

17.08.2021

Digital Image Processing (CSE/ECE 478)

Lecture-1: Overview



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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.)

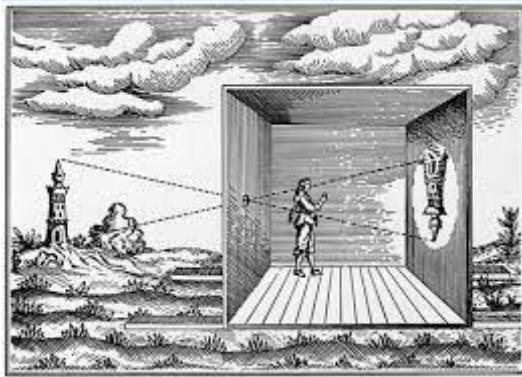
Before there were images

Depicting Our World: Middle Ages

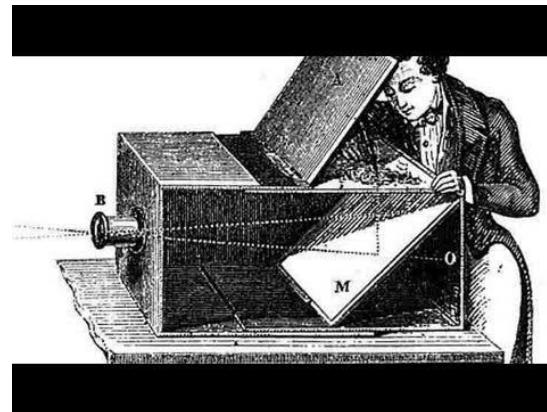


**The Empress Theodora with her court.
Ravenna, St. Vitale 6th c.**

Before there were images



Camera Obscura



Girl with a pearl earring, J. Vermeer, 1665



And then there were images

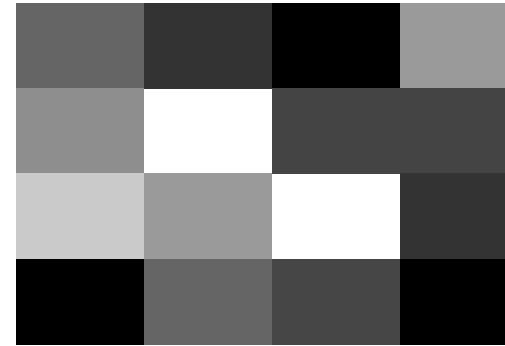


Still Life, Louis Jaques Mande Daguerre, 1837

What is a **digital** image ?

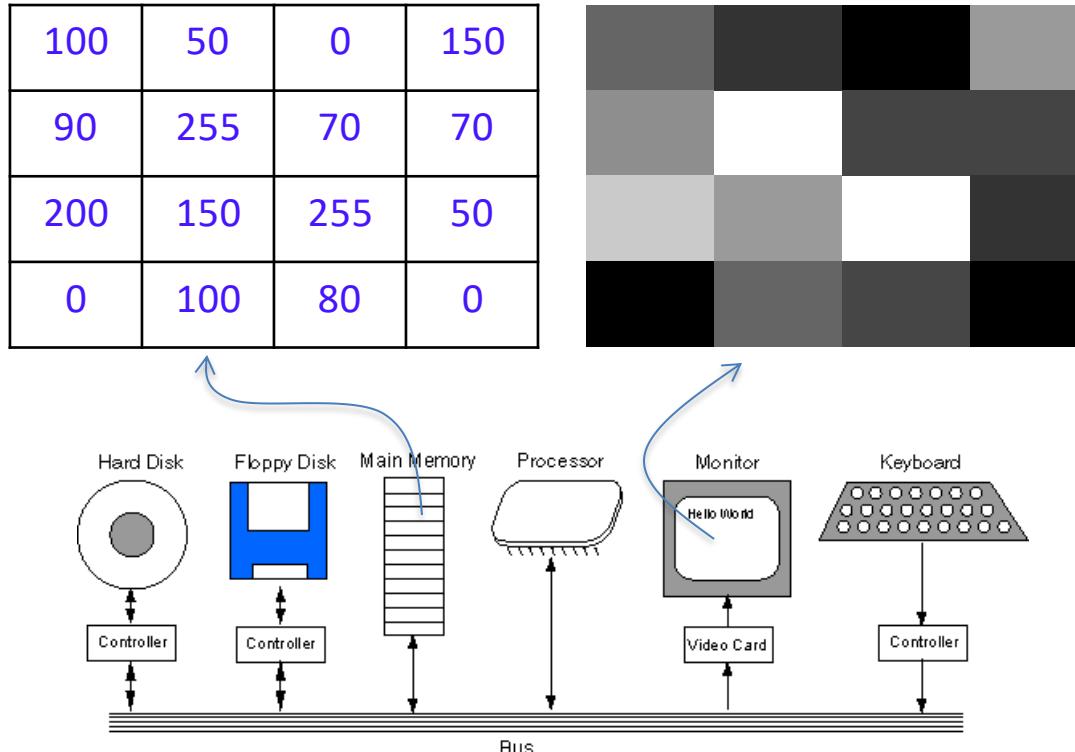
- An **array** of numbers representing **color intensities**

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



What is a **digital** image ?

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



What is a **digital** image ?

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

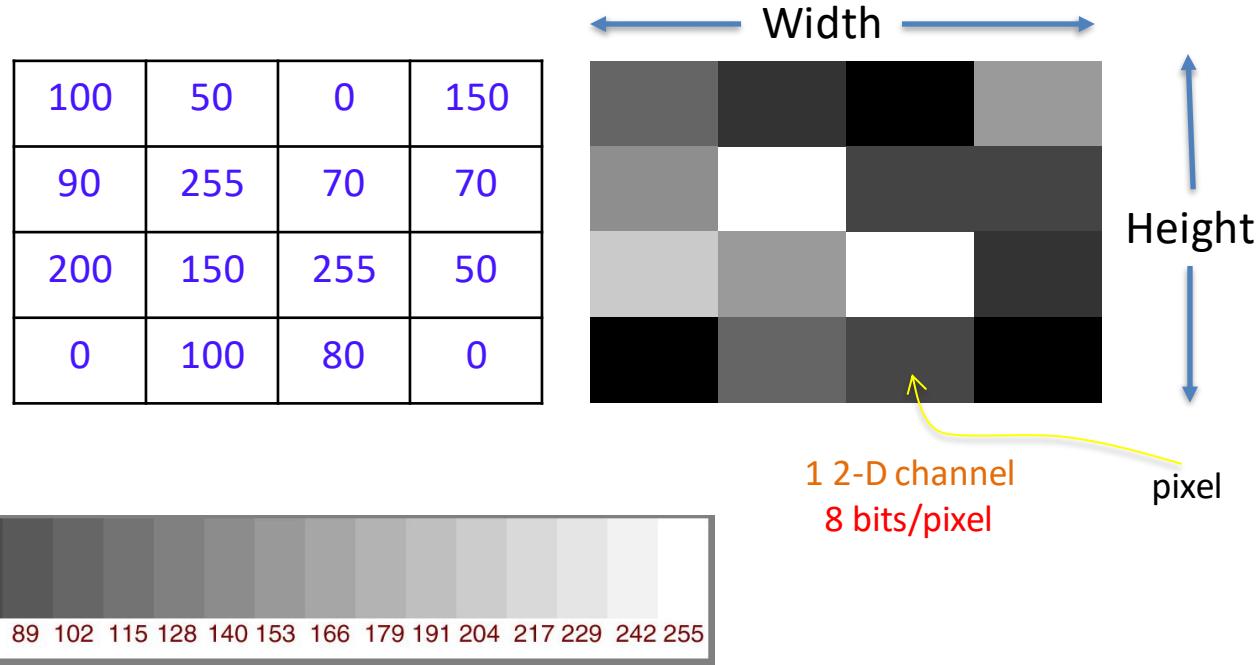
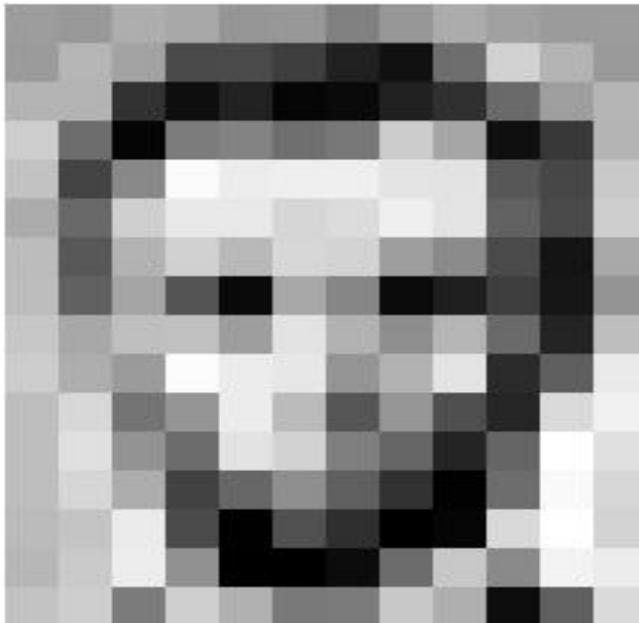


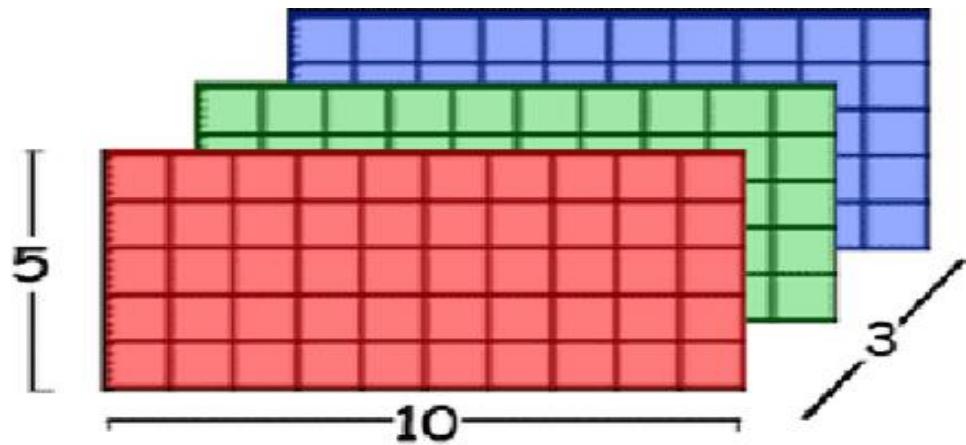
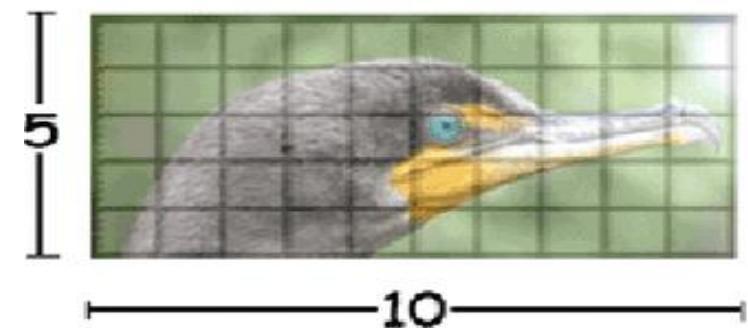
Image Representation (Grayscale)



157	153	174	168	160	152	129	151	172	161	165	156
156	182	163	74	75	62	33	17	110	210	180	154
180	180	50	14	94	6	10	33	48	106	159	181
206	109	5	124	131	111	120	204	165	15	56	180
194	68	137	251	237	239	239	228	227	87	71	201
172	106	207	233	233	214	220	239	228	98	74	206
188	88	179	209	186	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	105	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	108	227	210	127	102	36	101	255	224
190	214	173	65	103	143	95	50	2	109	249	215
187	196	238	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



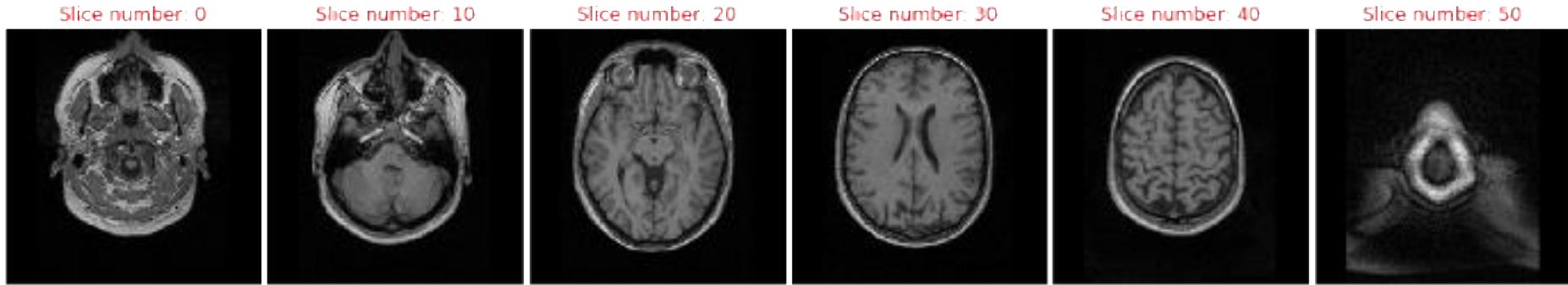
Image Representation (RGB)



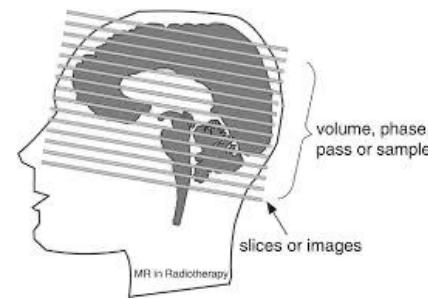
3 2-D channels
24 bits per pixel

Image Representation

fMRI image slices



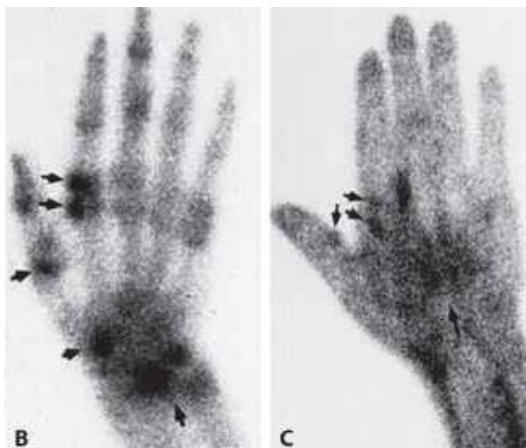
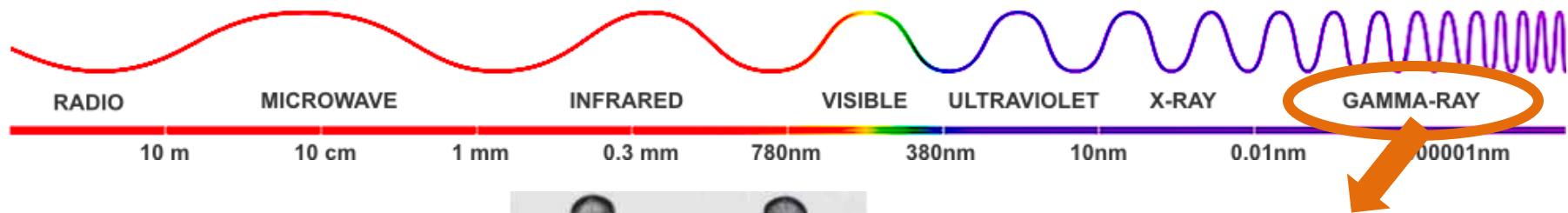
56 2-D channels



Types of Images (classification on source)

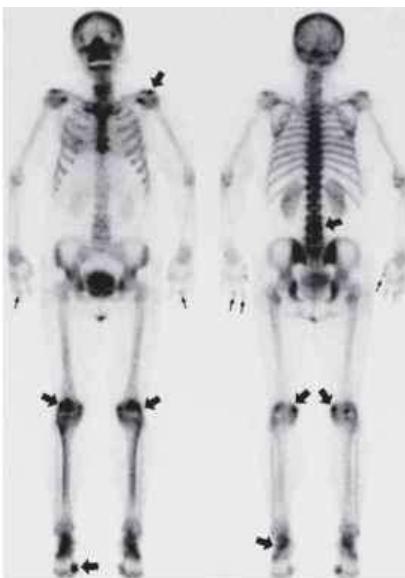
- Radiation from EM spectrum
- Acoustic/ultrasonic/spectrogram
- Electronic
- Computer generated

