



Digital Image Processing (CS7.404)

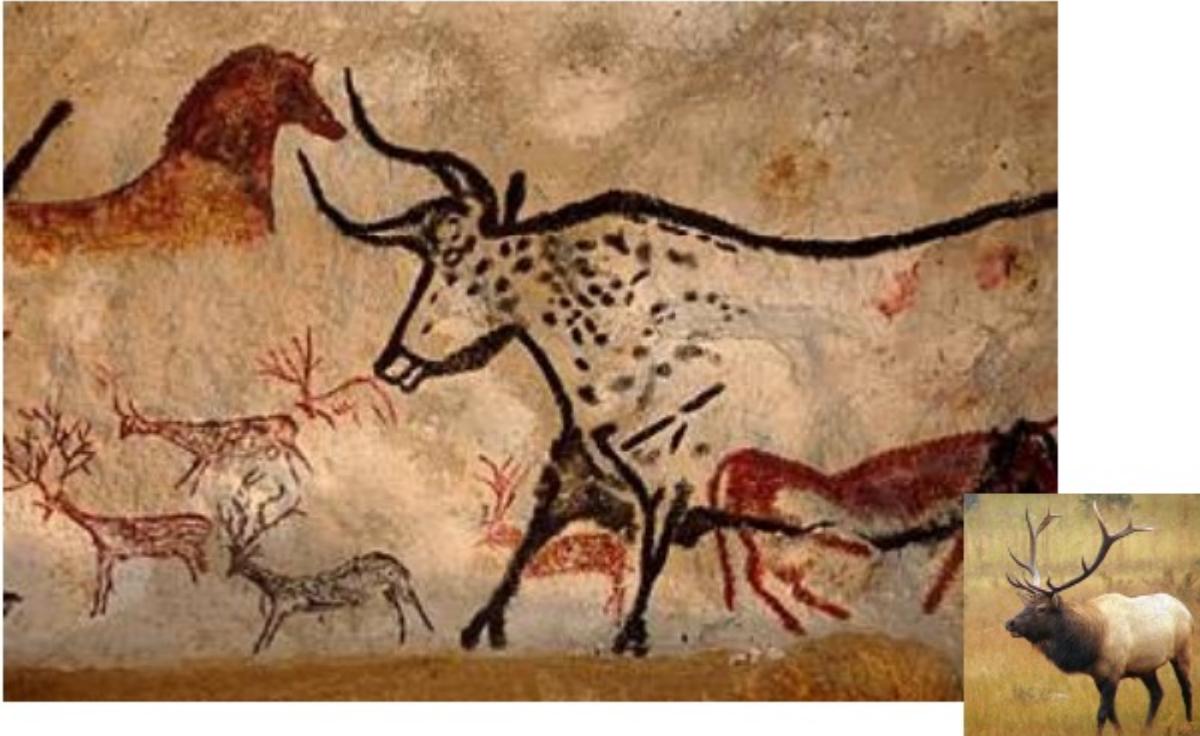
Lecture-1: Overview

Anoop M Namboodiri



Many slides borrowed from Vineet Gandhi and various sources

Before there were images



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

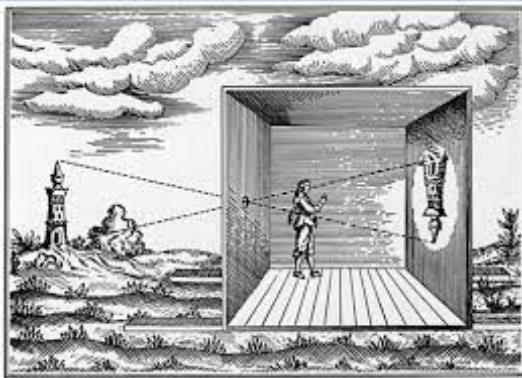
Before there were images

Depicting Our World: Middle Ages

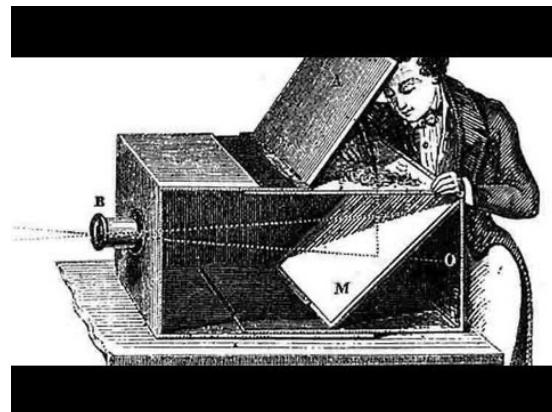


**The Empress Theodora with her court.
Ravenna, St. Vitale 6th c.**

Before there were images



Camera Obscura



Girl with a pearl earring, J. Vermeer, 1665



And then there were images

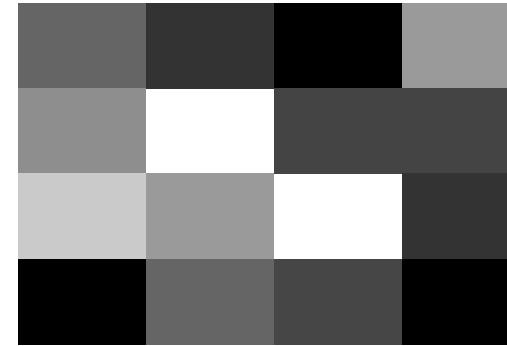


Still Life, Louis Jaques Mande Daguerre, 1837

What is a **digital** image ?

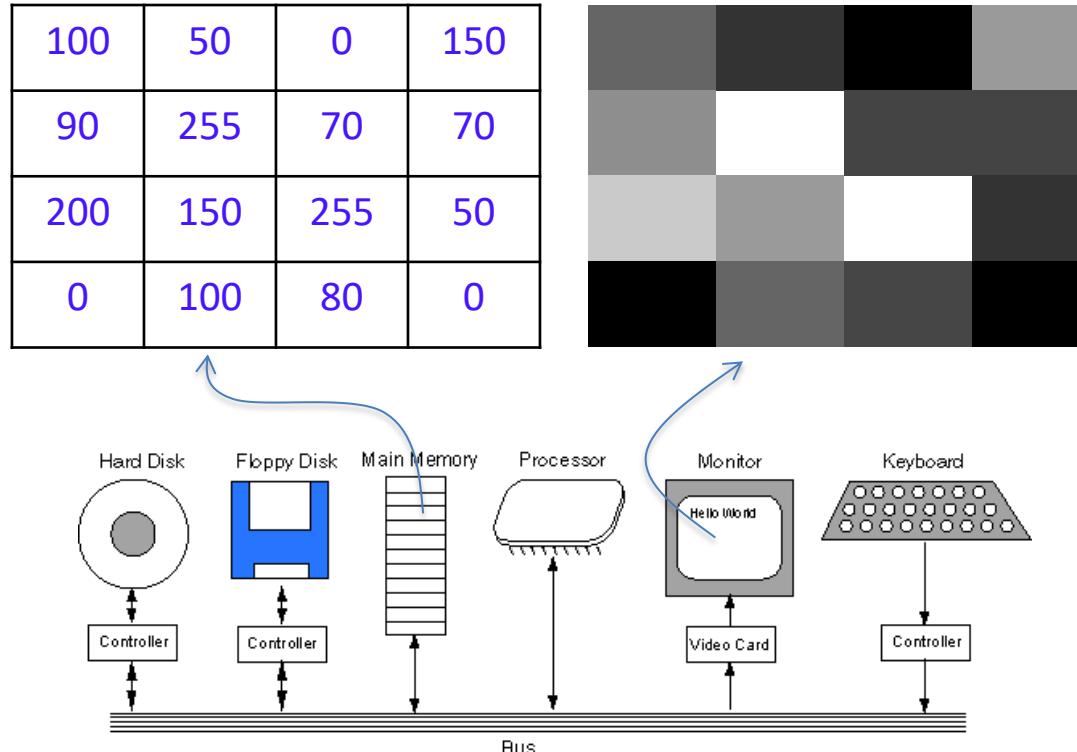
- An **array** of numbers representing **color intensities**

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**

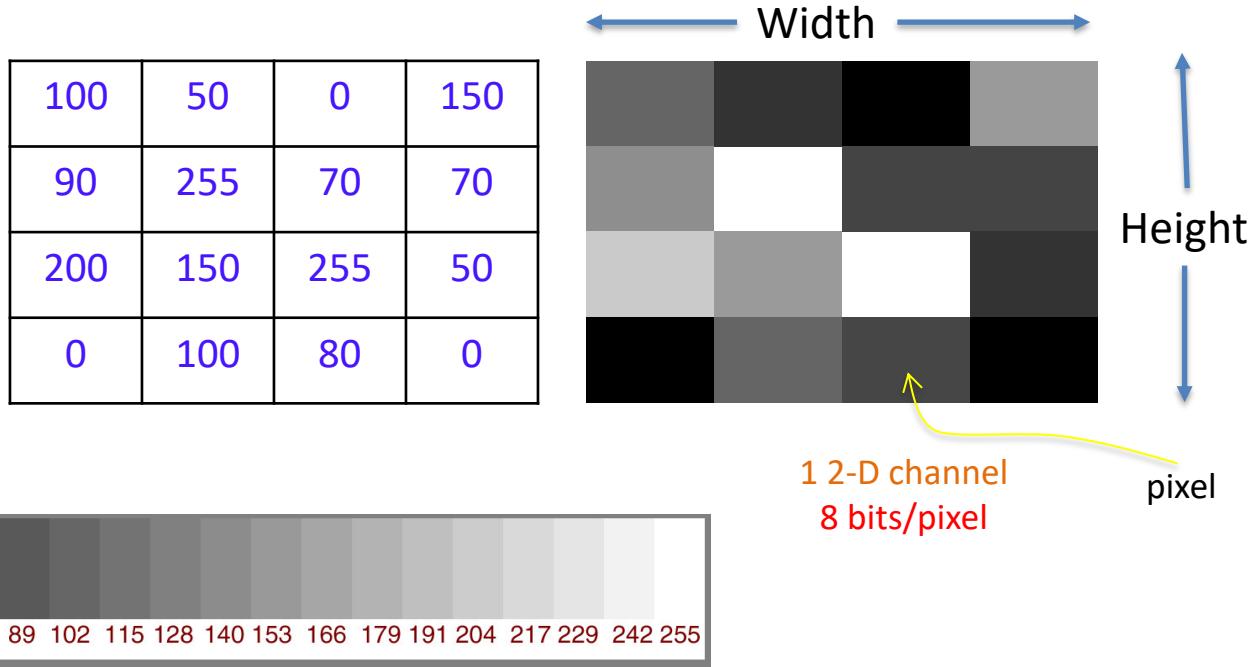


Image Representation (Grayscale)

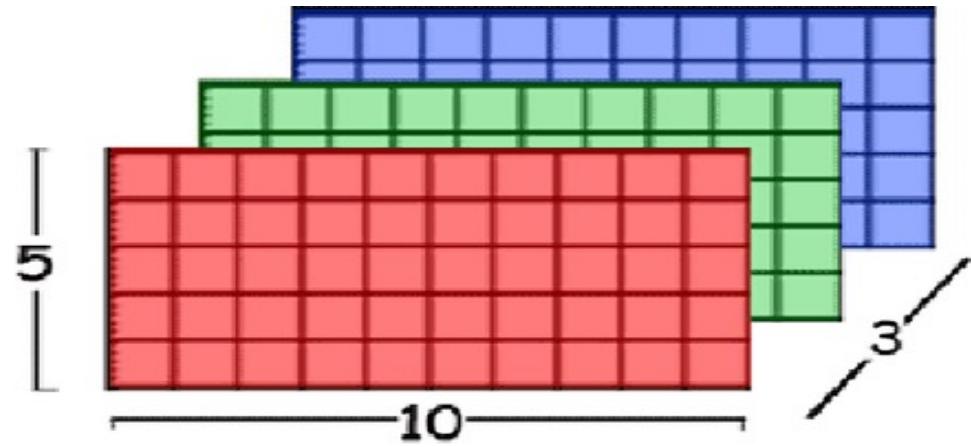
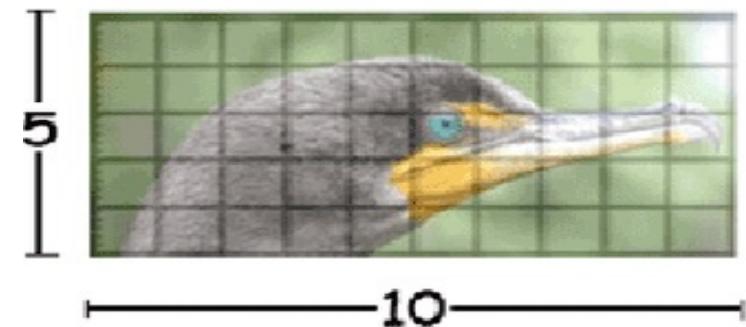


157	153	174	168	150	152	129	151	172	161	155	156
155	182	163	74	75	62	33	17	110	210	180	154
180	180	50	14	94	6	10	33	48	106	159	181
206	109	5	124	131	111	120	204	165	15	56	180
194	68	137	251	237	239	239	228	227	87	71	201
172	105	207	233	233	214	220	239	228	98	74	206
188	88	179	209	185	215	211	158	139	75	20	169
189	97	165	84	10	168	134	11	31	62	22	148
199	168	191	193	158	227	178	143	182	105	36	190
205	174	155	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	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	6	0	12	108	209	138	243	236
196	206	123	207	177	121	123	200	175	13	96	218



0 13 25 38 51 64 76 89 102 115 128 140 153 166 179 191 204 217 229 242 255

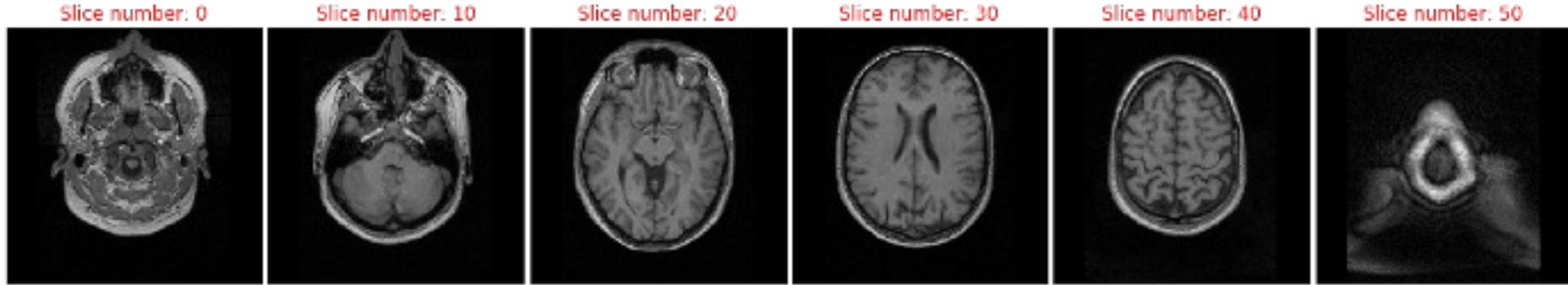
Image Representation (RGB)



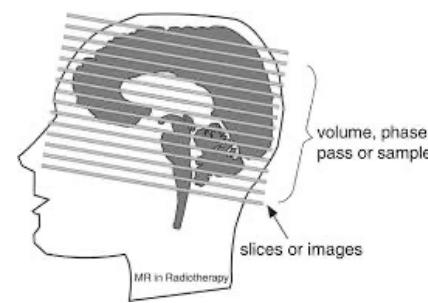
3 2-D channels
24 bits per pixel

Image Representation

fMRI image slices



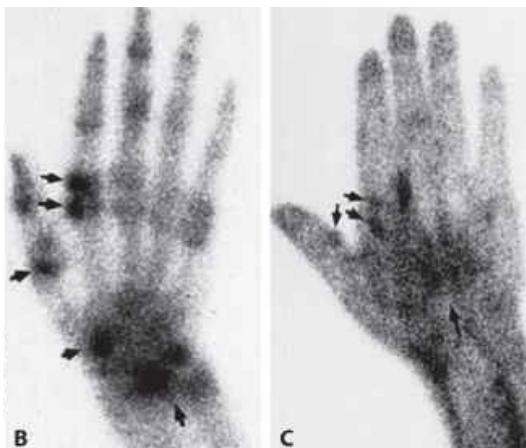
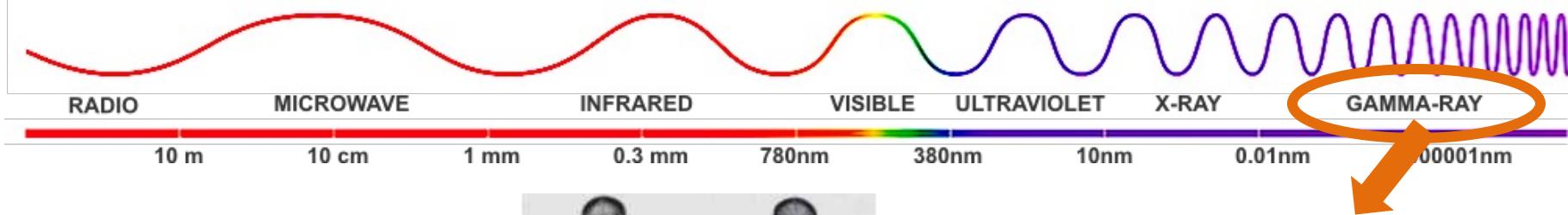
56 2-D channels



