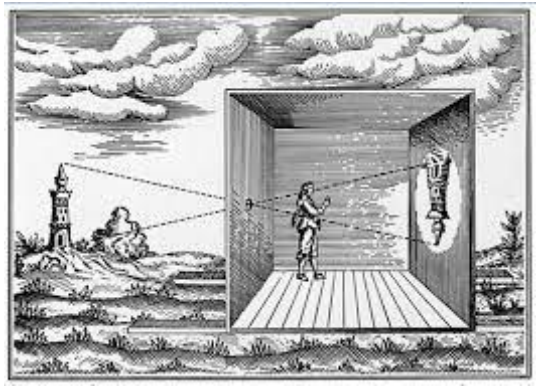
Prehistoric Painting, Lascaux Cave, France
~ 13,000 -- 15,000 B.C. (Aurochs, dun horses, deer.)

Before there were images ….

Depicting Our World: Middle Ages

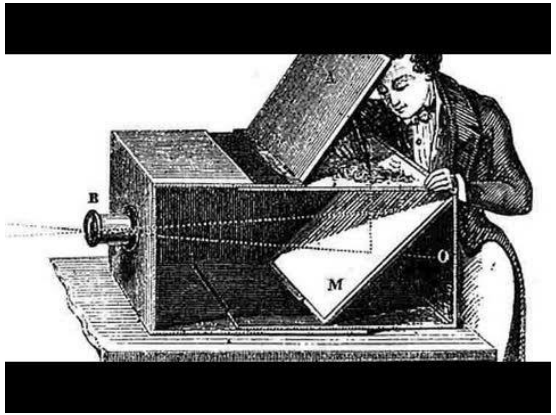
The Empress Theodora with her court.
Ravenna, St. Vitale 6th c.

Before there were images ….



Girl with a pearl earring, J. Vermeer, 1665

Camera Obscura



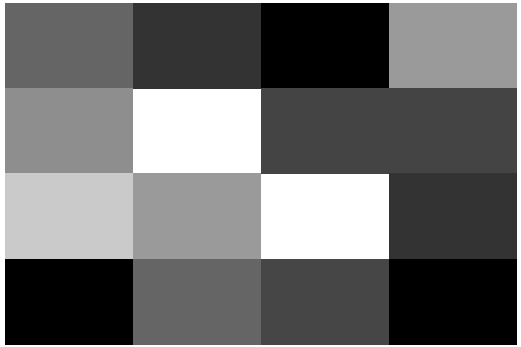
And then there were images ….

Still Life, Louis Jaques Mande Daguerre, 1837

What is a **digital** image ?

- An **array** of numbers representing color intensities

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



http://www.cs.ucc.ie/~gavin/cs1001/Notes/chap01/ch01_4.html

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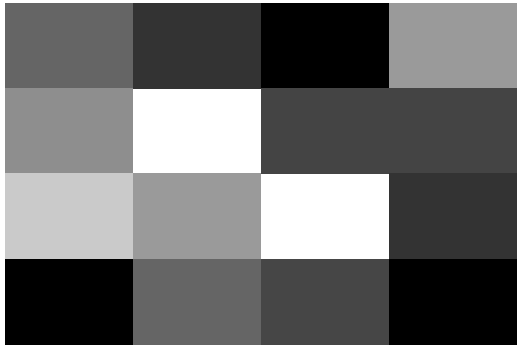

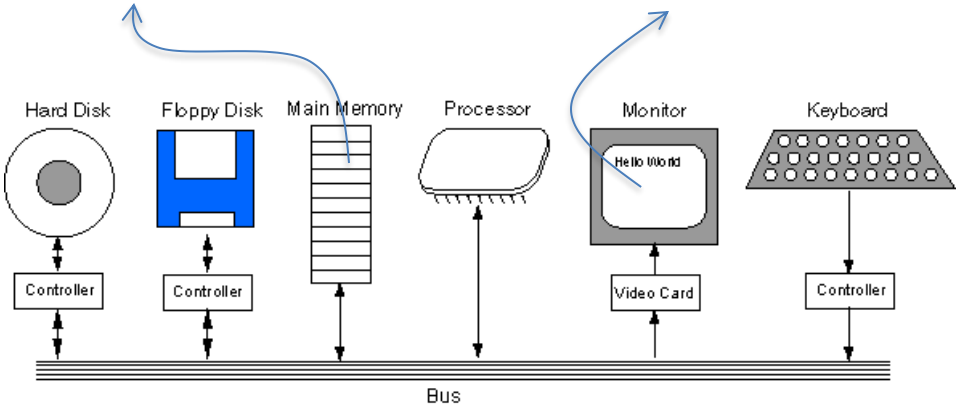

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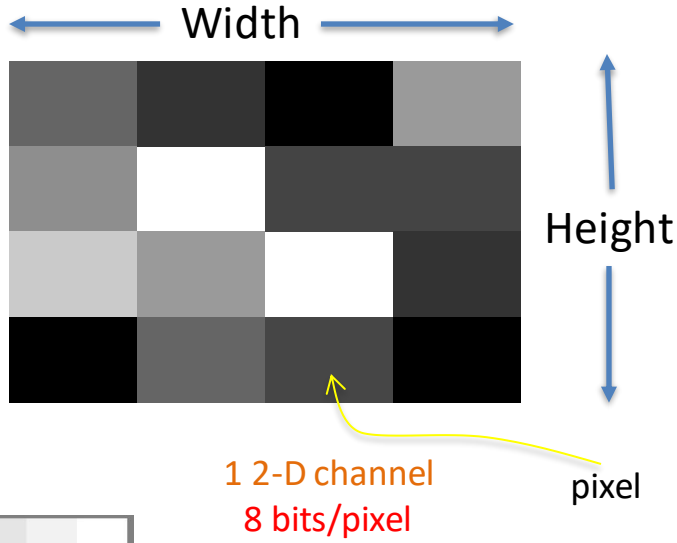


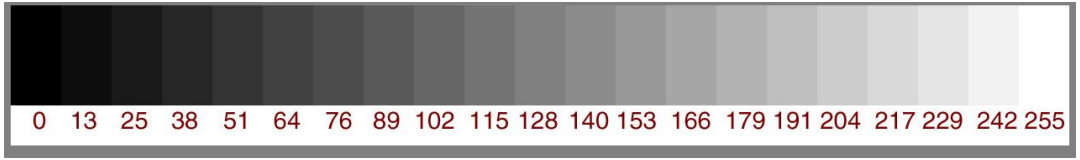
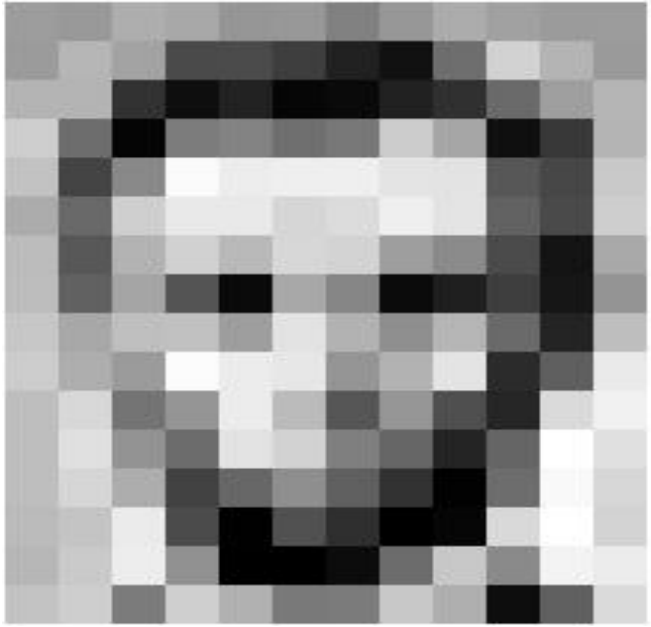
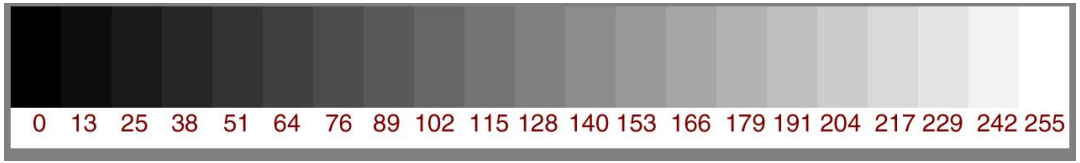


Image Representation (Grayscale)

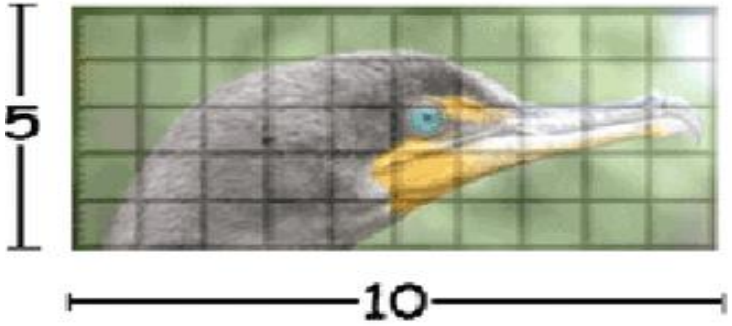


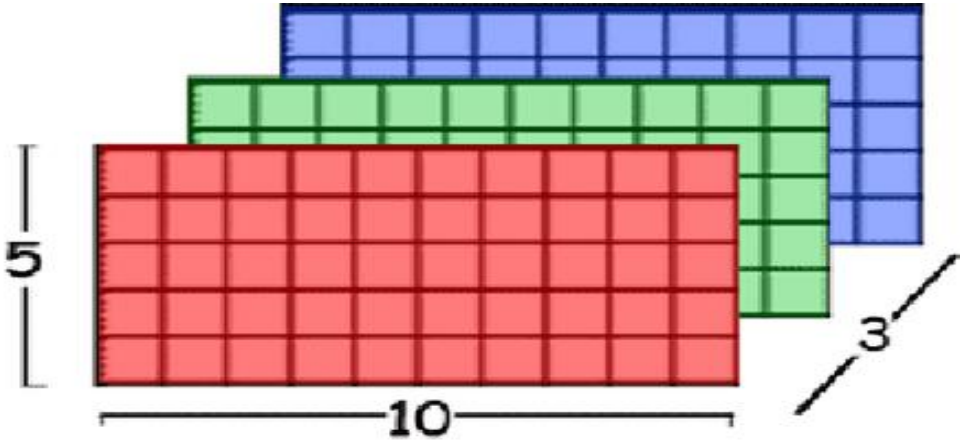
157	153	174	168	150	152	129	151	172	161	155	156
155	182	163	74	75	62	33	17	110	210	180	154
180	180	50	14	34	6	10	33	48	106	159	181
206	109	5	124	131	111	120	204	166	15	56	180
194	68	137	251	237	239	239	228	227	87	71	201
172	105	207	233	233	214	220	239	228	98	74	206
188	88	179	209	185	215	211	158	139	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	96	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



https://openframeworks.cc/ofBook/images/image_processing_computer_vision/

Image Representation (RGB)

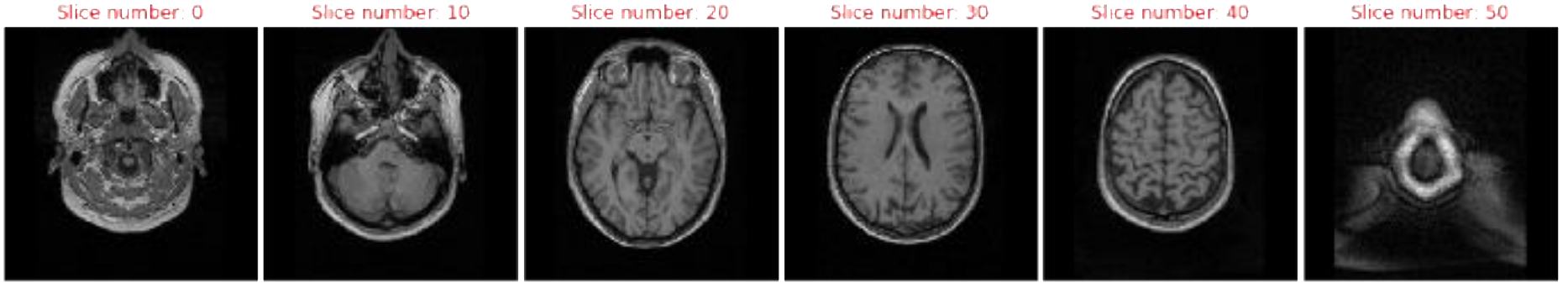




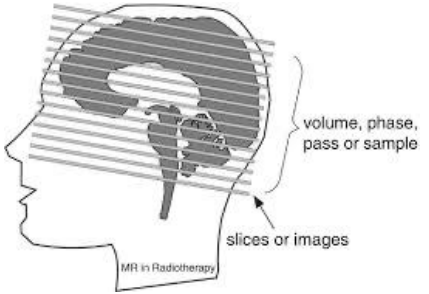
3 2-D channels
24 bits per pixel

Image Representation

fMRI image slices



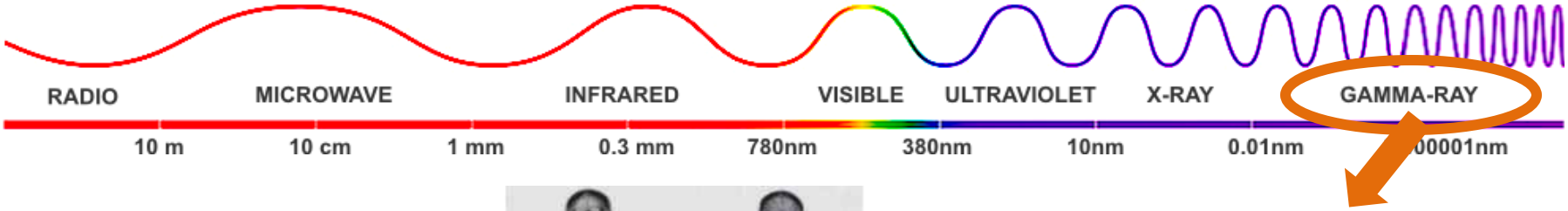
56 2-D channels

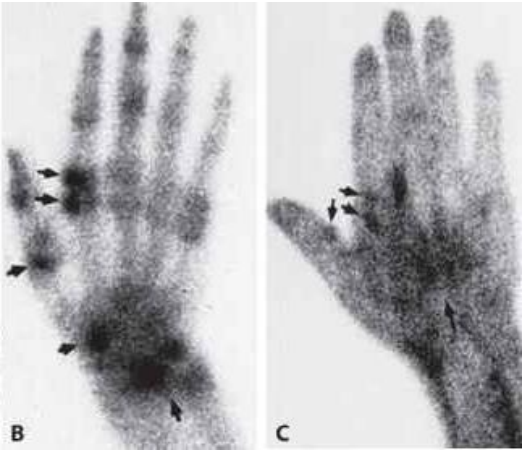


Types of Images (classification on source)