EM spectrum



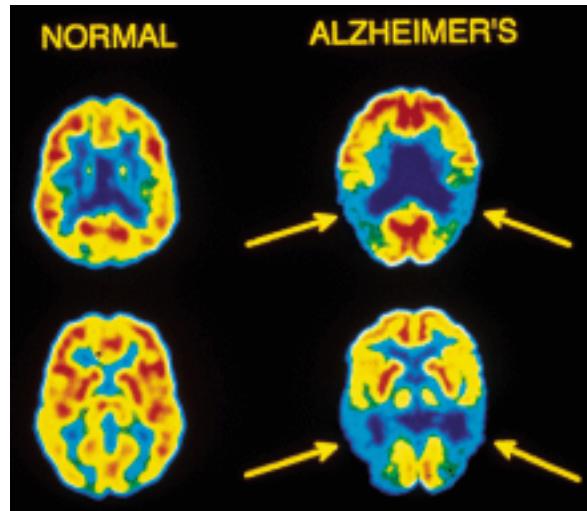
BLOOD FLOW SCAN

courtesy: artheritisresearch.us



BONE SCAN

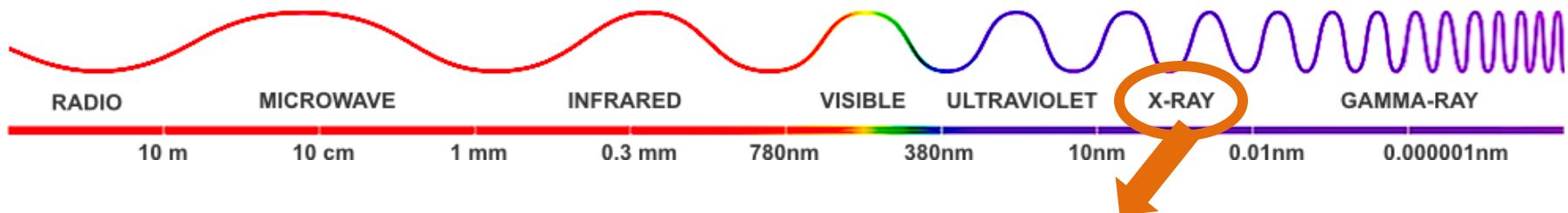
courtesy: artheritisresearch.us



PET SCAN

courtesy: research.ucla.edu

EM spectrum



Wilhelm Röntgen



HAND MIT RINGEN

courtesy: wikipedia



CHEST RADIOGRAPH

courtesy: wikipedia



CT SCAN

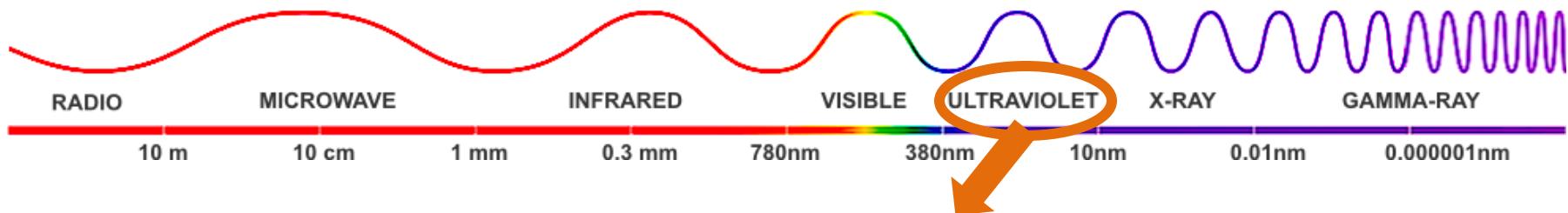
courtesy: wikipedia



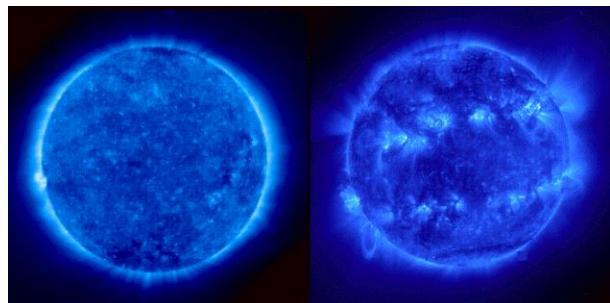
AIRPORT SCAN

courtesy: dpl-surveillance-equipment

EM spectrum



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

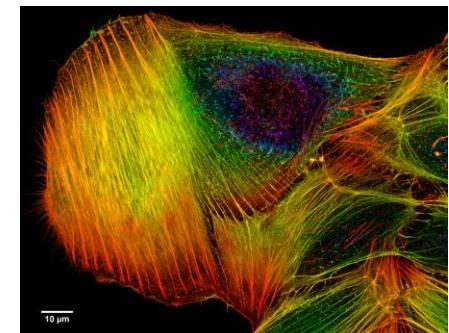


SUN (2 years apart)
courtesy: NASA



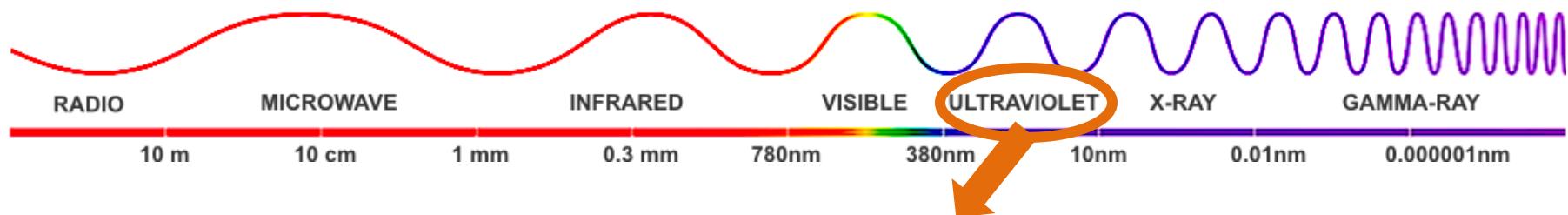
100 EURO BILL
courtesy: lifepixel.com

Eric Betzig, William Moerner and Stefan Hell



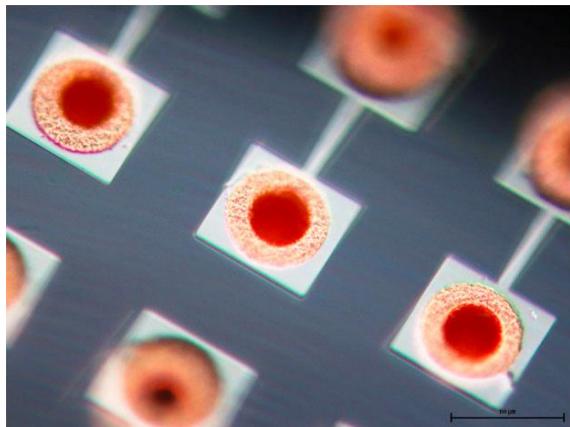
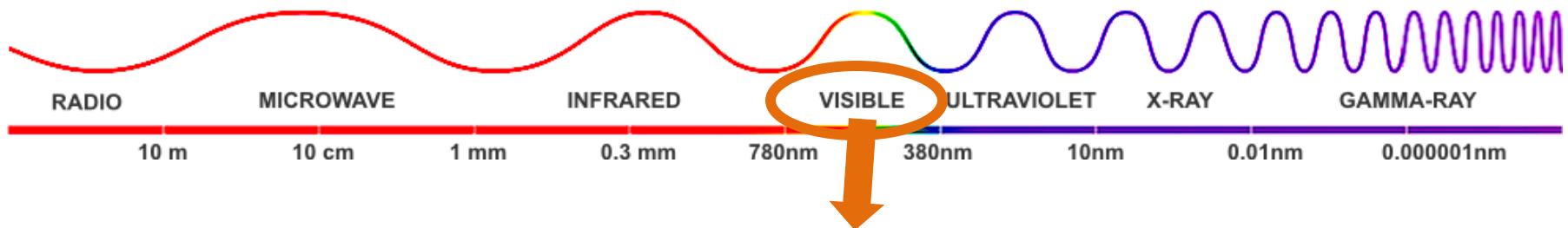
Cell Phalloidin
courtesy: wikipedia

EM spectrum



Source:
Lifepixel.com

EM spectrum



Chips (optical microscopy)

courtesy: EPFL microelectronics systems laboratory



High Speed Photograph

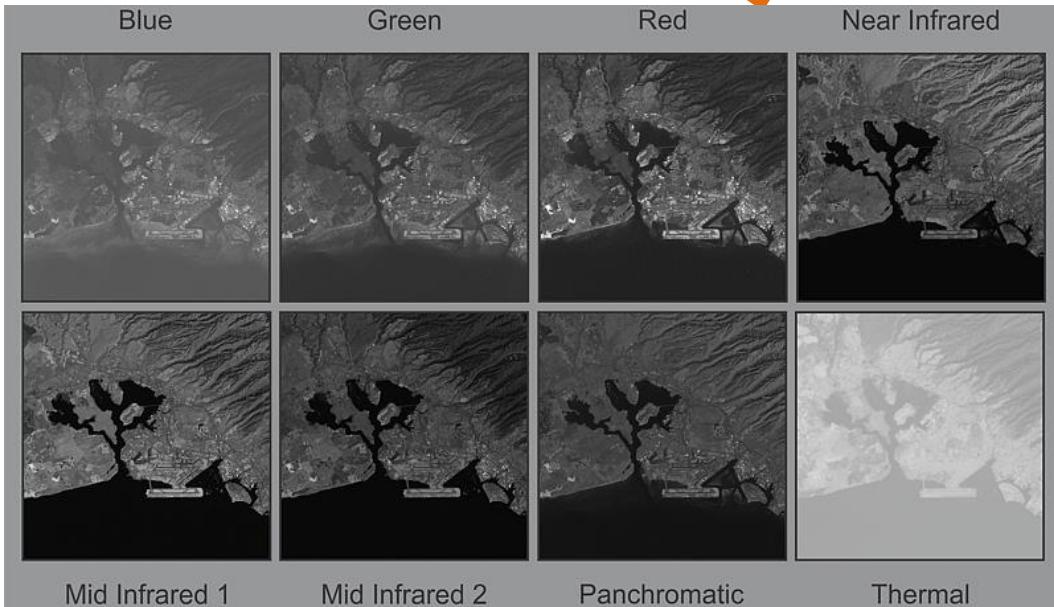
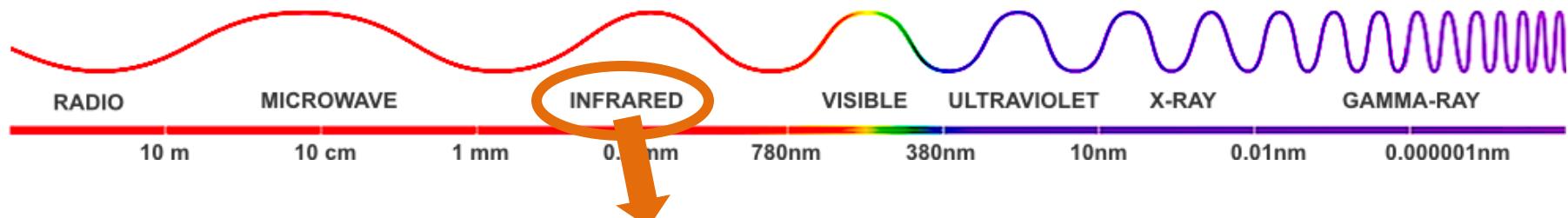
courtesy: Alan Sailer



Satellite Image (Hurricane Katrina)

courtesy: britannica.com

EM spectrum

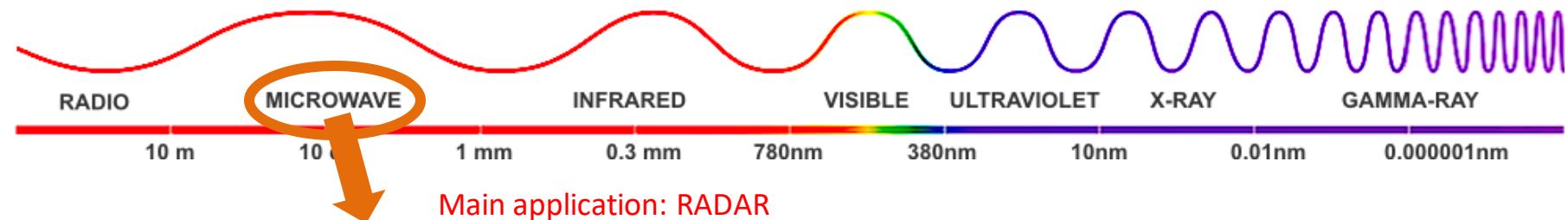


courtesy: LANDSAT (NASA)



courtesy: imaging1.com

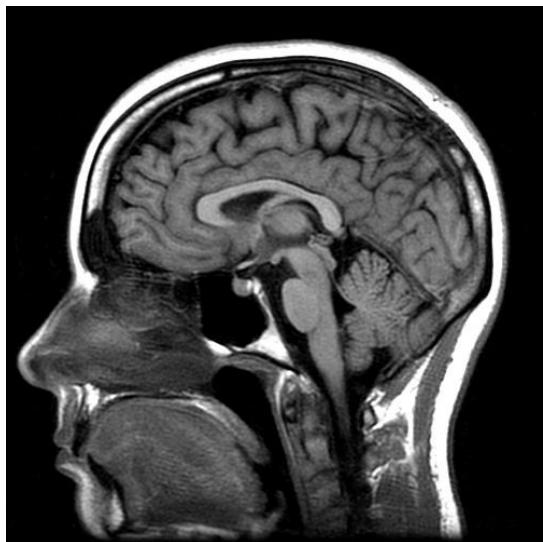
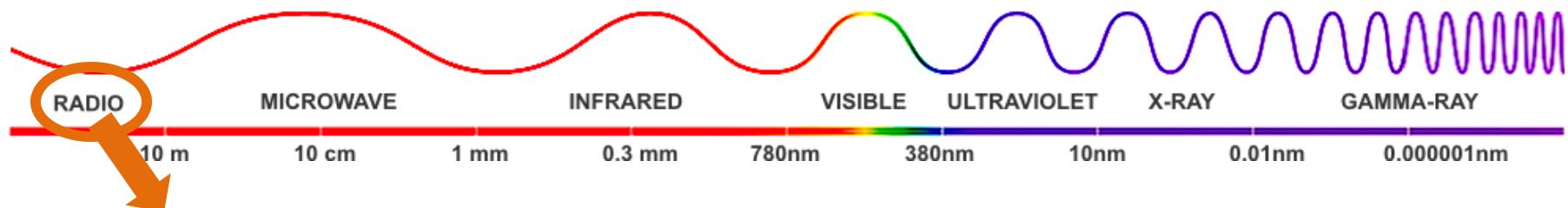
EM spectrum



SOUTHEAST TIBET MOUNTAINS

courtesy: NASA

EM spectrum



MRI Brain

courtesy: mritnt.com



MRI Knee

courtesy: mri-tip.com

Types of Images (classification on source)