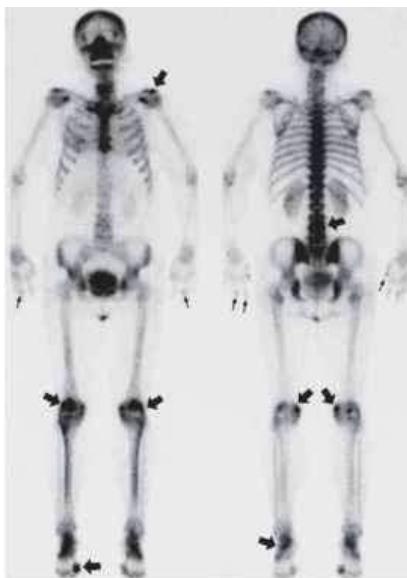
Types of Images (classification on source)

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

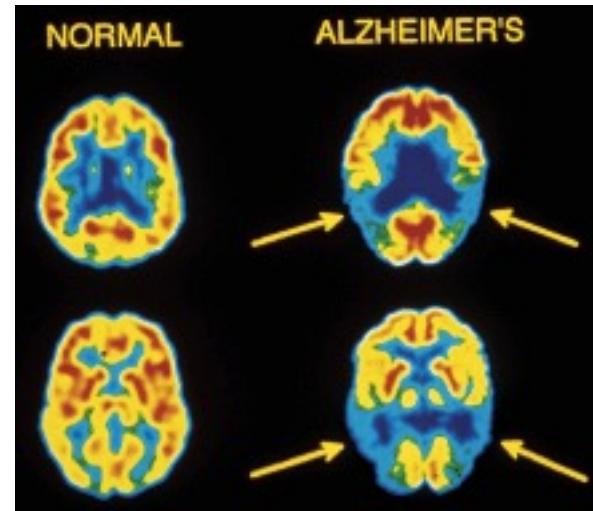
EM spectrum



courtesy: artheritisresearch.us



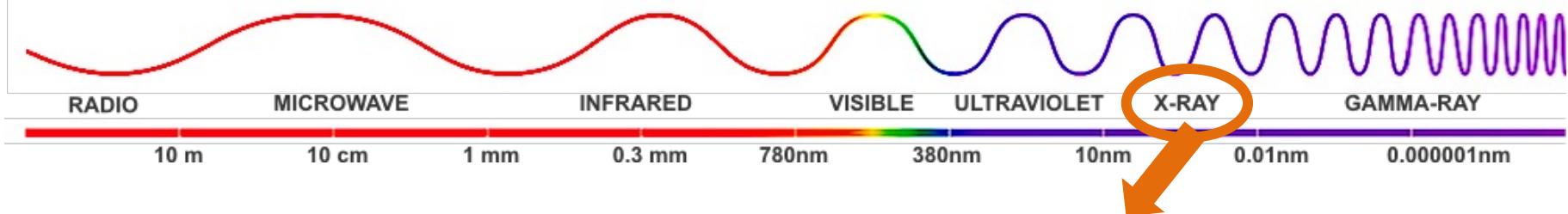
courtesy: artheritisresearch.us



PET SCAN

courtesy: research.ucla.edu

EM spectrum

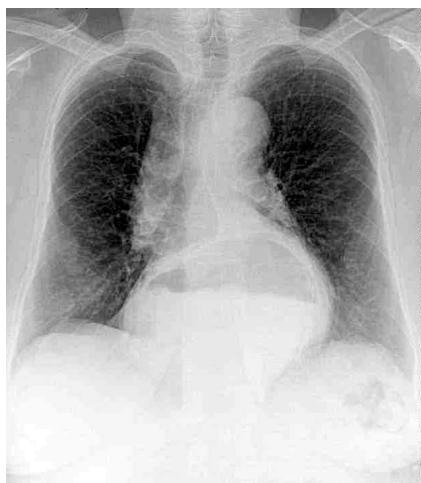


Wilhelm Röntgen



HAND MIT RINGEN

courtesy: wikipedia



CHEST RADIOGRAPH

courtesy: wikipedia



CT SCAN

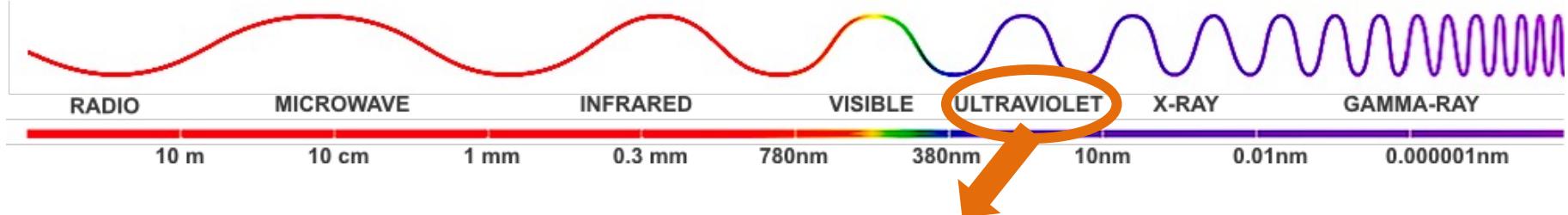
courtesy: wikipedia



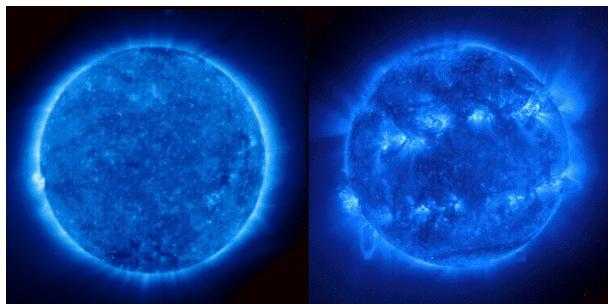
AIRPORT SCAN

courtesy: dpl-surveillance-equipment

EM spectrum



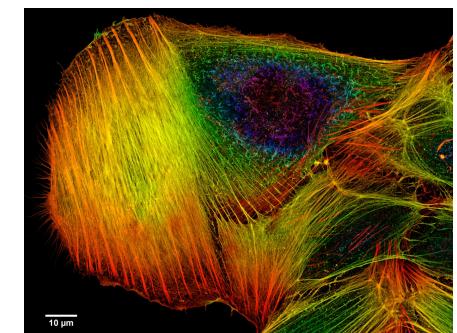
Lithography, industrial inspection, microscopy, lasers, astronomical observations, fluorescence microscopy etc.



SUN (2 years apart)
courtesy: NASA



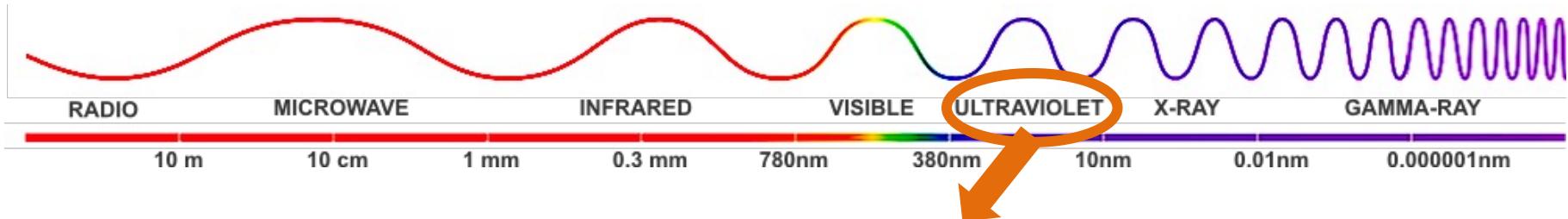
100 EURO BILL
courtesy: lifepixel.com



Cell Phalloidin
courtesy: wikipedia

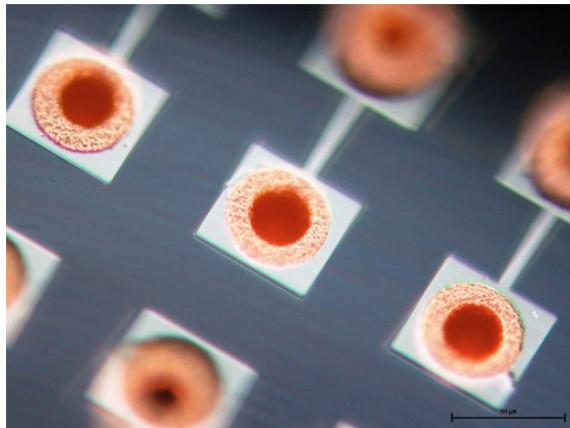
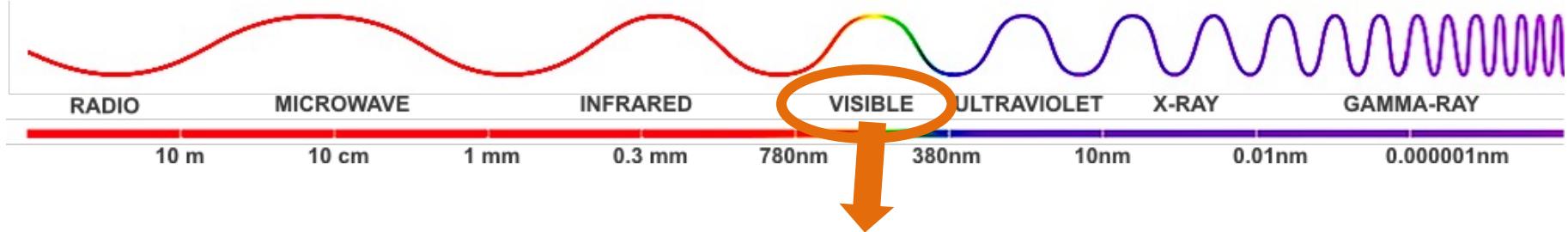
Eric Betzig, William Moerner and Stefan Hell

EM spectrum



Source:
Lifepixel.com

EM spectrum



Chips (optical microscopy)

courtesy: EPFL microelectronics systems laboratory



High Speed Photograph

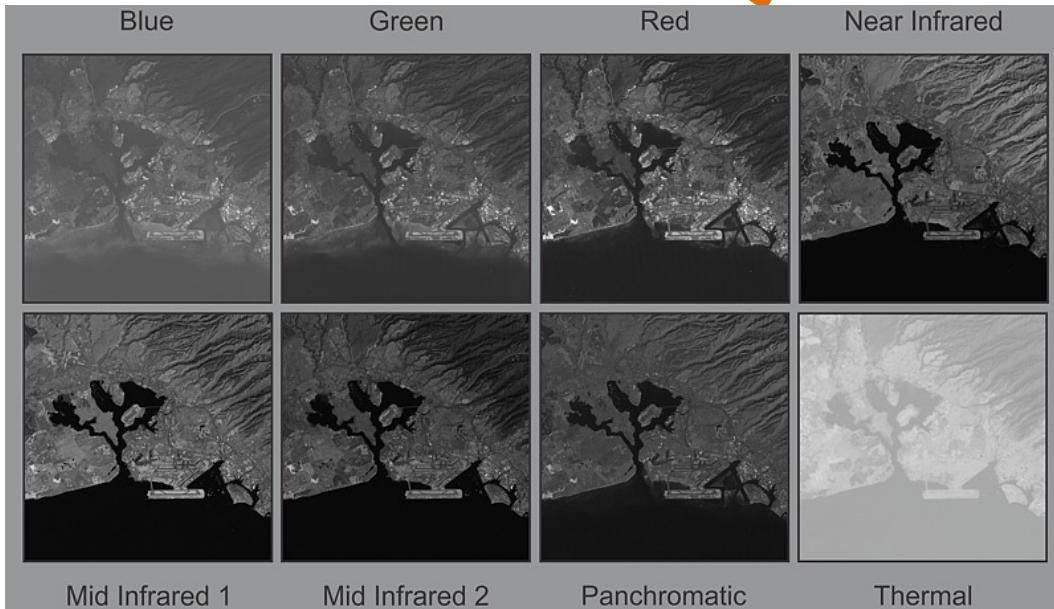
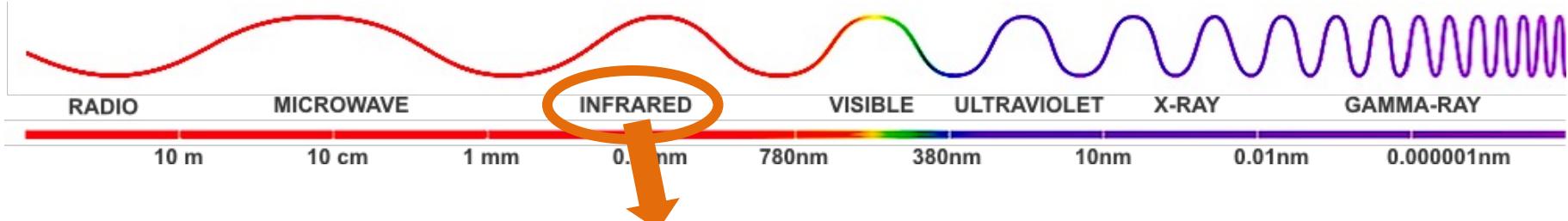
courtesy: Alan Sailer



Satellite Image (Hurricane Katrina)

courtesy: britannica.com

EM spectrum

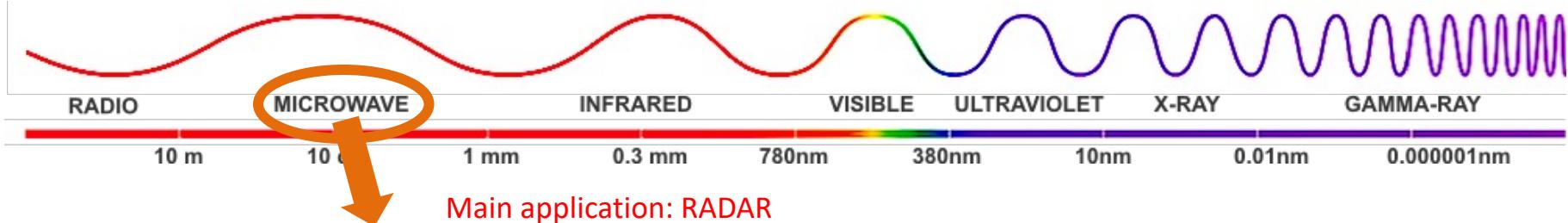


courtesy: LANDSAT (NASA)