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

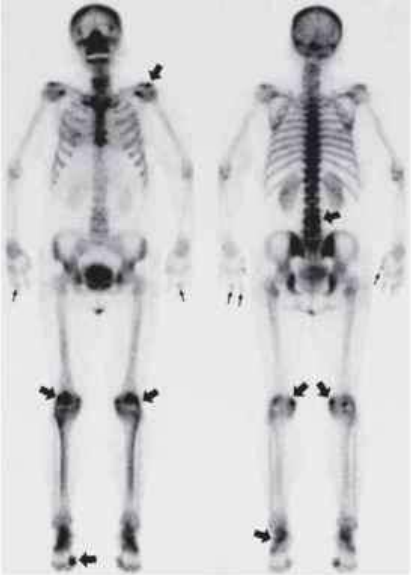
EM spectrum





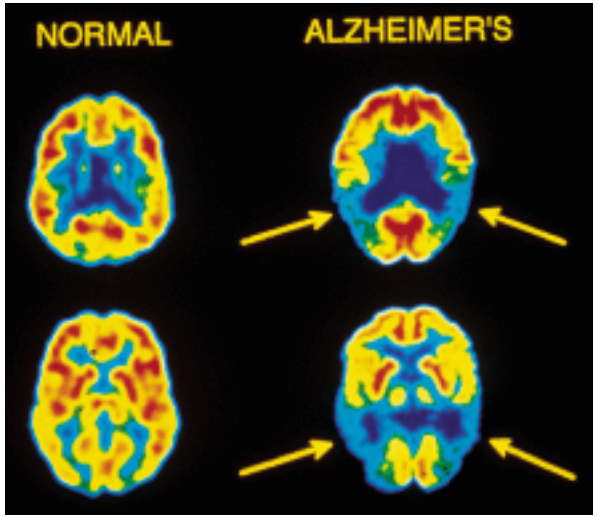
BLOOD FLOW SCAN

courtesy: artheristisresearch.us



BONE SCAN

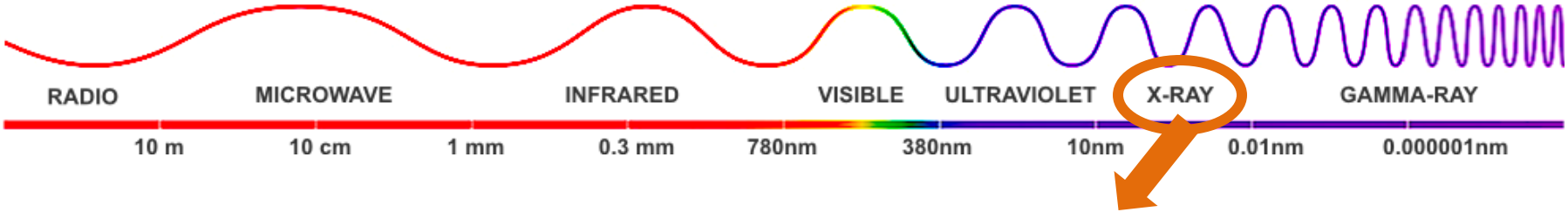
courtesy: artheristisresearch.us



PET SCAN

courtesy: research.ucla.edu

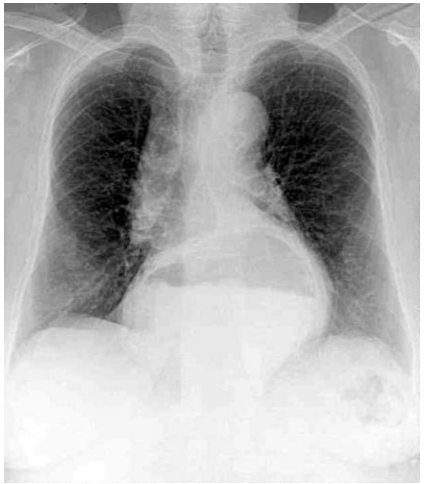
EM spectrum



Wilhelm Röntgen

HAND MIT RINGEN

courtesy: wikipedia



CHEST RADIOGRAPH

courtesy: wikipedia

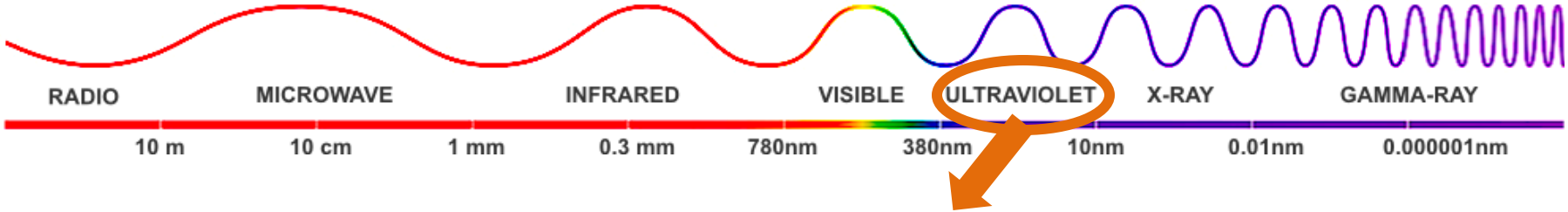
CT SCAN

courtesy: wikipedia

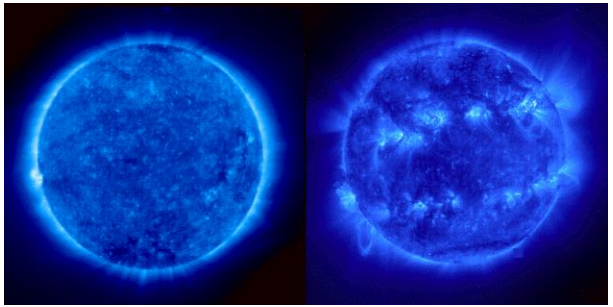
AIRPORT SCAN

courtesy: dpl-surveillance-equipment

EM spectrum



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



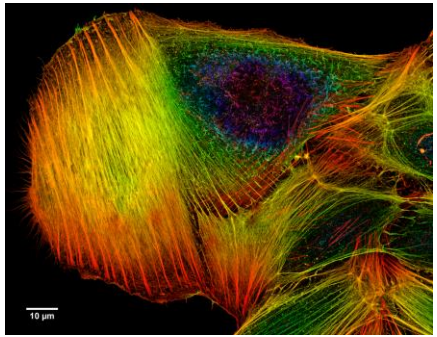
SUN (2 years apart)

courtesy: NASA

100 EURO BILL

courtesy: lifepixel.com

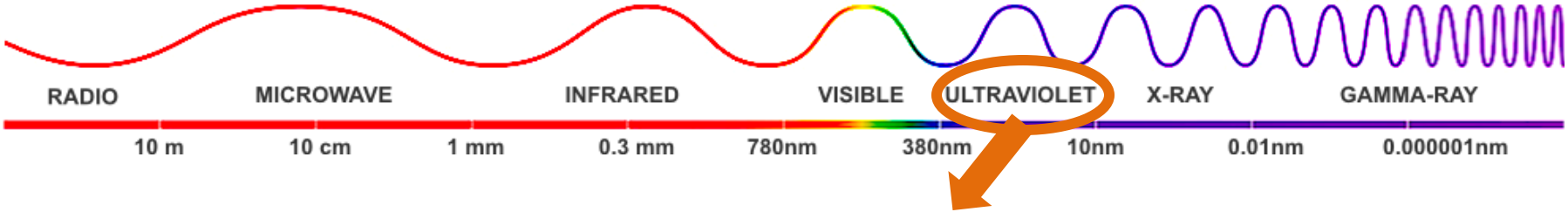
Eric Betzig, William Moerner and Stefan Hell



Cell Phalloidin

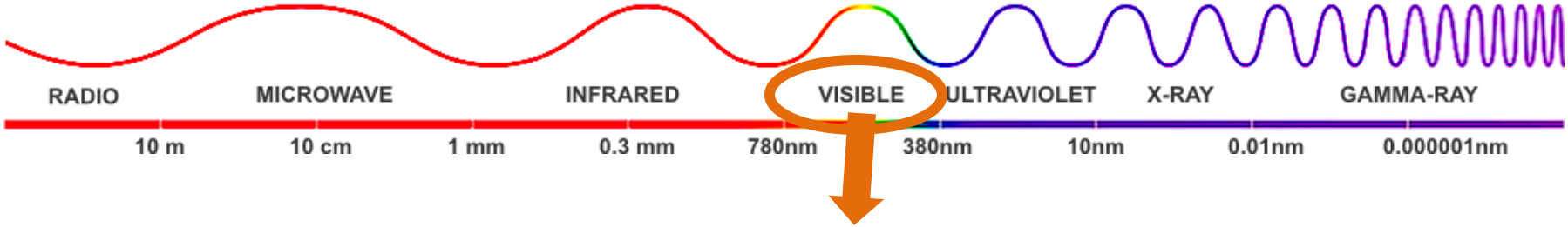
courtesy: wikipedia

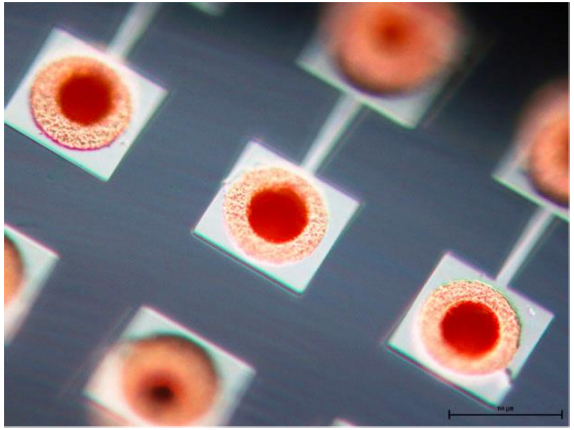
EM spectrum



Source:
Lifepixel.com

EM spectrum



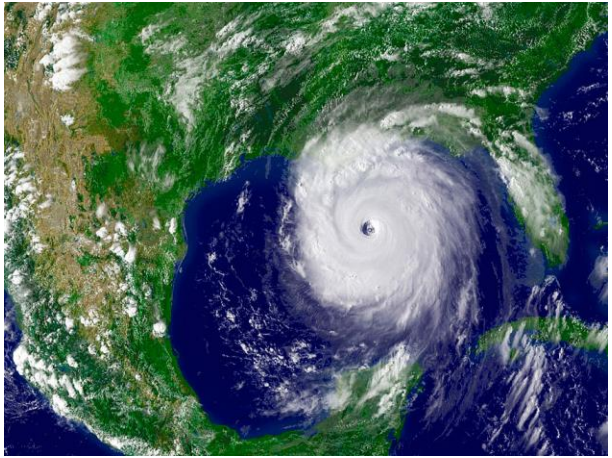


Chips (optical microscopy)

courtesy: EPFL microelectornics systems laboratory

High Speed Photograph

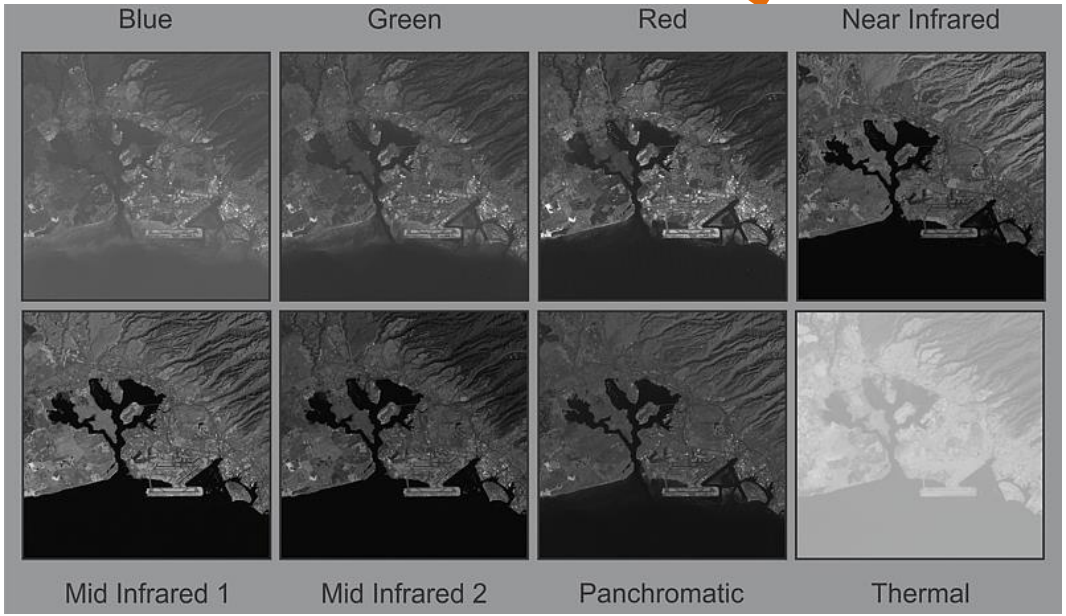
courtesy:Alan Sailer



Satellite Image (Hurricane Katrina)

courtesy: britannica.com

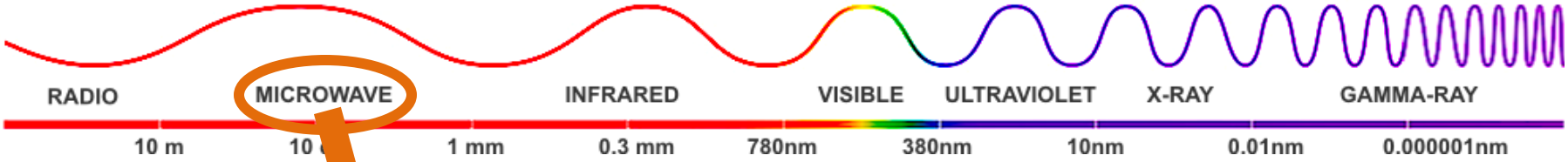
EM spectrum



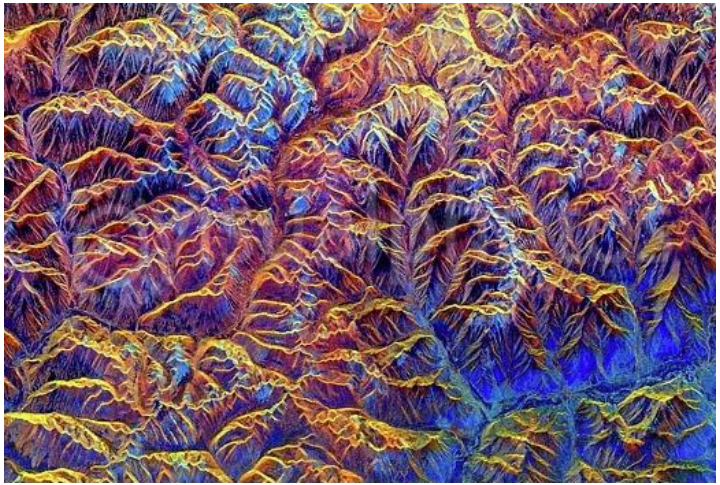
courtesy: LANDSAT (NASA)

courtesy: imaging1.com

EM spectrum



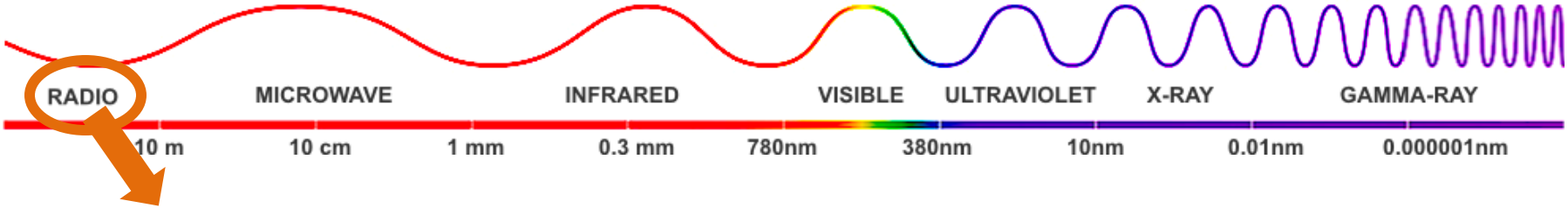
Main application: RADAR



SOUTHEAST TIBET MOUNTAINS

courtesy: NASA

EM spectrum



MRI Brain

courtesy: mritnt.com

MRI Knee

courtesy: mri-tip.com

Types of Images (classification on source)