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

Ultrasound



ULTRASOUND

courtesy: wikipedia



ULTRASOUND TWINS

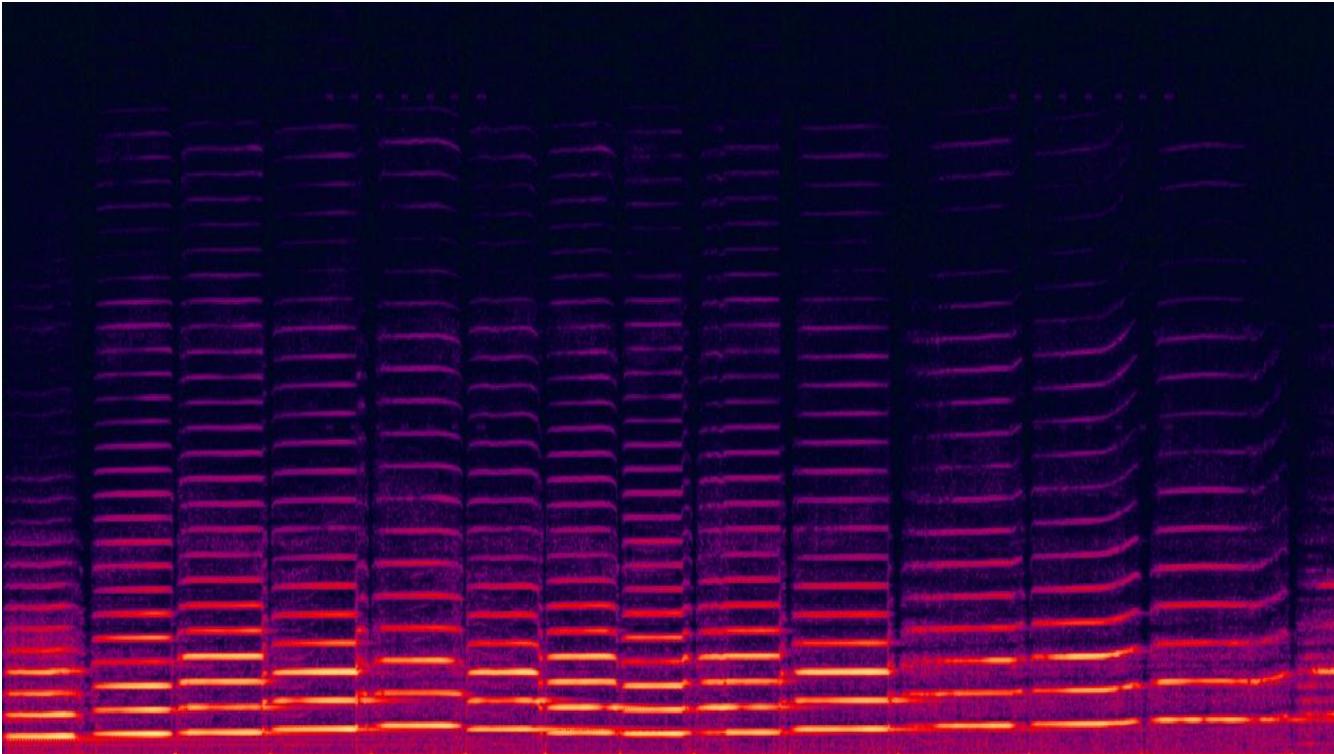
courtesy: pinterest



ULTRASOUND 3D

courtesy: peek3D.com

Spectrogram



Violin Recording
courtesy: wikipedia

Spectrogram

right
tree

eight
bed

cat
happy

go

dog

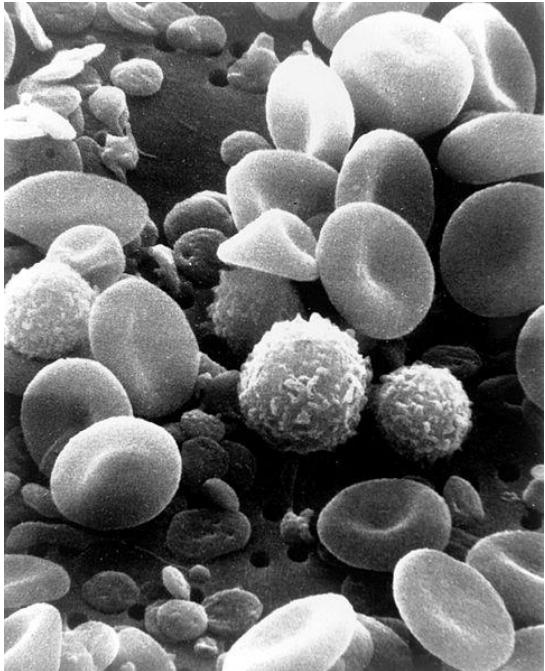
no

Types of Images (classification on source)

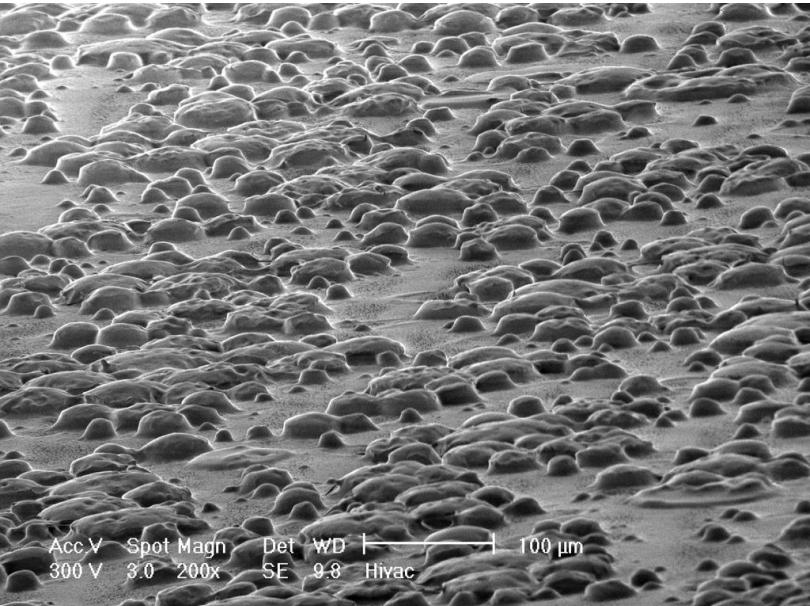
- Radiation from EM spectrum
- Acoustic/ultrasonic/spectrogram
- Electronic
- Computer generated



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
- Electronic
- Computer generated

Computer generated



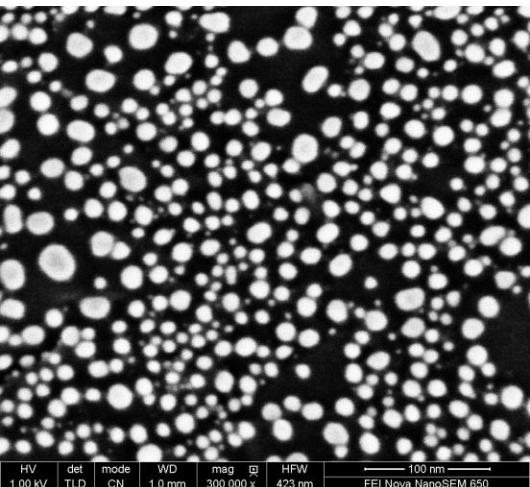
Happy Birthday Nana
courtesy: Dan Roarty





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

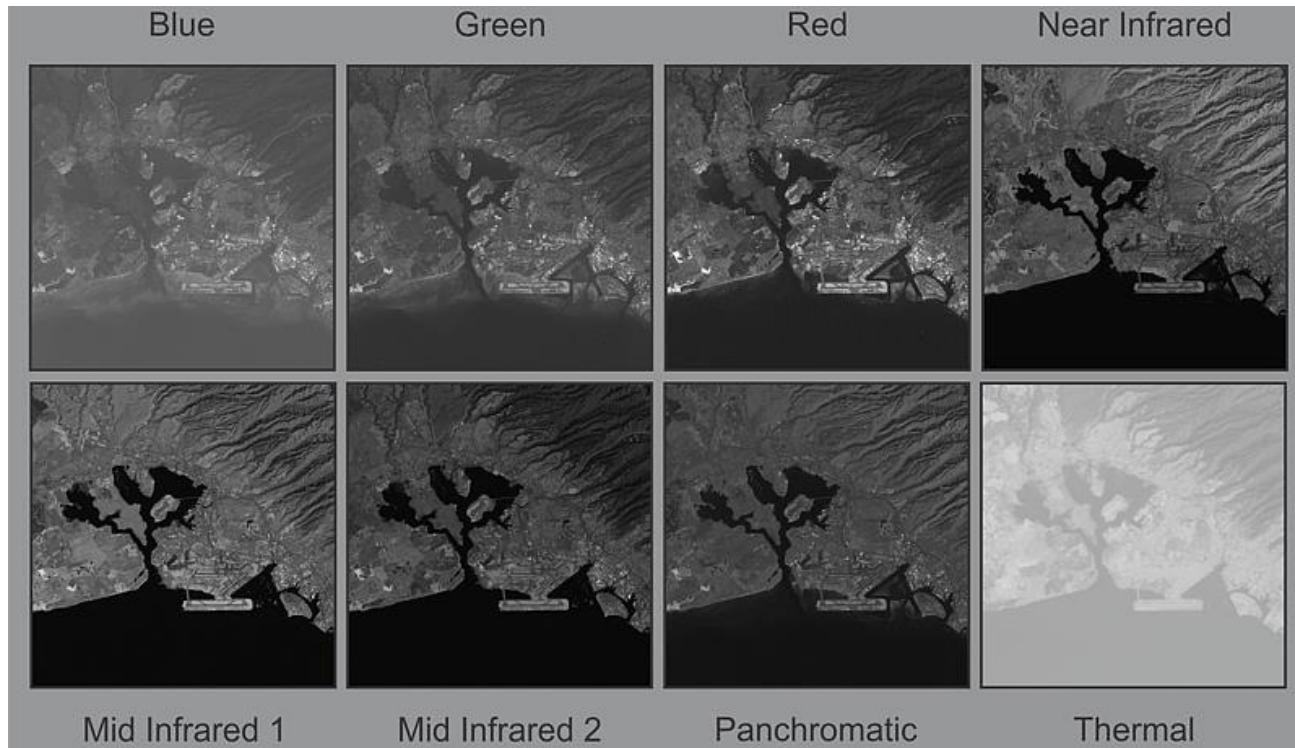
Information primarily about internal properties

Information primarily about internal structure

Types on images (classification on arrangement)

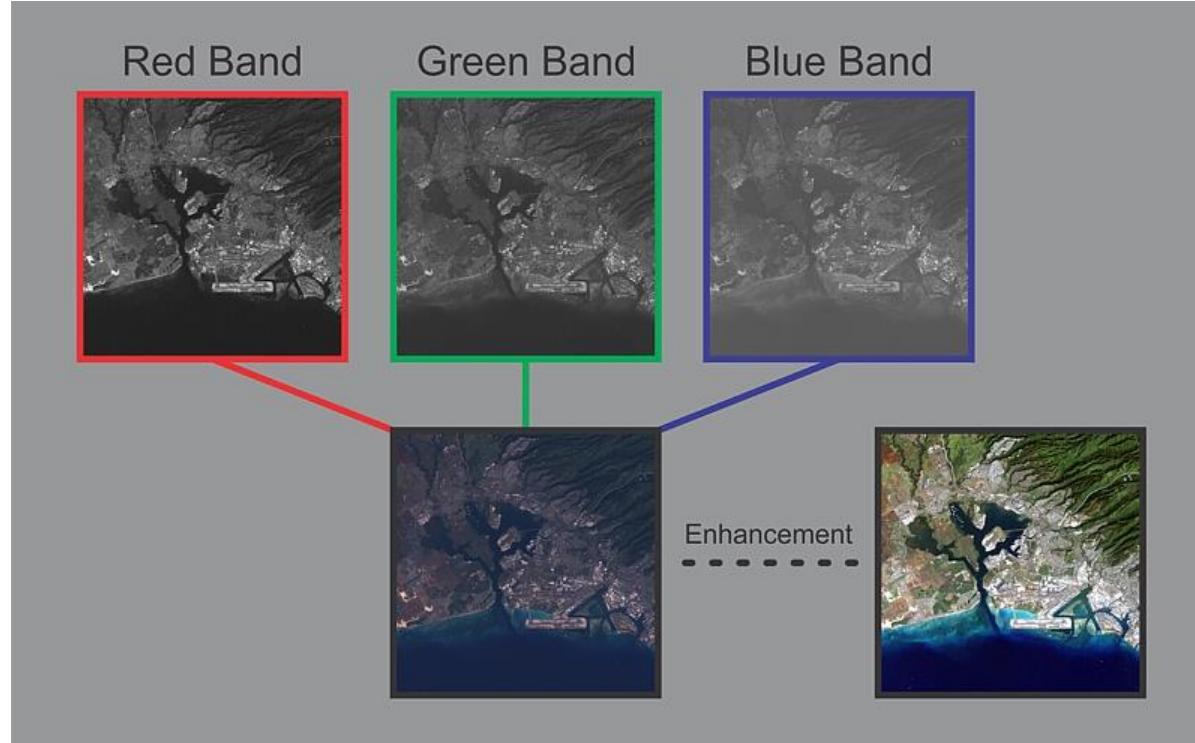
- Grayscale
- RGB
- Multispectral images
- Stereo images
- Multi-view images