courtesy: imaging1.com

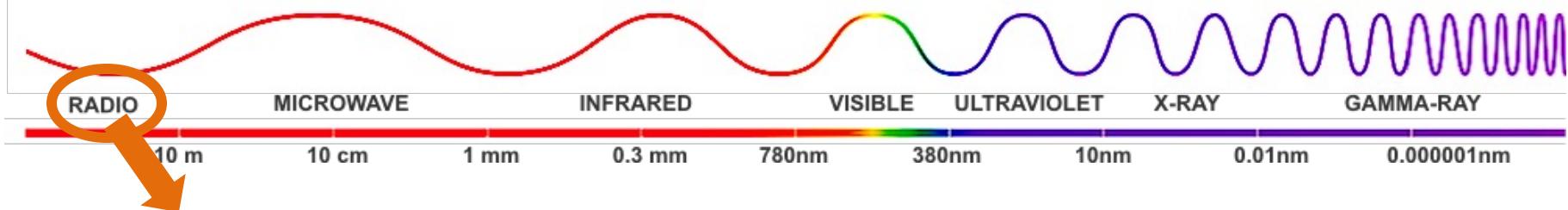
EM spectrum



SOUTHEAST TIBET MOUNTAINS

courtesy: NASA

EM spectrum



MRI Brain

courtesy: mritnt.com



MRI Knee

courtesy: mri-tip.com

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Ultrasound



ULTRASOUND

courtesy: wikipedia



ULTRASOUND TWINS

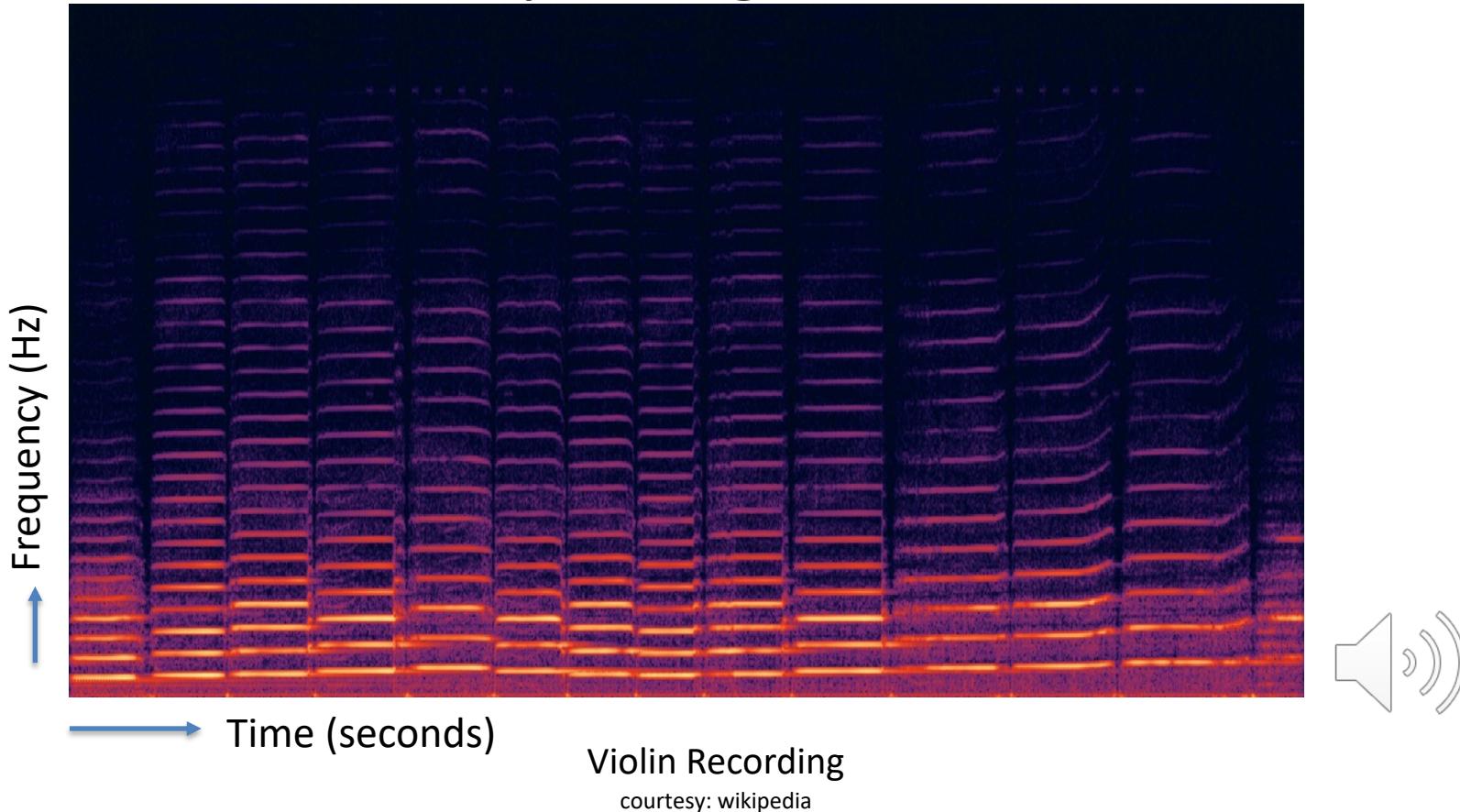
courtesy: pinterest



ULTRASOUND 3D

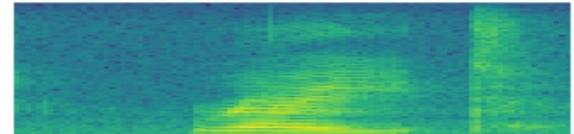
courtesy: peek3D.com

Spectrogram

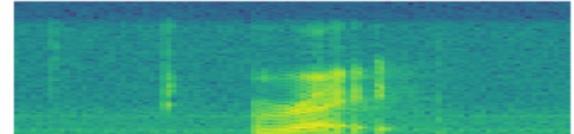


Spectrogram

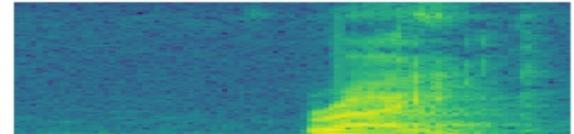
right



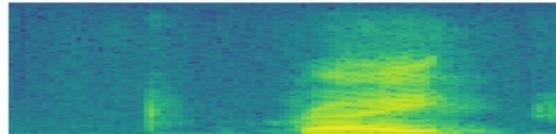
tree



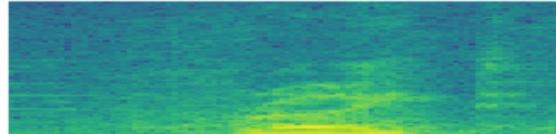
go



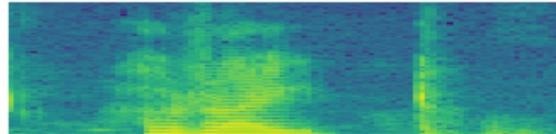
eight



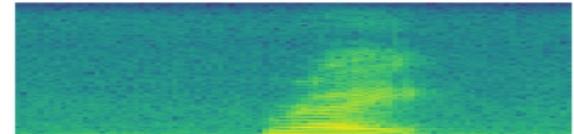
bed



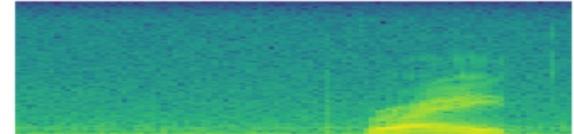
dog



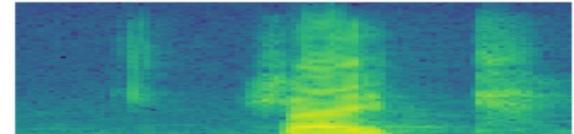
cat



happy



no

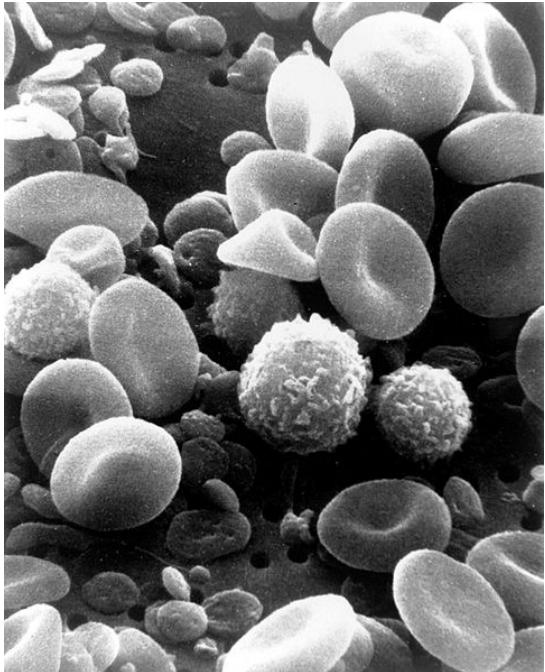


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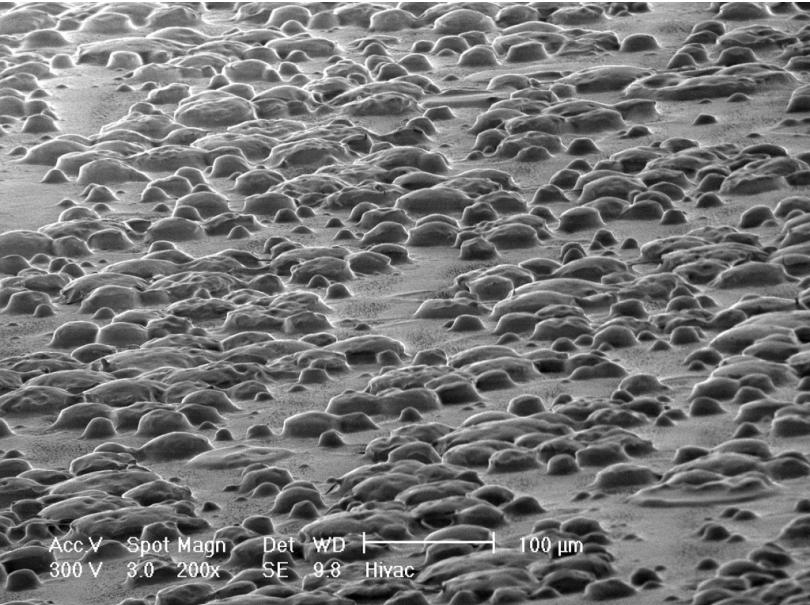


Scanning Electron Microscopy



Normal Circulating Human Blood

courtesy: National Cancer Institute



Adhesive on Post-it note

courtesy: wikipedia

Types of Images (classification on source)

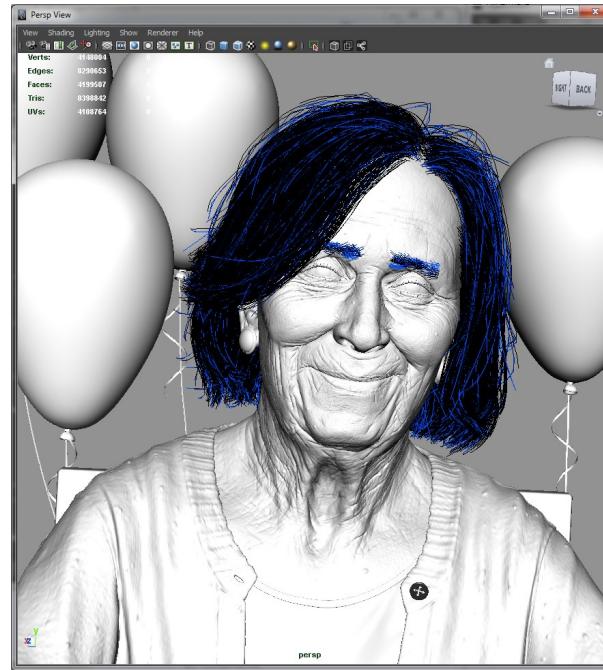
- Radiation from EM spectrum
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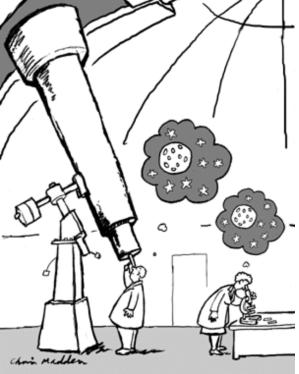
Computer generated



Happy Birthday Nana

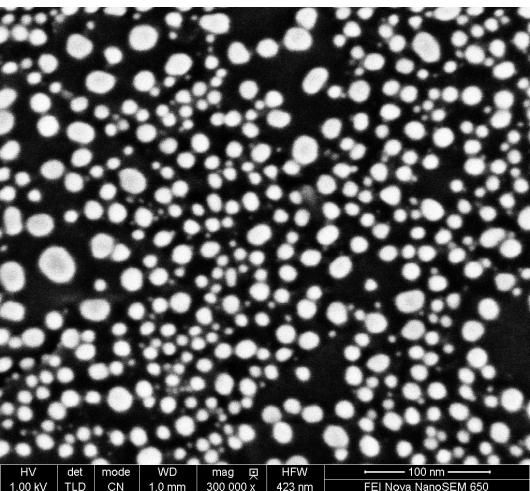
courtesy: Dan Roarty





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



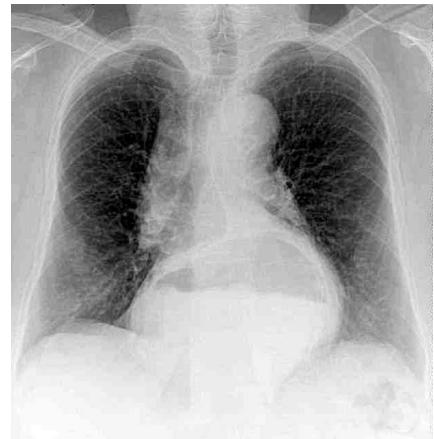
Information primarily about objects surface

2. Emission Images



Information primarily about internal properties

3. Absorption Images

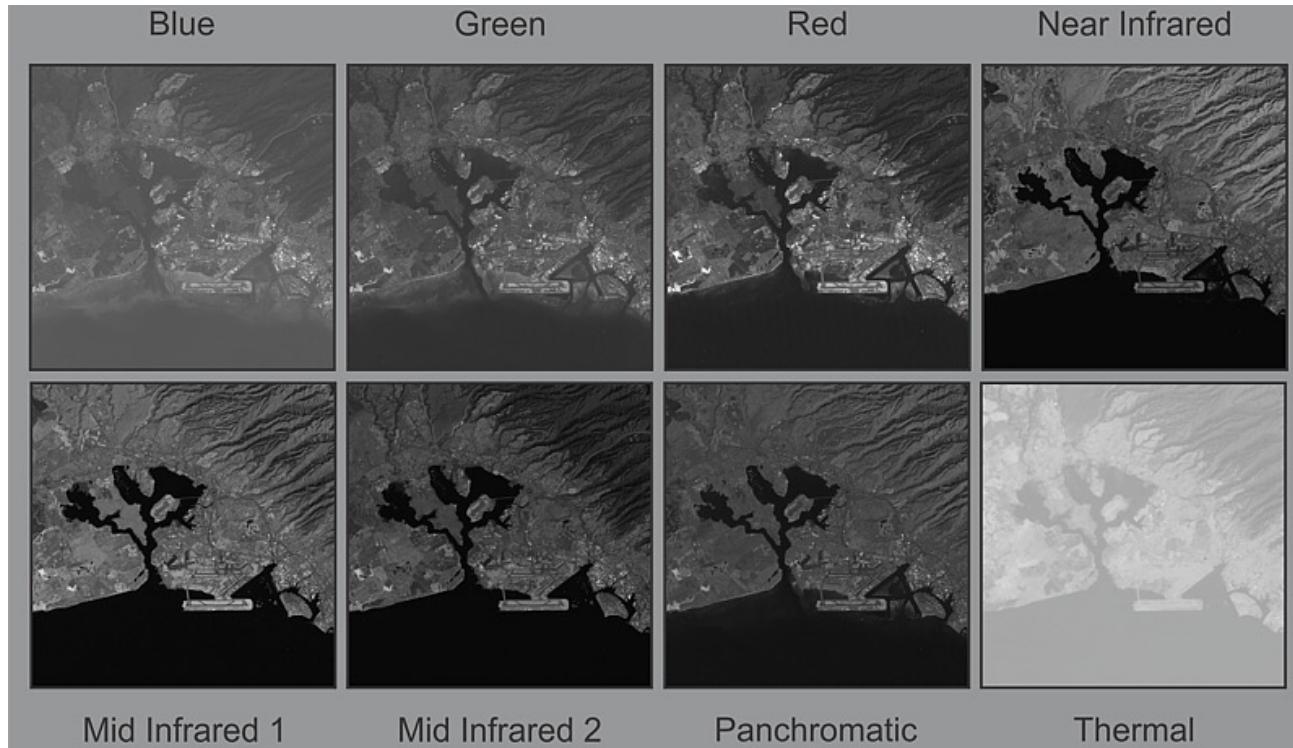


Information primarily about internal structure

Types on images (classification on arrangement)