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Ultrasound

ULTRASOUND

courtesy: wikipedia

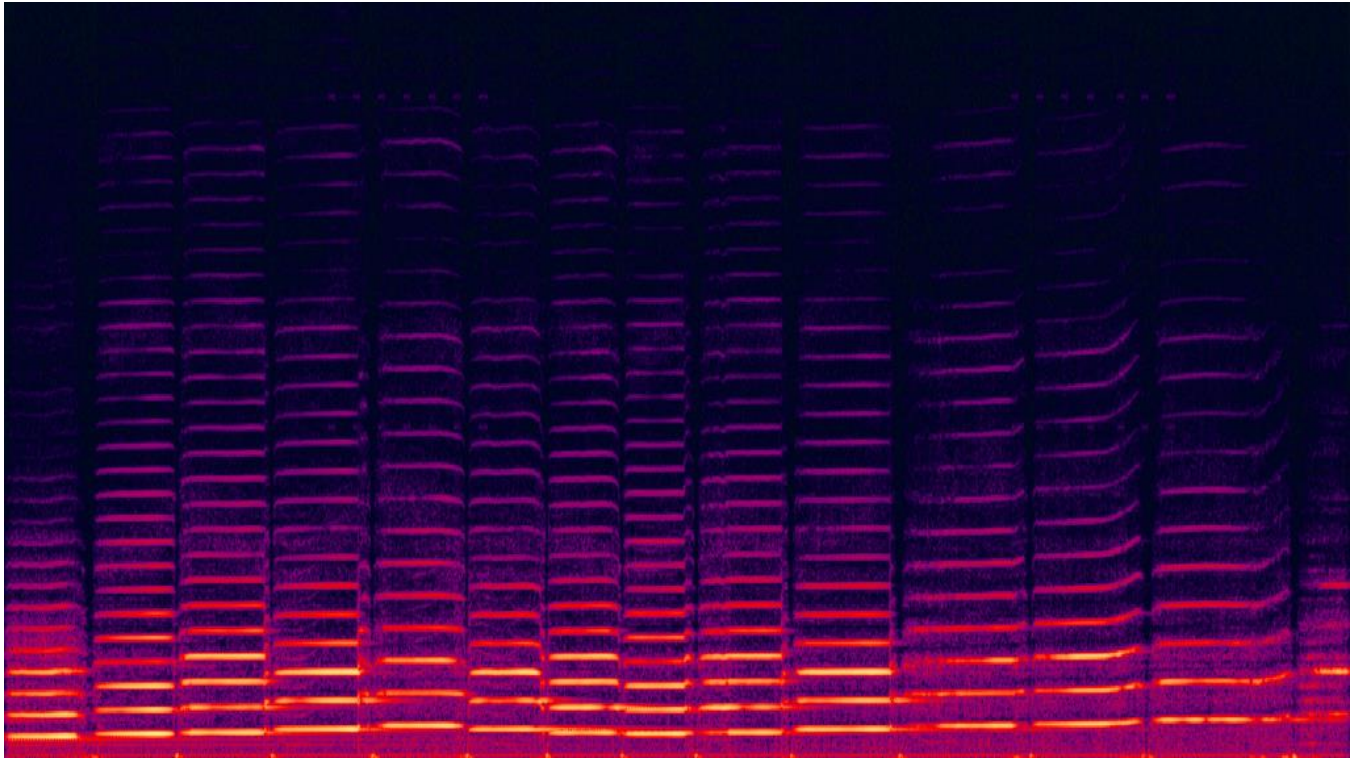
ULTRASOUND TWINS

courtesy: pinterest

ULTRASOUND 3D

courtesy: peek3D.com

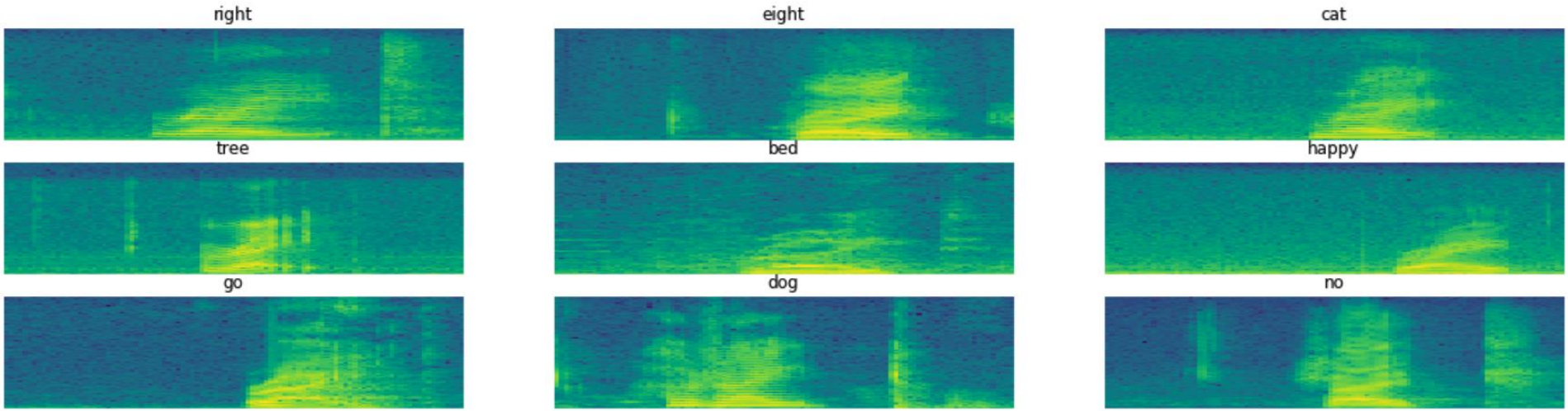
Spectrogram



Violin Recording

courtesy: wikipedia

Spectrogram



https://elvinouyang.github.io/project/training-cnn-for-voice-command/

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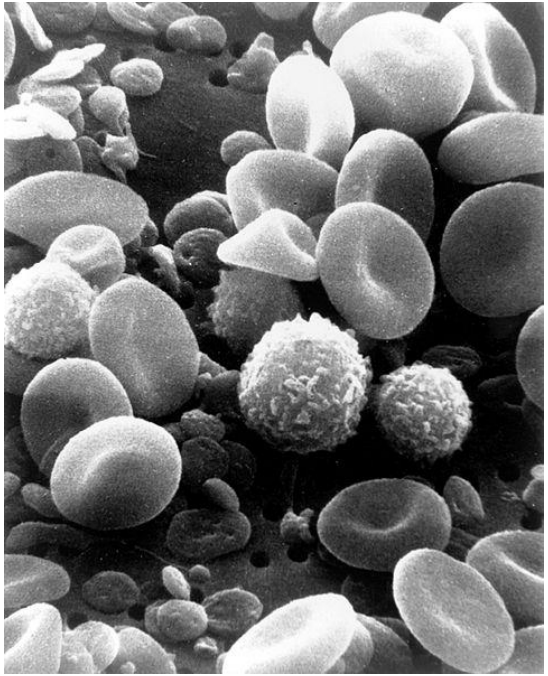
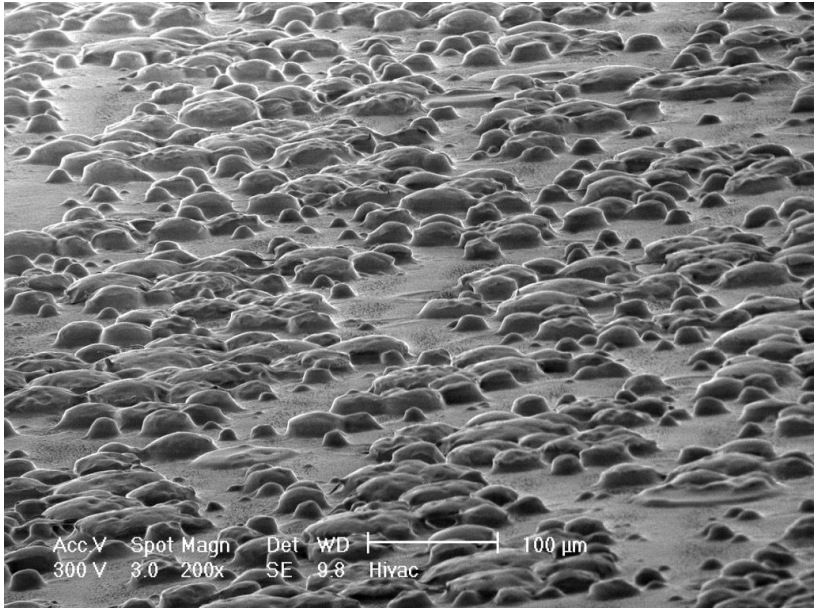
Scanning Electron Microscopy



Normal Circulating Human Blood

courtesy: National Cancer Institute



Adhesive on Post-it note

courtesy: wikipedia

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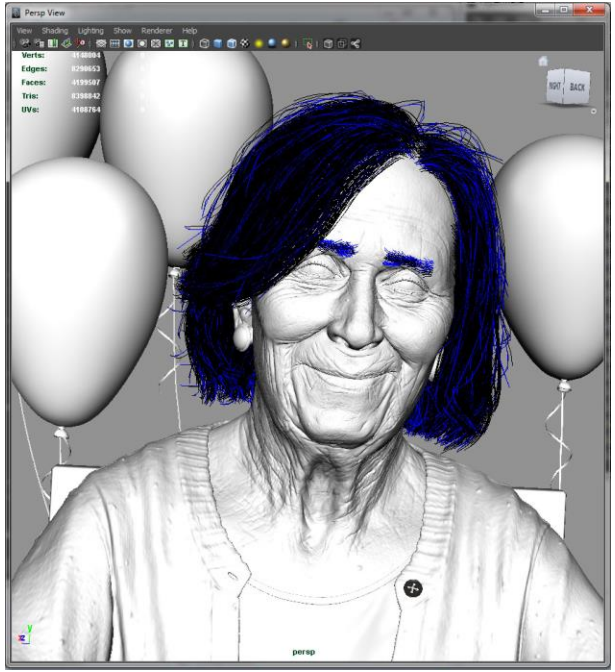
Computer generated

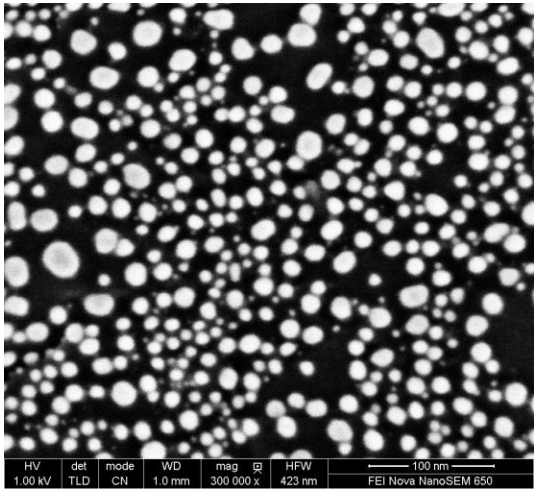
Happy Birthday Nana

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)

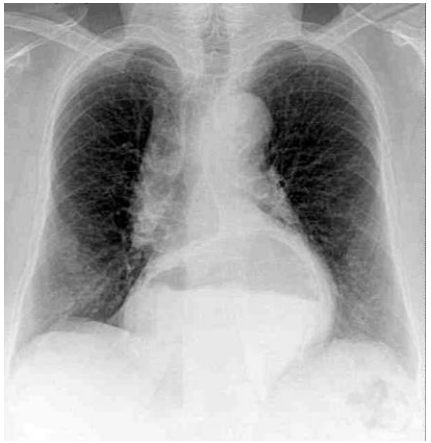
1. Reflection Images

Information primarily about objects surface

2. Emission Images

Information primarily about internal properties

3. Absorption Images

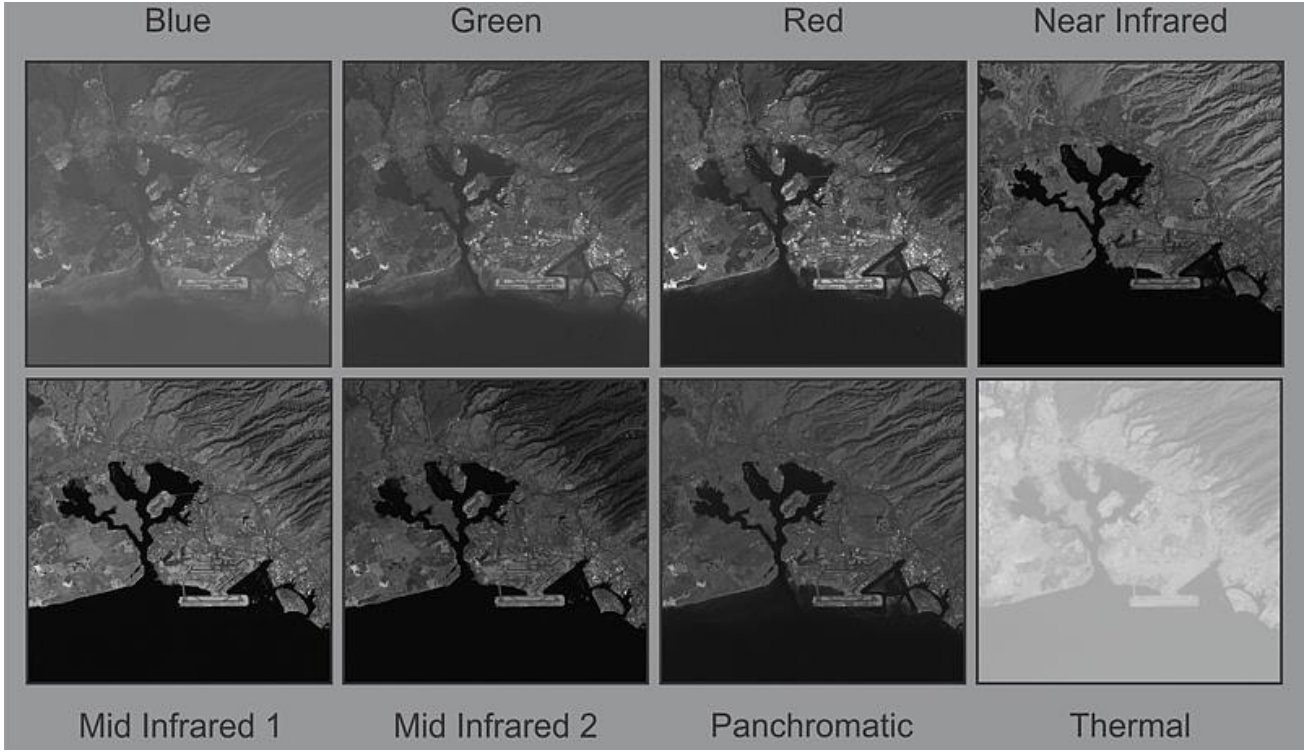


Information primarily about internal structure

Types on images (classification on arrangement)

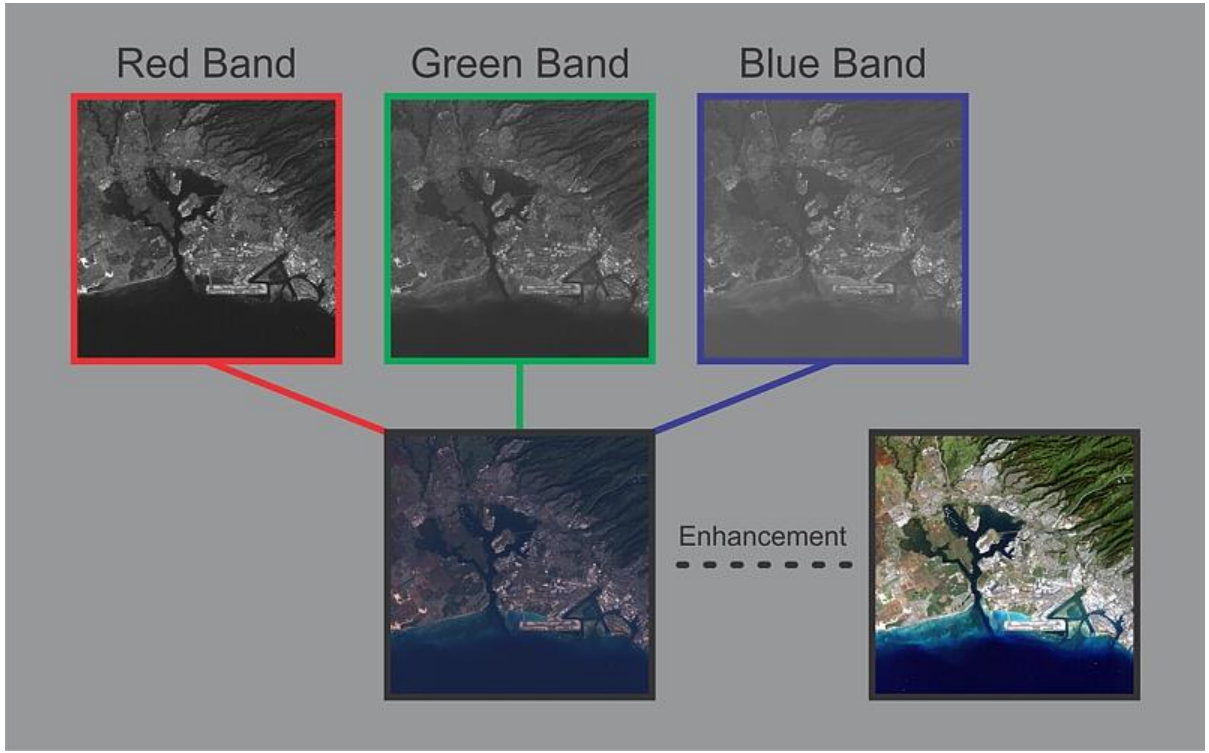
- Grayscale
- RGB
- Multispectral images
- Stereo images
- Multi-view images