Multi spectral images



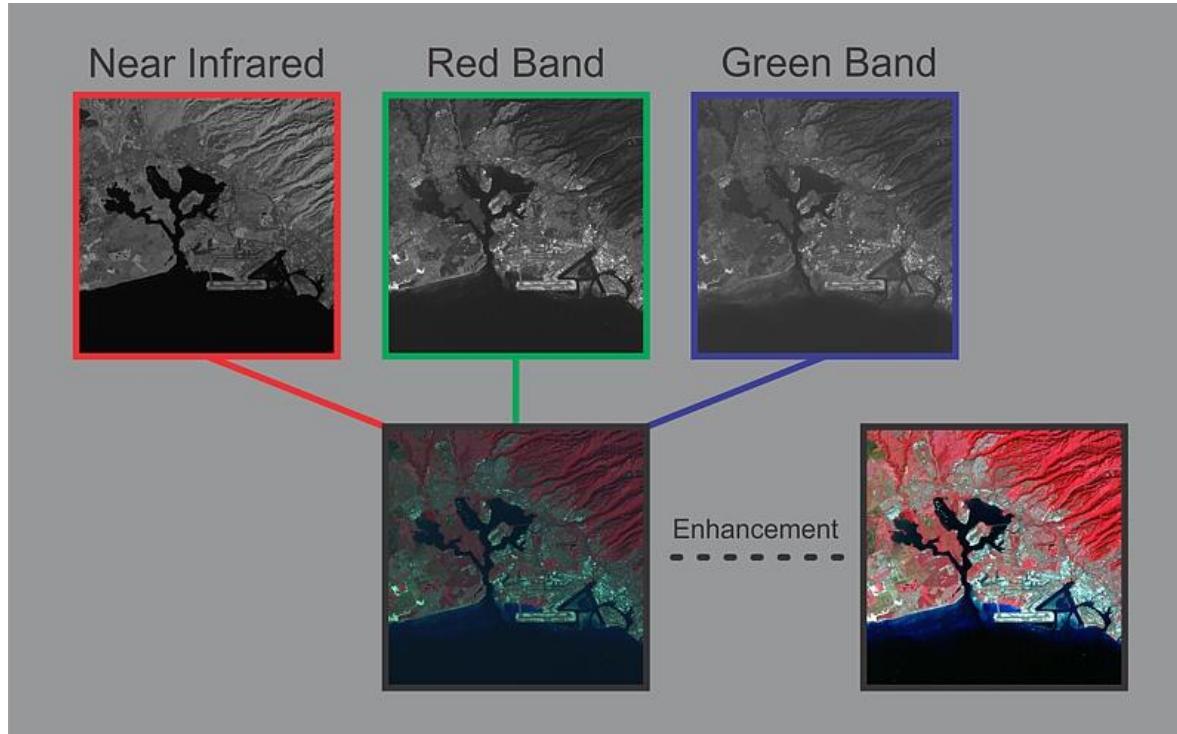
Courtesy: LANDSAT

Multi spectral images



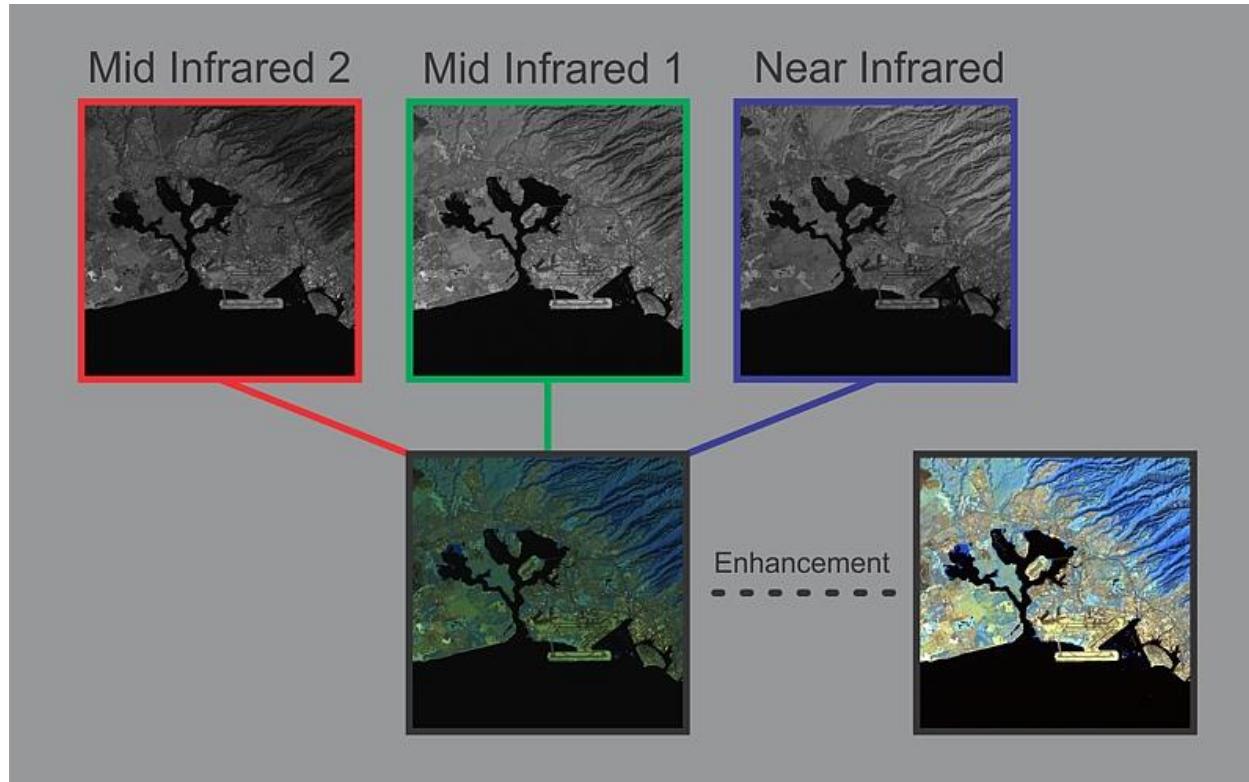
Courtesy: LANDSAT

Multi spectral images



Courtesy: LANDSAT

Multi spectral images



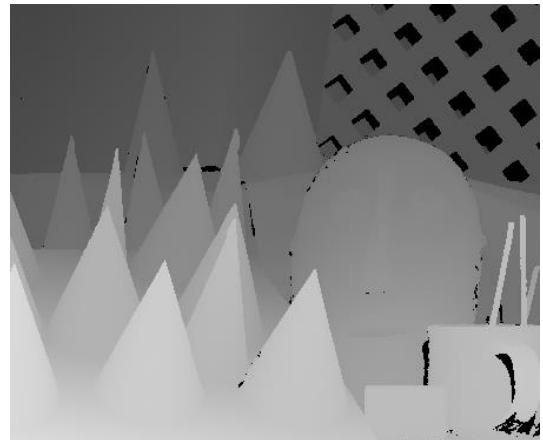
Courtesy: LANDSAT

Stereo Images



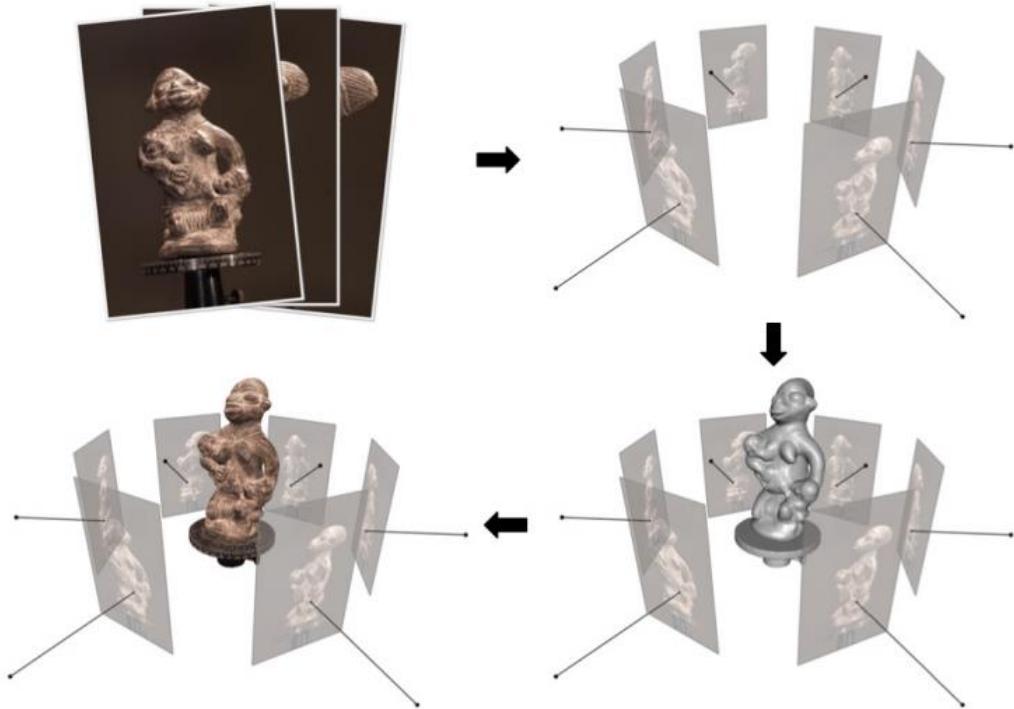
courtesy: wikipedia.com

Stereo Images

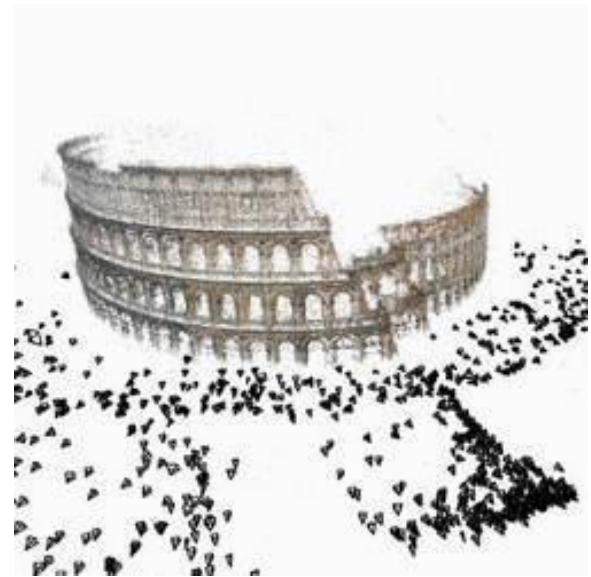


courtesy: vision.middlebury.edu

Multi-view images



courtesy: Yasutaka Furukawa



courtesy: Sameer Agarwal

Kinect images

Color (RGB) Image



Depth Image

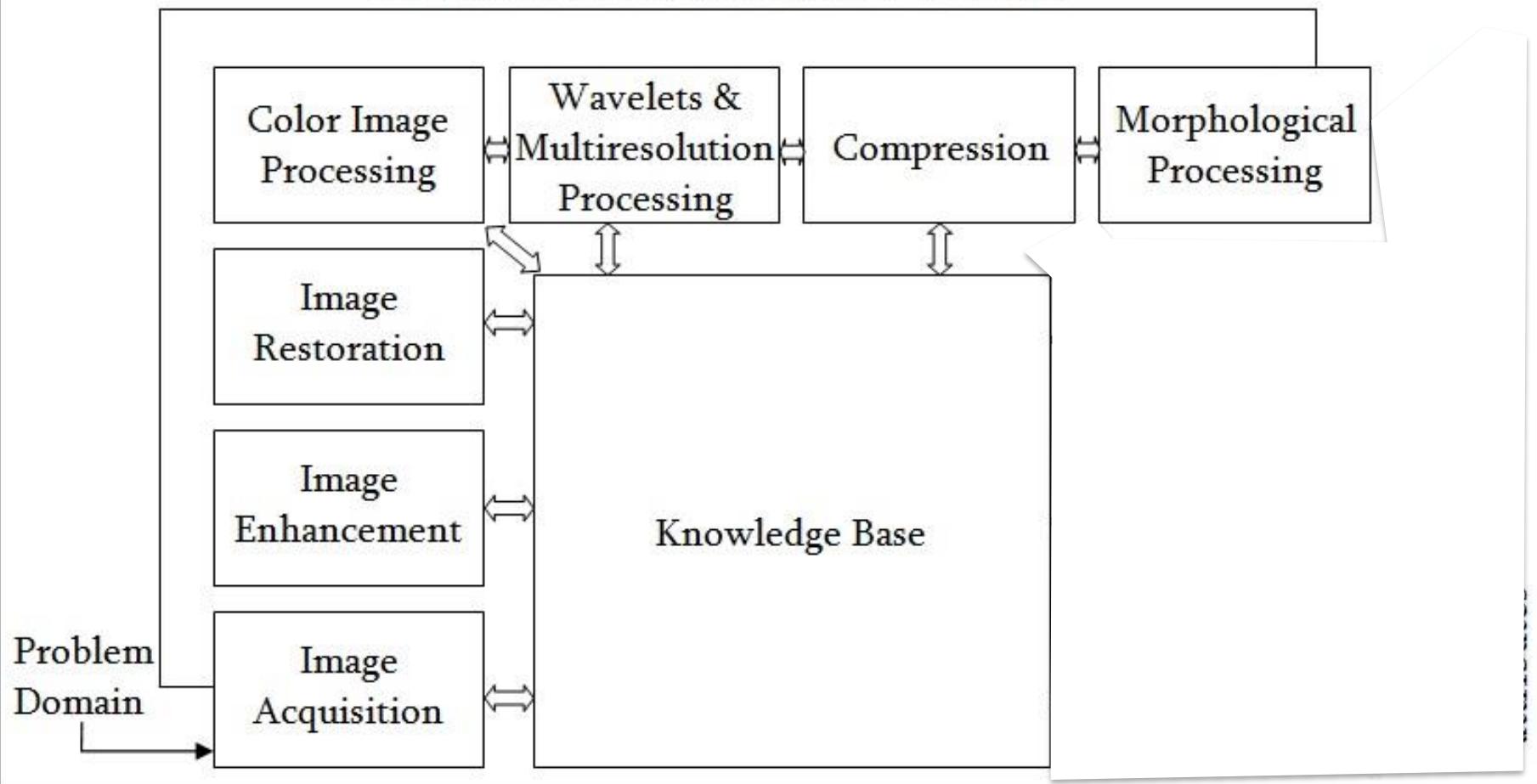


courtesy: kinect and prime sense

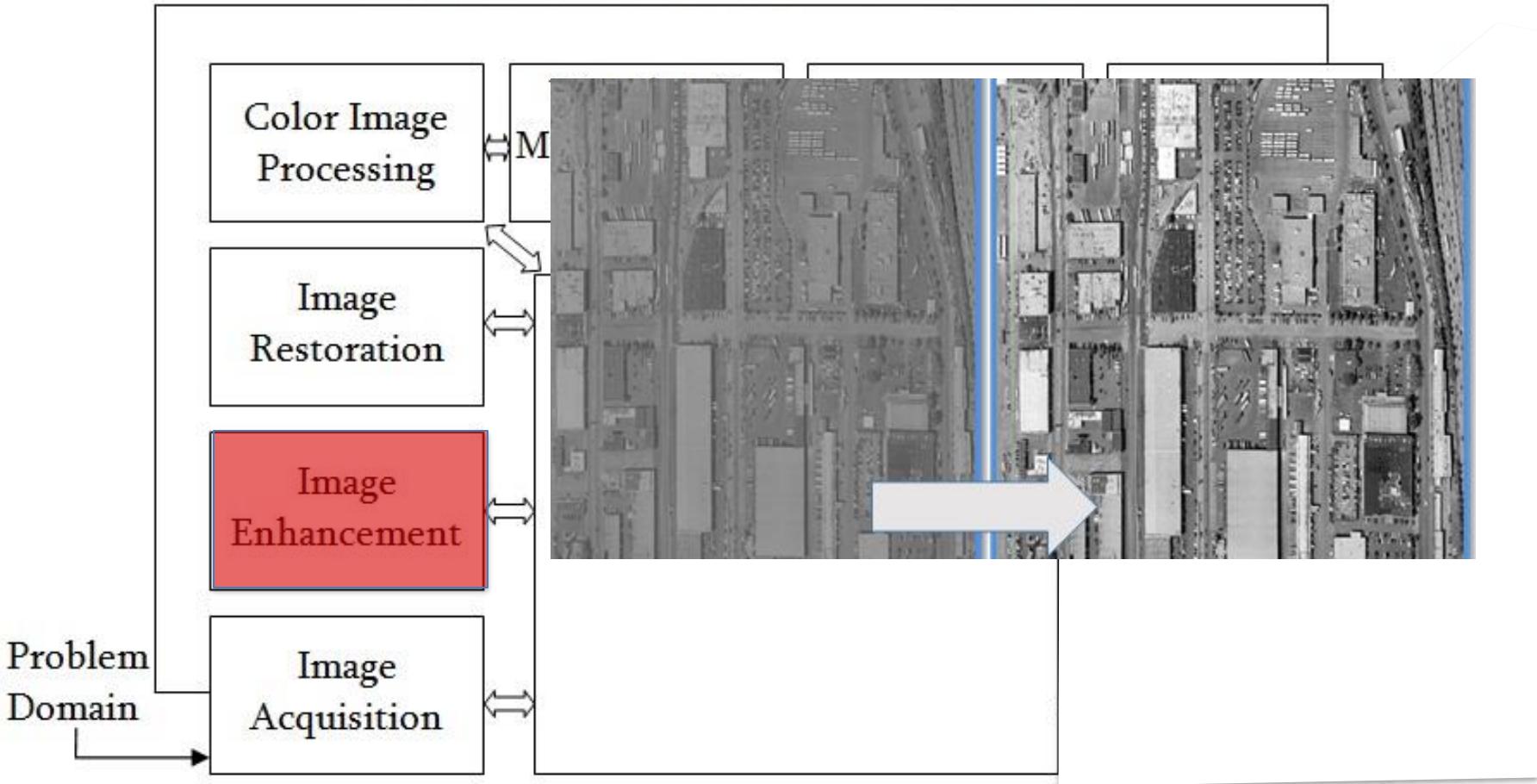
Digital Image processing

- 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

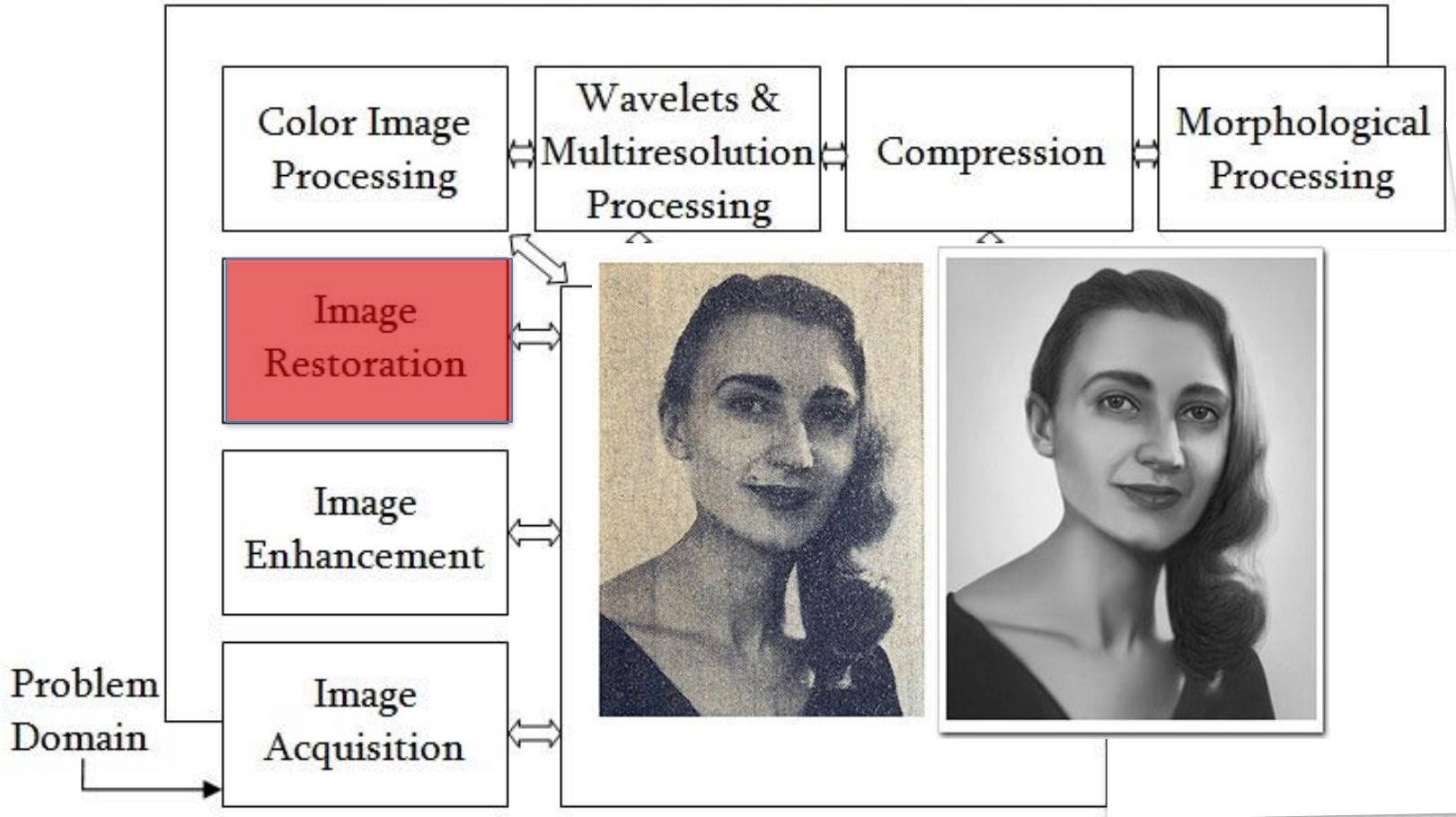
Outputs of these steps are generally images