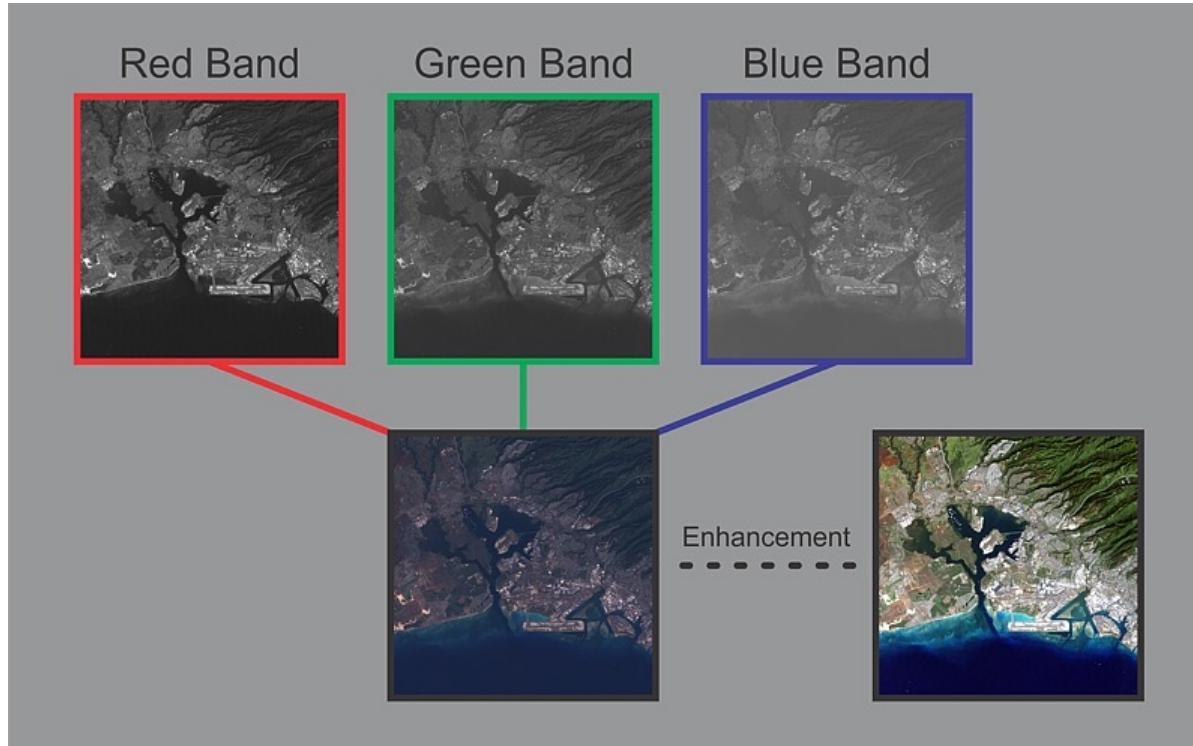
- Grayscale
- RGB
- Multispectral images
- Stereo images
- Multi-view images

Multi spectral images



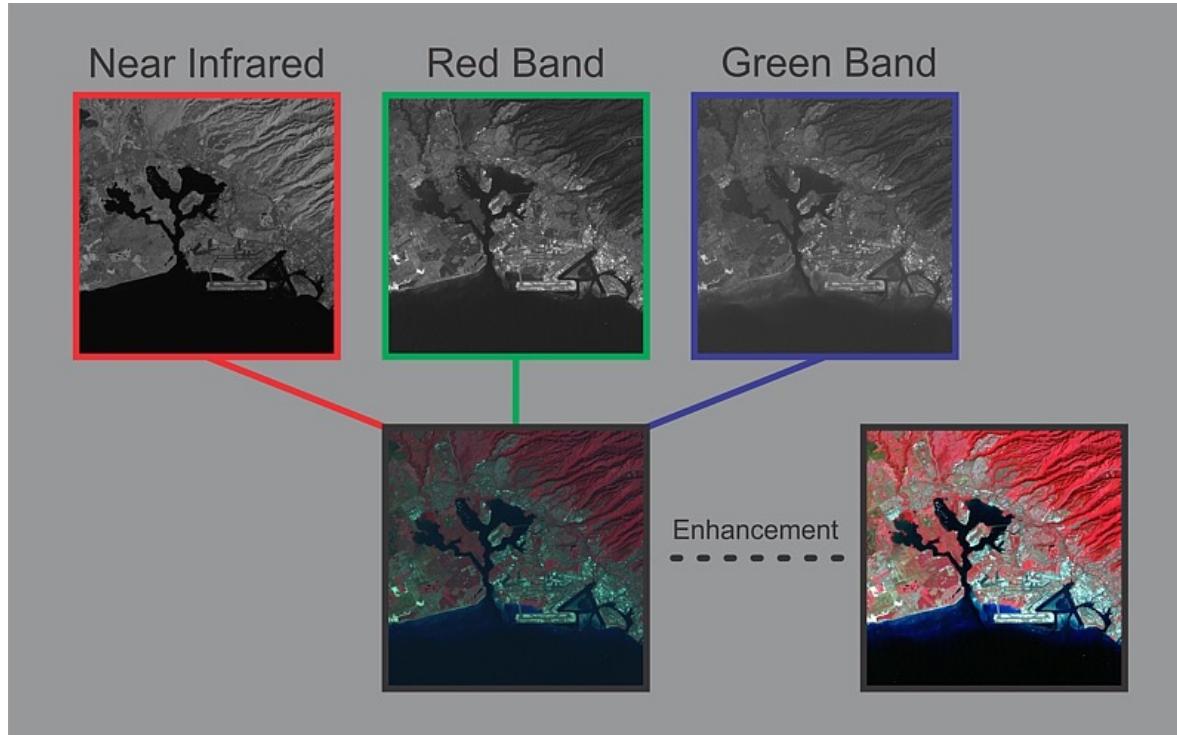
Courtesy: LANDSAT

Multi spectral images



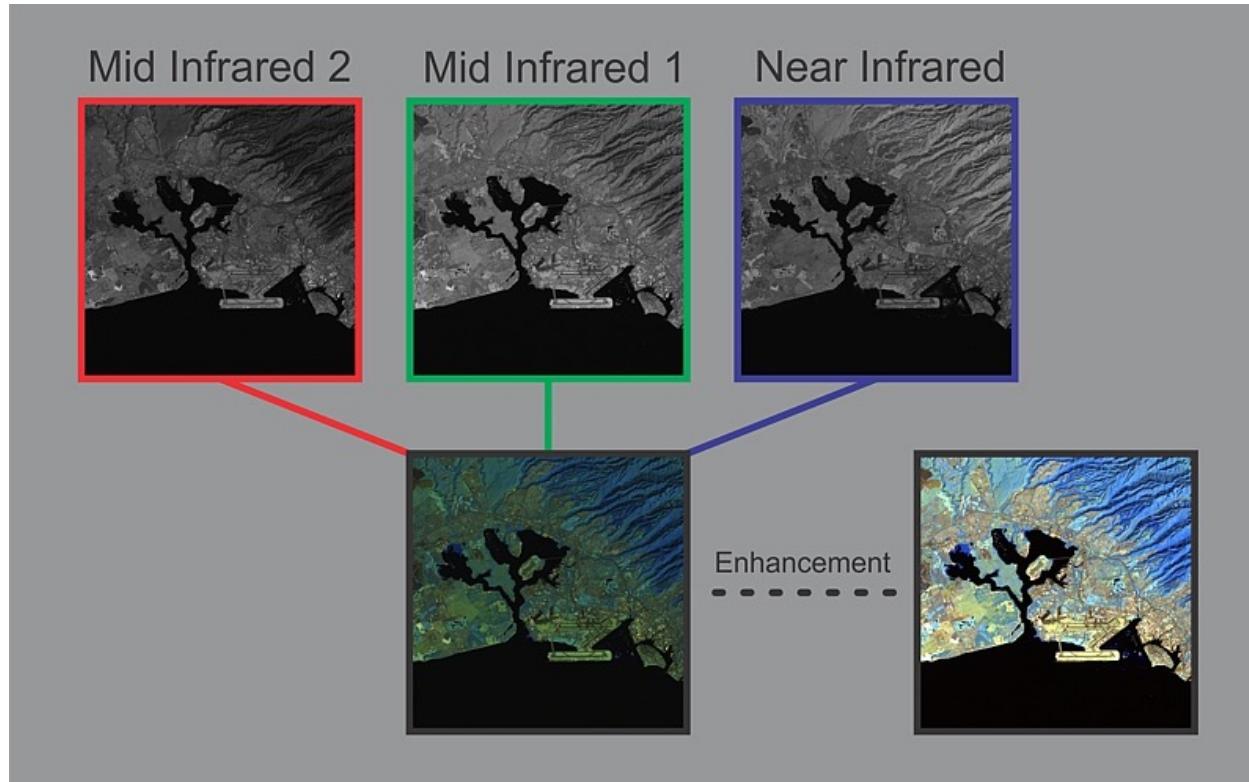
Courtesy: LANDSAT

Multi spectral images



Courtesy: LANDSAT

Multi spectral images

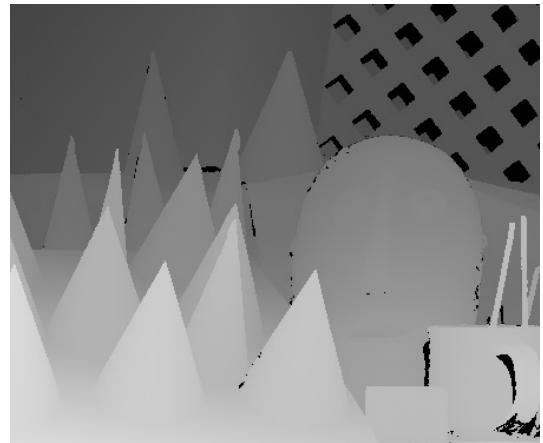
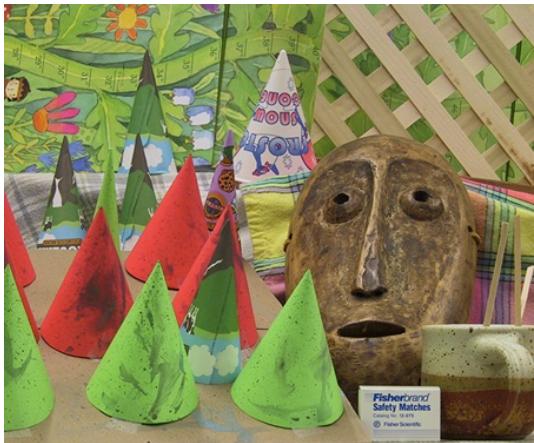


Stereo Images



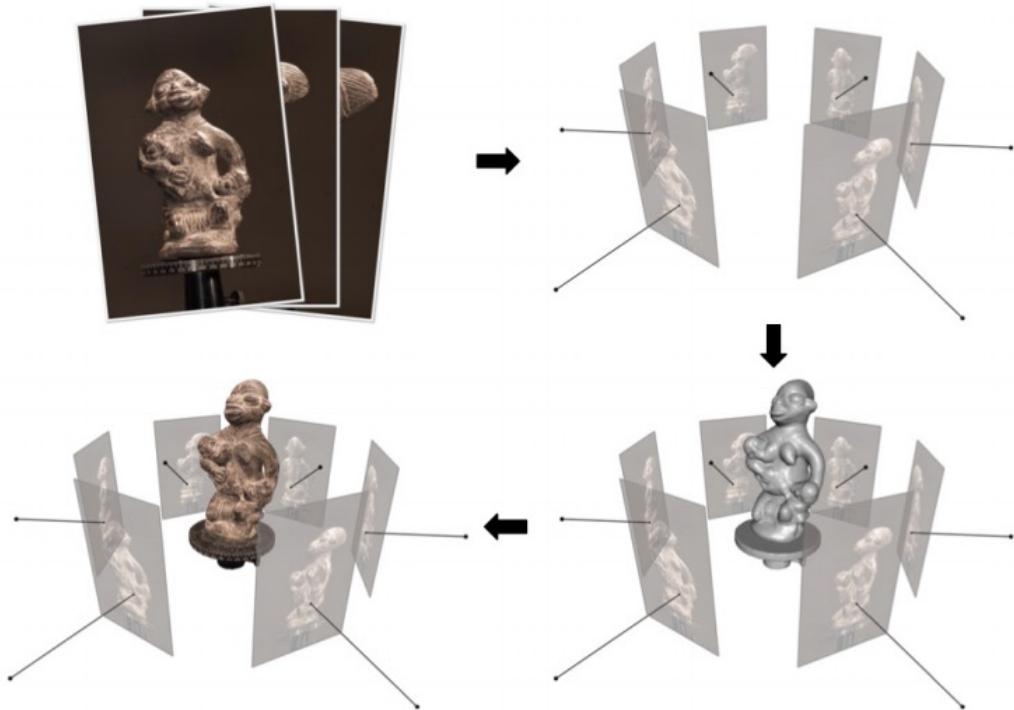
courtesy: [wikimedia.com](#)