Multi spectral images



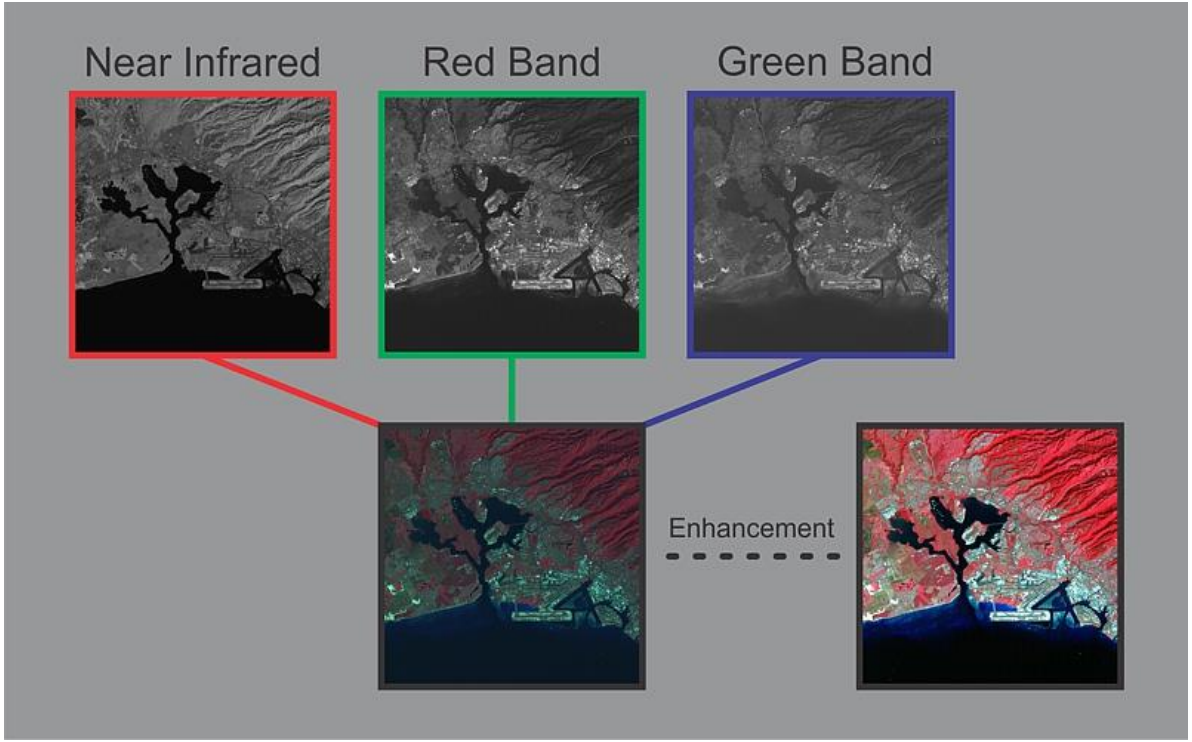
Courtesy: LANDSAT

Multi spectral images



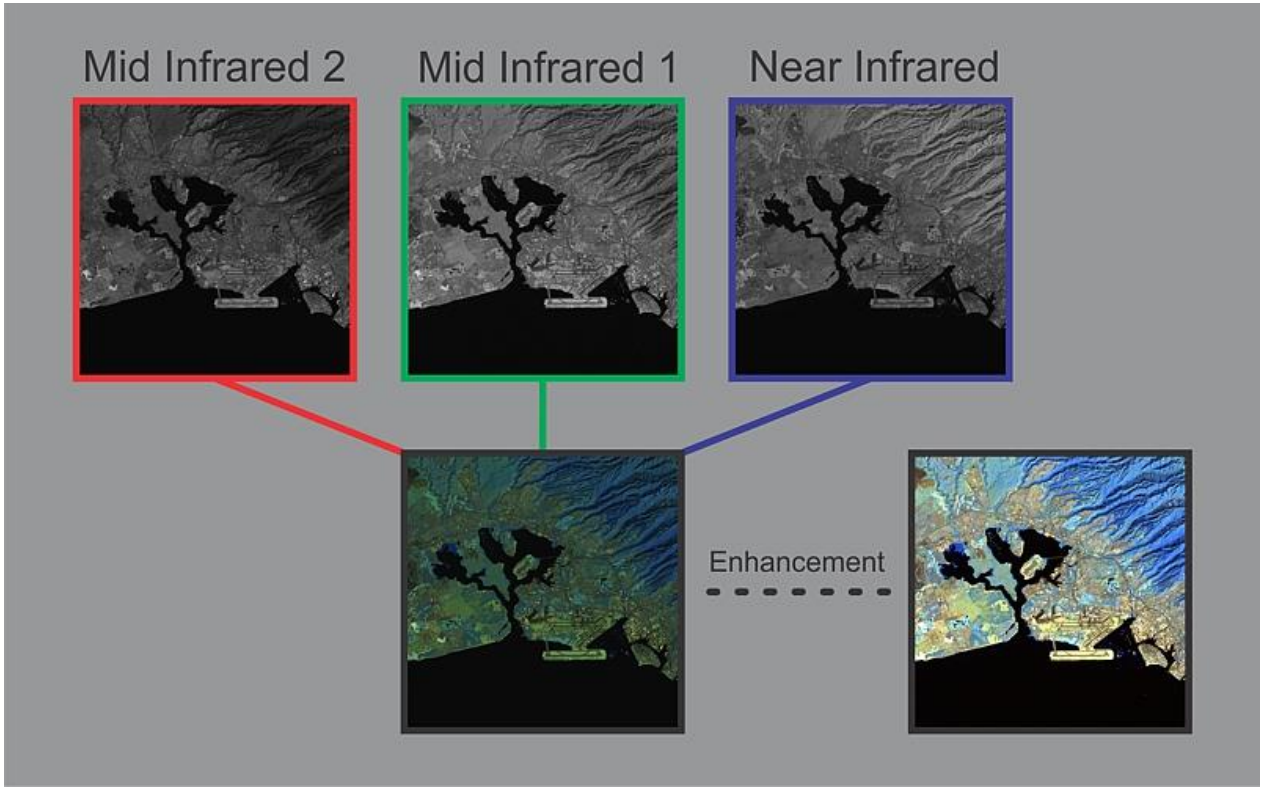
Courtesy: LANDSAT

Multi spectral images



Courtesy: LANDSAT

Multi spectral images

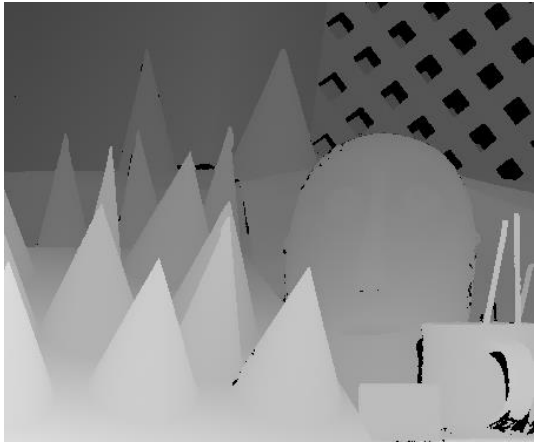


Courtesy: LANDSAT

Stereo Images

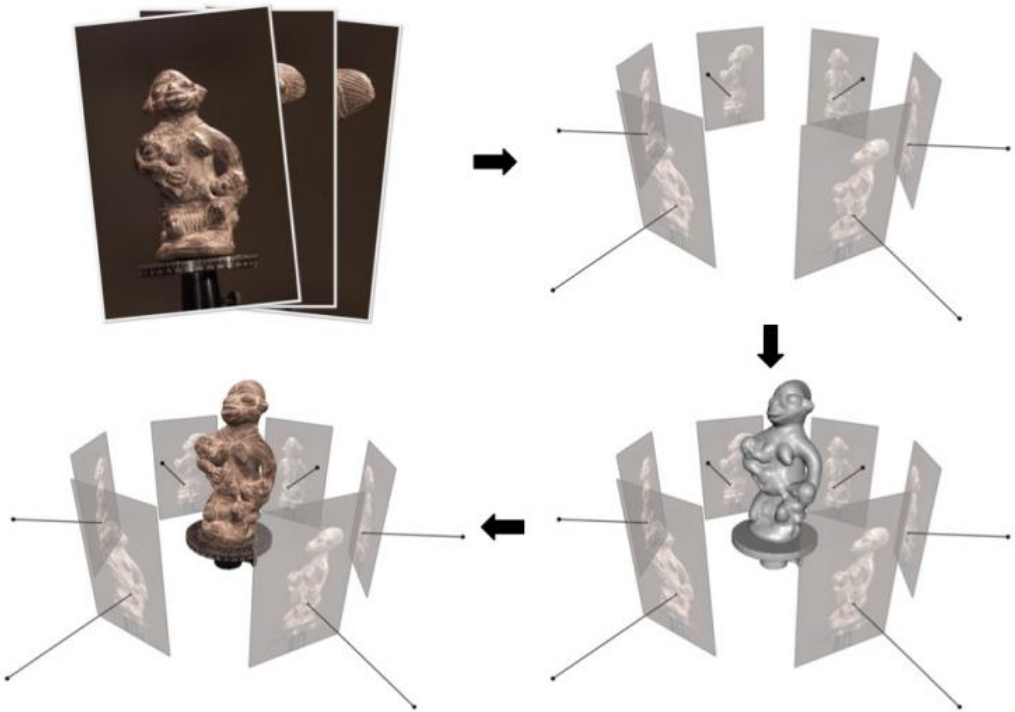
courtesy: wikimedia.com

Stereo Images



courtesy: vision.middlebury.edu

Multi-view images



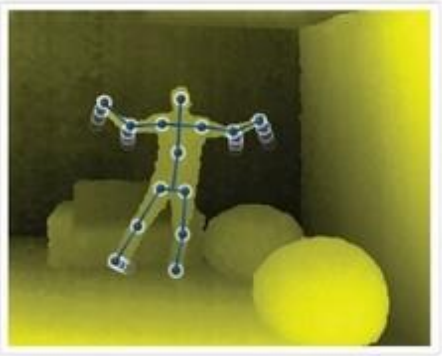
courtesy: Yasutaka Furukawa

courtesy: Sameer Agarwal

Kinect images

Color (RGB) Image

Depth Image

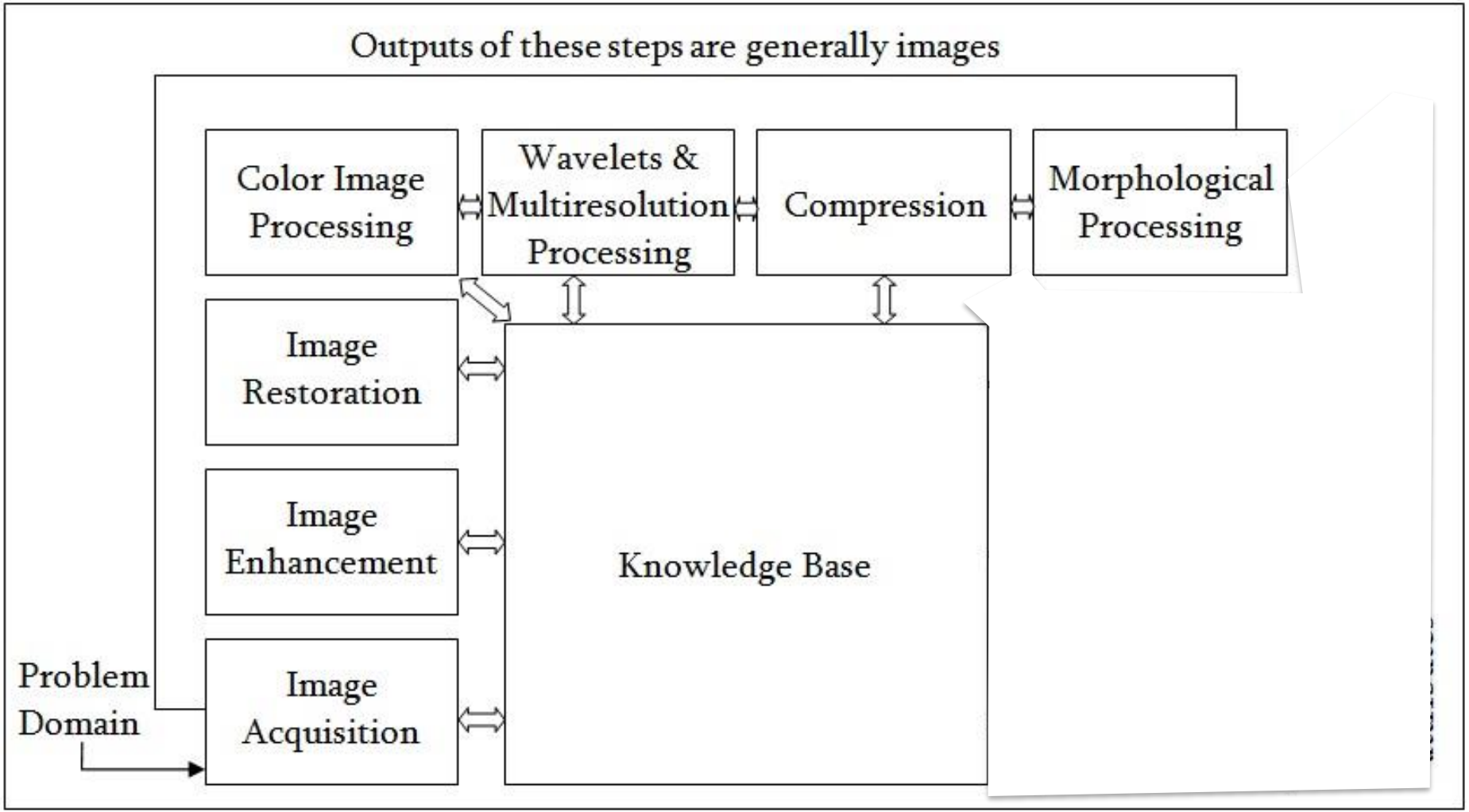


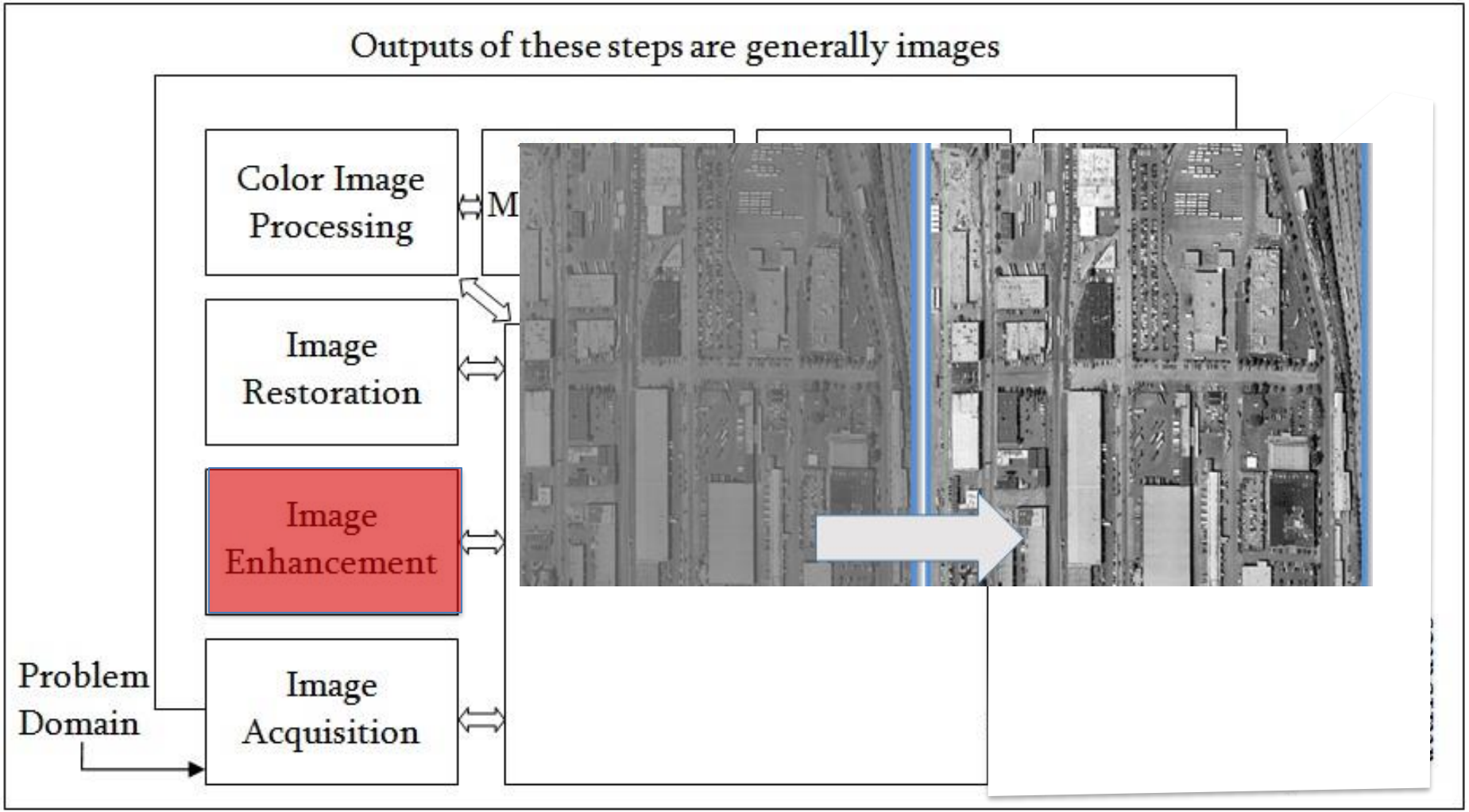
courtesy: kinect and prime sense

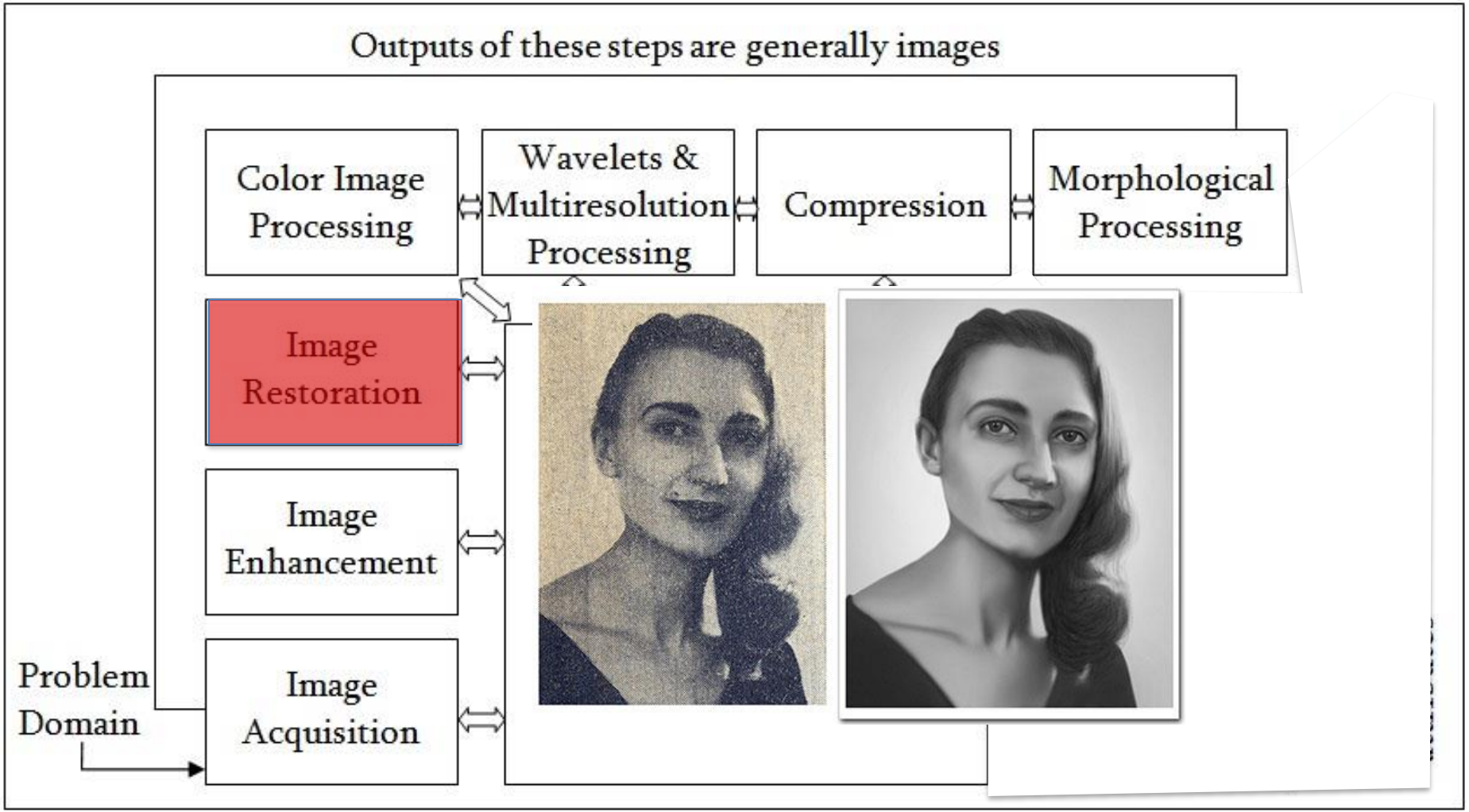
Digital Image **processing**

- Study and Development of algorithms that operate on an image
  - To create new image(s)
  - To retrieve its attributes

- Consumer-based view
  - For consumption by human eyes
  - For consumption by machine-based processes


Outputs of these steps are generally images
Color Image Processing
Wavelets & Multiresolution Processing
Compression
Morphological Processing
Image Restoration
Image Enhancement
Knowledge Base
Problem Domain
Image Acquisition


Outputs of these steps are generally images
Color Image Processing
M
Image Restoration
Image Enhancement
Image Acquisition
Problem Domain


Outputs of these steps are generally images
Color Image Processing
Wavelets & Multiresolution Processing
Compression
Morphological Processing
Image Restoration
Image Enhancement
Image Acquisition
Problem Domain