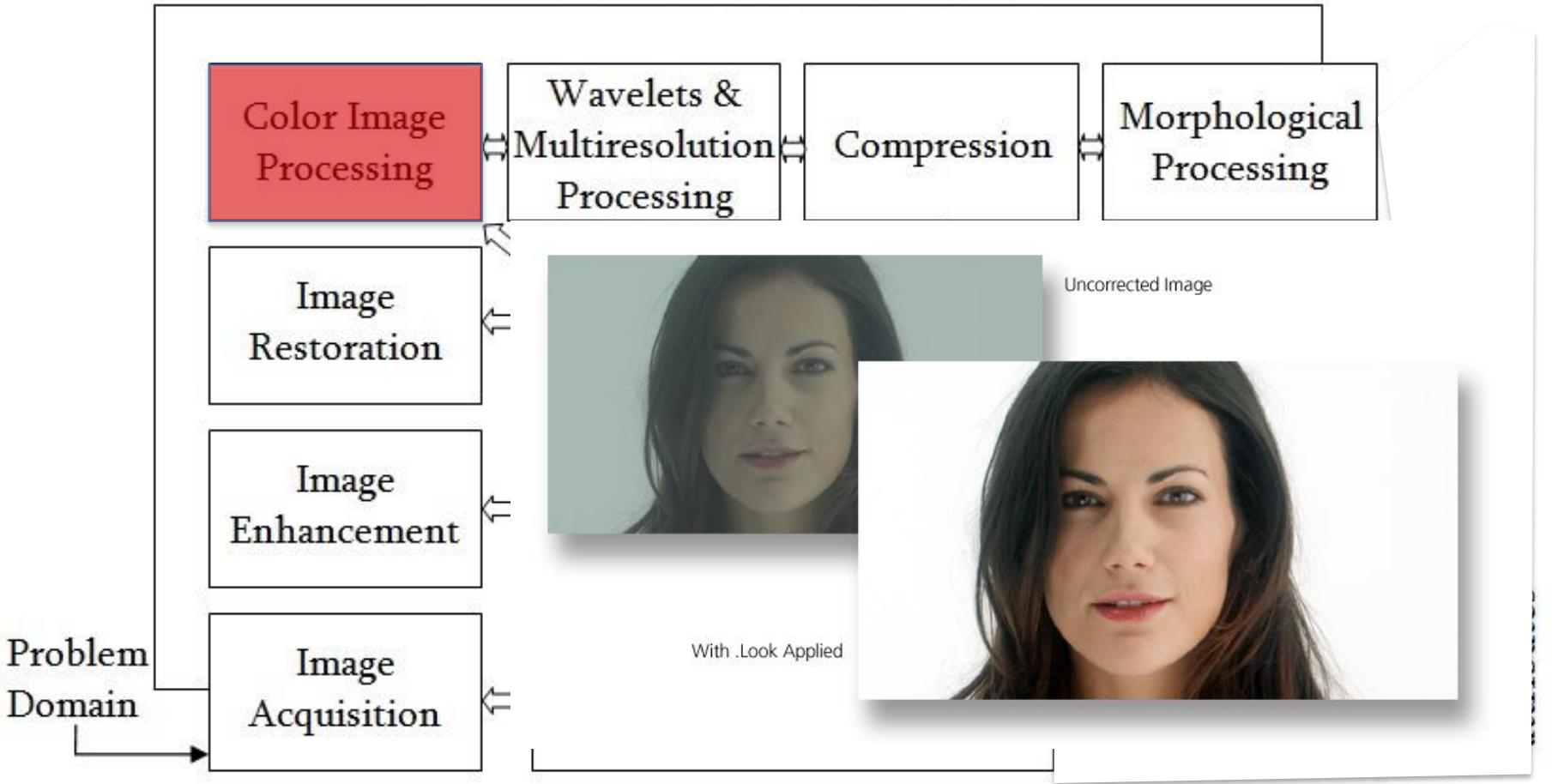
Outputs of these steps are generally images



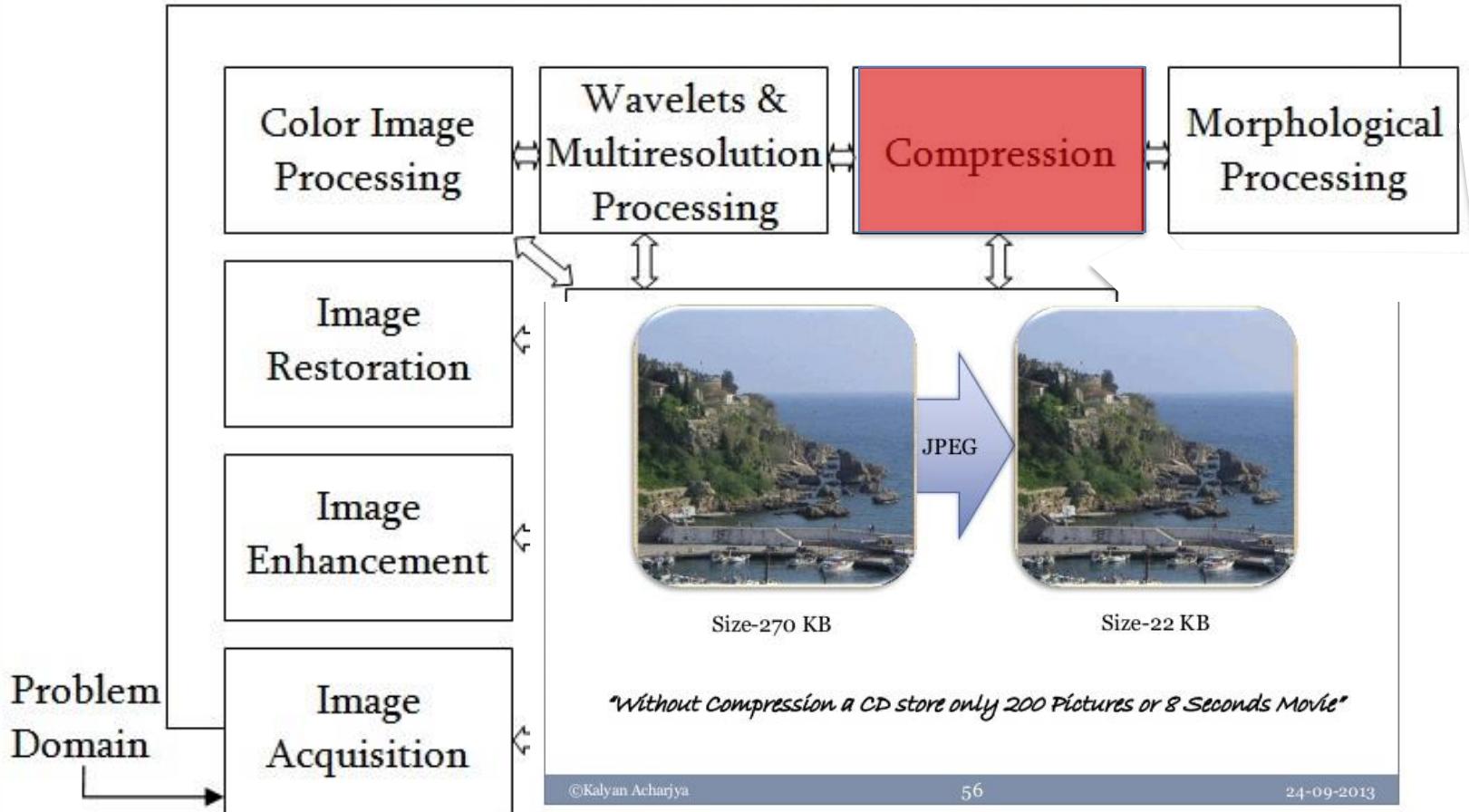
Outputs of these steps are generally images



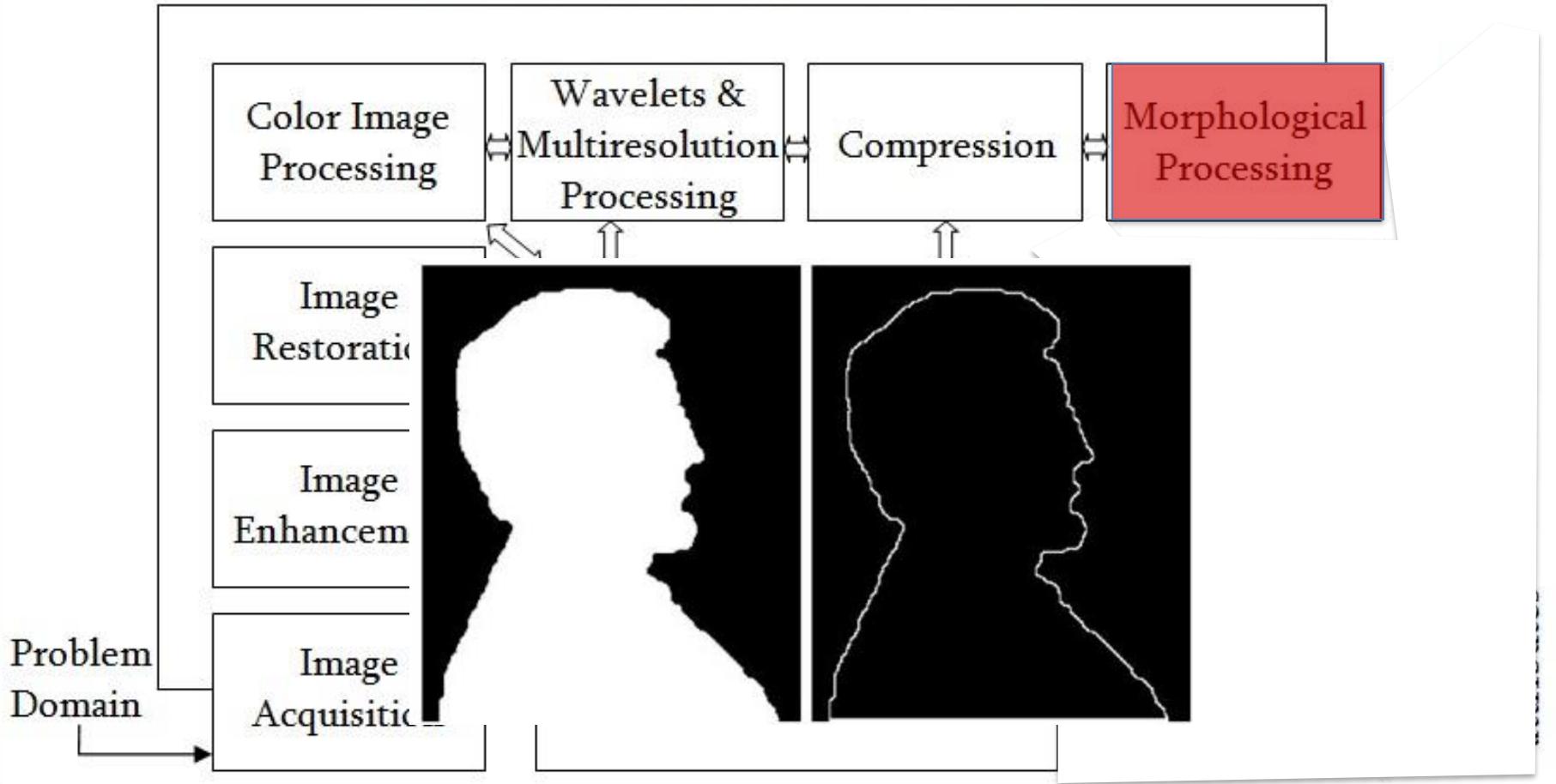
Outputs of these steps are generally images



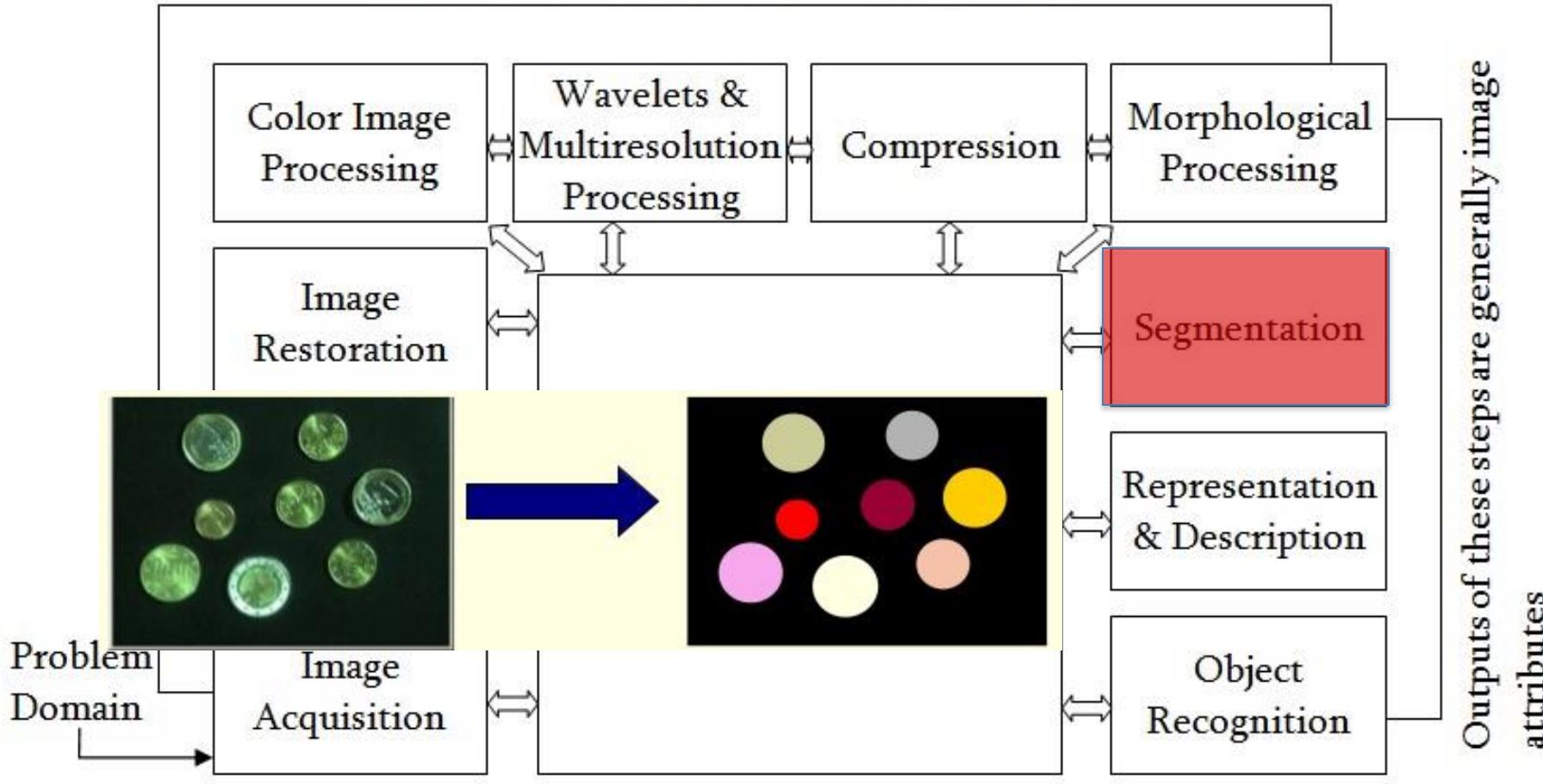
Outputs of these steps are generally images