Stereo Images



courtesy: vision.middlebury.edu

Multi-view images



courtesy: Yasutaka Furukawa



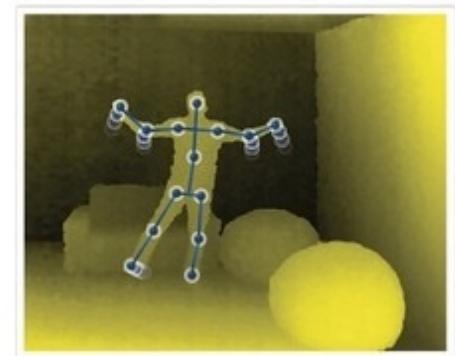
courtesy: Sameer Agarwal

RGB-D images

Color (RGB) Image



Depth Image

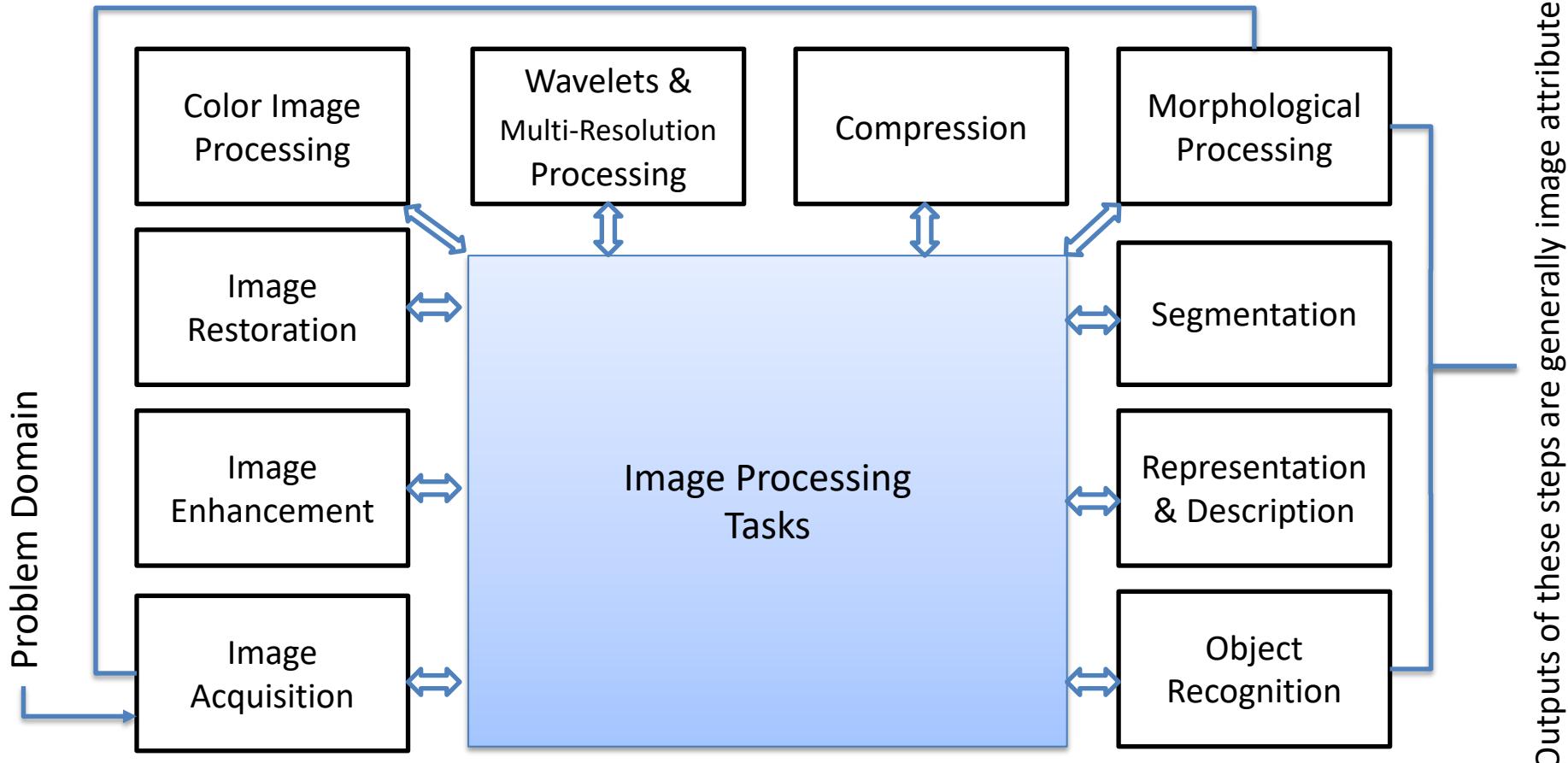


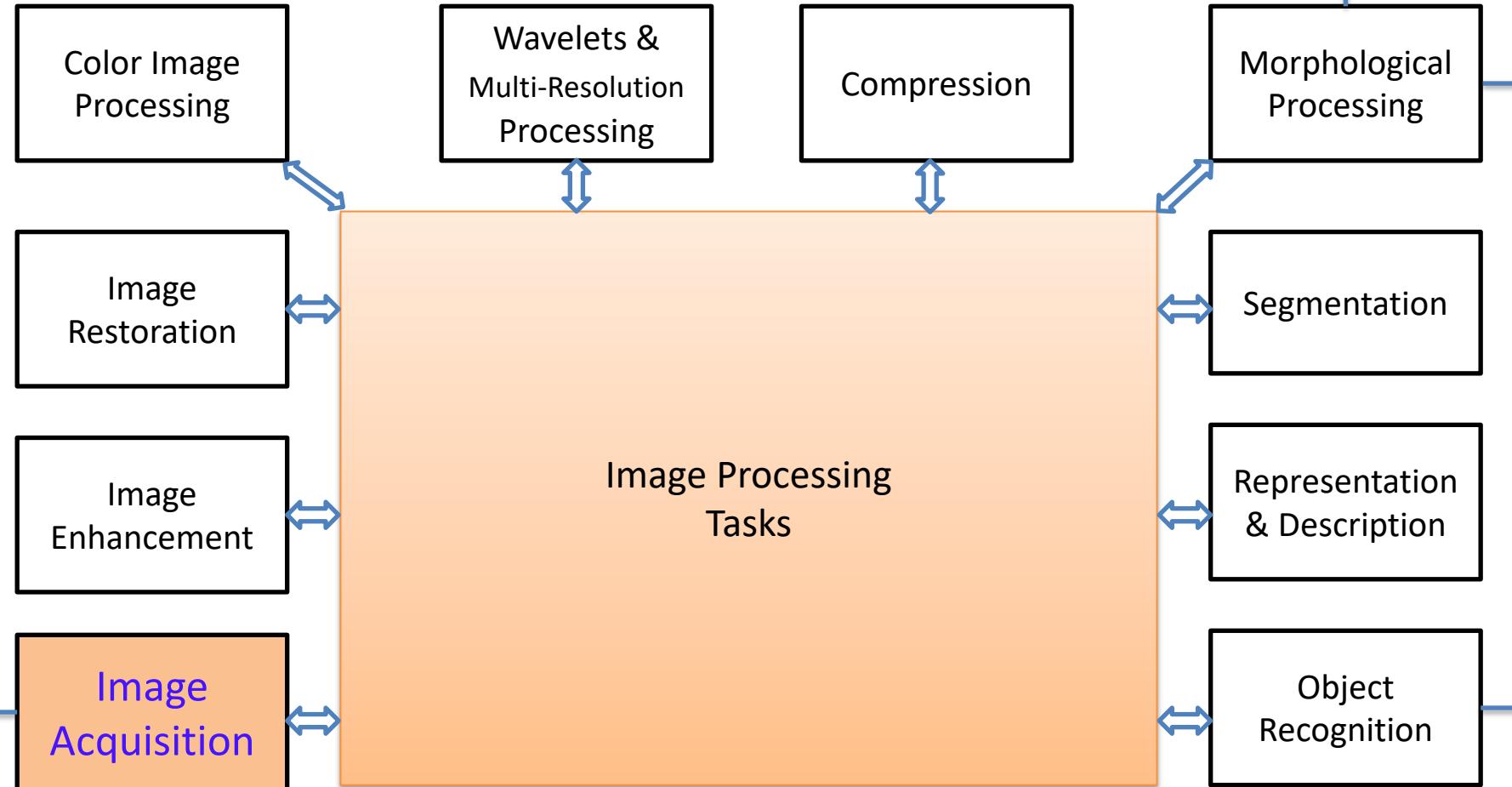
courtesy: kinect and prime sense

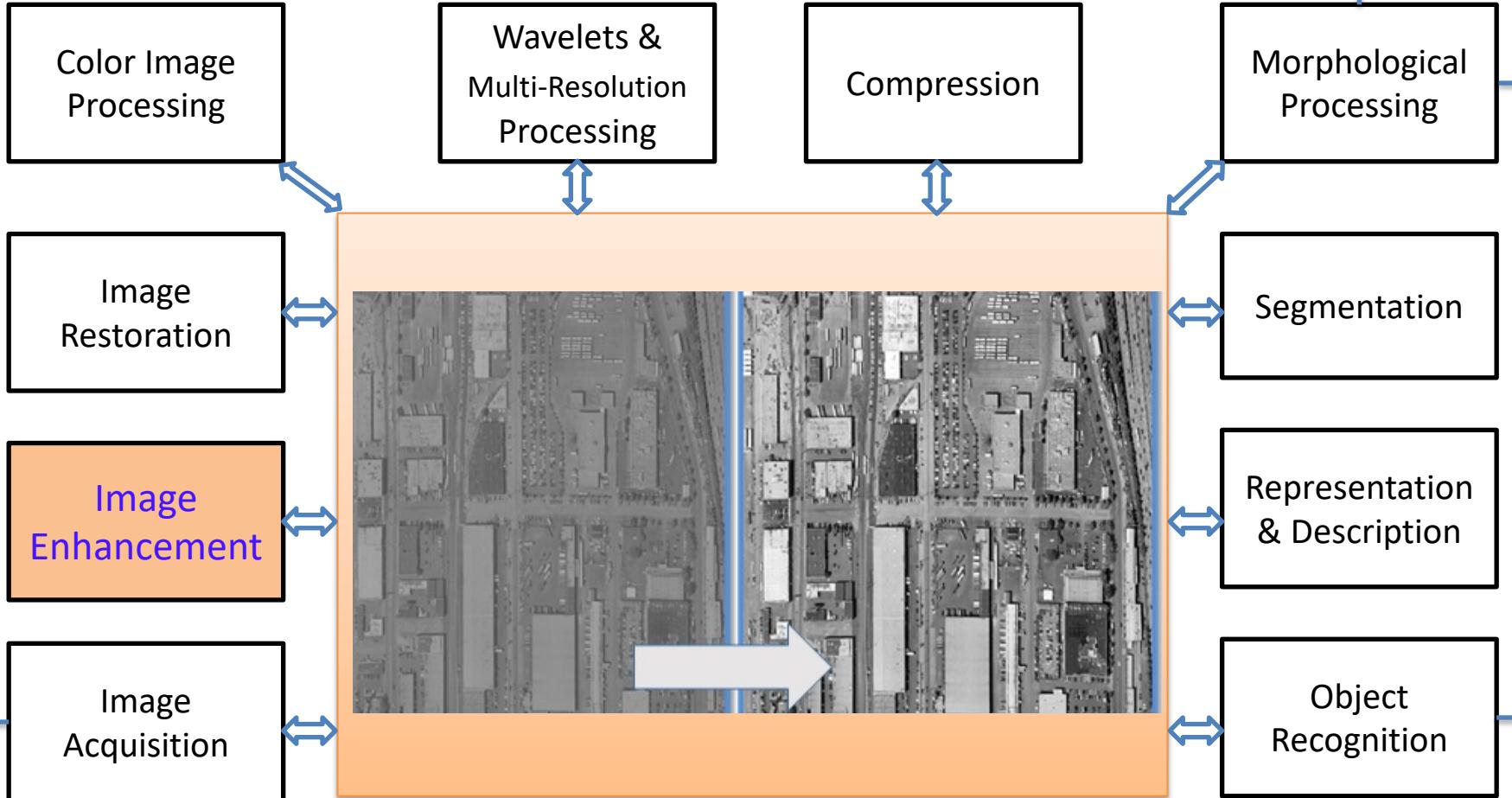
Digital Image **processing**

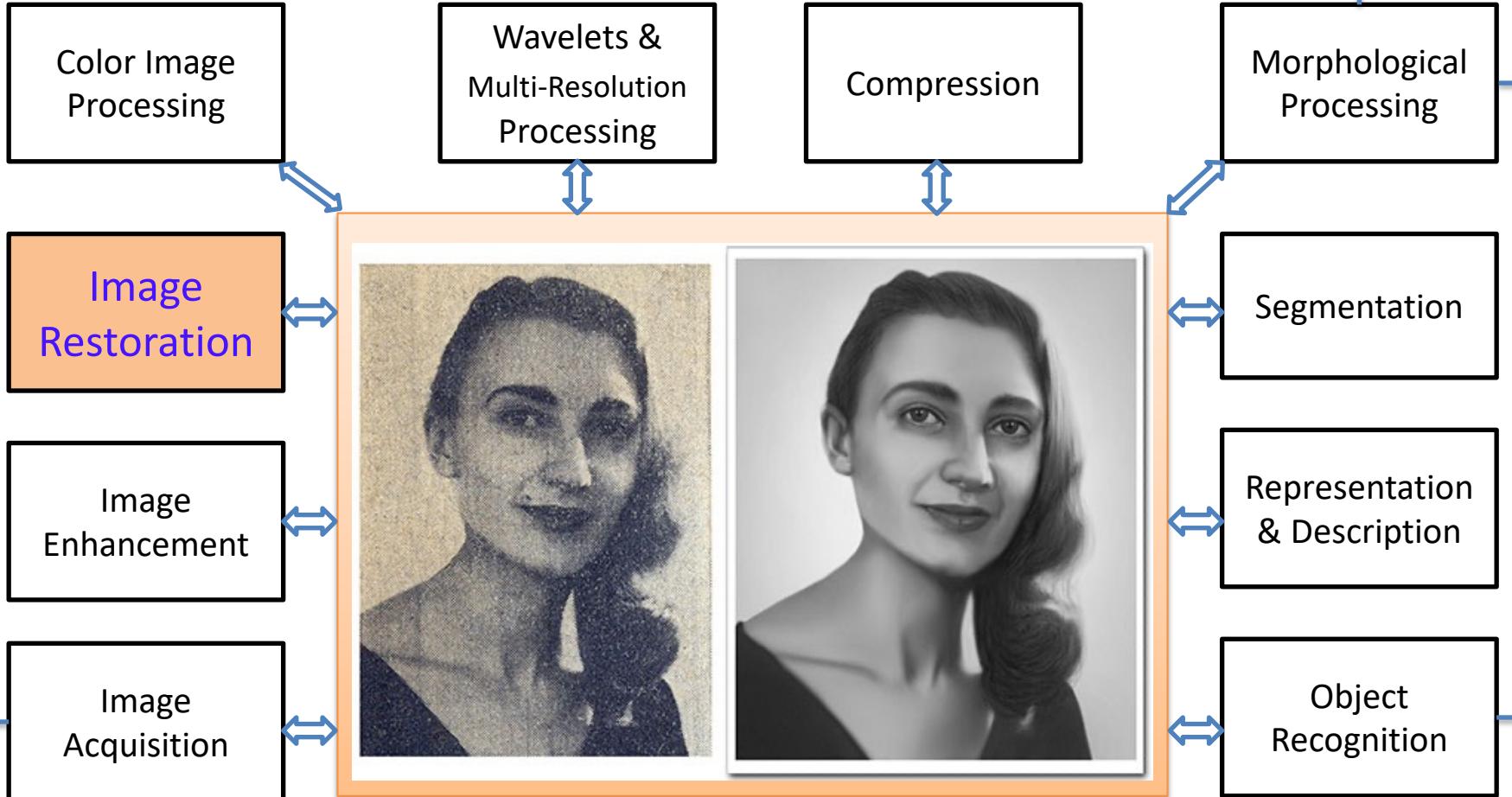
- Study and Development of algorithms that operate on an image
 - To create new image(s)
 - To retrieve its attributes
- Consumer-based view
 - For consumption by human eyes
 - For consumption by machine-based processes

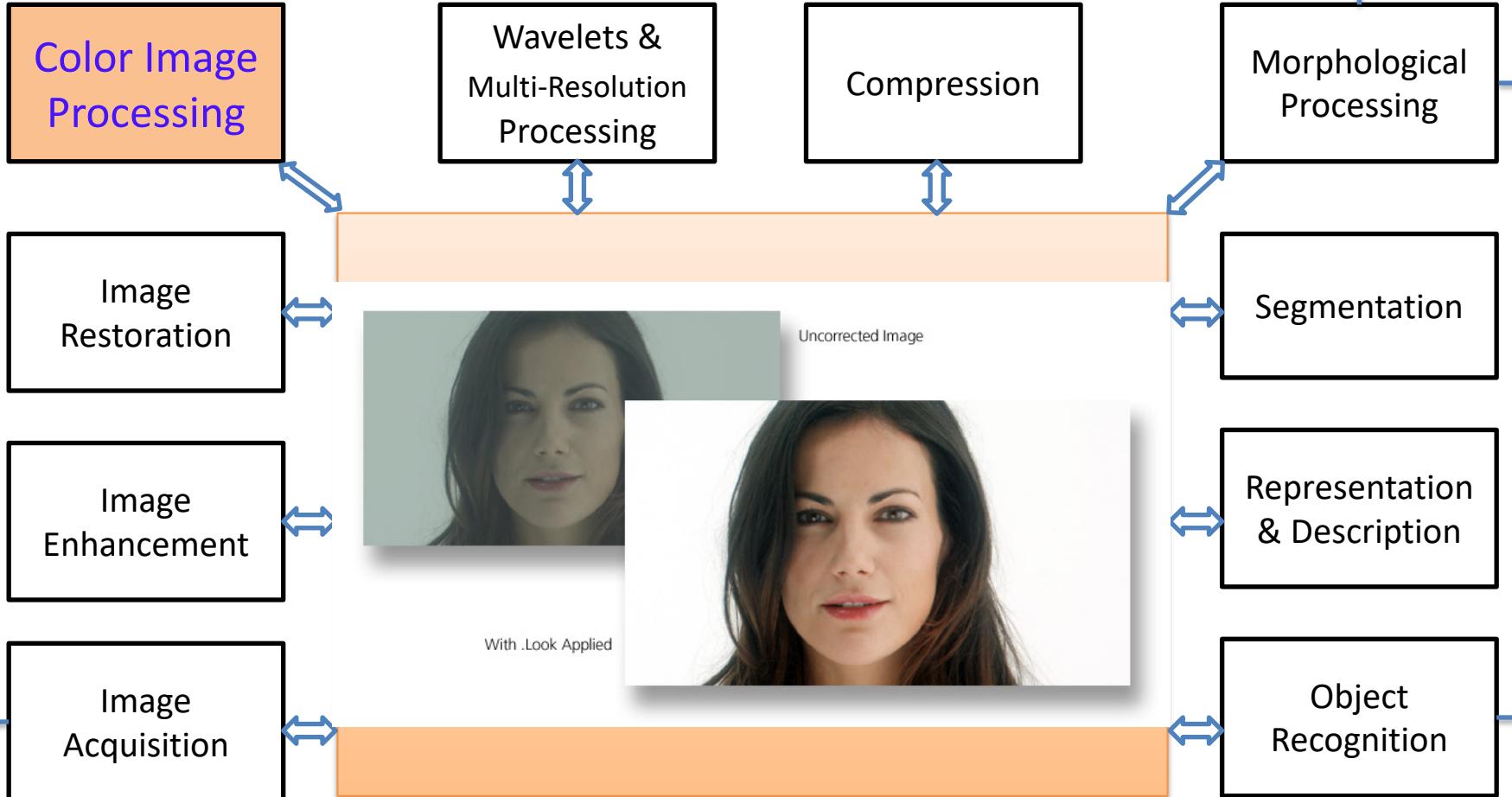
Outputs of these steps are generally images