Outputs of these steps are generally images

Color Image Processing

Wavelets & Multiresolution Processing

Compression

Morphological Processing

Image Restoration

Image Enhancement

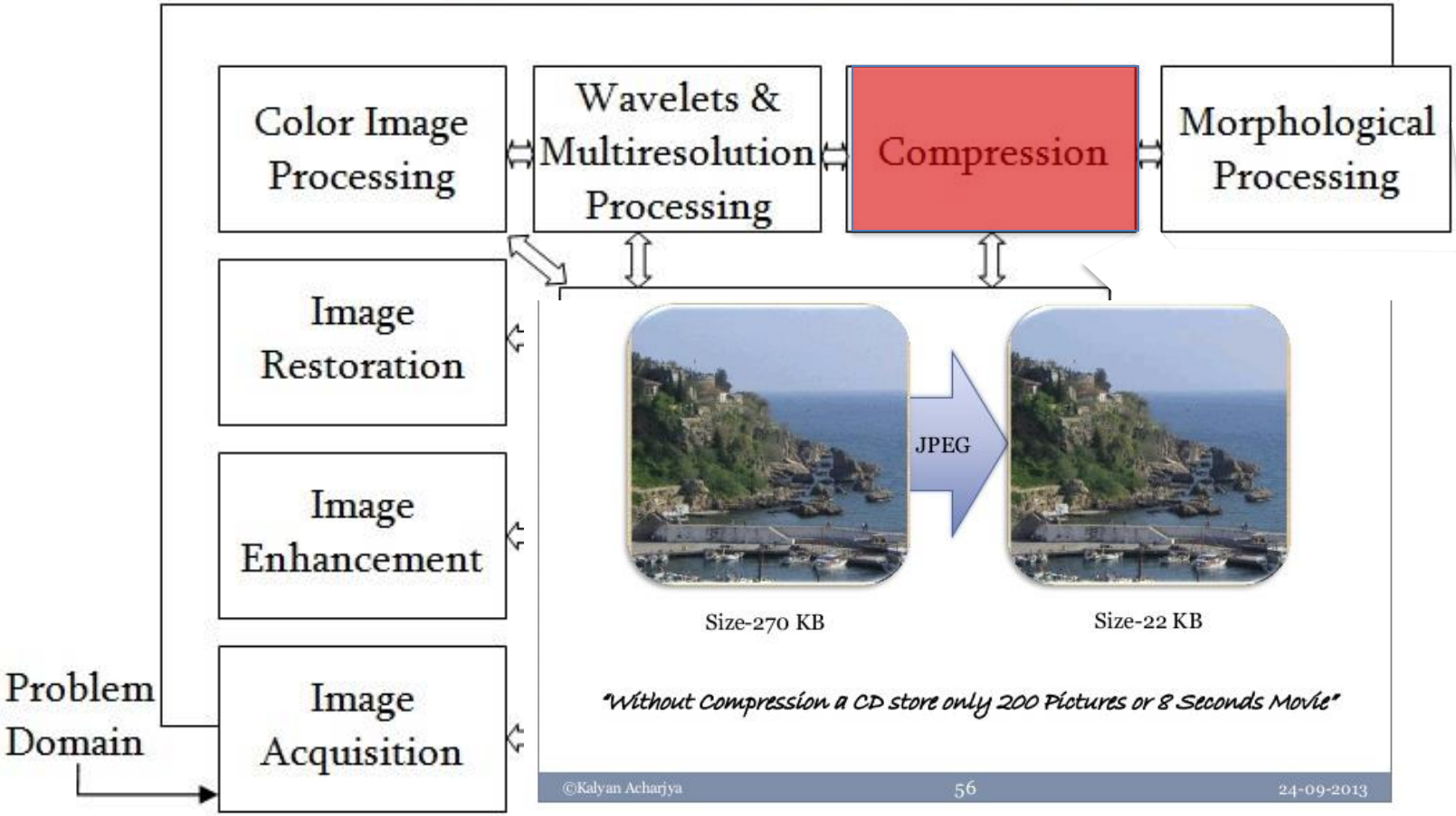
Image Acquisition

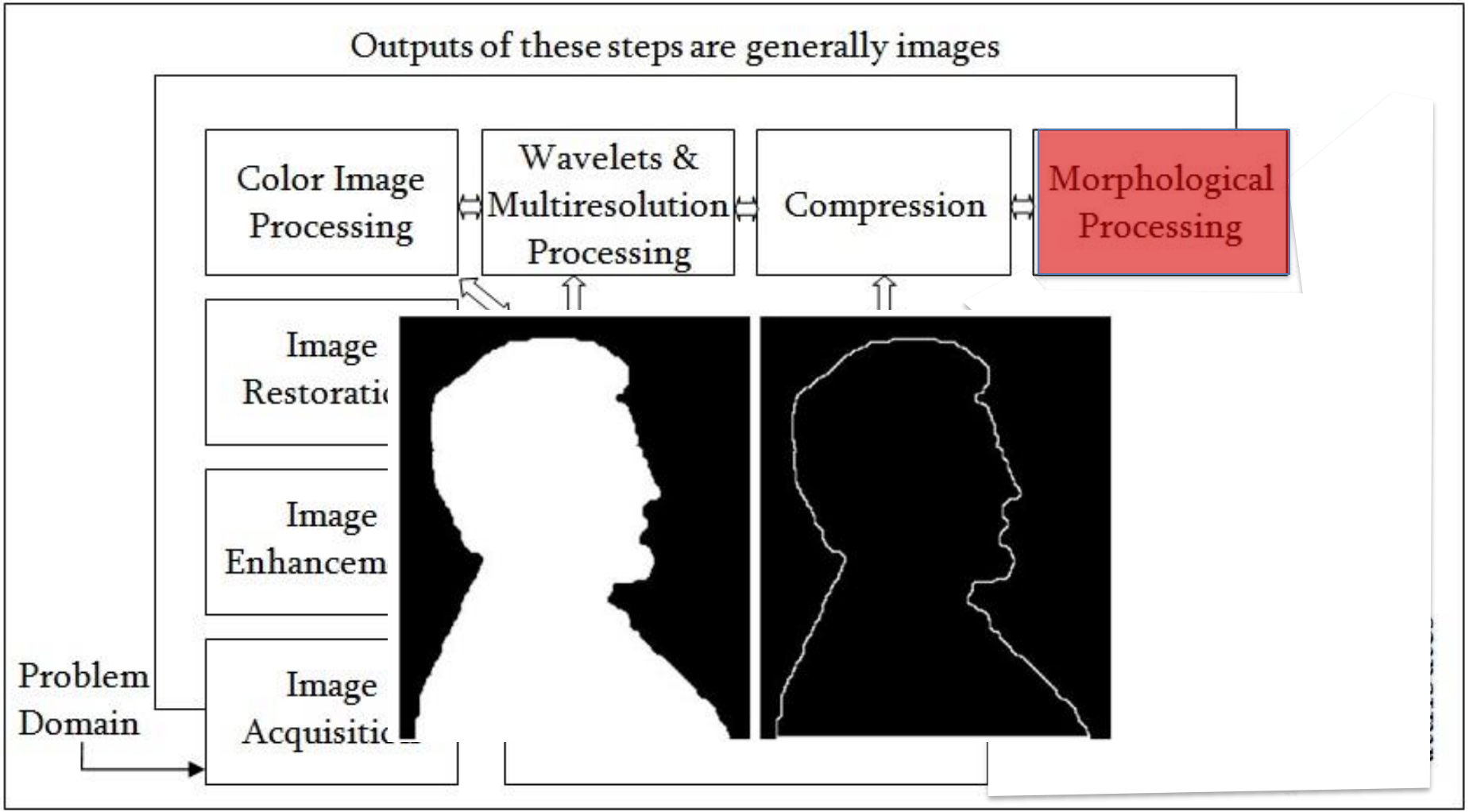
Problem Domain

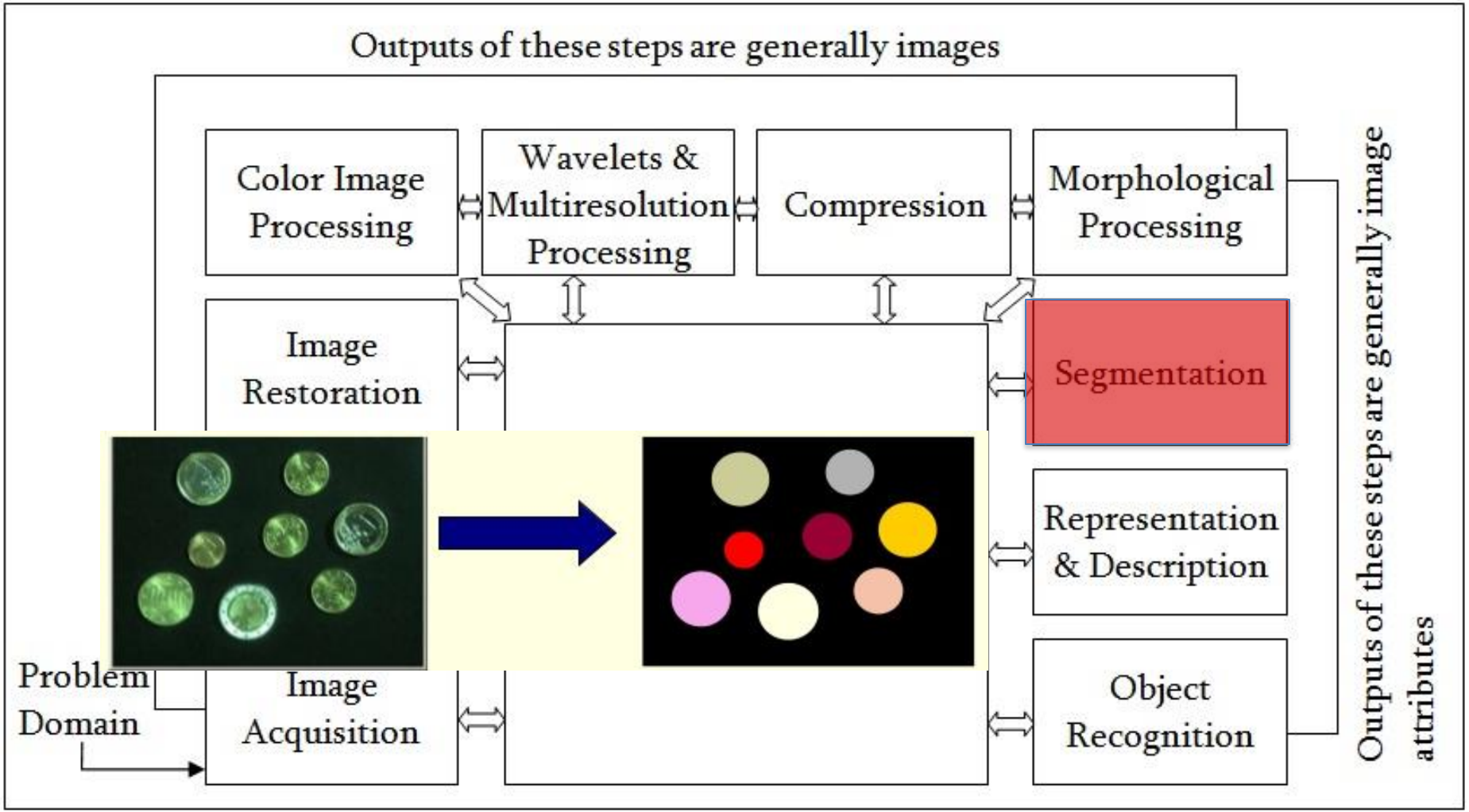
Uncorrected Image

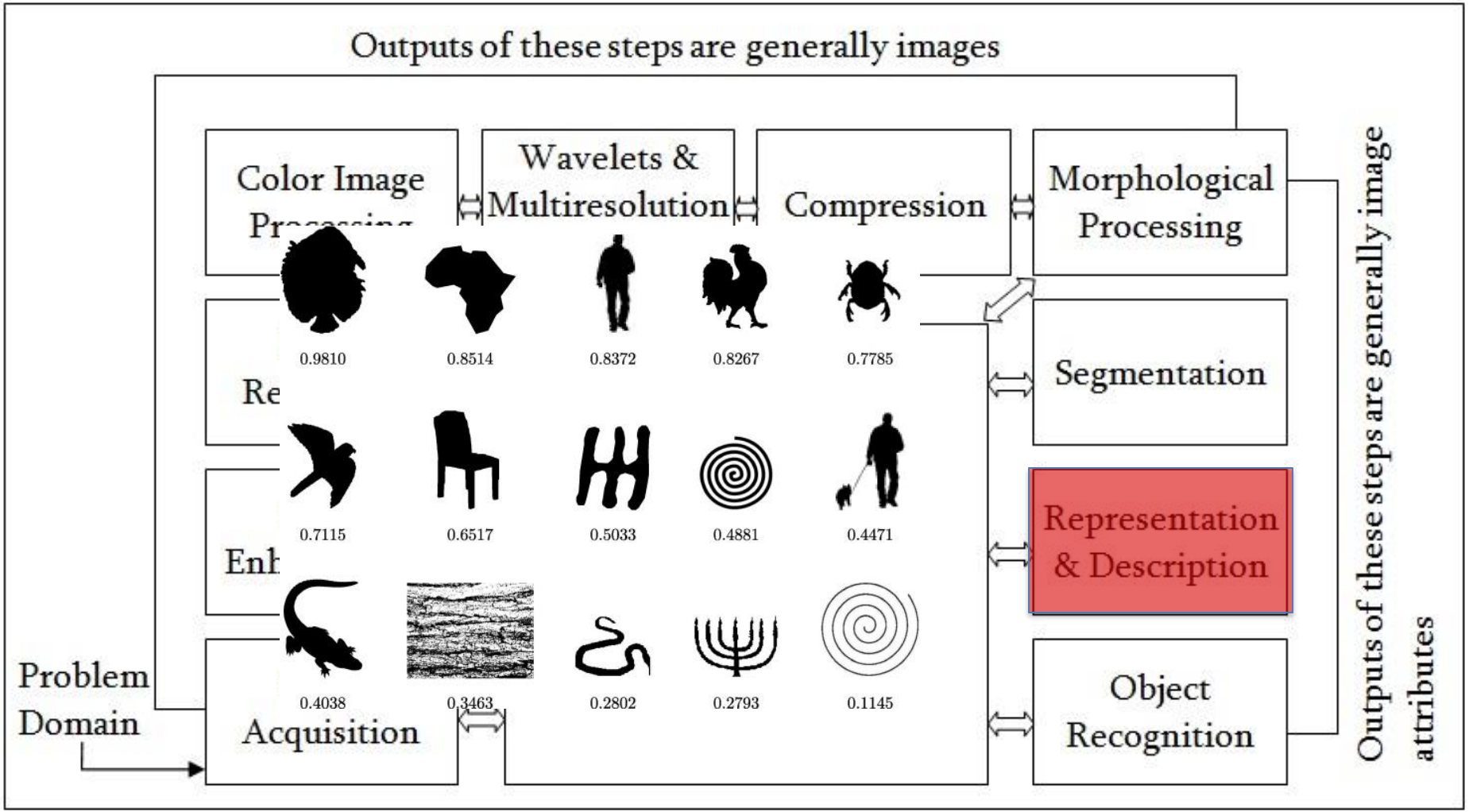
With .Look Applied

Outputs of these steps are generally images




Outputs of these steps are generally images
Color Image Processing
Wavelets & Multiresolution Processing
Compression
Morphological Processing
Image Restoratio
Image Enhancem
Image Acquisitio
Problem Domain


Outputs of these steps are generally images
Color Image Processing
Wavelets & Multiresolution Processing
Compression
Morphological Processing
Image Restoration
Segmentation
Representation & Description
Object Recognition
Image Acquisition
Problem Domain
Outputs of these steps are generally image attributes


Outputs of these steps are generally images
Color Image Processing
Wavelets & Multiresolution
Compression
Morphological Processing
Segmentation
Representation & Description
Object Recognition
Acquisition
Problem Domain
Outputs of these steps are generally image attributes
0.9810
0.8514
0.8372
0.8267
0.7785
0.7115
0.6517
0.5033
0.4881
0.4471
0.4038
0.3463
0.2802
0.2793
0.1145