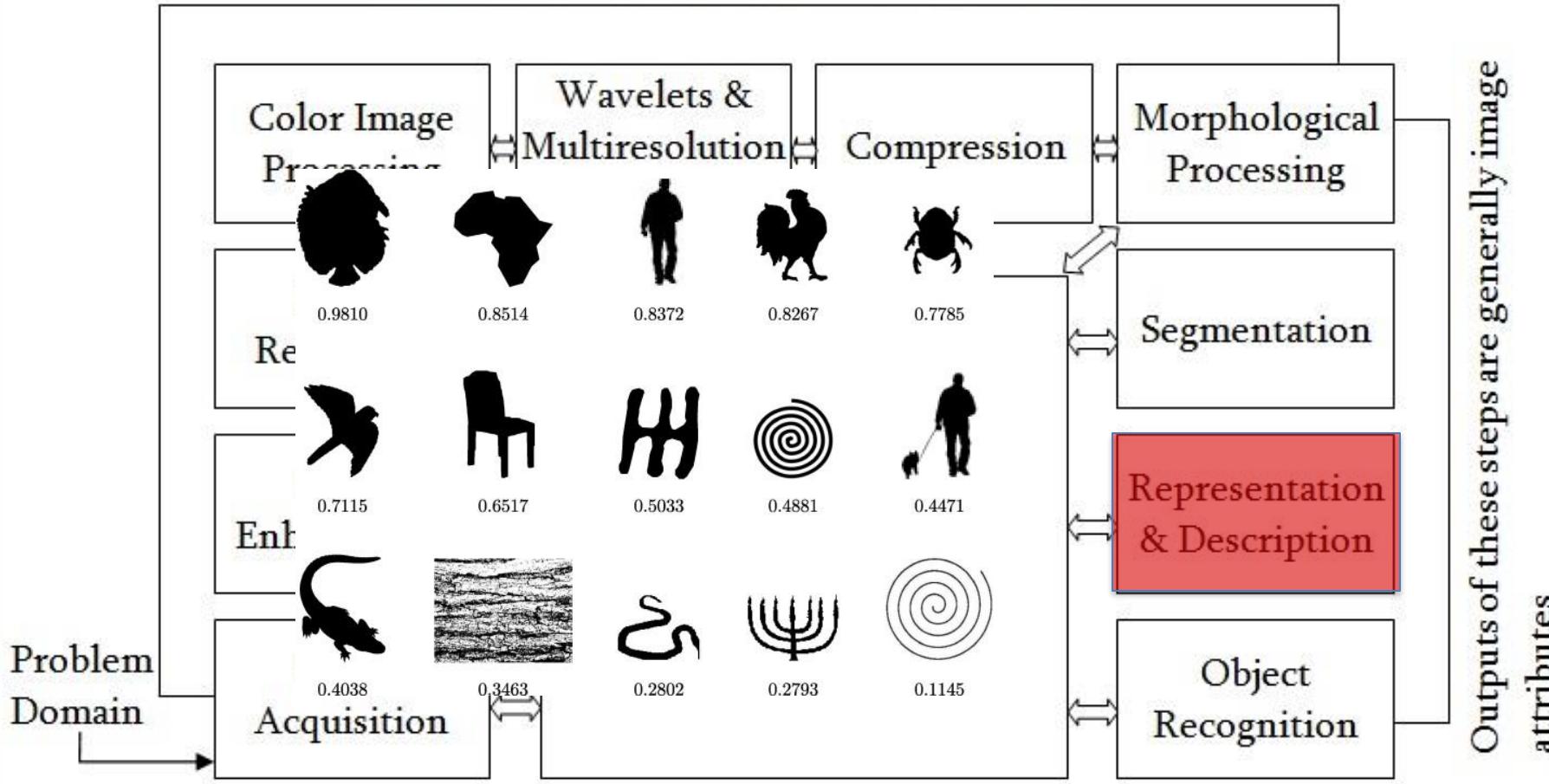
Outputs of these steps are generally images



Outputs of these steps are generally images



Outputs of these steps are generally images



Outputs of these steps are generally images

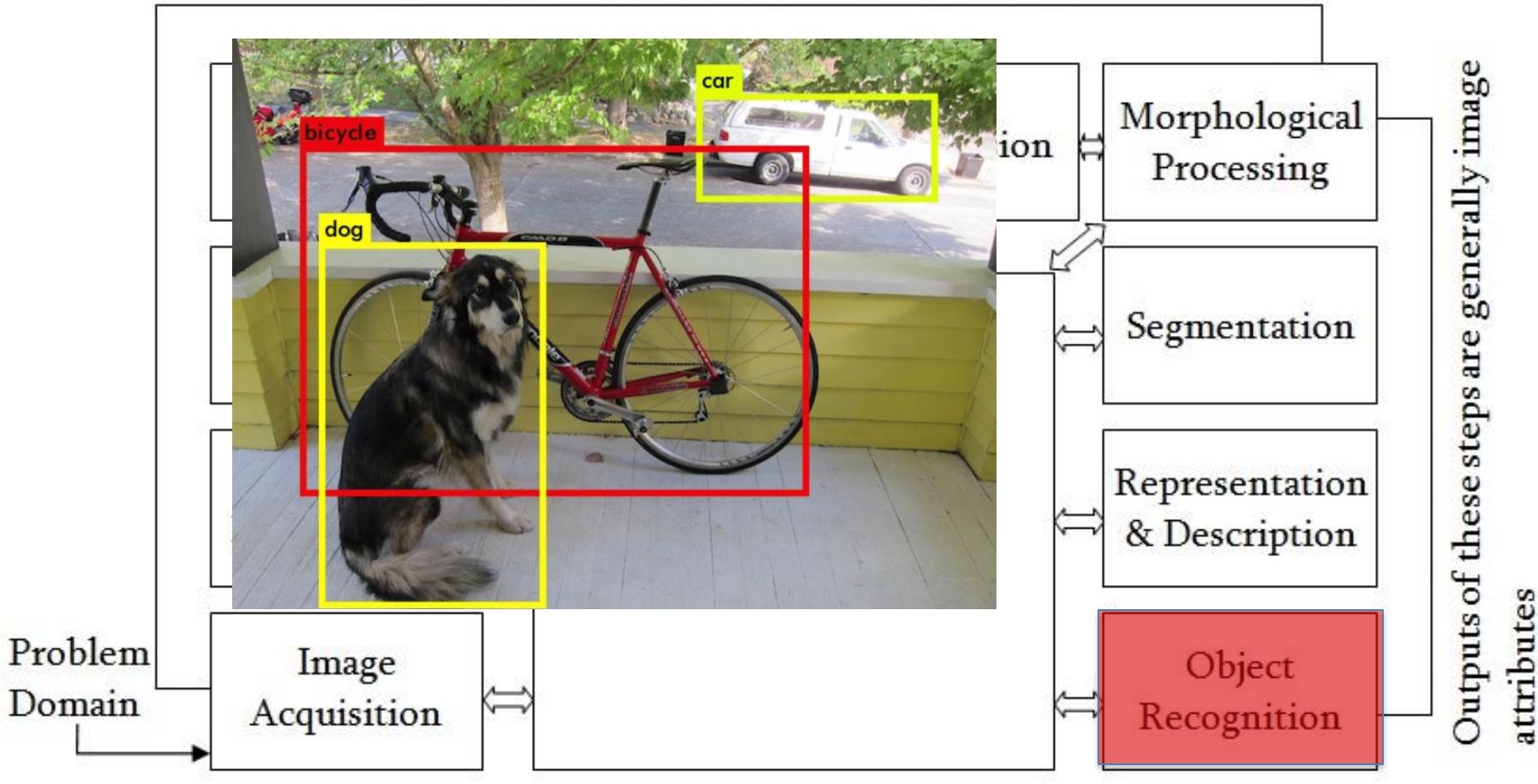
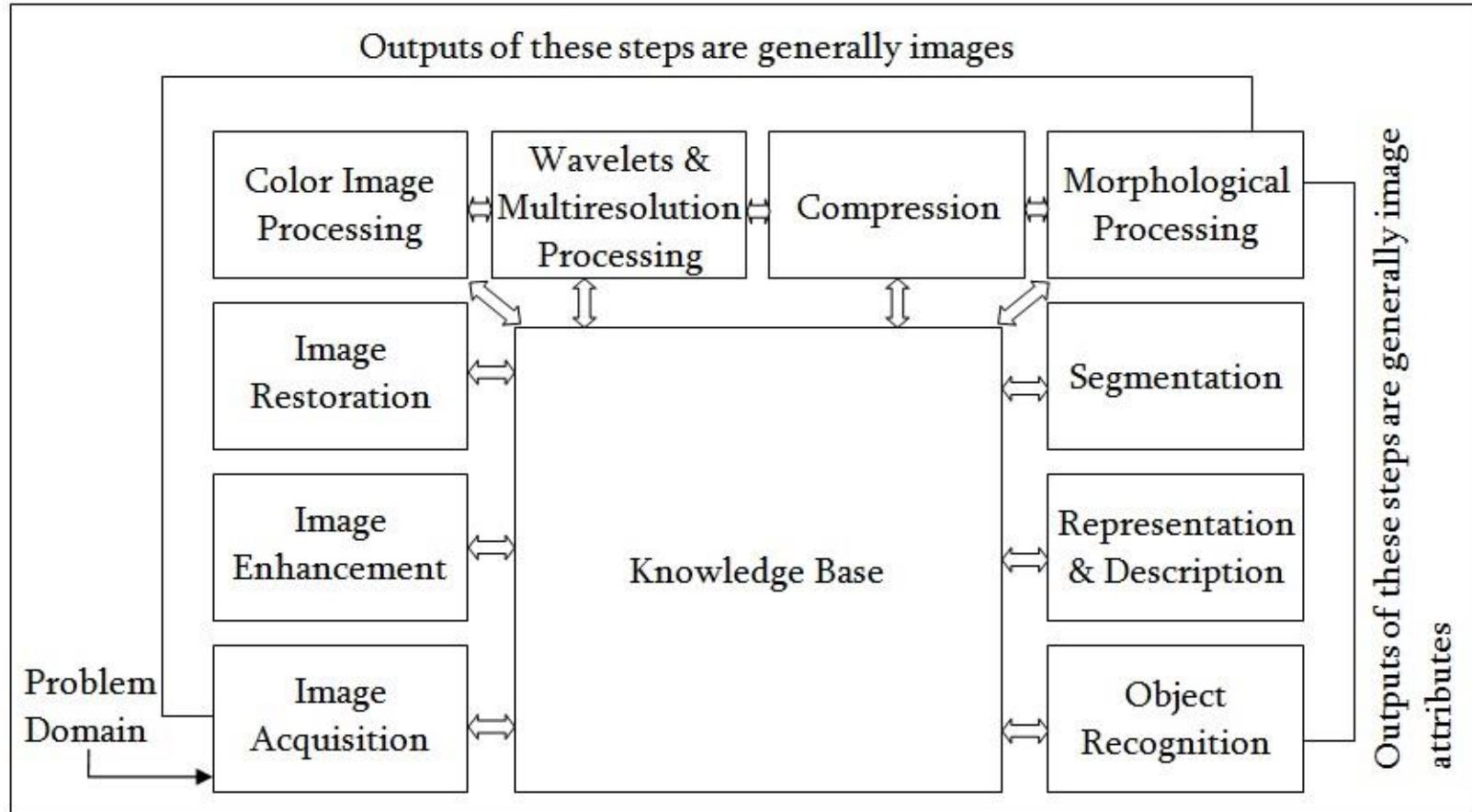


Image Processing Tasks



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

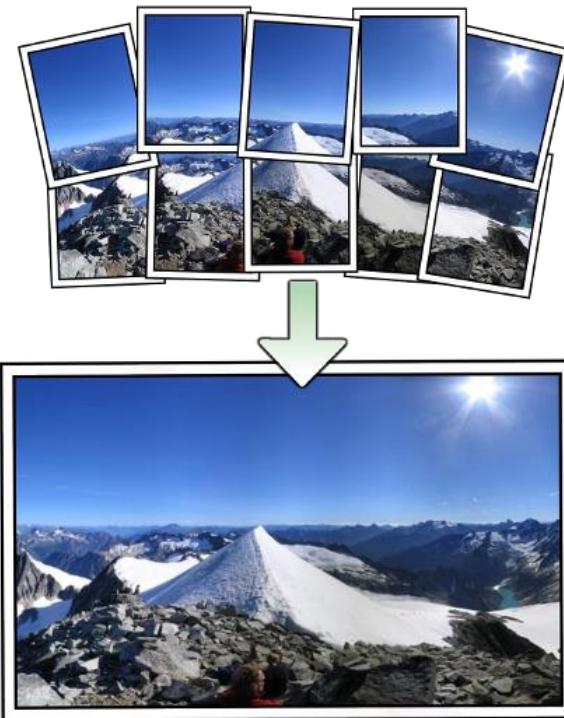


Image courtesy: autostitch

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



Before



After

Image courtesy: webneel.com

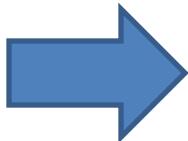


Image courtesy: Jon Morse



BW to Color

Mayabazar (1957), Vijaya Vauhini Studios



Colorized (2010)