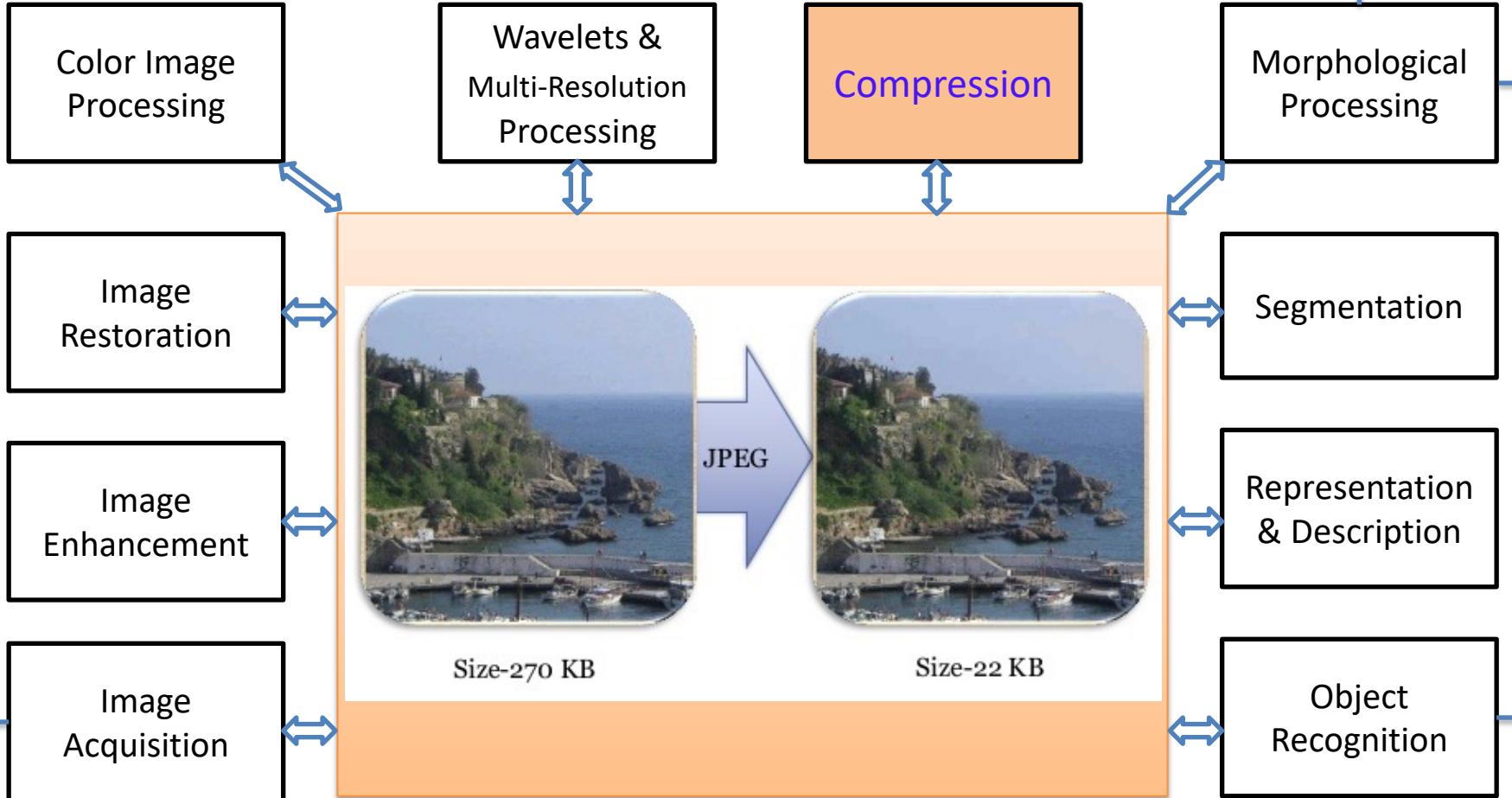


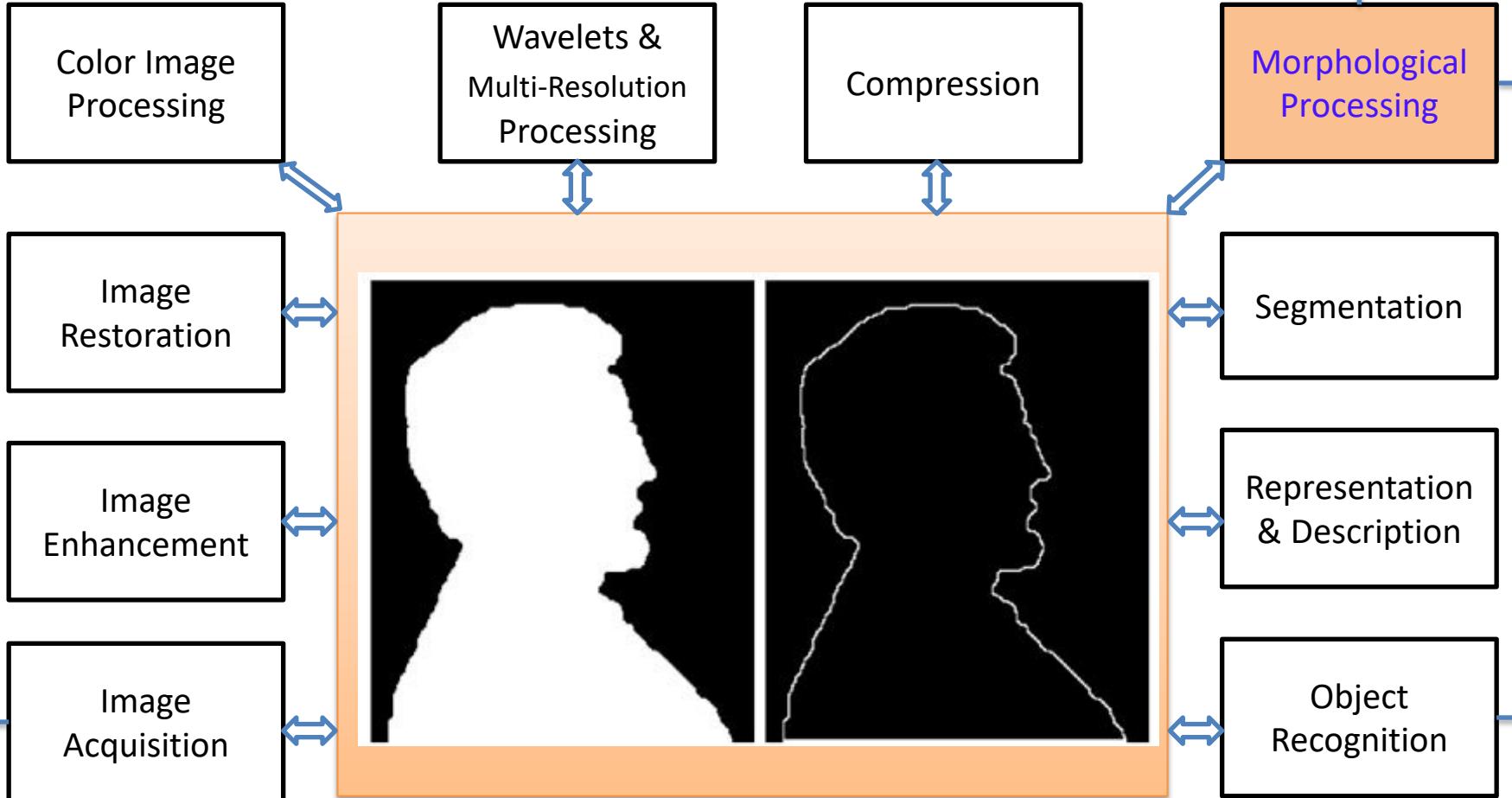


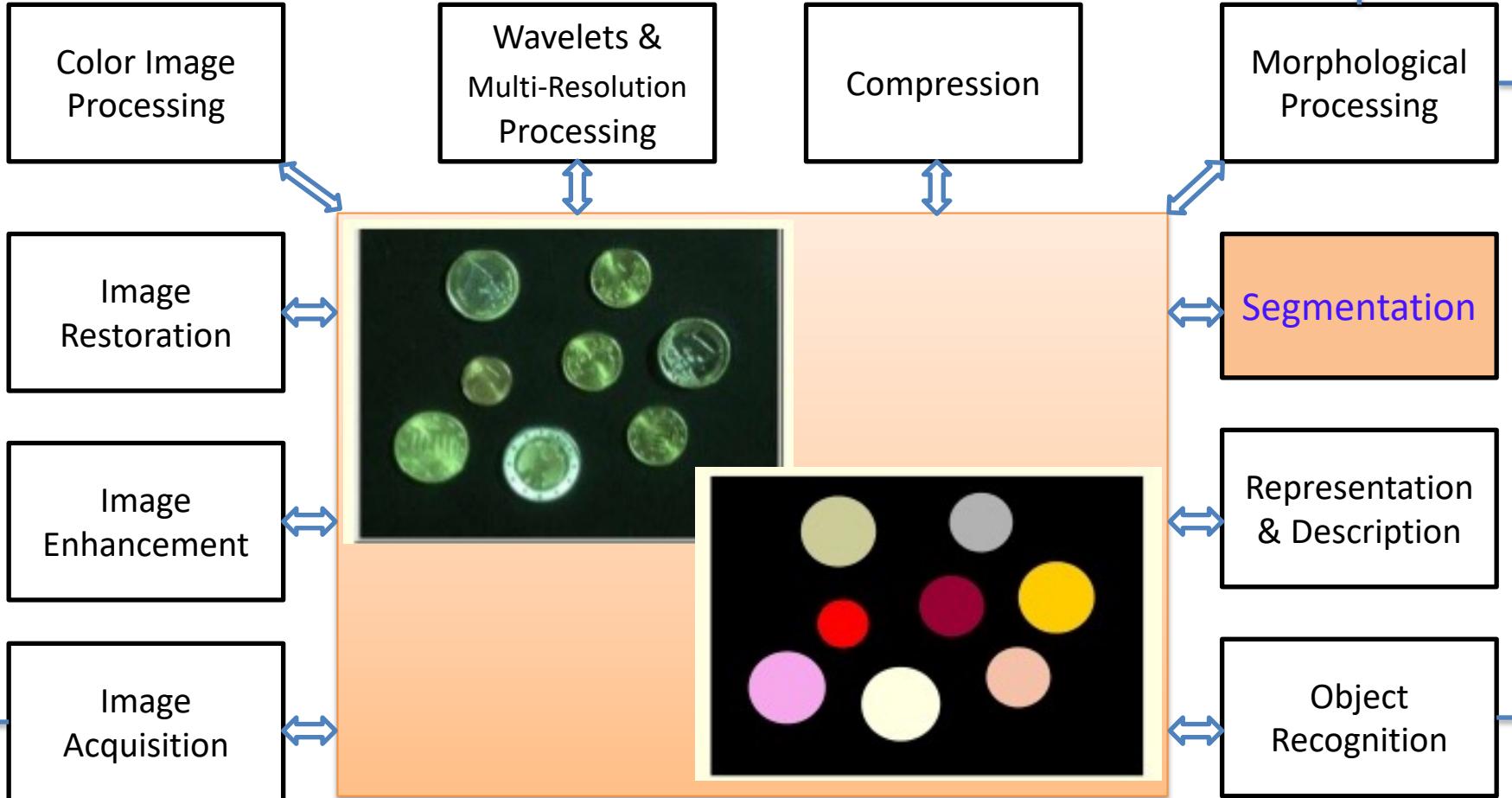


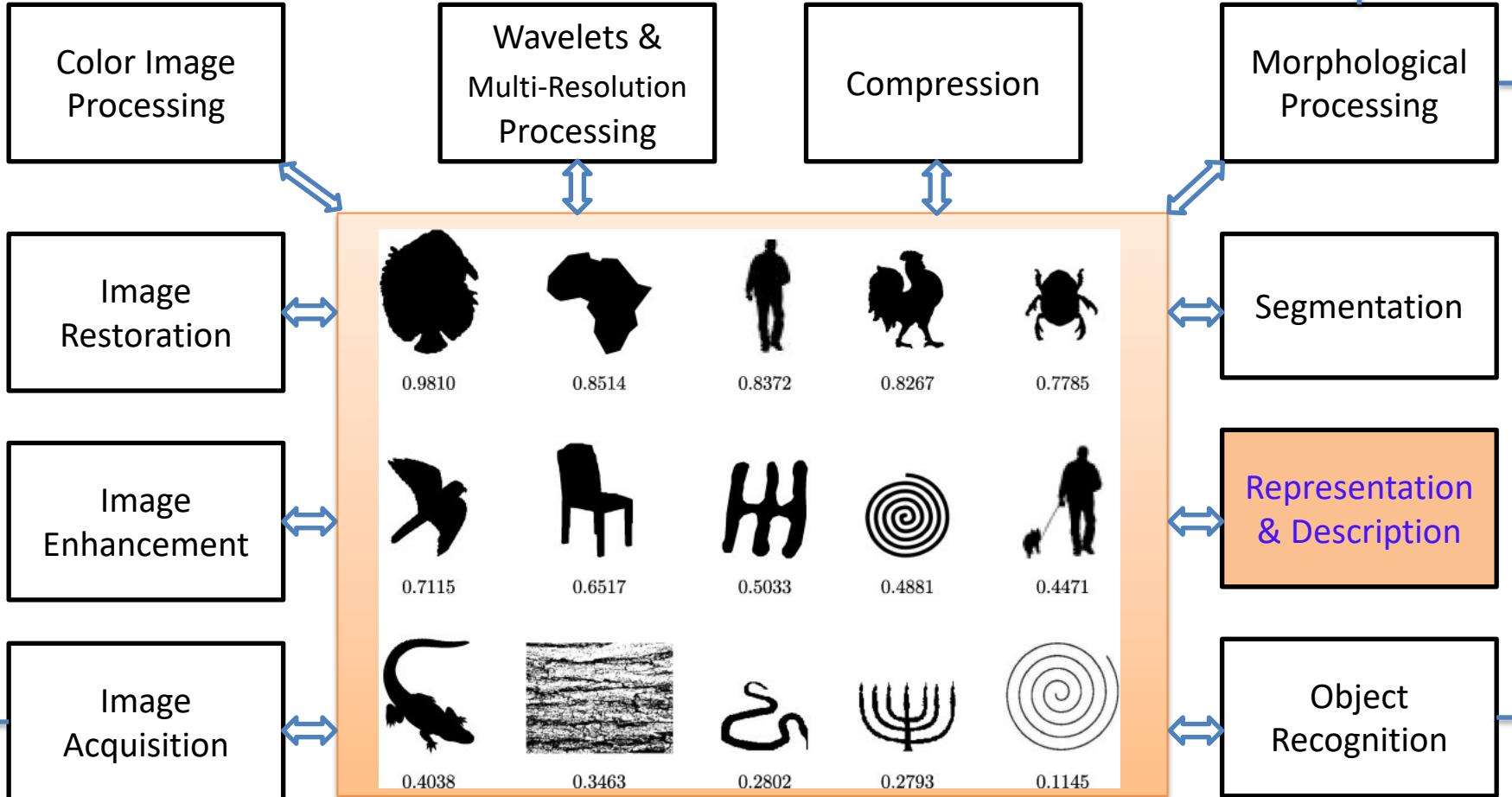












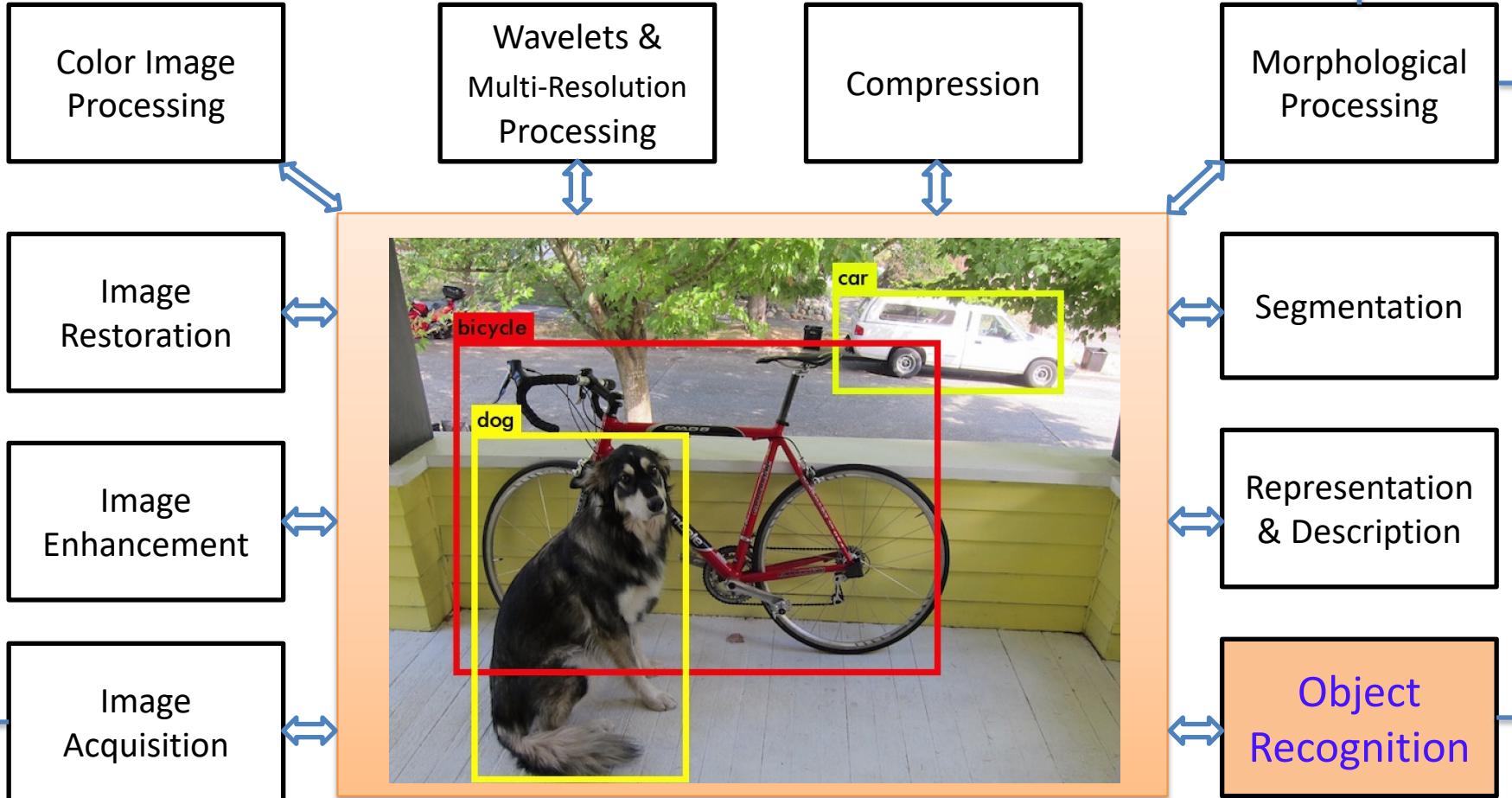
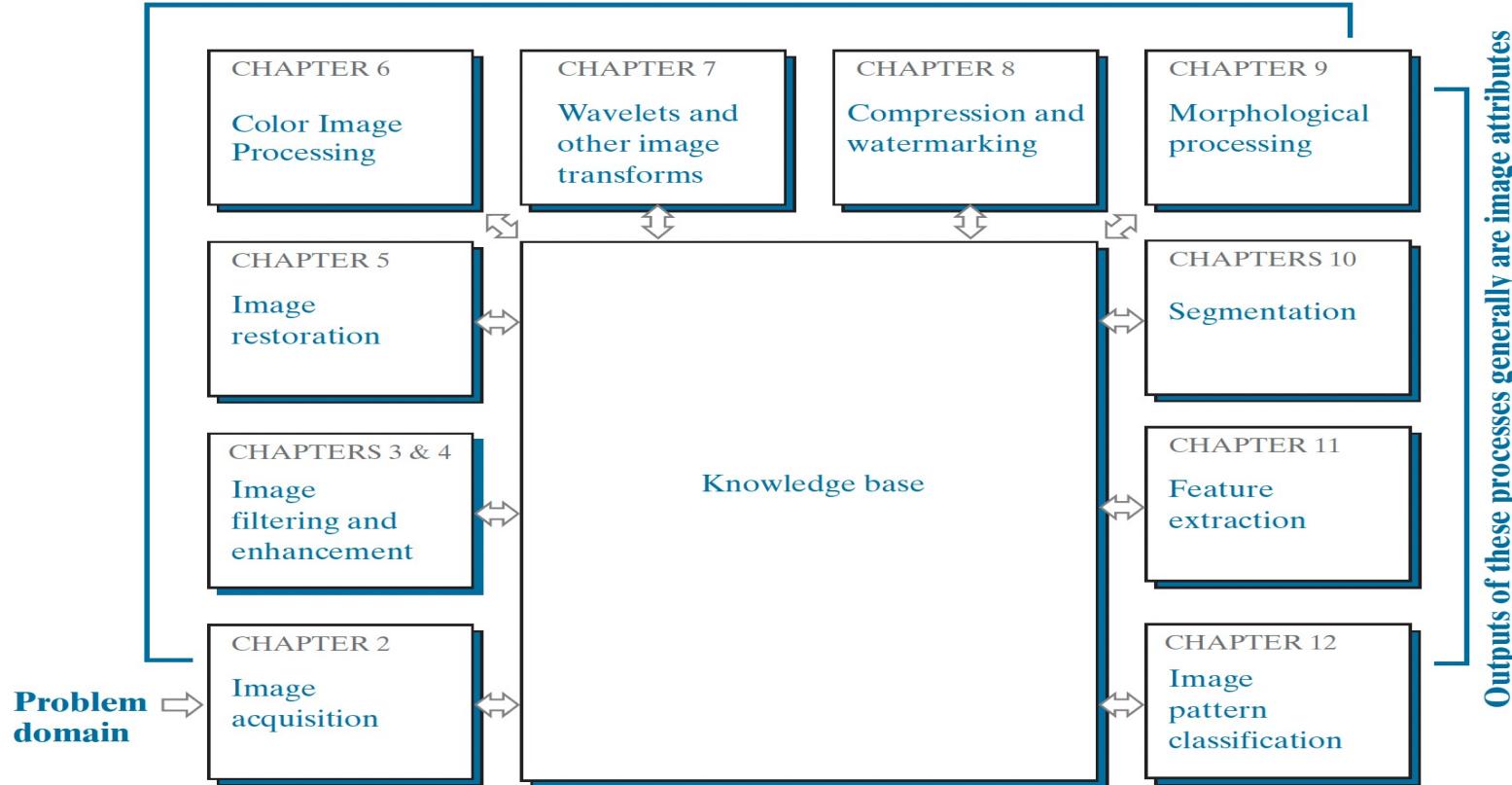


Image Processing Tasks

Outputs of these processes generally are images



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

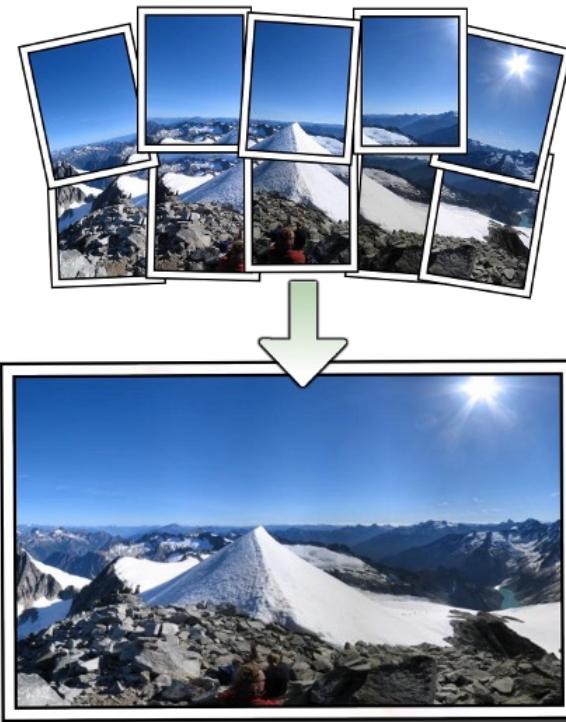


Image courtesy: autostitch

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

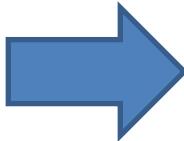
Image courtesy: webneel.com



Image courtesy: Jon Morse

BW to Color

Mayabazar (1957), Vijaya Vauhini Studios



Colorized (2010)