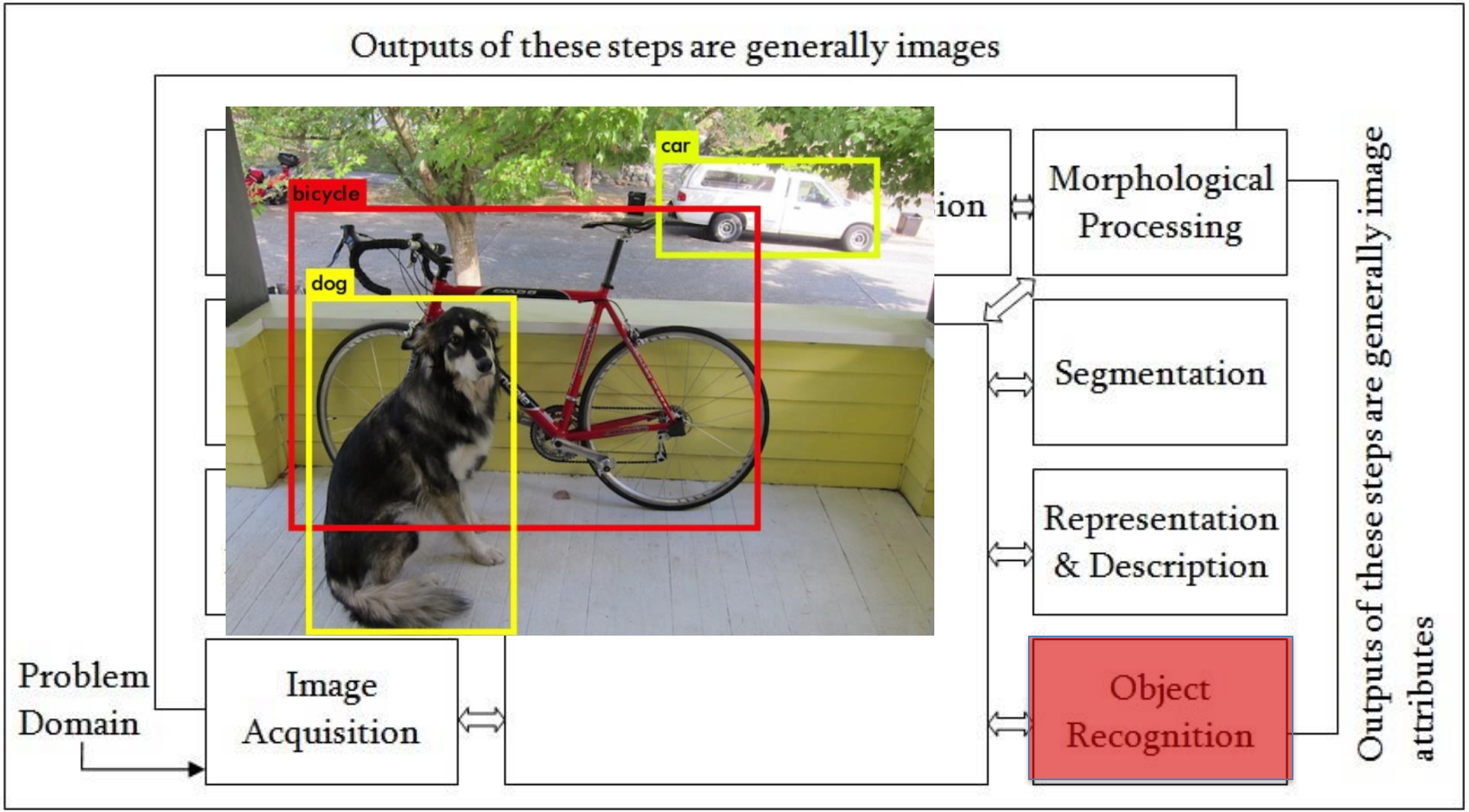
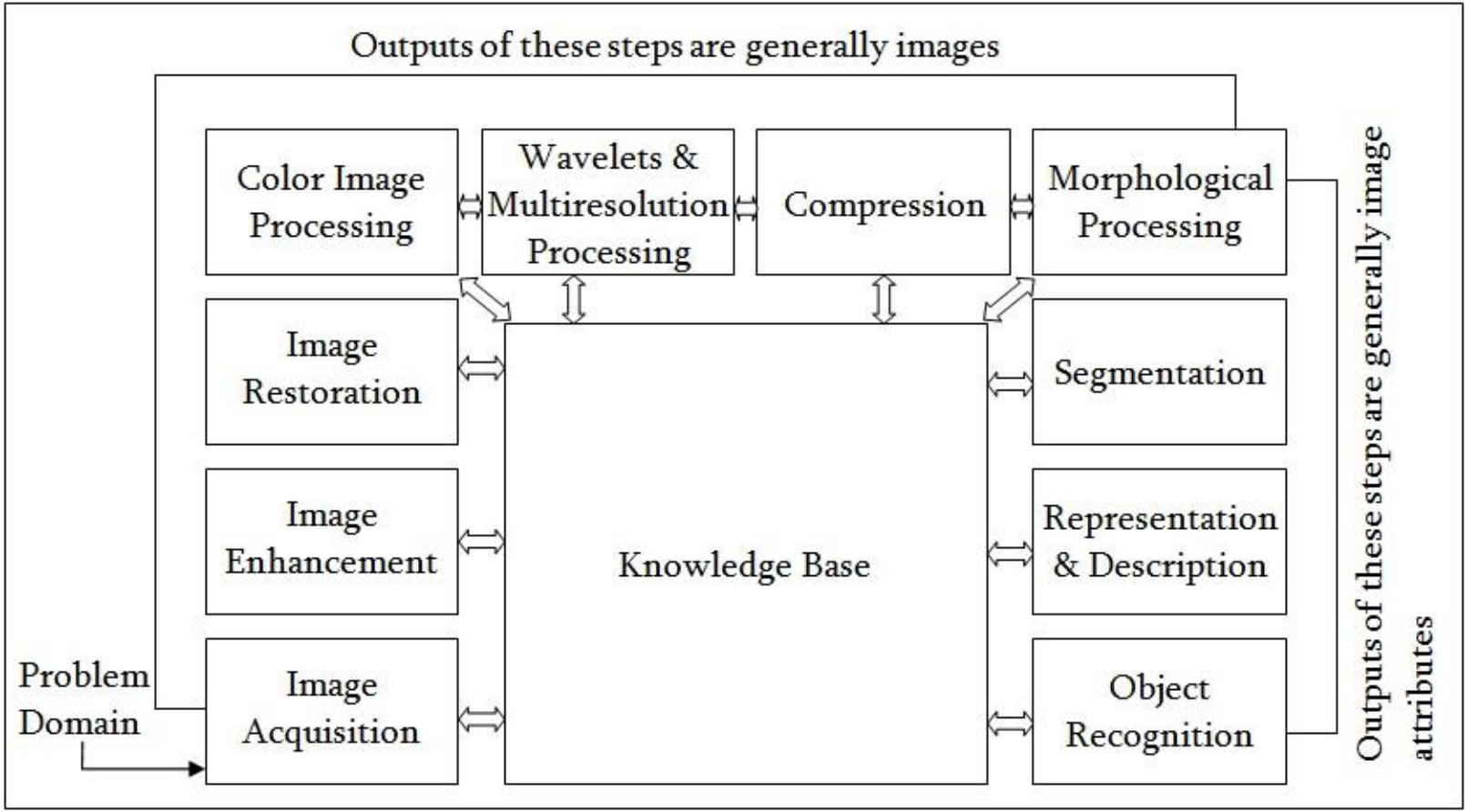

Outputs of these steps are generally images
car
bicycle
dog
ion
Morphological Processing
Segmentation
Representation & Description
Object Recognition
Outputs of these steps are generally image attributes
Problem Domain
Image Acquisition

Image Processing Tasks



Tasks of interest: Contrast adjustment

Image courtesy: mathworks

Tasks of interest: Edge Detection

Image courtesy: mathworks

Tasks of interest: Feature detection + stitching

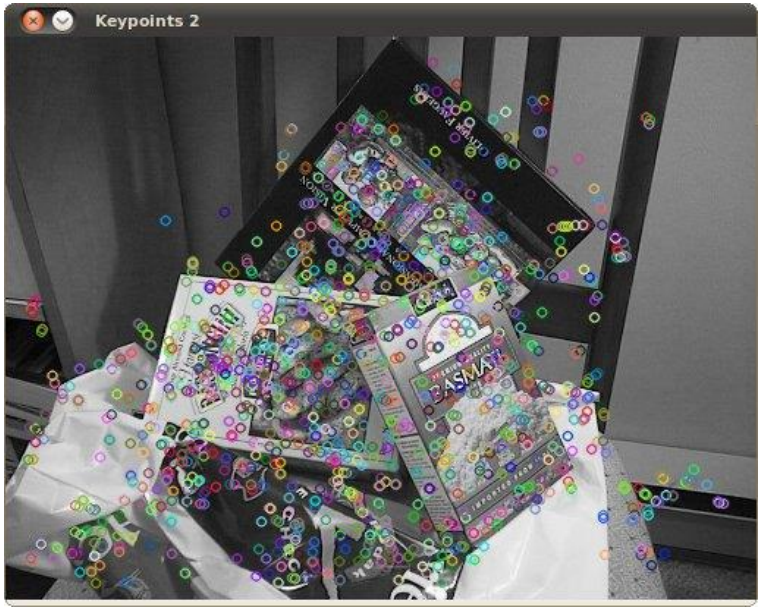


Image courtesy: opencv

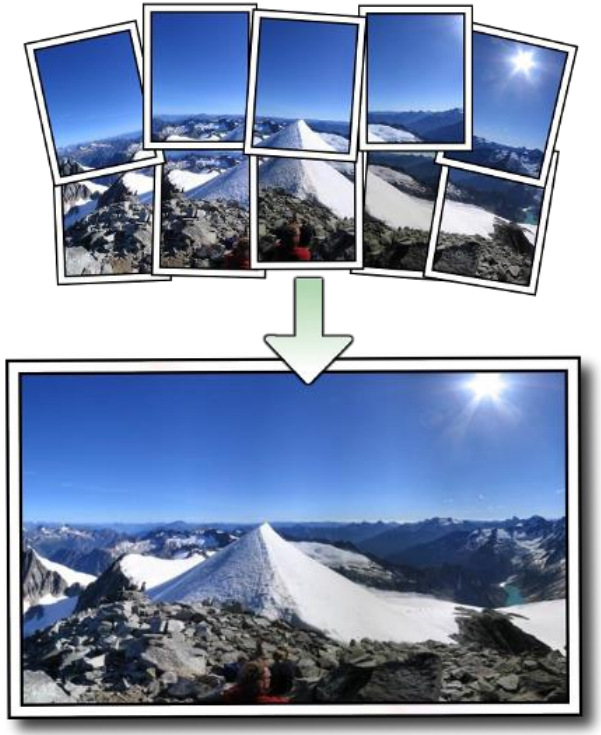


Image courtesy: autostitch

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]

Retouch Personal Photos!

©Images taken from the web.

Tasks of interest: Artistic enhancement

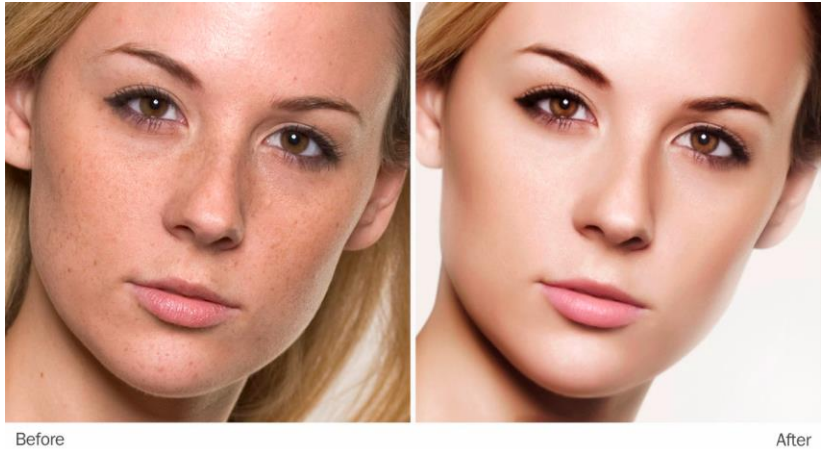


Image courtesy: webneel.com

Image courtesy: Jon Morse

BW to Color

Mayabazar (1957), Vijaya Vauhini Studios

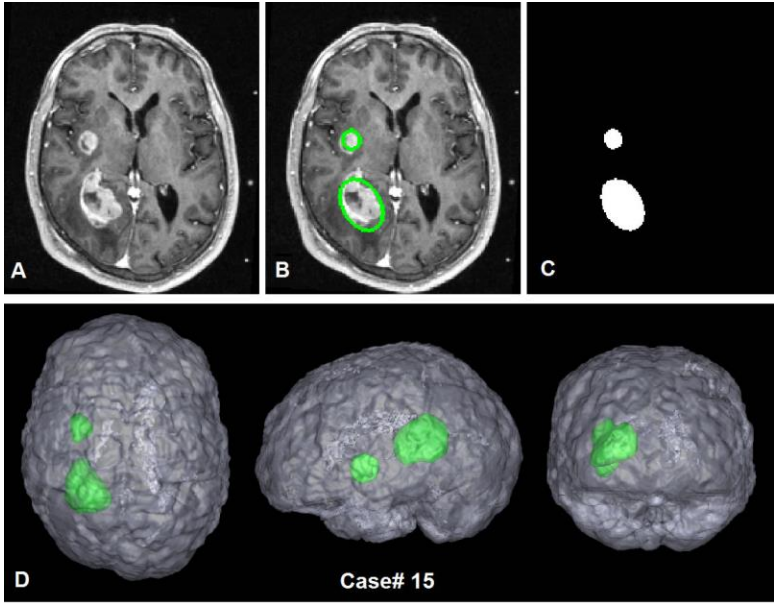
Colorized (2010)

Tasks of interest: Cinematic Grading

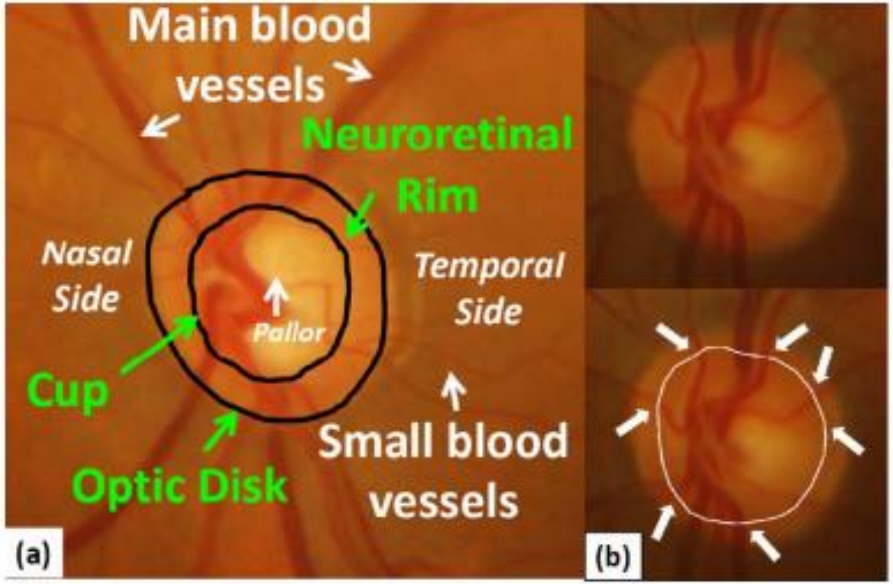
Mission Impossible - Ghost Protocol, Paramount Pictures

Image courtesy: juanmelara.com

Tasks of interest: Segmentation

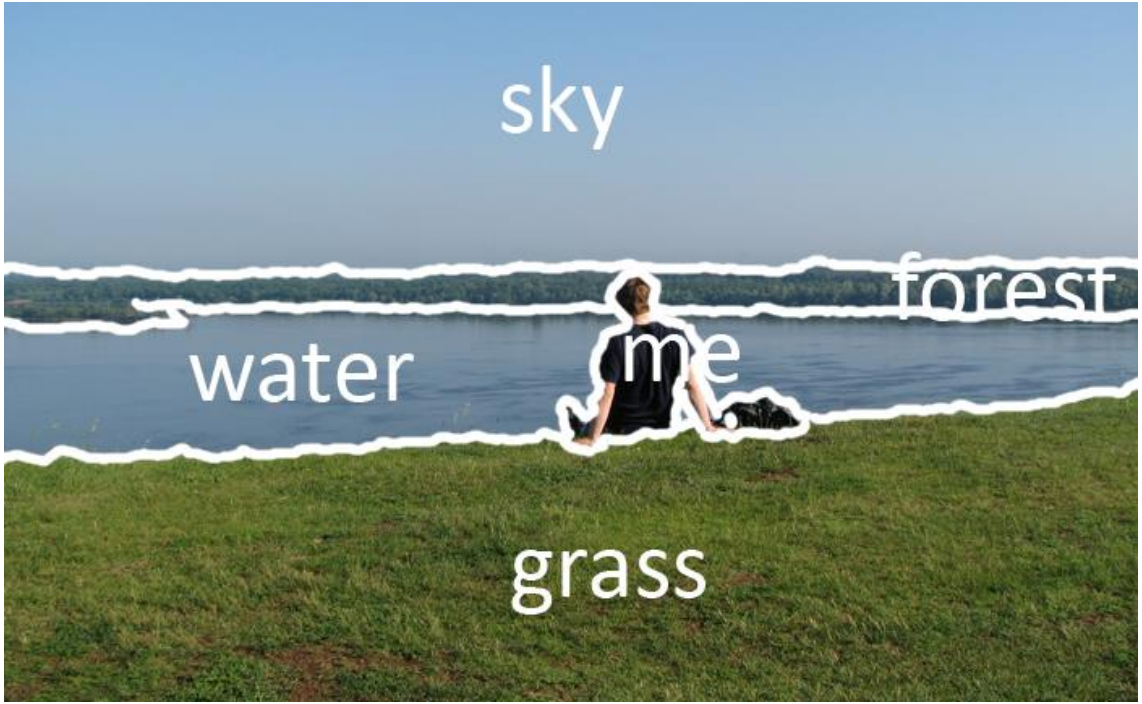


Tumour Segmentation [Yu et al. MICCAI 2010]



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)