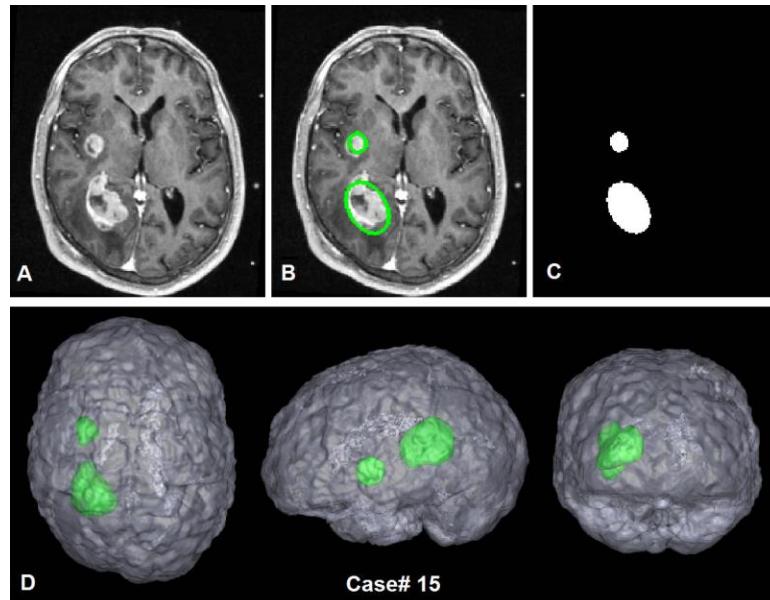
Tasks of interest: Cinematic Grading

Mission Impossible - Ghost Protocol, Paramount Pictures

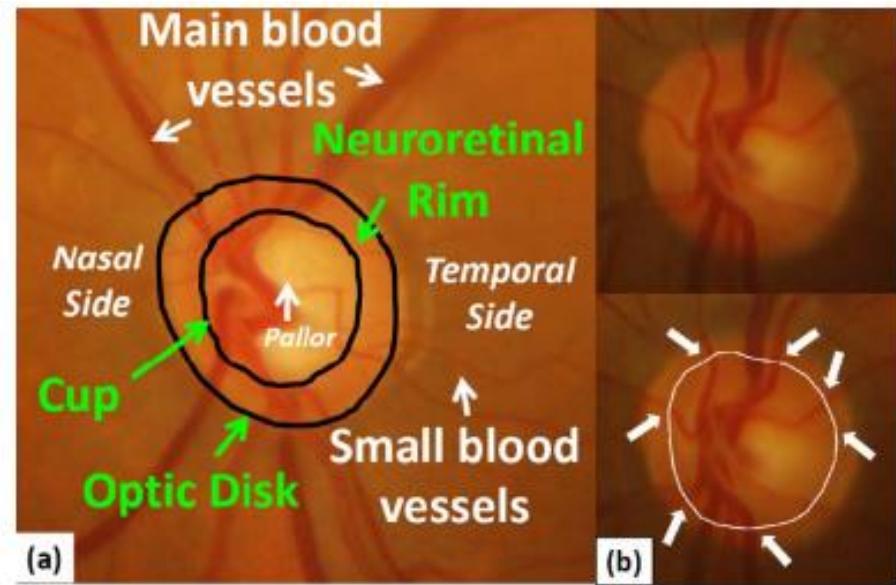


Image courtesy: juanmelara.com

Tasks of interest: Segmentation

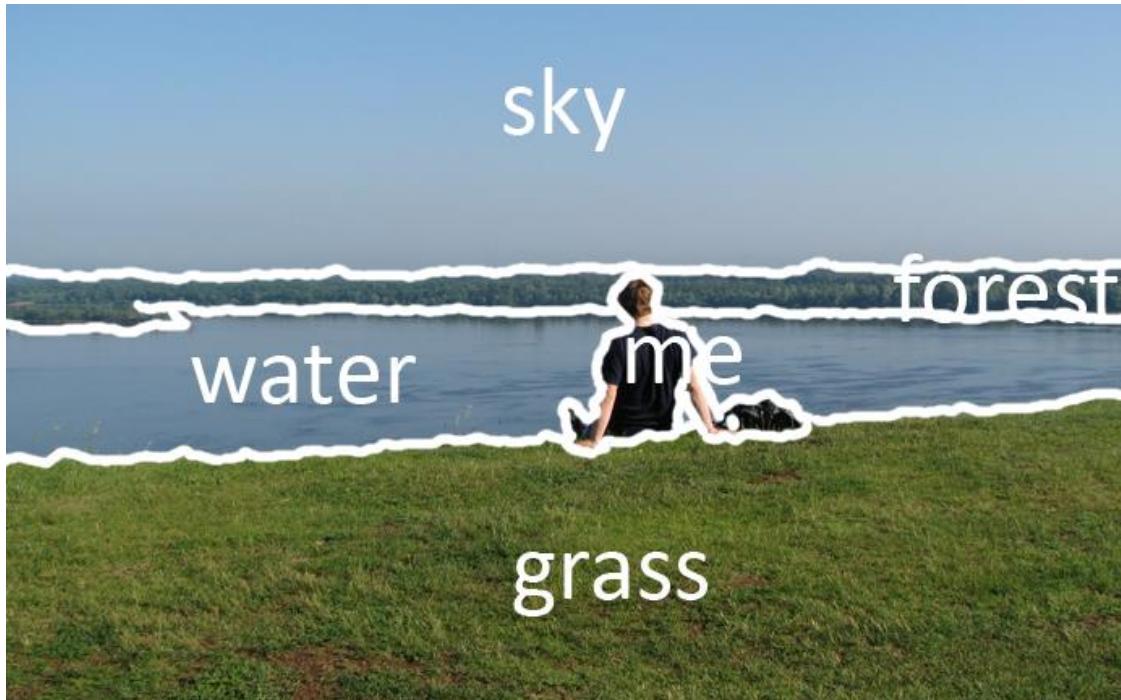


Tumour Segmentation [Yu et al. MICCAI 2010]



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

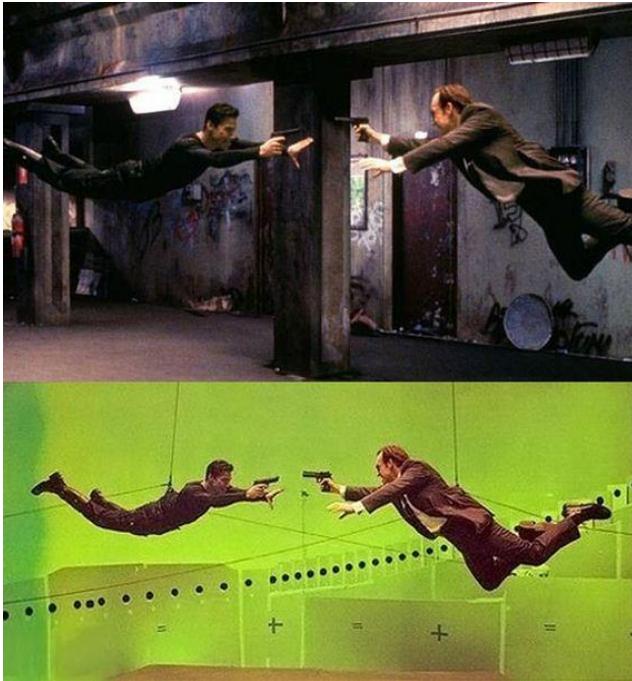


RESTORED



Bertalmio et al. SIGGRAPH 2010

Tasks of interest: Special effects

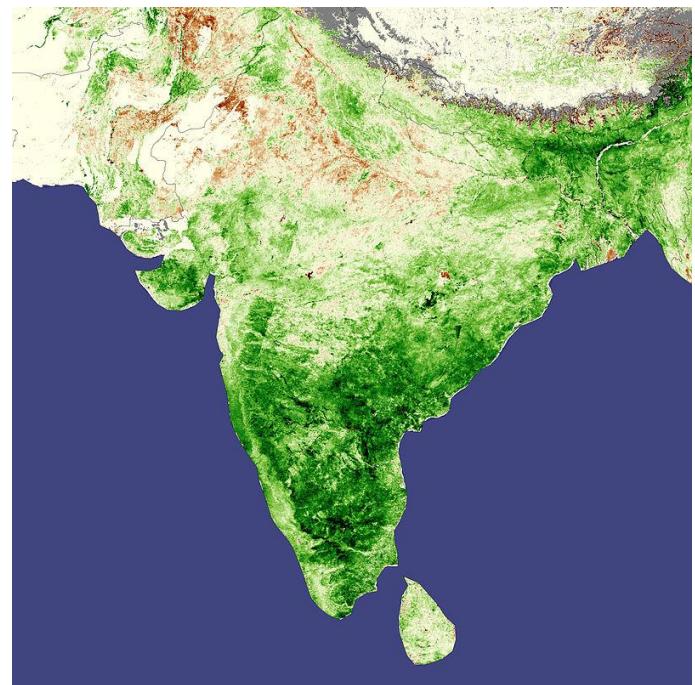
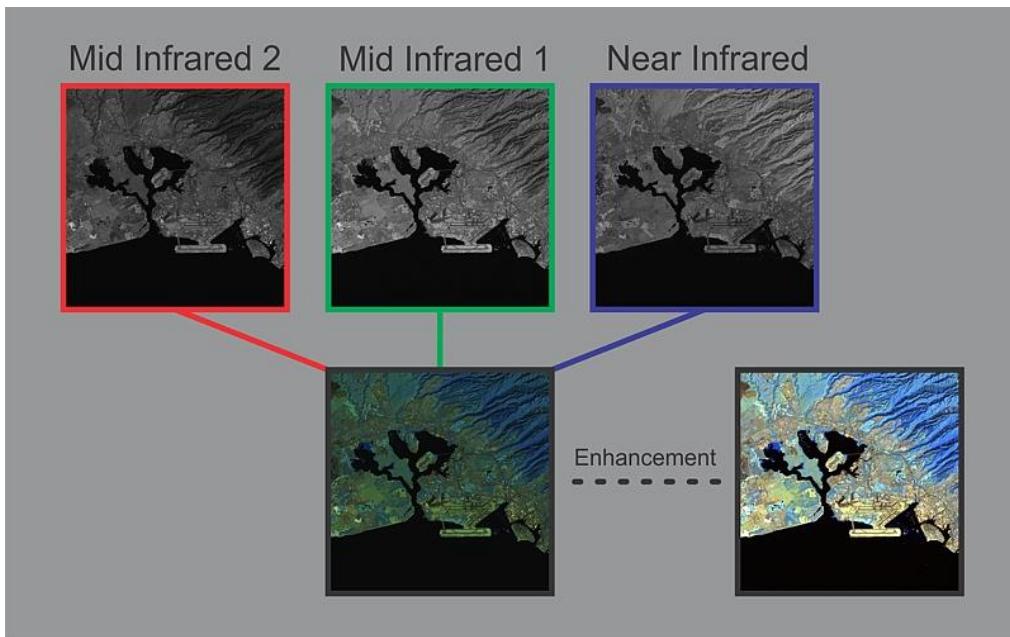


courtesy: wachowsky brothers (matrix)



courtesy: Miller et al. (sin city)

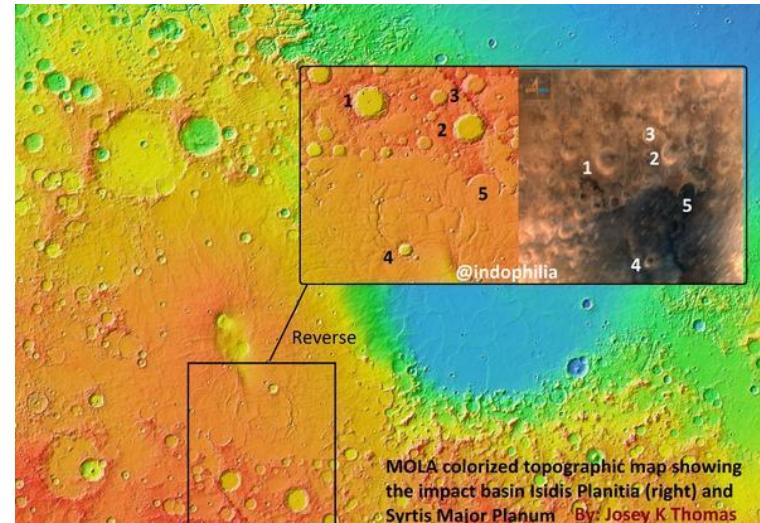
Tasks of interest: Satellite imaging



Terrain classification, weather predictions etc.

courtesy: NASA

Tasks of interest: Astronomy

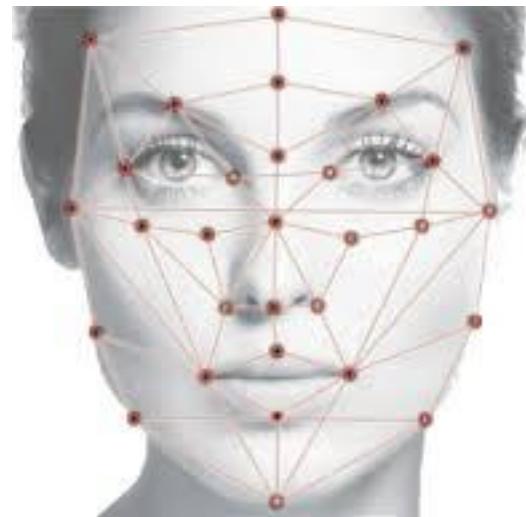


courtesy: ISRO

Tasks of interest: Biometrics

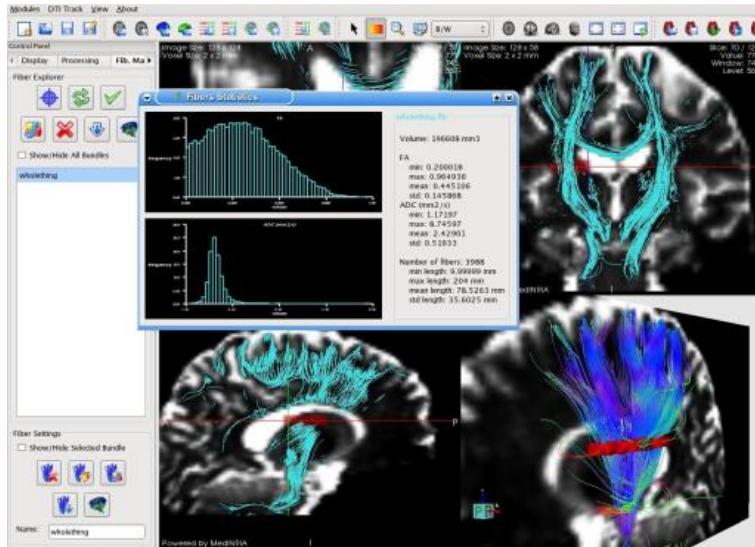


courtesy: dqindia.com

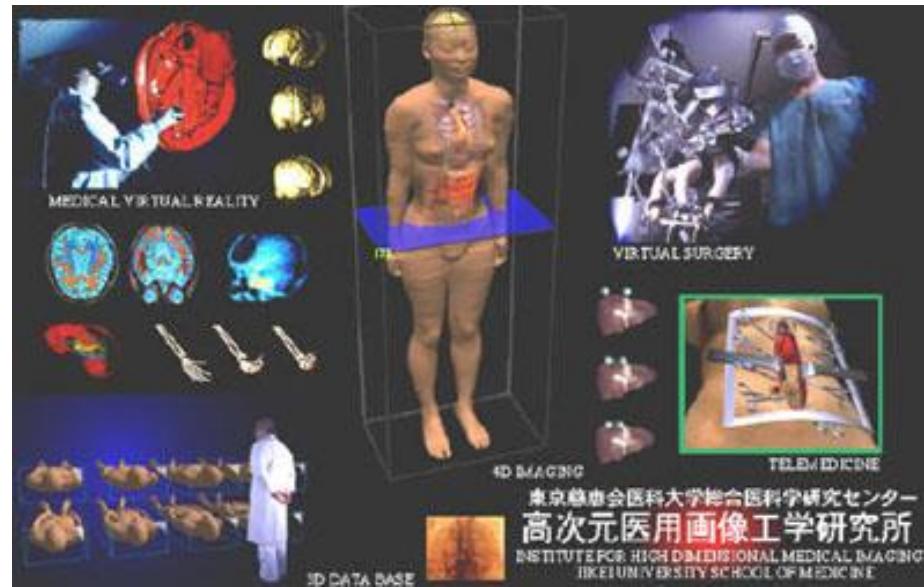


courtesy: heyce.com

Tasks of interest: Medicine



Courtesy: medINRIA



Courtesy: Naoki Suzuki

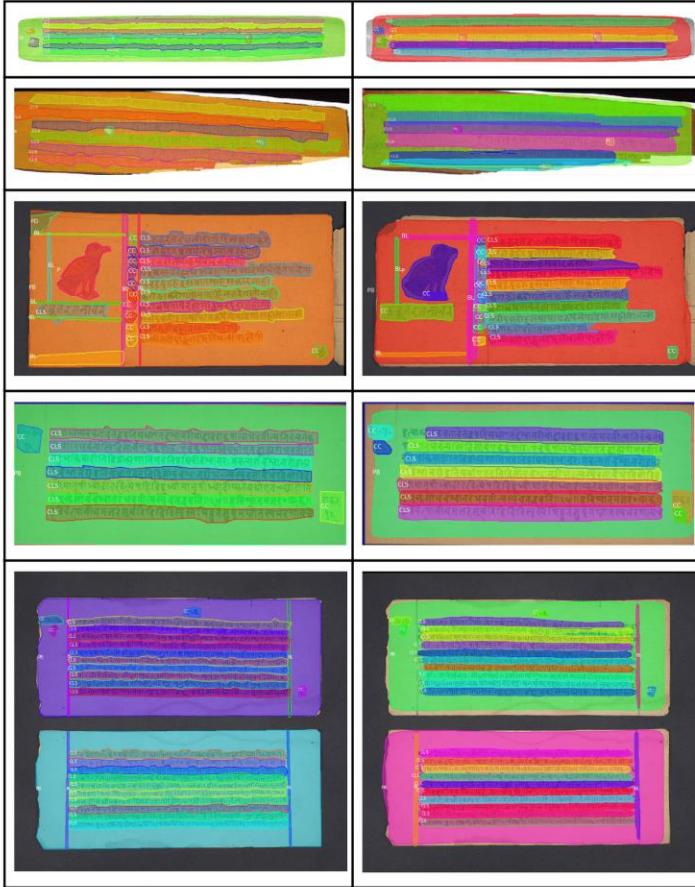
Tasks of interest: Driverless Vehicle Systems