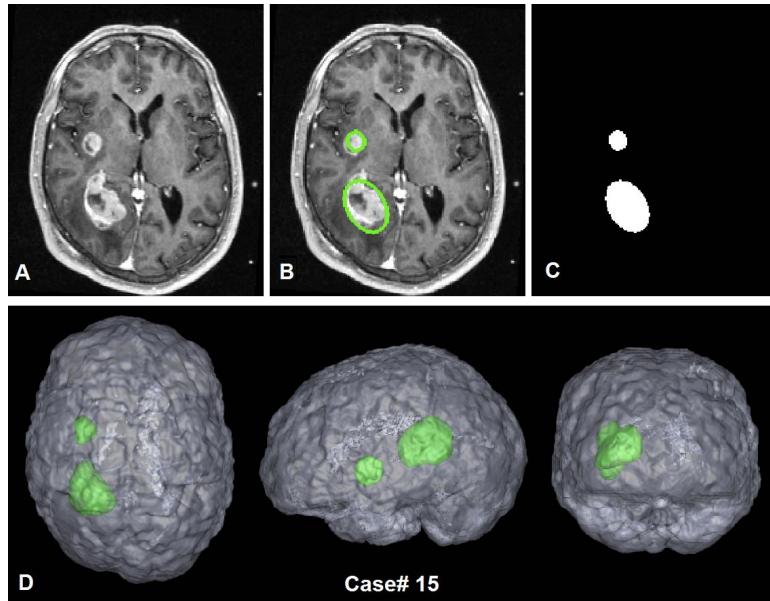
Tasks of interest: Cinematic Grading

Mission Impossible - Ghost Protocol, Paramount Pictures

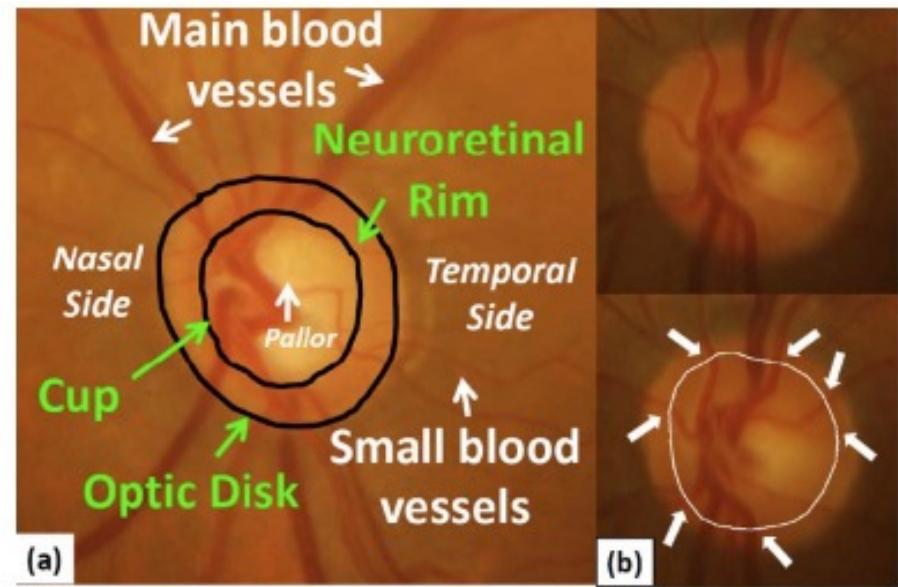


Image courtesy: juanmelara.com

Tasks of interest: Segmentation

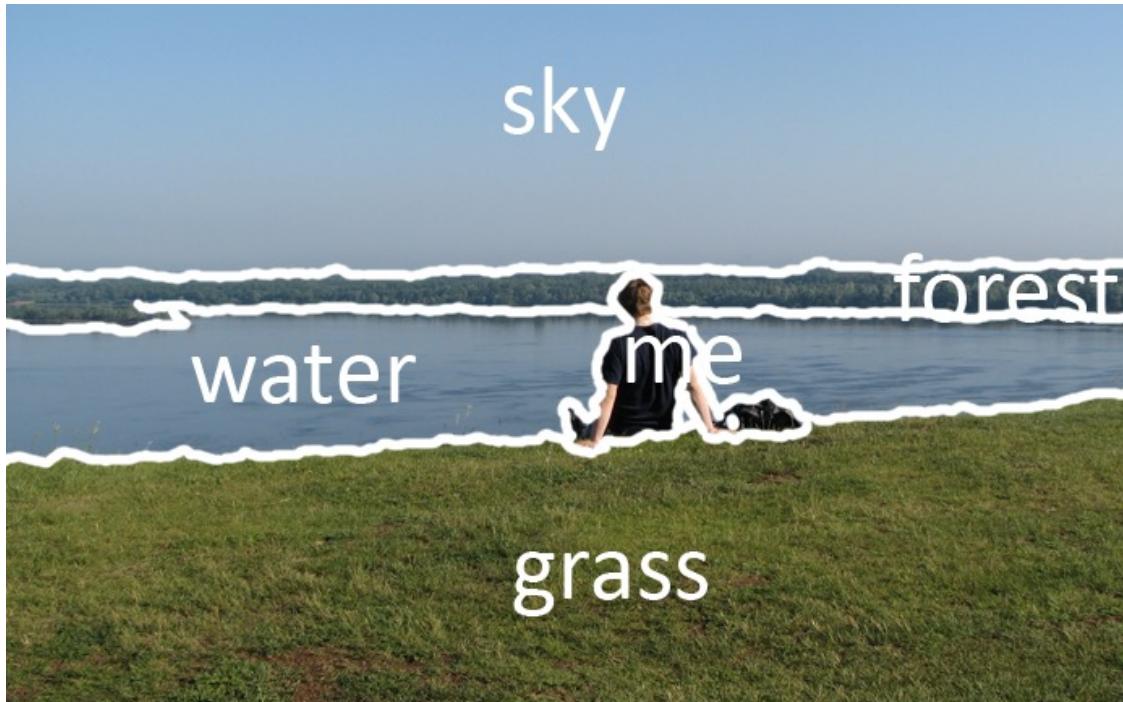


Tumour Segmentation [Yu et al. MICCAI 2010]



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

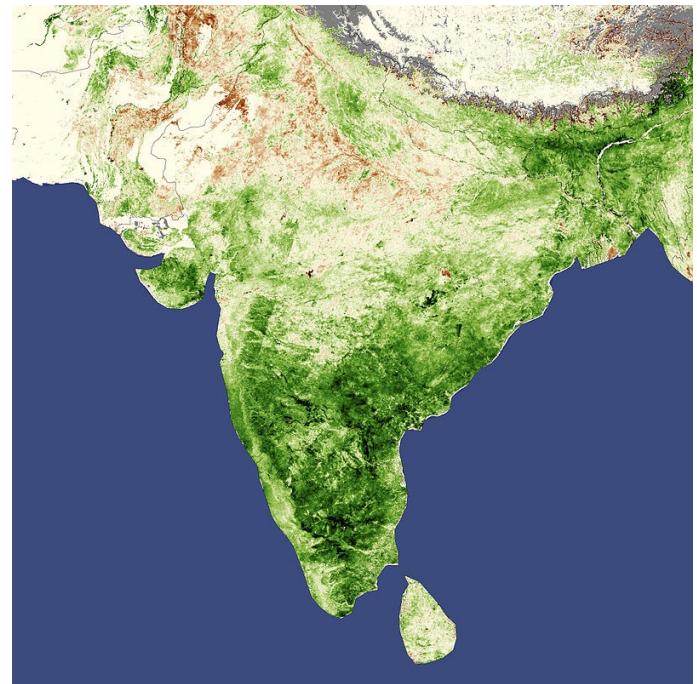
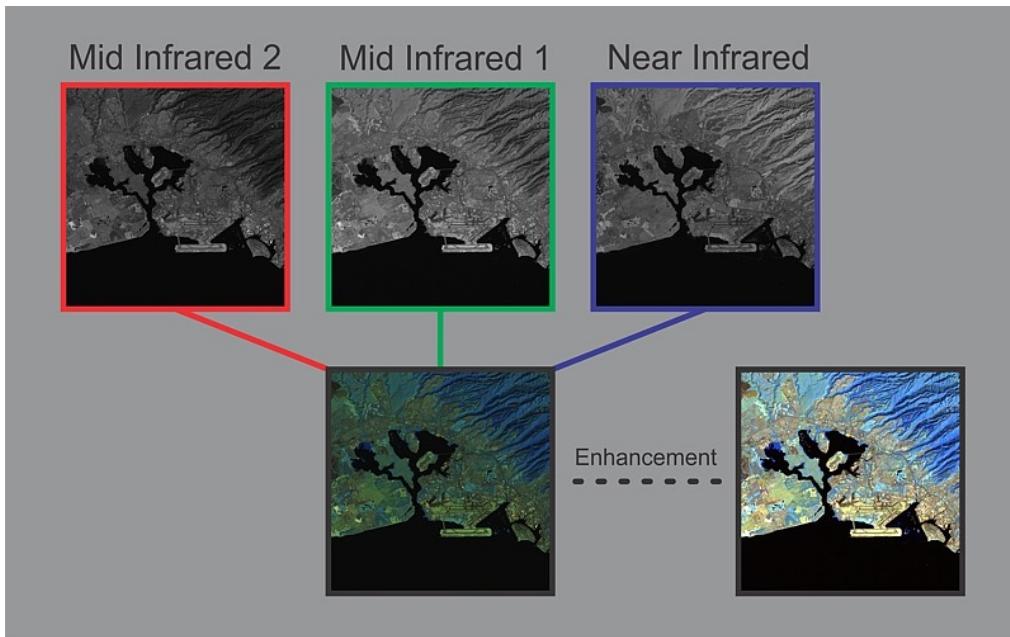


courtesy: wachowsky brothers (matrix)



courtesy: Miller et al. (sin city)

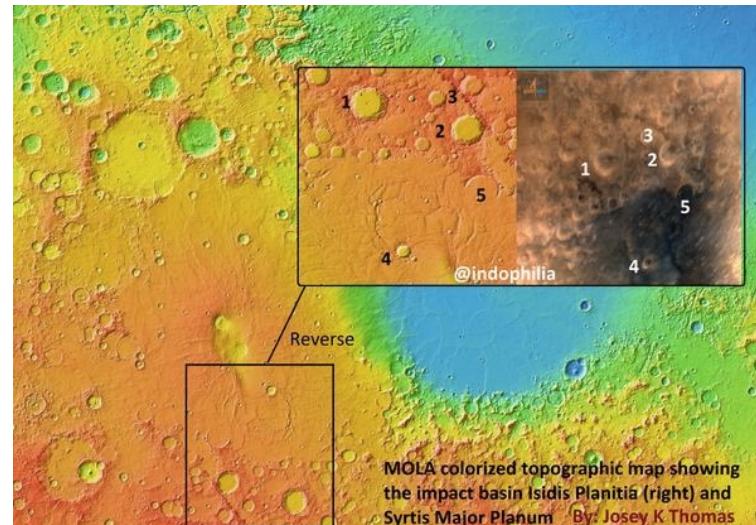
Tasks of interest: Satellite imaging



Terrain classification, weather predictions etc.