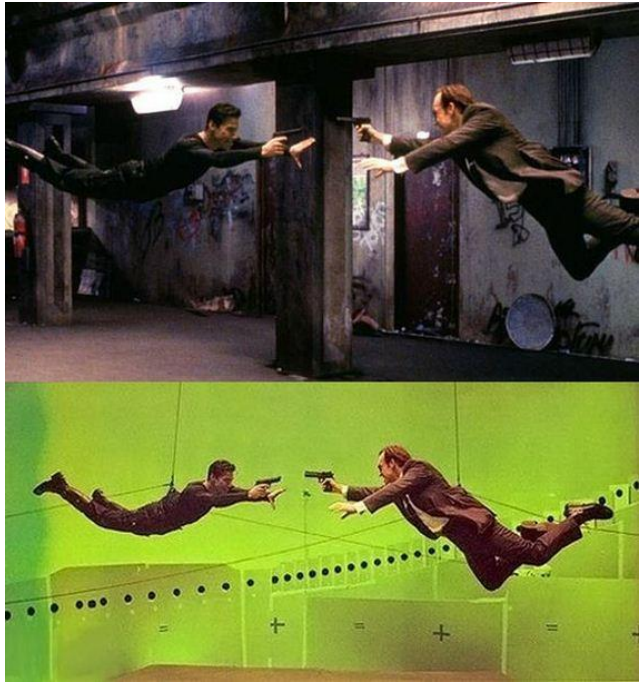
Tasks of interest: Inpainting

DAMAGED

RESTORED

Bertalmio et al. SIGGRAPH 2010

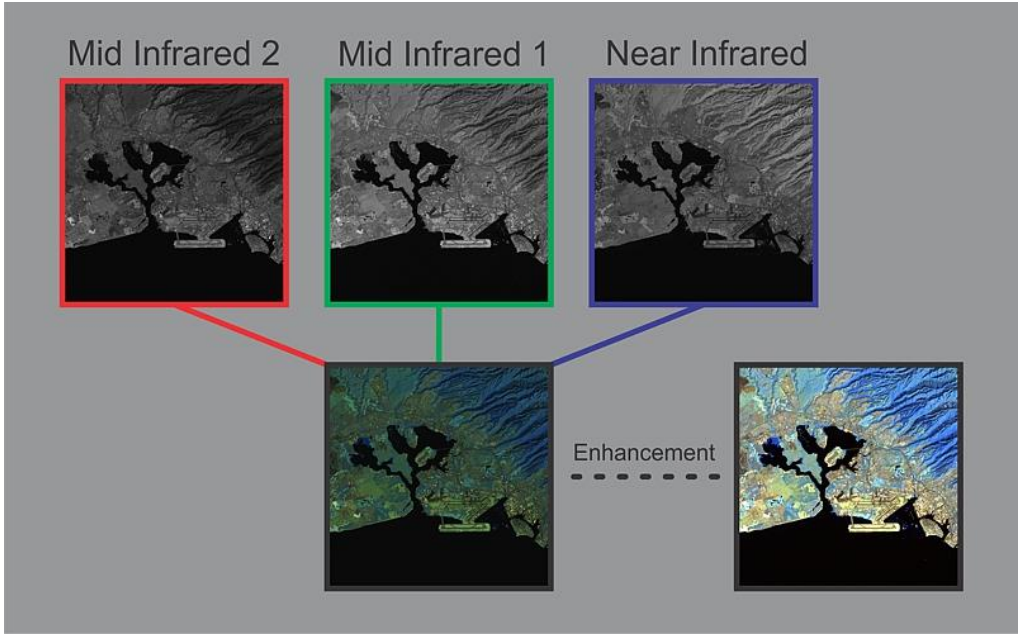
Tasks of interest: Special effects

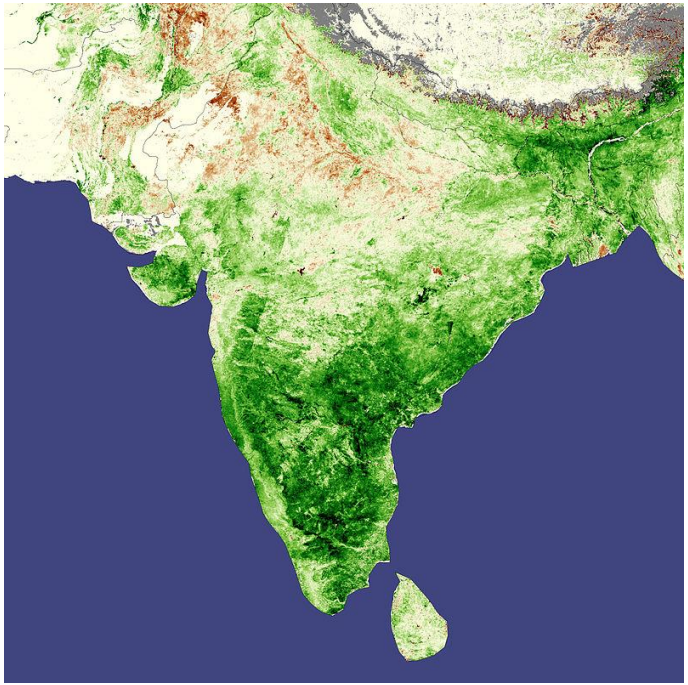


courtesy: wachowski brothers (matrix)

courtesy: Miller et al. (sin city)

Tasks of interest: Satellite imaging

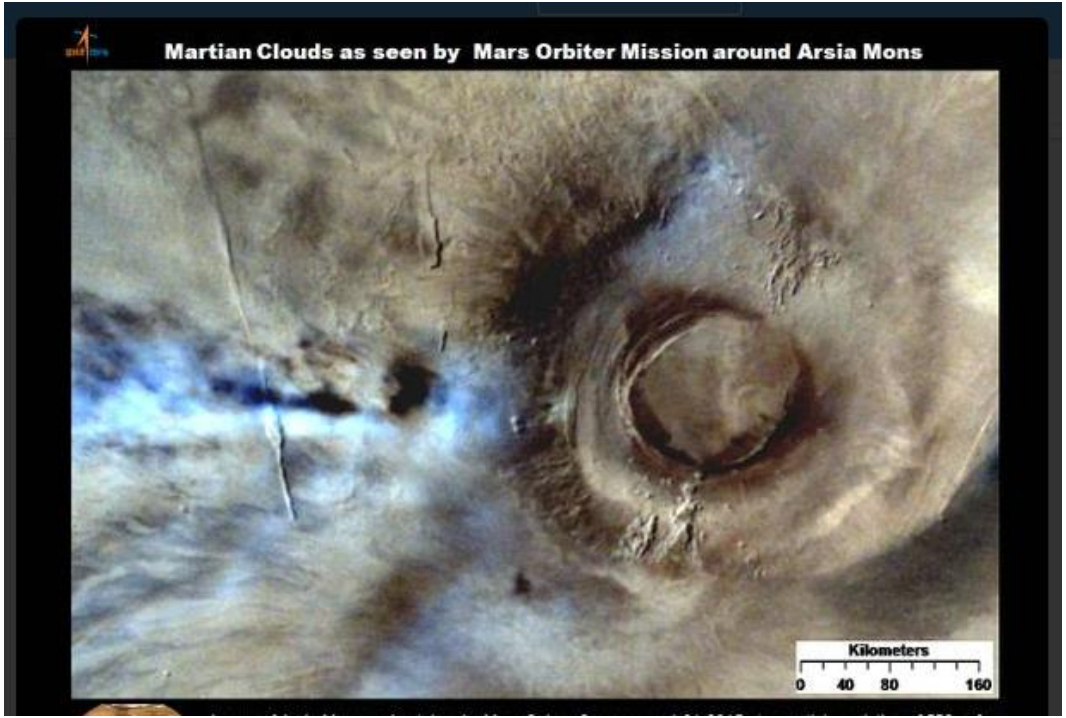


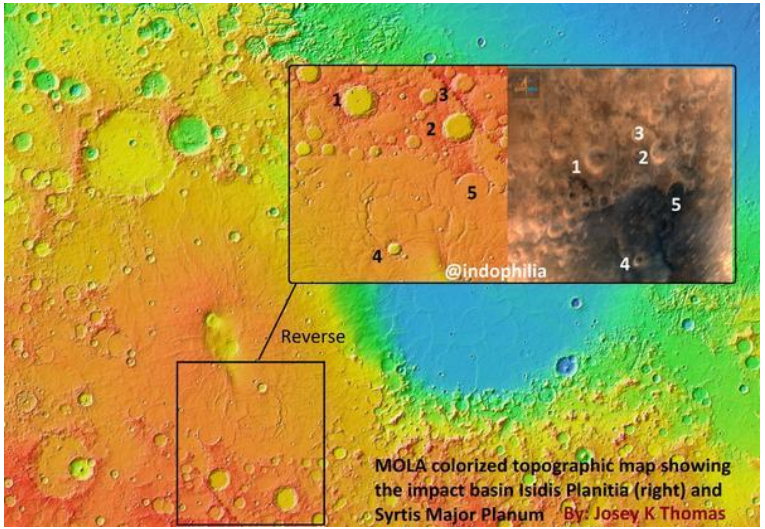


Terrain classification, weather predictions etc.

courtesy: NASA

Tasks of interest: Astronomy

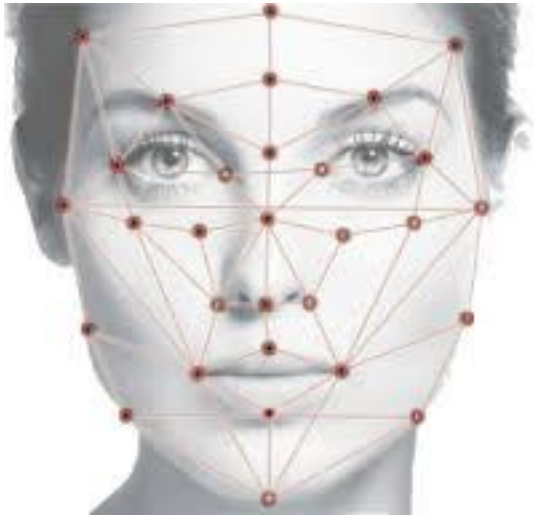




courtesy: ISRO

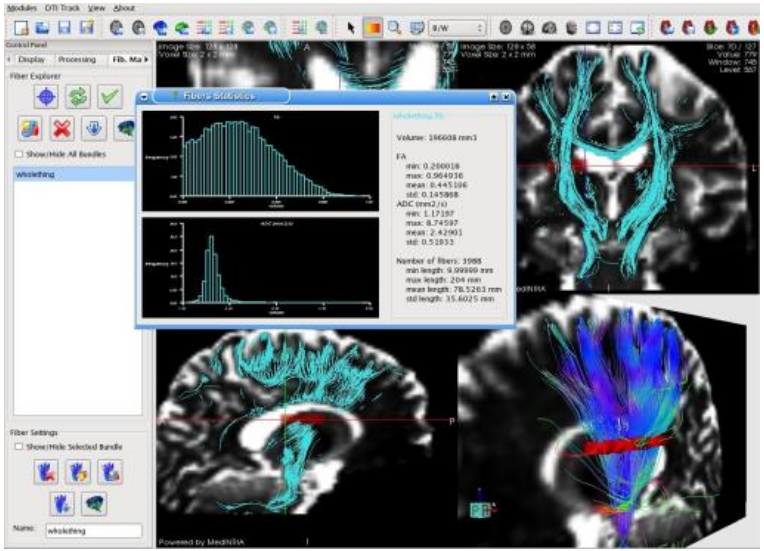
Tasks of interest: Biometrics

courtesy: dqindia.com

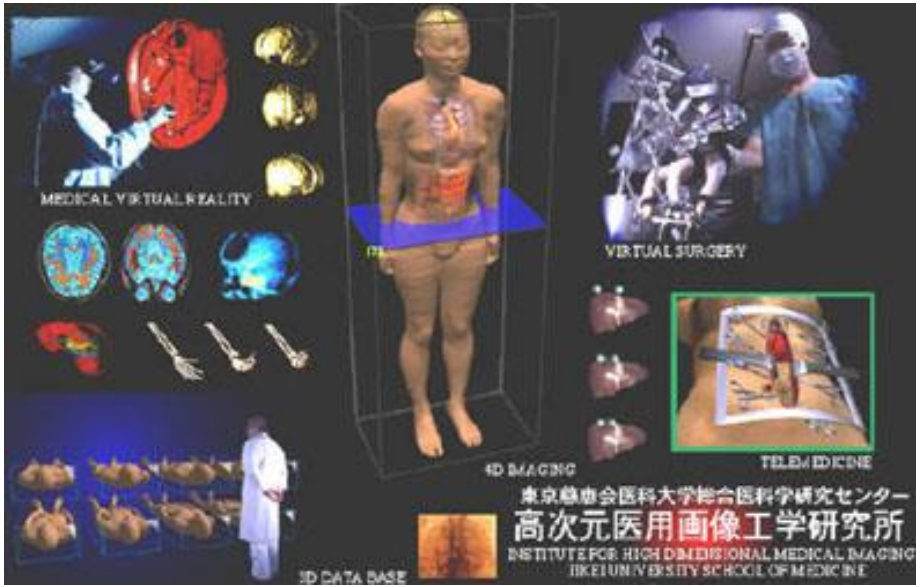


courtesy: heyce.com

Tasks of interest: Medicine



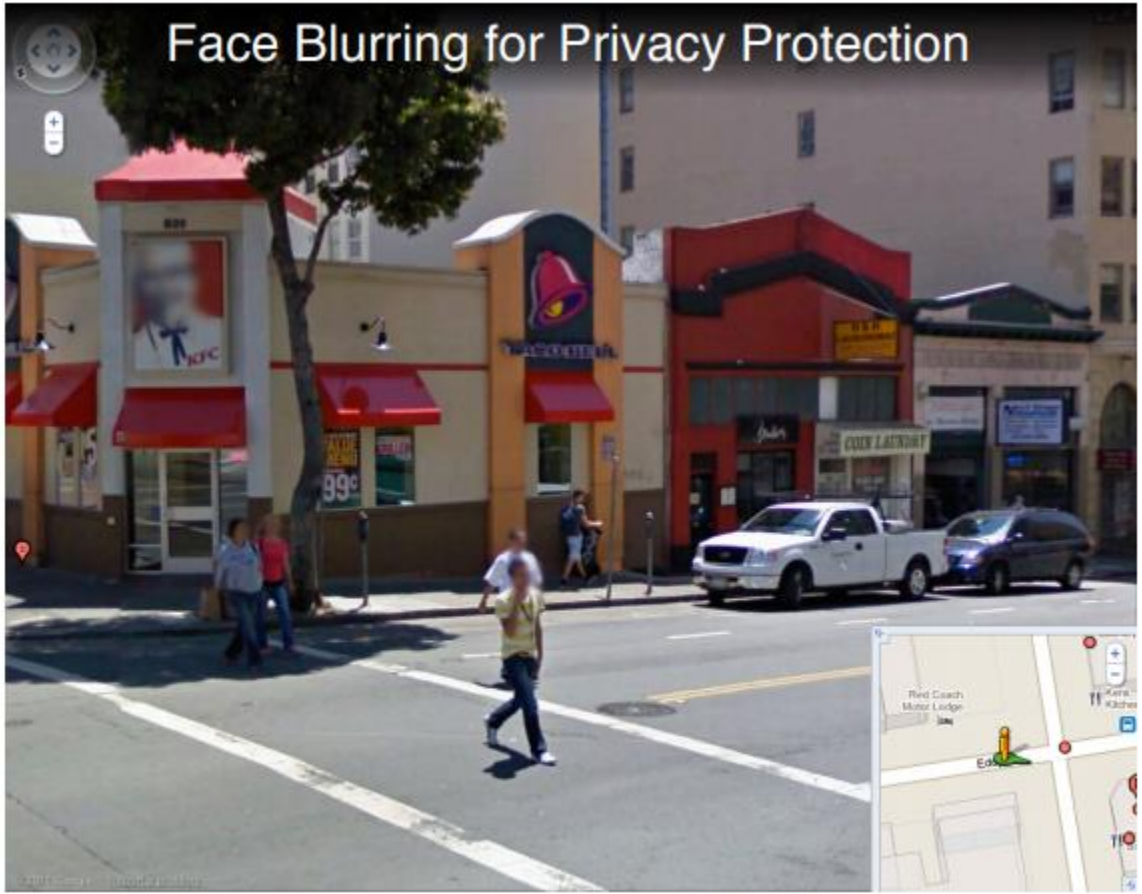
Courtesy: medINRIA



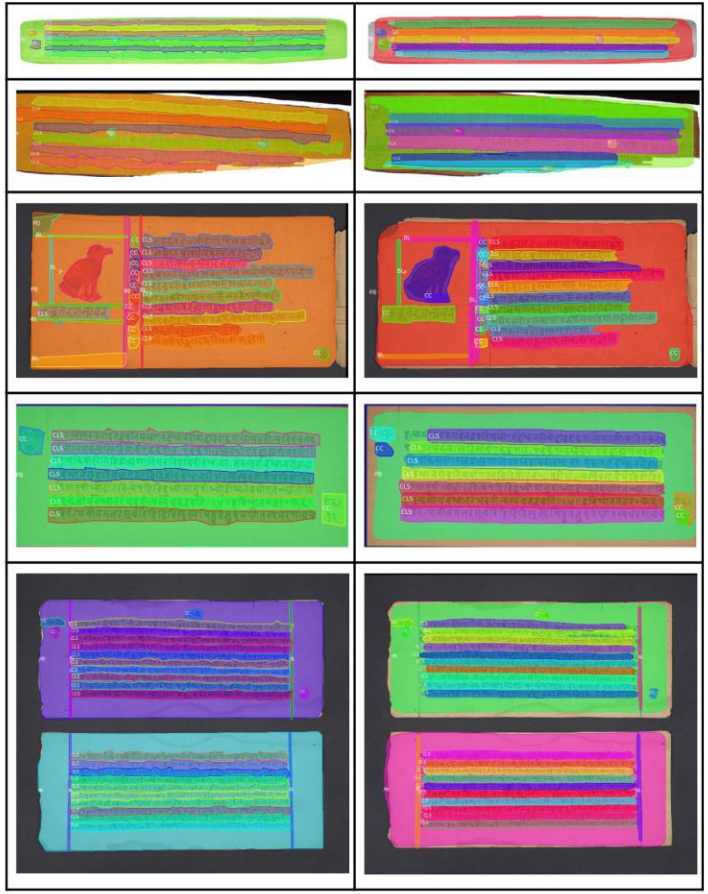
Courtesy: Naoki Suzuki

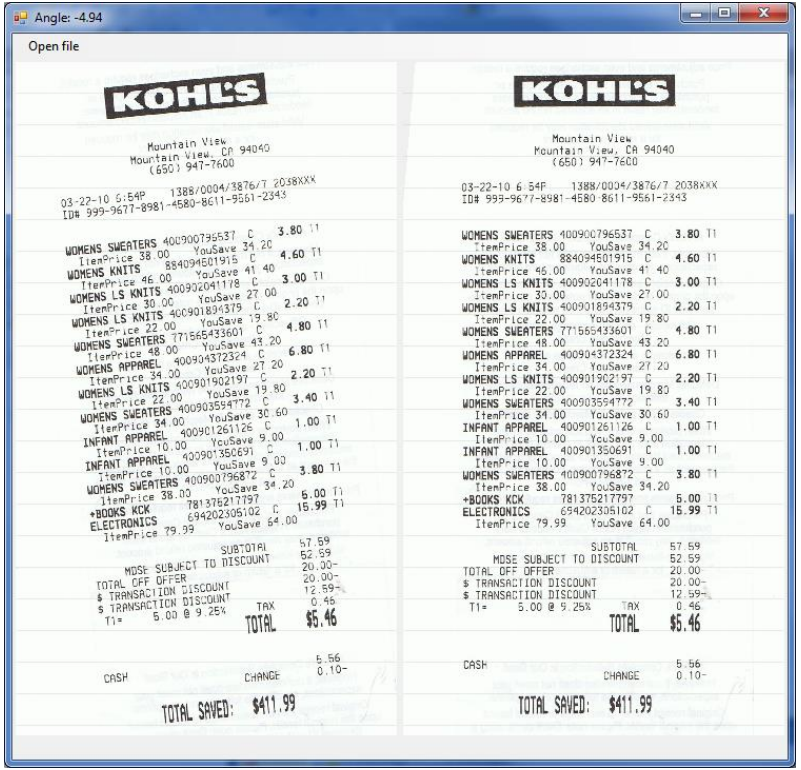
Tasks of interest: Driverless Vehicle Systems