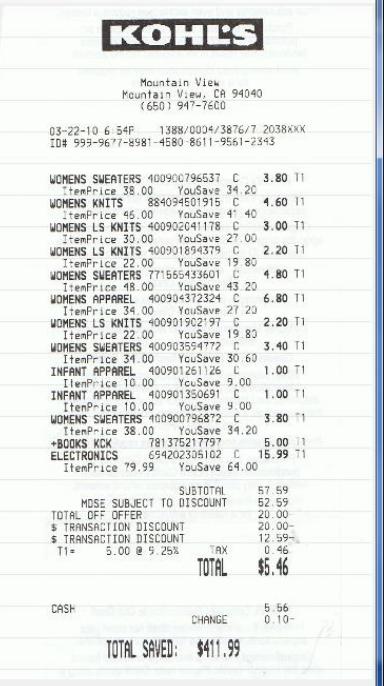


Face Blurring for Privacy Protection



Tasks of interest: Document Image Analysis



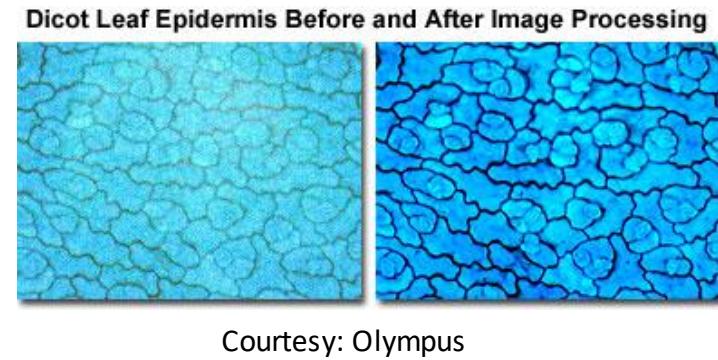
Angle: -4.94	
Open file	
	
WOMENS SWEATERS 400900796537 C 3.80 11 ItemPrice 38.00 YouSave 34.20 WOMENS KNITS 884094801915 C 4.60 11 ItemPrice 46.00 YouSave 41.40 WOMENS LS KNITS 400902041178 C 3.00 11 ItemPrice 30.00 YouSave 27.00 WOMENS LS KNITS 400901894379 C 2.20 11 ItemPrice 22.00 YouSave 19.80 WOMENS SWEATERS 771565433601 C 4.80 11 ItemPrice 48.00 YouSave 43.20 WOMENS APPAREL 400904372324 C 6.80 11 ItemPrice 68.00 YouSave 61.20 WOMENS LS KNITS 400901904907 C 2.20 11 ItemPrice 22.00 YouSave 19.80 WOMENS SWEATERS 400903554772 C 3.40 11 ItemPrice 34.00 YouSave 30.60 INFANT APPAREL 400901261126 C 1.00 11 ItemPrice 10.00 YouSave 9.00 INFANT APPAREL 400901356971 C 1.00 11 ItemPrice 10.00 YouSave 9.00 WOMENS SWEATERS 400900796572 C 3.80 11 ItemPrice 38.00 YouSave 34.20 +BOOKS KDK 781376217797 C 15.99 11 ELECTRONICS 694202305102 C 15.99 11 ItemPrice 79.99 YouSave 64.00	SUBTOTAL 57.59 MOS SUBJECT TO DISCOUNT 52.59 TOTAL OFF OFFER 20.00- \$ TRANSACTION DISCOUNT 12.59- \$ TRANSACTION DISCOUNT 0.46 T1= 5.00 @ 9.25% TAX 0.46 TOTAL \$5.46
CASH 5.56 CHANGE 0.10- TOTAL SAVED: \$411.99	CASH 5.56 CHANGE 0.10- TOTAL SAVED: \$411.99

Tasks of interest: Many more

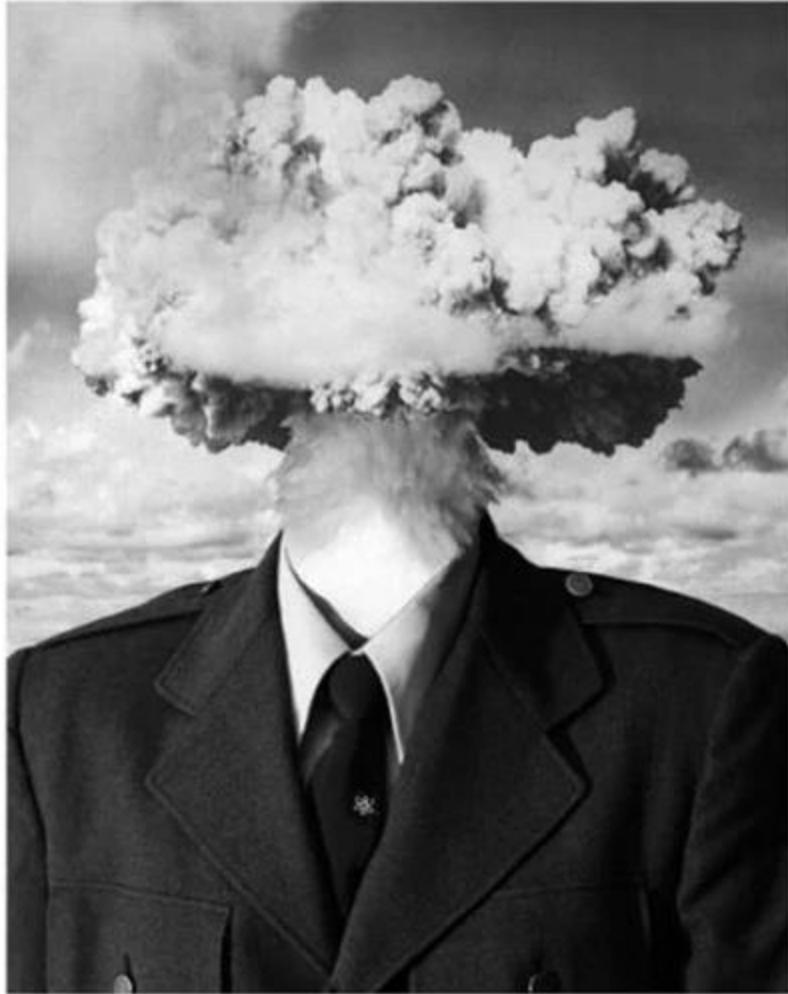
- Biology
- HCI
- Number Plate recognition
- Gesture recognition

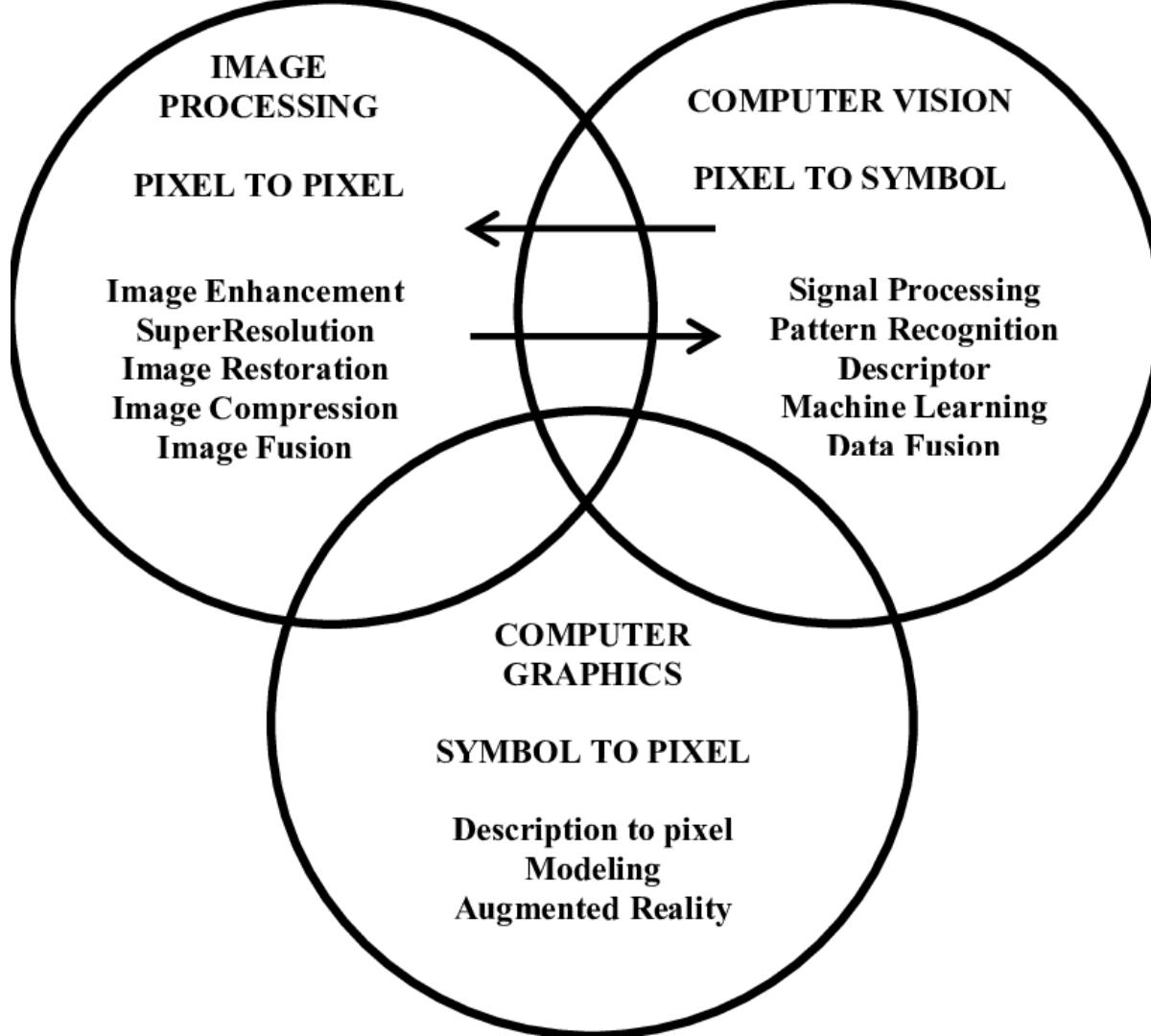


Courtesy: Perviverzov et al. 2012



Courtesy: researchdesignlab.com





Computer Graphics



- + easy to create new worlds
- + easy to manipulate objects/viewpoint
- Very hard to look realistic

Computational Photography

Realism
Manipulation
Ease of capture

Photography



- + instantly realistic
- + easy to acquire
- very hard to manipulate objects/viewpoint

A picture is
worth a
thousand
words



A picture is
worth a
thousand
words





Companies and Software



AUTODESK®
PIXLR®



Adobe® Premiere®



Final Cut Pro X
Everything just changed in post.



Canon

You Tube



SAMSUNG

Microsoft

PHILIPS

xerox

SIEMENS

intel®

QUALCOMM®

Research

- Journals



Research

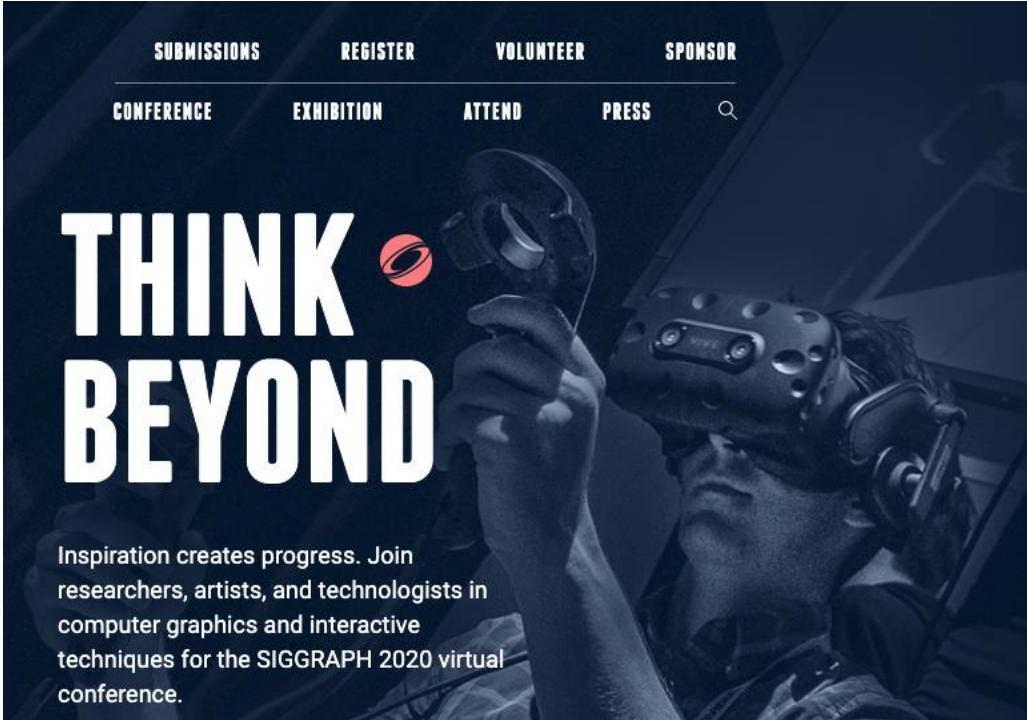
- Conferences



The image shows the homepage of the ICASSP 2020 website. At the top, there is a navigation bar with links for GENERAL, AUTHORS, REGISTRATION, CONFERENCE PROGRAM, INDUSTRY TRACK, and PATRONS, along with a search icon. Below the navigation bar is a large, scenic photograph of the city of Barcelona, featuring the distinctive architecture of the Sagrada Família. Overlaid on this image is the text "Welcome to ICASSP 2020!" in large, white, sans-serif letters. Below this, in smaller white text, is "Virtual Barcelona, May 4-8 2020". At the bottom of the image, the conference's theme is stated: "Signal Processing: from Sensors to Information, at the Heart of Data Science".

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

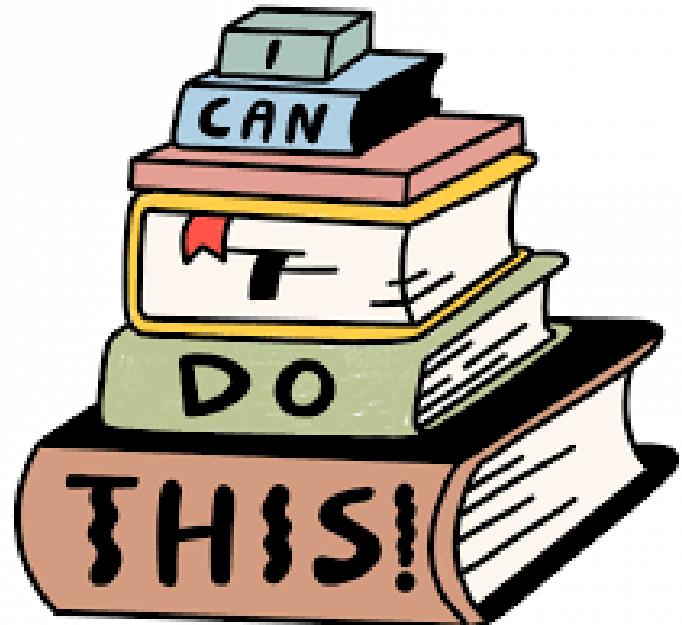
- [Text] Digital Image Processing by Gonzalez and Woods
- Scattered Resources across Internet
- Syllabus (tentative) – posted on Moodle

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 must 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 not 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)