courtesy: NASA

Tasks of interest: Astronomy

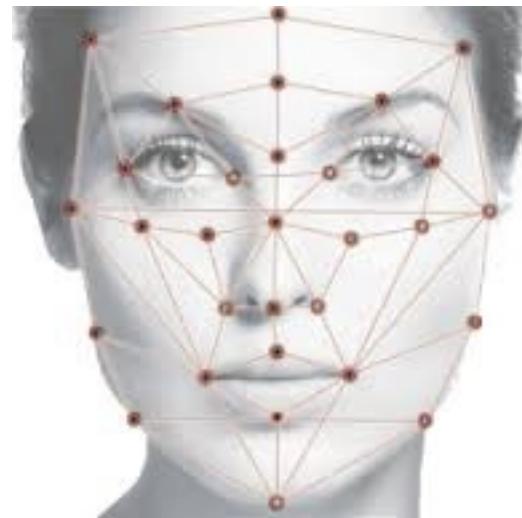


courtesy: ISRO

Tasks of interest: Biometrics

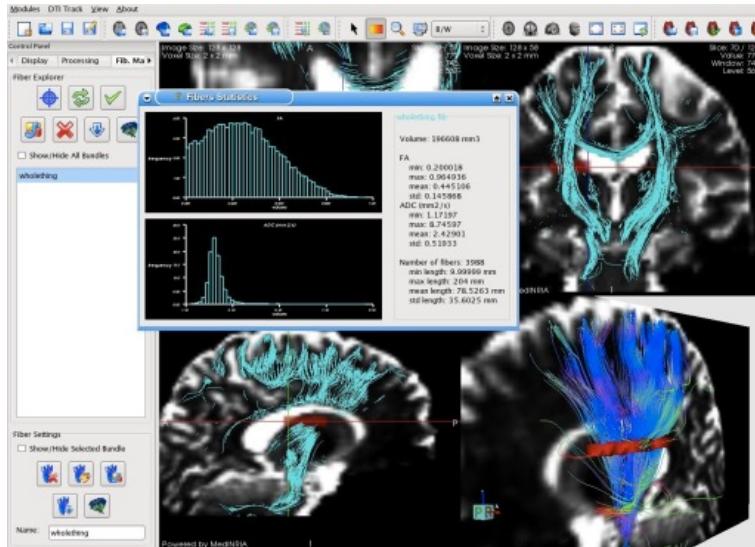


courtesy: dqindia.com

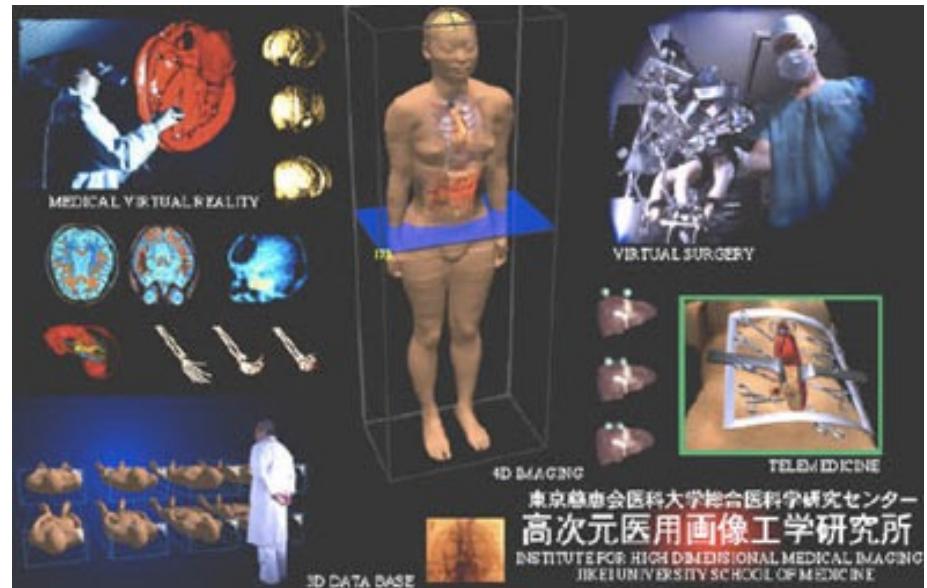


courtesy: heyce.com

Tasks of interest: Medicine



Courtesy: medINRIA



Courtesy: Naoki Suzuki

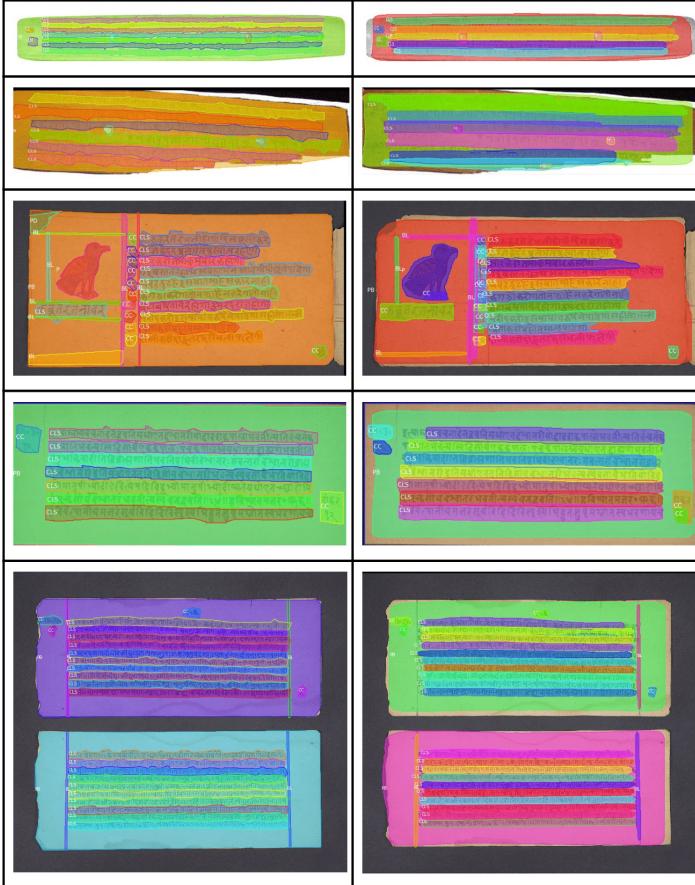
Tasks of interest: Driverless Vehicle Systems



Face Blurring for Privacy Protection



Tasks of interest: Document Image Analysis



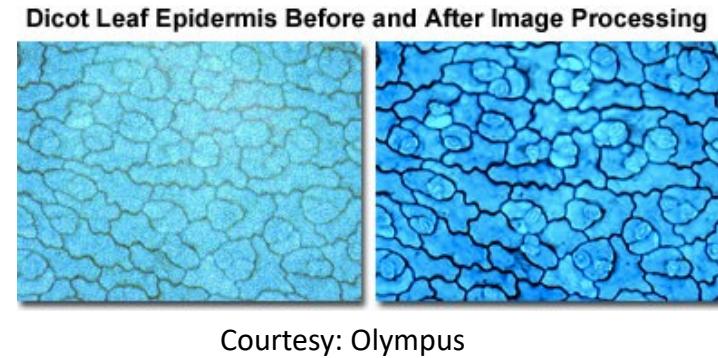
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CASH 5.56 CHANGE 0.10- TOTAL SAVED: \$411.99	CASH 5.56 CHANGE 0.10- TOTAL SAVED: \$411.99

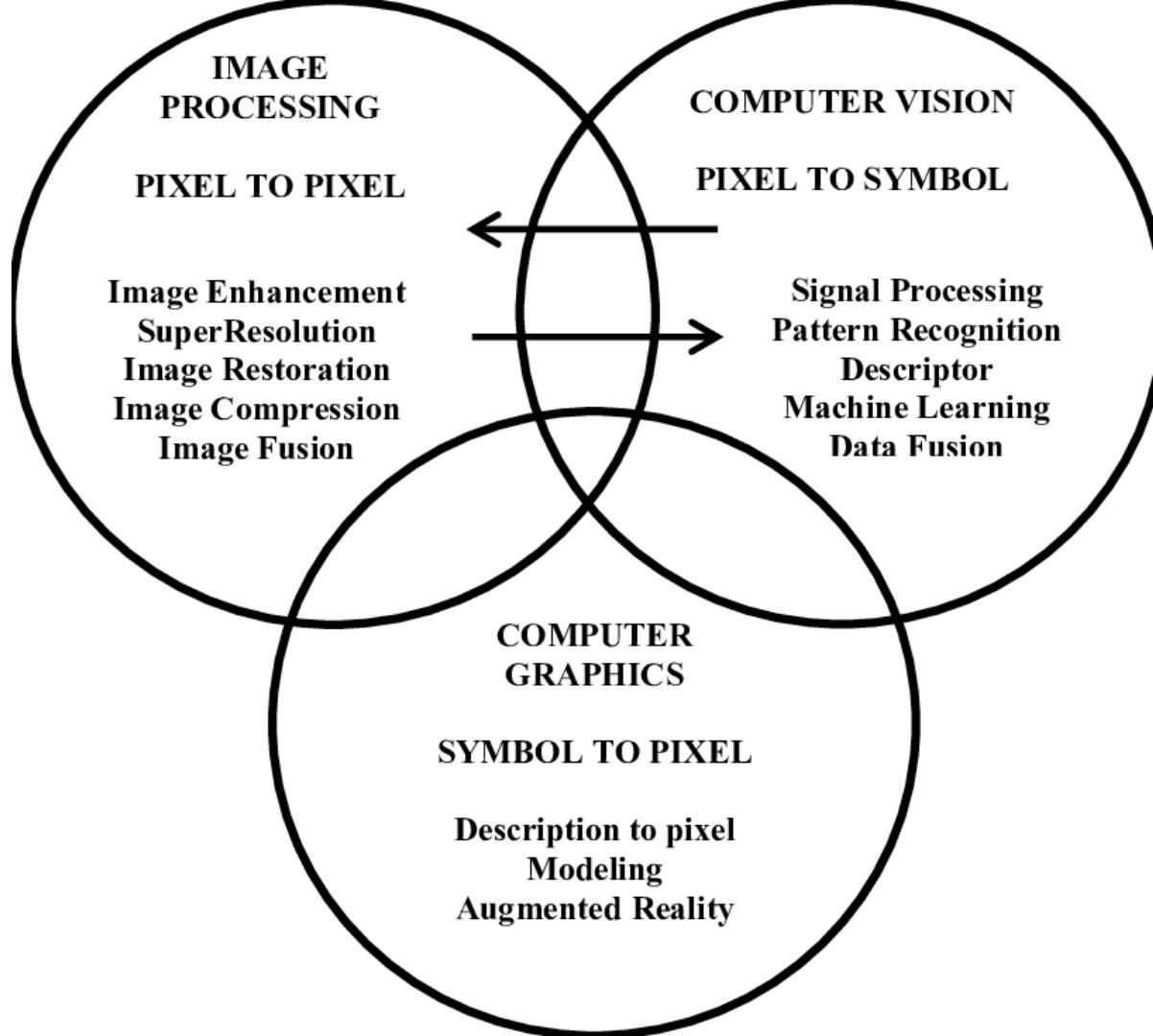
Tasks of interest: Many more

- Biology
- HCI
- Number Plate recognition
- Gesture recognition



Courtesy: Perviverzov et al. 2012





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®



Canon

You Tube



SAMSUNG

Microsoft

PHILIPS

xerox

SIEMENS

intel®

QUALCOMM®

Research

- Journals



Research

- Conferences



The banner for the 2023 IEEE International Conference on Acoustics, Speech and Signal Processing (ICASSP 2023) features a collage of three images: a medieval castle, a harbor at night, and a city skyline. Overlaid text includes the conference title in large blue letters, the dates '4 - 9 JUNE, RHODES ISLAND, GREECE', and the tagline 'Signal Processing in the AI era'. The IEEE logo is in the bottom right corner.

2023 IEEE International Conference on
Acoustics, Speech and Signal Processing

4 - 9 JUNE, RHODES ISLAND, GREECE

Signal Processing in the AI era

ICASSP 2023

IEEE

Research

- Conferences

SIGGRAPH 2023
LOS ANGELES+ 6-10 AUG

ABOUT THE CONFERENCE FULL PROGRAM THE EXHIBITION PLAN TO ATTEND VOLUNTEER WITH US SUBMIT TO SIGGRAPH REGISTER TODAY

WELCOME TO SIGGRAPH 2023

THE PREMIER CONFERENCE & EXHIBITION ON COMPUTER GRAPHICS & INTERACTIVE TECHNIQUES

Celebrate 50 years of SIGGRAPH and join us in Los Angeles or online starting 6 August. Learn more by exploring your unique areas of interest.

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See All Programming

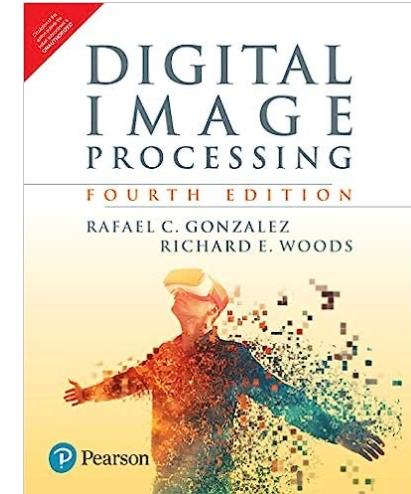
Research

- Conferences



About the course

- Timings: Mon, Thu (**11:40am – 1:05pm**)
- Pre-requisites
 - (CS): Programming, Data Structures, Algorithms
 - (MA): Basics of Linear Algebra, Calculus
 - (DSP): Minimal sense of signal processing.
- **Textbook:** *Digital Image Processing*, Gonzalez and Woods (4th ed)
- Other resources from the internet

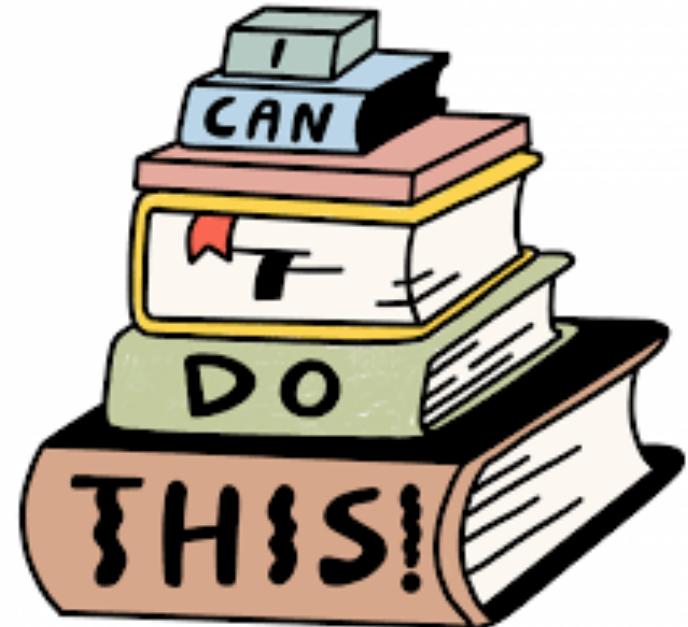


About the course

- Teaching Assistants:
 - Sanjay P + 3 (will be announced soon)
- Office Hours :
 - Mon, Thu: 1:45pm-2:30pm [after class]

About the course: Grading Policy

- Assessment
 - Assignments (4) : 24 %
 - Quizzes (2) : 16 %
 - Mid Sem : 15 %
 - End Sem : 20 %
 - Group Project : 25 %



About the course: Assignments

- Python (mandatory)
 - Github Classroom
 - Image Processing / Data Processing Libraries
 - scikit-image , opencv-python, kornia
 - 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



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/Project Late Policy:** 20% penalty if one day late; 40% 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.

Additionally ...

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



How to Learn

- **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.

Learning Resources

- PGSSP/MS/PhD
 - 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.

Be there the whole way

- Put away phone and other distractions ...
- Do NOT make end of semester travel plans until project evaluations are completed.
- Book your tickets after
 - 30th November 2023
 - 5th December if you want to see the final exam paper

Taking Notes

- Take notes actively !
 - Improves ability to summarize key ideas (core career skill !)
 - Do well in quizzes
 - Antidote to sleepiness ☺
 - Tip: Note slide headings – useful for revision/recap

Welcome and Have Fun

- DIP is extremely interesting
 - Visual
 - Mathematical
 - Practical
 - Challenging
 - Lots of interesting applications