Face Blurring for Privacy Protection



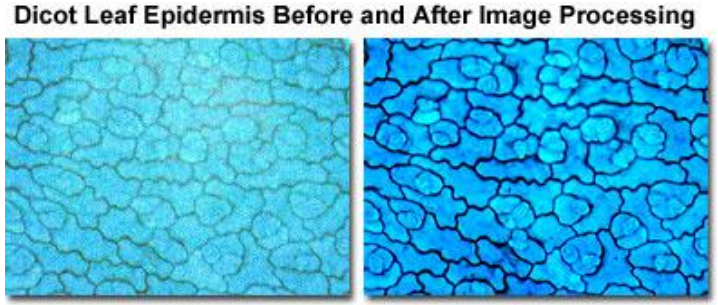
Tasks of interest: Document Image Analysis



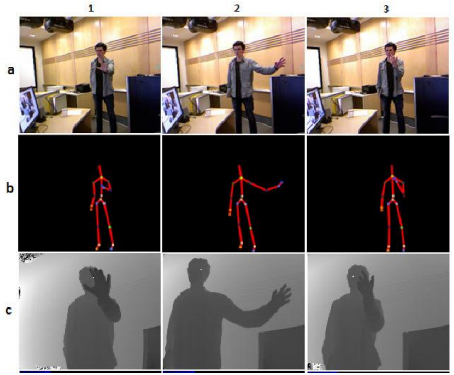


Tasks of interest: Many more

- Biology
- HCI
- Number Plate recognition
- Gesture recognition



Courtesy: Olympus



Courtesy: Perviverzov et al. 2012

Courtesy: researchdesignlab.com

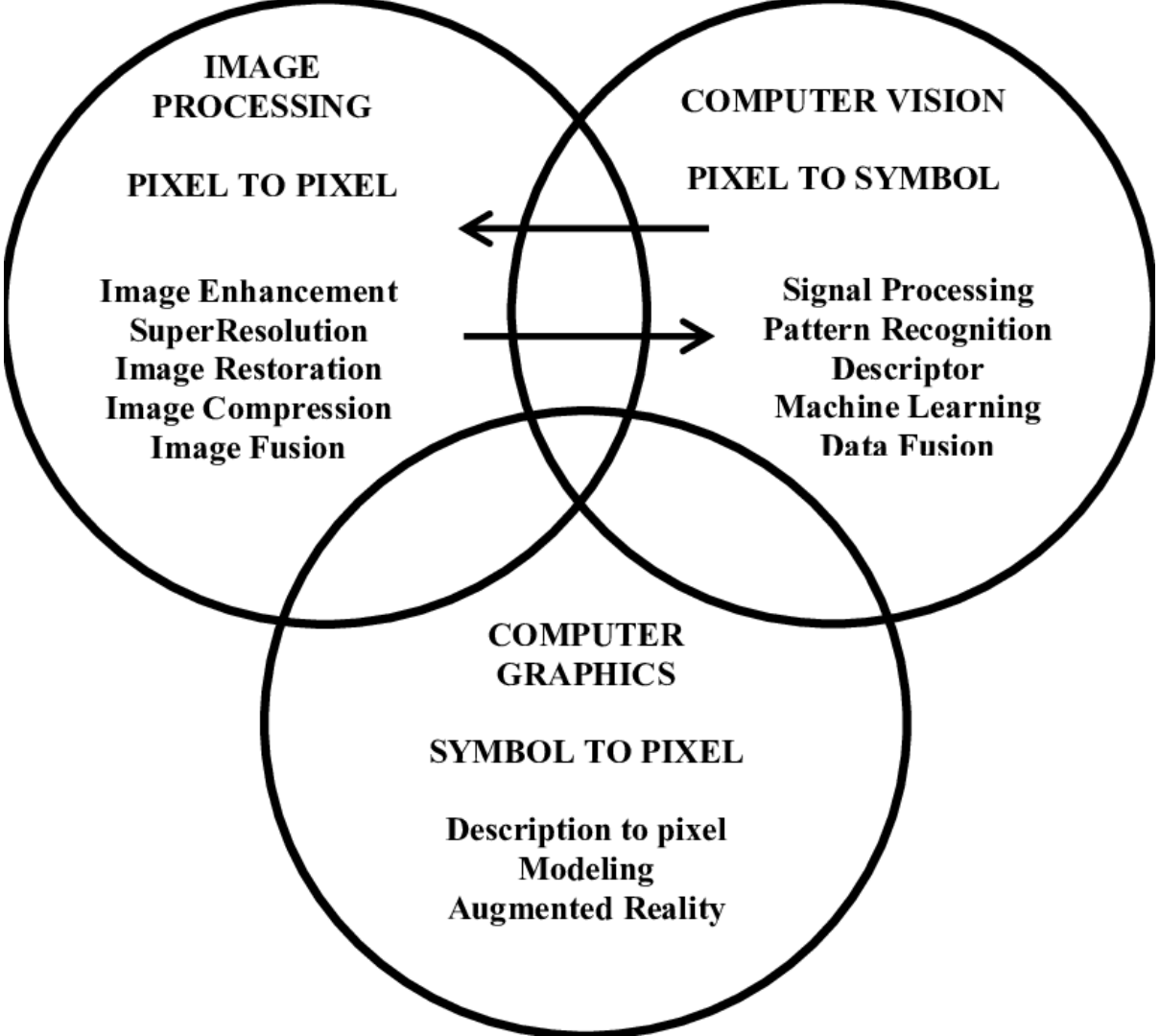


IMAGE PROCESSING
PIXEL TO PIXEL
Image Enhancement
SuperResolution
Image Restoration
Image Compression
Image Fusion
COMPUTER VISION
PIXEL TO SYMBOL
Signal Processing
Pattern Recognition
Descriptor
Machine Learning
Data Fusion
COMPUTER GRAPHICS
SYMBOL TO PIXEL
Description to pixel
Modeling
Augmented Reality

Computational Photography

Computer Graphics

+ easy to create new worlds

+ easy to manipulate objects/viewpoint

- Very hard to look realistic

Realism
Manipulation
Ease of capture

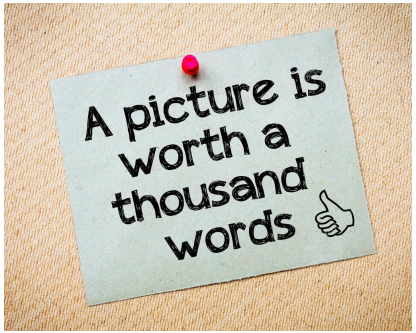
Photography

+ instantly realistic

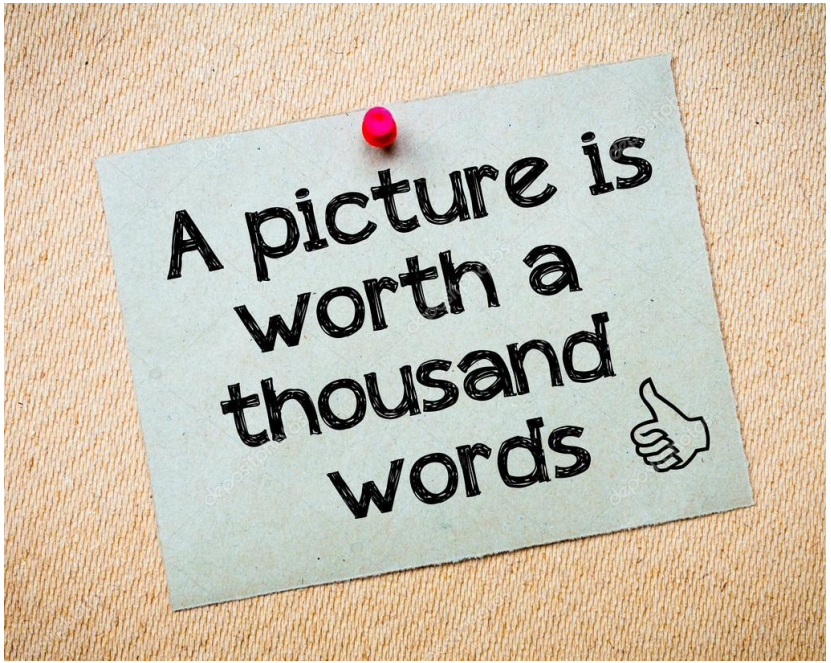
+ easy to aquire

- very hard to manipulate objects/viewpoint

http://www.cs.toronto.edu/~guerzhoy/320/lec/Introduction.pdf



http://karpathy.github.io/2012/10/22/state-of-computer-vision/


A picture is worth a thousand words

TACO BELL

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FOR OUR

Companies and Software

AUTODESK®
PIXLR®

Adobe Premiere

Final Cut Pro X
Everything just changed in post.

Picasa

Canon

SAMSUNG

PHILIPS

SIEMENS

Research

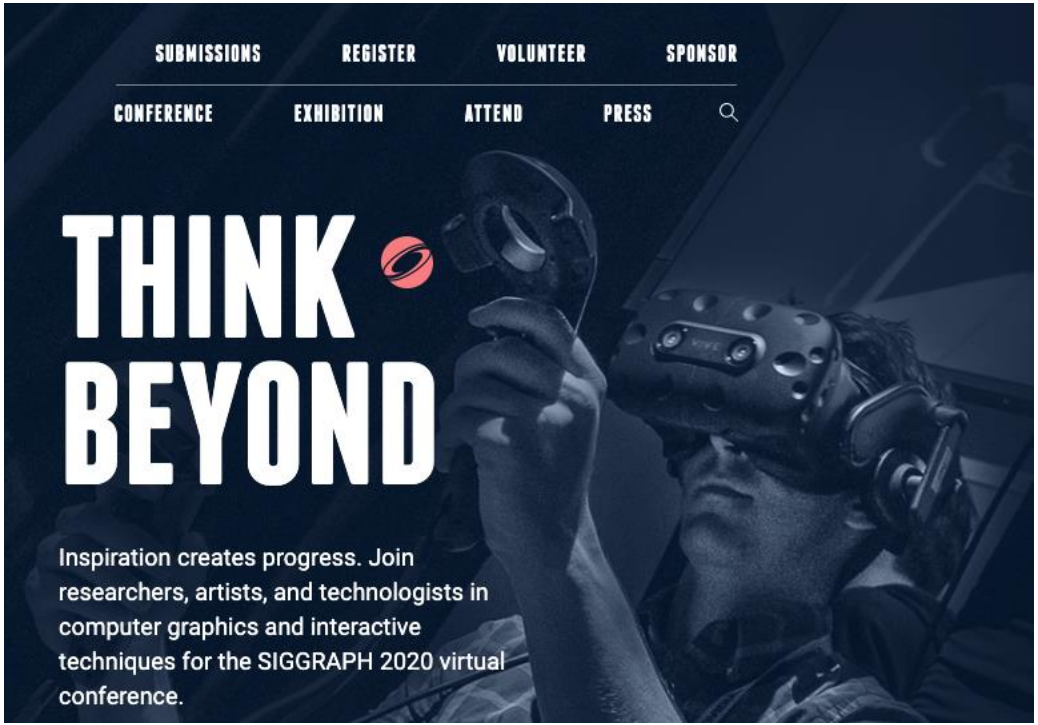
- Journals

Research

- Conferences

Research

- Conferences



About the course

- Timings: Tue, Fri (Online, **03.30pm – 05.00pm**)
- Pre-requisites
  - (CS): Programming, Data Structures, Algorithms
  - (MA): Basics of Linear Algebra, Calculus

About the course - Material

- [Text] Digital Image Processing by Gonzalez and Woods
- Scattered Resources across Internet

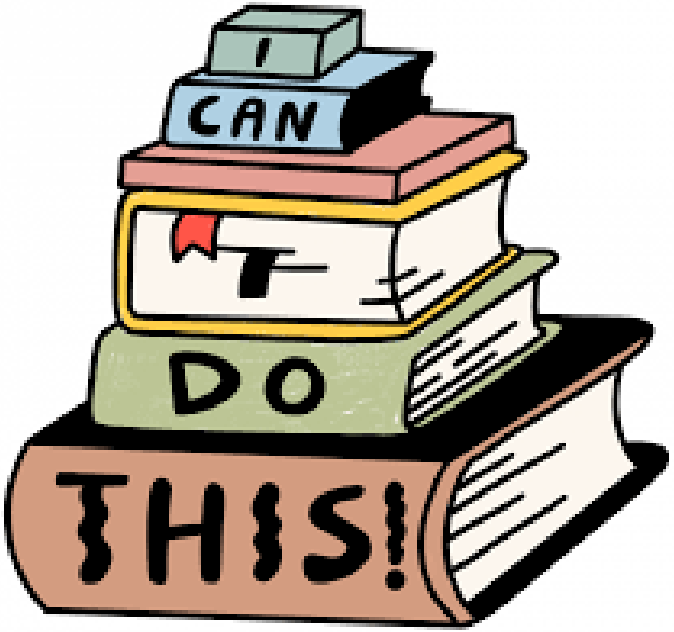
- Syllabus (tentative) – posted on Moodle

About the course

- Teaching Assistants : Will be announced in next class
- Office Hours :
  - Tuesday, Friday : 5.00pm – 5.30pm [after class]

About the course – Grading Policy

- Assessment
  - Assignments (3) : 30 %
  - Quizzes (3) : 30 %
  - Mini Quizzes (best 5/8) : 10 %
  - Group Project : 20 %
  - Your Class Notes : 10 %



About the course – Grading Policy

- Class Notes [from next class onwards]
  - Take handwritten notes during the class in your notebook
  - Take photos of class notes, convert to pdf (e.g. using CamScanner) and upload.
  - Upload instructions will be shared.
  - Upload <u>must</u> be completed within 15 minutes of class ending (i.e. by 5.15 pm).
    - For those who have a class at 5pm, send us email mentioning the course and course instructor. You can submit by 6.45pm.

About the course – Grading Policy

- Class Notes [from next class onwards]
  - Guidelines
    - Contain key ideas, formulae etc. from the lecture
    - Be more than literally writing down stuff from slides
    - Show that you have paid attention through the lecture
  - Will be checked for plagiarism
  - Easiest set of marks to score !
    - But also possible to get a 0 if notes do not follow guidelines
  - If in doubt, take more notes ☺

About the course – Grading Policy

- Mini Quizzes
  - 8 quizzes, 10 minute duration
  - 10 minutes before end of class
  - Best 5 scores considered for marks

About the course – Grading Policy

- Quizzes
  - 3 quizzes, 30 minute duration
  - Wednesday / Saturday afternoons

About the course - assignments

- Rolling / Incremental

About the course - assignments

- Python (mandatory)
- Github Classroom
- Image Processing / Data Processing Libraries
  - scikit-image , opencv-python
  - pandas
  - scikit-learn
  - Do <u>not</u> use libraries for assignments unless explicitly allowed.

About the course – collaboration policy

- OK to discuss questions, 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 !

[redacted]
@[redacted]

Trust nobody not even yourself

6/8/14, 10:22 PM

3,827 RETWEETS **3,114** FAVORITES

About the course – final projects

- Teams of 4
- 5 ➔ stricter grading, higher expectations

About the course – Project

- Creating resources (datasets, tutorials)
- Replicate an interesting research paper
- Original research
- Comparing different existing algorithms

- Deliverables
  - Release the final code (github – code check-in analytics will form basis of marks)
  - Give a group presentation

About the course – Grading Policy

- Homework Late Policy: 25% penalty if one day late; 50% if two days late; 100% if more than two days late
- Project Late Policy: 25% penalty if one day late; 50% if two days late; 100 % if more than two days late
- A one-time late submission bonus:
  - only applicable to assignments (with maximum of 3 days delay).
  - must adhere to standard late submission policy after using your late submission bonus.
  - No exceptions will be made.

About the course - S/W ecosystem

- Tutorial at 6pm-8pm, Saturday + Assignment-0
- Create a Github account (if you don't already have one)
- After creating Github account, FILL THE FORM BELOW BY END OF TODAY: https://forms.office.com/r/QHWQqk2V64
- Do not fill more than once

Additionally …

- **The course load is fairly substantial**
- Elective → Conscious choice
- Starting early on assignments helps
- Spending time everyday on material covered in class helps

Additionally …

- **Understand**, don’t just memorize
- Understand the theory behind library calls !
- Capture the broad ideas and insights (useful years down the line)
- Implement ! No substitute for experience.

Additionally …

- PGSSP / MS
  - Take some time understanding the Moodle portal and other IIIT e-services
  - Consider forming e-study / discussion groups
- Reach out to TAs, me in case you have difficulty with material.
- Feedback need not wait until end of course.

Online

- Do not watch/participate by smartphone
- Use headphones
- Pretend you are in physical classroom (put away phone and other distractions)
- Mute/Close browser windows.
- Watch in full-screen mode

Online

- Take notes actively !
  - Improves ability to summarize key ideas (core career skill !)
  - Do well in mini quizzes

Welcome … and just have fun ☺

Tutorial at 6pm-8pm, Saturday

- Create a Github account
- FILL THIS FORM BY END OF TODAY:
https://forms.office.com/r/QHWQqk2V64

Lecture, Quiz and Assignment Schedule: **https://tinyurl.com/y2bnto6h** **(subject to change)**